COMPUTATIONAL LINGUISTICS

III

COMPUTING CENTRE OF THE HUNGARIAN ACADEMY OF SCIENCES
BUDAPEST, 1964

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APPENDIX

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HOW COMPUTERS UNDERSTAND SENTENCES[*]

by

F. Kiefer and S. Abraham

Introduction

Many problems concerning machine translation can be solved if semantic aspects of the languages under consideration are also taken into account. Up to the present semantic aspects could not be introduced into the programs for the analysis in the source language or the synthesis in the target language because semantics has not been formalized. The authors of the present paper have recently outlined a formal semantic theory which makes the formal treatment of semantic features possible. A Theory of Structural Semantics, to be published by Mouton and Co., The Hague, henceforward designated TSS/. On the basis of the results obtained in that work we have now elaborated a new scheme of machine translation. This scheme is shown in Fig. 1. and Fig. 2.

The input of the 1. level of Step One consists of sentences which we assume to be grammatically correct.This assumption is not essential from the point of view of our model because if we want to test the grammaticalness of the input sentences, all we have to do is to introduce a more complete first level.

The first level has to provide a grammatical analysis of the input sentence s. As the transformational grammar is considered the most adequate grammar of language, the abovementioned analysis is carried out on the basis of the transformational grammar. So the 1. level should give as output

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[*] It should be made clear that the present paper gives only the rough outlines of the model and does not claim to solve all the problems involved in it. The details will be elaborated in subsequent papers.

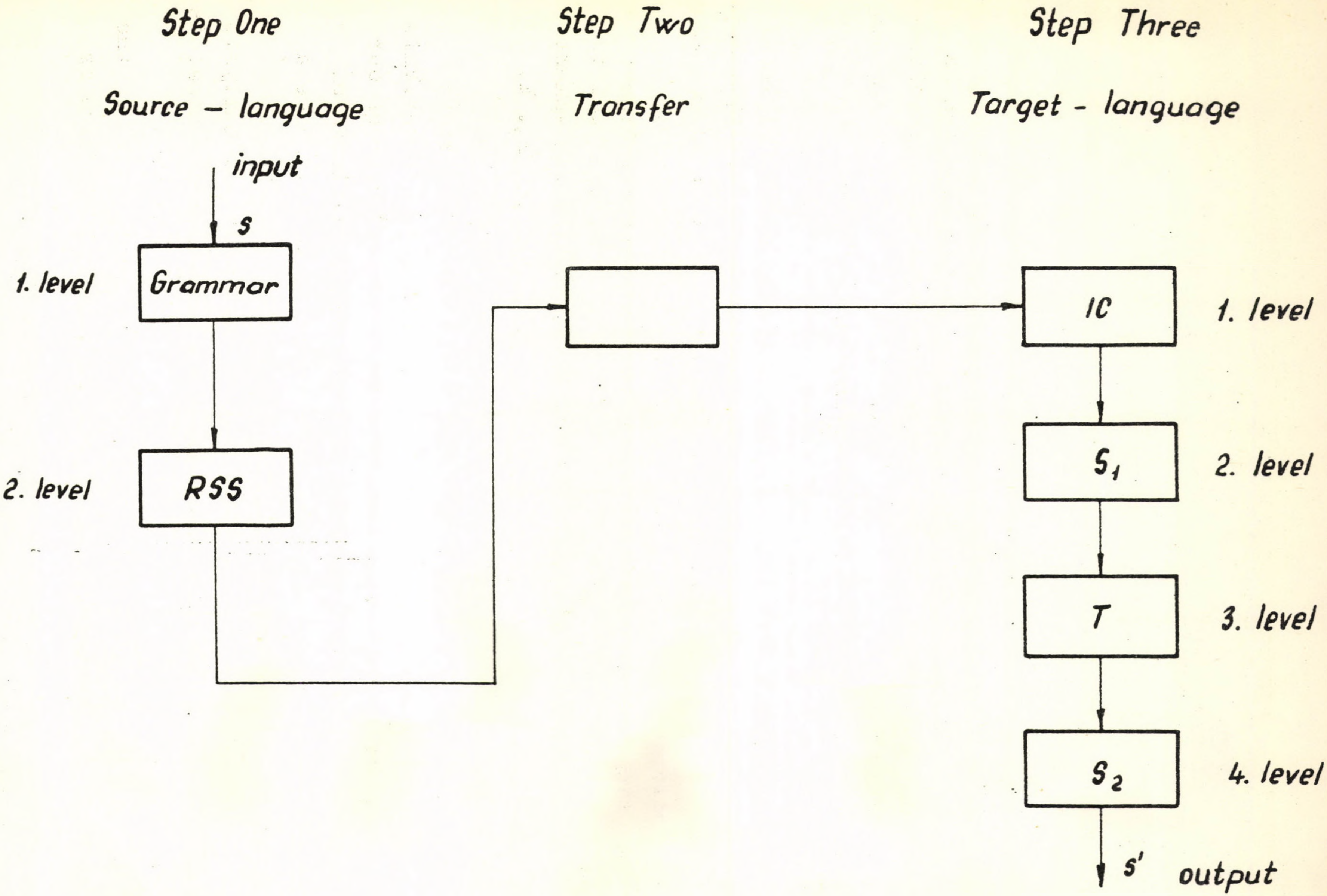

Step One
Step Two
Step Three
Source - language
Transfer
Target - language
input
s
1. level
Grammar
2. level
RSS
IC
1. level
S_1
2. level
T
3. level
S_2
4. level
s'
output

Fig. 1.

Step Four

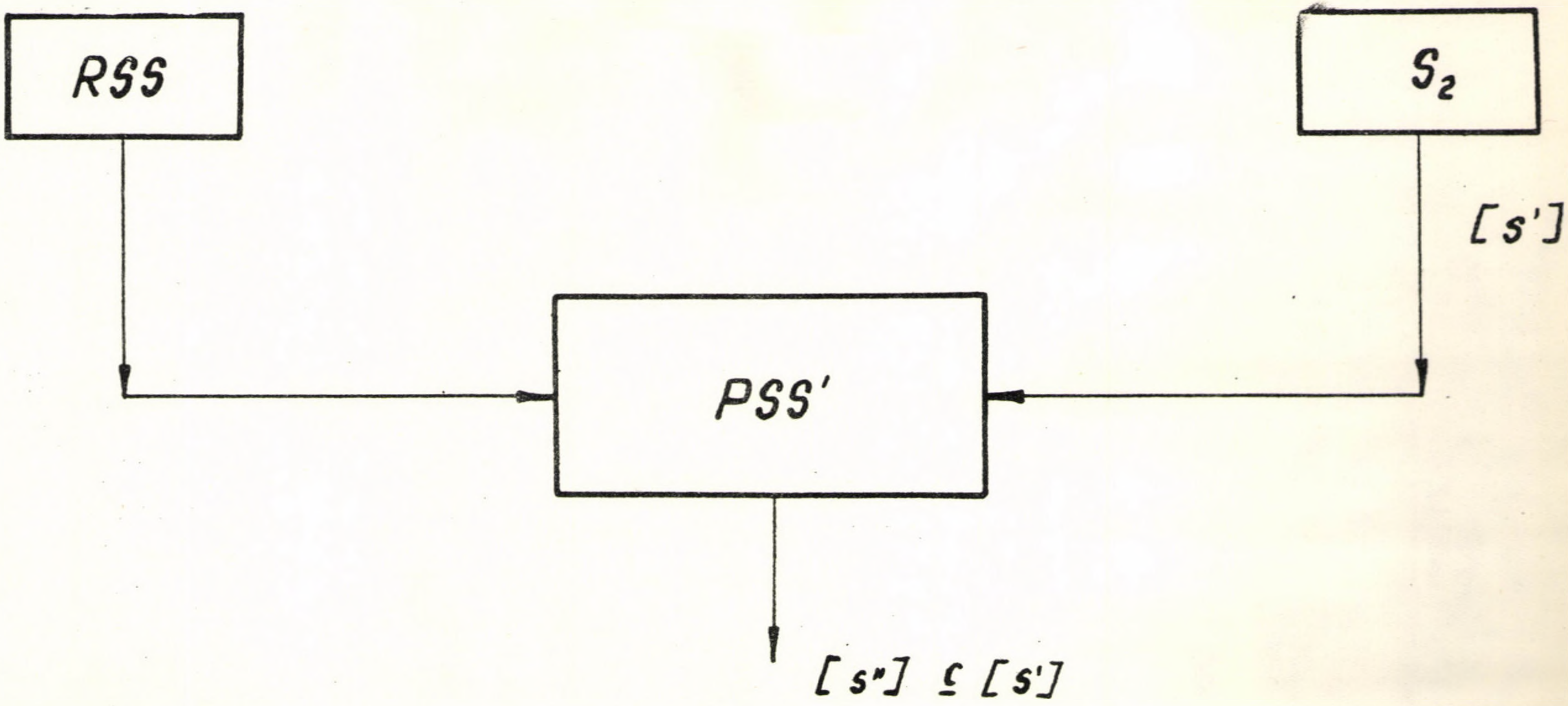


Fig. 2.

i. the underlying kernel sentences of s and their P-markers;

ii. the ordered set of the applied transformational rules, if any.

To fulfil both these tasks, a transformational grammar must first be formulated in exact terms and preferably formulated as normal Markov-algorithms because if the transformational grammar is given in the form of normal Markov algorithms, it is easier for computers to handle. On the other hand, the construction of a recognition transformational grammar in the knowledge of the generative one is also possible if the latter is formulated as normal Markov-algorithms, of which we know how to construct the inverse algorithms. In this way, the requirements i. and ii. can be realized.

After the grammatical analysis is carried out, the second level of Step One is put to work. The second level has to fulfil the following tasks:

i. First it has to establish whether the sentence s is semantically correct or anomalous. Of course, in this case too we could assume that the input of the second level consists only of semantically correct sentences. But even if we assume this, we ought to be able to detect the semantic correctness of sentences because the first level may provide more than one analysis for a sentence and it is obvious that there may exist such analyses to which no correct semantic readings correspond. In this way those grammatical analyses to which no correct semantic readings correspond are ruled out.

ii. Evidently, the words that form s may have more than one meaning. The second level has to rule out those meanings of the words which do not occur in the semantically correct readings of s.

iii. The second level has to provide for every reading such a semantic marker that enables us to check whether the sentence s', which is the translation of s, has the semantic reading as s or not.

The input of the transfer /Step Two/ consists of

i. the input-dictionary of the first level of Step One and the readings of words provided by the second level of the Step One.

Let us have the sentence s consisting of the words $w_1, w_2, \ldots, w_m$ i.e.

$$s = w_1 w_2 \ldots\ldots w_m$$

Each w_i $/1 \leq i \leq m/$ can have more than one reading, i.e.

$$w_i \longrightarrow \left\{ \begin{matrix} r^{(1)}_{w_i} \\ \vdots \\ r^{(l)}_{w_i} \end{matrix} \right\}$$

where l is a given natural number. From these readings after the second level has done its work, there remain k $/1 \leq k \leq /$ readings.

ii. besides i. the input of the transfer consists of IC-rules generating the underlying kernel sentences and the set of transformational rules applied to obtain s.

More precisely, the input of the transfer is the following quadruple

$$Q = \left\{ V_{p_i}, \Sigma_i, R_i, T_i \right\}$$

where V_{p_i} stands for the subset of V_p containing the words which form s with their admitted readings, Σ_i is the set of the initial strings which underly the kernel sentences, R_i stands for the IC-rules which applied to Σ_i yield the underlying kernel sentences /more precisely, we have here a union of subsets, namely, each underlying kernel sentence has an own set of IC-rules which generate it/ and T_i stands for the applied transformational rules.

The transfer has to provide a

$$Q' = \left\{V'_{P_i}, \ \Sigma'_i, R'_i, T'_i\right\}$$

that corresponds to Q in the following sence: namely, by using V'_{P_i} and after the application of the R'_i rules to Σ'_i we must obtain those kernel sentences that when applying the transformational rules T_i generate the set $[s'_i]$ which we call the translation of s. The term "translation" is not defined here. We shall return to this problem and give a definition of "translation" in the dicussion of Step Four.

The theory of the transfer is the real theory of translation from a scientific point of view. Besides, the elaboration of the theory of translation will lead to a typology of languages where pairs of languages may be compared on the basis of their transformational grammars. Since the transformational grammar completed by a semantic level is a full description of language, so a typology based on such a system is the most complete typology of all the possible ones.

Step Three has to expand the quadruple Q on four levels. The first two levels generate all meaningful kernel sentences obtainable from Q' the third level generates the set of sentences $[s'_i]$ mentioned while discussing the transfer part. The fourth level provides the readings of the sentences of s_i by constructing their semantic markers.

Step Four yields the possibility of comparing the semantic markers of [s] and those of $[s'_i]$ and on the basis of this comparison it must ensure that we are able to chose those readings of $[s'_i]$ which correspond to the readings of s . And those sentences of $[s'_i]$ whose semantic markers correspond to the semantic markers of $[s'_i]$ will be called the translations of [s]. /The definition of the term 'translation'/.

A semantic recognition system

The first level of Step One has to establish first the set of the underlying kernel sentences of s $\left\{s_i^k\right\}$ and the set of the applied transformational rules $\{T_i\}$. After this is carried out this level has to find out all the possible P-markers of these kernel sentences, more precisely, those IC-rules which, when applied to some element of Σ, yield $\{s_i^k\}$. The set of those IC-rules, by applying of which s_i^k is generated, is denoted by $R_i^{(i)}$. The set of all $R_i^{(i)}$-s are denoted simply by R_i. The set of the elements to which the IC-rules are applied we denote by Σ_i.

So, the output of the 1. level of Step One consists of the quadruple

$$\{V_{P_i}, \Sigma_i, R_i, T_i\}$$

where V_{P_i} stands for the set of words which form s with all its readings. By one reading of a word we understand a set of markers of the given word. A word has as many different readings as different sets of markers. What is meant by a marker will be explained below.

The semantic level consists above all of a dictionary, in which each entry has the following form

$$w_i, /v_1^i, v_2^i \; . \; . \; . \; . \; . \; . \; v_i^i \; . \; . \; .$$

where w stands for a given word and v_1^i, v_2^i . . . . . v_i^i . . . . is a linear matrix. v_i^i is called the *i-th value of the matrix* and each value is either 1 or 0. The values of the matrices may be labelled with different names, e. g. noun, verb, being, human, etc., called *categories* and then value 1 means that the given word *belongs* to the category that value is labelled with, while value 0 means that the given word does not belong to this category. The categories may be devided in to two groups: the *grammatical markers* and the semantic markers which are needed for the formal characterization of the words. /A more detailed discussion of this topic is to be found in TSS/.

Each word has at least one matrix. The matrix /matrices belonging to a word are the reading/readings of the word. That is, we may formulate the above statement about readings in the following way: A word has as many readings as different matrices.

Obviously, an unambiguous formal characterization of the words of a given language presupposes the fulfilment of the requirement that different words must have different matrices except in the case of synonymy.

Besides the dictionary the second level of Step One contains a finite set of rules, called semantic rules s_i^r of the form

$$t_1 \ldots t_n \longrightarrow t$$

where each t_i $/1 \leq i \leq n/$ and t stand for a table and "$\longrightarrow$" means the replacement of the left-hand side by the right-hand side. By a table we understand a matrix in which not every square is filled. /When filled then only with 1 or 0/.

The second level works as follows. When a sentence s arrives at this level the words of s are first replaced by the matrices of the words found in the dictionary. So instead of a sequence of words /sentence/ we always obtain a sequence of matrices. This sequence of matrices is called the lexical value of s. Obviously, each sentence may have more than one lexical value.

The rules S_i apply to the lexical values in the following way.

We shall say that a table t_i coincides with a matrix m_j when the following conditions are fulfilled:

a/ Both are of the type p x q /i. e. both of them consist of p rows and q columns/.

b/ t_i and m_j have the same value /1 or 0/ in the squares in which both are filled.

Now if we have a sequence of matrices /a subsequence of the lexical value/

$$m_1 m_2 \ldots m_r$$

and there exists such a rule S the left-hand side of which coincides with it, more precisely, if each table t_i of this S rule coincides one after the other with the m_j matrices of this sequences then this S rule may be applied to it, i.e.

it can be replaced by a single matrix which must coincide with t. /The right-hand side of the S rule/.

If there exists a natural number n such that after applying n times the rules from the set S we obtain a sequence of matrices M to which no rule S can be further applied, then we have one of the following situations:

a/ M consists of one single matrix;

b/ M consists of more than one matrix.

In case a/ we say that the /kernel/ sentence s^k is meaningful and the /single/ matrix M is called the semantic value of s^k, denoted by s^k_s.

In case b/ or when such an n does not exist, the /kernel/ sentence s^k has no meaning.

The sentence s is meaningful only if each of its underlying kernel sentences is meaningful, and only then.

If there exists at least one underlying kernel sentence which turns out to have no meaning then s has no meaning either and the process of the translation comes to a halt. If all underlying kernel sencences are meaningful then the procedure continues in te following way.

We may have two basic possibilities again.

i. The sentence s is obtained from one meaningful kernel sentence s^k by applying the transformational rules T_1, T_2, ... T_i. In this case we define the structural meaning of s as

$$(s^k_s, T_1, T_2, \ldots\ldots, T_i)$$

ii. The sentence s is obtained from the meaningful kernel sentences $s_1{}^k, s_2{}^k, \ldots\ldots, s_r{}^k$ by applying the transformational rule T. In this case we define the structural meaning of s as

$$(s^k_{s,1}, s^k_{s,2}, \ldots\ldots, s^k_{s,r}, T)$$

All other cases are combinations of i. and ii.

We introduce - in order to be able to continue the procedure three fundamental operations called semantic operations.

i. $\textcircled{\sim}$ is the operation of adding a column or a row or both to a given matrix.

ii. Υ is the operation of replacing some values of the given matrix with others.

iii. $H^{(n)}$ is a mapping of the set of M into the set N where N is the set of all matrices and M the set of sequences of the form

$$s_{s_1}, s_{s_2}, \ldots, s_{s_n}$$

where each s_{s_i} is a semantic value for every $1 \leq i \leq n$

To each transformational rule T_i we assing a combination of the operations $\textcircled{\sim}$ and Υ and denote this cominations by Γ_i.

In the case when the structural meaning takes the form

$$s_{s_1}, s_{s_2}, s_3 \ldots, s_{s_n}, T$$

we apply first operation iii. and after this is carried out the operation Γ_i.

In all cases mentioned above we obtain a single matrix after the application of the semantic operations. This matrix is called distinctive semantic matrix. Obviously, a sentence s may have more then one distinctive semantic matrix. The sentence s has as many readings as distinctive semantic matrices.

So the output of Step One when operating on the sentence s is:

i. The quadruple

$$\left\{V_p, \Sigma_i, R_i, T_i\right\}$$

provided by the first level.

ii. The distinctive semantic matrix or matrices provided by the second level.

The transfer and the semantic generative system

The transfer yields for the quadruple

$$\left\{V_{p_i}, \Sigma_i, R_i, T_i\right\}$$

the corresponding one in the target-language, i.e.

$$Q' = \left\{V'_{p_i}, \sum'_i, R'_i, T'_i\right\}$$

Step Three generates on the basis of Q on the first level all the possible kernel sentences using the first three sets of Q'. The set of these kernel sentences we shall denote

$$\left\{s_i^{k'}\right\}$$

The second level rules out those kernel sentences of the set $\left\{s_i^{k'}\right\}$ that have no meaning. This is done similarily as in Step One. The dictionary component has to have the form

$$w_i \rightarrow m_i$$

where w_i stands for a terminal symbol /word/, m_i for a linear matrix and " $\rightarrow$ " means replace w_i by m_i. These rules are called lexical rules and are denoted by $L_i^{(r)}$. The dictionary refers here to the target language.

By the application of the lexical rules we obtain the <u>lexical value</u> of the sentence or sentences $s_i^{k'}$ under consideration. To the lexical values of $s_i^{k'}$ the rules $S_i^{(r)}$ are applied, where the rules $S_i^{(r)}$ are analogously built up as in the case of Step One /source language/. If we obtain a single matrix by this procedure the <u>semantic value</u> of the corresponding kernel sentence $s_i^{k'}$/ the kernel sentence under consideration is meaningful, if not, it has no meaning.

So the output of the second level of Step Three consists of

i. the semantic values of the meaningful kernel sentences generated by the first level;

ii. and the set of transformational rules obtained in Step Two $\left\{T_i'\right\}$.

The third level generates on the basis of the meaningful sentences by applying the $\left\{T_i'\right\}$ transformational rules the set of sentences $\left\{s_i'\right\}$.

By applying the operations $\textcircled{\sim}$, $\mathfrak{r}$, $H^{(n)}$ the fourth level generates the distinctive semantic matrices of the sentences from $\{s'_i\}$.

The output of Step Three is

i. the meaningful sentences s'_i ;

ii. the distinctive semantic matrices of s'_i .

Now Step Four has as input

i. the distinctive semantic matrices of s /the output of Step One/

ii. the distinctive semantic matrices of s'/the output of Step Three/.

Step Four compares the distinctive semantic matrices of ii. with those of i.

The comparison is realized in the following way.

If the two distinctive semantic matrices to be compared are of the same type p x q then they will be said to be identical if they have the same value /1 or 0/ in each cooresponding square. If one is of the type $p_1 \times q_1$ the other of the type $p_2 \times q_2$ then we construct for each of them the matrix of the type $p' \times q'$ where

$$p' = \max (p_1, p_2)$$

and

$$q' = \max (q_1, q_2)$$

and the free squares are filled in with 0's. Then the two matrices can be compared as both being of the same type.

Those s'_i - s are called the translation of s which have at least one distinctive semantic matrix identical with a distinctive semantic matrix of s.

Examples

We take the sentence

A toll kiesett a kezéből

Here we have for

$V_{p_i} = \{$kiesett, a, toll, kezéből$\}$

$\sum_i = S$

R_i : S→NP VP, NP→A N, VP→V NP, NP→A N, A→a, N→toll,
V→kiesett, N→kezéből

and $\{T_i\}$ is an empty set.

It should be noted that the IC-rules are here oversimplified because we are not interested in the grammatical part of the translating system only in the semantic one.

Thus, the input of the second level of the first step is the triple

$$\{V_{p_i}, S, R_i\}$$

The semantic level /2. level/ consists above all- as mentioned of a dictionary component. The dictionary will contain the following entries in our case:

a	(1 o o o o o o o o o o o o o o o)	(1)
toll	(o 1 1 o o o o o o o o 1 1 1 o o)	(2)
toll	(o 1 1 o o o o o o o o 1 1 o o o)	(3)
toll	(o 1 1 o o o o o o o o 1 o o o o)	(4)
toll	(o 1 o o o o o o o o o o o o o 1)	(5)
toll	(o 1 1 o o o o o o o o 1 1 1 1 o)	(6)
kiesett	(o o o 1 1 o o o o o o o o o o o)	(7)
kiesett	(o o o 1 o o o o o o o o o o o o)	(8)
kezéből	(o 1 1 o o o 1 1 1 1 1 o o o o o)	(9)

The categories used here for the characterizations of the words are: article, noun, concrete, verb, concrete, auxiliary, adverb, place, preposition, pronoun, possesive, object, instrument, production, part, activity. It is true, the use of 16 categories seems to be quite redundant but we must always have the union of the categories used for the characterization of words both in the source-language and the target-language. We want to stress that these categories are only assumed for the sake of illustration; are neither sufficient for a full semantic characterization of the given words nor are they necessarily the categories at all needed for a full characterization.

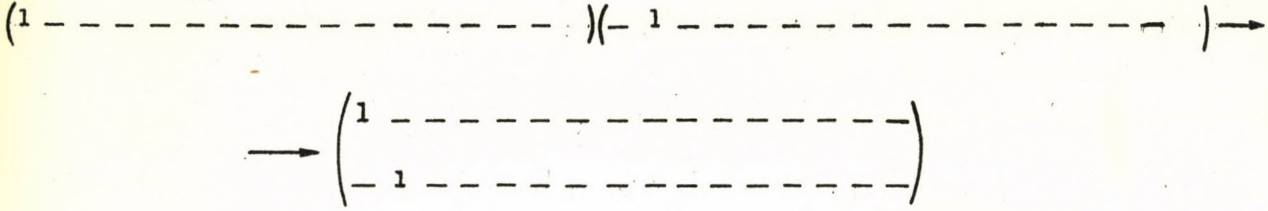
We obtain the following sequences of matrices for our sentence

(1')	(1)	(2)	(7)	(1)	(9)
(2')	(1)	(3)	(7)	(1)	(9)
(3')	(1)	(4)	(7)	(1)	(9)
(4')	(1)	(5)	(7)	(1)	(9)
(5')	(1)	(6)	(7)	(1)	(9)
(6')	(1)	(2)	(8)	(1)	(9)
(7')	(1)	(3)	(8)	(1)	(9)
(8')	(1)	(4)	(8)	(1)	(9)
(9')	(1)	(5)	(8)	(1)	(9)
(10')	(1)	(6)	(8)	(1)	(9)

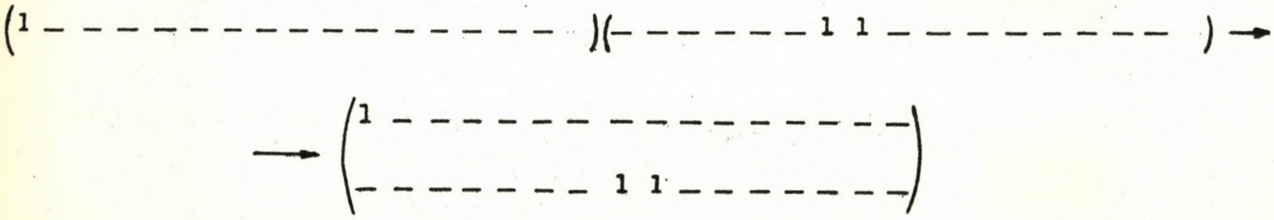
(The figures in parantheses 1-9 refer to the matrices given above.)

Besides, we have the S_i^r rules: S_1^r, S_2^r, S_3^r, S_4^r and S_5^r

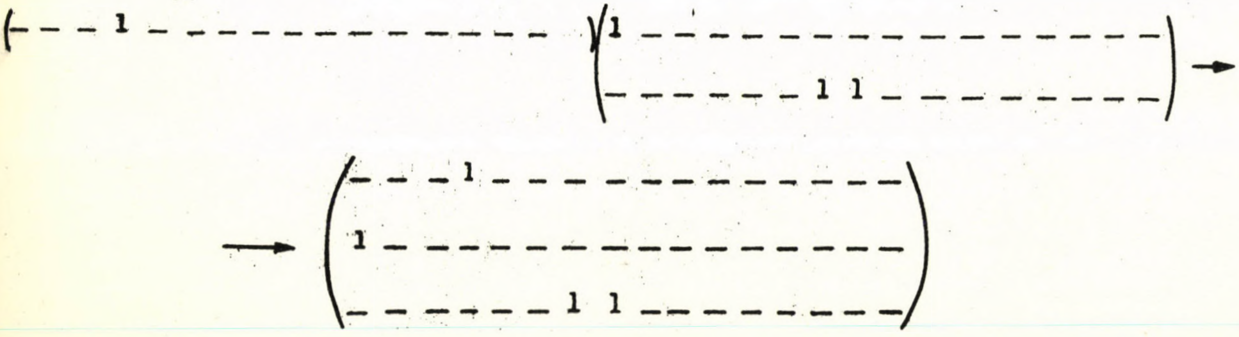
1.



2.



3.



$$\begin{pmatrix} 1 - - - - - - - - - - - - - - - \\ - 1 1 - - - - - - - - - - - - - \end{pmatrix} \begin{pmatrix} - - - 1 1 - - - - - - - - - - - \\ 1 - - - - - - - - - - - - - - - \\ - - - - - - - 1 1 - - - - - - - \end{pmatrix} \rightarrow$$

$$\rightarrow \begin{pmatrix} 1 - - - - - - - - - - - - - - - \\ - 1 1 - - - - - - - - - - - - - \\ - - - 1 1 - - - - - - - - - - - \\ 1 - - - - - - - - - - - - - - - \\ - - - - - - - 1 1 - - - - - - - \end{pmatrix}$$

$$\begin{pmatrix} 1 - - - - - - - - - - - - - - - \end{pmatrix} \begin{pmatrix} - - - 1 0 - - - - - - - - - - - \\ 1 - - - - - - - - - - - - - - - \\ - - - - - - - 1 1 - - - - - - - \end{pmatrix} \rightarrow$$

$$\rightarrow \begin{pmatrix} 1 - - - - - - - - - - - - - - - \\ - 1 0 - - - - - - - - - - - - - \\ - - - 1 0 - - - - - - - - - - - \\ 1 - - - - - - - - - - - - - - - \\ - - - - - - - 1 1 - - - - - - - \end{pmatrix}$$

First we apply the rules S_1^r, S_2^r, S_3^r, S_4^r, to 1. So we obtain successively the sequences of matrices:

Step 1. $\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&0&0 \end{pmatrix}$ (7) (1) (9)

Step 2. $\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&0&0 \end{pmatrix}$ (7)

$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$

Step 3.
$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&0&0 \end{pmatrix}$$

$$\begin{pmatrix} 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

Step 4.

(i)
$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&0&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

So we obtain for (1') a single matrix which we call the <u>semantic value</u> of (1').

Similarly we obtain single matrices for (2'), (3'), (5') and (9'). The semantic values for these sequences are given below.

(ii)
$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&0&0&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

(iii)
$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

(iv)
$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&1&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

$$(v)\quad \begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\ 0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0\\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

In the cases (4'), (6'), (7'), (8') and (10') we do not obtain a single matrix. Let us consider only case (4'). We apply the rules S_i^r to (4') successively and in all possible ways:

Step 1.

After applying the rule S_1^r we obtain

$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1 \end{pmatrix} \quad (7)\ (1)\ (9)$$

Step 2.

After applying the rule S_2^r we obtain

$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1 \end{pmatrix} \quad (7)$$

$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

Step 3.

After applying the rule S_3^r we obtain

$$\begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1 \end{pmatrix}$$

$$\begin{pmatrix} 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\ 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

Neither S_4^r nor S_5^r applies to this sequence.

As our sentence is a kernel sentence and no transformational rules have been applied, so the semantic values i - v are also the structural meanings and the distinctive semantic matrices of the sentence under consideration. A simple comparison shows that there is no identity between the distinctive semantic matrices, so our sentence has five different readings.

The output of the first step is in our case

i/ the triple $Q = \{V_{p_i}, S, R_i\}$

and

ii/ the distinctive semantic matrices (i) - (v).

The transfer yields the quadruple $\{V'_{p_i}, \Sigma'_i, R'_i, T'_i\}$ corresponding to Q in the source language. Say, we have obtained

$V'_{p_i} = \{$the, has fallen, out, of, his, her, hand, feather, quill, pen, spring /of lock/, /of key/, bit, blade /of oar, scull, paddle, sweep/$\}$

$$\Sigma'_i = S$$

$R'_i \div S \rightarrow NP\ \ VP$
$NP \rightarrow A\ \ N$
$VP \rightarrow V\ \ NP_1$
$V \rightarrow A_n\ \ P$
$NP_1 \rightarrow P'_r\ \ NP_2$
$A \rightarrow$ the
$N \rightarrow$ hand, feather, quill, pen, spring, bit, blade
$P'_r \rightarrow$ out $P'_r \rightarrow$ of

First Step 3. generates the following kernel centences

1 The hand has fallen out of his hand
2 The feather "
3 The quill "
4 The pen "
5 The spring "
6 The bit "
7 The blade "

8 The hand has fallen out of his feather
9 The feather "
10 The quill "
11 The pen "
12 The spring "
13 The bit "
14 The blade "
15 The hand has fallen out of his quill
16 The feather "
17 The quill "
18 The pen "
19 The spring "
20 The bit "
21 The blade "
22 The hand has fallen out of his pen
23 The feather "
24 The quill "
25 The pen "
26 The spring "
27 The bit "
28 The blade "
28 The hand has fallen out of his spring
30 The feather has fallan out of his spring
31 The quill "
32 The pen "
33 The spring "
34 The bis has fallen out of his spring
35 The blade "
36 The hand "
37 The feather "
38 The quill "
39 The pen "
40 The spring "
41 The bit "
42 The blade "
43 The hand has fallen out of his blade
44 The feather "

45 The quill has fallen out of his blade
46 The pen "
47 The spring "
48 The bit "
49 The blade "

As mentioned, the second level of this step has to rule out those /kernel/ sentences from 1 -49 that have no meaning. This level consists first of dictionary component formulated as rules /the lexical rules L_i^r/.

$$W_i \longrightarrow m_i$$

Here we have the following lexical rules:

the → (1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)
has → (0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0)
fall → (0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0)
fall → (0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)
out → (0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)
of → (0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)
his → (0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0)
hand → (0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0)
feather → (0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0)
quill → (0 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0)
pen → (0 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0)
spring → (0 1 1 0 0 0 0 0 0 0 0 1 1 1 1 0)
bit → (0 1 1 0 0 0 0 0 0 0 0 1 1 1 1 0)
blade → (0 1 1 0 0 0 0 0 0 0 0 1 1 1 1 0)

where the categories are the same as in the case of the source language.

With the use of the dictionary we obtain 98 sentences. As "kiesett" in the Hungarian sentence has also a figurative sense, we must take into account the figurative sense of the English word "fall". We have now 49 sentences generated by the grammatical level and in each of them "fall" may also occur in a figurative sense. In this way we obtain 98 possibilities. These may be reduced by the application of the R_i - rules.

Before establishing the $R_i^{(2)}$ rules we point to the fact that the transfer specifies the $R_i^{(2)}$ rules depend not only upon the language they are concerned with but also upon the source-language.

The $R_i^{(2)}$-rules may refer to the grammatical or to the semantic categories only or to both. In the case when they refer to the grammatical categories they may refer to those grammatical categories which may be in a way understood as semantic ones as well. For example, the category "concrete" with respect to a noun may be both a semantic and a grammatical category.

There we have the following $R_i^{(2)}$-rules:

$R_1^{(2)}$:

(– – – 1 – 1 – – – – – – – – – –) (– – – 1 – – – – – – – – – – – – –) →

→ (– – – 1 – 0 – – – – – – – – – – –)

$R_2^{(2)}$:

(– – – – – – 1 – – – – – – – – –) (– – – – – – – – 1 – – – – – – –)

(– – – – – – – – – – 1 1 – – – – –) (– 1 – – – – – – – – – – – – – –) →

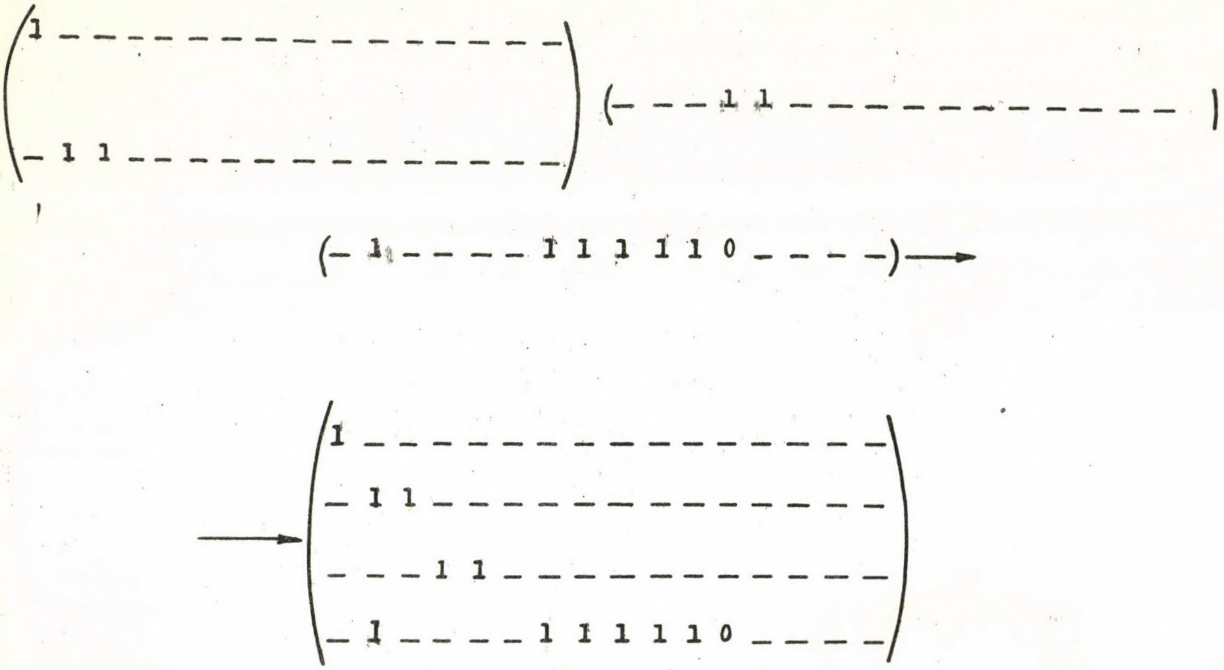
→ (– 1 – – – – 1 1 1 1 1 – – – – –)

$R_3^{(2)}$:

(1 – – – – – – – – – – – – – – –) (– 1 – – – – – – – – – – – – – –) →

$$\rightarrow \begin{pmatrix} 1 - - - - - - - - - - - - - - \\ - 1 - - - - - - - - - - - - - \end{pmatrix}$$

$R_4^{(2)}$:



From these rules, as it may be seen, $R_1^{(2)}$ links the auxiliary verb with the main verb, $R_2^{(2)}$ links the adverb, the preposition the possessive pronoun and the noun /concrete but not an object/ to an adverb of place, $R_3^{(2)}$ links the article with any noun; $R_4^{(2)}$ links a concrete noun /with article/ with a concrete verb and an adverb of place; $R_2^{(2)}$ rules out those cases when the noun is concrete and the verb is figurative. As mentioned the rule $R_2^{(2)}$ rules out all those cases in which the noun in the adverb of place is an object. This restriction, however,calls for an explanation. It is clear that the sentence:

The spring has fallen out of his car

is meaningful and here "car" is an object. But - as we have pointed out - the $R^{(2)}$ rules are not independent of the source-language. The semantic structure of the sentence in the source language imposes restrictions on the $R^{(2)}$-rules.

As natural as are the restrictions imposed on the $R^{(2)}$ rules it is natural that we have to take into consideration only those meanings of the words of the target language that are given by the transfer. So, for instance "spring" has a lot of further meanings but we are interested only in the meaning 'spring of a lock.'

After the application of the $R^{(2)}$-rules only the sequences of matrices correponding to the sentences

[1'] The feather has fallen out of his hand
[2'] The quill "
[3'] The pen "
[4'] The spring "
[5'] The bit "
[6'] The blade "

remain. All these sentences are in a way synonymous. To obtain the synonymous readings of these sentences we have to consult the dictionary and to repeat the whole procedure. For the sentences we obtain the following distinctive semantic matrices:

$$1'' \quad \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$2'' \quad \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$3'' \quad \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$4'' \quad \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$5'' \quad \begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&1&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

$$6'' \quad \begin{pmatrix} 1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&0&0&0&0&0&1&1&1&1&0 \\ 0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0 \\ 0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0 \end{pmatrix}$$

It should be noted that 1"-6" are originally the semantic values of the corresponding sentences. But in the case of kernel sentences the semantic value, the structural meaning and the distinctive semantic matrices coincide. The sentences being kernel sentences we do not need the 3. and 4. level of Step Three. The output of Step Three are the pairs where s'_i stands for the generated sentences admitted by the 2. level, and D'_i for the corresponding distinctive semantic matrices.

Now we have to proceed with Step Four for the comparison of the distinctive semantic matrices of the sentence s of the source language and the distinctive semantic matrices of the corresponding sentence s'_i of the target language. However, in the most cases, as also in our case, the direct comparison of the distinctive semantic matrices is quite impossible. Namely, they are only in a few cases of the same type $m \times n$. So we need a mapping $\mathfrak{U}$ which maps the distinctive semantic matrices obtained in the source and in the target language, into the set of matrices $p \times q$. The function $\mathfrak{U}$ consists - among others - of operations of adding a row or a column to a matrix or of deleting one row or one column of the matrix. The function $\mathfrak{U}$ is in a way determined by the transfer.

In the present case the distinctive semantic matrices of the source language have one row more than that of the target language. This row corresponds to the definite article. But we know that in English as well as in German, and some other languages, no definite article can occur before a possessive pronoun. So if in the target language a possessive pronoun occurs and the target language is, for instance, English, then the definite article must not be translated. In this way the transfer specifies the function $\mathfrak{A}$. For the sake of comparison the function $\mathfrak{A}$ may in this case delete the row corresponding to the definite article "a̲". In this way we obtain the following matrices of the source language:

$$\text{i'}\quad\begin{pmatrix}1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&0&0&0&0&0&1&1&1&0&0\\0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0\end{pmatrix}$$

$$\text{ii'}\quad\begin{pmatrix}1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&0&0&0&0&0&1&1&0&0&0\\0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0\end{pmatrix}$$

$$\text{iii'}\quad\begin{pmatrix}1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0\\0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0\end{pmatrix}$$

$$\text{iv'}\quad\begin{pmatrix}1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&0&0&0&0&0&1&1&1&1&0\\0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0\end{pmatrix}$$

$$\text{v'}\quad\begin{pmatrix}1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&0&0&0&1&1&1&1&1&0&0&0&0&0\end{pmatrix}$$

We can now proceed to Step Four A. Simple comparison shows that

3570 dé.

i’	corresponds to	3"
ii’	"	2"
iii’	"	1"
iv’	"	4", 5", 6"
v’	"	---

Let us consider the corresponding sentences:

A toll kiesett a kezéből with the distinctive semantic matrix i’ corresponds to *The pen has fallen out of his hand*.

A toll kiesett a kezéből with the distinctive semantic matrix ii’ corresponds to *The quill has fallen out of his hand.*

A toll kiesett a kezéből with the distinctive semantic matrix *iii’* corresponds to *The feather has fallen out of his hand*.

A toll kiesett a kezéből with the distinctive semantic matrix iv’ has three correspondences, namely *The spring has fallen out of his hand.* *The bit has fallen out of his hand*. *The blade has fallen out of his hand* where *spring* is here understood *as spring of lock, bit* as *bit of key* and *blade* as *blade of oar*, *blade of scull*, *blade of paddle*, *blade of sweep.*

A toll kiesett a kezéből with the distinctive semantic matrix v’ strictly has no correspondence in English. As can be seen in this case both "toll" /pen/ and "kiesett" /has fallen/ are meant in a figurative sense. The Hungarian sentence has the idiomatic meaning "The writer died". If we give the idioms in a list we may get a suitable translation for our sentence with the distinctive semantic matrix v’, namely, for instance,

He died

In this way we have obtained the translations and all of them, of the Hungarian sentence

A toll kiesett a kezéből.

Another problem is, of course, how to find out the suitable translation of this sentence, if it occurs in a context.

In our case the sentence has been regarded separately with no restrictions imposed on the meaning. The next problem we want to scrutinize is how the restrictions imposed on the source-language sentence can be transfered to the corresponding sentence /s/ in the target-language.

AN ALGORITHM FOR SYNTACTIC ANALYSIS

by

Bálint Dömölki

The analysis of a symbol string with respect to some formal, mathematically defined grammar is an important part both of the translation of natural and of artificial /programming/ languages as well.

This paper is intended to give a short description of a suggested method for this <u>syntactic analysis</u> followed by the algorithm itself written in terms of the international programming language ALGOL-60 /see [1]/. The formal proof of the statements, some extensions of the method /first of all in the direction of context restricted grammars/ and some further theoretical remarks will follow in a subsequent paper.

1. The problem of the syntactic analysis of context free phrase structure languages /see [2]/ can be defined as follows:

Let σ and τ finite sets be called the sets of symbols and syntactic categories respectively:

$$\sigma = \{\sigma_1, \sigma_2, \ldots\ldots \sigma_n\}$$
$$\tau = \{\tau_1, \tau_2, \ldots\ldots \tau_m\}$$

and for any finite set α let $S(\alpha)$ denote the set of all symbol strings which can be formed from the elements of α /i.e. $S(\alpha)$ is the free semigroup, generated by α /. A grammar G can be defined as a function assigning to each syntactic category $\tau_i \in \tau$ a finite set $G(\tau_i) \subset S(\sigma \cup \tau)$ This grammar will generate to each category τ_i a set /called language/ $L_G(\tau_i) \subseteq S(\sigma)$ in the following way:

a/ let us extend the definition of the sets σ to the set σ defining $(1 \leq i \leq n)$

$$L_G(\sigma_i) = \{\sigma_i\} \subset S(\sigma)$$

as sets containing only one element;

b/ for any symbol string $a \in S(\sigma)$ if $a \in G(\tau_i)$ then $a \in L_G(\tau_i)$ as well;

c/ if

$$x = x_1\, x_2 \ldots x_q \in G(\tau_i) \qquad (x_j \in \sigma \cup \tau)$$

and there are symbol strings $a_1, a_2, \ldots a_q$ for which

$$a_j \in L_G(x_j) \qquad (1 \leq j \leq q)$$

then

$$a = a_1\, a_2 \ldots a_q \in L_G(\tau_i) \;;$$

d/ no symbol strings, other then those defined by a/ - c/ belong to the sets L_G.

The equivalence of this definition with the well-known notion of the context free phrase structure languages of Chomsky [2] can be easily proved.

The problem of syntactic analysis is now to answer the question whether a given symbol string belongs to some set $L_G(\vartheta_i)$ with respect to the given grammar, or not.

2. We shall slightly modify the definition given in 1. permitting only some special finite sets as $G(\tau_i)$. These special sets can be defined by means of tables /see [3] or [4] /

$$T^i = \begin{bmatrix} t^i_{11} & t^i_{21} & \ldots & t^i_{p1} \\ t^i_{12} & t^i_{22} & \ldots & t^i_{p2} \\ \ldots & \ldots & \ldots & \ldots \\ t^i_{1h_1} & t^i_{2h_2} & \ldots & t^i_{ph_p} \end{bmatrix}$$

where

$$t^i_{jk} \in \sigma \cup \tau \qquad (1 \leq j \leq p,\; 1 \leq k \leq h_j).$$

Each table T^i will generate a finite set T^i which is defined to contain all such words of length p_i

$$y = y_1\, y_2 \dots y_{p_i} \qquad (y_j \in \sigma \cup \tau \;,\; 1 \leq j \leq p_i)$$

the particular letters of which belong to the corresponding columns of the table T^i

$$y_j = t^i_{jk}$$

for some k, with $1 \leq k \leq h_j$.

It can be proved that each grammar G can be defined by means of a set of tables

$$T^1,\, T^2,\, \dots\, T^{m'} \qquad m' \geq m$$

in the following sense: each language $L_G(\tau_i)$ generated by the grammar G can be obtained as the union of some languages $L_{G'}(\tau_j)$, generated by the grammar G', defined by the relations

$$G'(\tau_j) = \widetilde{T^j} \qquad (1 \leq j \leq m')$$

In the following we restrict our considerations to grammars defined by this type of finite sets only.

3. The algorithm of syntactic analysis works according to a "trial-error" method: the symbol string is scanned from left to right and the first substring, belonging to any of the sets $G(\tau_i)$ is temporarily recognized as a syntactic category and substituted by that symbol. This gives us a new string /belonging to $S(\sigma \cup \tau)$/, to which the same procedure is applied, until either no recognition is possible or a so called final syntactic category is recognized. In the first case the last temporary recognition will be deleted, the corresponding situation restored from a stack and the procedure continued from that situation. On the other hand, in order to terminate the analysis process some syntactic categories are chosen as final categories, which has the following meaning: the recognition of a final category will not be temporary, but will result the actual

substitution of the cathegory symbol into the input string and this substitution cannot be deleted any more. Moreover, a final recognition will make final all the temporary recognitions within its scope.

