TENSE GENERATION IN AN INTELLIGENT TUTOR FOR FOREIGN LANGUAGE TEACHING: SOME ISSUES IN THE DESIGN OF THE VERB EXPERT

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ABSTRACT

The paper presents some of the results obtained within a research project aimed at developing ET (English Tutor), an intelligent tutoring system which supports Italian students in learning the English verbs. We concentrate on one of the most important modules of the system, the domain (i.e. verb) expert which is devoted to generate, in a cognitively transparent way, the right tense for the verb(s) appearing in the exercises presented to the student. An example which highlights the main capabilities of the verb expert is provided. A prototype version of ET has been fully implemented.

1. INTRODUCTION

In the course of its evolution, English has lost most of the complexities which still characterize other Indo-European languages. Modern English, for example, has no declensions, it makes minimum use of the subjunctive mood and adopts 'natural' gender instead of the grammatical one. The language, on the other hand, has become more precise in other ways: cases have thus been replaced by prepositions and fixed word order while subtle meaning distinctions can be conveyed through a highly sophisticated use of tense expressions. Learning correct verb usage is however extremely difficult for non native speakers and causes troubles to people who study English as a foreign language. In order to overcome the difficulties which can be found in this and several other grammatical areas, various attempts have been made to utilize Artificial Intelligence techniques for developing very sophisticated systems, called Intelligent Tutoring Systems, in the specifi domain of foreign language teachin (Barchan, Woodmansee, and Yazdani, 1985 Cunningham, Iberall, and Woolf, 1986 Schuster and Finin, 1986; Weischedel, Voge and James, 1978; Zoch, Sabah, and Alvisei 1986).

An Intelligent Tutoring System (ITS, fo short) is a program capable of providin students with tutorial guidance in a give subject (Lawler and Yazdani, 1987; Sleema and Brown, 1982; Wenger, 1987). A full fledged ITS: (a) has specific domai expertise; (b) is capable of modeling th student knowledge in order to discover th reason(s) of his mistakes, and (c) is able t make teaching more effective by applyin different tutorial strategies. ITS technolog seems particularly promising in fields, lik language teaching, where a solid core of fact is actually surrounded by a more nebulou area in which subtle discriminations, persona points of view, and pragmatic factors ar involved (Close, 1981).

In this paper we present some of the result obtained within a research project aimed a developing ET (English Tutor), an ITS whic helps Italian students to learn the English ver system. An overall description of ET, of it structure and mode of operation has bee given elsewhere (Fum, Giangrandi, an Tasso, 1988). We concentrate here on one o the most important modules of the system, th domain (i.e. verb) expert which is devoted t generate, in a cognitively transparent way, th right tense for the verb(s) appearing in th exercises presented to the student. The pape analyzes some issues that have been dea with in developing the verb expert focusin on the knowledge and processing mechanisms utilized. The paper is organized as follows. Section two introduces our approach to the problem of tense generation in the context of a tutor for second language teaching. Section three briefly illustrates the ET general architecture and mode of operation. Section four constitutes the core of the paper and presents the design requirements, knowledge bases and reasoning algorithms of the verb expert together with an example which highlights its main capabilities. The final section deals with the relevance of the present proposal both in the framework of linguistic studies on verb generation and of intelligent tutoring systems for language teaching.

2. THE TENSE GENERATION PROBLEM

An important part of the meaning of a sentence is constituted by temporal information. Every complete sentence must contain a main verb and this verb, in all Indo-European languages, is temporally marked. The tense of the verb indicates the relation between the interval or instant of time in which the situation (i.e. state, event, activity etc.) described in the sentence takes place and the moment in which the sentence is uttered, and may also indicate subtle temporal relations between the main situation and other situations described or referenced in the same sentence. Other information can be derived from the mood and aspect of the verb, from the lexical category which the verb is a member of and, more generally, from several kinds of temporal expressions that may appear in the sentence. Moreover, the choice of the tense is determined by other information, not directly related with temporal meaning, such as speaker's intention and perspective, rhetoric characteristics of discourse, etc. Very complex relations exist among all these features which native speakers take into account in understanding a sentence or in generating an appropriate tense for a given clause or sentence.

The problem of choosing the right verb tense in order to convey the exact meaning a sentence is intended to express has aroused the interest of linguists, philosophers, logicians and people interested in computational accounts of language usage (see, for example: Ehrich, 1987; Fuenmayor, 1987; Matthiessen, 1984). There is however no agreement on, and no complete theoretical account of, the factors which contribute to tense generation. The different proposals which exist in the literature greatly vary according to the different features that are actually identified as being critical and their level of explicitness, i.e. which features are given directly to the tense selection process and which must be inferred through some form of reasoning

Our interest in this topic focuses on developing a system for tense selection capable of covering most of the cases which can be found in practice and usable for teaching English as a foreign language. A basic requirement which we have followed in designing ET is its cognitive adequacy: not only the final result (i.e. the tense which is generated), but also the knowledge and reasoning used in producing it should mirror those utilized by a human expert in the field (i.e. by a competent native speaker). The ITS must thus be an 'articulated' or 'glass-box' expert.

