TRANSLATING POLISH TEXTS INTO SIGN LANGUAGE IN THE TGT SYSTEM

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ABSTRACT

In the paper a method of translation applied in a new system TGT is discussed. TGT translates texts written in Polish into corresponding utterances in the Polish sign language. Discussion is focused on text-into-text translation phase. Proper translation is done on the level of a predicative representation of the sentence. The representation is built on the basis of syntactic graph that depicts the composition and mutual connections of syntactic groups, which exist in the sentence and are identified at the syntactic analysis stage. An essential element of translation process is complementing the initial predicative graph with nodes, which correspond to lacking sentence members. The method acts for primitive sentences as well as for compound ones, with some limitations, however. A translation example is given which illustrates main transformations done on the linguistic level. It is complemented by samples of images generated by the animating part of the system.

KEY WORDS:

natural language processing, sign language, syntax analysis

1. INTRODUCTION

In the Institute of Computer Science at the Silesian Institute of Technology a prototype of an experimental system for translation of texts written in Polish into the Polish sign language has been recently released. To the prototype the working name TGT-1 (from: Text-into-Gesture Translator) has been given. Several papers devoted to the system itself and to the project, which was the framework for its development, have been already published. Some of them, the most relevant to the present one, should be mentioned here. The assumptions for the system were outlined in [1]. System operation seen from the side of the end-user and persons involved in the maintenance of system resources was described in [2]. An outline of the translation algorithm applied on the linguistic level can be found in [3]. The method of gesture generation was presented in [4].

In this paper we focus on exposing the principles of operation of these system components, which realize processing on linguistic level, excluding however its morphologic analyzer discussed elsewhere [5]. We present the idea of syntactic and predicative structure graphs used in our system, the role they play in the translation process, and the method adapted for constructing them for input and output sentences. We consider an advanced example of compound sentence processing. We complement it with a short overview of the system structure and operation. In the example presented we use images generated by the latest version of the system.

The task of linguistic transformation in our system coincides to a high degree with the general task of machine translation (MT). An extensive introduction to MT themes can be found e.g. in [6]. Solutions similar to ours in the matter of the general organization of processing, one can meet in different works upon MT-systems, for example in [7]. However, they have many individual traits, what is dependent – among others – on the pair(s) of input and output languages involved.

Our approach is an alternative for methods that require text pre- or post-editions, or are based on large grammars. Those methods are – among others – discussed in [8]. We don't think them to be adequate to our pair of languages and intended system applications: Methods from the first group cannot be used in on-line translations. Methods from the second group require using a complex formal apparatus, excessive as opposed to a rather simple in construction output language, which is the sign language. Apart from implementation problems, the barrier for practical application of these methods can be their high demand for computing power.

2. GENERAL INFORMATION ABOUT THE TGT-1 SYSTEM

The task of the system is to translate texts written in Polish into animated sequences of Polish sign language gestures displayed on the screen. Input texts have the form of text files, without any technical annotations.

Translation is performed in full-automatic mode. The system can work in real-time on personal computers with rather typical parameters (Pentium 600 MHz processor, 256 MB RAM, hardware accelerated graphics card).

Processing is partitioned into two phases – linguistic and animating one. They are realized in two loosely coupled system parts. In the linguistic phase, the input utterance is transformed into a corresponding output one in a textual form. In the animating phase, output utterance words are interpreted one by one and in effect the utterance gets the desired graphical form.

3. PRINCIPLES OF TRANSFORMATIONS IN THE LINGUISTIC PHASE

The following principles were assumed for input text processing on linguistic level:

1. Processing is performed according to the classical scheme: input text analysis, result interpretation and output text generation.

2 Processing is aimed at getting a text in a form suitable for animation in the word–gesture mode. The results of processing are transferred to the animation part of the TGT system in the form of a file.

3. Input text is considered to be a set of independent sentences. It means that during analysis any relationships between sentences are ignored.

4. All transformations connected with the analysis, interpretation and generation are performed on primitive sentences. Compound sentences (of restricted types) are partitioned into primitive sentences, i.e. ones with only one predicative center. Sentences that arise in consequence of partition are considered independent – further interpretation and generation is done individually for each of them.