The main goal of the syntactic analysis /e.g. the sentence in the case of natural languages or the statement in the case of programming languages/ should always be chosen as final. In addition, the same can be done for some intermediate categories too, if the definition of the grammar makes it sure that it will not be necessary to delete any recognition of this category later on.

4. The output of the analysis procedure is given by the so-called semantical subroutines, which are called after every final recognition of a syntactic category. These subroutines can be used either to translate the substring, corresponding to the category, or to construct a tree, containing all the information about the finally recognized substrings, which gives the possibility to perform the translation later. The nature and content of these subroutines will not be dealt with in this paper, since it always very much depends on the particular problem the syntactic analysis is used for.

5. The realization of the algorithm on digital computers is based on a method for the recognition of certain properties of symbol strings, given in [3] and [4] . According to this method, the tables T^i are represented by Boolean matrices where

$$b^i_{jk} = \begin{cases} 1, & \text{if the j-th symbol is contained in the} \\ & \text{k-th column of the table } T^i, \\ 0, & \text{otherwise.} \end{cases}$$

/here by "the j-th symbol" σ_j is meant if $j \leq n$, an τ_{j-m} if $j > n$/

The Boolean matrix B, representing the whole system of tables T^1. T^2, ... T^m is constructed by placing the matrices B^i, representing the particular tables one after the other:

$$B = B^1 B^2 \dots B^m.$$

Two Boolean vectors, U and V are defined to mark the position of the first and last columns of each table respectively.

It can be proved /see [3] and [4] /, that the Boolean vector Q, computed by the recursive formulas

$$Q_o = 0$$

$$Q_{t+1} = (\tfrac{1}{2} Q_t \vee U) \wedge B[x_{t+1}],$$

where the multiplication by $\frac{1}{2}$ denotes the right shift of the vector by 1 position and B[i] is the i-th row of the matrix B, has the following properties:

a/ $$Q_t \wedge V \neq 0$$

if and only if there is a table T^i, that

$$x_{t-p_i+1} x_{t-p_i+2} \dots x_t \in \widetilde{T^i}$$

b/ if $Q_t = 0$, then the symbol x_t cannot get inside any recognizable substring any more. This fact - sometimes in the future - will cause a situation, where no recognition is possible, consequently this is the case, when the last temporary recognition shuold be deleted.

The values of these Q-vectors are stored in a stack, in order to have the possibility to recover the former situations when it becomes necessary. After any temporary recognition some information is stored in the same stack about the recognized category, its scope, and the address of the information about the last temporary recognition. The Q-vector in this case is stored in a modified form: the bit, corresponding to the recognized category /i.e. the most significant 1 in the vector $Q \wedge V$/ is cleared. This modified value will be used after the recognition has been deleted.

6. In the case of a practically interesting syntax the length of the Boolean vectors can be several hundreds of bits, which makes it necessary to store these vectors in the

computer in many consecutive machine words. In this way, the storage requirements may become too big, however a considerable amount of the words will contain only 0. In this case, it would be more effective to store the non-0 machine words only, together with the serial number of the word inside the vector. This storage method will of course complicate the vector-operations, but the considerable savings in storage requirements as well as in speed /owing to the operations on the 0-vectors/ will compensate this disadvantage.

In this paper the algorithm will be presented with the above mentioned storage method. According to this, the grammar is stored in the following arrays:

a/ dir - a "directory", where after the first n entries, left for the basic symbols, each entry corresponds to a column of the B-matrix. Actually only the entries corresponding to the last columns of the tables are used: dir [u] will contain the index, where the first word of the row, corresponding to the syntactic category, represented by the table in question /or to the basic symbol σ_n if $u \leq n$/ is stored in the matrices Be and Bm /see below/;

b/ Be - this vector is generally used to store the serial number of the machine word, stored in the corresponding element of the vector Bm, except the following two cases: the number of non-0 elements of the row is stored in Be [dir [u]], and the length of the table corresponding to the entry dir [u] is stored in Be [dir [u] - 1] .

c/ Bm - is generally used to store the machine words of the Boolean vectors, corresponding to the serial number, stored in Be, except the element Bm [dir [u]] , which will contain information about the semantic subroutine, associated with this category /e.g. the address of the subroutine/. For final categories this number should be negative.

d/ U and V - the arrays marking the borders of the particular tables in the matrix B, as mentioned above.

In the program the arrays

stack, STe, STm

are used to store the previous values of the Q-vector in a similar way as the arrays

dir, Be, m

store the rows of the matrix B.

The input string is stored in the arrays

symb, link

in the form of a list: the successor of the symbol symb [i] will be symb [link [i]] . The beginning of the input string is marked by the integer i0: the first symbol will be symb [link [i0]] .

7. In this paragraph the complete algorithm is given, written in the language ALGOL-60. It should be emphasized that ALGOL-60 is not a language, specially suitable to describe this sort of "symbol manipulation" algorithms, and this description is intended for publication purposes rather than for effective realization. In machine-code programming e.g. the arrays Be, Bm and STe, STm can be stored in the exponent and mantissa part of floating point words and some other simplifications can be made as well.

The input part of the program is omitted and it is assumed that the arrays

dir, Be, Bm, U, V, symb, link

and the integer i0 are non-local to the block containing the program and their initial values are already assigned.

The semantic subroutines are given by the

<u>procedure</u> translate (x, i),

which is also assumed to be non-local and will not be described details. The parameters of this procedure are: the syntactic category in question denoted by x, and the beginning of its scope denoted by i.

The other non-local identifiers of the program are:

w - the length of machine words, used to store the Boolean vectors;

jmax, pmax, Umax - integers, defining the upper bounds of the arrays, occuring in the program, their value depends on the storage capacity of the computer;

TO - a constant, whose value depends on the actual realization of the machine-code procedure Normalize (x, y, z). /see below/

The body of some procedures in the program has to be written in machine code. In the case of these, the corresponding machine code program has to be substituted in place of the comment, describing the action, required from the procedure. The machine words, storing the parts of Boolean vectors are declared as integers, and the logical operations are defined by means of the above mentioned procedures.

```
begin
   integer array stack [0:jmax+4] , STe, STm [0:pmax+Umax+1];
   integer i,j,p,f,x,p0,e,e1, y,y1,y2,d,p1,k,R,r1,f2,m,m1;
   integer procedure Conj (x,y): integer x, y;
    begin comment To produce the conjunction of the binary
                  codes of the integers x and y;
    end;
   integer procedure Disj (x,y) ; integer x, y;
    begin comment To produce the disjunction of the binary
                  codes of the integers x and y;
    end;
   procedure Normalize (x,y,z) ; integer x, y, z;
    begin comment To assign to y the number of 0-s before the
                  most significant 1 in the full /W bit of
                  length/ binary code of the integer x and to
                  assign to z the most significant 1 itself;
    end;
   procedure error;
    begin comment To produce a monitor print-out in the case
                  of a stack overflow or if a non existing
                  temporary recognition has to be deleted;
    end;
   initial values:  i := STm [0] := i0;
                    f := stack [0] := STe [0] := 0;
                    j := p := 1;
                    R := -1;
```

```
new symbol:   i := STm [p] := link [i] ;
              x := symb [i] ;
              y1 := dir [x] ;
nex Q: p0 := stack [j] := p;
       j := j + 1;
       p := p + 1; if j > jmax v p > pmax then error;
       s1 := e1 := 0;
       y2 := y1 + Be [y1] ;
       f2 := f  + STe [f] ;
                            comment The following cycle
                            will compute the new value of
                            the Q-vector and store it in
                            the top of the stack. The old
                            value of Q is in STe, STm
                            between the integers f and f2;

for y := y1+1 step 1 until y2 do
  begin e := Be [y] ;
         m := U [e] ;
         nextf: if f  f2 then
                  begin d := STe [f+1] - e;
                        if d ≥ 0 then
                         begin f := f + 1;
                               if d ≠ 0 then go to nextf;
                               m := Disj m (STm [f] ÷ 2);
                         end
                  end;
         m := Conj (m, Bm [y] ) ;
         if m ≠ 0 then
          begin if Conj (m, V [e] ) ≠ 0 then
                 begin e1 := e;
                       m1 := Conj (m, V [e] ) ;
                       p1 := p
                 end:
                STe [p] := e;
                STm [p] := m;
                p := p + 1;
                s1 := s1 + 1
```

```
                    end
                end for y;
               STe [p0]   := sl;
               f := p0;
test 0: if sl = 0 then
               begin                          comment Delete the last tem-
                                              porary recognition, which can
                                              be recovered from the stack
                                              by R;
                      if R < 0 then error;
                      j    := R - 2;
                      f    := stack [j-1] ;
                      R    := stack [R] ;
                      sl   := STe [f] ;
                      i    := STm [f] ;
                      p    := f + sl + 1;
                      el   := 0;

               for y := f+1 step 1 until p-1 do
                begin m := STm [y] ;
                      if m = 0 then sl := sl - 1;
                      if Conj (m, V [STe [y]]      ≠ 0 then
                       begin el := STe [y]  ;
                             ml := Conj (m, V [STe [y]]) ;
                             pl := y
                       end
                end of the cycle recovering the old value of Q;
               go to test 0
           end of deleting;
if el = 0 then go to new symbol;
Normalize (ml, d, m);                         comment Temporary
x := T0 + W X el + d;                         recognition;
STm [pl]   := STm [pl] - m;
yl  := dir [x] ;
k   := j - l - Be [yl-1] ;
rl   := R:
for d  := k - rl while d ≤ 0 do
```

```
 begin k := stack [rl-1] ;
       new rl: rl := stack [rl] :
               if rl > k then go to new [rl];
               k := k + d
 end The scope of the temporarily recognized category
     begins at the index k;
stack [j]  := x:
stack [j+1]  := k;
stack [j+2]  := R;
R := j + 2;
j := j + 3;

if Bm [yl] < 0 then
 begin                         comment Final recognition;
       stack [j]  := p := stack [k+1] ;
       d := j := j + 1;
       next R: stack [j]  := R;
               R := stack  R ;
               j := j + 1;  if j > jmax then error;
               if r ≥ k then go to next R;
       for y := j - 1 step -1 until d do
        begin  rl := stack [y] ;
               x  := stack [rl-2] ;
               k  := stack [rl-1] ;
               i  := link [STm  [stack  [k]]]  ;
               translate  (x, i);
               symb [i]  := x;
               link [i]  := link [STm [stack [rl-3]]]  ;
               STm  [stack [rl+1]]  := i;
        end of the cycle, where the temporary recognitions
            within the scope of the final one are made to
            be final;
        j := k + 1
       end for final category;
      f := stack [k] ;
      go to new Q
end of the analysis program;
```

The following example may help the reader to see the meaning of the definitions and the work of the algorithm:

Let

$$\sigma = \{a, b, c, d\}$$
$$\Upsilon = \{\Upsilon_1, \Upsilon_2\}$$

and the grammar G defined as follows:

$$G(\Upsilon_1) = \{\Upsilon_1 a, \Upsilon_1 b, a, b\}$$

$$G(\Upsilon_2) = \{a\Upsilon_1 c, a\Upsilon_2 c, b\Upsilon_1 d, b\Upsilon_2 d\}$$

The languages defined by this grammar will be

$L_G(\Upsilon_1)$ = any sequence of the symbols a and b

$L_G(\Upsilon_2)$ = any element of $L_G(\Upsilon_1)$ enclosed between equal number of symbols a and c or b and d

For example

$$a\ a\ b\ a\ b\ b\ a \in L_G(\Upsilon_1)$$
$$a\ a\ b\ a\ b\ c\ c \in L_G(\Upsilon_2)$$
$$a\ a\ a\ b\ b\ c \in L_G(\Upsilon_2)$$
$$b\ b\ b\ a\ a\ b\ d\ d \in L_G(\Upsilon_2)$$

but

$$a\ a\ b\ b\ a\ d \notin L_G(\Upsilon_2)$$
$$a\ b\ b\ c\ b\ c \notin L_G(\Upsilon_2)$$
$$b\ b\ a\ a\ b\ c \notin L_G(\Upsilon_2)$$

The modification described in [2] gives us the following set of tables

$$T^1 = \begin{bmatrix} a & a \\ b & b \\ T^1 & \end{bmatrix} \qquad G'(\mathcal{T}'_1) = \tilde{T}^1$$

$$T^2 = \begin{bmatrix} & a & \\ & b & \\ a & T^1 & c \\ & T^2 & \\ & T^3 & \end{bmatrix} \qquad G'(\mathcal{T}'_2) = \tilde{T}^2$$

$$T^3 = \begin{bmatrix} & a & \\ & b & \\ b & T^1 & d \\ & T^2 & \\ & T^3 & \end{bmatrix} \qquad G'(\mathcal{T}'_3) = \tilde{T}^3$$

and it is easy to see, that

$$L_G(\mathcal{T}_1) = L_{G'}(a) \cup L_{G'}(b) \cup L_{G'}(\mathcal{T}'_1)$$
$$L_G(\mathcal{T}_2) = L_{G'}(\mathcal{T}'_2) \cup L_{G'}(\mathcal{T}'_3)$$

The Boolean matrix, representing the system will be

$$\begin{array}{c} (a) \\ (b) \\ (c) \\ (d) \\ (\tau'_1) \\ (\tau'_2) \\ (\tau'_3) \end{array} \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \end{bmatrix}$$

with

$$u = (1\ 0\ 1\ 0\ 0\ 1\ 0\ 0)$$
$$v = (0\ 1\ 0\ 0\ 1\ 0\ 0\ 1)$$

In order to illustrate the way, how the Boolean vectors are stored in more then one machine word, let us assume the non-realistic case of $W = 5$. This gives us the following arrays to store the syntax /the indifferent values are denoted by " – " / :

	i	dir [i]	i	Be [i]	Bm [i]
(a)	1	1	0	-	-
			1	2	-
			2	1	1 1 1 1 0
			3	2	0 1 0 0 0
(b)	2	5	4	-	-
			5	2	-
			6	1	1 1 0 1 0
			7	2	1 1 0 0 0
(c)	3	9	8	-	-
			9	1	-
			10	1	0 0 0 0 1
			11	-	-
(d)	4	12	12	1	-
			13	2	0 0 1 0 0
	5	-	14	2	-
(T^1)	6	15	15	2	subroutine of $(\mathcal{T}_1{}')$
			16	1	1 0 0 1 0
	7	-	17	2	0 1 0 0 0
	8	-	18	3	-
(T^2)	9	19	19	2	subroutine of $(\mathcal{T}_2{}')$
	10	-	20	1	0 0 0 1 0
	11	-	21	2	0 1 0 0 0
(T^3)	12	23	22	3	-
			23	2	subroutine of $(\mathcal{T}_3{}')$
			24	1	0 0 0 1 0
			25	2	0 1 0 0 0

and

U [1] = (1 0 1 0 0), U [2] = (1 0 0 0 0)
V [1] = (0 1 0 0 1), V [2] = (0 0 1 0 0)

Let the categories $(\mathcal{T}_2')$ and $(\mathcal{T}_3')$ chosen to be final, i.e. the information about the corresponding semantical subroutine, stored in Bm [19] and Bm [23] should be negative.

If the string

b a b a c d

has to be analysed, this is stored in the following way:

i	symb [i]	link [i]
0	–	1
1	b	2
2	a	3
3	b	4
4	a	5
5	c	6
6	d	–

with i 0 = 0

The analysis procedure will at first temporarily recognize the strings

ba, bab, baba

as T^1, and will get Q = 0 with T^1c. This makes to delete the last temporary recognition, but the remaining T^1 a c also gives Q = 0. After deleting the second recognition, T_1 b a c can be recognized as T^1 T^1 c which again has no meaning, thus the first recignition has to be deleted, too. Now b a b and b a b a will be recignized as b T^1, but b T^1 c yields again Q = 0, and this makes necessary to delete these recognitions, too. Finally b a b a will be recognized as b a T^1, which makes possible to recognize b a T^1 c as b T^2, and this will be a final recognition, making final the temporary recognition of T^1, too. This makes the following alterations in the input string /the values in brackets have lost their meaning/:

i	symb [i]	link [i]		i	symb [i]	link [i]
0	–	1		0	–	1
1	b	2		1	b	2
2	a	3		2	T^2	6
3	T^1	5	and	3	(T^1)	(5)
4	(a)	(5)		4	(a)	(5)
5	c	6		5	(c)	(6)
b	d	–		6	d	–

Now the remaining string b T^2 d can be recognized as the final category T^3 and this gets us to the end of the analysis procedure.

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YNGVE'S HYPOTHESIS AND SOME PROBLEMS OF THE MECHANICAL ANALYSIS*

by

D. Varga

The papers of V.Yngve [1], [2] which called forth much controversies seems to have been very fruitful with respect to some theoretic viewpoints of linguistics. They did not yield a final solution of the raised problems but focused the attention to the unsolved questions concerning syntactic complexity and even in an simplified way but yet they gave in the same time the main features of the solution, too.

However, it should be stressed that Yngve's hypothesis is also from a practical point of view, i.e. with respect to machine translation, important. This paper aims at outlining an algorithm for the syntactic analysis of languages with progressive structure which may be based on the algorithm of B.Dömölki [3].

On the other hand, Yngve's hypothesis may be useful also for the typology of languages because the notions of progressive and regressive structures, jointly with other notions, may yield the basis of a classification of languages. In the second part of the present paper I shall point to some of these possibilities in connection with the examination of the regressive structures of Hungarian.

I.1. Yngve's hypothesis and above all the explicit form of this hypothesis, has doubtlessly some questionable points beside its indisputable merits.

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* Despite of the deductive structure of this article its practical conslusions are mostly attained by induction. I am indepted to F. Papp for having called to my attention the close connections between my practical observations and Yngve's hypothesis. Acknowledgement should also be given to Gy. Szépe, who has read the manuscript and contributed with his helpful suggestions to its final wording.

1. First of all Yngve based his theory on some psychological, general considerations from which it follows that his statements must hold for all languages. Yngve has drawn his conclusions on the basis of concrete linguistic material /this is the source of their force/ but it has the appearence if it were the results of theoretic considerations. This deductive treatment is necessarily inappropriate, as the scope of his observations is narrower than what would be required by the treatment employed.

2. It is not clear to what sort of units the magic number 7 refers.[x] Even with respect to the psychological tests [4] it is not the same if we consider random <u>numbers</u> or random <u>figures.</u> And then arises the question why Yngve takes the words as units and why not, say, the morphemes. Yngve himself thinks of this possibility too when examining the saxon Genitive,[xx] but he does not solve the problems in a satisfactory manner. As a matter of fact, in the case of English this question does not arise so sharply because English does not belong to the languages with rich morphology. It is worth while, however, to examine Chomsky's Japanese example [5] from this point of view.[xx]

In Japanese some "comparative" morphemes may not occur as independent units but only after other words, as their supplement:

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[x] Yngve, V., A Model ... p. 452.

[xx] Op. cit. p. 463.

[xx] Chomsky, N., Rule of Grammar, p. 10.

あしを
a-si-o

おじいさんの
o-zí-i-sa-ŋ̄-no

うちに
u-ti-ni

まえに
má-e-ni

Fig. 1.

Their role is therefore similar to the flexional endings inflected to the end of words in Hungarian. It is not obvious at all whether such morphemes must be regarded as independent words or not. In the Japanese syllabic script wich does not mark the boundaries of words, these problems does not raise, only after it is transliterated into Latin letters. Bloch [6] regards them as independent words, it may be because in Indo-European languages the prepositions, having there a similar function, are regarded as independent words. However, we cannot agree with this way of looking, that much less, because prepositions stand before the words, and to spell them as two words is justified already for the sake of lucidity, and besides some complements may be inserted, too. If we follow Hungarian orthography - which may be more reasonable because of the typological similarities between the two languages* - then we must not spell such a morpheme and the following word as two independent words. It turns out that Yngve's depth depends on the orthography of the language under consideration, on the way the sentence is broken up in words, i.e. on more or less subjective factors. We have a similar situation in the example of Yngve, too:

his mother's brother's son's daughter's hat

if broken up into morphemes, provides depth 9, but if broken

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* I am indebted to Gy. Szépe, who called my attention to the striking similarity between structures in Japanese and Hungarian.

up into words, only depth 5.[**] The depth 9 in Chomsky's example[***] refers also to the breaking up into morphemes and if we take words instead of morphemes (according to the Hungarian orthography) the depth of the structure is only 5.

The tree of the Japanese example given by Chomsky:

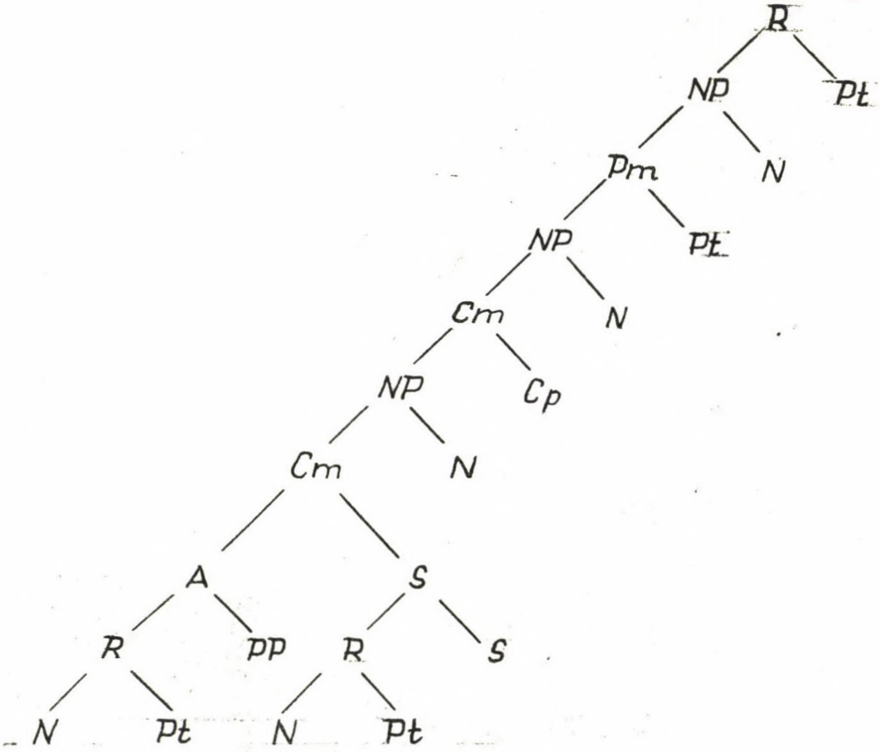

Fig. 2.

The same structure if we do not regard the "comparative" elements as independent units:

[**] Op. cit. p. 463.

[***] Op.cit. p. 10.

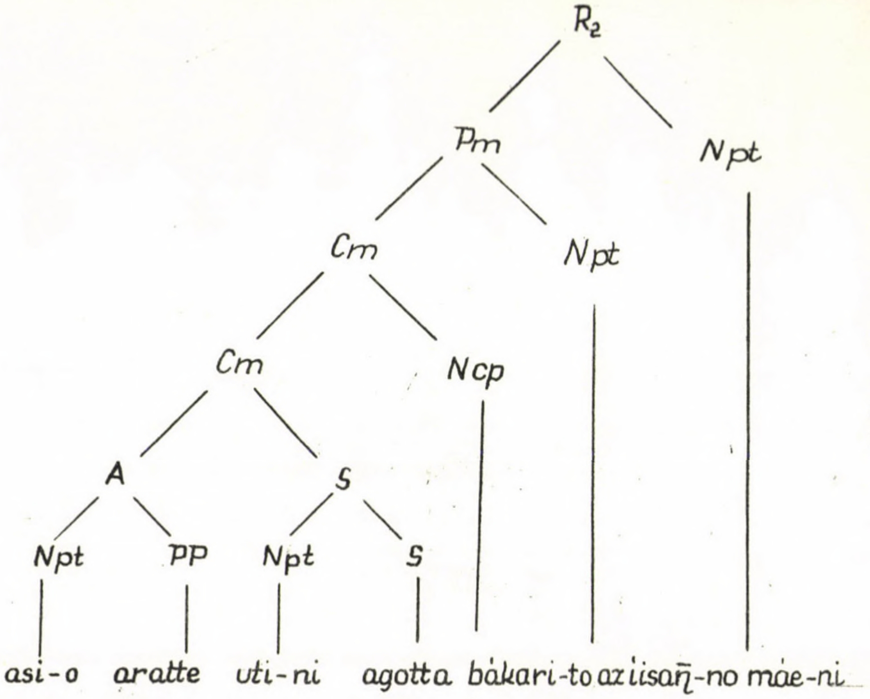

Fig. 3.

asi-o aratte uti-ni agatta bákari-no oziisan-no máe-ni

On the other hand, it is not obvious why Yngve compares the grouping in the case of algebraic expression with the breaking up into words.[x] Why would not be possible, to regard, say, (a+b) or (a-b) as words? The calculated depth would, of course, be quite different.

3. Yngve endevours, by introducing the notion of depth, to take into consideration also some psychological viewpoints in linguistic theory. No doubt, the description of natural languages will attain a more greater adequacy. In my opinion, however, also the differencies between human memory and the

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[x] Op. cit. p. 452

memory of machines should be taken into account. Namely, the computer stores the data in its memory so long as it does not obtain a device for deletion. A computer remembers something or does not remember it but does this independently of the time the information was stored. Human memory deletes step by step, the stored data "fade out". For human memory time is by far not indifferent. The problem of memory is not therefore a one-dimensional problem but at least a two-dimensional one: not only the question, how many data the temporary memory stores is of great interest but also another question: how long the data have been stored. For these reasons, Chomsky's example exhibits intuitively a greater depth, though this is not supported by Yngve's depth-calculation:[x]

I called the man who read the book that was on the table that was near the door up.

4. Yngve - with comprehensible exaggeration - points only to the tendency for restricting depth which accounts for some anomalies in word order or the establishment of discontinuous structures. Chomsky calls attention to the fact that a sentence as

I called almost all of the men from Boston up.

is more natural as

I called the men from Boston up.[xx]

To account for this fact it is not sufficient to refer exclusively to the tendency toward the restriction of depth, i.e. toward easier intelligibility. We may observe that in Russian the discontuinuity is exactly in the simplest phrases or sentences consisting of a few words a very frequent phenomenon: especially in the case of interrogative words /direct or oblique question, exclamation/. As a rule, the highly stressed interrogative word is followed by a slightly stressed word /pronoun, adverb etc./:

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[x] Op.cit. p.15.
[xx] Op.cit. p.15.

Какое сегодня число?
Что вы делаете?
Когда вы приехали?
Какие у вас есть книги?
Как это возможно?
Какой у тебя отец!

In writing too:

Можно исходить из данного обьема общих издержек, который предписывает, сколько всего имеется возможности затрат на замену импорта и на производство.

We are presumably not wrong if we stress the requirement of the rythm of certain linguistic elements in the construction of sentences, besides the requirement of intelligibility. No doubt, in prosaic works intelligibility is the most important requirement but if it does not go at its expense, then there is a free possibility for these secondary tendencies as well.

I.2. Chomsky deals in two papers [5], [7] with Yngve's hypothesis, more precisely, with the realization of this hypothesis in Yngve's model.

Chomsky assumes - on the basis of Yngve's model - the hypothesis (A), according to which the speaker produces the P-marker of the sentence exclusively "from top to bottom" and opposes to it another hypothesis called (B), according to which the hearer produces the P-marker strictly "from bottom to the top". In Chomsky's opinion there are no reasons to give preference the former hypothesis.[ж]

Chomsky believes to find a contradiction between the hypotheses (A) and (B) because from the hypothesis (A) it 'follows immediately' that left-branching cannot be continued over a given limit and from the hypothesis (B) the same holds for right-branching because of 'quite similar reasons.'[жж]

[ж] Op.cit. p.13.

[жж] Op.cit. p.14.

Chomsky assumes here tacitly another condition too. Namely, the complementary condition which stems from Yngve is assumed which says that the speaker "expands" always the leftmost element first, or, with respect to the hearer, that the analysis is done also from left to rigth. In Chomsky's second paper [7] this condition is given explicitly:

M accepts /or produces/ sentences from left-to-right in a single pass.[*]

In fact, there is no contradiction between the hypotheses (A) and (B), but we arrive at a contradiction if we link these hypotheses with the same complementary condition.

In fact, Yngve's model cannot be regarded as the exact model of the speaker but - I think - it does not pretend to be more than a model for the generation of sentences by a computer. With respect to a human speaker Yngve states only that "it is unreasonable to assume that sentences are formed in the mind of the speaker in their full detail before he starts to utter them".[**]

Chomsky is right by pointing to the fact that with respect to the speaker the situation is by far not so simple as it would turn out to be on the basis of hypothesis (A).[***] It is clear that the grammatical features of the words which the speaker want to use, may react upon the grammatical structure. By expanding a sentence, while speaking, a commenced grammatical structure may be modified corresponding to the words we want to make use /special rections, expressions etc./

Yngve - in his model- simplifies the situation for the sake of the realization on the computer. Yngve's hypothesis is, however, in my opinion, a more powerful one than that which could be realized in such a model.

According to Yngve's basic concept the sentence is potentially infinite and therefore it is not sufficient to

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[*] Chomsky,N., Miller,G.A., Finitary Models... p.472

[**] Op.cit. p.445.

[***] Chomsky,N., Rule of Grammar p.14.

have a static model for sentence structure, a dynamic model is required which describes the process of sentence building and not the result of this process.

The uttered part of the sentence determines more or less the possibilities of the continuation. We could regard these connections which refer to the continuation, as a bundle of information where Yngve wants to give some restrictions on the cross-section of this bundle.

It is ease to see the analogy between this interpretation of Yngve's hypothesis and the predictive analysis of Ida Rhodes [8], [9]. Rhodes' predictive analysis is similar to the hearer's model /although it is not identical to it, as Yngve's model is not identic to the speaker's model either/. Nevertheless Rhodes' model is not the inverse of Yngve's model as it makes the analysis from top to bottom rather than from bottom to the top. It does not start with given data but with possibilities, i.e. it is interested in the question where predictions can be made on the basis of the elements of a tree standing of the top of it with respect to the elements standing beneath the above-mentioned ones.

With respect to the realization on the computer it is doubtlessly advantageous if we stick to the analysis "from bottom to the top". In this case it will be possible - by applying the inverse IC-rules - to arrive step by step at symbols standing for greater units. Thus we can reverse Yngve's model, but it should be made clear that we do not reverse the speaker's model in this way and we do not similarly obtain as a result the hearer's model. We may reverse the model established for the computer generation of sentences to obtain a model apt to execute a mechanical analysis. On the other hand, if we want to obtain the inverse of the original model, then we must take as a complementary condition not the left-to-right but the right-to-left direction of the analysis.* In the case of such a complementary condition Chomsky himself does not arrive at a contradiction with respect to the hypotheses (A) and (B) either because the hypothesis (B) together with this condition imposes similarily some restrictions upon the regressive structures.

With respect to the hearer the absurdity of the condition in such form is quite obvious, because the hearer perceives likewise "in a left-to-right order" the sentence [10] as the speaker utters it in this way. But if we refer the "reversed" analysis not to the whole sentence but only to a part of it, then this hypothesis does not seem to be so absurd.

The hearer processes the words not immediately, not one by one and not isolated from each other [11], at least not always and not necessarily so. Often the heard words are only remembered as on a tape-recorder and after a certain time, they are processed by sections. As that word which was heard at last is living freshest in one's mind, if we want to establish an order at all events, we may conceive the process as being rolled up backwards by the hearer. This processing presupposes, however, that the sentence may be grouped into units relatively closed each of which may be independently or at least almost independently processed. This statement seems to agree with the fact that the processing of projective sentences [12] is by far easier not only for the computer but also for the human   It should be add that probably also the processing of nonprojective sentence may be executed in this way if the deviation is not too big with respect to the "pattern" projective sentences by remembering

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* Parker-Rhodes applies a similar method, i.e. he analyzes the English sentences from right-to-left, nevertheless his solution differs essentially from that given above. Cf. A.F.Parker-Rhodes, A New Model of Syntactic Description, in Proceedings of the 1961 International Conference on MT Vol.I. London 1962, pp. 49-59.

the words or connections which do not fit into the given construction or which the given construction fails to have.

I.3. During the examinations of natural languages one may be haunted by the thought that the structure of natural languages can be compared to the essentially simpler and clear-cut system of artificial languages. It seems to be palpable to compare the structure of natural languages to the "language" of algebra. The sentence of a natural language may be regarded in this way as an algebraic expression in which the words are the operandi but neither the operators nor the order of the operations is given in an explicit manner. It is known [15] that in the case when the sentence is projective the order of operations, i.e. the direct or indirect connections of the differenc units of the sentence, may be marked by setting parantheses between the words. Natural languages, however, fail to exhibit such parantheses pointing to the syntactic connections. It is possible to mark the order of operations uniquely with the help of the so-called Polish-notation (paranthesis-free notation) - but natural languages fail to have operators such which guarantee an unambiguous notation. For that very reason it may be important to make a trial with exploiting by the analysis the progressive character of certain languages /e.g. Russian/.

What lesson may be drawn from this with respect to the mechanical analysis?

The consideration of the progressive or regressive structures of languages may be useful from various reasons:

1. With respect to the languages with progressive structures the analysis may be speeded by the avoidance of the blind-alleys resulting from the lack of parantheses.

2. For the languages with progressive structure it seems possible to construct by simple means an algorithm which is stronger than context-free grammars.

Let us start with the reversed application of the IC-rules of generative grammar. We do not impose any restriction on the number of elements:

$$A_{k1} + A_{k2} + \dots + A_{kn} \longrightarrow T_k ,$$

where A_{ki} / $1 \leq i \leq n$/ may stand for

a/ terminal symbols,

b/ primary symbols corresponding to the terminal symbols (the symbols on the right-hand side of the terminal rules),

c/ comprehensive symbols (i.e. the non-primary symbols of the P-marker).

Depending on the symbols standing on the left-hand side of the rewriting rules we may devide the rules into the following groups:

1\. We call <u>terminal rules</u> such rewriting rules which have on their left-hand side only terminal symbols. In these rules we generally have n=1, i.e. one primary symbol corresponds to one terminal symbol but not necessarily: namely, in the case of expressions /idioms/ it may happen that $n \neq 1$, e.g. a single symbol corresponds to the expression "таким образом".

2\. We call <u>rewriting rules of first type</u> those rules which have on their left-hand side <u>only</u> primary symbols;

3\. We call <u>rewriting rules of second type</u> those rules which have on their left-hand side primary and comprehensive symbols.

4\. We call <u>rewriting rules of third type</u> those rules which may have on the left-hand side only comprehensive symbols or some special primary symbols /punctuation marks, conjunctions etc./.

If we leave out of consideration the parantheses which are implied in the sentence but are not really set, i.e. if we undertake a <u>context-free analysis,</u> then we may think to have found direct connections between two neighbouring words in such cases too when in reality these words would be separated from one another by a paranthesis. For instance, if we take Khinchin's sentence:[ж]

Вы знаете много теорем о пределах

we might find direct connections according to the corresponding rewriting rules between

вы знаете
знаете много
много теорем
теорем о
о пределах

As a matter of fact, this sentence exhibits the following structure

(вы (знаете (много (теорем (о пределах)))))

According to this structure the word "теорем" cannot be linked directly with the word "о" but only the syntagma "о пределах" in the used algorithm which carries out the analysis from the bottom to the top. (By the way, the advantage of the use of dependency grammar in the analysis consists of the fact that by considering one word as a representative of the subordinate word-group it is not necessary to execute the analysis strictly from the bottom to the top.)

The analysis was rendered difficult by the fact that we did not know <u>where to begin the analysis, where to look for the "bottom"</u> from which proceeding upwards the whole sentence may be rolled up or at least we may arrive in this way at a point where another branch is connected with the structure.

According to the above 1.) it is not irrevelant to which part of the sentence or the string the rewriting rules are applied; 2.) it is equally not irrevelant which types of rewriting rules are applied.

[ж] Хинчин А.Я., Пределы, in Восемь лекций по математическому анализу.

In the case of languages with progressive structure it is a natural phenomenon that *the parantheses accumulate at the end of the sentence or at the end of a relatively closed group of words* and the bottommost point of the whole sentence or the lowermost points of the different branches may be found on these very places. This means practically that by reversing Yngve's model and by postulating instead of the hypothesis (B) of Chomsky complemented with the left-to-right "condition" the hypothesis complemented with the right-to-left "condition" we may begin with the analysis at the end of the sentence, and may proceed in this way backwards by rolling up the sentence until we do not arrive at a point, where we have to stop because another branch is linked there to the structure. In a similar manner also the other branches must be rolled up and then the processing of the obtained symbols may begin, in an analogeous way.

The algorithm works as follows:

1. After applying the *terminal rules* the terminal symbols are replaced by primary symbols. (This step contains also the processing of idioms.) In the case of ambiguity the most probable correspondence is taken into consideration, the other are remembered (ramification N$^{\underline{o}}$ 1).

2. The string of primary symbols obtained in this way are investigated from right to left and those *rewriting rules of first type* are chosen which contain the symbol standing nearest the rightmost symbol. (By the aid of Dömölki's algorithm [3] the choice of all these rules may be executed *simultaneously*.) From these that rules is chosen which is apt to rewrite the longest string /or the first of these/, the others are remembered (ramification N$^{\underline{o}}$ 2).

3. From the *rewriting rules of second type* those are chosen, which contain the comprehensive symbols obtained in the previous step. From these rules that is chosen which a) leaves on the right the minimum quantity of symbols unprocessed and b) makes the processing of the longest string possible (if more than one rule fulfills this re-

quirement, then we chose the first of these); the other rules are remembered (ramification Nº 3).

4. It must be examined whether step 3. may be applied again or not, if so, then the algorithm goes to step 3., if not, then the result is remembered and the unprocessed part of the sequence of primary symbols is regarded as initial string and the analysis continued with step 2. If there are no unprocessed sequence of primary symbols then the algorithm goes to step 5.

5. If the rewriting rules of third type may be applied, then the algorithm works similarly to step 2., if there are no corresponding rules, then the algorithm goes to step 7.

6. The algorithm goes back to step 3.

7. Control is made whether all symbols are processed and whether the result is the symbol s. If so, then the analysis may be stopped or continued depending on the fact whether we want the algorithm to search for any constructive homonimy. If not, then it returns to the last ramification and from the previously recorded but not applied rules that rules are chosen, which corresponds to the requirements the best.

If we denote $\mathfrak{A}_1$ $\mathfrak{A}_2$ $\mathfrak{A}_3$ respectively the sub-algorithms that apply rewriting rules of type 1, 2 and 3 and Pr ($\mathfrak{A}_1$), Pr ($\mathfrak{A}_2$), Pr ($\mathfrak{A}_3$) the control concerning the applicability of the corresponding sub-algorithm, then we can represent the functioning of the algorithm by the following sketch: (Fig.4.)

The condition referring to the rewriting of the longest sequence of symbols may be replaced by another condition refering to the rewriting of the most probable sequence of symbols, if such a grading may be done.

Our algorithm yields all the analyses which may be conceived within the reversed context-free grammar, but we arrive at the desired result much earlier in the case of the analyses which correspond to the presumed progressive structure of the sentence, which exhibits therefore a lesser degree of depth--according to Yngve's conception.

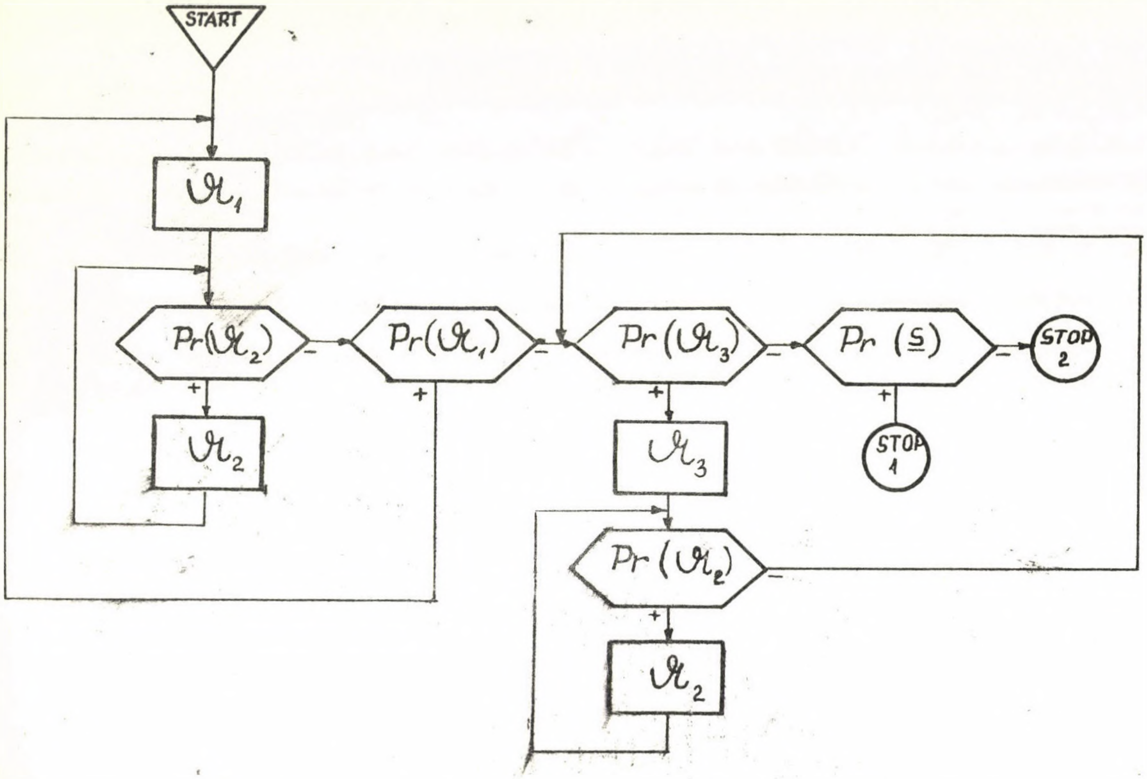

Fig. 4.

II. 1. Yngve assumes that every language has its own means for limiting the regressive structures.[x] According to Chomsky every language contains progressive, regressive and self-embedding structures. In English, for example, there are more progressive, in Japanese and Turkish more regressive structures.[xx]

From the point of view of regressivity it is well worth examining the Hungarian language so much the more as, along with other Finno-Ugrian languages, it is also agglutinating just as the Turkish languages, and, strangely enough, there is some typological affinity even with Japanese in a number of respects. (Suffixes, derivative endings are added in both to the end of the word, both languages use postpositions, no-

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[x] Op.cit. p.452.

[xx] Op.cit. p.472.

minative has no special inflexional ending, genders are absent, a word qualified by a numeral is in the singular, the attribute precedes the word it qualifies, the possessive (genitive) precedes the possession, the object the verb etc. [16], [17]. The analysis shows that Hungarian may be ranged with languages with predominantly regressive structure. It is clear that the concept of regressivity expounded by Yngve is closely related to other typological features, thereby it may be useful for the typological classification of languages. This does not mean, of course, that in Hungarian there are no progressive structures, but doubtlessly, the regressive structures play relatively a far greater role than, for example, either in English or in Russian or, perhaps it might be said, in Indo-European.

A double genitive structure displays, for instance, the following difference in the relation of Russian and Hungarian:

In Russian: ’страница книги ученика’

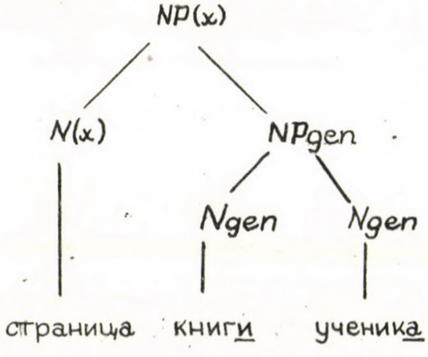


Fig. 5.

(These use of the argument x means that the symbol marked by it depends upon the embedding of the structure in the sentence.)

The transcription rules are:

$$NP(x) \longrightarrow N(x) + NP_{gen}$$
$$NP(x) \longrightarrow N(x)$$

(Specially:

$$NP_{gen} \longrightarrow N_{gen} + NP_{gen}$$
$$NP_{gen} \longrightarrow N_{gen}\ )$$

In Hungarian (disregarding the preposition):

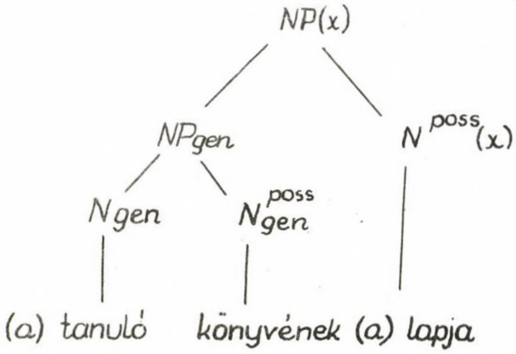


Fig. 6.

Transcription rules:

$$NP(x) \longrightarrow NP_{gen} + N^{poss}(x)$$
$$NP(x) \longrightarrow N(x)$$

(Specially:

$$NP_{gen} \longrightarrow NP_{gen} + N^{poss}_{gen}$$
$$NP_{gen} \longrightarrow N_{gen})$$

(In Hungarian the genitive may, in the case of a simple genitive structure, be with or without flexional ending, whereas in a double genitive structure the first (’tanuló’ in the above example) is always without, the second (’könyvének’) with flexional ending. The genitive relation is indicated not so much by this flexional ending (which is, as a matter of fact, the ending of the dative and not the genitive case) as by the possession affixes a/e/ja/je at the end of the possession:

'a tanuló könyve' - the pupil's book
'a könyv lapja' - the book's page

In our denotation N^{poss})

Thus, in the case of Russian the rule $A \longrightarrow fA$, and in Hungarian the rule $A \longrightarrow Af$ are valid. There is, however, a fundamental difference between the applicabilities of the two rules. Whereas in the Russian there is no grammatical limit whatsoever for the application of the rule

$$NP \longrightarrow N + NP_{gen},$$

in Hungarian the corresponding rule

$$NP \longrightarrow NP_{gen} + N^{poss}$$

may, at most, be applied three times in succession, its application for the fourth time being too forced [18] :

az iskola tanulója könyve lapjának a széle
the school's pupil's book's page's margin -

is ungrammatical.

In this case there is a grammatical limit against the overgrowth of the regressive structure indeed.

This is why translation into Hungarian of such strings of varying depth is a constant headache for translators. There are three patterns in translating such genitive structures (in a special sense of the word we might call them "transformations", even though what is implied here is not the transformation of sentence):

1) Instead of $N_{gen} + N^{poss}$

the application of A + N, that is, the adjectivization of the genitive noun:

instead of 'az intézet orvosa' /the physician of the clinic/
'intézeti orvos' /clinic physician/
instead of 'az ut pora' /the dust of the road/
'uti por' /road dust/ etc.

The expression thus created is, however, not always and not fully equivalent to the genitive structure; a) it is of a more general character: 'az ember életkora' the age of man (concrete or general), 'emberi életkor' (average) human age (general) b) it cannot absorb the attribute of the genitive noun: 'az uj intézet orvosa' (the physician of the new clinic) ≠ uj intézeti orvos /new clinic physician/.

2) By means of compounding:

instead of 'az irók szövetsége' /association of writers/
irószövetség /'writer association'/
instead of 'a ceruza hegye' /point of a pencil/
'ceruzahegy' /pencil-point/ etc.

This method is essentially the same as 1) - now this now the other is the more convential form.