3. THE ET SYSTEM

ET is an intelligent tutoring system devoted to support Italian students in learning the usage of English verbs. The system, organized around the classical architecture of an ITS (Sleeman and Brown 1982), consists essentially of:
- the *Tutor*, which is devoted to manage the teaching activity and the interaction with the student,
- the *Student Modeler* which is able to evaluate the student's competence in the specific domain, and
- the *Domain* (i.e. verb) *Expert* which is an articulated expert in the specific domain dealt with by the system.

In what follows, in order to better understand the discussion of the Domain Expert, a sketchy account of the system mode of operation is given.

At the beginning of each session, the Tutor starts the interaction with the student by presenting him an exercise on a given topic. The same exercise is given to the Domain Expert which will provide both the correct solution and a trace of the reasoning employed for producing it. At this point, the Student Modeler compares the answer of the student with that of the expert in order to identify the errors, if any, present in the former and to formulate some hypotheses about their causes. On the basis of these hypotheses, the Tutor selects the next exercise which will test the student on the critical aspects pointed out so far and will allow the Modeler to gather further information which could be useful for refining the hypotheses previously drawn. Eventually, when some misconceptions have been identified, the refined and validated hypotheses will be used in order to explain the errors to the student and to suggest possible remediations. When a topic has been thoroughly analyzed, the Tutor will possibly switch to other topics.

4. THE DOMAIN EXPERT

The Domain Expert is devoted to generate the right answers for the exercises proposed to the student. Usually, exercises are constituted by a few English sentences in which some of the verbs (*open items*) are given in infinitive form and have to be conjugated into an appropriate tense. Sometimes, in order to avoid ambiguities, additional information describing the correct interpretation (as far as the temporal point of view is concerned) of the sentence is given. Consequently, the Domain Expert must be able:
i) to select the grammatical tense to employ for each open item of the exercise in order to correctly describe the status of the world the sentence is intended to represent, and
ii) to appropriately conjugate the verb according to the chosen tense.

Besides these basic functionalities, the tutoring environment in which the Domain Expert operates imposes a further requirement, i.e. the expert must be able:
iii) to explain to the student how the solution has been found, which kind of knowledge has been utilized, and why.

While the sentences that are presented to the student are in natural language form, the verb expert receives in input a schematic description of the sentence.
Every sentence of the exercise is constituted by one or more clauses playing a particular role in it (major clauses and minor clauses at various levels of subordination). Each clause is represented inside the system through a series of attribute-value pairs (called *exercise descriptors*) that highlight the information relevant for the tense selection process. This information includes, for example, the kind of clause (main, coordinate, subordinate), whether the clause has a verb to be solved, the voice and form of the clause, the kind of event described by the clause, the time interval associated with the event described in the clause, etc. Some of the exercise descriptors must be manually coded and inserted in the exercise data base whereas the others (mainly concerning purely linguistic features) can be automatically inferred by a preprocessor devoted to parsing the exercise text. For instance, the schematic description of:

ET > EXERCISE-1:
'I (live) in this house for ten years. Now the roof needs repairing.'

is the following (with the items automatically inferred by the parser preceded by the symbol @):

EXERCISE: ex1
text: 'I (live) in this house for ten years. Now the roof needs repairing.'
@sentence_structure: c1, c2
@clauses_to_resolve: c1

CLAUSE: c1

text: 'I (live) in this house for ten years'
@clause_kind: main
@clause_verb: live
@superordinate: nil
@subordinate: nil
@previous_coordinate: nil
@clause_form: affirmative
@subject: I
@subject_case: [singular first]
@voice: active
@event_time: t1
@time_expression: ['for ten years' t2]

@category: state
aspect: persistent
context: informal
intentionality: nil

CLAUSE: c2

. . .

TIME_RELATIONS: ex1

meet(t2, now)
equal(t1, t2).

. . .

When solving an open item, the Domain Expert must infer from the exercise descriptors all the remaining information needed to make the final choice of the appropriate tense. This information is constituted by several *tense features*, each one describing some facet of the situation that is necessary to take into account. The choice of which tense features are to be considered in the tense selection process represents a fundamental step in the design of the verb generation module. This problem has no agreed upon solution, and it constitutes one of the most critical parts of any theory of tense generation (Ehrich, 1987; Fuenmayor, 1987; Matthiessen, 1984). The main features considered by the Domain Expert are listed below. Some of the features are already included in the exercise descriptors (1 to 4), whereas the others must be inferred by the system when solving the exercise (5 to 8):

1. *Category*, which identifies the kind of situation described by the clause (e.g., event, state, action, activity, etc.).
2. *Aspect*, which concerns the different viewpoints that can be utilized for describing a situation.
3. *Intentionality*, which states whether the situation describes a course of action that has been premeditated or not.
4. *Context*, which concerns the type of discourse in which the clause or sentence appears.
5. *Duration*, which refers to the time span (long, short, instantaneous, etc.) occupied by a situation.
6. *Perspective*, which refers to the position along the temporal axis of the situation or to its relation with the present time.
7. *Temporal Relations*, which refer to the temporal relations (simultaneity, contiguity, precedence, etc.) that occur between the situation dealt with in the current clause and the situations described in other clauses.
8. *Adverbial Information*, which is related to the meaning of possible temporal adverbials specified in the same clause.