According to the aforementioned principles, the processing chain is as follows: The analysis of texts is performed until the level of the predicative representation of primitive sentences is reached. The predicative representation is interpreted and in effect it is transformed into its analogue corresponding to the output sentence. On this basis the output sentence is generated. Generation consists in ordering the member elements of the predicative representation according to the sign language syntax rules, and then in deploying these elements to the form of a sequence of words set in an appropriate order.

4. SYNTAX ANALYSIS

The main part of linguistic processing is done by a Polish syntax analyzer. It uses data supplied by a morphological analyzer, which has been described elsewhere [5]. In the syntactic analyzer our method of syntactic analysis for languages with free sentence order have been implemented; Polish is one of such languages. In our approach the structure of a sentence is represented by a set of so called syntactic groups (SG). The syntactic group formalism was for the first time described in [9], and its adaptation to the needs of computer analysis of natural languages was exposed in [10]. SG is some set of words, which appear in the sentence. There is no obligation for them to be neighbors. The syntactic representation of a sentence covers also the relationships occurring between SG member elements on all of the levels. The syntactic structure can be viewed as a graph whose nodes are SGs and arcs – syntactic relationships between SGs. The root of the graph is a verb group (VG).

The SG set is successively built at several stages. The process is ruled by a syntactic group grammar. An SG-grammar covers rules that define the conditions and the mode for aggregating words in groups as well as rules for finding syntactic relationships and determining grammatical attributes of SGs according to their components. In the SG, the order in which these rules should be applied is also defined. In the system we use a SG-grammar for Polish, which we have elaborated.

The aforementioned partition of compound sentences to primitive ones is done at the syntactic analysis stage. In its present state, the analyzer can partition but some strictly defined kinds of sentences. It is due to the lack of corresponding SG-grammar rules that either have not yet been defined or are known but not yet implemented.

As it was said, after partition each sentence is processed separately. Evidently, such approach is not appropriate for many output languages since after the analysis has ended one has to determine relations between sentences and to consolidate them again. In our case a part of those reservations loses its power: since there is no compound sentences in the sign language and utterances are for the most part short, then signing sentences in succession can be considered possible. In fact, in our system sometimes it happens that translation of an apparently simple sentence is incomprehensible. However, in many cases it is satisfactory. For example, let's consider the sentence:

Słyszałem, że masz dostać nową pracę.
(I have heard you are about to get a new job.)

The sentence will be partitioned into two primitive ones:

Słyszałem   (I have heard)

and

Masz dostać nową pracę

(You are about to get a new job)