From our point of view the third pattern is far more interesting:

3) Instead of $N_{gen} + N^{poss}$

the application of AP + N, where AP represents a participial structure with an interpolated (real or formal) participle which structure includes the first N as well:

$$AP \longrightarrow NP + AP$$

$$AP \longrightarrow NP + V_{part}$$

$$AP \longrightarrow N + V_{part}$$

For example:

Russian: 'План восстановления и развития народного хозяйства'
/The plan of the reconstruction and development of the people's economy/

Hungarian: 'A népgazdaság helyreállitására és fejlesztésére irányuló terv'
(The plan directed to the reconstruction and development of the people's economy)

By the use of these patterns, for instance, a well-developed Russian genitive string may be translated in the following way:

In Russian:

N^1 N^2 N^3_{gen} N^4_{gen} A_{gen} N^5_{gen}
Замещение галоидом атомов водорода боковых цепей

N^6_{geh} N^7_{gen}
гомологов бензола

(Substitution by haloid of atoms of hidrogen of side chains of homologues of benzol)

In Hungarian:

N^I N^{II}_{poss} V_{part} N^{III}
A benzolhomológok oldalláncaiban lévő hidrogénatomoknak

N^{IV} V_{part} N^V_{poss}
haloiddal való helyettesitése,

/the substitution by haloid of the hydrogen atoms inherent in the side chains of the benzol homologues/, where

$$N^6 + N^7 \longrightarrow N^I \quad \text{(pattern No. 2)}$$

$$A + N^5 \longrightarrow N^{II}$$

$$N^3 + N^4 \longrightarrow N^{III} \quad \text{(pattern No. 2)}$$

$$N^2 \longrightarrow N^{IV}$$

$$N^1 \longrightarrow N^V,$$

and again

$$N^{II}_{gen} + N^{III}_{poss} \longrightarrow N^{II} + V_{part} +$$

$$+ N^{III} \quad \text{(pattern No. 3)},$$

as well as

$$N^{III}_{gen} + N^{IV} + N^V_{poss} \longrightarrow N^{III}_{gen} +$$

$$+ N^{IV} + V_{part} + N^V_{poss}$$

(The latter V_{part} serves for embedding the N^{IV} into the structure.)

Represented by tree:
The Russian structure: Fig.7.
Its Hungarian equivalent: Fig.8.

As against the genitive relation of a depth of 2 examined before, here, by the use of the AP structure the structure has changed into a depth of 5 (omitting the preposition). This structure does not comparise but splits up the structure re-shaping it, as it were, into the first transformation grade which thus behaves as a separate sentence embedded into the principal clause. For connecting the structures thus verbified, i.e. participialized (which in Hungarian means a connection of the constituants one before the other) there

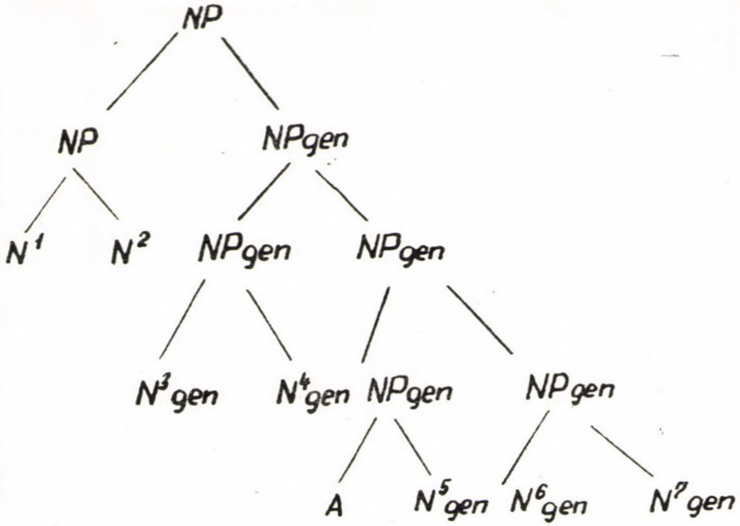

NP
NP
NPgen
N1
N2
NPgen
NPgen
N3gen
N4gen
NPgen
NPgen
A
N5gen
N6gen
N7gen

Fig. 7

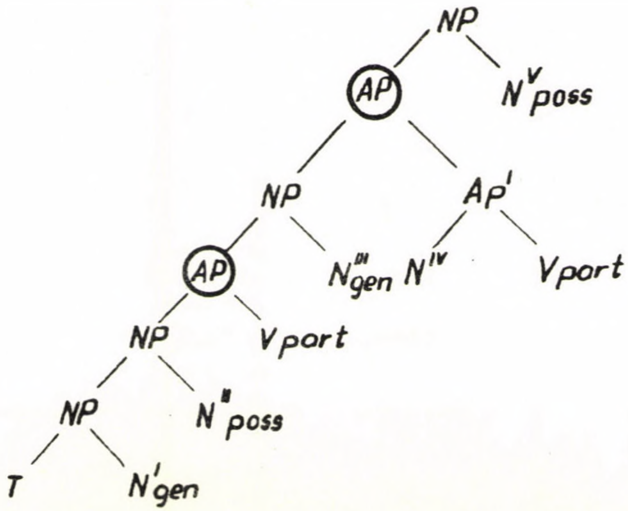

NP
AP
N V poss
NP
AP I
AP
N III gen
N IV
V part
NP
V part
NP
N II poss
T
N I gen

Fig. 8.

is no grammatical limit whatsoever, so that with this method a regressive structure of any lenght may be construed in the Hungarian language.

By way of example we might quote a comical toast from one of Gábor Fehér's short stories of student life [19]:

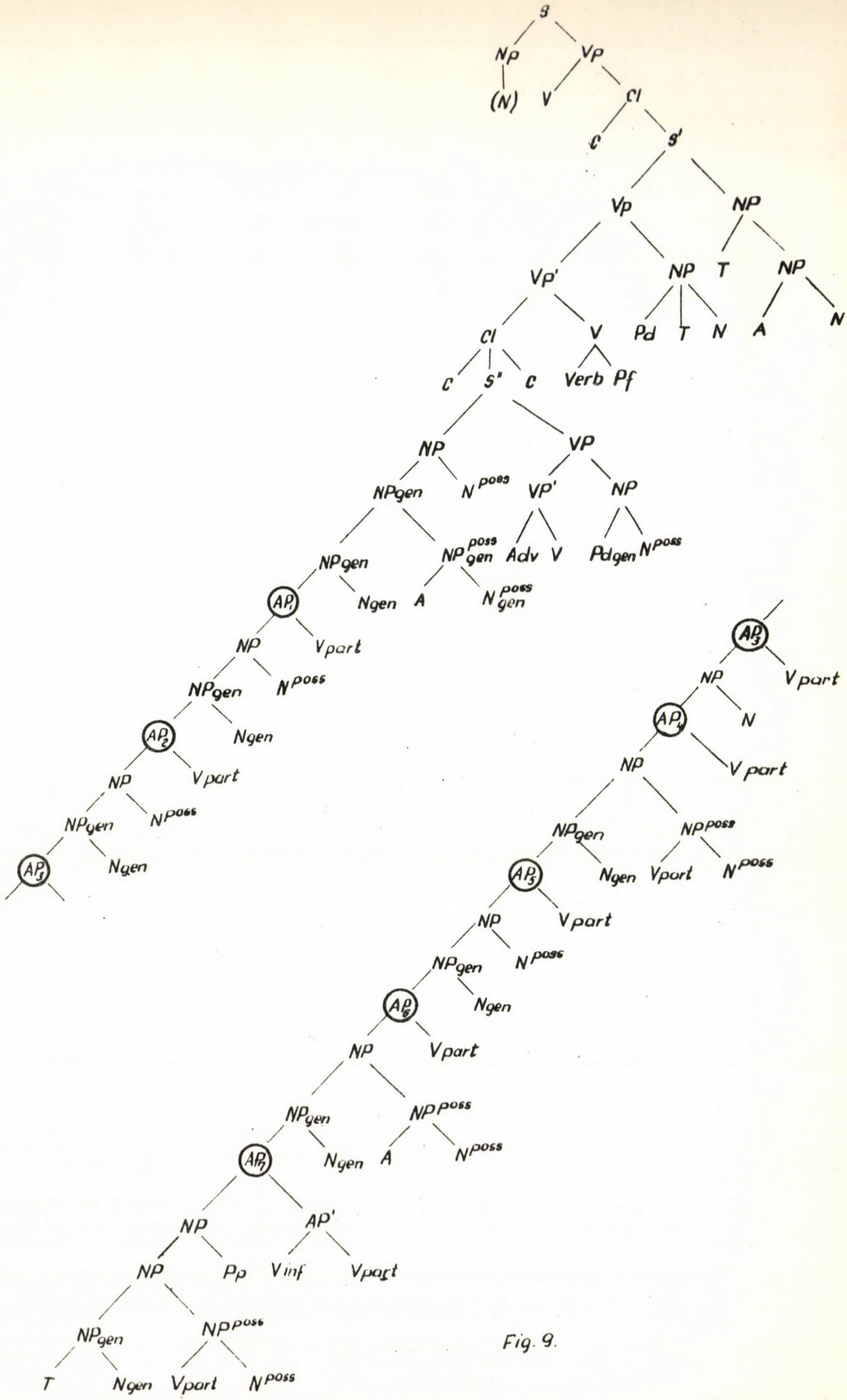
"Kivánom, hogy valamint az agyag ölelő karjai közül kibontakozni $\overset{7}{\text{akaró}}$ kocsikerék rettentő nyikorgásától $\overset{6}{\text{megriadt}}$ juhászkutya bundájába $\overset{5}{\text{kapaszkodó}}$ kullancs kidülledt félszeméből $\overset{4}{\text{alácseppent}}$ könnycseppben $\overset{3}{\text{visszatükröződő}}$ holdvilág fényétől $\overset{2}{\text{illuminált}}$ rablólovagvár felvonóhidjából $\overset{1}{\text{kiálló}}$ vasszegek kohéziós erejének hatása évszázadokra összetartja annak matériáját, aképpen tartsa össze ezt a társaságot az igaz szeretet."

"I wish that just as the effect of the cohesive force of iron nails $\overset{1}{\text{sticking out}}$ of the drawbridge of the robber baron's castle $\overset{2}{\text{illuminated}}$ by the moonlight $\overset{3}{\text{reflected}}$ in a tear drop $\overset{4}{\text{dropped down}}$ from the goggle-eyed half eyes of the dog-tick $\overset{5}{\text{sticking to}}$ the fur of the sheep-dog $\overset{6}{\text{startled with}}$ the terrific creaks of cart-wheel $\overset{7}{\text{desiring}}$ to get rid of the embrace of the mud -- so shall true love fasten together this company!"

/Fig.9./

This, of course, does not mean that constructions of such kind are in fact used in Hungarian. But, I presume, Yngve himself would not claim this to be the case with a number of his examples. The fact remains, however, that grammatically no objections whatsoever can be raised against such a sentence: its construction is in perfect harmony with the grammatical rules of Hungarian.

The example is of special interest, for the participles cropping up at regular intervals may easily be seen: it is clear from the construction that the very use of these participles makes it possible to transgress the otherwise existing limit of the regressive structures. (A similar phenomenon may be observed in the Japanese example of Chomsky.)


S
NP
VP
(N)
V
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C
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VP
NP
VP'
NP
T
NP
Cl
V
Pd
T
N
A
N
C
S'
C
Verb
Pf
NP
VP
NPgen
N^{poss}
VP'
NP
NPgen
NP^{poss}_{gen}
Adv
V
Pdgen
N^{poss}
AP_1
Ngen
A
N^{poss}_{gen}
NP
Vpart
NPgen
N^{poss}
AP_2
Ngen
NP
Vpart
NPgen
N^{poss}
AP_3
Ngen
AP_3
NP
Vpart
AP_4
N
NP
Vpart
NPgen
NP^{poss}
AP_5
Ngen
Vpart
N^{poss}
NP
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NPgen
N^{poss}
AP_6
Ngen
NP
Vpart
NPgen
NP^{poss}
AP_7
Ngen
A
N^{poss}
NP
AP'
NP
Pp
Vinf
Vpart
NPgen
NP^{poss}
T
Ngen
Vpart
N^{poss}

Fig. 9.

Thus, a number of unsolved problems still arise in connection with the typological use of the progressive and regressive structures. 1) In what manner is the application of the progressive and regressive structures related to other typological symbols (e.g. the use of preposition and postposition, the word-order of the genitive relation as well as the subject-object-verb (SOV).) [17] [20]. 2) Is there really any grammatical limit in the particular languages for the use of the regressive structures? In particular, what are the structures that make it possible to extend and develop a sentence in a regressive direction? 3) Is there any similar limit in the languages employing regressive structures in connection with the progressive structures?

It would be worth while dealing with these questions in more detail.

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SUR LA NOTION DE PROJECTIVITÉ

by

Solomon Marcus

Introduction

D'une manière implicite, la notion de projectivité se trouve, pour la première fois, chez Harper et Hays [10] . Le programme décrit par ces auteurs ne peut engendrer que des phrases projectives, mais ils font mention seulement de l'hypothèse de compacité. Un an plus tard, D.G.Hays introduit les grammaires de dépendances [11] (voir aussi [12] et [13] ; la description de ces grammaires contient une condition équivalente à la notion de projectivité. Presque en même temps, Y.Lecerf et P.Ihm introduisent l'hypothèse de projectivité et font une étude détaillée de cette notion [18] , [15] , [16] , [17] . Une analyse algébrique d'un critère de projectivité de Lecerf-Ihm a été faite par P.Camion [4] . La condition de projectivité est très importante pour la traduction automatique ([1] , p.8), mais ses origines sont de nature purement linguistique. (Par exemples, voir [34]).

Une grammaire est dite projective si elle engendre une langue formées exclusivement de phrases projectives. On sait maintenant que les grammaires projectives sont équivalentes - dans un certain sens - avec les grammaires "context-free" introduites par N.Chomsky [5] , [6] , [7] ; cette équivalence a été prouvé par C.Gaifman [9] (voir aussi [1] , p.8). Une confrontation plus systématique de la condition de projectivité avec les langues naturelles a été faite par Irina Lynch [19] (en ce qui concerne la langue russe) et par Lydia Hirschberg [14] (pour plusieurs langues, mais surtout pour le français. On constate que l'hypothèse de projectivité n'est qu'une première approximation, mieux adaptées a certaines langues naturelles qu'a d'autres. Une discussion de la même nature, très systématique et détaillée, à été donnée par E.V.Padučeva pour le russe [23] .

Des présentations qui retrouvent certaines des notions ci-dessus, (dans une terminologie différente), mais ajoutent aussi des nouveaux points de vue, ont été données par S.I. Fitialov [8] et par M.I.Beleckiĭ, V.M.Grigorjan et I.D. Zaslavskiĭ [2] . Il est intéressant à remarquer que la condition de projectivité est aussi utilisée dans les études purement linguistiques; voir, par exemple, le travail récent de I.A.Melčuk [20] .

Dans le présent travail, nous allons définir et étudier plusieurs types de projectivité, dont certains ont été déja utilisés dans la littérature.

Dépendance et subordination

Considérons un vocabulaire fini V et une phrase $f=x_1x_2...x_n$ sur V (c'est-a-dire un élément du demi-groupe libre engendré par V). L'entier n est, par définition, la longueur de la phrase. Certaines paires ordonnées $\{x_i,x_j\}$ $(1\leq i\ ,\ j\leq n)$ seront considérées comme marquées. Si $\{x_i,x_j\}$ est une paire marquée, alors nous dirons que x_i dépend de x_j. On a défini ainsi une relation de dépendance entre certains termes de la phrase f considérée. Il y a dans la littérature des méthodes de définir d'une manière constructive des relations de dépendances de divers degrés, mais cette question reste en dehors du but de ce travail.

On peut définir maintenant la relation de subordination de deux termes de f. On dira que x_i est subordonné à x_j $(1\leq i\ ,\ j\leq n)$ s'il existe une suite finie $y_1,y_2,...,y_k,y_{k+1},......,y_m$ de termes de f, telles que $y_1 = x_i$, $y_m = x_j$ et x_k dépend de y_{k+1} pour $1\leq k\leq m-1$. On peut supposer toujours que pour $x_p = y_k$ et $x_n = y_{k+1}$ on a $p\neq n$.

Nous convenons de considérer que pour chaque i , $1\leq i\leq n$, x_i est subordonné a x_i , c'est-à-dire la relation de subordination est reflexive.

La relation de dépendance est dite antireflexive si du fait que x_i dépend de x_j il résulte que $i\neq j$. La relation de dépendance est dite antisymétrique si du fait que x_i dépend de x_j il résulte que x_j ne dépend pas de x_i.

Il est aisé de voir que la subordination est une relation transitive : si x_i, x_j et x_k sont des termes de la phrase f, tels que x_i est subordonné à x_j et x_j est subordonné à x_k, alors x_i est subordonné à x_k.

Évidemment, la dépendance est un cas particulier de subordination.

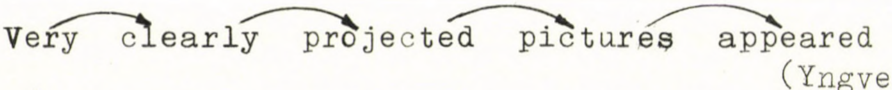
Divers types de projectivité

Il y a certaines contraintes qui réduisent sensiblement les possibilités de dépendances et de subordination. Ces contraintes varient d'une langue a une autre et, a l'intérieur d'une même langue, d'une phrase à une autre. C'est pour cela qu'il faut considérer plusieure types de telles contraintes.

Considérons une phrase $f = x_1 x_2 \ldots x_i \ldots x_n$. Convenons de noter : par $x_i < x_j$ le fait que $i < j$ (c'est-à-dire le fait que x_i est à gauche de x_j) ; par $x_i \leq x_j$ le fait que $i \leq j$; par $x_i \longrightarrow x_j$ le fait que x_i dépend de x_j ; par $x_i \Longrightarrow x_j$ le fait que x_i est subordonné a x_j (ces notations sont prises de [2]).

Définition 1. La phrase f est monotonement projective à droite lorsque, pour $i \neq j$, $x_i \Longrightarrow x_j$ si et seulement si $x_i < x_j$.

Exemple de l'anglais:

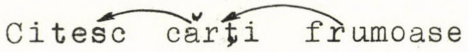

Very clearly projected pictures appeared

(Yngve [25], p.136).

(La flèche désigne toujours la relation de dépendance : $\overset{\frown}{x \ldots y}$ veut dire que x dépend de y).

Définition 2. La phrase f est monotonement projective à gauche lorsque, pour $i \neq j$, $x_i \Longrightarrow x_j$ si et seulement si $x_j < x_i$.

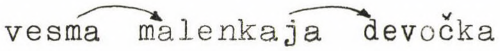
Exemple du roumain



Définition 3. La phrase f est monotonement projective si elle est monotonement projective à droite ou bien monotonement projective à gauche.

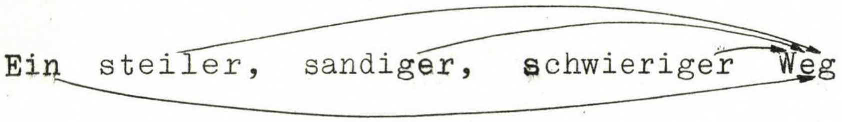
Définition 4. La phrase f est projective au sens fort si les relations $x_i \rightrightarrows x_j$ et $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightarrow x_j$.

Exemple du russe:



Définition 5. La phrase f est projective au sens étroit si les relations $x_i \rightarrow x_j$ et $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightarrow x_j$.

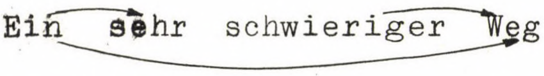
Exemple de l'allemand:



(Tesnière [24], chapitre 8)

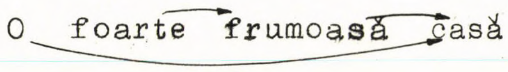
Définition 6. La phrase f est projective au sens de Harper et Hays (ou projective H - H) si les relations $x_i \rightarrow x_j$ et $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightrightarrows x_j$.

Exemple de l'allemand:



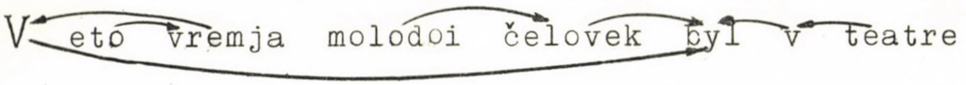
Définition 7. La phrase f est projective au sens de Lecerf et Ihm (ou projective L - I) si les relations $x_i \rightrightarrows x_j$ et $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightrightarrows x_j$.

Exemple du roumain:



<u>Définition 8.</u> La phrase f est <u>projective au sens de Fitialov</u> (ou <u>F - projective</u>) si les relations $x_i \rightrightarrows x_m$, $x_j \rightrightarrows x_m$, $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightrightarrows x_m$.

Exemple du russe:

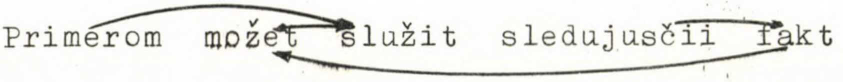


(Fitialov [8], p.105)

<u>Remarque</u>. Ce qu'on appelle dans [18] ,p.8, "condition Pr(I)" est, sous une forme cachée, justement la condition de F-projectivité. Donc c'est [18] le premier travail qui a considéré cette notion.

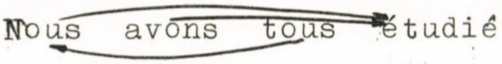
<u>Définition 9.</u> La phrase f est <u>quasiprojective</u> si les relations $x_i \rightrightarrows x_m$, $x_j \rightrightarrows x_m$, $i \neq m \neq j$, $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightrightarrows x_m$.

Exemple du russe:



(Padučeva [23], p.112)

Exemple du français:



(Hirschberg, [14], exemple 3)

<u>Quelques propriétés de la projectivité monotone</u>

<u>Proposition 1. Si la phrase</u> f <u>est projectivement monotone à droite, alors on a</u> $x_i \rightarrow x_{i+1}$ <u>pour</u> $1 \leq i \leq n-1$ <u>et, pour</u> $j \neq i$, <u>la relation</u> $x_i \rightarrow x_j$ <u>entraîne</u> $i < j$.

<u>Démonstration</u>. Supposons, par absurde, qu'il existe j, $1 \leq j \leq n-1$, tel que x_j ne dépend pas de x_{j+1}. Mais, à la suite de la projectivité monotone à droite, on a $x_j \rightrightarrows x_{j+1}$ donc il existe une suite finie $y_1, \dots, y_m$

de termes de f, tels qu'on ait $x_j = y_1$, $x_{j+1} = y_m$ et $y_k \longrightarrow y_{k+1}$ pour $1 \leqslant k \leqslant m-1$. Compte tenu que la dépendance est un cas particulier de subordination, on a $y_k < y_{k+1}$ pour $1 \leqslant k \leqslant m-1$. En particulier, on a $y_1 < y_2$, donc $x_j < y_2$. On a aussi $x_j \rightarrow y_2$, donc $y_2 \neq x_{j+1}$, donc $x_{j+1} < y_2$. Il s'ensuit que $x_{j+1} < y_s$ pour $s \geqslant 2$, donc $x_{j+1} < y_m = x_{j+1}$, ce qui est absurde.

Soit maintenant $x_i \longrightarrow x_j$ $(i \neq j)$. On a donc $x_i \rightrightarrows x_j$, d'où, à la suite de la projectivité monotone à droite, ou déduit $x_i < x_j$, donc $i < j$.

Proposition 2. Si la phrase f *est telle que* $x_i \rightarrow x_{i+1}$ *pour* $1 \leqslant i \leqslant n-1$ *et si la relation* $x_i — x_j$ $(i \neq j)$ *entraîne* $i < j$, *alors* f *est projectivement monotone à droite.*

Démonstration. On doit montrer que $x_i \rightrightarrows x_j$ $(i \neq j)$ si et seulement si $x_i < x_j$. Soit d'abord $x_i \rightrightarrows x_j$. Il y a une suite $y_1, \ldots, y_m$ de termes de f, tels que $y_1 = x_i$, $y_m = x_j$ et $y_k \rightarrow y_{k+1}$ pour $1 \leqslant k \leqslant m-1$. Il s'ensuit que $y_k < y_{k+1}$ pour $1 \leqslant k \leqslant m-1$, donc, à plus forte raison, $x_i < x_j$. Soit maintenant $x_i < x_j$. On a, par hypothèse, $x_i \rightarrow x_{i+1} \rightarrow \ldots \longrightarrow x_{j-1} \rightarrow x_j$ donc, à la suite de la transitivité de $\rightrightarrows$, on déduit $x_i \rightrightarrows x_j$.

Les propositions 1 et 2 conduisent immédiatement au

Théoreme 1. La phrase f *est projectivement monotone à droite si et seulement si les deux conditions suivantes sont remplies :* 1° $x_i \longrightarrow x_{i+1}$ *pour* $1 \leqslant i \leqslant n-1$; 2° *la relation* $x_i \longrightarrow x_j$ $(i \neq j)$ *entraîne* $x_i < x_j$.

Par une voie analogue on obtient le

Théorème 1'. La phrase f *est projectivement monotone à gauche si et seulement si les deux conditions suivantes sont remplies :* 1° $x_i \longrightarrow x_{i-1}$ *pour* $2 \leqslant i \leqslant n$; *la relation* $x_i — x_j (i \neq j)$ *entraîne* $x_j < x_i$.

Remarque. Le théoreme 1 montre que la projectivité monotone à droite correspond au structures purement regressives (*regressive structures* au sens de Yngve [25]) ou, pour adopter la terminologie de Tesnière, aux phrases centripètes ([24] , ch.8). Le théorème 1'montre que la projectivité monotone à gauche correspond aux structures purement progressives (progressive structures au sens de Yngve [25]) ou, pour adopter la terminologie de Tesnière, aux phrases centrifuges ([24] , ch.8).

On sait (voir, par exemple, [24]) que la langue turque est très riche en phrases centripètes, tandis que l'hébreu est très riche en phrases centrifuges. Entre ces deux situations en quelque sorte extrêmes, on peut dire que l'anglais et l'allemand sont des langues moins centripètes que le turque, le latin est une langue moins centripètes que l'anlais et l'allemand, tandis que le français et le roumain sont plus centrifuges que le latin, mais moins centrifugues que l'hébreu.

Il s'ensuit que le turque et l'hébreu se prétent mieux à la description à l'aide d'un modèle monotonement projective.

En ce qui concerne la projectivité monotone à droite, il y a aussi des contraintes d'ordre psychologique, concernant la capacité de la mémoire, qui limitent considérablement la longueur d'une phrase monotonement projective à droite. En échange, la longueur d'une phrase monotonement projective à gauche peut dépasser, théoriquement, un nombre entier donné ([21] , [25]).

Relations entre la projectivité monotone et les autres types de projectivité

Théoreme 2. Si la phrase f est monotonément projective, alors f est projective L - I.

Démonstration. Soit d'abord f monotonement projective à droite. Soit $x_i \rightrightarrows x_j$ et min $(i,j) < k <$ max (i,j). On a $x_i < x_j$, donc $i < j$, donc $i < k < j$. En vertu du théorème 1, on a $x_i \rightarrow x_{i+1} \rightarrow \ldots \rightarrow x_{k-1} \rightarrow x_k \rightarrow x_{k+1} \rightarrow \ldots \rightarrow x_{j-1} \rightarrow x_j$. En tenant compte que $\rightarrow$ est un cas particulier de $\rightrightarrows$ et que $\rightrightarrows$ est transitive, on deduit $x_k \rightrightarrows x_j$. On a prouvé ainsi que f est projective L - I.

Si f est monotonement projective à gauche, alors de $x_i \rightrightarrows x_j$ et $\min(i,j) < k < \max(i,j)$ on déduit $x_j < x_i$, donc $j < i$ et $j < k < i$. En vertu du théorème 1', on a $x_i \rightarrow x_{i-1} \rightarrow \ldots \rightarrow x_{k+1} \rightarrow x_k \rightarrow x_{k-1} \rightarrow \ldots \rightarrow x_{j+1} \rightarrow x_j$. En tenant compte que $\rightarrow$ est un cas particulier de $\rightrightarrows$ et que $\rightrightarrows$ est transitive, on déduit $x_k \rightrightarrows x_j$. Donc, dans ce cas aussi, f est projective L - I.

Proposition 3. Il existe une phrase projective L - I qui n'est pas monotonement projective.

Démonstration. Une telle phrase est, par exemple, la suivante

Cette phrase est évidement projective L - I mais, à la suite des théorèmes 1 et 1', elle n'est ni monotonement projective à droite, ni monotonement projective à gauche.

Voici une réalistaion française d'une telle phrase:

Proposition 4. Il existe une phrase monotonement projective qui n'est pas projective au sens fort. Il existe une phrase projective au sens fort qui n'est pas monotonement projective.

Démonstration. La phrase

est monotonement projective (en vertu du théorème 1), mais ellen n'est pas projective au sens fort, car $x_1 \rightrightarrows x_4$, mais on n'a pas $x_2 \rightarrow x_4$. (Une réalisation en anglais, d'une telle phrase, est

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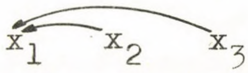
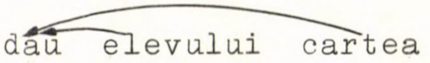
La phrase



est projective au sens fort mais, en vertu des théoremes 1 et 1', elle n'est pas monotonement projective. (Une réalisation, en roumain, d'une telle phrase, est



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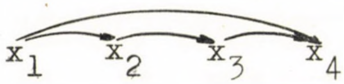
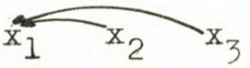
Proposition 5. Il existe une phrase monotonement projective qui n'est pas projective au sens étroit. Il existe une phrase projective au sens étroit qui n'est pas monotonement projective.

Démonstration. La phrase



est monotonement projective à droite, car les conditions 1^o et 2^o du théorème 1 sont satisfaites; mais cette phrase n'est pas projective au sens étroit, car on a $x_1 \longrightarrow x_2$ sans avoir $x_2 \longrightarrow x_4$.

La phrase



est projective au sens étroit mais, en vertu des théorèmes 1 et 1', elle n'est pas monotonement projective. (Voir ci-dessus une réalisation, en roumain, d'une telle phrase).

Les relations entre la projectivité monotone, d'une part, et la projectivité H - H, la F-projectivité et la quasiprojectivité, d'autre part, résulteront des théorèmes ci-dessous.

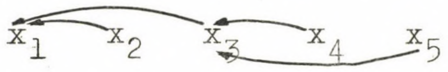
Projectivité au sens étroit et projectivité au sens fort

Ces types de projectivité ont été introduits par les définitions 5 et 4. Nous allons donner maintenant quelques résultats qui justifient, en certaine mesure, leurs désignations.

Proposition 6. Toute phrase projective au sens fort est projective au sens étroit, mais il existe une phrase projective au sens étroit qui n'est pas projective au sens fort.

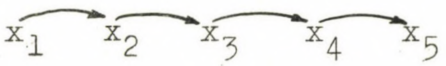
Démonstration. Soit f projective au sens fort et soit $x_i \rightarrow x_j$, $\min(i,j) < k < \max(i,j)$. Il s'ensuit que $x_i \rightrightarrows x_j$ donc, à la suite de la projectivité au sens fort, on a $x_k \rightarrow x_j$ et f est projective au sens étroit.

La phrase



est projective au sens étroit, mais elle n'est pas projective au sens fort, car on a $x_5 \rightrightarrows x_1$, mais on n'a pas $x_4 \rightarrow x_1$ (Une réalisation, en roumain, d'une telle phrase, est

Un autre exemple : la phrase



est aussi projective au sens étroit (d'une manière triviale), sans être projective au sens fort (car on a $x_1 \rightrightarrows x_5$ sans avoir $x_2 \rightarrow x_5$). Une réalisation, en anglais, d'une telle phrase est l'exemple, déjà cité, de Yngve (après la définition 1). Cet exemple suggère la

Proposition 7. Si la longueur d'une phrase f monotonement projective n'est pas inférieure a 4 et si pour $x_i \rightarrow x_j$ on a toujours $i - j \leqslant 1$, alors f est projective au sens étroit, sans être projective au sens fort.

Démonstration. La projectivité au sens étroit a lieu d'une façon triviale. D'autre part, supposons, pour fixer les idées, que la phrase f est monotonement projective à droite. On a donc $x_i \rightrightarrows x_j$ dès que $i < j$. Prenons $i = 1$ et $j = 4$ (ce qui est possible, car la longueur de la phrase n'est pas inférieure à 4). On a $x_1 \rightrightarrows x_4$ mais, en vertu de l'hypothèse, on n'a pas $x_2 \rightarrow x_4$; donc f n'est pas projective au sens fort.

Si f est monotonement projective à gauche, le raisonnement est, en essence, le même; on a $x_4 \rightrightarrows x_1$ sans avoir $x_3 \rightarrow x_1$ (en vertu de l'hypothèse).

Théorème 3. Toute phrase projective au sens étroit est projective L - I, mais il existe une phrase projective L - I qui n'est pas projective au sens étroit.

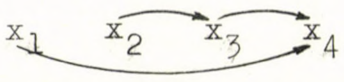
Démonstration. Soit f projective au sens étroit et soit $x_i \rightrightarrows x_j$ $(1 \leq i,\ j \leq n)$ et k tel que min $(i,j) < k <$ max (i,j). D'après la définition de $\rightrightarrows$, il existe une suite $y_1, y_2, \dots, y_t$ de termes de f, tels que $x_i = y_1$, $x_j = x_t$ et $y_m \rightarrow y_{m+1}$ pour tout m tel que $1 \leq m \leq t-1$. S'il existe un m tel que $x_k = y_m$, alors on a évidemment $x_k \rightrightarrows x_j$; sinon, on distingue deux possibilités:

1° $i < j$. Dans ce cas, soit s le plus petit entier m tel que $x_k < y_m$. On a $1 < s \leq t$ et $y_{s-1} < x_k < y_s$. Du fait que $y_{s-1} \rightarrow x_s$ et en tenant compte que f est projective au sens étroit, on déduit $x_k \rightarrow y_s$, donc $x_k \rightrightarrows y_s$. D'autre part, on a $y_s \rightrightarrows x_j$, donc, à la suite de la transitivité de $\rightrightarrows$, on a $x_k \rightrightarrows x_j$.

2° $i > j$. Dans ce cas, soit s le grand entier m tel que $x_k < y_m$. On a $1 \leq s < t$ et $y_{s+1} < x_k < y_s$. Du fait que $y_s \rightarrow y_{s+1}$ et en tenant compte que f est projective au sens étroit, on déduit $x_k \rightarrow y_{s+1}$, donc $x_k \rightrightarrows y_{s+1}$. D'autre part, on a $y_{s+1} \rightrightarrows x_j$, donc, a la suite de la transitivité de $\rightrightarrows$, on a $x_k \rightrightarrows x_j$.

On a établi ainsi que les relations $x_i \rightrightarrows x_j$ et min $(i,j) < k <$ max (i,j) impliquent la relation $x_k \rightrightarrows x_j$, donc f est projective L - I.

La phrase



est projective L - I, mais n'est pas projective au sens étroit, car $x_1 \rightarrow x_4$ sans que $x_2 \rightarrow x_4$. (Une réalisation, en allemand, d'une telle phrase, est ein sehr alter Mann).

Corollaire. Toute phrase projective au sens fort est projective L-I, mais la réciproque n'est pas vraie.

Démonstration. Conséquence immédiate de la proposition 6 et du théorème 3.

La projectivité H - H, la projectivité L - I et la F- projectivité sont équivalentes

Nous allons établir maintenant l'équivalence des notions de projectivité introduites par Harper et Hays [10], Lecerf et Ihm [18] et Fitialov [8].

Théorème 4. Toute phrase projective H-H est projective L - I et réciproquement.

Démonstration. Soit f une phrase projective H-H. Soit $x_i \rightrightarrows x_j$ $(1 \leqslant i,\ j \leqslant n)$ et $\min(i,j) < k < \max(i,j)$. En vertu de la définition de $\rightrightarrows$, il existe une suite $y_1, y_2, \dots, y_t$ de termes de f, tels que $x_i = y_1$, $x_j = y_t$ et $y_m \rightarrow y_{m+1}$ pour $1 \leqslant m \leqslant t-1$. S'il existe un m tel que $x_k = y_m$, alors on a évidemment $x_k \rightrightarrows x_j$. Si un tel m n'existe pas, nous allons distinguer deux possibilités:

1^o $i < j$. Soit s le plus petit entier m tel que $x_k < y_m$. On a $1 < s \leqslant t$ et $y_{s-1} < x_k < y_s$. Du fait que $y_{s-1} \rightarrow y_s$ et en tenant compte que f est projective H-H, on déduit $x_k \rightrightarrows y_s$. D'autre part, on a $y_s \rightrightarrows x_j$, donc $x_k \rightrightarrows x_j$.

2^o $i > j$. Soit s le plus grand entier m tel que $x_k < y_m$. On a $1 \leqslant s < t$ et $y_{s+1} < x_k < y_s$. Du fait que $y_s \rightarrow y_{s+1}$ et en tenant compte que f est projective H-H, on déduit $x_k \rightrightarrows y_{s+1}$. Mais on a aussi $y_{s+1} \rightrightarrows x_j$, donc $x_k \rightrightarrows x_j$.

On a, dans tous les cas, $x_k \rightrightarrows x_j$, donc f est projective L-I.

Soit maintenant f une phrase projective L-I. Soit $x_i \to x_j$ et $\min(i,j) < k < \max(i,j)$. On a donc $x_i \rightrightarrows x_j$ et, en vertu de la projectivité L-I, il s'ensuit que $x_k \rightrightarrows x_j$. Donc les relations $x_i \to x_j$ et $\min(i,j) < k < \max(i,j)$ impliquent la relation $x_k \rightrightarrows x_j$; c'est justement la projectivité H - H.

Théorème 5. Toute phrase F-projective est projective L-I et réciproquement.

Démonstration. Soit f une phrase F-projective. Soit $x_i \rightrightarrows x_j$ et $\min(i,j) < k < \max(i,j)$. En vertu de la reflexivité de la relation $\rightrightarrows$, on a aussi $x_j \rightrightarrows x_j$. En faisant usage de la F-projectivité de f (définition 8, avec $m = j$), on déduit que $x_k \rightrightarrows x_j$, donc f est projective L-I.

Soit maintenant f une phrase projective L-I. Supposons que $x_i \rightrightarrows x_m$, $x_j \rightrightarrows x_m$ et $\min(i,j) < k < \max(i,j)$. Nous allons distinguer trois cas:

1° $k = m$; en vertu de la reflexivité de $\rightrightarrows$, on a $x_k \rightrightarrows x_m$.

2° $k < m$. Si $i < k$ alors on a $x_i < x_k < x_m$ et, en vertu de la projectivité L-I et du fait que $x_i \rightrightarrows x_m$, on déduit $x_k \rightrightarrows x_m$. Si $i > k$, alors $j < k$ et, donc, $x_j < x_k < x_m$. En vertu de la projectivité L-I et du fait que $x_j \rightrightarrows x_m$, on déduit $x_k \rightrightarrows x_m$.

3° $k > m$. Si $j > k$, alors on a $x_m < x_k < x_j$. En vertu de la projectivité L-I et du fait que $x_j \rightrightarrows x_m$ on déduit $x_k \rightrightarrows x_m$. Si $j < k$, alors on a $i > k$, donc $x_m < x_k < x_i$. En vertu de la projectivité L-I et du fait que $x_i \rightrightarrows x_m$, on déduit $x_k \rightrightarrows x_m$.

On a donc, dans tous les cas, $x_k \rightrightarrows x_m$; la phrase f est F-projective.

Remarques. Dans une autre variante et par une autre voie, le théoreme 5 a été esquissé dans [18].

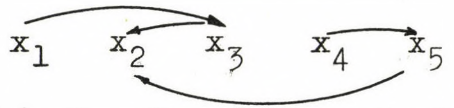
La quasiprojectivité est une généralisation de la projectivité L - I

Nous allons montrer maintenant que la notion de quasiprojectivité (voir la définition 9) est une généralisation de la notion de projectivité L-I. D'ailleur, ce fait a été déja anticipé même par la terminologie utilisée.

Théoreme 6. Toute phrase projective L-I est quasiprojective, mais il existe une phrase quasiprojective qui n'est pas projective L-I.

Démonstration. En vertu du théoreme 5, la projectivité L-I est équivalente à la F-projectivité. Le théoreme 6 sera donc démontré dès qu'on prouve que toute phrase F-projective est quasiprojective, mais pas réciproquement. Mais si f est F-projective alors les relations $x_i \Rightarrow x_m$, $x_j \Rightarrow x_m$, $\min(i,j) < k \nless \max(i,j)$ impliquent la relation $x_k \Rightarrow x_m$ (voir la définition 8) donc, à plus forte raison, les relations $x_i \Rightarrow x_m$, $x_j \Rightarrow x_m$, $\min(i,j) < k < \mathrm{mas}\,(i,j)$ et $i \neq m \neq j$ impliquent la relation $x_k \Rightarrow x_m$; mais c'est ici justement la définition de la quasiprojectivité (voir la définition 9).

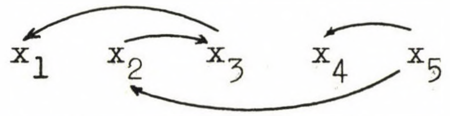
Un exemple de phrase quasiprojective qui n'est pas projective L-I est le suivant:



La nonprojectivité L - I résulte du fait que $x_1 \Rightarrow x_3$ et $x_1 < x_2 < x_3$, mais on n'a pas $x_2 \Rightarrow x_3$.

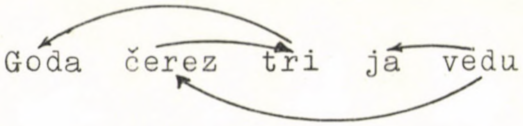
Une réalisation, en russe, d'une telle phrase est celle donnée après la définition 9.

Remarque. Il y a des phrases qui ne sont pas quasiprojectives. Une telle phrase est, par exemple,



En effet, on a $x_2 \Rightarrow x_3, \Rightarrow x_5 \Rightarrow x_3$ et $x_2 < x_4 < x_5$, mais on n'a pas $x_4 \Rightarrow x_3$.

Une réalisation, en russe, d'une telle phrase, est ([2], p.73)



Remarques finales

Une langue sur le vocabulaire V est, par définition, une partie du demigroupe libre engendré par V. En associant à chaque phrase d'une langue L une structure de dépendance (qui induit une structure de subordination), on dira que L est une langue projective L - I (resp. projective H - H, F-projective, monotonement projective, projective au sens fort, projective au sens étroit, quasi projective) si toutes ses phrases sont projectives L-I (resp. projectives H-H, F-projectives, monotonement projectives, projective au sens fort, projectives au sens étroit, quasi-projectives). En approfondissant les résultats de [9], il serait intéressant d'établir la place de chacune de ces langues dans les classifications de Chomsky [5], [6], [7].

Nous avons envisagé, ci-dessus, des phrases quelconques. Beaucoups de résultats nouveaux s'obtiennent (spécialement, a l'aide de la théorie des graphes [3], [22]), si l'on envisage des classes particulières de phrases - plus proches de ce qu'on appelle, d'habitude, une proposition. C'est justement ce point de vue - adopté explicitement dans [8] et [2] et - implicitement - dans presque tous les travaux, qui nous permettra, dans un autre travail, d'obtenir de nouveaux critères de projectivité et de montrer - en suivant [18] - la nature géométrique de cette notion.

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О МАШИННОМ ПЕРЕВОДЕ РУССКИХ СТРАДАТЕЛЬНЫХ КОНСТРУКЦИЙ НА ВЕНГЕРСКИЙ ЯЗЫК

Л. Дэже

1.

Русский язык располагает двумя возможностями для выражения пассива, и обе они имеют точно определенную область применения. При первом способе страдательная конструкция образуется глаголом несовершенного вида с частицей -ся: дом строится /каменщиком/, при втором в страдательном обороте выступает глагол совершенного вида в описательной форме: дом построен /каменщиком/. Обе конструкции поддаются трансформации в действительный оборот: 1/ каменщик строит дом и 2/ каменщик построил дом. Однако в связи с трансформацией мы должны отметить следующее. Изменяя время страдательного глагола несовершенного вида, мы находим, что в соответствии с ним изменяется и время его трансформационного эквивалента: дом строился (будет строиться) каменщиком; каменщик строил (будет строить) дом, то есть три трансформационные пары стоят рядом. С глаголом же совершенного вида дело обстоит иначе. При конструкции: дом построен каменщиком тоже наблюдается еще два временных варианта: дом был (будет) построен каменщиком, но действительный трансформ имеет лишь две формы: каменщик построил дом и каменщик построит дом. Дело в том, что построить, будучи глаголом совершенного вида со значением результативности употребляется лишь в форме простого будущего и прошедшего времен, в то время как его страдательный эквивалент, хотя тоже выражает результативность, способен к выражению всех трех времен.

В другом замечании мы хотели бы упомянуть о том, что агент действия может опускаться при обеих формах образования пассива, и мы имеем дело с неопределенным агентом или подлежащим: дом строится ⟶ строят дом, дом построен ⟶ построили дом.

Такие два способа выражения пассива были впервые представлены в книге А.В.Исаченко "Грамматический строй русского языка в сопоставлении с словацким. Морфология". т. 11. /Братислава, 1960. стр. 358-373/, а в венгерской учебной литературе они встречаются в книге Д.Хелла, Д.Шипёци "Перевод технической литературы" /"Az orosz szakszövegek fordítása." Budapest,1961. 35, 110-112/. Значительной заслугой обеих работ является определение двойственного характера описательных форм, что обнаруживается при сопоставлении с словацким или с венгерским переводом. Одно из значений является процессуальным: Дом построен в прошлом году, а другое статальным: Дом построен из кирпича /ср. Исаченко ук. соч. 365/. Однако взгляды авторов цитированных работ расходятся в том, что Дёрдь Хелл и Дёзё Шипёци не причисляют статальные формы к пассивным /ук. соч. 35/, в отличие от А.В. Исаченко /ук.соч. 363/. На наш взгляд вопрос нуждается в дальнейшем исследовании, мы рассматриваем статальные формы как пассивные, однако считаемся с их особенностями.

В отдельной статье[x] мы уже рассмотрели тот тип страдательных конструкций, который образуется с глаголами на-ся, и так мы анализируем лишь второй, описательный способ выражения пассива.

2.

Приступая к анализу возможностей перевода русских пассивных конструкций, мы рассмотрим выборочные совокупности трех работ, содержащих больше 350 описательных страдательных конструкций, первая по математике: П.С.Александров, Введение в общую теорию множенств и функций. М.Л. 1948 /сокращ. Введение/, в венгерском переводе: Bevezetés a halmazok és függvények általános elméletébe. Budapest, 1952 /сокращ.:

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Bevezetés /, перевод Д. Бизама, вторая по атомной физике: Л.В. Грошев, И.С. Шапиро, Спектроскопия атомных ядер. М. 1952 /сокращ.: Спектр./, венгерский перевод: Atommag-spektroszkópia. Budapest, 1958 (сокращ. Atommag) сделан Д. Берени, а третья работа служит для ориентации в переводе политического текста: Н.С.Хрущев, О программе Коммунистической Партии Советского Союза. М. 1961. (сокращ. О программе), в венгерском переводе: "A kommunizmus épitőinek kongresszusa /Budapest/, 1961, 151-283 /сокращ. A kom. épit/.

Конструкции с русским страдательным причастием прошедшего времени переводятся иногда близким к нему венгерским прилагательным, происходящим от страдательного причастия прошедшего времени: множество упорядочено /Введение 83/, по венгерски: halmaz... rendezett /Bevezetés 58/, или: переходы...запрещены /Спектр.285/, átmenetek... tiltottak /Atommag 229/. В таких случаях русское причастие воспринимается скорее как краткое прилагательное, и такие термины могут помещаться в специальном машинном словаре как прилагательные. Слова, застывшие в функции прилагательного, как: открытый, ограниченный, nyilt, korlátolt, считаются прилагательными.

