Text Structure Aiming at Machine Translation

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Abstract

Machine translation relies on the existence of a meaning representation which must be able to capture the semantic content of the original text. The work presented here is concerned with the automatic generation of such a representation, to be used by a machine translation system. We have used as source text scientific abstracts in Portuguese. The emphasis of the work is on the determination of the text structure of such abstracts, making use of the notions of cohesion and coherence. The main cohesion phenomena considered here is definite anaphora.

Keywords: Machine Translation, Textual Structure, Coherence Relations, Definite Anaphora.

1 Introduction

A Machine Translation (MT) system can be seen as a special kind of Natural Language Understanding (NLU) system. The text in the Source Language (SL) is analysed by a program which produces a meaning representation of the text, to be used by a generation program which will produce the conveyed message in the Target Language (TL), see Figure 1.

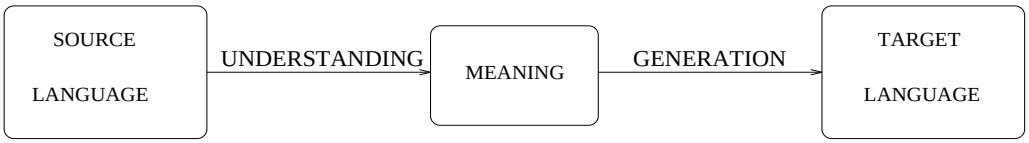

Figure 1: NLU System

This kind of approach to MT relies on the existence of an *interlingua*, a kind of language free representation, which includes semantic and syntactic features necessary for representing the exact meaning of words and sentences [Lewis, 1992].

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Meaning representations in MT systems are usually extensions of syntactic representations [Tucker, 1984, Scolum, 1985] and, as a result, text is represented as a disconnected sequence of sentences. The choice on the representation will influence aspects such as fidelity to the original text [Danlos, 1987]. We are concerned here with the development of a meaning representation of abstracts for technical papers in Portuguese, to be used by an MT system. In our approach, text is treated as a coherent and cohesive whole. We aim at an explicit representation of some discourse phenomena as a means of obtaining high quality translation. The main idea is that the representation must include not only the propositional content of the text, but also the coherence relations that tie propositions together in the text. We believe that the representation of coherence relations in an abstract form improves the right choice of connectives and superficial forms during the generation process [Moore and Paris, 1994]. The choice of a connective also imposes restrictions on the realization of the propositions involved in the relation.

The rest of the paper is organized as follows: in Section 2 the general structure of an abstract is presented; in Section 3 we introduce the meaning representation which will be generated by the system; in Section 4 the process of automatic construction of the representation is shown; in Section 5 we present a detailed example and, finally, in Section 6 we present our conclusions.

2 Abstracts and their Structure

An abstract is the first section of a report, coming after the title and before the introduction. It provides the reader with a brief preview of the paper. Many readers depend on the abstract to give them enough information about the work in order to decide if they will read the entire report or not. Abstracts from almost all fields are written in a very similar way.

In spite of the fact that abstracts are written to be as brief and concise as possible, they present characteristics observed in larger texts, in particular coherence and cohesive relations [Hobbs, 1978a, Hobbs, 1978b, Mann and Thompson, 1983, Mann and Thompson, 1987, Halliday and Hasan, 1976].

According to [Hutchins, 1985, Jordan, 1991], two basic types of abstracts are identified: *informative*, which include actual results, figures and conclusions from source documents, and *indicative*, which simply state the fact that certain topics are covered. But in general an abstract will be a mixture of both.

The type and the order of the information included in an abstract are very conventional. According to the Brazilian Technical Norms Association (ABNT) [ABNT, 1987], and according to [Weissberg and Buker, 1990, Hutchins, 1985, Jordan, 1991], an abstract may include the following information:

- *background:* where, as the name says, background information must be given;
- *purpose or objective:* where the objectives of the work must be described;
- *method:* where new techniques and methodological principles are described;

- *results:* where new facts are presented;
- *conclusion.*

As well as norms on which information should be presented in an abstract, there are also language conventions. The most common is the convention on verb uses, which is: when talking about the purpose of the work, verbs should be in the present tense; when talking about the method which was used and the results which were obtained, verbs should be in the past tense; in the conclusion verbs could either be in the present tense or modal auxiliaries might be used.

