Developing an Intelligent Web-Based Thai Tutor: Some Issues in the Temporal Expert

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Abstract

Computer aided language learning system is an attractive application of Artificial Intelligence in Education. This paper presents details of a web-based Thai language tutoring system. The system, called Thai Tutor (TT), assists students who are learning Thai as a second language. Since temporal information constitutes an important part to the meaning of a sentence, we concentrate on a module of the system called the temporal expert. This domain dependent expert is devoted to represent and reason the temporal knowledge by using Allen's interval-based temporal logic. The temporal expert provides information about the order of events so as to convey the intended meaning of the sentence.

Keywords: intelligent language tutoring system, web-based language instruction, temporal reasoning

1. Introduction

Capability in language learning is individual. This may depend on his/her first language, culture, talent, and teaching environment. Effective learning method needs a self-controlled system that allows students to practice and revise the lessons on demand. Classical lecture conveys all subjects' contents as scheduled in the teaching plan. In contrast, tutors, who normally accommodate only a small group of students, can follow the progress of each student through assignments and revision exercises as needed. Specifically, one-to-one human tutoring is widely accepted as a well-understood way of communicating knowledge. It allows learning to be highly individualized and consistently yields better outcomes than other methods of teaching [2]. However, one-to-one tutoring is limited by the number of qualified tutors as well as their availability.

An intelligent tutoring system (ITS) is a program capable of providing students with tutorial guidance in a given subject. The program mimics the way one-to-one tutors conduct their classes. Lessons and practices are dynamically chosen according to the student's language proficiency and progress. A full fledged ITS: a) has specific domain expertise; b) is capable of modeling the student's knowledge in order to discover the reason(s) of his mistakes; and c) is able to make teaching more effective by applying different tutorial strategies [4]. Records and updated histories of individual students are kept in *Student Model*. These details assist in the determination of the next activity for that student. The evaluation process of the student, in order to designate the proper activity, is performed in the *Tutorial Module*. Using the expert system concept, the ITS stores the various teaching methodologies on how to convey subject knowledge to students with diverse background and ability. It allows the overall system to demonstrate or model a correct way of teaching the subject. Both the *Student Model* and *Tutorial Module* will refer to knowledge about ideal student actions in the expert system.

Our preliminary paper proposed in [12] investigates the *Thai Tutor* (TT) system architecture, various learning behavior, and basic Thai lessons structure. Here, we extend the system's ability to train students about tenses by using Allen's interval-based temporal logic.

2. Characteristics of Thai language

2.1 Sentence structure

Thai grammar refers mostly to word order and the use of words like "*dai*" and "*laeo*", so called *function words*. These words have basic meanings related to time and action, which alter tenses or give phrases and sentences different shades of meaning. Verbs in Thai sentences consist only their root form. There is no transformation according to tenses, number, gender of subjects, or subjective mood. The expression of different situation is done by adding to the sentence different wordings with the desired meaning.

Thai words are often interchangeable as parts of speech. Moreover, some of the words in a sentence may be optional. All Thai sentences have a complete form, where words may be omitted depending on the context and the formality of the situation [7]. In general, the more wordings a sentence has, the more formal it sounds. This interchangeability and flexibility of the language increase learning difficulties, especially to learners who are more familiar with languages where tenses are intentional.

2.2 Expression of temporal information in Thai

An important part of a sentence meaning is constituted by temporal information. The information implied by tenses indicates the order of events or situations. An event can be either time interval or instance of time in which the situation described in the sentence takes place and the moment in which the sentence is uttered. The relationship between events described the series of events constituting a scenario. Even though, verbs in Thai sentences are not modified according to tenses as mentioned earlier, using proper functional words or adverbs of time are essential for communicating the right meaning. For example, consider the sentence "I bought some food when I went to the market." The action "I bought some food" happened sometime when I was at the market. In Thai, we can express this two-clause sentence as:

ฉัน*ซื้ออาหาร***ขณะที่**ฉัน*ไป*ตลาด or

ฉัน*ซื้ออาหาร***ตอนที่**ฉัน*ไป*ตลาด

The *italic* words indicate verbs of each clause, while the **bold** words specify the conjunctions having the same meaning "while".

However, consider

ฉัน*ซื้ออาหาร***หลังจากที่**ฉัน*ไป*ตลาด

By changing the conjunction, the meaning is changed to "I bought some food after I went to the market", in other words, the first clause happened after the second. Note that the verbs in each clause for all the sentences remain the same (no modification according to tenses). Each sentence uses the bold wording to specify the tense and order of the clauses.