В ходе перевода русская конструкция нуждается лишь в небольшом формальном изменении, если в венгерском на месте русского причастия стоит деепричастие с суффиксом - va, а русский глагол бытия заменяется венгерским глаголом бытия: дано число /Введение 83/, adva van...rendszám (Bevezetés 58), намечены... кривые /Спектр.223/, fel vannak tüntetve... görbéi /Atommag 192/. Таким способом перевода пользовались переводчики математического и физического текстов в 10% случаев.

Возможно избежать большего изменения венгерской конструкции и тогда, если русское страдательное причастие переводится причастием, образованным от венгерского глагола с суффиксом - hat. Этот способ перевода может применяться, главным образом, тогда, если в русском наблюдается вспомогательный глагол мочь, выражающий возможность, но он применим и тогда, если имеется в виду общее утверждение, а не конкретное действие, так что оттенок возможности не имеет значения. Рассмотрим такой пример, в котором употребляется глагол мочь: утверждение может быть сформулировано /Введение 87/, tétel fejezhető ki /Bevezetés 60/ и другой пример, в котором нет глагола мочь: коэффициент ... промерен /Спект.202/, koefficiense... kimérhető /Atommag 191/. Перевод с глаголом на -hat применено переводчиками математического и физического текстов в 10 и 20% примеров.

Простым способом перевода является замена русской описательной страдательной конструкции таким венгерским глаголом, который может ее заменить в личной форме. В значительной части наблюдаемых случаев такой глагол имеет суффикс - ul ~ - ül, например: закон... будет выполнен /Спектр. 331/, törvénye... teljesül /Atommag 274/, будут возведены гидроэлектростанции /О программе 36/, vizierőmüvek épülnek /A kom.épit. 185/. Намного реже встречаются глаголы с суффиксом - ódik ~ - ődik: будет решена задача /О программе 68/, megoldódik a feladat /A kom. épit.216/. В остальных случаях переводчики употребляли иные глаголы, воспользуясь часто возможностями свободы перевода.

В рассмотренных случаях не было необходимо совершить трансформацию русской страдательной конструкции в венгерскую действительную. Однако приблизительно в половине исследуемых случаев /в математическом тексте в 40%/ мы находим венгерскую действительную конструкцию на месте русской страдательной. Трансформация имеет два обязательных момента: на месте русского существительного в именительном падеже стоит венгерское существительное в винительном: $N_N \longrightarrow N_A$, и русская описательная страдательная форма заменяется венгерским переходным глаголом. Если в русском агент действия налицо, то на место русского существительного в творительном падеже должно вступить венгерское существительное в именительном падеже: $N_I \longrightarrow N_N$. Если агент отсутствует, то при определении лица венгерского переходного глагола мы сталкиваемся с значительными трудностями. Но вначале рассмотрим случаи, в которых субъект действия отмечен.

В рассмотренных нами текстах редки были случаи, когда в страдательной конструкции выражен агент в творительном падеже. В тексте по атомной физике и политике 8%, в математических текстах 2%. В таких случаях осуществляется трансформация русского N_I в венгерское N_N: топология... определена тем /Введение 390/, topológiát meghatározza /Bevezetés 258/ и: метод... был использован Эллисом /Спектр. 231/, a módszert...Ellis...alkalmazta /Atommag 190/. В математических текстах N_I не является одушевленным существительным /или местоимением/, но в физических текстах - за исключением одного примера - N_I обозначает лицо или коллектив. Это важно потому, что одушевленное существительное выступает почти исключительно агентом, а остальные существительные могут иметь и другие функции.[x]

В венгерском переводе в роли подлежащего может наблюдаться и такое существительное, которое не выступает в роли агента русской конструкции. В рассмотренных политических текстах в 9% случаев, а в физических в 8% существительное в предложном падеже с предлогами в или на переводится как подлежащее венгерского предложения: $N_{L+v} \longrightarrow N_N$ и $N_{L+na} \longrightarrow N_N$ в физическом тексте встречались оба, а в политическом только первое, например: Вопрос .... рассмотрен в работе /Спектр.85/, kérdést...tárgyalja... munka /Atommag 80/, и: В проекте... выражен курс /О программе 88/, (programm) tervezet megmutatja...utat /A kom.épit.234/ или: На рис 86. дана зависимость /Спектр. 135/. A 86. ábra...függést adja (Atommag 116). Данное явление может быть хорошо определено лексически, потому что в физическом тексте предлоги в и на стоят перед существительными работа, статья, рисунок, диаграмма, а в политическом предлог в сочетается с существительным проект. В ходе машинного анализа следует учесть эти слова.

30-40% всех рассмотренных конструкций составляют случаи, в которых агент пассивной конструкции не отмечен, все же для

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x/ - Данный вопрос был более обстоятельно рассмотрен в нашей статье "Машинный перевод русских конструкций с глаголами на - ся на венгерский язык. Studia Slavica IX стр. 249/.

трансформации русского страдательного глагола необходимо установить, в каком лице будет стоять венгерский действительный глагол. В математическом тексте - почти исключительно - переводчик употреблял 1-е лицо множественного числа, т.е. данное утверждение присвоено автору книги, например: теорема... доказана /Введение 84/, tételt bebizonyitottuk /Bevezetés 58/. В венгерских переводах физического и политического текстов могут выступать как 1-е лицо, так и 3-е лицо множественного числа. В переводе физического текста 1-е лицо мн. числа наблюдается только в настоящем и будущем временах, то же самое можно сказать и о переводе политического текста /отмечено лишь одно исключение/. В тех же текстах 3-е лицо мн. числа употребляется в настоящем и прошедшем временах. Итак, если глагол русской конструкции стоит в прошедшем времени, то-по данным - следует употребить 3-е лицо мн. числа, а, если глагол настоящего времени, в венгерском он может ставиться и в 1-ом, и в 3-ем лице мн. числа. Рассмотрим несколько примеров, в венгерском 1-е лицо или 3-е лицо мн. числа, а русский глагол в настоящем или в будущем времени: внимание будет обращено /Спектр 136/, figyelmet...forditjuk /Atommag 117/, формула выведена /Спектр. 35/, formulát vezették be /Atommag 34/, или производство будет увеличено /О программе 37/, gyártását növeljük /A kom.épit. 188/, проект обсужден /О программе 115/, a tervezetet megvitatták /A kom. épit. 250/, и в венгерском 1-е лицо мн. числа, а в русском глагол настоящего времени: расчеты были проделаны /Спектр. 233/, számitásokat ...hajtottak végre /Atommag 191/.

При переводе физического и политического текстов выбор 1-го или 3-го лица мн. числа зависит от смысла текста, так что при МП таких текстов мы должны обратиться к другому способу перевода, если мы хотим добиться полностью правильного перевода.

Следует еще отметить, что в 10-15% всех случаев переводчики переводили не дословно, а свободно, хотя по смыслу правильно. Это не обозначает, что в таких случаях нельзя было бы дать дословно верный перевод, только он был бы тяжеловатым или привел бы к повторениям.

При рассмотрении возможностей перевода мы старались указать и на такие явления, которые приводят к трудностям при МП. Прежде чем установить приемы перевода, служащие основой для алгоритма, мы вкратце рассмотрим некоторые вопросы венгерских конструкций, соответствующих русским страдательным оборотам.[x]

Для перевода русских описательных страдательных конструкций могут служить венгерские глаголы, так глаголы с возвратными суффиксами -ul ∼ -ül и -ódik∼-ődik могут выступать в роли эквивалента русского пассива /ср. A mai magyar nyelv rendszere. Leíró nyelvtan. I. Budapest, 1961. стр. 358-359. сокращ. MMNyR/. Первоначальный венгерский суффикс пассива -ik и вторичный, но тоже устарелый суффикс -tatik ∼ -tetik не наблюдаются уже в наших текстах /ср. MMNyR 204, 205, 358/.

Другой возможностью выражения пассива является образование венгерских описательных форм. Выше мы видели два вида таких форм: при первом глагол бытия сочетается с деепричастием с суффиксом -va при втором глагол бытия стоит с формой настоящего времени причастия несовершенного вида глагола с -hat /ср. MMNyR 205, 258, 231/. Область употребления последнего ограничена. Если оттенок возможности нерелевантен в данной речевой ситуации, например, в общем настоящем времени, форма с глаголом на -hat применима, иначе ею можем пользоваться лишь тогда, если в русской конструкции наблюдается глагол мочь. Так как первое условие трудно учесть в алгоритме, мы ее будем употреблять лишь во втором случае.

Круг употребления русских описательных страдательных конструкций сходен с тем, в котором употребляются венгерские обороты с - va, так что употребление таких венгерских форм обусловлено, даже при МП мы можем пользоваться ими чаще, это сделано переводчиками.

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[x] x/ - На тех вопросах, которые были исследованы в нашей выше упомянутой статье /Studia Slavica IX/ мы не остановимся.

При МП часто возникает необходимость использования описательной формы с – va, ибо мы наталкивались на значительные трудности при трансформации русских страдательных конструкций в венгерские действительные, если отсутствовал агент русской конструкции, и нехватало формальных критериев для решения того, употребляется ли 1-е или 3-е лицо мн. числа в физическом и политическом текстах.

Рассматривая такие случаи, мы находим, что для их перевода применимы и те способы перевода, о которых говорилось выше, например: спектр представлен на рис. 93 /Спектр 140/, может переводиться не только так: a spektrumot a 93.ábrán mutatjuk be /Atommag 120/, но и путем превращения существительного рисунок в подлежащее венгерского предложения, о чем говорилось выше: a spektrumot a 93. ábra mutatja be. Число таких примеров значительно. Среди них встречаются и такие, в которых наблюдается глагол мочь: Кривая может быть получена /Спектр. 140/, görbéjét kapjuk /Atommag 120/, или же: görbéje kapható (nyerhető). Если в русской конструкции находится и прилагательное должен, нет необходимости определить лицо венгерского глагола: должен быть помножен... коэффициент /Спектр. 234/, meg kell szorozni a koefficienst. В 15% всех примеров физического текста, т.е. в 40% всех случаев, мы нуждаемся в переводе при помощи формы с -va. Рассмотрев эти случаи, мы нашли, что обычно получаются правильные венгерские предложения. Однако встречаются и такие глаголы, которые не применимы в таких случаях: графики получены /Спектр. 381/, по-венгерски было бы: grafikonok kapva vannak, так что следует употребить другой перевод, например, grafikonok...nyerhetők. При них машинный словарь должен содержать соответствующее указание на способ перевода.

Употребление описательных конструкций с – va не будет необычайно широким. Конструкции с – va принадлежат к числу продуктивных моделей, они часто встречаются в разговорном языке, так что их частое употребление не противоречит закономерностям нашего языка. Но не желаем их употребить, если возможен и другой перевод, и особенно тогда, если их употребление приводит к необычным конструкциям, например, при наличии агента: метод... был использован Эллисом /Спектр. 231/, a módszer Ellistől volt alkalmazva тяжеловато, лучше: a módszert... Ellis alkalmazta /Atommag 19C/, или при наличии глагола мочь: обстоятельство может быть использовано /Спектр. 236/, по-венгерски: körülmény ki lehet használva, неправильно, поэтому переводим так: a körülmény kihasználható.

На основе вышесказанных можно употребить следующие венгерские конструкции для перевода русского пассива.

В русском

совершенный вид	несовершенный вид
/1/ Глаголы с суффиксами – ul ~-ül- и –	ódik ~-ődik
épül, épült, épülni fog	felépült, felépül
iródik, iródott, iródni fog	megiródott, megiródik
/2/ Описательные конструкции	
/А/ Причастие с суффисом – ó ~-ő глаголов с – hat сочетается с глаголом бытия в прошедшем и будущем временах.	
irható, irható volt, irható lesz	megirható, megirható volt, megirható lesz
/Б/ Деепричастие с суффиксом – va сочетается с глаголом бытия	meg van irva, meg volt irva, meg lesz irva.

Первый столбец /Б/ оставлен пустым, хотя имеется форма irva van, но она не является продуктивной.

Венгерские глаголы, соответствующие русским страдательным формам несовершенного вида, располагают всеми тремя временами, а глаголы, служащие для перевода русских конструкций совершенного вида, только двумя. Венгерские описательные формы, как и русские, имеют три времени.

Более подробно рассмотрим первую группу. Следующие русские страдательные конструкции без агента: дом строится и дом построен действительно переводятся глаголами с суффиксом

-ul ~ -ül: a ház épül и a ház felépült, но если агент налицо: дом строится каменщиком и дом построен каменщиком их уже нельзя перевести так: a ház épül a kőmüvestől /által/ и a ház felépült a kőmüvestől /által/. В последних случаях следует употреблять действительную конструкцию в венгерском: a kőmüves épiti a házat и a kőmüves épitette fel a házat. Конечно, и первые два примера переводимы активным глаголом в безличной форме: épitik a házat, felépitették a házat. Русская страдательная конструкция без агента ближе к медиальным глаголам, но она может быть дополнена агентом без всяких изменений, в венгерском глагол с суффиксом -ul, ~ -ül не допускает субъекта, и его надо заменить активным глаголом. Венгерский глагол épül еще очень близок к медиальному fordul, и не стал еще полностью пассивным глаголом.

Дополним агентом конструкции, образованные глаголами с суффиксом - ódik. ~ -ődik: задание пишется учеником или задание написано учеником, в венгерском: a feladat a tanulótól /által/ iródik, a feladat megiródott a tanulótól /által/. Конструкция, полученная в результате перевода, является необычной, так что ее употребление нежелательно при МП. Это объясняется тем, что глаголы с -ódik ~ -ődik не стали еще настоящими пассивными глаголами в литературном языке, хотя данная тенденция значительно продвинулась вперед в некоторых говорах.

Рассмотрим описательные конструкции: какими они будут по введении агента? Впервые анализируем конструкции с -hat-ó. О них установлено, что они применимы лишь тогда, если оттенок возможности, выраженная суффиксом - hat, не изменяет смысла перевода, или если в русском стоит глагол мочь, например: задание пишется пером или карандашом, по-венгерски: a feladat irható tollal vagy ceruzával, при том N_I обозначает не агент, а орудие действия, или: коэффициент... либо промерен, либо очень мал /Спектр. 232/, a koefficiense vagy kimérhető, vagy nagyon kicsi /Atommag 191/. Агент может быть налицо: задание пишется Петром или Павлом, в венгерском: a feladat irható Pétertől /által/ vagy Páltól /által/. Если венгерский глагол имеет лишь один аспект, русский глагол несовершенного вида переводится венгерским приставочным глаголом: задача решается машиной, a feladat megoldható géppel. И наконец берем описательную конструкцию с глаголом мочь: задание могло быть написано и Петром, и Павлом, a feladat megirható volt Pétertől (által) is, Páltól (által) is. И здесь следует установить, что при наличии агента желателен перевод с активным глаголом: a feladatot megirhatta Péter is, Pál is. Исключением является лишь такой случай, в котором агент является и средством действия: a feladat megoldható géppel.

Выше мы уже анализировали перевод с помощью конструкции с -va при наличии агента: метод... был использован Эллисом /Спектр. 231/, a módszer Ellisstől volt alkalmazva, и установили, что такой перевод тяжеловат, и не следует его употребить.

Вкратце подытаживая сказанное, можно установить, что венгерские конструкции нельзя считать адектватными парами русских страдательных оборотов, они не могут выполнить полностью роль пассива. Это обстоятельство надо учесть при МП, и русские конструкции с агентом трансформируются в венгенрские активные.

Алгоритм МП должен быть построен на основе следующих:
/1/ Установить, имеется ли агент, выраженный N_I, в русской конструкции. Если есть, провести трансформацию $N_I \longrightarrow N_N$, $N_N \longrightarrow N_A$, и венгерский глагол будет активным.
/2/ Если нет N_I, установить, не предшествуют ли предлоги в, на существительному в предложном падеже с определенным номером кода. Если имеется такое существительное, провести трансформацию N_{L+v} или $N_{L+na} \longrightarrow N_I$ и еще $N_N \longrightarrow N_A$, а глагол будет активным.
/3/ Если нет такого N_{L+v} или N_{L+na}, надо установить, есть ли в русской конструкции глагол мочь. Если да, главному глаголу и глаголу мочь в венгерском соответствует форма с суффиксом -ható главного глагола. В прошедшем и настоящем временах добавляется и соответствующий глагол бытия.
/4/ Если нет глагола мочь, установить, есть ли в конструкции модальное прилагательное должен. Если да, глагол и должен

переводятся вспомогателлным глаголом. Совершить и трансформацию $N_N \longrightarrow N_A$.

/5/ Если нет прилагательного <u>должен</u>, установить, не имеет ли глагол такой номер кода в машинном словаре, который указывает на то, что глагол переводится простым венгерским глаголом /с выше рассмотренными суффиксами/. Если русская конструкция в настоящем или прошедшем времени, то венгерский глагол стоит в прошедшем, если в русском будущее время, в венгерском то же самое.

/6/ Если нет такого номера кода, установить, есть ли в конструкции вспомогательный глагол в прошедшем времени, если да, венгерский активный глагол ставится в 3-е лицо мн. числа, и проводится трансформация $N_N \longrightarrow N_A$.

/7/ Если нет вспомогательного глагола в прошедшем времени, венгерский активный глагол принимает форму деепричастия с <u>-va</u>. Венгерский вспомогательный глагол обязателен во всех трех временах. Однако, если венгерский глагол имеет определенный номер кода, для перевода надо прибегнуть к одному из выше перечисленных способов.

При математических текстах пункт /6/ будет следующим:

/6/ Если нет N_{L+v} и N_{L+na}, действительный глагол ставится в 1-е лицо мн. числа, и проводится трансформация $N_N \longrightarrow N_A$.

Пункт /7/ отсутствует при переводе математических текстов.

Кроме того приходится установить порядок слов венгерского предложения.

В нашей статье на эту же тему[x] и в другой статье о МП русских конструкций на - <u>ся</u>[xx] нами были рассмотрены некоторые вопросы порядка слов соответствующих русских конструкций и их венгерских эквивалентов. Здесь мы хотели бы вкратце обобщить некоторые из наших наблюдений.

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[x] Az orosz szenvedő szerkezetek gépi forditásának nyelvtani kérdései. Magyar Nyelvőr. 87:445-53.

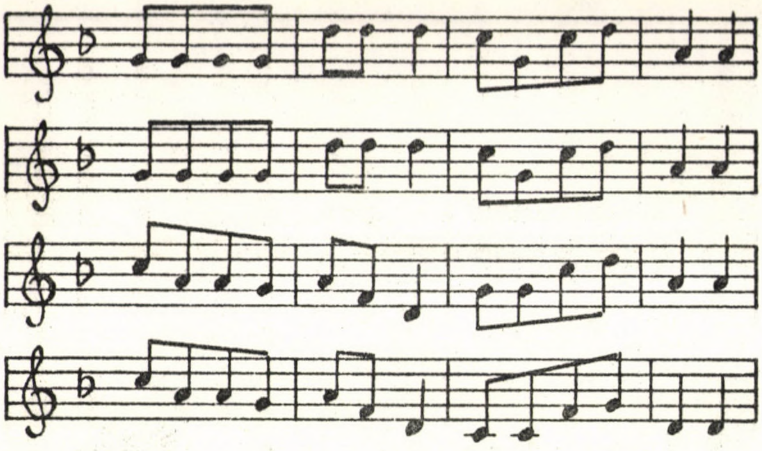
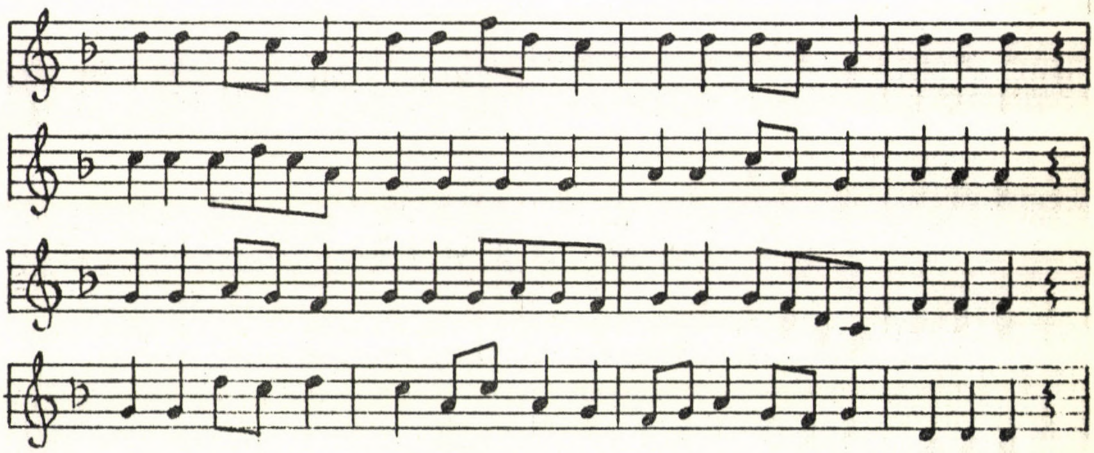
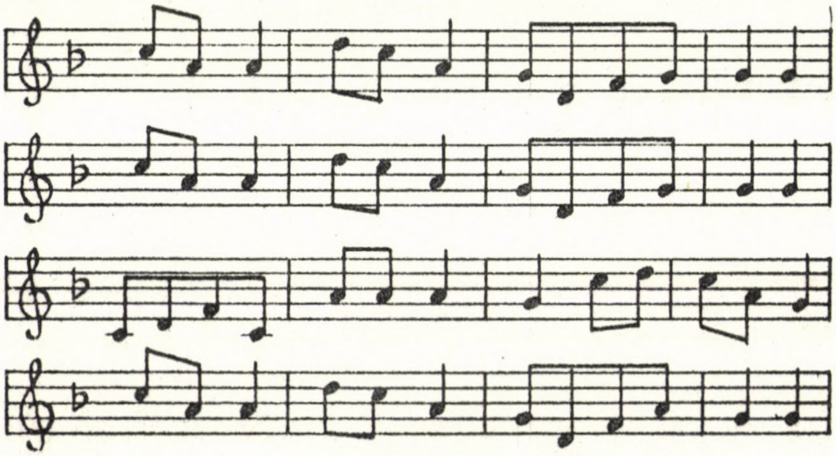
[xx] Машинный перевод русских конструкций с глаголами на-<u>ся</u> на венгерский язык. Studia Slavica IX.239-55.

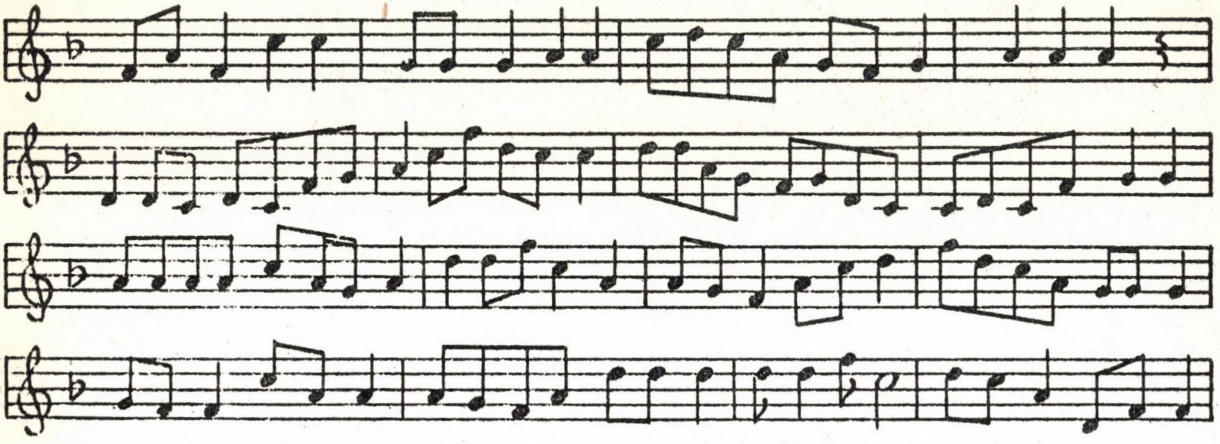
В русских текстах доминирует прямой порядок слов: $N^{1}_{N}\ V\ N^{2}$, который встречается в 60-78% всех случаев, при том его доля в физическом тексте ниже /60%/, в математических выше /73-78%/, а в политическом средняя /68%/. В соответствующих венгерских текстах русскому прямому порядку слов отвечает такой же порядок слов, но прямой порядок слов наблюдается частично и при переводе русских конструкций с обратным порядком слов. Это объясняется тем, что за русским обстоятельством (особенно обстоятельством места), выдвинутым на первое место предложения, следуют сказуемое и подлежащее в обратном порядке, а в венгерском такого явления нет, так как венгерский обратный порядок слов наблюдается лишь при выдвижении по смыслу другого члена предложения.

Установление порядка слов венгерского предложения проводится в двух фазах: /1/ установить внутренний порядок слов номинальных синтагм, и /2/ расположить синтаксически свободные единицы предложения. В дальнейшем нас интересует только последнее задание, для которого нам нужны определенные сведения о порядке слов русского текста. Обязательно надо знать, является ли русский порядок слов прямым или обратным. А если наблюдается обратный порядок слов: какое слово выдвигается на первое место, (при этом имеются в виду слова, порядок слов которых свободен). На основе таких информаций выбирается схема венгерского предложения, служащая основой для расположения венгерских слов.

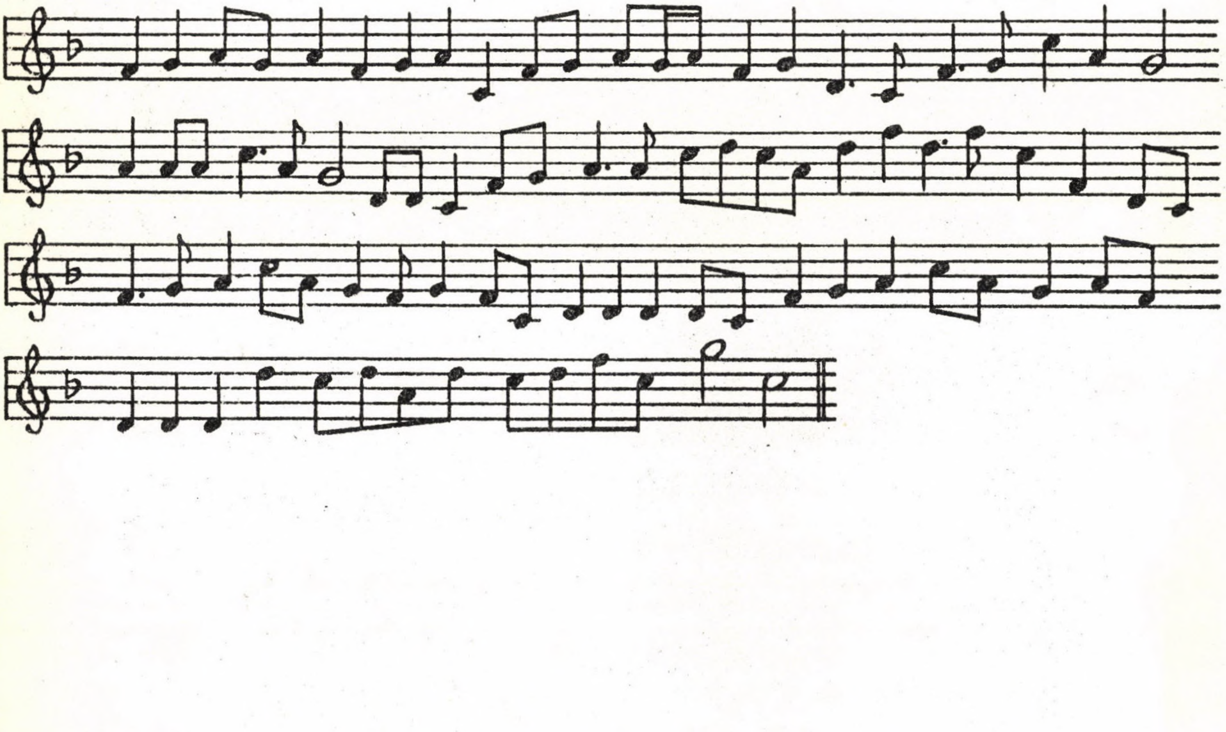
Исследования в области порядка слов МП надо проводить в двух областях: /1/ структурный, формальный анализ венгерского порядка слов, /2/ анализ русского порядка слов для получения сведений, необходимых для определения венгерского порядка слов. В ходе работы над венгерским порядком слов устанавливаются схемы венгерских предложений с двумя, тремя и больше независимыми членами разных типов. При каждом из них отмечается: является ли предложение нейтральным, или подчеркивается какой-нибудь из его членов. Надо уделить внимание и частоте употребления синонимичных схем. Так, например, русскому прямому порядку слов: N^1_N V N^2 могут соответствовать две венгерские схемы: N^1_N V N^2 и N^1_N N^2 V, но последняя является обычным, а первая более редким в научных текстах.

To Havass's paper /pp. 107-127/:

1.

2.

3.

4.



5.



page	line	incorrect	correct
46	1. f.b.	MOCKBA.	MOCKBA. 1965.N°1. pp. 80-99.
56	10. f.b.	human	human being
64	7. f.a.	preposition	article
126	7. f.a.	wich	wish
148	15. f.a.	eve	eye
168	18. f.a.	RAND	RANDOM
169	18. f.a.	X (I - 1)X O + J	X[(I - 1)X Q + J]
170	2-5. f.a.	L C : =	L [C] : =
		M C : =	M [C] : =
		P C : =	P [C] : =

Footnote to the ALGOL program on pp. 150 and 169-170:

In the text X represents both "variable X" and the multiplication sign. Nevertheless, in actual occurences it can be decided easily which interpretation is valid. While the programs were written also the rules of ELLIOTT-ALGOL have been taken into consideration. This will explain some slight deviations from the standard ALGOL 60 notation /e.g. underlining of basic words omitted/.

ERRATA

page	line	incorrect	correct
29	4. f.b.	sets σ to	sets L_G to
30	16. f.a.	L_G (σ_i)	L_G ($\mathcal{T}_i$)
31	1. f.a.	set T^i	set $\tilde{T}^i$
32	5. f.b.	an $\mathcal{T}_{j-m}$	and $\mathcal{T}_{j-n}$
35	3. f.a.	Be, m	Be, Bm
35	10-9. f.b.	described details	described in details
35	5. f.b.	- the length	W - the length
37	4. f.a.	nex Q:	new Q:
37	19. f.a.	if f f2	if f < f2
37	24. f.a.	Disj m (STm	Disj (m, STm
38	21. f.a.	(m,V[STe [y]] ≠ 0	(m,V[STe [y]]) ≠ 0
39	3. f.a.	go to new [rl];	go to new rl;
39	11. f.a.	j=j+3;	j=j+3; STm[p]:=i;
39	17. f.a.	R:=stack R;	R:=stack [R];
39	19. f.a.	if r ≥ k	if R ≥ k
40	1. f.a.	The	8. The
40	2. f.b.	in [2] gives	in 2. gives

A SIMULATION OF MUSICAL COMPOSITION SYNTHETICALLY COMPOSED FOLKMUSIC

by

M. Havass

1. Introduction

The present work is a short account of some experiments executed on the National Elliott 803/B for a simulation of musical composition. The area of problems which can be handled by computers becomes more and more ample and - as it is well known - the process of composing can also be formalized and therefore simulated by computers.

It is clear that it is impossible to formalize the whole process of musical composition but there are some general principles which one uses - as a rule only intuitively - while composing and these motives of composing may be modelled by the programer and on the basis of this model an algorithm may be elaborated. Nevertheless it cannot be the primary goal of the programer to have the machine compose pieces of music because the whole process of composing cannot be formalized and so the works which a computer can compose are only dilettant works which fail to have the creative power and depth of a piece composed by a composer. But computers may be used for the musical analysis, i.e. for the establishment of the exact rules which may underly a composition.

If the above-mentioned exact rules are known and are programmed and the computer composes on the basis of the obtained system a piece of music, this piece may be compared to known musical material and in this way it will be possible to detect some differences and regularities. For this comparison the correlation analysis may be used.

Another field for the use of computers with respect to musicology is the statistical investigation of folk music.

It is obvious that the linguistic affinity must reveal itself also in the statistic structure of the music of different nations. To get some information in this respect we have only to look at the Markov-matrix obtained as a side-product of the composition and to state its structure the settlement of its condensation points.

On the other hand, the Markov-analysis may yield a succesful tool for establishing the undefined or unclearly defined notions of musical theory which are, however, used very often, as, for instance, the notions of tonality, motive, variant.

With the help of statistical investigations the taking down of songs may be executed by computers which are capable to register such slight differences which could not be expressed by the traditional musical notation.

Another application of the Markov-analysis is mentioned in another paper of the author written jointly with E.N. Ferentzy which is to be found in the same volume of Computational Linguistics. [12]

Some other possibilities of its application are mentioned by Hiller and Isaacson. [8]

We shall now turn out attention to the description of the composition of monophonic and pentatonic melodies and in connection with this also a new conception of the musical composition is developed.

2. What is meant by composition?

Let be given a set H_n of n-dimensional vectors

$$\mathbf{h} = [h_1, h_2, \ldots, h_n]$$

where an $\mathbf{h} \in H_n$ vector contains as components all possible characteristics of a musical tone /pitch, sound intensity, timbre etc./. From these we call some significant others insignificant variables. The differentiation depends generally on the given situation. The pitch is, for instance in each cases a significant variable, i.e. a variable that determines the music.

Let us regard a system of rules S_n consisting of the vectors

$$\mathfrak{s} = [s_1, s_2, \dots, s_n]$$

A rule $\mathfrak{s}$ may impose at the same time some restrictions on all characteristics of the musical tone. If this does not hold, then the corresponding component s_i of the rules is taken for 0.

In this cases the process of musical composition [1] with some oversimplifications, i.e. the semantics of the compositions are left out of considerations and only the structural side, the syntax of the compositions are taken into account - consists of the selection of some elements of the set H_n and of the forming of a series of these selected elements and in the meanwhile meeting the restrictions $\mathfrak{s}$ imposed by the set of rules S_n . [2]

By assigning to each value of the time interval $\tau_1 \leq \tau \leq \tau_2$ and $h_y \in H_n$ vector we have interpreted a scalar-vector function which is nothing else as the result of the composition process: the musical piece itself.

By taking down the musical pieces we practically do nothing else as to define all points of this function $f/h_1, h_2, \dots, h_n/$. Because of the continuum power of the point of the timeinterval we cannot define the function in this way, so we define the function only for some given points which are important with respect to the significant variables. The definition is done in that way that the vectors representing the values of the function are increased by one component /t = time variable/ that defines in a recursive way that point of the interval (τ_1, τ_2) for which the value of the function is given again. Between two points given in this way the function may be regarded with respect to the significant variables as being constant. The musical notation is now given by the following function

$$f^*/h_1, h_2, \dots, h_n; t/.$$

We could -with good reason - regard the function f^*as the musical piece because the customary form of the communication between the composer and the interpreters is not the living music but the musical notation.

Thereafter the interpreter who receives the function defined by I discret points in the above way /where I stands for the number of tones occuring in the composition/ and he carries out-while performing the "composition" - an interpolation with respect to the given points and developes in this way a function $\tilde{f}$ which can be conceived as the realization, as the interpretation of the composition. The nearer the function $\tilde{f}$ stands to f , the truer is the interpretation.

Now if we could define the suitable measure, so we could state also the affinity of n different interpretations, when undertaking the required number of examinations with respect to the values of the function $\tilde{f}_j$ /j=1,2,...,i/.

3. The composition by computer

After the general outlines of the mathematical theory of the composition process the question may be raised, how this process may be simulated by a computer.

First we must select the set of vectors H_n. This means that:

1. we have to define the dimension of the vectors we want to make use /i.e. we must decide how many characteristics of music should be taken into consideration. We do not commit a great fault if we regard only the significant variables./

2. We have to state which values the components of the vectors can have. /Let be, for instance, s_1 the pitch. In this case we must decide the interval unit we use and the number of octaves/.

On the other hand, we have to decide which set of rules S_n the computer has to follow. We shall tackle this question in more detail below.

We must generate for composing the tones random numbers with given distribution which meet the requirement imposed by the set of rules S_n /i.e. the distribution is defined by this set/. Because of their randomness they may represent the "free will" of the composer.

The most problematic part is the second one, i.e. the establishment of the set of rules S_n.

For the sake of simplicity we shall now understand by a tone only the pitch of the tone. The mean direction of our investigations concerns namely the pitch. In the case of folk music the above restriction is fully justified then -as Járdányi says -: "...in the two broad layers of Hungarian folk music the leading role belongs to the melody and not to the rhythm." [13] It is a general observation that in the European music the melody has the most pregnant and most characteristic role which however does not hold with respect to the folk music of Africa.

It seems to be obvious to regard any tone as a probabilistic variable. The elementary events may be in this case the occurence of the tones of a previously given scala. For the sake of simplicity we may handle the system as a discret system because of the customary quantization in music. Naturally by sounding one single tone the probability of the occurence of any elementary event is identical.

This model will be useful only if we regard the composition as a sequence of tones. In this case the occurence of the elementary events is not the same. The occuring tones are namely in a complicated interconnection, correlation. In this case we have to find out the distribution functions of the single probabilistic variables which yield the wohole set of rules of the musical composition. As this function cannot be given in an exact form our aim is to construct suitable approximative functions.

Isaacson and Hiller have defined a kind of approximative distribution functions in their first three experiments when programming concrete musical prohibitions, rules /as, for instance, the prohibition of three unisono steps, the approval of two unisono steps, the prohibition of minor seventh skips etc./, so that a certain set A of events have zero probability, while each pair of elements of the complementary set have equal probability.

In their fourth experiment Isaacson and Hiller construct different approximative functions /harmonic function, proximiti function and combined function obtained by the combination of the two former functions/ in a direct way, the compositions "composed" on the basis of these functions are "perhaps, not too different from conventional melodic writing". [8]

We can, however, seek for a more constructive method for the approximation of the functions in question. It seems to be obvious that we have first to analyze the statistic structure of the compositions by a computer and by means of this analysis we may obtain some general rules. The principles for such an analysis stem from C.E.Shannon [7] , who has elaborated the method for the analysis of speech sounds which was supported by the basic work of Markov "Essai d'une recherche statistique sur le texte du roman 'Eugén Onegin', illustrant la liaison des épreuves en chaine". [6]. Because of the structural similarities of music and speech it can be assumed with good reason that Shannon's method may be applied with success also to the analysis of musical material.

Let us have a finite event system $A_o, A_1, \ldots, A_n$ consisting of the tones of a scale of n-degree as elementary events and let us assume that the result of any experiment is the occurence of one of these events. The n experiments should be characterized by the probabilistic variables X_i so that if A_k has been the result of this experiment then

$$X_i = k \ ; \ /i=0,1,\ldots \ ; \ k= o,1,\ldots,n/.$$

It can be assumed that the sequence of the variables X_i forms a Markov-chain and the corresponding transition probabilities may replace the desired distribution functions. Thus we aim at the determination of the probabilities of the transitions. This may be done by the aid of the statistical investigations of the selected musical material. The process that yields the desired result is known as Markov analysis.

We understand by a Markov analysis of Pth degree a process by the aid of which it can be stated with what a probability the individual events of the finite event system $A_o, A_1, \dots, A_n$ may occur after P-1 events have already occured. During the analysis we construct the stochastic matrix π consisting of the transition probabilities which yield the system of rules S_n in the long run. The latter may be the starting point -as we have seen - for the mentioned musical analysis. The system of rules S_n obtained in the form of a Markov matrix is apt to determine the distribution which regulates the generation of random numbers.

Let us assume that the sequence of tones $X_1, X_2, \dots, X_K$ is given. Then to obtain X_{k+1} we have nothing else to do as to consider the elementary probabilities belonging to the rows $X_1, X_2, \dots X_k$ of the Markov matrix because the distribution function formed from these probabilities yields the basis for the random generation number.

The next question which arises is: What can be expected from the composition given by the computer? To what an extent does it fit into the set of "human" compositions? /Of course, this "fitting" can only be understood in terms of the syntax./

Let be given a real system of rules V which consists of n rules /the knowledge of it is not necessary, and is not even possible according to that which was said about music in general/, and let us denote by V_k the possible compositions based on these rules. Thereafter we give /either a priori or by means of statistical investigation/ a K artificial system of rules and let us denote by K_k the possible compositions permitted by these rules.

Then we can have the following situations:

a/ $V_k \cap K_k = 0$ this means, the artficial system of rules contradict the real system completely.

b/ $V_k \cap K_k \neq 0$ In this case we can distinguish the following subcases:

$V_k = K_k$ this is the ideal case which we strive to attain but which comes true only if $V = K$, i.e. when we have a complete knowledge of the real system of rules. As a matter of fact, this case may not occur in reality.

$K_k \subset V_k$ this case is quite impossible, because if it were true the equality $K = V + C$ ought to hold /where C stand for an indefinite value/, which presupposes the complete knowledge of V.

$V_k \subset K_k$ this means that from the n rules of the system V_k m /$<$ n/ rules are known and the composition is carried out in the very knowledge of these rules

$$V_k \cap K_k \neq 0 \wedge \left[(V_k \cup K_k \neq V_k) \wedge (V_k \cup K_k \neq K_k) \right]$$

/where $\wedge$ stands for the conjunction and V for the disjunction/, this is the most general case where we aim at the amelioration of the degree of approximation so that the intersection of the two systems be as big as possible.

We have pointed to thid approximation /which may be carried out by means of statistical investigations/ in the introduction. Namely, if we have a V and we construct a $K^{(1)}$ /where (1) stands for the degree of approximation/, then by simple comparison of V_k and $K^{(1)}$ we may obtain a $K^{(2)}$ and then by comparison of V_k and $K_k^{(2)}$ a $K^{(3)}$ and so forth, in general a system $K^{(i)}$, where $i \to \infty$.

It should also be noted that both V_k and K_k may have parts which do not belong to the other. Let us assume, for instance, that we want to approximate the system V_k consisting of n rules with the help of a system consisting of m /$<$ n/ rules obtained by means of a statistical analysis. If the analyzed works are not representative with respect to the whole group then it may happen that among the m rules we have one or probably more rules that do not belong to the system V. Such a case occur, for instance, when we take - for tha sake of analysis - only such compositions from the considered system which end in the same tone /for instance, in do/. So this fact is registered as a rule which will belong to the system of rules K. As a consequence, V_k may have such an element /for instance, a composition ending in re/ which does not belong to K_k.

For the "creation" of suitable compositions three requirements established by Neumann must be fulfilled [10]:

1. The examined material must be homogenous to the extent that it must exhibit a common structure. On the other hand, it must be heterogenous to the extent that it give sufficient freedom for the "creation" of new compositions.

2. The examined material must be comprehensive enough for the common structure could be determined.

3. Each examined material exhibits an advantegous degree of the analysis. This degree is characteristic of the material.

The last question which must be answered is: What a degree must have the Markov analysis which we apply in the outlined process? As it has been supported by the Neumann's experiments in the case of a low degree we obtain rather unmelodious compositions, while in the case of too high degree the computer plagiarizes more or less from the analyzed material. The question of degree may be decided practically by giving the computer the possibility to carry out analyses of different degrees and after the examination of the obtained compositions the suitable degree can be chosen easily.

4. The details of the experiment

We give now a short account of the most important parts of the experiment. The program has been elaborated according to the principles outlined above for the computer National Elliott 803/B.

4.1 Input

The first task is the input of the musical material which has to be examined from a statistical point of view. It is clear that the compositions are not stored in the memory in their form $f/h_1,h_2,\ldots,h_n/$ /i.e. in their sounding form/ but in their form $f^*/h_1,h_2,\ldots,h_m;t/$ which may be characterized with discret values. For our present experiment and for the sake of simplicity we have chosen as basic set the set H_2, so the vectors have three variables /one of them is the time variable/. In other words, the variabls refer to the pitch, stress and rhythm. As a consequence, we obtain the system of rules S_2 out of the manifold of the compositions of the form

$$f^*/h_1,\ h_2;\ t/$$

The compositions may be put into the computer in the following two ways:

1. The living music may be put into the computer immediately. Then the computer has the task to construct the vector values of the discret function $f^*/h_1,h_2;t/$. The construction of a key-board suitable for such a direct input is under work. The instrument will be presented be for the conference of the "International Folk Music Council" which will take place in Budapest /August, 1964/.

2. As we have not such an equipment at our disposal at present, we have to transform the compositions in question into binary codes. Our work has been facilitated by the fact that - within certain limits - the musical notation determines the values of the function f^* in the given points in an exact and clear-cut manner. So we have only to seek for a suitable mapping in which numbers correspond to notes.

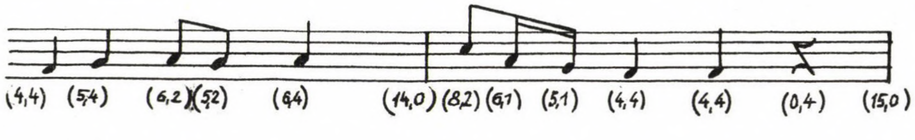
For the time being we must transform the notes by handicraft. But the automatic head "Lector" of the Leo Computers L.T.D. may be rendered suitable by the aid of a convenient program for the reading and transforming of notes. We obtain a one-to-one correspondence in the case when we assign to each tone an ordered pair of numbers /a, b / /as indentifier/, where from the numbers a and b a stands for the pitch and b for the length. As a complementary condition we may require the fulfilment of the condition $0 \leq a,b \leq 15$. As a consequence, it is enough to have 4+4 bits for the representation of any tone. In a similar manner also the pause may be represented /i.e. by an ordered pair of numbers /as such a tone whose pitch is zero but which has a certain length. Similarly we are able to represent the bar lines by ordered pairs of numbers /which are apt to mark the accent/, the ends of the lines and melodies. By marking these features it will be possible to execute a more intensive analysis /concerning form or tonality, for instance/. The codes which serve for marking the pitch and the span of time may represent, substitute the tones in itself and it is possible to carry out operations with them independently from each other, so the pairs of numbers representing them have only a signaling function.

The code-numbers are compiled in the following way: /It should be noted that we used the solmization system instead of an arbitrarily chosen absolute system/

so,	1	so	8
la,	2	la	9
ti,	3	ti	10
do	4	do'	11
re	5	re'	12
mi	6	mi'	13
fi	7	pause	0

In our material we have use only the tones of the la-pentatony which contains besides the tones of the pure pentatony also the tones <u>fi</u> and <u>ti.</u> As we have been conerned conerned with vocal works, the given range of voice is quite sufficient. The codes of the length:

𝅘𝅥𝅯	1	𝅘𝅥	4
𝅘𝅥𝅮	2	𝅘𝅥.	6
𝅘𝅥𝅮.	3	𝅗𝅥	8
	0	𝅗𝅥.	12

The bar line has been represented by /14,0/, the end of line marked by a bar line by the pair /15,0/, the end of the melody /15,15/. E.g.

b.

4.2. <u>The generation of random numbers</u>

As we have pointed out the generation of random numbers stands in the middlepoint of the composition process.