Our research is based on a corpus of abstracts taken from the "Revista de Ensino de Engenharia"[1]. We have chosen to study abstracts from this magazine because submissions to it must agree with the norms from the ABNT.

Some empirical facts can be verified in the corpus. For example, present tense in the active or passive voice is usually used when the author is talking about the paper. As the work is generally previous to the paper, past tense is used to introduce details about the scientific work (experiments, experiences, methodological and theoretical framework). These "cues" are useful for the identification of the type of information present in the abstract.

Figure 2 shows an example of an abstract [da Silveira Neto and Hernandez Mendoza, 1988] taken from this magazine :

> *(1) Trocadores de calor compactos são elementos básicos e de alta eficiência. (2) Este trabalho apresenta um método simples (3) usado para o desenvolvimento, (4) teste e (5) análise térmica deste tipo de trocador.(6) Usando o método recomendado, (7) alunos de graduação podem estimar a queda da pressão e coeficientes de troca de calor (8) normalmente utilizados em engenharia térmica.*
>
> (1) Compact heat exchangers are basic and high efficiency elements. (2) This work shows a simple method, (3) used for the development, (4) testing and (5) thermal analysis of this type of heat exchanger. (6) Using the recommended method (7) undergraduate level students can estimate pressure drops and heat exchange coefficients (8) commonly used in thermal engineering.

Figure 2: A first sample abstract

The numbers attached to the text are not present in the original; they are provided for easy reference in the rest of the paper.

3 Representing the Structure of the Text

In our approach text is represented as a structure which captures the *informational content*, the *coherence relations* between parts of the text and the *propositional content*. The

[1] In English: Engeneering Teaching Magazine

representation can be seen as a forest. Each tree in the forest represents a different kind of information actually present in the abstract. This is based on the fact that different parts of the text will convey different kinds of information [Grimes, 1975]. The root of the tree represents a different informational status (background information, method, conclusions, etc) and copes with a group of sentences which constitutes one of the main segments of the text. Internal nodes of the tree represent coherence relations between subsegments of the text, which can be either single propositions or groups of propositions tied together by coherence relations. Finally, the leaves represent the propositional content.

3.1 Informational Content

The informational content represents the main segments of the abstract. It is obtained through a partition of the text into text spans, which are linear sequences of sentences grouped together according to syntactic and semantic information. We are working with a set of *Informational Categories* (IC) to represent each text span. These categories were defined according to the type of information present in the text (as described in Section 2) and also according to the analysis of the corpus of abstracts taken from the magazine. The identification of each category which appears in an abstract relies on syntactic and semantic information, such as tense, aspect, and semantic features attached to the lexical items. These categories are:

$$IC \equiv \{Background, Objective, Method, Experiment, Recommendation, Suggestions, Conclusion, Results\}$$

The overall text is represented through a subset of IC. From the example shown in Figure 2, we obtain the following subset:

$$Abstract \equiv \{Background, Objective, Recommendation\}$$

Background is given in proposition (1), *Objective* is given in propositions from (2) to (5), and *Recommendation* in propositions from (6) to (8). In Section 5 we describe in detail how this partition was made. The identification of these categories in the source text will assist a generator in the choices to be made when the time for translation comes.

3.2 Coherence Relations

The analysis of the corpus revealed the existence of various coherence relations, accounting for local coherence. Several researchers have already investigated the relations that hold in a piece of coherent text: *Coherence Relations* [Hobbs, 1978a], *Rhetorical Relations* [Mann and Thompson, 1983], *Semantic Relations* [Hutchins, 1987]. In our work we gave formal definitions to these relations aiming at their computational use by an automatic system.

We are working with the following set of relations:

$$CR \equiv \{Elaboration, Parallel, Sequence, TemporalSequence, CauseConsequence, Contrast\}$$

Relations may relate propositions or groups of propositions. The *Elaboration* relation holds between two propositions (a) and (b) if (a) introduces an entity that is further elaborated in proposition (b). One of the rules for the *Elaboration* relation follows:

$$\{p(Event1, X, Y) \in (a)$$
$$q(Event2, Y, Z) \in (b)\} \models (a)Elaboration(b)$$

This rule states that there exists an *Elaboration* relation between two propositions (a) and (b) if proposition (a) contains a verbal predicate p which introduces an entity Y, and proposition (b) contains a verbal predicate q which "talks about" the same entity Y. There are other rules for *Elaboration* which will not be presented here.