The Domain Expert operation is supported by a knowledge base constituted by a partitioned set of production rules which express in a transparent and cognitively consistent way what is necessary to do in order to generate a verb tense. Its activity is mostly concerned with the derivation of the tense features strictly related to temporal reasoning. The exercise descriptors include for this purpose only basic information related to the specific temporal adverbials or conjunctions which appear in the exercise. This information is utilized to build a *temporal model* of the situation described in the exercise. Initially, the temporal model is only partially known and is then augmented through the application of a set of *temporal relation rules*. This rules constitute a set of axioms of a temporal logic - similar to that utilized by Allen (1984)- which has been specifically developed for: (a) representing the basic temporal knowledge about the situations described in the exercise; (b) reasoning about these knowledge in order to compute some of the tense features not explicitly present in the schematic description of the exercise. The first task of the expert module is therefore that of deriving possible new relations which hold among situations described in the exercise.

In the schematic description of exercise 1 we can see two time relations explicitly asserted:
meet(t2, now) and
equal(t1, t2).
The meaning of the first clause is that the time interval t2 (corresponding to the temporal expression 'for ten years') precedes and is contiguous to the time interval indicated by now (i.e. the speaking time). The meaning of the second clause is that the time interval t1 (representing the state or event expressed by the main verb) is equal to the time interval t2.

From the explicit time relation it is possible to derive, by employing the following time relation rule:
meet(tx, ty) & equal(tx, tz) => meet(tz, ty).
the inferred relation:

meet(t1, now).
The Domain Expert tries then to infer, for every exercise clause, the so-called *reference time,* i.e., the moment of time which the situation described in the sentence refers to (Matthiessen, 1984; Fuenmayor, 1987). In order to determine the reference time of every clause, the expert utilizes a set of *reference time identification rules* whose condition part takes into account the structural description of the sentence.

An example of reference time identification rule is the following:

IF
1 - clause_kind = main,
2 - previous_coordinate = nil OR
    new_speaker = nil OR
    clause_form = interrogative,
3 - time_expression <> nil
THEN
set the reference_time to the most specific
    time expression

By applying this rule to the structural description of Exercise 1 it is possible to infer that the reference time of the clause c1 is the interval t2 that, being the only time expression present in the clause, is also the most specific one.

When all the reference times have been determined, the Domain Expert looks only for the clauses with open items in order to compute (through the temporal axioms) three particular temporal relations (Ehrich, 1987): deictic (between reference time and speaking time: RT-ST), intrinsic (between event time and reference time: ET-RT) and ordering (between event time and speaking time: ET-ST). When these relations have been computed, all the needed tense features are known, and the final tense selection can be performed. Again, a set of *selection rules* takes care of this activity.

In our example, the following selection rules can be applied:

IF
1 - category = state OR
    category = iterated_action,
2 - meet(event_time, now),
3 - meet(reference_time, now),
4 - equal(event_time, reference_time),
5 - aspect = persistent
THEN
apply the present perfect tense.

IF
1 - category = single_action OR
    category = state,
2 - meet(event_time, now),
3 - meet(reference_time, now),
4 - equal(event_time, reference_time),
5 - duration <> short,
6 - aspect = persistent,
7 - context <> formal,
8 - verb accepts ing_form
THEN
apply the present perfect continuous tense.

which provide two different (both correc solutions for the open item.

Once the tense to be used has been identifie the verb is conjugated utilizing an appropria set of *conjugation rules*. In our example tl present perfect is obtained through tl application, among others, of the followir rules:

IF
tense = present perfect
THEN
the verb sequence is formed with:
- simple present of 'to have'
- past participle of the verb.

IF
1 - tense = past participle,
2 - verb is regular
THEN
the verb sequence is formed with:
- 'ed-form' of the verb.

5. CONCLUSIONS

In the paper we have presented some issu involved in the design of a verb generatic module within a research project aimed developing an ITS capable of teaching tl English verb system. A first prototype of E has been fully implemented in MRS (LIS augmented with logic and rule-programmir capabilities and with specific mechanism f representing meta-knowledge) on a SUN workstation.

Our primary goal in this phase of the project has been the cognitive adequacy of the verb expert. In order to develop it, we took a pragmatic approach, starting with the identification of the features traditionally considered by grammars, constructing rules of tense selection grounded on this features and, finally, refining features and rules according to the results obtained through their use.

The work presented here relates both to the research carried out in the fields of linguistics and philosophy, concerning theories of verb generation and the temporal meaning of verbs, respectively, and the field of intelligent tutoring systems. As far as the first topic is concerned, we claim that teaching a foreign language can constitute a good benchmark for evaluating the soundness and completeness of such theories. In the field of foreign language teaching, on the other hand, the only way to build articulated, glass-box experts is to provide them with language capabilities such as those devised and described by linguistic theories.

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