Syntax analysis will represent the first sentence as a single-node syntactic graph. The syntactic graph of the second sentence consists of two nodes. It is shown in Fig. 1. (Note that in figures we use some denotations coming from TGT system translation report. We believe the reader can interpret them without exhaustive explanations.)
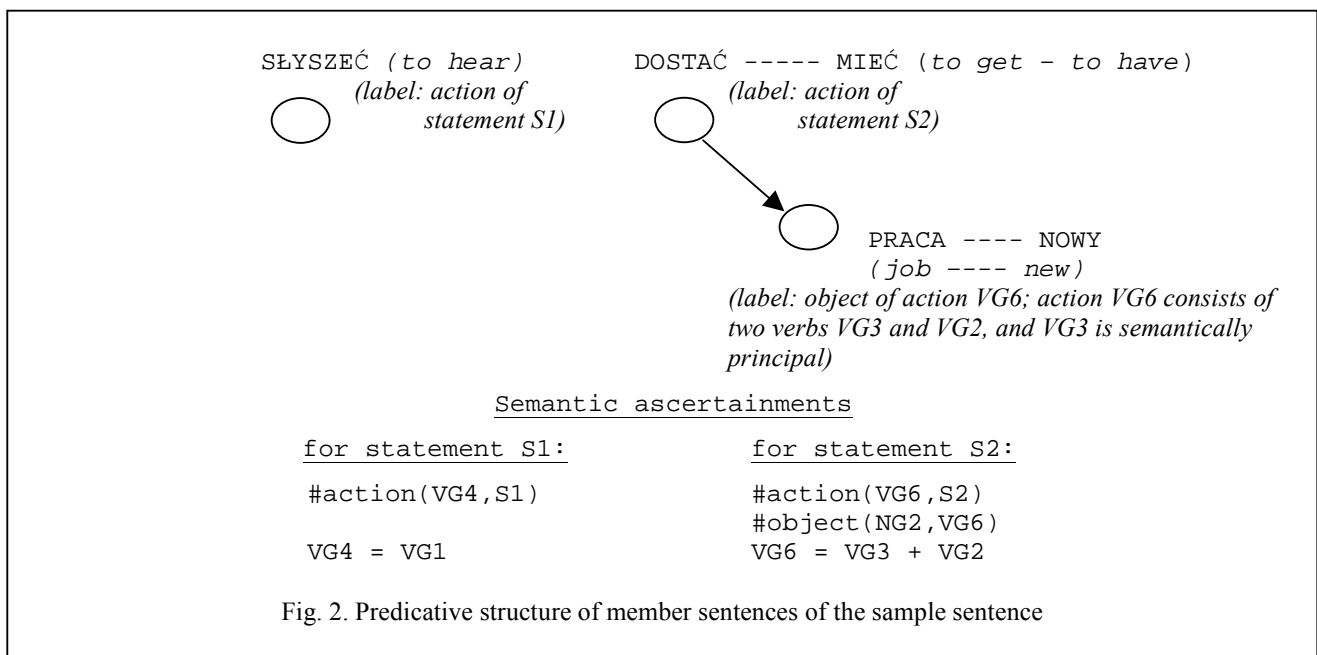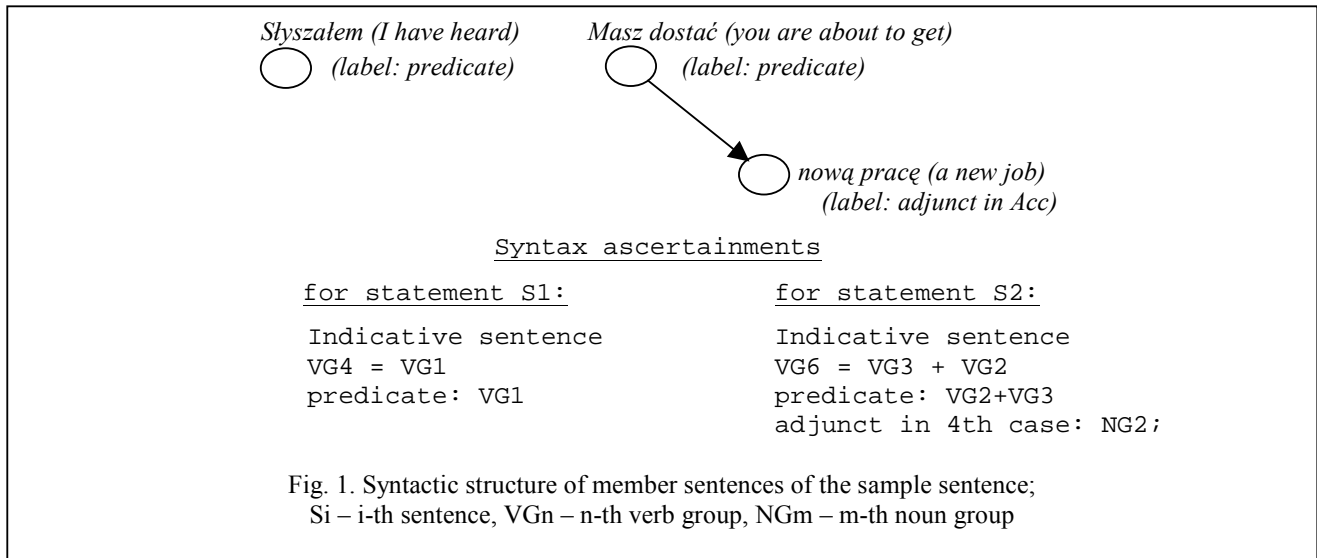
5. BUILDING THE PREDICATIVE REPRESENTATION OF THE INPUT SENTENCE

The predicative representation of a sentence is a graph, which is an extension of the syntactic graph: the structure of the graph is conserved, but individual nodes are additionally attributed by semantic roles (i.e. concerning so-called deep cases [11]). Of 16 semantic roles proposed in [12], in our system we use just 3, which we considered to be the most important: Action, Agent and Object.