In Figure 2 proposition (2) introduces the entity "método" that is further elaborated in propositions from (3) to (5). The elaboration lies on the utilization of the "método". The same relation holds between propositions (7) and (8); (7) introduces the entities "queda da pressão" and "coeficientes de troca de calor"; the two are further elaborated in proposition (8).

In this case we have the following structure:

- proposition (7): $estimate(EstimateEvent, X, Y)$
- proposition (8): $use(UseEvent, Y, Z)$

The *Contrast* relation links two propositions (a) and (b) if both propositions share the same main predicator, but the arguments are in contrast. More formally

$$\{p(Event1, X, Y) \in (a)$$
$$p(Event2, X, Z) \in (b)$$
$$contrast(Y, Z)\} \models (a)Contrast(b)$$

where the *contrast* predicate must be defined. This relation is not present in the abstract from Figure 2. Consider now the text segment presented in Figure 3 [Bazzo and Pereira, 1989]:

> *(1) A engenharia depende cada vez mais das ciências e de técnicas nelas baseadas, (2)* **mas** *jamais vai prescindir do empirismo e da criatividade de quem a usa.*
>
> (1) Engineering depends more and more on science and specific techniques, (2) **however** empiricism and creativity will never be disregarded.

Figure 3: Text segment from the corpus

The explicit mark "mas" is an indication of contrast. The contrast can actually be verified between propositions (1) and (2): in proposition (1) "engenharia" is presented as dependent on science, and in proposition (2) it is presented as dependent on "criatividade", two opposed concepts.

Other relations are similarly specified, and several rules are defined for each of them.

3.3 Propositional Content

Each sentence in the source text originates one or more *propositions* as a result of syntactic and semantic analysis. The propositional content is a set of propositions that carry the message of the abstract. The representation is based on *first order* representations. Propositions are represented through:

- *A set of variables*
  representing the entity referents and event referents in the proposition.
- *A set of predicates*
  standing for relations of fixed arity, which relate the entities in the proposition. Predicates are associated with items from the Portuguese language.

Entities are derived from noun phrases in the sentence. Events and states are derived from verb phrases. Predicates have mandatory arguments and a list is used to represent the multiple cases of complementation. Each sentence in the text is analysed according to grammatical rules and it is broken down into propositions according to the syntactic tree (parse tree) produced by the analysis [Winograd, 1983]. The tree is also used to identify pairs of non co-referring expressions (intrasentential anaphora) using syntactic restrictions [Raposo, 1992]. Semantic analysis produces predicates and arguments based on the structure of the syntactic tree and on the semantic information attached to lexical items.

In order to correctly represent the entities in the propositional content, definite anaphora [Hirst, 1981a, Hirst, 1981b] must be resolved. The resolution is based on syntactic restrictions (genre, number) as well as on world knowledge [Nirenburg and Carbonell, 1987]. A set of known entities, which restrict the possible antecedents for a definite noun phrase in the following text, is maintained. The set includes the entities earlier introduced (explicitly) as well as the entities associated with them. Pronoun resolution is essential in every MT system [Wilks, 1973] and the correct choice of an antecedent for a definite full noun phrase is essential in the verification of the coherence relations.

As another example, consider the abstract presented in Figure 4 [de Araújo and Szeremeta, 1985]:

The resolution of the definite noun phrase "esta disciplina" is required, because the semantic interpretation of the noun phrase resulted in a incomplete entity represented by the expression (a):

(a) *disciplina(X1)*

The resolution of the expression is based on the search for an antecedent in the list of known entities. The search is based on the predicate "disciplina". As it can be seen, there is no previous explicit occurrence of this predicate in the text. Nevertheless, in the first sentence of the abstract, the noun phrase "Cálculo Numérico" was introduced and the semantic interpretation of this expression produced the following term, which indeed belongs to the list of known entities:

(b) *disciplina(X2,name:CALCULO_NUMERICO)*

Com a utilização de calculadoras programáveis e microcomputadores, torna-se necessária a adequação do plano de ensino de Cálculo Numérico para a formação dos futuros engenheiros. Algumas alterações na metodologia de ensino **desta disciplina** *são sugeridas e feitas algumas recomendações quanto à utilização de calculadoras programáveis.*

With the increasing utilization of programmable calculators and microcomputers, it becomes necessary to update the teaching approach of Numerical Analysis instruction for future engineers. Some changes on the methodology for teaching **these subjects** are suggested and some recommendations are made for the utilization of programmable calculators.