The literature recommends a great number of methods for the generation of pseudo-random numbers. We have used a method developed by Ralston and Wilf [5] because it could be programmed easier. The following recursive formula serves serves for the generation of pseudo-random numbers with uniform distribution:

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$$\xi_0 = 1; \quad \xi_{n+1} = \xi_n \cdot k \pmod{2^a}$$

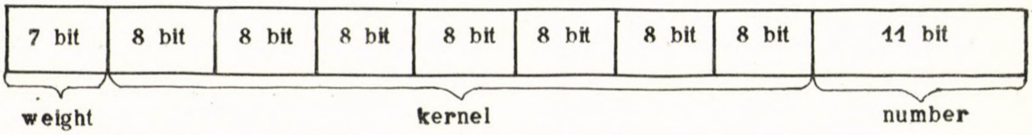
where ξ_n stands for the n-th random number, k stands for an odd power of three or five /it depends on the storage capacity of the computer/ and a stands for the word length of the computer in question. As it has been shown by O.Tausky and J.Todd [4] the period of the process is 2^{a-2}. We have submitted 1000 generated random numbers to an examination with respect to uniformity and the result turned out to be positive. The programming of the process is extraodrinarily simple when using the device 57 of the computer. After executing the multiplication $k.\xi_n$ the half part of the result which is stored in the auxiliary register can be placed into the accumulator which means, however, a reduction mod 2^a.

4.3 The analysis of the melody and rhythm

We shall now discuss the realization of the Markov analysis on the computer. First - for the sake of simplicity - we have determined the analysis only for the pitch but the program need not be essentially altered if the tone is characterized beside the pitch also by the rhythm and probably by the accent.

The degree of the analysis may be adjusted on the controlling table.

Each element of the matrix containing the transition probabilities has the following form. Two words are to be linked and then divided into 9 parts according to the following scheme:



The central 7x8 bits, the "kernel" of the word stores the symbols of the tones following each other in an left-to-right order. /1 tone = 8 bits, 4 bits serve for marking the pitch and 4 for marking the length/.

The last 11 bits, the "number" of the word, yields the frequency number of the tone-group standing in the "kernel" of the word. The degree of the analysis may be prescribed by giving the order to shifting. To be more precise, we state the last tone in the "frequency list" of the tonegroup /which is to be found in the last 8 bits of the word/ and tell with how many places this should be shifted to the left, i.e. how many tones from the "kernel" should be used for the analysis. It seems to be advisable to carry out an analysis with maximal degree and, before the composition of the single tunes, to determine when we want to have the tune as a result of an analysis of lower degree.

The first 7 bits of the word, the "weight" of the word, serve for marking the accent.

The figure 1 standing in one of the places of the first seven bits means that the tone with the same serial number is accentuated. If required, we may take into account the accents /on the beginning of the bar/ and determine the transition probabilities.

During the analysis we always examine the frequency of some tone groups characterized with a certain pitch, rhythm and accent. However, for the composition it is not necessary to take into account the whole matrix obtained in this way. The matrix may namely be transformed to a matrix of tones characterized only by the rhythm and pitch or only by the pitch. In the latter case we must, however, prescribe the rhythm of the tones in another way.

During the composition process we have to decide in which beat we want to have the composition /2/4, 3/4, 4/4/. The prescription of beat may be altered also during the composition process.

The last quarter is determined by a subroutine which guarantees that the length of the tones generated by a random process do not exceed the allowed limit. There is a possibility also not to prescribe the kind of beat.

4.4 Rhythm

So far, the rhythm of the composition has not been solved in these experiments in a satisfactory manner. In the earleast experiments only 2-3 kinds of beat were permitted and there was no possibility for mixing them. Besides, Zapirov prescribes within the bar some rhythm groups and only these are varied in a given manner [9] . There is no doubt that in the layer of music where the melody is the leading element, it seems not to be worthwhile examining independently the length by a Markov analysis.

Two solutions lend themselves for this purpose. One possibility is the synthesis of the pitch and the length and the examination of it by a Markov analysis /we have pointed to this solution in the previous item/.

This solution was followed by Neumann and this is recommended by Pinkerton. The method is doubtlessly advantageous because there is an interconnections between the pitch level and the rhythmic distributions, so, for instance, some leaps may often go hand in hand with some given rhythmic features. Its disadvantage is however that is does not shed light on some questions concerning beat and, on the other hand, the number of the elements of the matrix is increased such that it is necessary to augment the examined musical material, too. This method was suitable for Neumann and Pinkerton because they examined only Chorals and nursery tunes with very simple rhythm. [10],[11]

The other method that may give better information about the choice of bar consists of the following: the list of the kinds of bar occuring in the examined matarial is compiled by the aid of statistical analysis and then the different kinds of bar or bar groups respectively are examined with respect to frequency by the aid of Markov analysis while the end of the line or of the whole melody are regarded as separate bars. This method makes the alterations of the kinds of bar possible. The process of composition consists in this case also of the generation of random numbers, but here some kinds of bar correspond to the random numbers.

4.5 Form

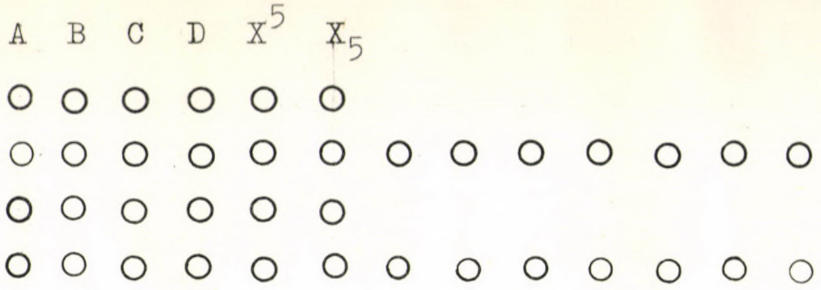
Even the question of form has not bean solved up to the present. Both the deductive method followed by Zaripov and the inductive one followed by Neumann determines a form whose frame is maintained during the composition process.

If we prescribe the composition of melodies with four lines, then we may "generate" by using the controlling table compositions with different forms. However, it should be emphasized that we work only with melodies with fixed form, i.e. we prescribe the composition only of melodies with fixed form. The structural differences between the fixed and free form are well-known. "The fact that it is impossible to adjust melodies with free and fixed form according to the same principles is indisputable for all folklorists". [13]

The simultaneous analysis of the melodies with fixed and free form would contadict to the first of Neumann's conditions.

A more precise handling would require the previous analysis for establishing the structure of the musical material /probably by means of the breakdown not according to the lines but according to the bars/ and the content elements of the lines or the bars, respectively. So far, however, even in musicology the are no clear-cut and exact definitons of these notions. An exact definition requires a lot of examinations, partly statistical investigations, and here there are wide possiblities for the use of computers.

For the difference between the form A and A_V are not defined, we do not give a positive possiblity for building of variants. But it is permitted to have four different lines /A-B-C-D/; to have congruent lines only, to have an exact repetition of the melody /more precisely, of the line/ a fifth lower. The desired form may be set by means of the four key rows of the number generator of the controlling table. In each row the first 6 keys are used for marking the form and the other are left free for the declaration of the degree of the analysis and for marking the kinds of bars.



Each line represents a line of the melody. The key pulled down in the column A means the congruence with the first line, save we have in the same line X^5 the key corresponding to X^5 or to the column of X_5 which prescribes a so called fifth construction. It is obvious that it is necessary to impose some restrictions. Most of them means only a formal restriction:

1. A transposition by a fifth downwards can only be prescribed if the line X serving as a base is already given.
2. The first line can only be A.
3. The second line cannot be of type C, D, B^5, B_5.
4. The third line cannot be of type D, C^5, C_5.
5. The forth line cannot be D^5, D_5.

If a transposition by a fifth upwards is prescribed of type X^5 and this is not compatible with the tonal system of the computer because of the pitch of the new tones, the computer will state this fact and automatically execute a transposition by a fifth downwards of type X_5. The same holds if X_5 is prescribed.

4.6 Tonality

The programming of tonality is a very difficult task. The problem is a complicated one because musical theory has not found out up to the present what this phenomenon consists of. But it has been decided that final and accentuated notes play an important role in the determination of tonality. To solve the problem we have programmed two different methods.

According to the first method the random numbers representing the tones are screened with the help of the list 3570-dé.

of the tones standing at the beginning of the bars in the following way: if a tone does not occur in the list, it is considered as having zero probability and is therefore rejected.

According to the second method, making use of the possibilities provided by the Markov analysis, the composition process is played from the end to the beginning and the desired final is guaranteed in this way in advance. So the analysis must be carried out in an reversed order. The program may, however, be modified to guarantee this.

At last we give the possibility for "generating" compositions by means of a Markov matrix consisting only of pitch values without any requirements on form, tonality and rhythm.

Below the possibilities of composition are compiled in a table:

	the analysis is based only on the pitch		the analysis is based on the pitch and the length		the whole Markov matrix is used /also the tonic accent/	
	A	B	A	B	A	B
the form is prescribed on the controlling table		U	V		W	
the form is not prescribed		U				

A: the kind of
bar is
prescribed

B: is not
prescribed

U: The rhythm according to 4.4.

V: The beat is kept by means of a subroutine.

W: The accentuated tones of the bar are guaranteed by means of a subroutine.

4.7 Output

As output we obtain again compositions of the form $f^*/h_1,h_2;t/$. Naturally, we may obtain our result also in form of codes which may be transformed to notes.

There are also possibilities to obtain the result by means of a loud-speaker immediately. The method for preparing a program for this is well-known. We have used a similar program to the National Elliott 803/B, and so we could obtain our results as "living music".

5. Results

By the aid of the elaborated program 100 tunes of the collection of Kodály /Ötfoku II./ have been analyzed. [3] With the help of the obtained table of rules the computer has composed different marching songs. The results support Neumann's statement with respect to the choice of the degree.

Without penetrating deeper into the musical analysis of the results /we shall take up this question in a later work/ we present here 5 examples. Two of them (1-2) stem from Kodály's collection and are given for the sake of comparison and two are (3-4) composed by the computer. As a matter of curiosity we give still one melody that was composed by the computer on the basis of the rules obtained only by the analysis of the pitchs (5).

The compositions are recorded on a magnetic tape. We wish to present these "tunes" on the abovementioned conference of the "International Folk Music Council".

I am indebted to K.Csébfalvi, leader of the Computing Centre of the Ministry of Heavy Industry, for his help in mathematical and programming questions, to Dr.P.Járdányi, head of Department of the Folklore Group of the Hungarian Acedemy of Sciences and to Dr.L.Vargyas for their helpful comments.

NOTES AND REFERENCES

1. It should be noted that we do not want to tackle the genetics of the works, we wich only to construct a model for the "created" works themselves.
2. These rules refer to the general characteristic of styl, i.e. there are characteristics which render a musical piece Baroque or impressionistic etc.
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HUMAN MOVEMENT ANALYSIS BY COMPUTER ELECTRONIC CHOREOGRAPHY AND MUSIC COMPOSITION

E.N. Ferentzy and M. Havass[x/]

Summary

The paper proposes to unify efforts directed up to now to the investigation of different movements with formalized methods, and to begin with a cybernetic human movement analysis in general, that is, to analyse human movement in space, time and under the influence of factors acting upon it. From these factors music is judged to be the most important and also apt for computer treatment at the present time. Therefore a formalized music analysis should be carried out from the precise point of view of movement relations.

In the preface distinctions are made for cybernetic movement and music analysis:

1. basic analysis /e.g. differential equations of a single movement; computer simulation of the human voice/
2. large-scale analysis /e.g. Markov analysis of choreographies; Markov analysis of compositions/
3. analysis of the middle range /e.g. analysis of dance and music interrelations in modern dances/.

In these frames of reference the paper indicates input and output means that would enable or accelerate research in all the above fields /2§ and 7§/. A mathematical systems language is proposed that would enable communications for present and future research in all the above branches /3§/.

[x/] For ease of reference it is noted that the responsibilities of the authors are: E.N. Ferentzy - movement analysis, M.Havass - music analysis.

The present research is concentrated on the large-scale and the middle range, following the above program: firstly movement analysis, secondly music analysis carried out with an eye to the movements. Also the fruitfulness of collaboration with existing groups doing basis analysis is asserted. The reason for not doing this up to now is only lack of information on such research groups.

Concerning the analysis and electronic composition please consult the "Contents" /4§, 5§, 6§/. For certain problems the paper will try to give direct answers in the form of computer programs /6§/, for others it is referred to the necessity of writing detailed account on the topics, two accounts of this kind appear in the volume of this paper. /P.Braun: On a human movement analyser. M. Havass: A simulation of the musical composition. Synthetically composed folk-music/.

Present and possible applications' fields are listed in 9§. Letters L, M, B identify which level of analysis is primarily required by the fields of applications.

Concerning the actual applications of the present research these are evidently restricted - as told above - to the categories L and M. Also in the middle range extensive applications have been hindered by the present lack of most of the automatic input-output devices proposed in 2§. /See also in the above noted paper of P. Braun/.

In the movement applications coded output similated choreographies produced up to now look promising. Music applications are given in a detailed exposition in the above cited paper of M. Havass. The folk-music composed synthetically is in the line of Kodály folk-songs. Results are fixed both on tape recorder and as music-scores. In the middle range, the most interesting results concern evaluations which give the degree of fitting of a musical recording for the rhythmic, dinamic and plastic structure of the dance for which it has been composed.

Of the possible applications beside those made realizable by applying large-scale methods with decisive help of basic analysis /in the contents indexed with B/ an inspiring one seems to be to investigate the subject in question as a function of cultural environment, e.g. to regard the dance--music interrelations in culture-sphere dependence /etnographical applications/.

Introduction

As indicated in the title, efforts are directed to incorporate the world of human movement into the variety of fields, treated effectively by cybernetical computerized methods.

The paper proposes to present an overall picture of the problems involved and introduces a new subject: the cybernetical analysis of human movements in general with the help of a computer system representation of movements and music. What is here lost in the detailed exposition of individual aspects for the sake of generality, will be made up for in separate papers. /The first two of which are [3] and [4]/.

Above all it seems necessary to clarify our working concepts and the contexts in which they are used and understood.

The subject to be treated is human movement, isolated on the one hand, but on the other hand, put into a real atmosphere so that its characteristics should come out most effectively: in time and space and in the focus of the phenomena bearing on it, like music and/or cultural environment.

The question here touched upon is quite a general one, namely, looking at things in an isolated way or in their interdependence.

Human behaviour for instance is investigated by psychology under isolated conditions in a laboratory, by sociology in the real time process in its social interactions. This was the reason why judgements of the same situation of both sciences were almost always contradictory until quite recently, when computers, introduced into the simulation of social processes /see the work done at M.I.T./ allowed the testing of the consequences of psychological laws experimented out in laboraties if acting in a real time process.

Applying the above categorization to movement analysis, the spectrum of possible ways of treatment can be subdivided in at least three parts.

1. Basic analysis: the laws to be investigated are those of one single movement /like e.g. taking a tea-spoon to the mouth/, as composed of its very elements.
2. Large-scale analysis begings exactly there where basic analysis has its end. At this level our instructions require from the body to go from one to another position in a way defined as standard. All the movements generated this way are regarded elementary and are not further investigated at this level.

The concretion of the movement-instructions /say: left arm right-before-high, elbow, hands, fingers in positions defined as normal/ is left for the human performer or if automised, then done according to the results of basic movemement analysis.

Large-scale analysis allows us to handle extensive movement sequences, like dances or whole choreographies, to analyse and simulate them on computer.

3. The analysis in the middle range.

There are cases when going into movement-elements is still not required, but standard movement instructions like those in a choreography-score do not say enough. This is e.g. the case when we want to formalize the characteristics of a modern dance /waltz, twist etc./ that has not so much different motives - at least if danced by an average performer -, but still performed in differenc ways for differenc music accompaniments.

The same categories can be distinguished in the case of music.

Basic analysis is done by the science of acoustics, by the research in simulating human voice on computers etc.

Large-scale analysis is done by traditional music-research and by most of the electronic simulations.

We might also speak here of an analysis of the middle-range, for illustration the same example can be used, as in the case of movement.

The aims of the present research

Although input and output means presented in the paper would allow it, and also the methods worked out for the mathematical systematization of information, in the research carried out till now it was not intended to do basic movement analysis, but the investigation was mainly concentrated on the large-scale analysis, going only into the middle-range when analysing dance and music interrelations in modern dances.

From the influencing factors the effects of music have been investigated. This necessitated in turn formalised music analysis and composition on the same levels as movement analysis has been done. The attention focused on movement relations naturally did not allow to apply known principles of this filed in an unaltered form. /See [4] /.

The authors are quite aware of the shortcoming of not doing basic analysis simultaneously, knowing that the results that might be expected of a common basic large-scale analysis are similar to those got by using psychological laws in sociological simulation.

One of the reasons of not doing this, that it was not possible for us to find access to good information sources presenting results existing in basic movement analysis and we should like to avoid repetitions or plagiarizing.

This lack of information refers also to the present actual existence of most of the input-output devices, listed in 2§ and 7§. Beside the work of development started by our technical experts, we only have information on the development done by the Bell Telephone Laboratories.

So most of the content of 2§ and 7§ should be regarded as propositions, that is, according to the opinion of the authors, solutions might be found by the methods enlisted. If any of the propositions has been realised already, we thank for any kind of information in this line.

It is hoped that by scientific collaboration in the future it will become possible to treat these aspects as well.

For the current and possible uses of the methods developed see paragraph 8.

2. Input means of the system

How to fix music and movements accessibly for the computer?*

a/ Input means for the music

Two basic ways can be thought of. One way is coding music scores. The method is well known in literature and it has been applied in the present work too.

Nevertheless, the fine structure music analysis required in exploring danse and music interrelations necessitates analog input in which case the style of the performing actor, the quality of the music instrumentation can be also taken into account.

One possible way of doing this, and also the solution actually chosen is the following:

a Level recorder Type 2305 /Brüel and Kjaer Ltd./ was used to generate plotted charts, which were then turned into digital data, apt for introduction into the computer. Firstly the analyser registers sound amplitude, but it is possible with the help of it also to select the sound amplitude curves of single frequencies, or that of the linear combinations of frequencies.

On the use of these data it will be reported in 3B§.

A third solution for introducing music information into the computer is to operate the keys of a piano on-line with the computer. Simultaneously with a note struck, a contact is closed and the computer will receive an impulse.

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* The computer actually used up to the present state of the research is an ELLIOTT 803/B.

Although implicitly understood, it has to be emphasized that in this paragraph the subject treated is only the means, i.e. how to fix information. The way is a very long and tedious one from the fixing of the information /say, the impulses above/ to the equivalent computer-representation of it. This is even true for what will be said in the next section.

b/ Input means for the movement

The ways of attack are essentially the same as in the case of music.

Here again one way is coding dance scores, that is kinetogramms.

As the most widespread and developed dance score system is the Kinetography Laban, this was chosen as the basis of coding efforts. Although this is the subject of the next paragraph, it may be well to point to the differences between music score and dance score interpretation at this stage of the discussion. The Kinetography Laban is essentially a stenography-type language of human movement, so a real translator is required for information retrieval purposes.

The fine structure analysis again necessitates analog input, because it is only in this way that the laws essentially governing human movement can be detected.

This argument is also supported by the fact that the kinetography method of denoting movement is a much more laborious process than that of writing music scores. There are several ways how this a analog input can be conceived, What is common to all the methods are the results: the vector-scalar functions, describing the movement of the relevant points of the human body in the three-dimensional space as a function of time.

In more common terms, let the relevant point be, the left knee. Then, as a result, the knee is determined at the points of time t_1, t_2. ... /e.g. 1. sec, 2. sec. .../. The coordinate series $x/t_1/$, $y/t_1/$, $z/t_1/$, $x/t_2/$, $y/t_2/$, $z/t_2/$,... giving the position of the knee in the 3-dimensional space at the consecutive points of time defines the space-curve, representing the movement of the knee.

Naturally, the same has to be done with the right knee, with the head, with the elbows, in short, with all the relevant points of the human body, selected so as to come nearer to a real representation of human movement.

If we now turn to the technical realisation of what has been set out so far, the problem to solve is to make "snapshots" in consecutive points of time of the positions of the body, so that the spearation of the various relevant points of the body could be carried out in a safe and automatic way.

The first possibility is to try a mechanical way of attack. This can be done by applying the principle of the marionette-theatres /puppets moved by fine wires/, only so to say, in a form "played back".

In a marionette show the vertical and horizontal movement of wires is turned into the very complex movement of the puppets' body, by wiring up a human dancer, the movement of the body will cause wire-movement at the support points of the wires.

We do not think that the scope of the present paper justifies going any deeper into the technical details. Anyhow, the sulůtion sketched above is perhaps a working model for the first tests, to register movement curves. A real solution must utilize the possibilities of modern techniques, so e.g. the registration with cameras, the evaluation of the coordinates of the points with the help of automatic photocell decoding etc. We only refer here to a paper by P.Braun giving a technically correct, easy-to-realise and economical solution for the problem of the automatic electronic movement analysis. /P. Braun: On a human movement analyser. Computational Lingusitics III. Budapest, 1964./

3. Information retrieval

A/ Representation in independent coordinates

What we have fixed so far with the help of our analog devices, or what we have got ready in the form of dance or music scores, it can be regarded from the point of view of computer treatment only as the raw material of the analysis to be carried out. This is so because analog registratums contain a lot of noise effects and do not directly represent the independent categories of dance and music. Dance and musucal scores on the other hand, have been developed as typical "paper and pencil" methods of registration, i.e. they employ as often as possible shorthand notations to save space. This can be done because the human reader reading these scores will automatically use his intelligence and fill out the gaps according to the meaning of the preceding symbols or on the basis of the overall situation. Computers again are only capable of accepting information if this has been reduced to a well defined standard form. This is why much preliminary work has to be done before real mathematical analysis can begin.

a/ System language to be developed for computer representation of movements and music

- Music

The problems cited above are not so acute in the case of music scores. Therefore this set of questions is not treated in any more detail here but it is referred to papers like [4].

- Movement

On the contrary, if we try to envisage the same problem as applied to human movement, we encounter a vast field of very complex problems. First of all it has to be said, that in this field very serious scientific work has already been accomplished and development is still in progress. We think here of the Kinetography Laban, a dance score system, used to fix dances, or movements in general, in a similar way to music registration with music scores. Naturally, this system is also developed for the human user, and therefore in the next paragraph it will be necessary to outline the possibilities of translation from kinetography language to standardised language. But at this point what we can utilize from this language is the systematization of human movements underlying kinetographical description. So the following principles of human movement classification are based on the directives employed in Kinetography. What we want to describe is the movement of the human body. Fortunately the human body is not quite elastic, but it is held ridig by bones, so the movement of the whole body can be characterised by describing the movement of a few relevant points. The number of the relevant points is about 16, the exact number has to be defined according to the level of research /basic, etc./ and is dependent on the budget.

The movement of one relevant point

As it is known in physics, a point moving in the three dimensional space is characterised by the time functions of its three coordinates, the time functions of the first derivatives and second derivatives of these coordinates. The second derivative is naturally proportional to the forces, acting upon it so it represents the dynamical factor.

The movement of several relevant points

According to what has been said above, the movement of the human body is characterised by several sets of functions, and in each set of functions we have the coordinate vector-scalar function and the first and second derivatives of the same.

Up to this point it is clear that from a purely mathematic-scientific point of view the movement of the human body has to be characterized in this fashion. It is all the more surprising that in Kinetography Laban, developed by art research scientists, principally the same mode of representation has been chosen.

Categories classifying the human movement

Naturally the above functions cannot be defined on a continuous set of time points, but a certain amount of contraction must be carried out.

- The rhytmics

The first contraction is executed in the independent variable that is in the time. Only those time points are denoted where something is taking place. The speed of the sequence of the relevant time points is defined by the tempo both in dance and music. The fluctuation and the relative distance of the selected time points defines the rhythmics of the phenomena investigated. The topic of rhytmics is concerned in itself only with the independent variable. So this means we cannot speak of a function. We can do this only, it we derive information from the other specifications of the dependent variables. In this way we come to a set of time-point samples whose structure is called rhytmics.

- The plastics

Mathematically by plastics is simply meant the definition of the vector-scalar coordinate time function in definite points of time. Plastics can be regarded also separately, and then it simply means the sequence of different space phases not taking account of the fact in which time points the "tableaus" are realised.

- How to describe a "tableau"?

If we put now the problem of the definition at a given time point of the situation of the human body by the means of its relevant points, the best solution again is basically to follow the solution chosen in the Kinetography Laban. This method of representation is a polar-coordinate representation. That is, first of all the "support" is specified, that is the part of the body carrying the weigth. /Let us suppose, for the sake of better visualization, that in our case the support is the left, or right foot, or both feet./ Secondly the place is specified, where the weight carrying part of the body is to be fixed at a given time point. This can be done with two items of data, say α and r relating the load point to the previous load point. /See Fig. 1./

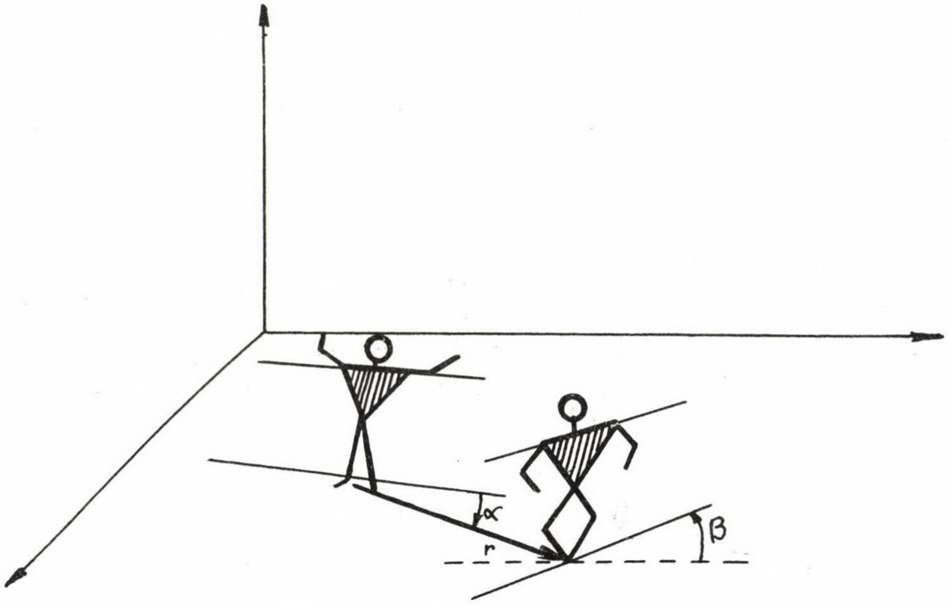

Fig. 1.

In the case, when at the given time point the whole body is in the air, that is a jump is being carried out the above specification is not required.

Secondly, if the load point is already defined, the direction-plane of the body has to be defined with a new angle. /See Fig. 1./

If the situation of the body is already defined approximatly, it is necessary to give the detailed relations in which the parts of the body are near to each other. If it is intended to enumerate only those configurations which are quite well distinguishable for the human eye, and which can play a decisive role in a choreography, if separated from all the other configurations, we come to an incredibly large number. /It is about $10^{30} - 10^{50}$/. This is the reason why human movement analysis is so very difficult and the reason that scientific research, classification, systematic dance scoring begun only a few decades ago. To see how this immense number of configurations are generated, let us examine as an example how the detailed position of one leg can be specified. /See Fig. 3./.

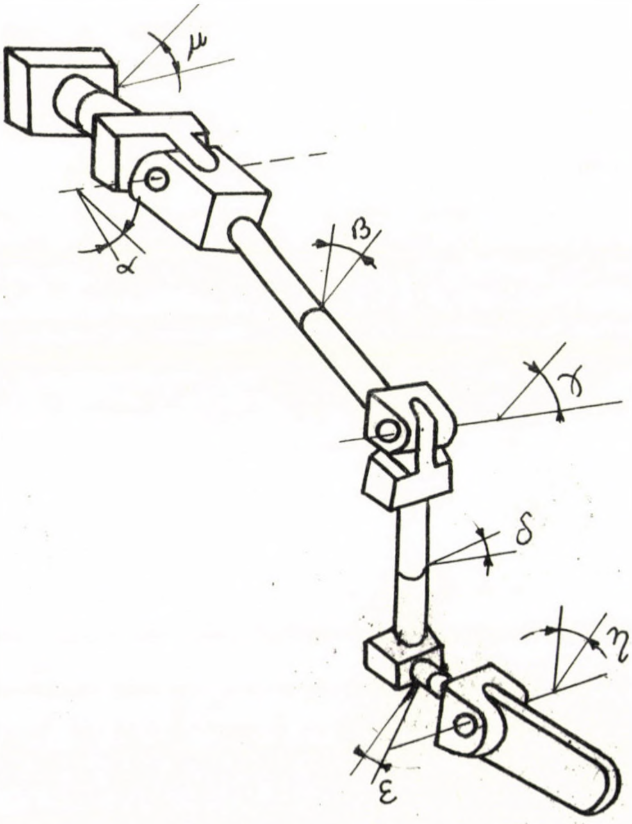

Fig. 2.

The 7 angles denoted on the figure define in an exact way the position of the leg, naturally with the additional information concerning the other leg, and with the information that the leg in question is carrying the full weight of the body or only part of it or nothing at all. Let us take for one angle say α, only 10-20 distinguishable values /and this has to be done because α specifies the directions in which the leg is swinging, but here not only the 9 basic directions can be distinguished by the human eye, i.e.: forward left, right etc. but also intermediate directions which may give the movement a very characteristic shape/. If we take into consideration that such a range of distinguishable values has to be assumed for all the other angles we immediately get a number of the magnitude 10^5-10^7, and this is only an enumeration of the configurations differing in one leg, but identical in all other respects. If we now add to the positions stated so far all other possible positions of the other leg, then we add to this the possible positions of the arms, of the head, of the trunk and so on, we reach in a very short time the number $10^{30} - 10^{50}$, mentioned above.

The method of using discrete angle values, demonstrated ind defining the positions of one leg is quite generally applicable to the definition of the all-detailed positions of the human body.

There is one remark to be added: because the above angles cannot be specified with infinite accuracy, therefore some redundant categories have to be introduced. Returning to the example of one leg, if all the angles would be given very accurately for both legs, then for the leg in question the touching point of the corresponding foot with the soil would be automatically defined. But as these angles are not given with infinite accuracy, there must be a new specifying parameter introduced, defining which part of the foot is touching the soil, or if it is not touching at all.

Enlarged with such new parameters, this system of angles is capable of defining the detailed position of the human body. To remind us once again, the overall definition of the position of the human body in a given time point is carried out with the help of one length data /giving the distance from the last load point/ and a set of angle data.

This way of representation can be regarded as a representation in independent categories suitable for computer-mathematical analysis.

/Better as, say, a representation in Descartes coordinates./

- The dynamics

If the categories introduced up-to-now had been represented by an infinite set of values for the independent time-variable and by an infinite set of corresponding function-values describing the positions, in this case /as in the case of vector-scalar functions defined in an interval/ the first and second derivatives could be derived according to the rules of mathematics.

But as in the given case the vector-scalar function can only be defined in discrete time points the exact shape of the curve is not yet specified.

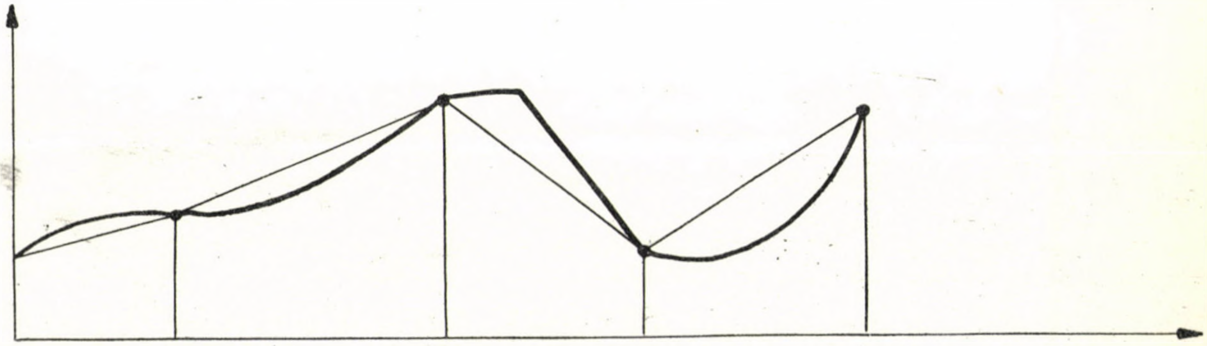

Fig. 3.

As the above figure shows it, through the given function-values there are many ways to draw curves going through these points. To determine the exact shape of the curve, therefor the value of the derivates are given in certain time-points.

With the help of the categories introduced now, using different combinations of data on the function and the derivatives, the vector-scalar curve can be determined according to any exactness required. It is up to us what measure of ecactitude we require. According to whether we are doing a large scale analysis, a basic analysis, or an analysis of the middle-range, this measure of exactitude will differ. For the large-scale analysis - at which level Kinetography Laban works, we shall be satisfied with determining the derivatives in some time points by the signs of dynamics. These dynamical signs refer mostly to the level of power on which the movement had to be carried out, so they define different values for the second derivative. Only in some cases are such specifications used like "swinging" which can be identified as a speed type, i.e. first derivative specification.

Again as in the case of the independent time variable and in the case of the positions we can isolate the dynamical element and regard only the fluctuation of the dynamical level of the movement independently of the time points in which the changes in the dynamical character are occurring. So we get a pure dynamical characterization of the movement.

We have seen also, that for human movements a mathematical systems' language can be worked out. We have shown too that it is possible to give this systems' language such a shape, that it is able to ensure a reasonable representation of human movements. The most important thing is that the general mathematical representation is cleared, and basically in all levels of movement analysis, if a representation is worked out this can be, and should be turned to this common mathematical systems' language. This makes possible a collaboration between the research carried out in the basic analysis in the large scale analysis and in the analysis of the middle-range.

To begin with this program, it will be reported next on the investigation, aimed to show how from the language Kinetography Laban, used in traditional large-scale analysis, translation could be done into the systems'language presented above.

b/ Translation from the language of Kinetography Laban to the systems' language

The basic importance of Kinetography language in human movement representation has already been pointed out. This language has very interesting syntactical properties which on the one hand really fascinate the scientist specialising in computer languages, but on the other hand they make the task of restoring the information in the original form a rather difficult problem. This is so because Kinetography is a stenography-type language, i.e. firstly, only that is denoted which is absolutely necessary and cannot be deduced from the preceding symbols of the kinetogramm, secondly several abbreviation rules are introduced in building up the syntax.

To mention just one thing, to a scientist familiar with computer languages, the notion of prefix is well-known/ e.g. as used to determine print formates/. In computer languages there is in most cases a distinction between global and local prefixes. Global prefixes have as their scope of action for instance all the print instructions up to the next global prefix specifying instruction. A local prefix has for its scope of action only that instruction, in which it is declared. Now Kinetography is working not only with local and global prefixes, but there is a whole range of prefix action levels, leading up from the local to the global level. So the scope of a prefix might be only one instruction, or two or more instructions until the effect of the prefix is cancelled by another instruction; cancelling might be again conditional; and there are at last prefixes which are valid unconditionally for the whole dance score.

ALGOL 60 programm to demonstrate kinetogram translation

The writing of a complete kinetogram-translator is planned for the near future. Moreover it would require a paper, in itself. We must here restrict ourselves to present a partial solution of the problem. This solution does the translation only for an oversimplified movement, or rather the translation of a certain phenomenon connected with every movement. This phenomenon is the changing of the support. Let us suppose that the weight of the body is placed during the whole time of observation on at least one leg, and in the kinetogramm to be analysed we registered in the form of instructions only which leg /or both legs/ the weight of the body has to be put on.

We suppose also for the sake of simplicity that the legs are in the "normal" position throughout the process, the only change is in the transfer of the weight from one leg to the other, or from one leg to both legs, or from both legs to one leg.

The way how instructions in Kinetography are understood, and the basic line-system is illustrated in Fig. 4.

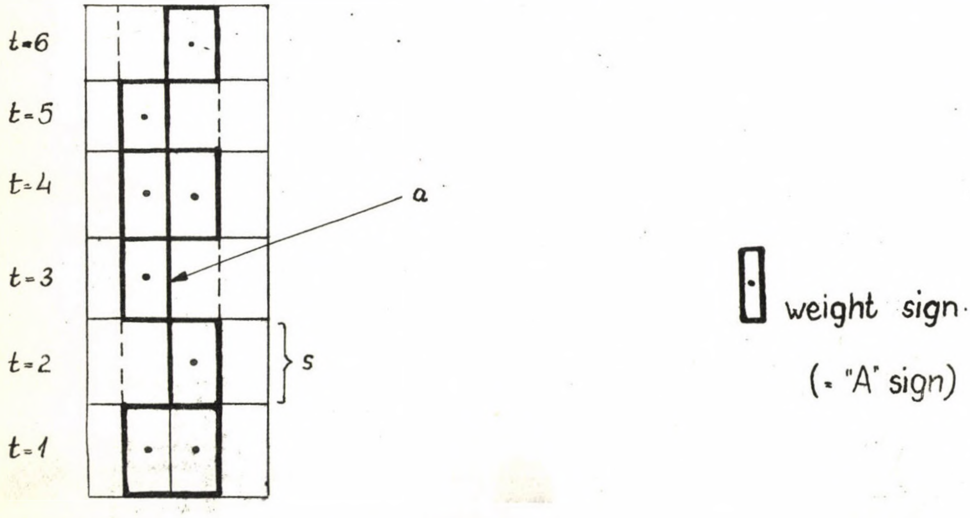

Fig.4.

The line denoted by a/ is called the weight-line. Beside this line are in general all the signs specifying the positions of the part of the body carrying the weight. In our case this is always a leg, and in normal position so we only have one sign denoted by ⊡ .

A horizontal segment like that denoted by S represents one time point. The signs appearing in this range define the position of the body at this time point. For the moment the only sign that can appear in one horizontal segment is the normal weight sign. In further we refer to it as A.

The meaning of A: if the sign A appears in one segment at a given side of the weight-line, then in that time phase the leg corresponding to the given side will carry the weight. The sign A does not specify in itself, whether the leg in question in the given time phase will carry a full weight or only a part of the weight. If in the rubrics beside the sign A there is an A, it means that both legs carry each a half weight. If in the rubrics beside a rubrics containing A no sign appears, this means that the full weight is carried by that leg where the sign A appears.

Here we see immedately that even in this very simple case the sign A does not determine in itself what the weight condition of the legs is. This is only a result of a certain logical procedure. Naturally if a situation like that represented in Fig.4. is seen by a human observer, then this analysis is carried out immediately, the human observer does not even realise thet he has made an analyis. On the other hand, if we want to make this procedure with a computer so these relations have to be made explicit.

We have made this little excursion in order to clarify the situation in the foregoing simple case because now we have to deal with a more complex situation introducing one more sign used in Kinetography, and this is the ○ /pause mark/.

The meaning of the pause sign: for the rubrics in which the pause sign is situated it has the same meaning as sign A. But the pause sign has also a transient effect. For simplicity sake we denote in the following the situation that one rubric is left empty by saying that in this rubric a blank sign has been written. Using this new definition, the pause sign is lending to every blank rubric after it /immediately after the pause sign or separated only by a blank series/ the same meaning as if it contained A. This is true with one exception: if the blank series leading to the blank in question has at one point a neighbouring A then the meaning of that blank and also of the following blanks becomes "0 weight". The last specification of the pause sign is: that it does not transfer a blank rubric in the zero weight status, but it also not lends him a positive weight. It is supposed also that the natural status of a blank rubric is a zero weight.

The pause sign has been introduced in Kinetography to economise pencil work and perhaps to give the human eve a better picture of the situation. For illustration we present in Fig.5. and Fig.6. the same kinetogramm, in Fig. 5. without the pause sign, in Fig.6.

If a human observer is evaluating such a kinetogramm like that represented in Fig.6. he finds in the kinetogramm three different signs, i.e. A, the pause sign and the blank. Only in this case it is much truer than in the foregoing case that a sign in itself does not allow immediately inferences about the weight situation of the leg in that given time point to which the sign observed relates. This can be best demonstrated by the possible meanings of the blanks. If we evaluate the kinetogramm in Fig.6., according to the rules given above, e.g. the blank in the time point 5, left, has the meaning: place half weight on the left leg in time point 5. The blank in time phase 11, left, has the meaning: place zero weight on the left leg in time phase 11. The blank in time phase 8, right, has the meaning: place full weight on the right leg in time phase 8.

We should like to get all this evaluation done by the computer, so that introducing the kinetogramm by coding the sequence of the A, pause sign and blank symbols the machine should be able to determine the actual weight situation in the time phases and then work with these data.

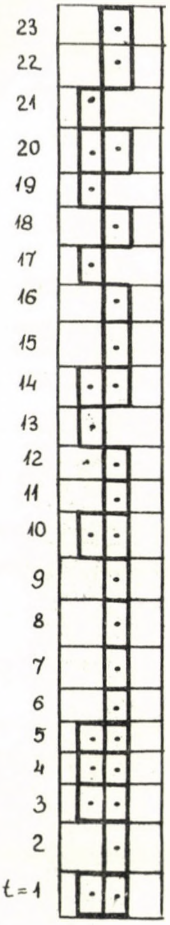

Fig. 5.

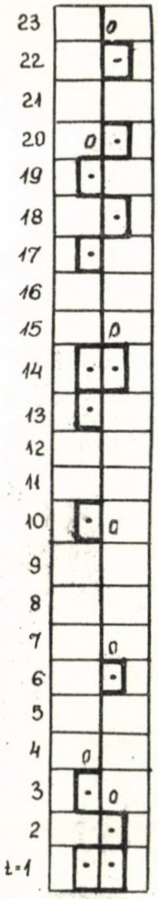

Fig. 6.

The ALGOL 60 program to be described next does exactly this. The input for the program are the codes chosen for the symbols A, pause sign and blank; or better to say the kinetogramm coded. The output of the program is the same kinetogramm only with a notation that immediately expresses the weight situation for the left and the right legs in the consecutive time phases. The codes employed are:

0- zero weight
0,5 -half weight
1 - full weight

In the program C1 denotes the code chosen for the blank, C2 the code chosen for A, C3 the code chosen for the pause sign. "E" is a small positive number.

The program is written according to the ALGOL 60 syntax plus READ and PRINT instructions, so that it can can be immediately run on computers with an ALGOL translator.

```
BEGIN INTEGER K,N, I, C1, C2, C3; SWITCH  S:= L1, L2, L3;
      REAL E,X,Y;                 INTEGER ARRAY A [1:1000,1:2] ;
      REAL ARRAY W [1:1000, 1:2] ;
      READ C1, C2, C3, E, N;
      FOR I:= STEP 1 UNTIL  N DO READ A [I,L],  A[I,2];
      FOR I:= 1 STEP  1  UNTIL N  DO
BEGIN FOR K:= 1,2 DO
BEGIN IF ¬A [I,K]= C1 THEN BEGIN X[K] : = E; Go TO L1 END
L2: IF A [I, IF K=1 THEN 2 ELSE 1]  = C2 THEN BEGIN X[K] :=0;
           GO TO L1 END
    IF A [I-1, K]= C3 THEN BEGIN X[K] : = E; GO TO L1 END
    IF A [I-1, 1]= C2 THEN BEGIN X[K] := 0; GO TO L1 END
          I :=I  - 1;
          GO TO L2;
L1: END  LOOP K;
    IF ¬X  [1]>0 THEN BEGIN W[I,1] := 0; W[I,2] := 1; GO TO L3 END
    IF  X  [2]>0 THEN BEGIN W[I,L]:=.5; W[I,2]:=.5; GO TO L3 END
                                        W[I,1] := 1; W I,2  := 0;
L3: END LOOP I;
       FOR  I: = 1 STEP 1 UNTIL N DO
                        PRINT W  [I, 1] , W[I,2]
    END
```

c/ <u>Pattern recognition of the analog registered movements and notes. Learning programs</u>

We refer to the paragraph entitled "Input means" where possibilities have been described ot the input of music and movement into the computer different from that of using music or dance scores. In all these cases the information is exposed to a continuously variable distortion that must be restored. The problem is essentially the same as that encountered when it is tried to automize the reading of hand written texts or printed texts. There is already an extensive literature dealing with this question and equipments have been developed with corresponding computer programs successfully solving this problem. There are also machines in operation wich do automatic letter-sorting in some post offices.

In this respect music and movement can be dealt with togather. If we regard the question from this point of view, the problems can be divided in two groups.

Pattern recognition of curves

Here the task is to select the accidental fluctuations from the curves. This can be done by applying correlation methods or other methods known in literature.

Pattern recognition of discrete signals

Such a problem arises e.g. when as in one of our experiments, a specially designed piano is on line operated with a computer. When a key of the piano is pressed, a circuit is closed for the duration of the key being touched, and this is registered by the computer. Now if the player is to play a crotchet then depending on the character of the actual stimulation etc. of the player, he will press down the key for a longer or shorter period of time. In fact, the time during which the key is pressed down is not in itself characteristic of the note to be played, because this is only determined by the overall situation, by the tempo, by the neighbouring notes, etc. The computer has the task also from the single data of the time of the key being pressed to infer on the real value of the note that has been intended to produce.

The first experiments have been done by analysing signals generated by a telegraph contact. The situation here is really simple, because the sign series consists of only two signs: the " - " and the " -- ". Naturally the " - " and the " -- " of different telegraphists differ in their time value to considerable extent. Now if we want to have an automatic evaluation of these telegraph impulses, a program must be written that learns the style of a given telegraphist on the basis of a certain number of signals for which it is also communicated with the machine what the meaning of the signal is. /A "-" or "--"/. After such a learning period the computer will be capable of analysing the later impulses and identify their meaning unless the style of the telegraphist is completely altered, which case can be ruled out.

The simple version of the pattern recognition of telegraph impulses has been dealt with only because it gives a very good illustration of the more complex case of evaluating on line operated piano impulses, and also made it possible to explain the principle of computer learning, which cannot be treated in detail for the more complex cases in the scope of the present paper.

B/ Derivation of the effect curve. Metrics to be introduced in the vector spaces of dance and music characteristics

To begin with, we have to stop for a moment to point out the necessity of introducing a concept like metrics in describing artistic phenomena.

If, for example the question to be investigated is to define the structure, the internal and external relations of a poliphonic music, then the basis on which all the decisions had to be done is the overall effect of all the voices together. That is, in reality the human listener, or in the case of dance, the human observer does not enjoy the single voices in the music or in the choreography separately but the voices give a summarized impression, and this forms the basis of the esthetic judgment of the piece in question. The problem is now that if we are incapable of following the very elaborate and stochastic laws governing this process of summing up different voices we are also incapable of getting a real insight in the structure of the piece to be investigated.

In order to explain the problem in a more mathematical way, let us suppose that we are dealing with only three voices and the identifiers of the status of the phenomenon in different time points are given by three dimensional vectors, whose origin is at the origo. Let us suppose further that the metrics valid in this case is simply the normal distance metrics usually introduced in three dimensional spaces.

The third supposition is that the effect of the vector components is expressed by the distance of the point specified by the three vector components from the origo, that is by the length of the three-dimensional vector.

Now if the characteristics of the piece in question is, as it is shown in Fig. 7. below, then it can be clearly seen, that the piece to be analyzed is a well-structured composition if regarded in its metrics. We see that a very definite fluctuation can be pointed out, also that the small fluctuations have a definite tendency and this is leading to greater, identifiable units.