In Fig. 2 we showed the predicative representation of sample sentences from the previous section. In the example being considered, nodes and edges of the syntactic (see Fig. 1) and the predicative graph are identical, but their labels are changed.

The predicative structure of a sentence depends upon the VG taken for the Action in this statement. The VG through its semantic trait called control model defines all possible semantic contexts in which it can appear and indicates what structures can take some places in this context. The control model indicates the full list of places, but in practice they are often not filled in. It is also the

Słyszałem (I have heard) (label: predicate)

Masz dostać (you are about to get) (label: predicate)

nową pracę (a new job) (label: adjunct in Acc)

Syntax ascertainments

for statement S1:

Indicative sentence
VG4 = VG1
predicate: VG1

for statement S2:

Indicative sentence
VG6 = VG3 + VG2
predicate: VG2+VG3
adjunct in 4th case: NG2;

Fig. 1. Syntactic structure of member sentences of the sample sentence;
Si – i-th sentence, VGn – n-th verb group, NGm – m-th noun group

SŁYSZEĆ *(to hear)* (label: action of statement S1)

DOSTAĆ ----- MIEĆ *(to get – to have)* (label: action of statement S2)

PRACA ---- NOWY *(job ---- new)* (label: object of action VG6; action VG6 consists of two verbs VG3 and VG2, and VG3 is semantically principal)

Semantic ascertainments

for statement S1:

#action(VG4,S1)

VG4 = VG1

for statement S2:

#action(VG6,S2)
#object(NG2,VG6)
VG6 = VG3 + VG2

Fig. 2. Predicative structure of member sentences of the sample sentence

case for our analysis, which does not complement lacking values by default ones. In Fig. 2 one can see that the predicative structure of both sentences is not complete and it corresponds to the actual structure of the sentence.

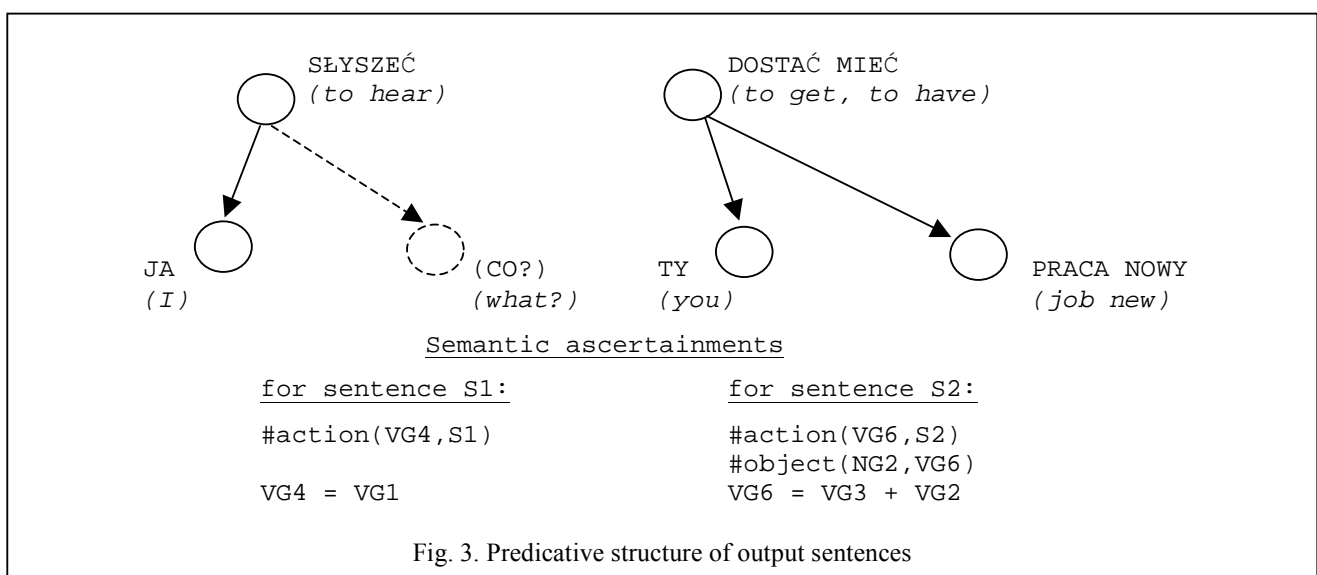# 6. BUILDING THE PREDICATIVE REPRESENTATION OF THE OUPUT SENTENCE