Figure 4: A second sample abstract

O presente trabalho tem como meta divulgar a disciplina Similitude em Engenharia ministrada no curso de Engenharia Mecânica da UFU a qual visa proporcionar aos alunos fundamentos básicos sobre a teoria de modelos. **O ciclo de aulas práticas** *tem como objetivos (...)*

The objective of this paper is to divulge the course Similitude in Engineering, taught at the Mechanical Engineering Department of UFU with the objective of providing the students with basic foundations of Modeling Theory. **Practical activities** were planned (...)

Figure 5: A third sample abstract

So, the resolution of expression (a) becames possible through expression (b).

As an additional example, consider the abstract presented in Figure 5 [Gomide and Fernández, 1985]:

In the second sentence of the abstract, the definite noun phrase "O ciclo de aulas práticas" is introduced and this phrase must be resolved; the semantic interpretation of this expression produced the following terms:

(c) *ciclo(X3,specifier:X4)*
(d) *aula(X4,qualifier:PRATICAS)*

Note that term (d) is incomplete because the system does not know the identity of the entity "aulas". In order to resolve the definite expression "O ciclo de aulas práticas", it is necessary to resolve expression (d). In the first sentence of the abstract the noun phrase "a disciplina Similitude em Engenharia" is introduced and the semantic interpretation of this noun phrase resulted in a complete expression represented by the following term:

(e) *disciplina(X5,name:SIMILITUDE_EM_ENGENHARIA)*

In addition to this expression, and taking into account the fact that a "disciplina" has "aulas" the system introduced the following term associated with expression (e):

(f) *aula(a(X5))*

With these terms incorporated to the list of known entities, the resolution of expression (d) becames finally possible.

4 Constructing the Meaning Representation

The diagram in Figure 6 shows the main processes and sources involved in the construction of the text structure. The structure is constructed by two main processes. The *Coherence Assembler* is responsible for selecting the coherence relations that link propositions in the text. The *Abstract Structure Assembler* links a coherent span to the global organization of the text.

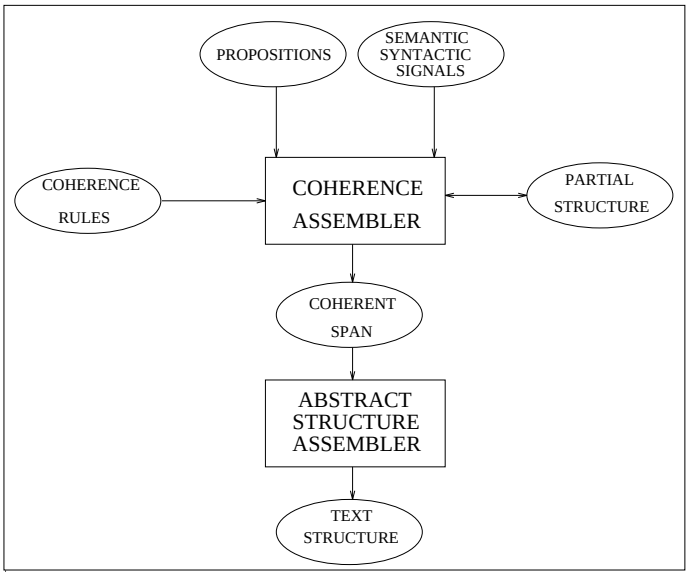

Figure 6: Meaning Representation Construction

These processes operate on the following components of the meaning representation:

- *Propositions:* are produced as a result of syntactic and semantic analysis.
- *Semantic and Syntactic Signals:* guide the coherence assembler in the selection of the coherence relations and also in deciding where a coherent span ends. Syntactic signals include *discourse markers* that directly signal the structure of the discourse [Hirschberg and Litman, 1993]. These markers are the primary indication of the presence of a coherence relation in the text. Tense, aspect and semantic information attached to lexical items provide a means to decide about the limits of a text span [Grosz and Sidner, 1986].

- *Partial Structure*: is used to store propositions and segments already linked and waiting for additional process. When processing a proposition P_k, two problems must be resolved:

  (a) decide to which text segment the proposition P_k will be attached;

  (b) decide on how the attachment to a segment will be done.

  Propositions must be temporarily saved until a decision is made.

- *Coherence Rules*: define conditions that propositions must satisfy in order to be linked together by a coherence relation.