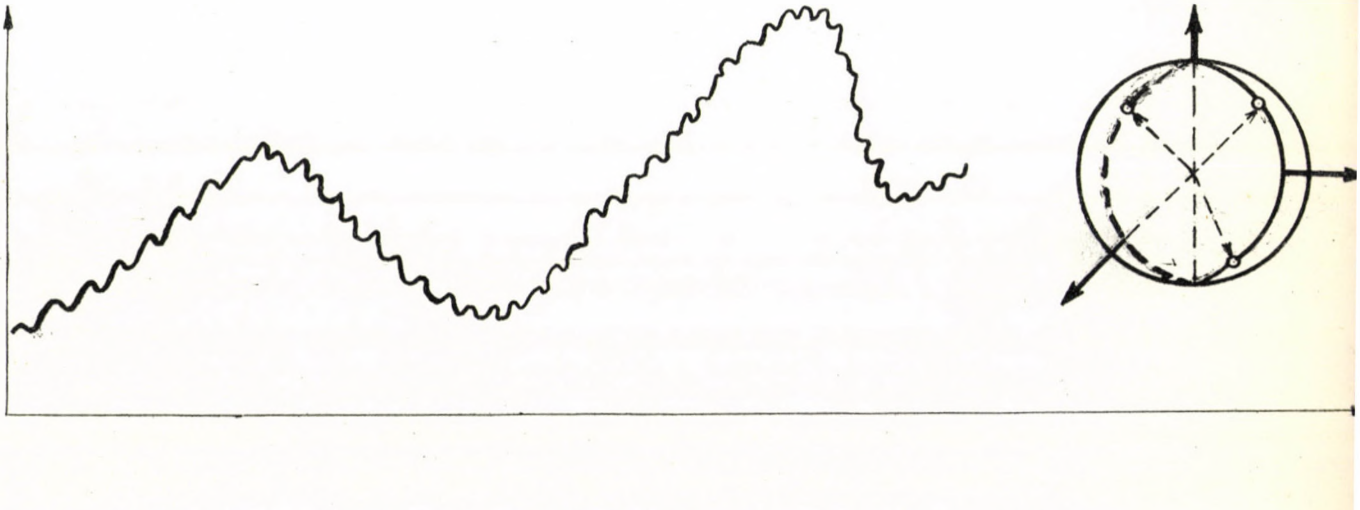

Fig. 7.

On the contrary, if we regerd not the length of the vectors but the consecutive sets of the coordinate triples defining the actual situation in every time point, we do not get any laws because e.g. the vectors having length 1 /the unit vectors/ are having in all their occurrences different coordinate triple realization. This is much truer if we have to deal with coordinate n-tuples where the same distance value may have even more basically different realizations than in the case of three dimensions.

a/ Music

Naturally, the realisation of the program, set out in the last paragraph, is a very hard task. In a certain sense some aspects of the problem can be solved more simply for music than for movement.

A start can be made using the analog music analyser described in the pragraph "Input means for the music". This device is capable of not only registering the amplitude curve of one single frequency but also of registering the compiled effect of the amplitude-curves of different frequencies. Moreover, the relative level on which a certain frequency is compiled into the effect-curve can be set also. So we were able to apply the results obtained by the psychology of hearing plus our own experiments with musically sensitive individuals to get to such a setting of the Level Recorder, that roughly the following can be said.

The setting is such that higher frequencies are compiled with an amplitude on a lower level. The setting has been formed in such a way that this norming of the different frequencies resulted in giving roughly constant curve for a voice effect /with decreasing amplitude and increasing frequency/ experienced as monotone by the human listener. This means, on the other hand, that - under certain limitations of course - we have succeeded to define the unit of a metrics defined upon the two -dimensional vector space of the sound-volume and of the pitch. This made it possible to carry out the mathematical analysis /to be presented in the next paragraph/ on such curves also.

Naturally, the situation is not so simple if the sum-effect is put together by different music intruments, i.e. the number of coordinates is higher than two. This is even truer if the question investigated is human movement or choreography together with musical accompaniment.

b/ Movement, choreography

The problem handled in the previous section becomes very hard to solve,in the case of structured phenomena belonging in the sphere of human movement. This is so, because, as pointed out in the paragraph dealing with the canonical representation of movement, the moving of one single person can be compared only with the play of a whole orchestra. All parts of the body, the arms, the legs, the trunk, the head-may play their own voice and every voice may have different rhytmic plastic and dynamic characteristics. Even if we take a very fine time series, so that all the relevant events at any of the significant parts of the body fall in a registered time-point of the time-coordinate, even then we have to sum up the effect of the single coordinates of a 2xn coordinate vector. Here n is the number of the parts of the body playing a relevant role in the choreography in question, the factor 2 means that every relevant point in every instance is characterized by its position /plastics/ and by its acceleration /dynamics/.

The aim of the present research is to develop results in this field. A promising method tested recently is to make an empirical start: that is we do not presuppose any function or metrics in the 2 x n dimensional vector space of movement but the analysis /to be presented in the next paragraph/ is carried out on the 2n-tuples of coordinates. Then a statistical evaluation is made for the purpose of determining, which 2n-tuples are interchangeable if we neglect certain small differences. Also the structural cuts are accepted to a certain degree made by human dance and music analysers. All this together enables us to state regularities, which is promising from the point of view of achieving a working system of metrics in this more complex case also.

4. Mathematical analysis

Mathematical analysis can start when the information is given in a form, in which the original meaning is restored, and the information gives a fairly good representation of the phenomena to be analysed.

a/ Markov analysis

One-level and selected multi-level analysis

The method of Markov-analysis is a well-known statistical procedure to determine stochastic laws underlying different processes. The theory of the Markov analysis is only referred to: see [7].

It is worthwile remarking that the Markov analysis as a mathematical method is very flexible one to describe phenomena which at first sight might appear greatly divergent. Such a divergence lies between unisonous folk-music and polyphonic music. Markov analysis deals with the relative occurences of identifiers. From this point of view, the only difference between unisonous or polyphonic phenomena is that the single states are identified in the first case by a vector of characteristics, in the second case by a hypervector composed of the identifying vectors of the single voices. But from the point of view of analysis a hypervector can be regarded as a normal one, only having more coordinates.

The question is also a practical one, namely that of space requirement in the computer memory. From this point of view, the analysis of polyphonic music or dance is of course, more difficult.

Now we have to explain what the expression "selected multi-level analysis" is undersood to mean. In the case of the one-level analysis we are satisfied by setting up a probability matrix, where the columns give the probability distribution of havin an element after a certain element preceding it. Such an analysis is insufficient in the most cases, because we have to take into account the transient effect of certain notes or movements in a composition, not to speak of the deeper structural interdependences of compositions. This clearly necessitates a multi-level analysis, that is we have to ask also what the probability distribution of the next following elements after an "ab" or a "cdb" identifier-configuration is.

This is the point where the necessity of some selection becomes evident. Because in case we work only with 10 identifiers /say 10 musical notes/ and we want to make a 5-level analysis, then we have to put into the computer memory a matrix having 10^5 columns, in each column figuring 10 numbers, defining the probability distribution for the next-following element on a "bcdaf" type series. Now, as we have to work simultaneously with all this information, this would necessitate a computer core memory with 10^6 locations.

This shows clearly that without any contraction even in a very limited analysis the multi-level method leads to impossible computer memory requirements. This is the reason why the selected multi-level analysis has to be introduced. In this form of analysis, processing the information with the help of computer learning principles, we select which identifier series have a different probability distribution for the next-following element, and only such distritubions are separately registered. All the other events are summed up in a common case, and are assigned only one column, i.e. one probability distribution.

Although the program of this selected analysis cannot be published here, the ALGOL 60 program of computer composition presented in paragraph 6 works with such probability matrixes, and this program shows also how e.g. for an ancestor combination given by the identifying numbers I [1], I[2], I[3] that column of the probability matrix is searched out in the run of composition, which contains the probability vector attached to the sequence I[1], I[2], I[3] /which probability vector may be attached also to several other identifier triples, which have been experienced in the analysis to have a fairly similar following-next-element-distribution/.

b/ Structural analysis via computing correlation functions

This method is called for mainly by practical considerations. From a strictly theoretical point of view the Markov analysis is always applicable, if we think on it in the multi-level form. Problems arise again from the point of view of impermissible computer memory requirements if we want to start with the analysis of larger structural units.

If we suppose that we are working with a uniform quantity /unisonous or the effect-curve of a polyphonic phenomenon/, then this quantity can be represented in time-dependence as a normal single-valued function. The figure below shows a function of this kind.

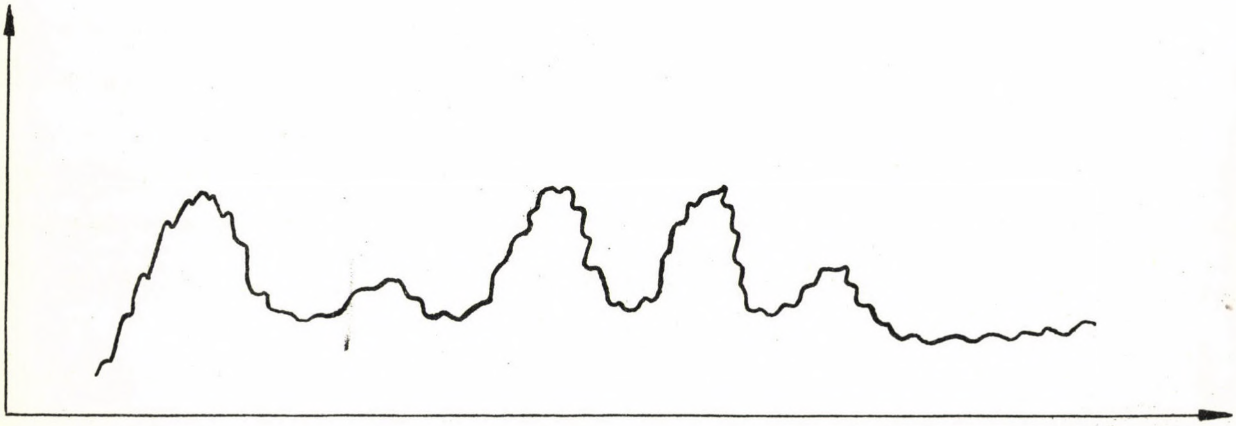

Fig. 8.

If we consider the pattern of the function presented in the figure, then even looking at it we can state two sorts of regularities. Firstly, there is a fluctuation regularly repeated at every interval of three phases. These small curve-pieces have the same shape, only they are put in slightly different positions. Secondly, the small curve-pieces are ordered in such a way that in the end a larger fluctuation is generated. This situation corresponds to the structure of musical or dance compositions, where first from small motives by varying them larger units, so motive -rows, themes, are built. These larger units have clearly distinguishabel patterns, and may again figure as the building elements of even larger units. Our figure shows only two levels.

Now if we make a Markov analysis on the motives figuring at the first level, and work with the multilevel method /this allows for the reasons explained before, a maximal depth of 5-10 lags/ so we get probability vectors describing the transition-probabilities taking into account a few preceding elements. On the other hand, if we have a look at the simple situation demonstrated in Fig.8., we see that there are quite different transition-laws valid in the occurences of one larger unit, and quite different transition laws working in the occurences of the other larger unit.

Our aim in the end is to be able to simulate the phenomena investigated. This can be done only, if we can tell in advance, which transition law is valid for an element in any position.

Looking at the possibility, that the same element might occur in the first and in the second larger structural unit, we could distinguish between the two cases /from the point of view, that which transition probability matrix is valid/ only, if the position of the element could be characterised up to the point saying in which larger unit it is contained. That means, that we had to go back in the multi-level Markov analysis so far, that we should reach the beginning of the foregoing larger structural unit, and so identify the role of our element from this point of view as well. For the reasons mentioned this method is inadmissible.

There are also other problems. If we make a Markov-analysis in such depth we get too definite report of the compositions analysed. This has the effect that beginning a computer composition we start immediately in plagiarizing the original compositions.

All these problems are avoided by using correlation techniques. With the help of correlation techniques it can be determined which curve-segments occur regularly, wich larger units compose themselves of smaller part-curves in an identical or slightly varied form. Also the correlation coefficient informs us whether this repetition is an identical one or not /correlation coefficient equals 1/ or what degree of freedom /correlation coefficient is less than 1/, we have to do with.

The organization of the computation for the analysis of a given curve is the following. The curve is defined as a consecution of function values in consecutive time-points. Now the basic step of the computation is that an n-element set of neighbouring abscissa-points is chosen /n going from 2 to a reasonable large number, approximately less or equal than the half of all the abscissa-points/, and all the correlation coefficients are computed among the curve-parts which have as their domain of definition an n-tuple of consecutive abscissa-points. So we come to a very great set of correlation coefficients. It is the task of an ordering program to determine which correlation coefficients, or sets of such coefficients, are near to 1.

With this method e.g. the structural construction of the composition whose representation is supposed to be the curve presented in Fig.8., can be clearly analysed. We have to get for all n-tuples corresponding to the small fluctuation curve-part a correlation coefficient 1, and also we get near to 1 correlation coefficient for the repeated larger unit. The method, explained with the help of a concrete example is naturally a quite generally applicable one.

Statistical verification of a priori motive types: combined man-machine analysis

An application of the above method just expounded is to test traditional methods applied to structurally reduce compositions to certain schemes in music and dance research. If the methods explained above are put to work, so the only thing that has to be tested is, that the structural decomposition done by the human analyst do correspond to the structural decompositon got by the correlation analysis or not. If the answer is negative, it can be investi ated again if perhaps in the case of the music piece or dance analysed the application of the applied cutting principles /cadence, stress etc./ cannot be justified, or perhaps in generating those curves, on which the correlation analysis has been carried out was not done correctly. This dual procedure has shown itself to be convergent, and very fruitful for both traditional and computerized art research.

c/ Reduction to given motive-types with generalized linear programming

One of the main tasks of every music and dance research is to reduce the given piece to certain standard elements, which together with their varied forms constitute the composition in question.

The only problem is that this decomposition is not unique. Moreover the number of possibilities to choose the basic standard elements /called motives/ is so great, that human analysts must always stop at a possible representation and cannot go ahead to find a representation which could be called a satisfying one.

The reason why linear methods can be applied is that all the varied forms between two standard motives can be generated from the two extremes, by mixing the two extreme motives in different proportions. As the standard motives as well the one which has to be reduced are represented by vectors, and as the only difference between the two extreme motives is a quantitative one /e.g. the bending of the knees in different degrees, this linear mixing of the extremes is justified.

The generalized linear programming problem

The problem of generalized linear programming can be formulated as follows. /For reference see [6]./

$$\max \left\{ c_1 x_1 + \dots + c_n x_n \right\}$$

$$\underline{a}_1 x_1 + \dots + \underline{a}_n x_n = \underline{b}$$

$$x_i \geq 0 \qquad \underline{a}_i \in B_i$$

$$i = 1, \dots, n$$

As can be seen from the formulae, the difference between the standard and the generalised linear programming is, that in the latter the vectors $\underline{a}_i$ are not constants, but they might be any of the vectors of the convex polyhedra B_i . Such a problem may be solved with the decomposition algorithm of Wolfe.

How to apply generalised linear programming for our purpose?

To apply the above method in our case is further simplified by the fact, that the convex polyhedra are given with their generating elements. These generating elements here are nothing else but the groups of motives of which we want to choose those motives which are able to generate a representation of the composition in question.

We generate first the convex polyhedra by grouping those motives together which have only quantitative differences among them. Such a group together with their convex linear combinations spans out a convex polyhedron. The task now is the following: If we take the parts of the composition one after the other /the coordinates defining one part are identical in number with the number of coordinates of the motives/, we have to find such elements $\underline{a}_i$ in the polyhedra B_i and such x_i that if we denote the composition part-vector by $\underline{b}$ it is true that

$$\underline{b} = \underline{a}_1 x_1 + \ldots + \underline{a}_n x_n, \ x_1 + \ldots + x_n = 1, \ x_i \geq 0 \ i = 1, \ldots, n$$

The second condition is necessary to ensure that the composition part $\underline{b}$ is really a mixing of the motives generating the polyhedra B_i.

By choosing the coordinates of the functional in different ways, that is solving the problem with different c_i-s it can be attained that motives of different groups will predominate in the representation.

5. Dance and music interrelations

The interrelations between danca and music, in folk dances, in modern dances, short, in all the cases where rhythmic movement appears together with rhythmic music, are instinctively clear for everybody. The aim of the present investigation is to find formal methods how this fact could be followed up with the means of mathematical analysis.

This investigation will be carried out partly in the domain of large-scale analysis, because, especially in the case of artistic compositions, the interrelations are very definite /cuts are at the same time points, the dynamical character is coordinated or, on the contrary, it is composed antipodically./.

But, if we want to do the same analysis for free-style dances, like folk dances or modern dances /waltz, tango etc./ where the rules are more or less statistical, we have to employ the analysis of the middle range, and work with analog registered music curves and with analog registered movements, or, at least with a more detailed movement representation than is required for specifying standard movements.

If a representation is given, whether in a notation of the large-scale analysis, or in the notation of the middle-

-range one, comparative mathematical-statistical evaluation can be given. Here, in principle, all the methods are applicable that have been presented in paragraph.4. The important thing is that if we want to make a Markov analysis, the identifier describing a time point is given by a vector containing coordinates describing both the music and the dance situation. Similarly, in a correlation analysis the curves describing the movement phenomena have to be compared with the curves of the music.

The tools for the mathematical analysis being specified,it may be asked, in which respect an interrelation is sought for between movement and music.

A rather simple investigation may have the aim that only the relevant time point distributions are compared for movement and music. Such a simple investigation will give valuable information concerning the adaptation of both fields, because in some cases there will be close rhythmic connection experienced, in other cases, the connection will be looser.

A more complex investigation has for its object to find out the probability distributions describing the appearance of constituent identifiers in a periodically repeated motive. This situation of fairly similar repeated cycles is especially characteristic of modern dances like waltz, twist, etc. It can than be asked, what is the functional correspondence between the probability distributions describing the dance part on the one hand, the music part on the other. The question is an interesting one even from a mathematical point of view because it is about functions having as domain of definitions, probability distributions and as domain of function values also probability distributions.

The detailed explanation of the regularities experianced would require a paper all to itself. It should only be noted here that on the basis of this function, mapping probability distributions into probability distributions, and that is independent of the dance type analysed /if we restrict ourselves to modern dances/ distinctions can be made between music pieces which are in accordance with the character of the dance and those which are not. So in this sense we get exact criteria to judge it e.g. a dance-music recording composed for a new dance is "good" or "bed". Short, from the point of view of dance relations we got a new viewpont that can be used in the comparative evaluation of dance music.

The larger structural interdependence of dance and music, as it is experienced in balletts, can also be investigated with mathematical methods. The rules analysed in this way may offer possibilities for a combined musical-choreographical electronic simulation. The principal thing is, that the rules must already be analysed, and the probability distribution of the identifying vectors of dance and/or music must be given. In this case the computer program to be presented next of electronic composition may be used to simulate music or dance, or to create a piece of music to a given choreography or a choreography to a given piece of music or to make both in a parallel way according to how the identifyers and the probability-transition matrices are specified.

6. Electronic composition of dance and music

To be able to begin with the computer composition - with all the reservations mentioned at the corresponding point of the 9§ - we have to have already analysed the set of laws underlying the creative activity of the given type that we want to simulate.

As the laws analysed will be almost exclusively of a non-deterministic character it is of decisive importance to find the methods how to simulate this.

Random number generator

The methods generally applied to simulate probabilitistic phenomena work with computer programmed random number generator.

We cannot go into the detailed description of the random number generator applied in our music and dance simulation. It can only be remarked, that it works with the congruence principle, and consists of 3 machine code instructions. For further information, see [7] and [4].

ALGOL 60 program of computer composition

The program works in several variants, as it can utilise the results of both a one-level and a multilevel Markov analysis. The program has been written with the finiteness of machine memories in mind therefore the probability vectors obtained in a multi-level Markov analysis are contracted in a suitable way. The representation of the input information with probability vectors contains as a special case the situation, when definite laws can be programmed. This simply means that certain probabilities become 1.

The input of the programm are motives. A special case of a motive is when it coincides with an identifyer describing one time point. /One movement phase or one musical note/. In general, the motives contain more phases, the numerical code contains more rows - according to what was determined in the previous analysis.

The rules of data presentation are flexible: several groups, each containing motives with different specifications /different number of rows, different number of digits specifying a row/ are allowed as input.

For illustration, a possible motive data-sheet is given:

```
      3
      3
  2       7
0 1 3 4 0 1 2
1 0 1 1 3 4 2
.
2 1 0 0 0 1 2
0 3 4 1 2 0 1
```

```
     3  1  2  1  0  3  1
     1  0  1  2  0  2  0
              2

        4           5
        1  0  2  7  5
        7  5  0  0  0
        0  3  0  1  1
        1  1  1  2  0

        7  0  0  3  1
        1  1  0  2  0
        0  3  0  1  1
        1  4  0  2  2
              1
           3     14
1 2 3 7 4 5 2 0 1 2 4 5 6 0
0 0 2 1 2 3 0 1 2 0 1 0 1 3
```

/The single numbers before the arrays serve to organise input/. For input it is also required to spedify the motive /or the hypotethical motive series/ to begin with.

The two possible ways of using the program are determined by the value of the input switch parameter: z = 0 one-level version, z = 1 multi-level version.

The transition-probability vectors from one motive to the others have to be introduced into the computer as data as well. In the multi-level case it must also be given the ancestor configuration, by which probability vectors should be used. For the more complicated case a sample input-format is shown below:

0	0	0	1	0	3	3. ancestor
0	1	2	2	4	4	2. ancestor
1	1	1	1	1	1	1. ancestor
.2	.1	0	0	0	0	1.
.3	.1	0	0	.1	0	2.
.1	0	0	0	0	0	3. motive No.
0	0	1	.7	.8	1	4.
0	.5	0	.3	.1	0	5.
.4	.3	0	0	0	0	6.

E.g. the meaning of the encircled element: .7 is the probability that a consecution of the motives 1 2 1 should be followed by motive 4. /Motives are numbered in the order of their input/.

Concerning the algorithm see the ALGOL 60 program itself.

The output of the program is a composition, that is a series of motives printed one after another.

The procedure RAND is a machine code block, generating random numbers in uniform distribution in the [0,1] interval.

The meaning of the basic cycle-limit variables:

M - the number of motives input
Q - lag-number in the multi-level case
N - the number of probability vectors

The program is written basically in ALGOL 60, but provided with READ and PRINT, and also formulated with single index variables, to facilitate machine adaptation for more simple computer languages too.

```
BEGIN INTEGER  Z, F, Q, I, C, N, N1, I,L, M, P, X, W1, S, R,K;
      REAL V;
      INTEGER ARRAY I [1:5] , L, M, P [1:50], X [1:500],
                                      A [1:7500];
      REAL ARRAY  P [1:50],  G[1:5000];
      SWITCH  Y : = U2, U3, U4, U5, U6, U7, U10, U12, U13;
      PROCEDURE RANDCM;
READ Z;
READ F;
IF Z = 0 THEN BEGIN I: = F; GO TO U4 END
READ Q;
FOR I : = 1 STEP 1 UNTIL  Q  DO READ I [J] ;
U4 : READ N;
     READ M;
     FOR I := 1 STEP 1 UNTIL  N  DO
     BEGIN
           IF Z = 0 THEN GO TO U5;
           FOR J  : = 1 STEP 1 UNTIL Q DO READ X  (I-1) XO+J ;
           U5: READ P [1];
           G [(I - 1) XM + I ] : = P[1]·
           FOR  J : = 2  STEP 1 UNTIL M  DO
     BEGIN READ  P [J];
           G [(I-1) XM+J] : = G[ (I-1) XM + J - 1] + P [J]
       END
     END

L: = 0;
W1 : = 0;
C : = 0;
READ S;
FOR R : = 1 STEP 1 UNTIL S  DO

BEGIN
          READ N 1
          READ M;
          READ P;
          FOR T: = 1 STEP L UNTIL N1 DO
```

```
          BEGIN
               C : = C+1;
               L C : = L;
               M C : = M;
               P C : = P;
              FOR J : = 1 STEP  1 UNTIL M [C] DO
              FOR K : = 1 STEP  1 UNTIL P [C] DO
              BEGIN L = L+1; READ  A [L]  END
          END
END

U3  : L : = 0;
      FOR J : = 1 STEP L UNTIL M [F]  DO
      FOR K : = 1 STEP 1 UNTIL P [F]  DO BEGIN L:=L+1;
                                         PRINT A [L [F] + L]  END
      IF Z : = 0 THEN BEGIN I: = F; GO TO U2 END
      I : = N;
U6  : IF [I] 1 = X  [1 + (I - 1) XQ]  THEN GO TO U7
      ELSE BEGIN  I: = I - 1; GO TO U6  END
U7  : J : = 2
U12: IF I [J] = X [J + (I-1) XQ ] THEN GO TO U10;
      IF X [J + (I-1) XQ] = 0 THEN GO TO U2;
      ELSE BEGIN I: = I-1; GO TO U12  END
U10: IF J = Q THEN GO TO U2
      ELSE BEGIN J: = J+1; GO TO U12  END
U2  : V: = RANDOM;
      F: = 1;
U13: IF V > G [(I-1) XM + F]  THEN
      BEGIN F: = F+1; GO TO U13  END
      IF Z = 0 THEN  GO TO U3;
      FOR J: = Q STEP -1 UNTIL 2 DO I [J]  : = I [J-1]  ;
      I[1]: = F;
      GO TO U3
END
```

7. Output means of the system

How to turn computer results into perceptible form?

Detailed technical exposition is left naturally also here for papers in preparation, but a brief survey of the possible output-means is presented.

a/ Output means for the music

In the case of music two basic ways are possible, the one is to output music scores, the other is to output the music itself through the computer's loud-speaker. In the present research both have been applied. For details see [4].

b/ Output means for the movements

In the movements case in principle we may reckon with the same two basic possible ways of output as in the case of music. One way is to print out kinetogramms. The problem here is that we have to prepare a translator program which translates from the standardized mathematical movement notation language to the kinetogramm language. Also - at least for the beginning - we probably must be satisfied with printing out kinetogramm in an easy decipherable coded form, because it would require a rather hard programming work to prepare the programs required to control a figure-plotting device that would be able to draw immediately kinetogramms. Theoretically here is no problem at all, appropriate program controlled data - plotters exist. One way to avoid this problem is to construct such a tape-controlled flexowriter similar to the stenotype machines which had as symbols immediately the symbols of Kinetography. Into this type of output belongs also, if we do not print a kinetogramm, but still information in a coded form. This is necessary if there was a middle-range analysis carried out, where the categories of Kinetography are already not fine enough to express the results.

Analog output

Because of the very complicated structure of human movement, the Kinetography language cannot be simple too. Consequently it is very hard exactly for active dancers and choreographists, who are in the most cases not used to deciphering hierogliphae, to work with result expressed in this form. Therefore it is in this case even more important than in the case of music, to look for analog means of output.

Automated puppet show - Robot man

We think here on the same marionette a fils as in the section about input means. Puppet-show-technique has already solved the problem how to transform the vertical-horizontal movement of threads into the very complicated movements of the puppets' body. The technical problem to solve is simply to observe to what extent the threads are pulled when a movement-with the relevant point to which the thread is attached - is carried out. If these values, or better to say functions, are ascertained, it is enough to mechanise the pulling of the threads and then to instruct the mechanical device with appropriate signals to carry out the movements required. Naturally as the original output information is in digital form /directly coming from the computer or coming from a paper-tape reader/ a digital-analog converter must be entered into the process, so that the mechanical thread-controlling devices should already become analog signals.

It belongs to this line of research to begin with the construction of a robot-man, that is able to carry out movements without being in physical contact with any threads.

The robot man has to be able to carry out movements according to the controll got from punched tape or computer directly.

To solve this problem by present techniques is quite thinkable. As to our present informations the Walt Disney produced "robot family", set up in the General Electric pavillon at the world Exposition, New York, seems to be a real development in this field. It is only lack of detailed information, why the authors dont think justifiable to say, that this is exactly the solution required.

It has to be mentioned here also the question of automated artificial limbs. Only this problem presupposes first very broad and hard research in the basic movement analysis, and also a biological research which would enable to turn the signals in the nerves into digital data. Only after these two problems have been solved can we reasonably think on the automation of movement output for the purpose of simulating limbs.

Synthetically composed film

In this method of output we want to turn the results of a computer procedure into visible form that way, that we generate automatically a film. So the end result is in this method always a film, distinctions can be made on other basis. One view-point is the technical realisation, the other viewpoint is how much information is directly derived of the real movements, and used to generate the film.

1. Computer controlled photograph mixing

The computer program generating the output film does only the organization of a given photograph library, does not generate the very pictures. The result of this procedure is, that according to the computer controll samples of the photograph library are copied togather.

The automatic film mixing procedure is essentialy belonging to the large-scale analysis /the level of Kinetography/. The method is basically the same, as if we would instruct a human dancer in terms of Kinetography to carry out a series of movements. The only difference is, that in the second case the single movements are linked togather to a dance by the human performer, in the first case the photographed equivalents of the movements are copied togather automatically.

The method described in short is the following: A human movement performer /say a bellet dancer/ is photographed or filmed in the different basic positions of which the others may be generated. A photo-library is put togather of the pictures. The signals representing the output have control on this photograph-store, so that the photos are automatically directed in the sequence as the output signals specify before a window where there is a copy made of them. So in the end we get a new film which consists of the required photographs in the required order, one photograph being very similar to the other, so that the film, if projected, will show the movement, that we have got at the beginning only in digital form, as the end-result of the computer process.

Naturally, certain restrictions must be made because all possible positions /even if we take only the characteristic and standard ones/ would give a prohibitively large number of photographs.

Another remark concerns the storing of the photographs. One possible way is to store them on one film and then let make the signals program the searching process in the same way as searching is done in the magnetic film-units of computers. A faster solution would be if the CRAM principle used in the NCR CRAM-units would be adopted. The principle, as it is well-known, consists in storing cards /in our case photographs/ in packages, and the digital signals control the bars holding the package. At a definite standing of the bars one and only one card becomes free and with the help of air-pressure it will be passed before a "window" where information is read out. /See Fig. 9./

This method seems to be exactly cast for the problem to be solved here.

The advantage of this output method against the other output means is that as the photographs are made of a human performer, all the very human characteristics are incorporated in the photographs /the style of movements, the play of muscles etc./.

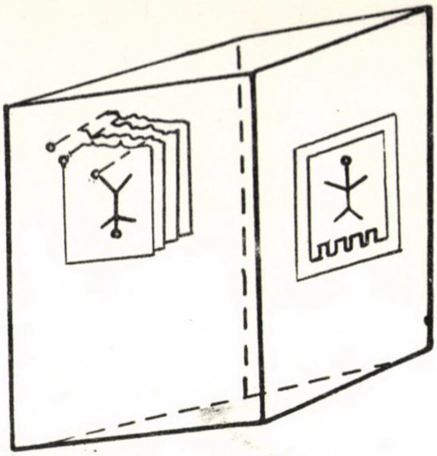

Fig. 9.

Disadvantages might be the difficulty of actual realisation /firstly mechanic problems/, and certain restrictions on the freedom of computer composition, if compared with the methods to follow.

2. Computer controlled TV beam: a solution developed by the Bell Telephone Laboratories

A more detailed explanation of the method see in [9].

The input of the system is a program. In the present form analog registered figures don't form part of the input, so all the information has to be contained in the program. The result of the computerized procedure is a synthetically composed film.

The units of the system: punch-card input for the program, the computer /actually used an IBM 7094/, magnetic film unit, TV screan unit /the sensing beam is controlled by the computer/, camera unit, making photographies of the TV screen /actually used an SC 4020 micro-film recorder/.

With an appropriate program any picture can be generated. Refining the dissolution of the TV screen theoretically the finest nuances will become programable.

It should be noted, that partial solutions to this problem have been giwen already at earlier stages of computer development.

So one output channel of the Siemens 2002 computer developed in 1955 was a computer controlled Kathod ray tube, apt transposing results into visual form. /Siemens Zeitschrift, 10. 1959./

3. Computer controlled TV beam as output, using analog registered movements as input

The presented method for outputing results of a computerized procedure directly in visible form is perfect of its kind. The only problem arising is, that all the information for the film generation has to be stored in the program, and developing the program, everything has to be built up synthetically, there are no means to abstract information from reality in a direct way.

All this problem are cleared, if the system of the previous section is equipped by an automatic movement registering unit /the description of such a device see e.g. in a paper of P. Braun, [3]/. If we do this, then the flexibility of programing is unified with the natural richess of living scene, that we snapshot and turn into digital data in a direct, automatic way.

So firstly the program does not has to generate the end-result film in all its details, but essentially this is compiled on the basis of the analog registered movements. The digital storing of the registered movements makes on the other hand possible, that generating the output film, transformations of many kind could be carried out.

Secondly, as it is possible to register a large set of movements data in detailed form, with the help of a Markov analysis the program itself can be enriched in a degree, that can't be hoped otherwise.

So if the automatic movement registering unit is built in as part of the synthetical film producing system this means a great advancement, and so it does first of all in the production of animated movies. If we have this enlarged system, we may produce immediately stylised equivalents to any real movement. With relatively simple programes speeded up or slown down images of movements, caricatures of several kind can be generated.

8. A realization of the total system

Before beginning the list of applications, it may be interesting to remark that at the present level of technical development it is not much more than a budget problem to realize in one cybernetical system what has been used as the principle of systematization of this paper. Namely, for example the following elements could be linked together: music source /e.g. an orchestra/ ——► input device /e.g. level recorder/: analog registration ——► analog digital converter ——► computer: mathematical analysis of music, composition of a dance in accordance with it ——► digital analog converter ——► output device /e.g. an automated puppet show or robot dancer/.

Such a system /built up of currently existing elements/ could simulate the human activity to perform movements to music like in ballet or in the modern dances.

Systems like this would permit the testing of system-dynamics in different human activites and present a very flexible tool for investigations in the applications to be listed below.

9. Present and possible applications of cybernetic /L = large-scale, M = middle range, B = basic/ movement plus music analysis-synthesis

Traditional movement research-L

The traditional movement research of dances and choreographies is based on the Kinetography language. Here a great problem is posed by the laborious work involved in drawing kinetograms. The analog registeration and computer information processing of movements could have as the first direct application in making a program controling an on line Graphomat device drawing automatically the kinetograms.

The applications in this field are naturally much deeper than this. Given a large set of coded dances and dance motives, the analyzing methods permit the finding of the best set of basic motives giving a good representation of all the material describing e.g. the dance culture of a folklore. /See 4 c §/. Also the results of a structural analysis via computing correlation functions /4 b §/ are directly commensurable with the results of the traditional formal dance analysis and so they can serve as mutual help.

Choreography identification - L

Large-scale fixing of choreographies in the form of kinetographical description and the analysis of the formal, substantial character of these choreographies would make it possible for us to speak of a sensible copyright of choreographies. As long as there are no ways, or there are only very laborious and slow ones to fix artistic creations in this field and there are no exact means to gain an insight into the structure or artistic creation of this kind we cannot expect even the most genuine dance composition to be protected from plagiarizing. As at present the only means to fix, say, a ballet, are to film it, it is enough for a good imitator to change the surface properties or to mix the order of a few motives or to alter the transitions between the phases, and as the film of the ballet lasts longer that it could be comprehended in its totality by a human observer, nobody will dare say that it is imitation, even if some similarity will be detected. Not to speak of the fact that at present even the standards of conformity are not yet fixed. Naturally, the setting up of such standards, and perhaps their introduction into the legal practice as decisive factors in dubious cases /usable also in court procedures/, can be thought of only following the guidance of the practitioners of this field.

Traditional music research - L

The advantages of large-scale cybernetical music analysis are essentially the same for the traditional research as the aid of computerized movement analysis is for the traditional one. The only difference is, that in this field we have already passed beyond the first stages of development and we can speak of a fruitful collaboration between the two sciences. Correlation-regression analyses are done at present based on an extensive folk-music material /1000 folk songs/ under the directives and for the expressed interest of the co-workers of the Folk Music Research Institute of the Hungarian Academy of Sciences. On the other hand, computer produced synthetic folk-music is highly appreciated by folk-music researchers and the aspects of the folk-music characteristics so revealed are useful for their work. /A detailed report of the synthetic folk-music composition is given in [4].

Evaluating dance performance - M-B

As indicated by the letters M and B the methods required here enter the middle range, more, the basic analysis. As we want to fix and analyse the style of a dancer we obviously cannot be satisfied with schematic general difinition of movements, but we have to study analog registratums. /For technical details, how to fix movements in an analog form see 2 § or [3]./

This way would permit the fixing of the style of the best ballet dancers and use it as standards. On this basis comparisons can also be made which measure the deviations from the registered standards.

Ballet teaching - M-B

This is only a logical extension of the above application, because if we succeed to work out fix standards of a given style, so this can be evidently used to train dancers to shape their performance step by step in conformity with fixed standards. It is worth remarking, that even if the setting up of an analog movement analyser would be at present too expensive in small training centres, the realization of such a plan would certainly be a rewarding enterprise in ballet schools because it could ensure a high level of performance of the rising generation.

Evaluating musical performance - M-B

This field of application also belongs to the middle-range and basic analysis. The means to do this are the analog registrata of the music or on line operated musical instruments with a computer. One of the possible solution will be presented to the 1964 International Folk Music Conference in the form of an on line operated piano. /For a more detailed description see 2§/. Such devices like this permit the analysis and the setting up of standards for musical performance.

Music teaching - M

The fixing of standards and the analysis of the actual style and performance of the artist playing a music instument had clearly the same consequences for music teaching as it does for dance teaching. Formal mathematical methods are quite general and apt to handle any sort of music where the analysis and fixing of standards is required, whether modern music or folk-music.

Evaluating records - M

The avaluation of records is based not only on the musical analysis, but also on the music-dance relations. /We speak here of the dance-music records./ As a whole paragraph has been devoted to this question, we would like to make only explanatory remarks here.

One is naturally aware of the fact that the actual success of a record is to a decisive degree dependent on the fashion, the popularity of the singer, which are all external to the basic melodic-rhythmic properties of the music and their relations to the plastic, rhythmic and dynamic character of the dance which will be performed to the music in question. What is asserted is only that we may give evaluations on factors /musical properties and music-dance congruence/ which in certain cases might be of definite importance in influencing the public in favour of one hit against an other. Such is the case, surely, when the question is, in which of two hits of the same star in fashion publicity should be invested. Galluppools may verify that these methods give correct answers, or in the future expensive public opinion studies might be replaced by the proposed method. It is worth noting that the employed treatment being a general one, it is also applicable if a new dance is coming into fashion, about the characteristics and music relations of which nothing is known at the start.

Sports applications - B

In this field the decisive work belongs to the basic research, large-scale analysis might help to apply results in larger dimensions, as they are used in practice. The analysis of the elementary laws valid for human movement is exactly the topic sports research in most sport branches is interested in. Cybernetical analysis again, as in the other fields, is able to set up rules, determine laws and help sports training to bring sportsmen nearer to the standards established.

Artificial limbs - B

This requires not only the analysis but also the simulation of elementary human movements. Here beside the basic analysis therefore also the results of electronic movement composition can be utilized. The research in this field requires the collaboration of biologists too, because only with their contribution can it be hoped that the biological signals coming from the body at the points, where the artificial limbs have contact, can be converted into a form which permits the control of the artificial limbs in a way similar to the biological signals.

Applications for space exploration - B

How should be movements imagined on other planets?

These applications will become possible when we have extensive knowledge concerning the abstract elementary laws of human movement. If we have such a set of laws in our hands, we may test the reactions of a moving body under conditions quite different from our terrestrial ones. An investigation of this type has to be carried out before actually sending a man to the moon.

Production of animated movies - L-M-B

The question has been dealt with already in 7§, "Synthetically composed film", point 3.

The important thing is, that conditions to start in this field are nearly ready. As output unit the synthetical film-producing device of the Bell Telephone Laboratories could be immediatly used. The only facility to be added is an automatic movement registering unit /see e.g. in [3]/.

This application has a very close connection with the next, because in the form of animated movies stilysed choreographies might also be produced.

Simulation of choreography and musical composition - L-M-B

The methods concerning computer composition of dance and/or music are treated at several places of this paper, and also in [4].

What is to be said here it is only to quard against certain misunderstandings. It is quite natural that in human artistic creation there is always an intrinsic feature that cannot be imitated. This does not exclude that a computer composition based on laws which have been analysed in works of human creativity, should manifest new beauty different of the beauty of the pieces analysed. But also in this case human beings are required to detect it and to enjoy it as they perceive the beauties in nature.

Such compositions synthetised with the help of cybernetical methods also serve pointing out the inherent consequences and possibilities of variation in the oeuvre of artists.

It is a very positive feature that these theoretical considerations are confirmed by the approval of leading personalities in the arts' life. The present research e.g. is carried out not only followed with sympathical attention of the compositor Z. Kodály, but it is enjoying hid definite help.

Ethnological applications - L-M-B

This application is at present a question of the future because it would require extensive international collaboration and preparatory work. The ethnographical aspect comes in when we start e.g. to regard the dance-music interrelations in their dependence of the cultural environment. It is evident for everybody that the same music does not have the same emotional effect on a European and on an Indonesian. Naturally, we cannot measure emotional effects, but we can compare with exact methods the dance movements by which emotional effects are expressed. So the differences of the music - dance mapping functions will be characteristic of the cultural setting of the performer. This may lead in turn to measuring the differences among culture-spheres in a new and more exact way.

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and movement analysis, to the research workers of the Folk Music Research Institute for guidance in music aspects of our paper. Thanks are also due to our technical experts, first of all to P. Braun, to marionette-artists and to all those who made suggestions concerning their fields, preventing our research from starting in false line in any of the sciences and arts involved.

We wish to express our thanks also to D.G.Williams, of the University of Missouri, for the information on the present availability of the Bell's Synthetical film composing system.

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Acknowledgement

ON A HUMAN MOVEMENT ANALYSER

by

P.Braun

Summary

In this paper a device is presented, designed to register and turn into digital data the positions of different points of a moving figure as the function of time

The device consists of two parts: a camera unit, to fix the positions of points, and an electronic analysing unit, giving as output numerical coordinates of the points.

In different scientific and technical investigations it is often necessary to analyse the movements of human beings or other moving bodies. /For an application of the analyser see [1]/.

The analyser has been designed in a way that it could be constructed of easy available standard commercial elements /automation elements, film cameras etc./.

The aim is to determine the location of the body or the locations of certain specified, relevant points of the body as the function /functions of time given with their three rectangular coordinates at every time point. It is left free how frequently "snapshots" are mode of the locations of the relevant points; i.e. the density of the time point series. The Descartes coordinate systems origo is fixed by us.

In the following we shall explain the working principles of such an analyser. The device in its present form is designed to generate automatically location-time functions of lo different points of a human being or any body in motion. Values for the location-time functions are obtained 5-times in every second, in 3 dimensional rectangular coordinates. The human being or body is moving in a closed space, the origo chosen is in the left bottom corner.

1. The working principle of the movement analyser

The analyser consists of two basic units: a camera unit fixing the movement on film, and an analysing unit, turning the information fixed on the films into digital data giving immediately the rectangular coordinates required, in numerical form.

The working principle of the camera unit

We have to decide in advance which points of the moving human being or moving body we regard as relevant, of which points we want to get space-time functions. We fix on these points electric bulbs. The body is moving in a darkened space, the bulbs flash in a time-multiplex system /that is one after the other consecutively/. Exactly when a bulb flashes, cameras associated with it make photographs of it and so fix its position. Naturally it must be ensured that the cameras associated with their bulbs should make an exposure only at the time when their bulbs flash and should be covered during the rest of the time. If this is ensured we get only one point fixed on the films of a camera-system giving the position of the "own bulb" of the camera-system. /We speak of camera-group/s/ instead of single cameras, because in order to fix the three coordinates of a moving point it is necessary to make minimum two photographs of it./ The time-multiplex process of photographing the bulbs' positions is illustrated in Fig.1. for three bulbs and three camera-groups respectively.

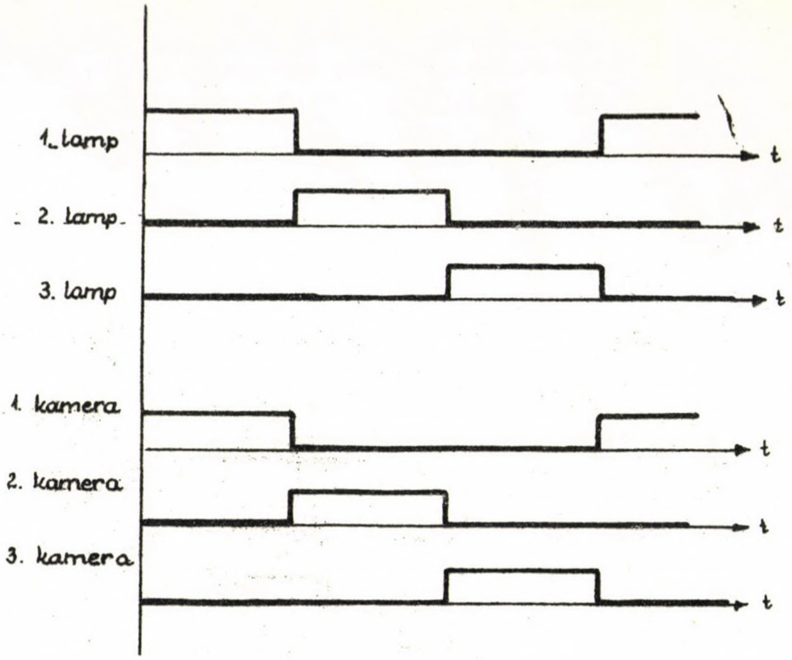

Fig. 1.

In this way we get on one film of a given camera such a series of photographs, that in a single photograph the whole picture is dark except the one light point. This light point is changing its position in the consecutive photographs according to how the corresponding coordinate of the point associated with the camera-group in question is changig during the time /See Fig. 2./

So for every bulb attached to the moving body we get two corresponding films. In the case of a human being bulbs will be attached naturally to points which are relevant in the sense that they are defining the movement of the whole human figure. Such points are e.g. the knees, the elbows, the top of the head etc.

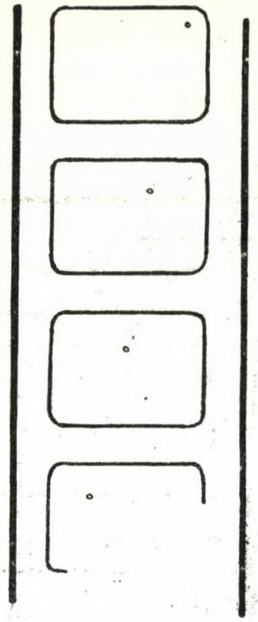

Fig. 2.

The working principle of the analysing unit

The task of this unit is to "feel /out/" the position of the light points on a shot, and determine the rectangular coordinates of the position of the light points and perforate the numbers giving these coordinates on a tape or store it on a magnetic tapeunit.

The sensing element of the analyser is a television camera, e.g. a vidicon. We project that shot of the film in question, that is having its turn, on the screen of the television camera, and then we scan the screen with the sensing-point according to Fig. 3.

As is shown in the figure the sensing point begins at the upper left corner of the screen and it scans the screen moving forward with small jumps from one position to the next right position and when it comes to the end of a row it begins the next row on the lefthand side. In Fig. 3.) (a 32 x 32 point screen is illustrated. When the scanning point has reached the last position /i.e. the position in the right lower corner/ it jumps back to the first position and the process is begins again in the same way.

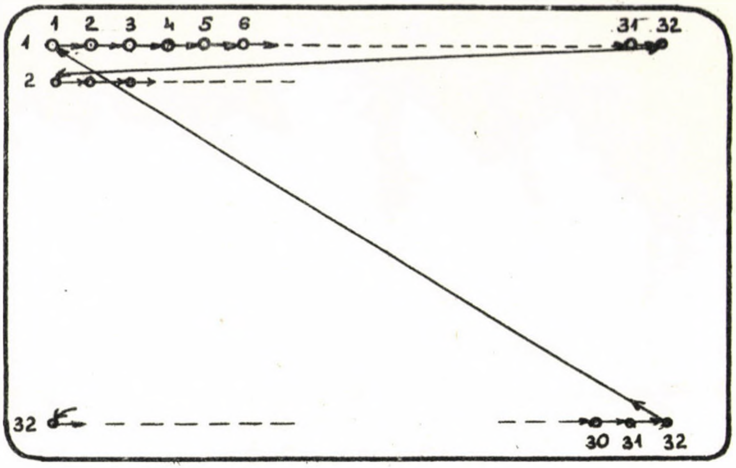

Fig. 3.