The predicative representation of the output sentence is a graph analogous as for the input sentence, but complemented with lacking items of the predicative structure, which is defined by the aforementioned semantic model of a sentence built around the given verb. To define such models, generative grammars are used, as for example one described in the dictionary [13]. We have a computer equivalent of this dictionary [14]. Since both input and output languages in our system are kinds of the same language (Polish), we think output sentences not to change their predicative structure. The structures should be complemented, however. The need for that issues from the fact that sign language sentence should be complete, that means it should contain an Action and all elements of its generative scheme.

Examples of predicative structures of output sentences are given in Fig. 3. As one can observe, the item for Agent has been completed: in the first sentence Agent is *ja (I)*, in the second – *ty (you)*. For the Action *słyszeć (to hear)* in turn, the place for Object has been left free. It is so since this place was assigned to the next sentence; as it was mentioned, we do not reconsolidate the sentence, and we have no other candidate to take the role of Object.

7. OUTPUT SENTENCE GENERATION

Output sentence generation starts from planning the future sentence on the syntactic level. The syntactic structure of output sentences corresponds to their predicative structure. In the example being considered, syntactic groups are given that will be used to fill up corresponding places in the sentence structure which is being planned. The sign language grammar requires strict equivalence of semantic category with the syntactic one to be preserved. In the sign language sentence Action should become the predicate, Agent – the subject and Object – the adjunct. Such equivalence can be justified by the fact that in the sign language the sense of a sentence is directly determined by the order of its syntactic (components). We do not give a separate figure to show the syntactic graph for our sample output sentences since it can be easily imagined after Fig. 3. Instead, in Fig. 4 we present the effect of the next processing step, which consists in ordering words into a sequence, which represents the sentence.

The final form of the output sentence differs a bit from the traditional one: the sentence is built „vertically", that is each word occupies a separate line. It is a technical nuance: such form makes input data analysis in the animating part of the system easier. Punctuation marks are generally dropped, as they cannot be signed. Only dots separating sentences are left since they play a role by controlling the course of animation. The case of letters has no importance, therefore only lower-case letters are used in output sentence. Some evident differences have deeper justification. There is no word inflection in the sign language, so all the words in the sentence are given in the form of lemmas. According to the sign language syntax requirements, additional elements may also appear in output sentences. For example, in the first output sentence in Fig.4 we can see the added word *już*

Semantic ascertainments

for sentence S1:

    #action(VG4,S1)

    VG4 = VG1

for sentence S2:

    #action(VG6,S2)
    #object(NG2,VG6)
    VG6 = VG3 + VG2

Fig. 3. Predicative structure of output sentences

```
ja          (I)
słyszeć     (hear)
już         (already)
.
ty          (you)
dostać      (get)
mieć        (have)
praca       (job)
nowy        (new)
.
```

Fig. 4. Result of output sentence generation

(already), which in the sign language is used in order to indicate the past tense.

8. PRESENTATION OF GESTURES

As we mentioned above in Section 2, presentation of gestures that compose the output utterance is a separate processing phase. Gestures are performed by a virtual character called avatar, intentionally designed in that purpose. The avatar has been implemented using the OpenGL technology. Avatar's movements are planned according to a symbolic description of distinctive features of individual signs of the sign language. To describe the gestures a specific notation has been used [15]. At present the dictionary of gestures used by the system counts 600 items.

Figure 5 can give an impression of how the presentation looks like. The pictures show initial cadres of animation for consecutive gestures of our sample output sentence from Fig. 4. The reader interested in details of construction and operation of the animating part of our system may refer [4].