- *Coherent Span*: is a group of propositions related by coherence relations. It carries informational content associated with one of the Informational Categories earlier presented.

5 Detailed Example

Figure 7 shows the structure produced as a result of the analysis of the example from Figure 2. The main processes that led to this structure are:

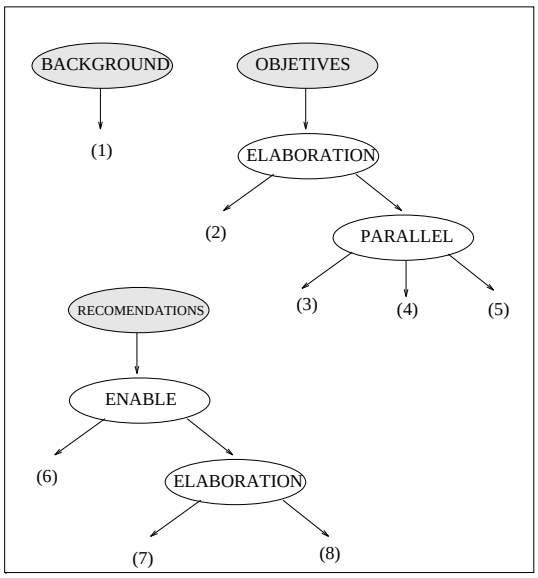

Figure 7: Text Structure

- *Breaking each sentence into propositions:* using syntactic and semantic analysis.

- *Determining references for definite anaphora:* the noun phrase "este trabalho" in proposition (2) is resolved using specific knowledge about abstracts. The corresponding definite noun phrase is "this paper".

Various entities only make sense in the context of abstracts. These entities include "the authors", "the paper", "the work", "the objective" and the like. This information is included in the knowledge base system and is very useful when looking for an antecedent for a definite noun phrase.

The noun phrase "este tipo de trocador" in proposition (5) is resolved using the preceding discourse. The antecedent is "trocadores de calor compactos" introduced in proposition (1). The noun phrase "o método recomendado" is also resolved using the previous discourse.

- *Determining the limits of each text span:* in proposition (1) the use of the verbal form "são" carries semantical information about general facts (one entity is "defined"). "Is-a" sentences are usually analysed in this form [Sidner, 1978]. So proposition (1) is classified as *background*. In proposition (2) the verb "apresentar" is used. This verb carries, in general, purpose or objective information [Jordan, 1991]. Additionally, the noun phrase "este trabalho", which was found to mean "this paper", is acting as subject in the sentence. Taking into account the fact that a "paper" has an objective, we can deduce that the proposition really marks the objective of the paper. So the *Objective* category is selected and it spans up to proposition (5). In proposition (6) the item "recomendado" marks the beginning of a new text span which is classified as *Recommendation*. Figure 7 shows the limits of each text span.

- *Determining Coherence Relations:* syntactic marks guide the selection of coherence relations. For example propositions from (3) to (5) are linked by coordination, syntactically indicated by commas and by the conjunction "e"; this could mark a *Parallel* or a *Sequence* relation. But note that the same argument, "este tipo de trocador", is used in the three propositions, which signals a preference for a *Parallel* relation. The other *CoherenceRelations* from the abstract shown in Figure 2 are shown in Figure 7.

6 Conclusions

Traditional approaches to machine translation have usually neglected the problem of text structure and the source input was treated as a disconnected sequence of sentences. As a result, the representation used by these approaches were not able to capture and to make use of the coherence phenomena present in the input.

We are concentrated on the specification and construction of a meaning representation of abstracts from scientific papers in Portuguese. This representation must capture the *informational content*, the *coherence relations* and the *propositional content* of the input text. We believe that this representation is appropriate for machine translation because it copes not only with the message which is being conveyed, but also with the structure of the text. Representing the linguistic structure of the text enables a generator program to choose the superficial forms in order to correctly express the message in the target language, preserving the original structure of the text. Several steps are involved in the construction of such a representation: syntactic analysis, semantic interpretation, anaphora resolution,

determination of text spans and determination of coherence relations. We are working with a set of these relations, which were defined according to the phenomena observed in the corpus. Additional research is needed in order to expand this set to cope with more relations. Also, we have only treated the problem of definite anaphora through the incorporation of knowledge about the domain of the discourse into the system; more research is also needed to cope with other kinds of anaphora.

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