During its way through the screen the sensing point will certainly come to the position where the light point is registered. At this point there will be a jump in the output signal of the camera-tube. Our task is to enregistrate automatically at which position this jump in the output signal is experienced, and naturally to ensure that the sensing point should follow its way in the manner described above.

2. The camera-unit

In the detailed design of the device described here we suppose the following data:

5, shot/sec

10, made of each of ten different points.

as we are using a time-multiplex system we have

$$t_v = \frac{1}{5.10} = 1/50 \text{ sec}$$

time for the exposure of one shot. This exposure time is enough even in the case of normal films. In the cameras the film has to be forwarded at every $t_f = 1/5 - 1/50$ sec. This does not raise any technical problem from the point of view of mechanic realisation /normal film cameras move with higher speed/. For better time utilisation the device has been designed so that it should forward the film immediately after exposure and then wait for the next exposure.

The exact order of exposure is ensured by a special eye-lash-system and this electronic unit will also ensure the synchronized flashes in the corresponding bulb.

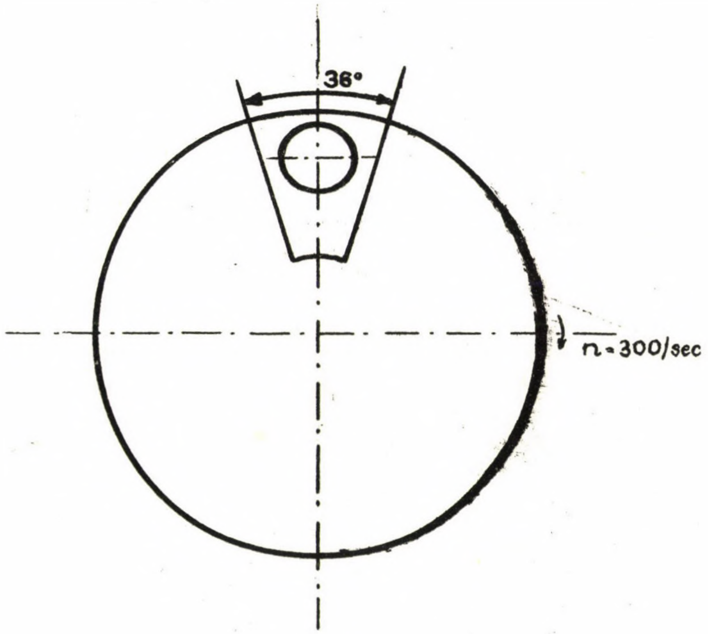

Fig. 4.

Before the objective lenses of a camera there is a rotating plate shown in Fig. 4. The cuts of the plates have an angle of 36° in the case of two neighbouring plates, because we have 10 plates and so the 360° are divided by ten. /See Fig. 5./

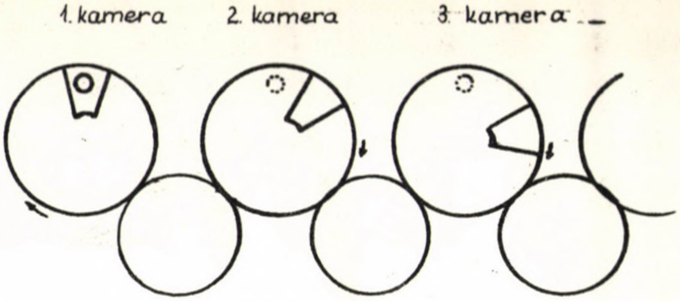

Fig. 5.

The rotation factor of the plate equals

$$n = 5.60 = 300 \text{ rot/min}$$

corresponding to the 5 shot/sec frequency. The time utilization for the exposition and film forwarding is shown in Fig. 6.

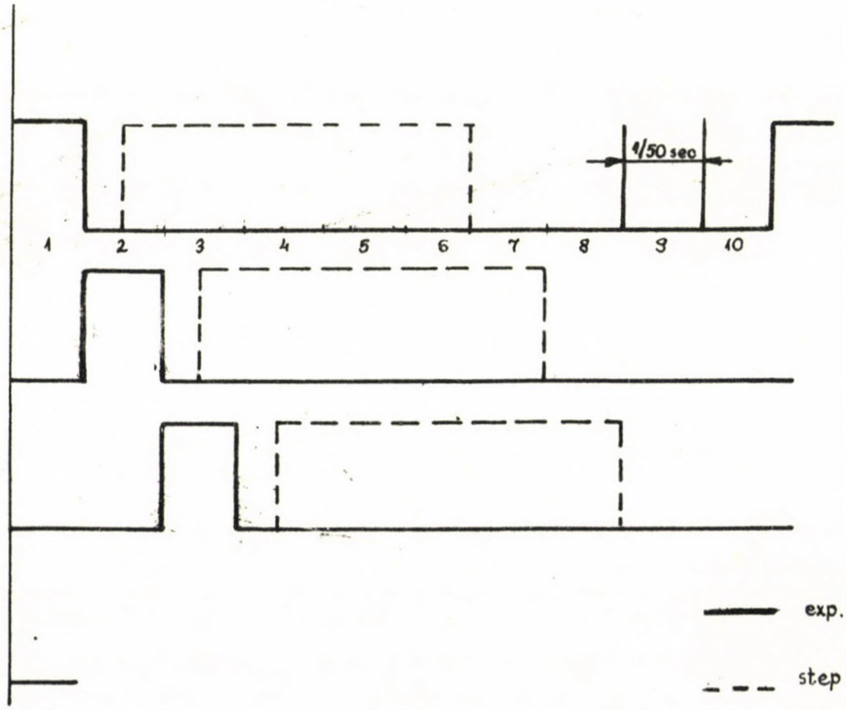

Fig. 6.

The synchronous flashes of the bulbs are ensured by a synchron rotating switching cylinder; i.e. the cylinder is rotating together with the plates. On this cylinder there are contacts giving at the moment of opening an objective lense a signal going to the bulb and causing it to flash. /See Fig. 7./

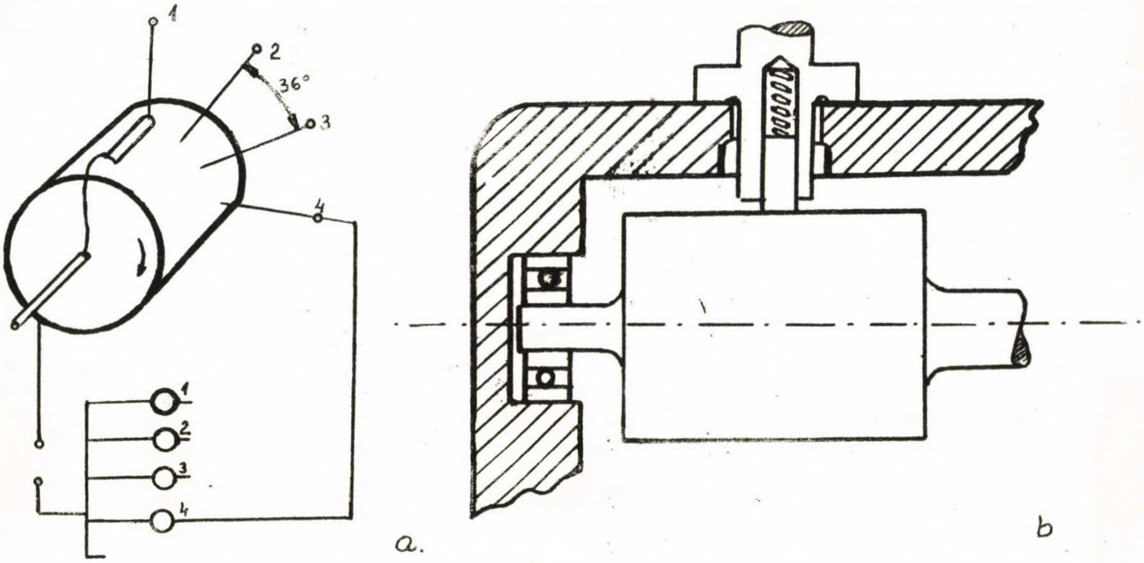

Fig. 7.

the principle of this switching commutator is illustrated by figure 7a, the practical realisation by fig. 7b. The bulbs used can be any bulbs with strong flash-light, so e.g. they can be stroboscope lamps.

It must be ensured that the bulbs fixed on the moving body should have their power supply; and also that the bulbs should get the required control. Although there are methods using portable small batteries and wireless communication, the use of cable contact is thought to be a simple solution.

The cable should lead to an appropriate point of the moving body, not hindering it in its movements. In the case of a human body the best solution seems to be to fix a sort of helmet on to the head to which the cable can be attached. Naturally it is necessary to ensure that the cable should not become slack. This can be done with the help of a spring-device, the same solution is applied in fencing. /See Fig.8./

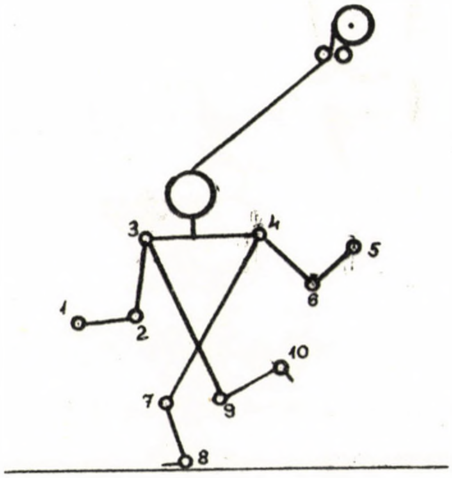

Fig. 8.

There is another contact series, the same in construction as the contract series controlling the bulbs which generates the forwarding signals to the cameras after the exposure.

We have to say a little more about the means how the points coordinates are fixed including all the three dimensions. At the beginning for the sake of simplicity we spoke of the necessity to use 2 cameras to photograph one point. although even the information got in this way is redundant, if we want to be sure that we get the coordinates of the position of the points in every case we have to work with more cameras. Theoretically 6 cameras could ensure that the point is not shaded allowing for all complicated positions. Taking budgetary viewpoints also into account we can be satisfied with 4 cameras.

The sketch of the camera unit is illustrated in Fig.9.

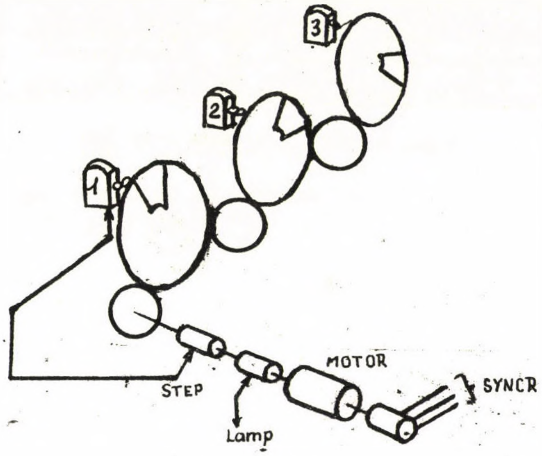

Fig. 9.

The discs of the cameras con be brought also in a position like that illustrated in Fig. 10. This configuration reduces distortions in the pictures, because cameras are nearer and parallism is better ensured.

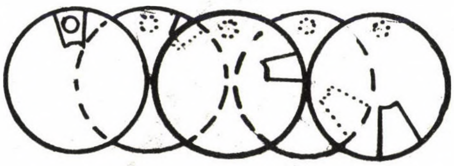

Fig. 10.

The synchronous operation of the cameras belonging to one camera-group can be controlled with the help of a double-beam oscilloscope. The method is to put a photocell-lamp pair to the disc-slice of the first camera of every camera-group. The circuit diagram of the control-device and the oscilloscope picture in the case of synchronous operation is shown in Fig. 11.

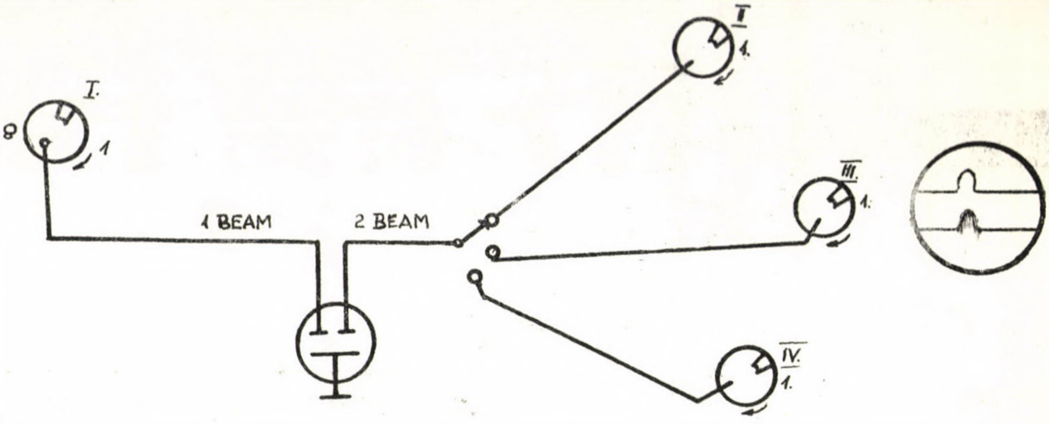

Fig. 11.

The analysing unit

The flow-diagram of the operation of the analysing unit is shown in Fig. 12.

The working principle of the device is the following: The task of the device is to reproduce in the form of digital signals the value of the coordinates of the light-point on the photograph, which has to be analyzed. The picture is projected on a television tube, e.g. a vidicon. The analysing unit is designed to read the information presented in this way.

Part 1 of the device is an oscillator sending impulses to scaler 2 counting these. Scaler 3 is counting parallelly with scaler 2. The status of scaler 2 is turned by a digital-analogue converter 4 into an analog signal and the analog signal produced this way is moving horizontally the sensing beam of the vidicon 20.

The problem to build a digital analog converter is a very easy one, one realisation is shown in Fig. 13.

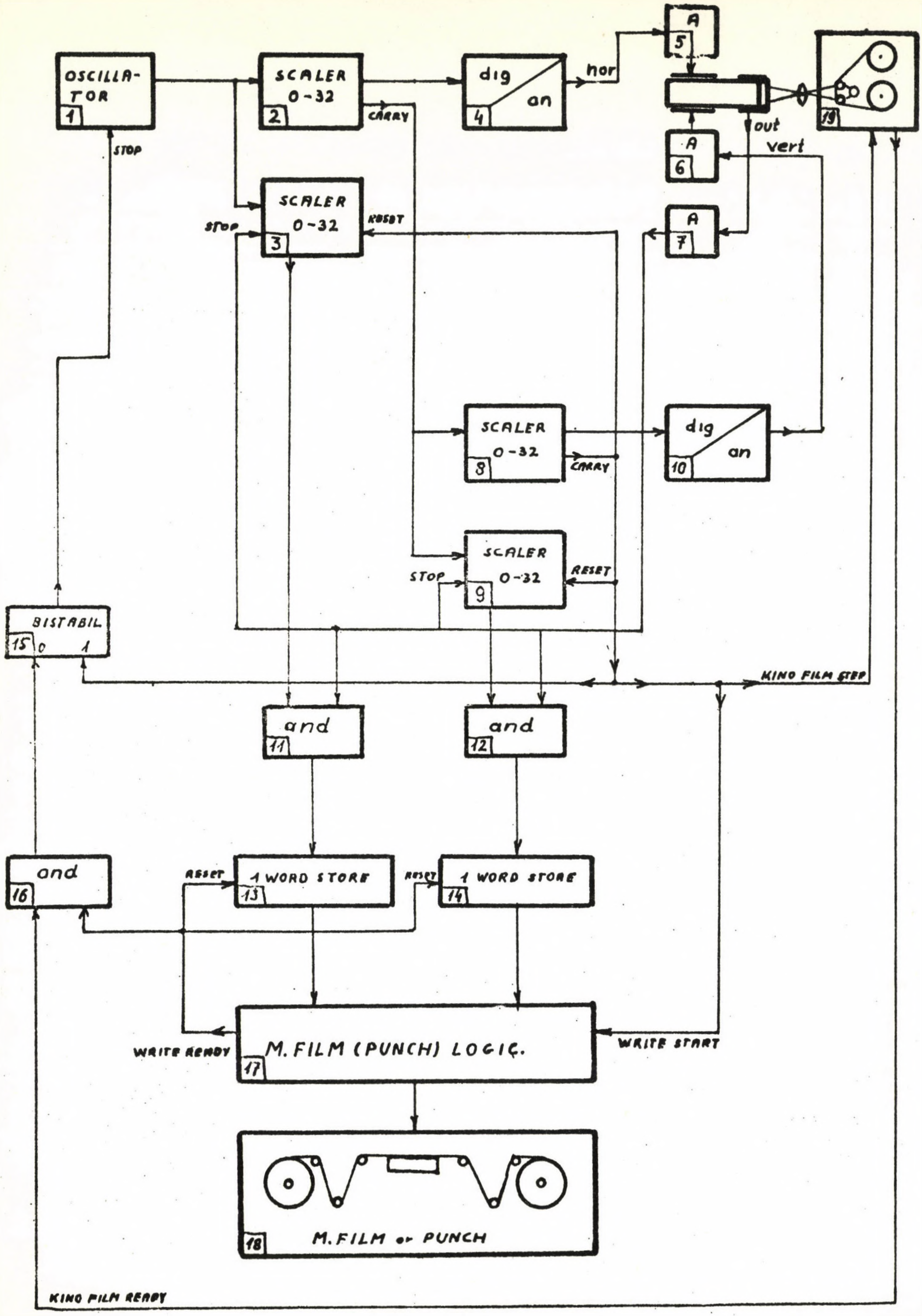
OSCILLA-TOR
1
STOP
SCALER 0-32
2
CARRY
dig an
4
nor
A
5
out
A
6
vert
A
7
19
SCALER 0-32
3
STOP
RESET
SCALER 0-32
8
CARRY
dig an
10
SCALER 0-32
9
STOP
RESET
BISTABIL
15
0
1
KINO FILM STEP
and
11
and
12
and
16
RESET
1 WORD STORE
13
RESET
1 WORD STORE
14
WRITE READY
M. FILM (PUNCH) LOGIÇ.
17
WRITE START
M. FILM or PUNCH
18
KINO FILM READY

Fig. 12.

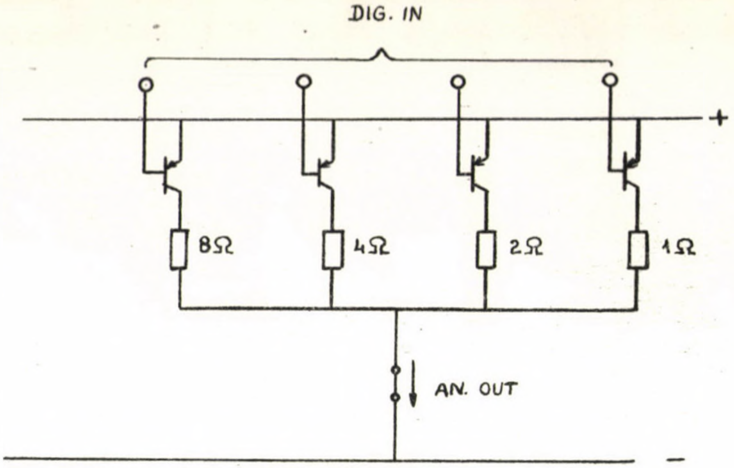

Fig. 13.

When scaler 2 is counting the 32th impulse there is a carry produced and the scaler is set back to 0. This has a double effect. One effect is that according to the state of zero of scaler 2, converter 4 gets no signal and so the vidicon's beam will not be deflected horizontally and this way the beam is dropped back to the lefthand side of the picture. The other effect is that the carry causes scalers 8 and 9 to count 1. This has the effect that the sensing beam of the vidicon is deflected by the analogue signal coming from converter 10 vertically with one row below.

Similarly to the way it was done in the first row, the sensing point sweeps all the rows. Amplifiers 5 and 6 generate the deflecting current.

When the sensing point has reached the light point we get an output-channel of the vidicon. This is amplified by amplifier 7. The signal will stop scalers 3 and 9 but scalers 2 and 8 continue their counting.

This way we have in scaler 3 the horizontal, and in scaler 9 the vertical coordinates of the point, in the position of which we are interested in, measured in a rectangular coordinate system, whose origo is put in the left top corner of the picture.

The output signal at the same time stops scalers 3 and 9, it opens contacts 11 and 12. Through these the content of the scalers is transferred into the one-word stores 13 and 14.

If a carry is produced in scaler 8 too, it means that all the cells of the picture have been "sensed". In this case the carry signal of scaler 8 has several functions. On the one hand, the bistabil stati-ciser 15 is set and through this the oscillator stops. Scalers 3 and 9 are reset /put to zero/. By this time the content of these scalers has already been transferred into the one word stores 13 and 14 respectively. Scalers 2 and 8 need not be reset, because they are in zero position /carry has been produced in both scalers by this time/. It is also one of the functions of the signal coming from scaler 8 to start the magnetic film-unit or paper-tape control to store or punch out the contents of 13 and 14 and also to start the unit, controlling the replacement of the film shots, to take the next picture.

When both units have finished their task, a signal is produced on the output of the "end" 16, re-setting the bistabil staticiser 15, the oscillator is started and the sensing of the next shot begins.

It can be seen that the device furnishes the x, y coordinates of the light points' positions directly in numerical form and it stores them in a form immediately suitable for computer utilization.

If there is no light point on the picture, the device prints the coordinates 0 0, and then in the computer interpreting program an interpolation must be done. /Naturally, so the situation 0 0 position and the situation "no light point" is identified. But having 32 x 32 positions in the picture this situation will occur very rarely and so practically it does not produce any distortions./

The device in the present form divides the picture into 32 x 32 positions. If such a grading is regarded to be insufficient, it is easy to increase the dissolution to

64 x 64 or 128 x 128, only in these cases, with the same oscillator, the time of the basic cycle will be increased too.

The device is designed as an input means. All the analyses of the data have to be done by computer programs working up the information obtained in this way, including some slight corrections that might be necessary because of the perspective distortions, which is already fixed with the position of the light point turned into digital data by the analyser.

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О ГОТОВЯЩЕМСЯ ОБРАТНОМ СЛОВАРЕ ВЕНГЕРСКОГО ЯЗЫКА

Ф. Пап

I.

Группой по Математической и прикладной лингвистике при университете им. Л.Кощута /Дебрецен/ и Вычислительным Центром АН Венгрии /Будапешт/ совместно подготавливается обратный словарь венгерского языка на перфокарточных машинах. Математическую часть работы, а также всю работу на САМ-ах выполняет З. Ботка, заведующий отделом Центрального статистического управления Венгрии /Будапешт/. По планам составителей первые результаты должны быть получены к концу 1965 г.

В основу словника обратного словаря /венгерское название: Szóvégmutató Szótár и его сокращение: VégSz./ положен только что вышедший академический Толковый словарь венгерского языка под ред. проф. Л. Орсага / A magyar nyelv értelmező szótára. Tt. 1-7. - Budapest 1959--1962. Принятое в венгерской лингвистической литературе сокращение этого словаря: ÉrtSz. В дальнейшем в русском тексте мы будем его называть как ТС/. Этот словник охватывает 60 тыс. слов венгерского языка, "стержневую часть" современной венгерской лексики. Правда, в этом словнике отсутствуют такие, в нашей специальности необходимые, слова, как algoritmus 'алгоритм' kód 'код' и некоторые им подобные; с другой стороны в него включены некоторые устарелые слова, встречающиеся в произведениях классиков венгерской литературы XIX-го века. Однако отбор слов был осуществлен для ТС на основе строго выдержанных принципов, слова в нем снабжены необходимыми стандартными грамматическими и стилистическими пометами, к тому же в настоящее время осуществимой казалась разработка именно подобного объема материала на машинах, стоящих в нашем распоряжении. -- Если в дальнейшем окажется нужным пополнение этого словника материалом из других источников, это легко можно будет сделать. При каждой из 60 тыс. слов, обрабатываемых в настоящее время, в первой графе расположен индекс источника -- ТС; дальнейшие источники в будущем получат соответственно свои индексы.

Сами слова будут написаны на карточках обычными буквами, имеющимися на алфавитном вводном устройстве ИБМ. Недостающие буквы /знаки некоторых венгерских долгих гласных/ заменены однозначными цифрами, не занятыми еще в целях обозначения букв в применяемой системе. Так как венгерское письмо довольно близко к фонологическому облику слов и между венгерскими письменными знаками, с одной стороны, и фонемами, с другой, легко устанавливается соответствие, введением цифр на месте некоторых букв облегчится не только расположение слов в алфавите, но и подсчет длины слов не только в письменных знаках, но и фонемах /если долгие гласные обозначать, например, двойным написанием знака короткого гласного -- aa на месте долгого á -- это было бы невозможно, или по крайней мере не так просто/. /Самое длинное слово, найденное до сих пор нами в словнике, состоит из 23 букв: megfellebbezhetetlenség 'безапелляционность'./

После кода источника и написания слова следуют на карточке закодированные грамматические, стилистические и т.п. информации. А после этих информаций на каждой карточке написано слово еще раз -- на этот раз "с правыми полями", т.е. так, что каждое слово кончается в одной и той же /последней, 80-ой/ колонке. Перенос слова с левой части, с левыми полями, на правую часть, с правыми полями, производится механически, после сортировки слов по длине /метод Э. Матера -- см. в нашей Библиографии № 20/. Тем фактом, что на одной и той же карточке одно и то же слово написано как с правыми, так и с левыми полями, обеспечивается возможность механической сортировки как слева /обычный алфавитный порядок/, так и справа порядок обратного словаря/.[1]

Сами грамматические информации /в широком смысле этого слова/, почерпнутые, где это только возможно, из ТС, имеют следующие разделы.

/1/ Сложное слово -- несложное слово. -- Предполагается, что в венгерском словаре "индекс словосложения" довольно высок, немало слов, состоящих из трех, а то и из четырех корней. Количество корней в слове отмечается в соответствующей колонке; отмечается также факт наличия приставки.

/2/ Омонимы — перенумерованы как в ТС.

/3/ Принадлежность к части речи в венгерском языке не так тривиальна, как, положим, в русском; венгерский язык в этом отношении типологически ближе к английскому. С той все же разницей, что в венгерском языке, наряду с возможным формальным совпадением /в исходной форме/ существительного с глаголом, чаще наблюдается формальное совпадение существительного и прилагательного; возможны, конечно, и иные совпадения. Все это — т.е. принадлежность слова к одной части речи, к двум, а то и к трем частям речи — точно отмечается на карточках.

/4/ Количество значений отмечается также. Принимается количество значений, отмеченное в ТС.

/5/ Стилистистические пометы кодируются также на основе источника.

/6/ Начиная с этой колонки значение кода, расположенного в соответствующем месте, зависит от части речи слова. Так, для некоторых типов слов /для неизменяемых/ эти колонки не заполняются вовсе. В случае имени колонка /6/ указывает на принадлежность имени к тому или иному типу основ. Именная основа по ходу словоизменения может оставаться неизменной, она может удлиняться, из нее перед некоторыми окончаниями может выпадать <u>е</u>, <u>о</u> или <u>ö</u> /стало быть, это — беглое <u>е</u>, <u>о</u> или <u>ö</u>, но такого понятия и термина в венгерской грамматической литературе нет/ и т.д.

В случае же глагола как эта, так и следующая колонка используются в совершенно иных целях. Дело не в том, как будто глагольная основа не менялась бы по ходу словоизменения. Однако эти изменения у части глаголов очень просто определимы, у другой же части слишком индивидуальны, не стоит их, видимо, давать машине сортировать. Как будет готов обратный список — так "вручную", кажется, экономней будет разбить глаголы на типы по изменению основы в случае заведомо известных нам концовок; в случае же иных концовок никакой проблемы нет. /Мы говорим о "концовках", т.к. венгерский глагол в третьем лице ед.ч. настоящего времени субъектного спряжения, вообще говоря, может оканчиваться на любой согласный и на долгий гласный верхнего подъема, при нулевом окончании. Может быть, это и не так и окажутся согласные, на которые глагол, т.е. глагольная основа с нулевым окончанием, не кончается –– но до составления обратного словаря это совершенно неизвестно./ Так же обстоит дело и с глагольными окончаниями /см. колонку /7//. На месте "типа основы" и "окончаний" в случае глаголов дается информация о сетке сильного управления глагола /в смысле Л.Н.Иорданской/. Вот это-то /т.е. сортировку "сильноуправляемых форм" /вручную выполнить было бы весьма трудоемко и, очевидно, не совсем надежно. Естетсвенно, сетка сильного управления дается весьма грубо. Так, не отмечаются "несовместимые" управления /см. указанную теорию Л.Н. Иорданской/, дается только одна сетка управлений, отмеченная в качестве первой при слове в ТС и пренебрегаются управления, вызванные другими значениями слова. Последний случай –– это, очевидно, случай омонимии, но подобные омонимы в словаре не отмечаются, поэтому для них мы не отводим особых карточек.

/7/ Окончания, кодируемые в этой колонке, являются в смысле выше сказанного лишь именными окончаниями /у неизменяемых слов здесь опять ничего нет, а у глаголов –– сильное управление/. Тогда как колонки, описанные до сих пор, занимали и в действительности только по одной колонке на карточке /сложность, омонимия/, или две /количество значений, тип осоновы, стиль/ или, наконец, в одном случае –– три /принадлежность к части речи: три колонки нужны были из-за факта, что одно и то же слово может относиться к разным частям речи/, окончания занимают целых шесть колонок. В этих шести колонках закодированы в случае существительного вин.п.ед.ч., им.п. мн. ч. и притяжательная форма третьего лица ед.ч.[2] На основе этих трех форм, если только данное слово не относится к "исключениям", можно однозначно определить все 714 форм существительного /столько парадигматических форм имеется у каждого венгерского существительного –– именно парадигматических и не словообразовательных, как можно было бы думать на основе астрономической для индоевропейского представления цифры/. И форм не только много, но в образовании некоторых из них наблюдаются характерные колебания. Так, упомянутая притяжательная форма третьего лица ед.ч. образуется либо морфой ja/je /в зависимости от гармонии гласных/, либо морфой a/e, либо, наконец, в случае некоторых окончаний /при этом опять неизвестно, на что вообще может оканчиваться венгерское существительное в исходной форме/ одинаково возможны и формы с -j- и без него. /В некоторых случаях, а именно, в случае более новых заимстований, даже гармония гласных может колебаться, т.е. теоретически одинаково возможны все четыре морфы при одном и том же слове для выражения одной и той же морфемы -- практически из этих четырех возможностей реализуется, как правило, лишь две или три./ Так, 'его/ее бульдозер' -- buldózere, buldózerje, buldózerja /теоретически возможная четвертая форма buldózera вряд ли встречается практически/. Смысловой разницы между этими формами нет никакой, грамматически они, естественно, также полностью перекрывают друг друга, в некоторых случаях можно говорить только о некотором стилистическом расхождении между ними /но в случае 'бульдозер' даже этого нет/ -- это просто факультативные варианты одной и той же грамматической формы. Все эти возможные параллельные формы. Все эти возможные параллельные формы при кодировании совершенно точно и детально учитываются, т.к. в них мы и усматриваем одну из интереснейших черт венгерского языка. Полный учет всех этих вариантов, их дальнейшая систематизация необходима для автоматического анализа венгерских текстов. В синтезе мы, конечно, удовлетворимся выбором одной из допустимых форм; будет выбираться форма, "более правильная" с точки зрения построенного алгоритма.

/8/ Наконец, указывается на происхождение слова /в случае сложного -- на происхождение каждого из входящих в него корней/.

Из сказанного видно, что при кодировании огромная работа проделывается "вручную". Эта работа выполняется студентами Дебреценского университета, специалистами по венгерскому языку, на основе предварительных занятий с ними. Каждый кодирующий студент получает однозначные предписания к кодированию, предусматривающие как можно больше или все множество возможных случаев. Каждое слово кодируется независимо друг от друга двумя студентами, в конце работы два списка сравниваются и ошибки таким путем исправляются. -- Происхождение слов кодируется не студентами, а преподавателями кафедры венгерского языка.

В силу изложенного нам кажется, обратный словарь венгерского языка будет еще интересней, поучительней, чем вообще обратные словари для таких языков, как русский, или даже английский. Более полный свод формальных правил венгерской грамматики, составление которого станет возможным на основе результатов обратного словаря, будет способствовать как МП с венгерского языка и -- особенно -- на него, так и венгерской грамматической теории.

Примечания

[1] "Левые поля" и "правые поля" выглядят на карточках, например, так /цифры указывают на порядковый номер колонки/:

4		80
bóra	грамматические информации	bóra
kamra	"	kamra
kapóra	"	kapóra
óra	"	óra

-- т.е. при первом написании каждое слово *начинается* в 4-ой колонке, при втором -- *кончается* в 80-ом. В случае первого написания слова, естественно, кончаются в разных колонках, в случае второго -- начинаются в разных колонках. Для грамматических информаций могут быть отведены, таким образом, колонки, остающиеся между двумя написаниями самого длинного слова. /Каждой строке в нашей иллюстрации соответствует, конечно, отдельная карточка./

[2]Проиллюстрируем это на некоторых примерах. Толковый словарь не дает никаких грамматических форм в случаях, когда для всех венгров без колебания "само собой разумеется", как образуется та или иная из названных выше трех форм. Таким образом, отчасти на основе информаций, содержащихся в Толковом словаре, отчасти / в "леггих" случаях/ опираясь на свои знания в родном языке, образуются следующие формы:

слово	морфы		притяж. 3-го
	вин. ед.	им.мн.	л.ед.ч.
hajó	t	k	ja
epe	t	k	je
ház	at	ak	a
méz	et	ek	e
arc	ot	ok	a
tök	öt	ök	je v e
modell	t	ek	je
algoritmus	t	ok	a
férfi	t	ak	ja.

Каждая морфа для каждой формы кодируется однозначной цифрой, в случае параллельных форм /как здесь в притяжательной форме слова tök рядом пишутся цифры, присвоенные каждой морфе в отдельности, на что обеспечена особая колонка. /Слов модель и алгоритм, по указанным выше причинам, не будет в нашем словаре./

МЕХАНИЗАЦИЯ ЛЕКСИКОГРАФИЧЕСКИХ РАБОТ И ОБРАТНЫЕ СЛОВАРИ

Библиография

Сост.: Л.Дэже и Ф.Пап

В связи с возросшим интересом к механизации лексикографических работ, а также в связи с тем, что в настоящее время на самах готовится обратный словарь венгерского языка, мы опубликовываем небольшую, выборочную библиографию на эти темы. В библиографию не включены более старые обратные словари /как обратный словарь венгерского языка 1809 г., составленный К.Шимаи, а также обратный список слов в словаре к Риг-веде Х. Грассмана [Лейпциг 1873], обратный словарь латинского языка О.Градевица [Страсбург 1904] и им подобные, о них, между прочим, см. Штиндлова 1960/.

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Употребляемые сокращения

BILAL = Bulletin d'Information du Laboratoire d'Analyse Lexicologique
CL = Cahiers de Lexicologie
ČMF = Časopis pro moderni filologii.
FLP = Forschung, Lehre, Praxis, N$^{\underline{o}}$ 4 /1961/
Lg = Language
SaS = Slovo a slovesnost

3570-dé.

SPRACHSTATISTISCHE UNTERSUCHUNGEN

/Zusammengefasst von S.J. Petőfi/

Auf die Anregung von I. Fónagy /Institut für Sprachwissenschaft, Ungarische Akademie der Wissenschaften/ wurden im Rechenzentrum die sprachstatistischen Untersuchungen in Gang gesetzt. Die Programmierung des von I.Fónagy und T.Szende zusammengestellten Materials erfolgte durch D.Dömölki. Mit diesem Programm wurde ein Teil der Werke der ungarischen Dichter Gyula Juhász und Lőrinc Szabó untersucht. Von den ersten Ergebnissen wurde im zweiten Band der Studien in der Allgemeinen Sprachwissenschaft /Általános Nyelvészeti Tanulmányok II., szerk. Kalmár László és Telegdi Zsigmond/ berichtet. /Vgl. B.Dömölki, I.Fónagy, T.Szende, Lautstatistische Untersuchungen der Umgangssprache auf Ungarisch./

Dieser kurze Bericht stürzt sich auf die erwähnte Arbeit, zieht aber vor allem den maschinellen Teil in Betracht und auch das modifizierte Programm, das von der inzwischen verstorbenen Á. Kalmár verfertigt wurde.

1. Bei der Transkription wurden die Buchstaben der ungarischen Phoneme beibehalten, nur zwischen die Elemente /d.h. Buchstaben/ der nicht eindeutigen Lautverbindungen wurde das Zeichen "/" gesetzt. /Z.B. vas/zár - Eisenschloss -, da es im Ungarischen auch ein Phonem sz gibt; und wenn ein Vokal mit seiner langen Variante nebeneinander steht, wie in le/eelni - ableben - /.

Jedem Wort wurde ein Code zur Bezeichnung der Wortart beigefügt mit Ausnahme der häufigsten Wörter, Welche im Speicher der Rechenanlage unterbracht sind und automatisch auf die entsprechenden Orte verteilt werden. Dabei wurden die folgenden Wortarten unterschieden: Verb, Substantiv, Infinitiv, Adjektiv, Verbaladjektiv, Numerale, Pronomina, Adverb, Partizip, modifizierendes Wort, Postposition, beigeordnetes Bindewort, Aufrufewort und trennbares Verbalpräfix.

Es wird auch das Komma, das Satzteile und Sätze voneinander trennt, unterschieden, ausserdem werden die Imperativ-, Aufrufe-, und Begehrsätze mit einem Zeichen voneinander unterschieden, dabei wird natürlich das Fragezeichen und der Punkt beibehalten.

Der den obigen Prinzipien gemäss vorbereitete Text wird in folgender Gestalt in die Maschine gespeist:

```
szemuekben01 meeg az isteni04 egeknek01
viszszfeenye01 csillog00 egyre01 elhaloobban05,,
fueluekben01 meeg zsong00 a kerubseregnek01
oeroek04 dalaabool01 egy sor01.lenn10 a porban01
meeg emleekeznek00 tuendoekloeoe05 napokra01,,
.............................................
```

/Die ersten Zeilen des Gedichtes "A bukott angyalok" von Gyula Juhász/

2. <u>Die Programme verrichten folgende aufgaben:</u>

a/ Phonemenverteilung

b/ Silbenverteilung nach Silbentypen

/In beiden Fällen wird das Vorkommen am Wortbeginn, am Wortende und das selbstädnige und Gesamt-Vorkommen zahlenmässig und prozentual angegeben./

c/ Digramm- und Trigrammverteilung

/Auch hier wird das Vorkommen am Wortbeginn, Wortende und auch das Gesamtvorkommen zahlenmässig und prozentual angegeben./

Vorläufig gab es keine Möglichkeit, sämtliche zwei- und dreigliedrige Phonemgruppen in Betracht zu ziehen, so gingen wir von den Phonementypen aus, die auf Grund des Ortes und Art und Weise der Lautbildung voneinander unterschieden wurden, und brachten dabei auf gemeinsamen Nenner die nasalen Konsonanten, die Affrikaten, die Verschlusslaute, die Reibelaute, die labialen und illabialen Vokale usw. Die Buchstaben in der Tabelle sind die Representanten dieser Typen.

d/ Wörterverteilung nach der Anzahl der Phoneme, der Silben und auf Grund der Wortarten.

e/ Sätzenverteilung nach der Satzlänge gemessen in Wörtern und Teilsätzen in bezug auf einzelne Satztypen.

Die Lösung der Aufgaben a/, b/, c/ und d/ auf dem Rechenautomaten erfolgt in zwei Schritten:

A/ Die Verarbeitung der Texte, Sammlung von Daten,

B/ Das tabellenförmige Ausschreiben der Ergebnisse.

Diese Auseinanderhaltung wird durch praktische Gesichtspunkte rechtfertigt, u.z. dass die Verarbeitung eines zusammenhängenden Textes - wegen Mangel an Zeit und sonstigen Aufgaben des Automaten - erfolgt nicht in einem Zuge und die Ausschreibung der Ergebnisse in einer Tabelle wird erst am Ende der Verarbeitung nötig.

Das Programm A/ zergliedert sich auch in zwei Teile:

A/1. Je ein Wort wird in den Speicher der Maschine gebracht und inzwischen werden folgende Aufgabe gelöst:
   1. Die Interpretation der mit mehreren Buchstaben bezeichneten Phoneme,
   2. die Festlegung der Silbengrenzen,
   3. die Errechnung der Wortlänge,
   4. die Interpretation der Zeichen, die sich auf die Wortart beziehen.

A/2. Die Verarbeitung des eigespeisten Wortes und das Zählen der nötigen Angaben
   1. nach jedem Phonem,
   2. am Ende jeder Silbe,
   3. am Ende jedes Wortes.

Die Programmteile A/1. und A/2. gelangen nacheinander zur Anwendung: nachdem das Programm A/1. ein Wort eigespeist und es nach den bestimmten Umänderungen im Speicher untergebracht hatte, kommt es zur Anwendung des Programms A/2., das zur Aufgabe das Sammeln von Daten auf Grund des gegebenen Wortes hat. Danach kommt es wieder zu Anwendung des Programms

A/1. usw. Die zu untersuchende Texte werden mittels eines Lochstreifens eingespeist.

Die einzelnen Buchstaben des eigespeisten Wortes, bzw. nach der Umänderung dessen Phoneme, werden durch das Programm in die aufeinanderfolgenden Speicherzellen gebracht /Wörterliste/ und eine Zählerzelle zeigt, in wievielte Zelle der nächste Buchstabe gebracht werden soll. Wenn der eingespeiste Buchstabe mit dem vorangehenden Buchstaben eine Kombination bildet, welche einem Phonem, das mit mehreren Buchstaben bezeichnet wurde, entspricht, so wird das letzte Element der Wörterliste dementsprechend modifiziert und der Inhalt der Zählerzelle nicht verändert.

Der Inhalt der Zählerzelle ist übrigens nach dem Einspeisen des Wortes stets um 1. grösser als die Anzahl der im Wort vorkommenden Laute, so wird auch dadurch die Wörterlänge bestimmt.

So z.B. im Falle des Wortes tél, dass auf den Lochstreifen als teel gelocht wird, arbeitet der Algorithmus folgenderweise:

Buchstabe vom Lochstreifen		t	e	e	l
Wörterliste		t	t	t	t
			e	é	é
					l
Zähler	1	2	3	3	4

Da ein Teil der Phoneme, die mit mehreren Buchstaben bezeichnet sind, durch die Wiederholung von Buchstaben oder Buchstabengruppen gekennzeichnet sind /z.B. ee, ii, oeoe/, um solche Fälle feststellen zu können, braucht man nur die zwei letzten Elemente der Wörterliste vergleichen. /Die Codenummer sind so gewählt, dass in solchen Fällen die Modifizierung immer die Addition derselben Zahl bedeute, so z.B., wenn die Codenummer des e-Lautes 20 beträgt, dann ist die Codenummer des é-Lautes 20 + 40 = 60; wenn die Codenummer des i-Lautes 14 beträgt, dann beträgt die Codenummer des í-Lautes 14 + 40 = 54 usw./

Zum Programm A/1. gehört noch die Festlegung der Silbengrenzen. Dies wird auf Grund folgender Regeln durchgefürt:

Ausser dem ersten Vokal des Wortes bedeutet jeder Vokal eine Silbergrenze, undzwar

ist das vorangehende Phonem auch ein Vokal, so liegt die Grenze nach diesem Phonem;

ist das vorangehende Phonem ein Konsonant, dann fällt die Grenze vor diesem Phonem;

das Wortende ist stets Silbenende;

das Zeichen "/" spielt in aller Hinsicht die Rolle des "Wortendes", bedeutet daher immer Silbenende, und der erste darauf folgende Vokal wird als "erster" Vokal des Wortes betrachtet.

Das Zeichen "/" spielt daher eine Doppelrolle: es trennt einerseits die mehrdeutigen Buchstabengruppen, andrerseits aber auch die in bezug auf die Silbentrennung unregelmässigen Wörter.

Die Codenummer, welche sich auf die Wortarten bezihen, werden vom Programm A/1. mittels einfacher Umwandlung als eine Zahl zwischen 1 und 15 gespeichert. Falls nach einem Wort das entsprechende Zeichen für die Wortart nicht angegeben ist /die Codenummer beträgt in diesem Fall 0/, dann wird schon vom Programm A/2. geprüft, ob dieses Wort unter den häufigsten Wörtern der Wörterliste vorkommt.

Das Programm A/2. besteht im Wesen aus drei Teilen.

1. Aufgaben, die nach jedem Phonem verrichtet werden müssen. Hierher gehört vor allem die Steigerung um 1 des Inhaltes jenes Maschinenwortes, das das Vorkommen des entsprechenden Phonem zählt. Dabei muss beachtet werden, ob es am Wortanfang, am Wortende oder im Wortinnern vorkommt. Auch die Trigramme müssen untersucht werden. Letztere Aufgabe wird folgendermassen durchgefürt: Jedem Phonem entspricht ein Maschinenwort, in welchem die Codenummer der phonetischen Eigenschaft des zu untersuchenden Phonems steht /eine Zahl zwischen 0 und 7/. Diese bilden letzten Endes eine dreistellige Zahl, die die Codenummer des entsprechenden Tri-

gramms darstellt. Diesem Trigramm entspricht auch ein Maschinenwort, dessen Inhalt um eins vergrössert wird. Natürlich wird diese Operation nach dem ersten und zweiten Buchstaben der Wörter nicht durchgeführt.

Alle Phoneme müssen in Betracht gezogen werden auch im Hinblick auf die Festlegung der Silbentypen. Dies erfolgt - da in jedem Silbentyp ein und nur ein Vokal vorkommen kann - dadurch, dass wir einmal die Konsonanten vor dem Vokal und dann eigens diejenigen nach dem Vokal zählen und auf Grund der erhaltenen Zahlen eine zweistellige Zahl zusammenstellen. Auf diese Weise entspricht z.B. die Codenummer 12 einem Silbentyp c-v-c-c, d.h. Konsonant -Vokal -Konsonant -Konsonant.

2. Nach jedem Silbenende wird der Inhalt des Maschinenwortes, welches der auf diese Weise konstruirte Codenummer entspricht, um ein erhöht. Dabei werden die ersten, letzten und inneren Silben des Wortes für sich untersucht.

3. Zu den Aufgaben, die nach dem Erreichen des Wortendes zu verrichten sind, gehört die Erhöhung des Inhaltes desjenigen Maschinenwortes, das zu der Wortlänge nach Phonemen und nach Silben bzw. zur Wortart gehört /falls die Wortart nicht angegeben ist, dann mit Hilfe des Aufsuchens des Wortes im "Wörterbuch" der häufigen Wörter/, nachher müssen die Aufgaben an die Reihe kommen, die sich auf das letzte Phonem, Trigramm bzw. Silbe des Wortes bezihen.