9. CONCLUSION

The method for text translation assuming transformation at the predicative representation level, which has been exposed in this paper, is practically applied in working prototype of the TGT-1 system. The method gives satisfactory results for rather numerous class of primitive and compound sentences. The class can be extended. To improve the operation in the case of primitive sentences, one have to increase the number of
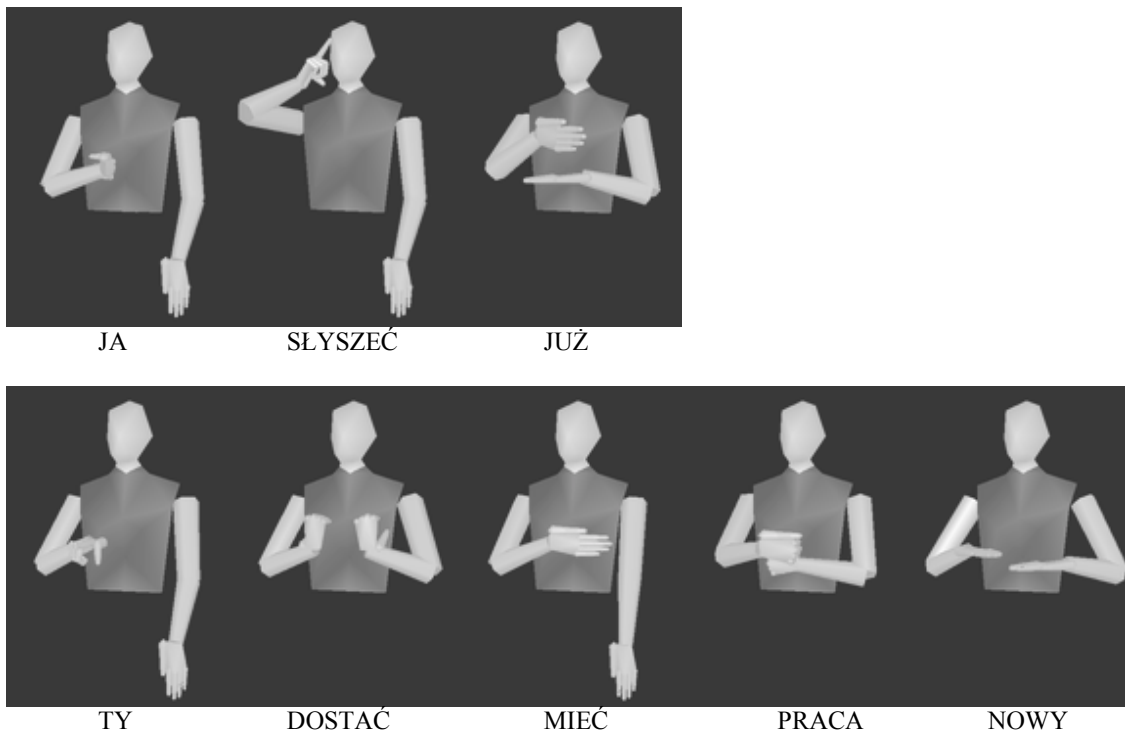

JA   SŁYSZEĆ   JUŻ

TY   DOSTAĆ   MIEĆ   PRACA   NOWY

Fig. 5. A sequence of gestures corresponding to the output sentence: *ja słyszeć już.*
ty dostać mieć praca nowy. (I hear already. you get have job new.)

semantic roles which are considered at the stage of creating the predicative representation of sentences; at present, in fear of efficiency, it is limited to three. In the case of compound statements, one should additionally fill the gaps in the specification of Polish language SG-grammar that cause some syntactic constructs (types of statements) not to be recognized. It would also be of use to raise the assumption, under which the sentences that arise in effect of compound sentence partition are processed independently.

Application of our method can be considered at least in two aspects. Firstly, one can try to apply the method for itself in translation of other language pairs. Using our former contacts, we are going to try first the translation from written Polish into the French sign language. Secondly, one should keep in mind that it is the very method on which the operation of the whole translation system we create is based. The system is intended to find its first application in the training of sign language teachers. We hope it will also support the services acting in the area of the first medical aid as well as the first-contact doctors. With the very application in mind the dictionaries used by the system have been configured.

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