Nach der Verrichtung dieser Aufgaben schreibt die Maschine - dem B/ Programm gemäss - das Ergebnis in folgender Form aus:

```
                    hangok taablaazata
                   /Tabelle  der  Laute/

    /selbständig   am Wortanfang  am Wortende     zusammen/

a     279 /01,51/   215 /01,16/    258 /01,39/    1711 /09,28/
aa        /00,00/    61 /00,33/        /00,00/     627 /03,40/
b         /00,00/   161 /00,87/     31 /00,16/     416 /02,25/
.......................................................................
zs        /00,00/     8 /00,04/        /00,00/      21 /00,11/
      416 /02,25/  3583 /19,43/   3585 /19,44/   18436 /100/
```

```
                     szootagok taablaazata
                    /Tabella der Silben/

    /selbständig   am Wortanfang  am Wortende      zusammen/

-       326 /04,30/   291 /03,84/    18 /00,23/    662 /08,73/
-+      504 /06,65/   258 /03,40/    36 /00,47/    807 /10,64/
-++      37 /00,48/     6 /00,07/     3 /00,03/     47 /00,62/
.....................................................................
+++-+     1 /00,01/       /00,00/       /00,00/      1 /00,01/
       1668 /22,01/  2331 /30,76/  2331 /30,76/   7578 /100/
```

```
                     digrammok taablaazata
                    /Tabelle der Digramme/
                  /64 verschiedene Digramme/
    /selbständig   am Wortanfang  am Wortende      zusammen/

mm     2 /00,01/     2 /00,01/    10 /00,06/      65 /00,45/
mk     1 /00,00/       /00,00/   140 /00,96/     333 /02,30/
.....................................................................
ki    63 /00,43/   269 /01,86/   113 /00,78/    1019 /07,05/
zm       /00,00/     2 /00,01/     1 /00,00/      40 /00,27/
.....................................................................
az   126 /00,87/    50 /00,34/    52 /00,36/     593 /04,10/
ac     6 /00,04/     1 /00,00/     2 /00,01/     116 /00,80/
.....................................................................
     548 /03,79/  3035 /21,02/  3035 /21,02/   14435 /100/
```

trigrammok taablaazata

/Tabelle der Trigramme/
/188 verschiedene Trigramme/

	/am Wortanfang	am Wortende	zusammen/
mmk	1 /00,00/	/00,00/	4 /00,03/
mma	/00,00/	/00,00/	10 /00,09/
....	....	....	....
kmm	/00,00/	1 /00,00/	1 /00,00/
kma	/00,00/	1 /00,00/	20 /00,18/
....	....	....	....
zam	39 /00,35/	23 /00,21/	99 /00,91/
zak	80 /00,73/	41 /00,37/	182 /01,67/
....	....	....	....
	3035 /27,96/	2496 /23,00/	10852 /100/

szavak taablaazata

/Tabelle der Wörter/

	/Nach der Zahl der Phoneme		nach der Silbenzahl		nach der Wortart/
1	416 /10,40/	1	1574 /39,35/	---	98 /02,45/
2	548 /13,70/	2	1337 /33,43/	10	231 /05,77/
....	....	....	....	....	....
15	2 /00,05/	6	4 /00,10/	06	35 /00,87/
16	1 /00,02/	7	1 /00,02/	07	251 /06,27/
	3999 /100/		3999 /100/		3999 /100/

Das Programm, das die Aufgabe e/ verrichtet, ist einfacher, so gehen wir auf die Einzelheiten dieses Programms nicht ein. Nach dem Durchführen dieses Programms schreibt die Maschine die Ergebnisse in folgender Form aus:

mondatok hossza szavakban
/Länge der Sätze nach Wörtern/

	.	?	,	,,	,,,
2	2 /00,79/	0	0	0	0
3	2 /00,79/	0	0	0	0
4	1 /00,39/	0	0	0	0
5	6 /02,37/	0	0	0	1 /00,39/
....	....	....	....	....	....
43	0	0	1 /00,39/	0	0
55	1 /00,39/	0	0	0	0
	185 /73,12/	7 /02,76/	7 /02,76/	3 /01,18/	51 /20,15/
	253 /100/				

mondatok hossza tagmondatokban
/Länge der Sätze nach Teilsätzen/

	.	?	,	,,	,,,
1	35 /13,83/	1 /00,39/	2 /00,79/	1 /00,39/	7 /02,76/
2	62 /24,50/	2 /00,79/	1 /00,39/	2 /00,79/	12 /04,74/
....	....	....	....	....	....
7	2 /00,79/	0	0	0	1 /00,39/
9	0	0	1 /00,39/	0	0

Ausserdem wird auch die Länge der Teilsätze nach Wörtern tabellenförmig angegeben. /Die angegebenen Tabellen beziehen sich auf ein Gedichtzyklus von Gyula Juhász./

\+ + +

Die Bewertung der bisherigen Ergebnisse ist im in der Einführung erwähnten Aufsatzes zu finden. Die Untersuchungen sind noch im Gange. Nach dem Aufarbeiten eines bedeutenden Teiles der Werke von Lőrinc Szabó, Gyula Juhász und Árpád Tóth, werden auch Prosawerke, nämlich Werke von Dezső Szabó und Ferenc Móra, aber auch wissenschaftliche Werke, nämlich die phonetischen Aufsätze von Gyula Lazichius und András O. Vértes, in Angriff genommen.

Die maschinelle Verwirklichung dieser statistischen Untersuchungen obliegt zur Zeit dem Verfasser dieses Referats.

Рецензия на статью И.А.Мельчука
"О МАШИННОМ ПЕРЕВОДЕ С ВЕНГЕРСКОГО ЯЗЫКА НА РУССКИЙ"
(Проблемы кибернетики, И.М., 1958 г.) стр. 222-264.

Ш. Кони

1. Из многочисленных публикаций по вопросам машинного перевода, вышедших в свет за последние годы, особого внимания заслуживает у нас в Венгрии статья И.А. Мельчука, которая появилась в сборнике статей "Проблемы кибернетики" /выпуск 1/, издаваемом Государственным издательством физико-математической литературы в Москве под редакцией А.А. Ляпунова.

1.1. И.А. Мельчук приступил к работе над опытным вариантом правил для машинного перевода с венгерского языка на русский вслед за работой над опытом машинного перевода с французского языка на русский[1]. Помимо практического значения, машинный перевод с венгерского языка на русский представляет для И.А. Мельчука интерес и в более общем плане. "Во-первых, некоторые структурные особенности венгерского языка оближают его с рядом других языков /он является агглютинирующим как тюрксине языки, как в германских языках в нём широко распространены сложные слова и отделяемые приставки; функцию предлогов в нём выполняют послелоги и т.д./... Во-вторых, в связи с тем, что порядок слов в венгерском языке очень сильно отличается от привычного порядка слов в русском языке... пришлось разработать специальную систему правил для преобразования порядка слов в получившейся после перевода русской фразе." /стр. 222/

1.2. Эти замечания автора следует дополнить следующими данными:[1] В венгерском языке действует закон гармонии и уподобления гласных. В большинстве слов встречаются либо только гласные переднего, либо - только заднего ряда. Почти все грамматические суффиксы имеют, в зависимости от этого, два варианта. Но если найден падежный оформитель, определён и падеж, так как в агглютинативных языках каждый аффикс имеет лишь одно значение.[2] Хотя имеется большое количество падежей (что затрудняет машинный перевод), имена склоняются в основном одинаково (даже во множественном числе употребляются те же оформители, что и в единственном), и это позволяет сократить таблицы суффиксов. Притом[3] в функции препозитивного определения имена (прилагательные, числительные, существительные и причастия) не согласуются с определяемым словом.[4] Для выражения грамматических отношений слов в предложении в венгерском языке служат послелоги и *падежи*.[5] Слог (слово) за небольшим исключением, может начинаться или с гласного или только с одного согласного. В силу этого, а также гармонии гласных слога (слова) могут быть менее разнообразными, чем, скажем, русские. Этим явлением об'ясняется[6] наличие в венгерском языке большого количества лексико-грамматических омонимов самых разных типов, например, *dob* "барабан" и "бросает", *dobban* "в барабане" и "издаёт глухой звук", *elég* "довольно" и "сгорит", *terem* "зал", "уродится" и "моя площадь", *mentek* "я спасаю", "вы идёте", "они шли" и "освобождённые /от чего-либо/" и т.д. Случаи омонимии, на которой основаны в венгерском языке всякие каламбуры, очень затрудняют ход анализа. Автор об этом не упоминает, и его различение омонимов /стр. 238-240/ едва ли можно признать достаточным.[7] В агглютинативных языках многочисленные суффиксы, признаки и окончания присоединяются к корню слова. Было бы интересно узнать, сколько морфем может стоять, с "машинной" точки зрения, позади основы /не корня!/. К сожалению, автор об этом ничего не говорит, однако судя по таблицам 1, 2 и 3 /стр. 233-235/ и примерам *módosulásaival*, *nehézségeire* /стр. 264/, можно полагать, что, по его мнению, таких морфем три /подробнее об этом будет сказано ниже/. По нашим представлениям позади основы может стоять шесть морфем, например, *legfelhasználhatóbbakéitól* "от принадлежащих наиболее используемым", "от принадлежащих тем, кого можно лучше всего использовать", где *használ* - основа, *hat* - суффикс потенциального глагола, *-ó* - формант причастия, *-bb* - признак сравнительной степени,

-ak – признак множественного числа, -éi – осложненный притяжательный признак обладателя, -tól – падежный оформитель аблатива, не считая префикса превосходной степени leg- и отделяемой приставке -fel-, предшествующих основе. /Основу нет необходимости разбирать./ Читатель легко может себе представить, с какими трудностями сталкивается машинный анализ венгерских слов.

2. После замечаний общего характера перейдём к разбору отдельных частей рецензируемой статьи.

2.1. Но прежде мы должны признать, что хотя И.А.Мельчук не мог и не ставил своей задачей детально разработать правила машинного перевода с венгерского языка на русский, ведь его статья является только первым опытом в данной области "и не претендует на полноту и окончательность результатов" (стр. 255), однако получилась такая ценная работа, с которой можно только согласиться.

Мы присоединяемся к мнению автора, который считает, что при поиске будет более удобным, если "короткая основа стоит позади всех более длинных, в которых она целиком содержится" (стр. 224). Мы согласны с тем, что для существительного и прилагательного указан ряд (задний или передний) (стр. 225 и "Словарь основ" на стр.256-262), что суффиксы существительных и прилагательных размещены в таблицах двумя параллельными колонками (стр.233-234), что в глагольном окончании s, sz, z, и гласные переднего ряда заменяются (стр.236), что "поиск ведётся сразу и в словаре, и в таблицах с попеременным обращением то туда, то сюда" (стр.232). К несомненным достоинствам данной работы следует отнести и применение "дополнительных указаний" (стр. 238,245), "особенностей" (стр.238,264) и "послеложного кода" (стр.227,228,263) и т.д. Мельчук совершенно прав, когда говорит о том, что первым и важнейшим этапом машинного перевода должно быть выделение синтагм (стр.254) и т.д.

2.2. Давая в целом положительную оценку проведённому исследованию, необходимо отметить и некоторые противоречия и отдельные явные промахи в нём.

3. На странице 226 названия "суффиксы I,II и III типа", а также "Послелоги I и II типа" нам кажутся неудачными. Они мешают пониманию, и читателю трудно разобраться в них, о чём свидетельствует и то, что и сам автор перепутал их. (Смотри об этом ниже, когда будет сказано о послесложном коде). Лучше было бы, где это возможно, употреблять принятые термины (прилепы, признаки и т.д.). Но мы подчёркиваем, что эти критические замечания касаются лишь только названий суффиксов, а не их распределения, против чего на первых порах машинного перевода с венгерского языка на русский нельзя серьёзно возражать. Разумеется, не вызывает возражений и то, что таблицы 1, 2 и 3 (стр. 233-235) содержат в себе далеко не все венгерские суффиксы.

4. На странице 226 ошибочно указывается, что после суффиксов - u/-ü не могут стоять другие суффиксы. Автор как бы забывает о том, что о помощью суффиксов -u/-ü образуются прилагательные от существительных, а прилагательные могут принимать падежные окончания, которые совпадают с падежными окончаниями существительных, например: ellenkező irányuval, не считая признака множественного числа - k и притяжательного признака обладателя -é. Некоторые из сложных прилагательных принимают даже признак сравнительной степени -bb, например: nagylelkübb "более великодушный".

5. На странице 227 автор об'ясняет последожный код. "Перевод послелогов II типа (т.е. падежных оформителей или прилеп[2]) ведётся с помощью специальных "Таблиц перевода послелогов", иначе - "Таблиц управления".

5.1. Тут необходимо отметить, что собственно речь идёт не о всех послелогах II типа, подразделяемых автором на три группы (стр. 226-234), а только о суффиксах существительных III типа (стр. 226 и 234), а также о вариантах оформителя винительного падежа, оказывающихся в группе II типа, значит о падежных оформителях, которые в грамматиках венгерского языка называются viszonyragok.

5.2. В "Таблицы управления" не включены ни суффиксы II типа (лично-притяжательные показатели и показатели множественного числа), ни суффиксы (képző) - u/-ü, хотя они по распределению автора являются тоже послелогами II типа (стр. 226, 227, 233). Автор не принимает во внимание, что "суффиксы II типа" частью могут, частью не могут управляться венгерскими глаголами. Сравните распространение в венгерском языке словосочетания van/nincs valamije "у него есть/нет чего-либо" и т.д. (Глагола со значением "иметь" в венгерском языке нет).

5.3. Из последнего примера вытекает, что словосочетание - nak/-nek lenni (van) установлено ошибочно (стр. 259 и 263), а правильнее дать оборот van/nincs vmije с послеложным кодом (с таблицей перевода послелогов) такого рола: -nak/-nek =у + с (родительный падеж). Вышеуказанное относится и к примеру 12 (на стр. 253): ... s ezért a legtöbb nyelvnek igen sok idegen eredetü szava van, хотя этот пример с точки зрения перевода неудачен, так как в данном предложении суффикс -nak/-nek передаётся в русском языке предлогом в и предложным падежом существительного. (Ср. и "Таблицу управления" № 7 на стр. 263).

Следует отметить, что в венгерском языке широко распространены словосочетания van/nincs vmije, в то время как неполные предложения van/nincs neki "у него есть / нет" встречается только в разговорном языке, и то редко.

5.4. Автор полагает (ср. примечание в сноске на стр. 253), что в вышеупомянутом примере 12 имеется налицо тот же оборот при lenni (van), что и в предыдущем примере 11: Különösen erős volt azonban a magyarság kapcsolata a kazárokkal (стр. 252). Но если точнее разобрать эти два предложения, следует установить, что в одном предложении есть притяжательное словосочетание magyarság kapcsolata, а в другом - никакого притяжательного словосочетания нет, а слово nyelvnek стоит в дательном педеже (dativus possessivus), который в таких конструкциях передаётся обычно предлогом у и родительным падежом существительного. Сравни словосочетание a fiu könyve "книга мальчика" и предложение a fiunak könyve van "у мальчика есть книга".

5.5. Далее проблему послеложного кода нужно дополнить замечанием о том, что венгерские глаголы могут управлять не только падежными оформителями, но и собственными послелогами (névutók), например, érdeklődik vki/vmi iránt "интересоваться кем-чем", harcol vki/vmi ellen "бороться с кем- с чем" и т.д.

5.6. Что касается послеложного кода, в графе 4 "Словаря основ" (стр. 255-262) и "Таблиц управления" (стр. 263), бросаются в глаза ошибочные управления beáll vmiben/vmin (?) "наступать в чём-либо, на чём-либо" (?), szó lenni (van) vminek (?) "идти речь чему-либо" (?). Подобное ложное управление мешает правильному установлению формальных связей слов в фразе (ср. стр. 228).

5.7. Нам представляется, что не надо давать в "Словаре основ" (стр. 261) при существительном szükség послеложный код, так как он нужен только при обороте szüksége van vmire (стр. 262).

5.71. В "Словаре основ" слова független и közeledik имеют явно ошибочный послеложный код: прилагательное független код 2 вместо 13, а глагол közeledik код 4 вместо 11.

5.72. При слове tulnyomóban указание на оборот вместо графы 3 неправильно напечатано в четвёртой (стр. 262).

5.8. В заключение ещё несколько слов о послеложном коде и "Таблицах управления". Думается, что И.А.Мельчук неправомерно расширил понимание управления: он включил в "Таблицы управления": 1. "падежные оформители, которые зависят от данного глагола и не могут быть переведены до его перевода"; 2. "послелоги, которые, хотя и зависят от глагола, но имеют (в данном случае) свой основной перевод - по таблице суффиксов существительных" (стр. 227); 3. "послелоги, которые грамматически вообще не связаны (!) с глаголом (они примыкают (!) к управляемому члену) и переводятся независимо от него" (стр. 228).

Здесь, как можно установить, не различается с необходимой последовательностью "сильное" управление и "слабое"[3]. Хотелось бы отметить, что 1. и примыкание является грамматической связью, 2. даже самое "слабое" управление - это управление, а не примыкание, 3. перечислить все послелоги II типа, управляемые данным словом, невозможно. Например, в "Таблице управления" глагола beszél (стр. 227. и 263) помещено только три падежных оформителя (-ról/-ről, -nak/-nek, -ban/-ben), но нам кажется, кроме этих суффиксов, с полным правом можно перечислить почти все прилепы: beszél mikrofonba, a fiához, az ablakból, elismerésért, hazáig, a gyülésen, bortól, magyarul, társával и т.д. и собственные послелоги (névutók): beszél a fa alatt, a ház mellett, a hid alól, a kórház mögött, a folyón tul, a gyülés előtt, az előadás után и т.д.

5.9. По нашим представлениям в "Таблицах управления" нужно поместить только типы "сильного" управления, т.е. те случаи, когда глагол (прилагательное и т.п.) обусловливает падежную форму подчинённого имени или местоимения, хотя различать случаи сильного и слабого управления иногда очень трудно, и это различение совершается интуитивно.

5.91. Следовательно нельзя, например, приписывать послеложный код "1" (в таблице 1 на стр. 263 оказываются послелоги II типа -ban/-ben и -on/-en(n)) глаголам áll, él, marad, müködik, nincs, terjed (см. "Словарь основ" на странице 256-262), так как эти глаголы не обусловливают с достаточно большой вероятностью падежную форму подчинённого им слова (Слабое управление).

5.92. С другой стороны, по нашим, хотя и суб'ективным представлениям, например, таблица управления к глаголу beszél (стр. 227 и 263) вместо падежных оформителей -ról/-ról, -nak/-nek, -ban/-ben должна содержать в себе прилепы -at/-et(t), -ról/-ről, -val/-vel ("говорить что; о ком-чём, с кем"). (Сильное управление).

6. Нам кажется, что между правилом I.4., согласно которому "при анализе тех или иных конструкций прилагательные, причастия и наречия не учитываются" (стр. 229) и между дополнительным указанием слова is в "Словаре основ" (стр. 258), где говорится: "ставится перед словом, после которого стояло" - есть противоречие. Ни в правиле I.4., ни в дополнительном указании мы ничего не читаем о том, как будет при

синтезе, если венгерское слово (существительное) имеет при себе определения. По указанию синтезирующего правила Г.3. (стр. 250) наречия ставятся перед словом, от которого они зависят. (По графе 2 "Словаря основ" слово is – наречие (?)). Итак вопрос остаётся нерешённым, и, например, конструкции a jó fiu is, a kertben szaladgáló fiu is передаются на русский язык "добрый и мальчик", "бегающий в саду и мальчик" вместо "и добрый мальчик", "и бегающий в саду мальчик".

7. По правилу I.6. (стр. 229) "последующая информация отменяет предыдущую". Это правило, вероятно, относится, в первую очередь, к определению времени и вида глаголов (стр. 246), к выработке дополнительного указания в правилах перевода числительных (стр. 245) и к суффиксам существительных III типа (стр. 234). Но автор ничего не говорит о том, как будет дальше, если последующая информация совпадает с предыдущей. (Имеются в виду окончания существительных -aik/-eik и т.п., о которых будет сказано ниже.)

8. В таблице суффиксов существительных (стр. 233) нет осложнённых лично-притяжательных окончаний -ai/-ei, а есть отдельно притяжательные суффиксы 3-его лица единственного числа -a/-e и отдельно показатель множественного числа -i. Повидимому, (указаний нет на протяжении всей статьи) путём сложения получается результат: 3-е лицо при одном обладателе со многими обладаемыми. И.А. Мельчук приводит примеры módosulásaival, nehézségeire (стр. 264), но нет таких примеров, как fái, kapui, где (при существительных, оканчивающихся на гласный звук) один суффикс -i указывает на 3-е лицо при одном обладателе со многими обладаемыми.

8.1. Вследствие того, что в вышеупомянутой таблице 1 (стр. 233) суффиксы -k и -i имеют одинаковое значение "множественное число", такие слова, как fésük "расчёски" и fésüi "его расчёски" не различаются, слово fésüi не указывает на обладателя. Совсем неясно, что будет с такими словами, как házaik "их дома", где по таблице 1 машина находит притяжательный суффикс 3-его лица единственного числа -a, показатель множественного числа -i и ещё раз показатель множественного числа -k. К сожалению, не рассматривается в работе, как анализировать, например, окончание -aink (házaink "наши дома"), ведь по таблице 1 -a - притяжательный суффикс 3-его лица единственного числа, -i- имеет значение "множественное число", -nk - притяжательный суффикс 1-ого лица множественного числа, значит, третья информация противоречит первой. По-нащему, в целях решения этого вопроса нужно разместить в таблице осложнённые лично-притяжательные окончания -aim/-eim, -aid/-eid, -ai/-ei, -aink/-eink и т.д.

9. В таблице суффиксов прилагательных (стр. 234) после суффиксов сравнительной степени -bb /-abb /-ebb нет дефиса, значит, не учитывается, что эти суффиксы могут иметь при себе и другие суффиксы: показатели множественного числа, прилепы и т.д. (Сравни вышеприведённый пример legfelhasználhatóbbakéitól).

10. В таблице глагольных суффиксов (стр. 235) грамматические омонимы не различаются с нужной последовательностью, например, не учитывается, что личное окончание иковых глаголов -ik встречается не только в 3-ем лице единственного числа безоб'ектного спряжения (ő eszik "он ест"), но и в 3-ем лице множественного числа об'ектного спряжения (ők eszik ezt "они едят это").

10.1. По пояснениям к этой таблице (стр. 236, пункт 6) "информация к окончанию, состоящему из двух суффиксов, получается путём поразрядного сложения информаций к каждому из суффиксов". Оказывается, что при сложении признака прошедшего времени -t с личными окончаниями -ák, -ak, -a, -unk получается правильная информация, но если сложить суффикс -j - с соответствующими окончаниями, то увидим, что только осложнённый суффикс -j-on указывает правильно на повелительное наклонение; -j-unk же считается ошибочно суффиксом из'явительного наклонения вместо повелительного. К суффиксам -j-ák, -j-a, -j-uk из таблицы получается информация "настоящее время (из'явительного наклюнения)" (Сравни пояснения к таблице 3, пукт 2, на стр. 236). Но так как в этих суффиксах совпадают формы из'явительного и повелительного наклонений, они рассматриваются и правилами VIII.A.1.a. (стр. 246) и VIII.A.1.б. (стр. 247). К сожалению, правило VIII.A.1.б. считает омоформой (из трёх) один суффикс -j-uk.

10.2. В таблице глагольных суффиксов (стр. 235) суффиксам -janak, -junk и -on явно неправильно приписано примечание "ставить "бы" после глагола", так как оно может относиться по праву только к окончаниям -nák, -nánk и т.д. (где речь идёт об условном наклонении: "читали бы" и т.п.); после русских эквивалентов окончаний -janak, -junk, -jon (в придаточных предложениях после прошедшего времени) нельзя ставить "бы", а нужно передать стоящий влево от глагола союз hogy через "чтобы". Эти примечания относятся и к правилу VIII.A.2. на странице 247, где якобы в знак неправильности применения частицы "бы" трижды получается команда "бы" опустить", а четвёртая команда VIII. A.2.б. оставляет, как было на таблице "прошедшее время несовершенного вида" плюс "бы". ("Читал бы" вместо "чтобы читал").

10.3. В глагольных окончаниях И.А.Мельчук заменяет e на a, ö на o, ő на ó, ü на u, а также s, sz, z на j (стр. 236, "Пояснения к таблице 3", пункт 1). Это временное решение допускается, так как отсутствуют личные окончания 1-ого лица единственного и множественного числа -em, -ek и т.д. и 2-ого лица единственного и множественного числа -ed, -itek и т.д. (ср. стр. 232), к которым эта замена неприменима. Но отметим, что и среди личных окончаний 3-его лица есть такие, которые переходя через замену (замены), искажаются до неузневаемости. Например, окончания -jen, -sen, -szen, -zen приводятся к окончанию -jan (вместо -jon) ; после замены -sék будет -ják (вместо -jon и -ják с повелительным значением). Приводя глаголы essék "пусть падает, чтобы падал" и keressék "пусть ищут, чтобы искали" к соответствующим формам "нормального" глагола vár, мы получаем в обоих случаях várják "ждут, пусть ждут, чтобы ждали", вместо várjon "пусть ждёт, чтобы ждали" и várják "пусть ждут, чтобы ждали".

10.4. В дополнении к таблице 3 (стр. 236) не учитывается, что позади слова, оканчивающегося на -ható могут стоять и другие морфемы(Ср. наш пример legfelhasználhatóbbakéitól).

10.5. В этом же дополнении (пункт 2) приводится "причастие прошедшего времени" (обозначение Pp, ср. стр. 223), оканчивающееся на -hatott. Необходимо отметить, что причастие такого рода в венгерском языке совсем неизвестно, и слово с окончанием -hatott может быть только личной формой потенциального глагола. Следовательно, "причастие" на -hatott совершенно неправильно и переводится (стр. 236).

11. Хотя и сам автор считает свои правила различения омонимов недостаточно точными (стр. 255), и по нашему имению, различение омонимов в венгерском языке является весьма сложным вопросом, всё-таки хотелось бы выявить некоторые недочёты и в этой части работы.

11.1. Автор забывает о том, что суффиксы существительных III типа -nak/-nek совпадают с личными окончаниями глагола, и поэтому, например, слово dobnak "барабану, бросают" по правилам III.A.1., III.A.11., III.A.11.0. (стр. 239) считается всегда существительным, хотя оно может быть и глаголом.

11.2. На странице 239 правила III.A.0. и III.A.01. - неточны. Если взять такое предложение, как egy sejt valamit, kettő nem sejt semmit "один предугадывает что-то, двое не предугадывают ничего", то по вышеупомянутым правилам слово sejt "предугадывать, ячейка" в виду того, что перед ним есть числительное (детерминатив), считается всегда существительным, хотя оно в настоящем предложении - глагол.

Другой пример: в предложении egy sejti, kettő nem sejti "один предугадывает это, двое не предугадывают" слово sejti по правилам III.A.1., III.A.11., III.A.11.1., а также III. A.0. и III.A.01. считается существительным, между тем оно в этом предложении глагол.

11.3. На странице 240 мы возражаем против правила III. В.1., согласно которому, если у омоформ SA (существительное - прилагательное) есть окончание, SA является существительным. Наше возражение относится и к особенности № 2 (стр. 264). Контрпримером может служить предложение такого рода: ezek csehszlovák tv-készülékek, ezek pedig magyarok "это чехословацкие телевизоры, а это венгерские" (а не"венгры").

12. В правилах перевода существительных (стр. 242-244) в нескольких местах нарушена дихотомия. Чаще всего это выражается просто в словах правила, т.е. перед машиной не ставится вопрос о выборе из двух возможностей (ср. стр. 231). Например, в правиле V.Б.00.1. стоит "проверить, в каком падеже будет С"..."; следовало напивать "проверить, будет ли в именительном падеже С"...". А дальше уже правильно: в правиле V.Б.00.10. стоит "... не в именительном падеже...", а в V.Б.00.11. - "...в именительном падеже..." (стр. 242).

Таким же образом нарушена дихотомия и в правилах V.В.11.00.1. и V.В.11.01.(стр. 244).

12.1. Но есть и другой случай. Напрасно будем исправлять слова правила V.Б.1. (стр. 243), последующее правило с ответом "нет" непременно отсутствует. Кроме того в правиле V.Б.1. не различаются суффиксы II и III типа (ср. правило V.Б.11.) и нет команды, нет даже упоминания о суффиксах II типа -u/-ü. В целях частичного исправления правил и включения суффиксов -u/-ü нужно было бы переработать правило V. Б.1. и последующие правила следующим образом:

1. Если у S' есть суффикс II типа - проверить, не -at/-et (t) ли это.

10. у S' есть суффикс II типа, но не -at/-et (t) - (значит есть -u/-ü) - взять информацию из таблицы 1.

11. Если у S' суффикс -at/-et (t) - проверить, нет ли nem перед глаголом, управляющим S".

12.2. На странице 243 к правилу V.Б.11. нет предыдущего правила. (Ср. правила V.Б.0. и V.Б.1.).

12.3. Судя по правилам V.Б.11.10. и V.Б.11.10.0. (стр. 243) , можно полагать, что, по мнению автора, такого рода притяжательного словосочетания, как orvosnak kocsija (где впереди или позади существительного с прилепом -nak/-nek нет детерминатива) не существует. Но ведь автор и сам приводит контрпример nyelvcsoportok történetének keretében "в рамках истории языковых групп" (стр. 264, фраза № 20). Так как он об этом забывает, русским эквивалентом суффиксов -nak/-nek в словосочетаниях подобного рода по "Правилам перевода послелогов" будет дательный падеж (вместо родительного).

12.4. Конструкция olcsó husnak hig a leve "навар дешёвого мяса - жидок" (стр. 243) в виду того, что по правилу I.4.(стр. 229) при анализе прилагательное не учитывается, и конструкция olcsó husnak a leve "навар дешёвого мяса" отождествляются. Отметим только, что эти две конструкции далеки друг от друга.[4]

12.5. В правилах определения лица существительного (стр. 243) нет вступительного правила: "Проверить, есть ли у S' притяжательный суффикс".

12.6. Слова "кроме -nak/-nek "в правиле V.B.11.0.. частично противоречат правилу V. B.11.1. (где этих слов нет), частично правилам V.B.11.10. и V. Б.11.10.0. (См. выше).

12.7. Правило V.B.11. (стр. 243)не принимает во внимание такие предложения, как a szomszédnak leégett a háza "у соседа сгорел дом", a kaszának eltörött a pengéje "у косы сломалось лезвие", т.е. фразы, в которых личный глагол отделяет существительное с суффиксом -nak/-nek от существительного с притяжательным суффиксом.

12.8. Не забывая о том, что разработанные И.А.Мельчуком в алгоритмической форме правила перевода с венгерского языка на руссий в таком виде, как они есть, не могут быть запрограммированы, отметим только, что некоторые из этих правил, по нашему мнению, содержат слишком много условий и команд. Примеры: в правиле 11.00.1. (стр. 231) команда такова: "присоединить её (глагольную приставку) спереди к искомому слову, заменять искомое слово на образованное таким образом и снова искать её в словаре". Другой пример - команда в правиле 11.11.0. : "прекратить поиск, взять словарную статью слова, найденного по правилу 11.11., проверить, нет ли остатка, и вернуться к правилу 11.10.0. или 11.10.1." (стр. 232). Ещё один пример - правило V.B.11.00.0. (стр. 244): "Влево от C' нет местоимений 1 и 2-ого лица в именительном падеже - поставить перед C' "свой"(род, и число определяется по ближайшему слева, хотя бы и за пределами фразы существительному)". Остановимся на последнем примере. Так как категория числа в притяжательном суффиксе не различается, по этому правилу передаются существительные венгерских предложений с разными значениями. Мы приводим здесь только их русские переводы: 1. "он читает свою книгу", 2. "он читает его (её) книгу", 3. "они читают его (её) книгу", 4. "он читает их книгу", 5. "они читают их книги", 6. "они читают свои книги". Следовательно, по нашему мнению, нужно было бы разбить такое правило на несколько.

13. На странице 245 к правилам VII.А. мы недосчитываем вступительного правила: Проверить, есть ли у N’ окончание".

13.1. К правилам VII.Б. тоже нет вступительной команды: "Проверить, не стоит ли N или слово с пометой " N " перед S’". Кроме того тут переменены альтернативы 0. и 1., ведь "0" даёт положительный ответ.

13.2. В дополнительных указаниях к правилам перевода числительных (стр. 245,VII.Б.) не учитывается, что из количественных числительных,оканчивающихся на 1,2,3,4, - числительные 11,12,13,14, а также количественные числительные, оканчивающиеся на 11,12,13,14, требуют постановки в русском языке существительного в родительном падеже множественного числа.

14. В заключение, говоря об алгоритмической записи разных правил, можно также отметить, что порядок 0-1 ("нет – "да") нам кажется неудобным, лучше был бы обратный порядок, чтобы как можно раньше получить положительный ответ.

15. На странице 264 фраза 14 Hiányzik azonban azoknak a pszichikai folyamatoknak az analizise является незаконченным предложением из-за наличия в (главном) предложении коррелятивного местоимения azoknak. Без этого местоимения фраза будет правильной.

16. В перечне литературы на странице 264 приведён "Краткий грамматический справочник венгерского язика" К.Е. Майтинской (М., 1951). Такое произведение нам неизвестно. Автор, наверное, имеет в виду словарь "М.Г. Кахана, К.Е. Майтинская, Венгерско-русский словарь, М., 1951 г.", в конце которого есть такой справочник.

17. Наименее удачной частью рецензируемой статьи мы считаем страницы, посвящённые вопросу механического членения венгерских существительных (стр. 233-234, 236-238).

17.1. Мы можем только пожалеть, что автор не включил в таблицу суффиксов существительных притяжательный признак обладателя -е, например, a hatalom a népé "власть принадлежит народу". По нашему мнению, надо было бы поместить в таблице и признак -é, на первых порах хотя бы только в этом простом виде (где позади него не стоит другая морфема). Когда после притяжательного признака -é присоединяются падежные окончания, признак может совпадать с лично-притяжательным окончанием -е, которое перед большинством прилепов переходит в -é. Ср. слова elnökéről и elnökéről в предложениях a kolhoz elnökéről beszéltünk "мы говорили о председателе колхоза" и nem az ön könyvéről volt szó, hanem az elnökéről "речь шла не о вашей книге, а о книге, принадлежащей председателю".

17.2. Судя по замечанию автора, что в его работе "нет правил поиска, анализа и перевода сложных причастий типа jégboritott csucs "покрытая льдом вершина" (стр. 255), мы полагаем, что он считает вопрос сложных существительных решённым.

Однако, нам представляестя, что из-за наличия в венгерском языке сложных существительных и закона гармонии и уподобления гласных, нельзя избежать введения дополнительных правил в механическом членении существительных.

17.3. Имеются в виду не только -jal/-jel (варианты суффиксов -val/-vel), которые по правилу II.10.11.0. (стр. 232) разлагаются на суффикс -j- (хотя он по таблице и не имеет значения) и на бессмысленное -al/-el, но и такие сложные существительные, в которой начало второй основы совпадает не с одним суффиксом таблицы 1, а с двумя, тремя такими суффиксами. Например: сложное слово hajójárat переводится при таком членении: hajó - корабл -, -já- (= ja = a) - притяжательный суффикс 3-его лица единственного числа, - ra - на + С (винительный) и - t винительный падеж. Нам не ясно, действует ли тут правило I.6. /"последующая информация отменяет предыдущую"/, или же второй остаток - t по таблице 1 окажется бессмысленным, в силу того, что в той же таблице позади суффикса -ra нет дефиса. Но любой приём будет неправильным, ведь járat - это вторая основа, и сложное слово hajójárat имеет значение "курс корабля, парохода". Другой пример: сложное существительное vasakaratnak "железной воле". В результате поиска получим: vas - желез-, - ak - множественное число, - a - притяжательный суффикс 3-его лица единственного числа, - ra - на + С (винительный), - t - винительный падеж, - nak - С (дательный). Ещё один пример: végeredmény "конечный результат". Слово по правилам разлагается так: vég- конец, -e - притяжательный суффикс 3-его лица единственного числа, - re - на + С (винительный), -d (по более полной таблице) - притяжательный суффикс 2-ого лица единственного числа, - m (по более полной таблице) - притяжательный суффикс 1-ого лица единственного числа, - é(=e) - притяжательный суфф. 3-его лица ед. числа, -n- в+С (предложный), и только -y не оказывается в таблице.

17.4. Чтобы решить вопрос правильного членения венгерских сложных существительных, мы сделали попытку составить дополнительные правила[5], которые в основном представляют собой правила последовательности морфем существительных. (Словсобразовательные элементы не учитываются).

Правильным считается анализ, когда морфемы следуют одна за другой в таком порядке:

1. основа - (прилеп)
2. основа - k - (прилеп)
3. основа - é - (прилеп)
4. основа - éi - (прилеп)
5. основа - k - é - (прилеп)
6. основа - k - éi - (прилеп)

В приведённых схемах -é и -éi обозначают самих себя, т.е. притяжательные признаки обладателя, но -k, кроме "показателя множественного числа" имеет и значение "лично-притяжательное окончание". (Под лично-притяжательными окончаниями мы понимаем и осложнённые - aink/-eink, - aik/-eik и т.д. См. выше.) Наконец, прилеп, как факультативный элемент, заключается в скобки.

Если ни одна из схем не подходит, нужно искать весь остаток не в таблице суффиксов существительных, а в словаре основ. Схема не подходит, если один из элементов повторяется: не допускаются, например, два прилепа или два суффикса из группы, обозначаемой буквой k. Ср. вышеприведённые примеры hajójárat, vasakaratnak, végeredmény. В слове vasakaratnak оба "суффикса" -ak и -a входят в группу суффиксов, обозначаемую буквой k (у И.А.Мельчука суффиксы I типа), поэтому нужно вернуться к словарю основ. Но не подходит схема и тогда, если при анализе машина обнаруживает какую-то бессмысленность. Пример: névjegyzék "поимённый список". Первый анализ: név - имя, - je лично-притяжательное окончание, - gyzék - бессмысленность; следовательно весь остаток jegyzék мы должны искать в словаре основ. Это также, как и у И.А.Мельчука.

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Принимая во внимание достоинства рецензируемой статьи и оригинальность мысли, надо признать, что все критические замечания не в состоянии серьёзно уменьшить значение этой работы. Мы должны пойти по пути, проложенному И.А. Мельчуком, ведь его статья послужит солидным фундаментом для всех, кто возьмётся за разработку более обширных правил машинного перевода с венгерского языка на русский.

Сноски

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2. Правильно: прилепов. Ср., например, К.Е.Майтинская, Венгерский язык, ч.I.М.,1955, стр. 130 /примечание в сноске/, 142.

3. О вопросе "сильного" и "слабого" управления в венгерском языке, см. К.Е.Майтинская, Венгерский язык, Ч.III.М., 1960, стр. 69-76.

4. См., например, A mai magyar nyelv rendszere. Leiró nyelvtan, I. (Szerkesztette: Tompa József), Budapest, 1961., 280.l.

5. См. работу Kónyi Sándor, A magyar-orosz gépi forditás néhány problémája,
в сборнике статей
Általános nyelvészeti tanulmányok II.
A matematikai nyelvészet és a gépi forditás kérdései (Szerkesztette:
Kalmár László és Telegdi Zsigmond).
Budapest.
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ÁLTALÁNOS NYELVÉSZETI TANULMÁNYOK I.

Szerkesztette Telegdi Zsigmond /Studien in allgemeiner Sprachwissenschaft, Band I. Redakteur Zs. Telegdi/, Budapest, Verlag der Ungarischen Akademie der Wissenschaften, 1963.

E. Moravcsik

Der Band Studien in allgemeiner Sprachwissenschaft - erster Band einer gleichnamigen Publikationsserie - setzt nicht bloss die Fortsetzung der bedeutenden Traditionen der ungarischen Sprachwissenschaft fort, sondern füllt auch eine bei uns in den letzten Jahren recht fühlbar gewordene Lücke auf diesem Gebiet aus. Sein Ziel steht erstens in der Bekanntmachung der bisher in Ungarn nur in engen Kreisen bekannten Ergebnisse der modernen, ihrer Sprachanschauung nach strukturellen, ihren Methoden nach exakten Sprachwissenschaft. In dieser Hinsicht schliesst er sich einigen weiteren Neuerscheinungen, Aufsätzen und ins Leben gerufenen Ausgabenreihen, die die Dokumente und jüngsten Ergebnisse der modernen Sprachphilosophie, der mathematischen Logik, der Kybernetik und des modernen Sprachunterrichts veröffentlichen, an. Ferner werden jene Ergebnisse in etlichen Artikeln des Bandes bedeutenderweise weiterentwickelt.

Die in 700 Exemplaren erschienene Sammlung enthält 18 Aufsätze, von welchen einige auch in fremdsprachlichen Publikationen veröffentlicht wurden. Es erschien auch eine Resumé-Sammlung des Werkes.

Das Vorwort und der Aufsatz über die Spaltung der Sprachwissenschaft vom Redakteur Zs. Telegdi [s. Acta Linguistica Hung. 12. 95-107 /1962/] bietet eine klare, lapidare Übersicht der Entwicklung der Sprachwissenschaft im XIX-XX. Jh., in welcher auf die einzelnen Etappen der stufenmässigen Entfaltung der modernen Richtung hingewiesen und mit sicherer Hand die Funktion, die dem Strukturalismus bei der Lösung von sprachlichen Problemen zufällt, bezeichnet wird. Mit kürzeren wissenschaftsgeschichtlichen Einleitungen sind mehrere Aufsätze versehen /S. Károly, F. Papp, Gy. Szépe, M. Temesi/. Die moderne Literatur der einen oder anderen sprachlichen Erscheinung wird in drei Artikeln besprochen. L. Antal gibt eine Kritik der psychologistischen Konzepzion des sprachlichen Zeichens, J. Berrár fasst die Bestrebungen der Beschreibung und Bestimmung des Satzes zusammen, wobei sie nach seinen formalen Kennzeichen sucht, K. Magdics endlich erörtert die Hauptergebnisse der Intonationsforschung im letzen Jahrzehnt. Etwa die Hälfte der Aufsätze gibt das Wirken je eines Vertreters der modernen Sprachwissenschaft bekannt, so schreibt L. Elekfi von der Laufbahn und dem Werk des J. Ries, E. Vértes von V. Brøndal's Wortarttheorie, M.Temesi über Weisgerbers Sprachtheorie. Gy. Szépe gibt die Besprechung nebst reichhaltiger bewertender Interpretation von N. Chomsky's Transformationsmodell der generativen Grammatik, indem er es durch ungarische Beispiele erläutert. Ähnliche Aufsätze erörternden, wertschätzenden und illustrativen Charakters beschprechen O.S. Kulagina's unmittelbare Verwendung der Mengenlehre in der Sprachwissenschaft /1958, F. Kiefer/, die Syntax von L. Tesnière /1959, S. Károly/, welche vom Rezensenten im wesentlichen als strukturelle Anschauung aufgefasst wird, P. Guiraud's statistische Methode in der Untersuchung des Wortschatzes /1954, 1959; K. J.-Soltész/, ferner die Arbeit von A. Graur über allgemeine Sprachwissenschaft aus dem Jahre 1960 /F. Bakos/.

Fünf Studien des Bandes enthalten selbstständige Ergebnisse, die auf eigenen Untersuchungen beruhen. Zwei von ihnen unterziehen fundamentale Prinzipien des Strukturalismus bzw. ihre übertriebenen Varianten einer strengen Revision und stellen etliche davon in Frage. M. Hutterer weist im Laufe seiner Erörterungen über die aktuellsten Probleme der Sprachgeographie und Mundartforschung jene Ansicht, laut welcher die Mundartforschung nicht dem Bereich der Sprachwissenschaft angehört, zurück, indem er darauf hinweist, dass die Mundarten als selbstständige sprachliche Corpora zu untersuchen seien, dass gerade die Mundartforschung es klarmacht, dass die synchronische Erforschung einer Sprache nur dann zu Ergebnissen führe, wenn sich ihr eine diachronische Interpretation anschliesst, ferner, dass man die Sprache nicht von den sogenannten metalinguistischen Faktoren abgesondert ausschliesslich auf exakter Art untersuchen darf. J. Herman's Studie: Über die Frage der Beziehung zwischen Form und Bedeutung, gibt eine eingehende Kritik jener Bestrebungen, die eine sich bloss auf formale Tatsachen stützende sprachliche Analyse erzielen. Er nimmt die distributive Analyse als Beispiel und stellt fest, dass auch diese Methode sich der Berücksichtigung der Bedeutung nicht entäussern vermag, und, dass die völlige Ausschaltung der Bedeutung einfach unmöglich ist. Doch warnt auch er seinerseits von den Gefahren, die sich bei der Feststellung der Bedeutung aus der individuellen Introspektion ergeben mögen. Über die unmittelbare kritik hinausgehend hebt er - die Untrennbarkeit von Form und Bedeutung betonend - jene Faktoren hervor, die die Trennung dieser beiden überhaupt ermöglicht haben und erörtert die Frage der Wechselwirkung, die sie auf einander ausüben.

Für die schöpferische Verwertung der modernen Sprachanschauung und Methoden sehen wir drei Beispiele in diesem Band. J. Balázs sucht den Platz der Eigennamen im System der sprachlichen Zeichen. Auf Grund der mittels Untersuchung von Eigennamen erhaltenen Strukturen zeigt er, dass diese nicht bloss denotativer, sondern auch konnotativer Art sind, einesteils da sie logisch zu gewissen Gruppen bzw. Klassen subsumiert werden können, anderenteils weil im sprachlichen Ausdruck entweder der zweite Teil des zusammengesetzten Eigennamens /z. B. Darmstandt/ oder die sich ihm anschliessende Apposition /z. B. mare Oceanus/, manchmal bloss der Zusammenhang im Text darauf hindeutet, was der Eigenname bezeichnet. /Es wäre vielleicht angebracht gewesen den Umstand zu erwähnen, dass dieser Hinweis bei gewissen Eigennamen nicht eindeutig sei, z. B. bei den Ortsnamen Bamberg, Hiddensee bei der ursprünglich Halbinsel bezeichnende Peloponnes. /I. Fónagy wendet das Kommunikationsmodell der Informationstheorie in der Stilprüfung an und erweist an der Hand der Untersuchung des Informationsinhaltes des gesprochenen, des lexikalischen, des konstituierenden und des individuellen Stils, dass in jedem der Fälle eine mit der Hauptmeldung interferierende sekundäre Meldung vorliegt, die in der mit dem Sprachlaut verwachsenen, expressiven Bewegung, in der ursprünglichen Bedeutung der im übertragenen Sinn gebrauchten Wörter, in der Transposition der Elemente auf der syntagmatischen oder paradigmatischen Axe oder im eigenartigen Wortgebrauch zum Ausdruck kommt. Die Studie von F. Papp ist eine Vorarbeit zur Transformationsgrammatik der ungarischen Sprache: er untersucht das Problem, wie man Konstruktionen, die aus gleichen Morphemenklassen bestehen, ohne Rücksicht auf die Bedeutung, einzig und allein mit Hilfe formaler Methoden zu unterscheiden vermag. Er bearbeitet mehr als zweitausend Syntagmata, die die Postposition "után" /"nach"/ enthalten, reiht sie in 17 morphologisch abgrenzbare Gruppen ein und analysiert sie mittels möglicher Transformationen. Aus alldem zieht er mit Recht die Konsequenz, dass die folgerichtige formale Analyse auch für die ungarische Sprache geeignet ist und dass durch die Verknüpfung der in der Erforschung der ungarischen Sprache eingebürgerten traditionellen deskriptiven Methoden mit denen, die neuerdings in der ganzen Welt im Umlauf sind, es möglich wird "eine neue Beschreibung der ungarischen Sprache zu schaffen, die sowohl für die ungarische als auch für die allgemeine Sprachwissenschaft vorteilhaft sein wird."

Der jüngst erschienene zweite Band der Serie - A matematikai nyelvészet és a gépi fordítás kérdései, szerkesztette Kalmár László és Telegdi Zsigmond /Fragen der mathematischen Linguistik und maschinellen Übersetzung, Redakteur L. Kalmár und Zs. Telegdi/, Budapest, Verlag der Ungarischen Akademie der Wissenschaften, 1964. - enthält das Material der Budapester Konferenz /1962/, auf welcher die Probleme der im Titel des Bandes bezeichneten Wissenschaftsgebiete zur Diskussion gebracht wurden. Seine Besprechung folgt in einem weiteren Heft unserer Periodik.

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