3. System architecture

3.1 The web-based *Thai Tutor* system

As web technologies for adapting existing educational content converge with increased bandwidth, web-based ITSs with integrated multimedia are increasingly expected to have higher degrees of adaptiveness and interactivity [6]. The diversity of users presents a challenge in system design. It needs to be general enough to suit a variety of competencies, and backgrounds. For example, when analyzing the mistakes from completed assignments, the intelligent language tutor has to do it based on the native language of the student [13] at least. An online system must adopt a more generic scheme in order to accommodate international access and cases where the native language of the user might not be known. However, system performance and efficiency are also an important issue. A visible delay between the browser and the servers defeats the purpose of an interactive system, and can distract the problem solving activity [3]. The *Thai Tutor* we are developing resides on a Linux machine and uses English as the communication tool.

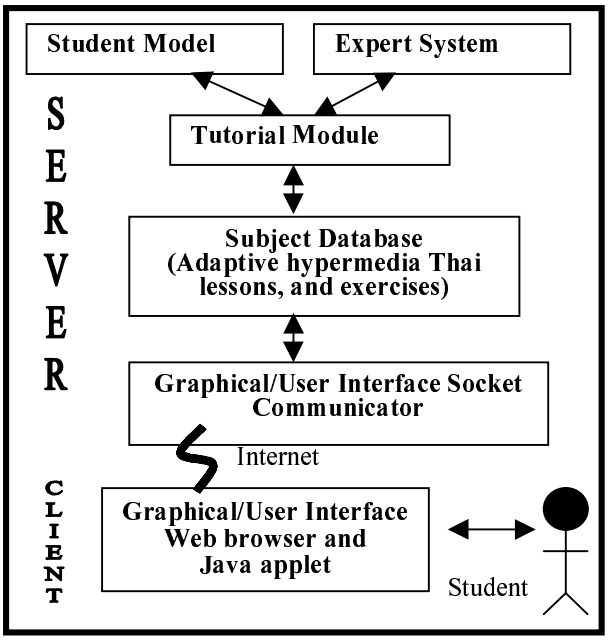

Figure 2. Web-based Thai tutoring system

Displaying Thai characters is a big issue when implementing a digital system. German and French, for example, employ English alphabets and some special symbols in writing, but this is not the case in Thai. Chinese writings, like Thai in some aspects, also have their own characters instead of using English alphabets to describe the languages. However, writing Thai is more complicated as compared to others. With one Thai character, there can be three levels of symbols located above and below it. Therefore, to provide the international access without any modification on the client side, Thai words are stored as image files. In this case, the system performance will be acceptable as the major display will be in English along with other adaptive multimedia files, such as sound and animation. Architecture of the *Thai Tutor* is then shown in Figure 2.

3.2 *Student Model*

In the literature, a number of student modeling techniques have been employed for ITS. The *Student Model* functions as an accumulative and adaptive database for each user. Therefore, a challenging task in implementing multi-user system is to identify users while maintaining user models adaptable to the individual. A number of solutions have been proposed which range from cookies [10], structured URLs [3], and hidden fields to login screens [13]. Deciding on an appropriate alternative depends primarily on the purpose of the application.

Our *Thai Tutor* system stores a database of users, each entry established by an initial login. The student login and password are used to identify a user. This is sufficient since students do not navigate through different HTML pages during learning, but can access a consistent applet. *Student Model* requires the user's identification for two main functions: a) to store scores across a number of error types, or nodes, such as pronunciation, vocabulary, punctuation, etc. Each node is broken down into more fine-grained categories. Dealing with pronunciation learning, the error will be categorized into various word tones of low, medium, and high sound characters. For example, a medium sound consonant when forming a word can have five tones. Thus, the student's error can be finely recognized as a unique tone to the medium sound word. This information is shown to the user at the end of each exercise set; b) to keep and update history of the learners. Depending on student's input, the score for each node will go up or down. These data will be used to adjust the lesson, emphasis of an exercise, etc. These two functions together allow the system to perform a fine-tuned assessment of student competency. Thus a single-error will not drastically change the student's overall assessment.

4. Temporal expert

4.1 Knowledge representation

Our Thai tutor needs an ability to generate and exercise the correct tense for each sentence. Since there is no tense transformation to the verb, TT system concentrates only on how to choose the appropriate function words, adverbs of time, and conjunctions, and also the degree of politeness. Based on Allen's temporal knowledge representation paradigm [1], we consider each primitive event as an interval of time. While a time interval can be an event, an activity or a situation.

The representation of a sentence starts with the sentence structure, which may consist of one or more clauses. The task to be solved is indicated in "Part_to_solve", e.g., finding proper function words, adverbs of time, and conjunctions. Information about each clause is schematically represented by a number of attributes that are:

- *Clause_type*: role of the clause i.e., main, co-ordinate, or subordinate clause;
- *Clause_form*: intention of the clause i.e., narration, question, negation, request, demand;
- *Relation*: a set of sub-attributes (a related interval, possible relation 1, possible relation 2, …, possible relation *n*);
- *Formality*: degree of formality to which situation the clause applies.

A possible relation between two intervals is a disjunction of the thirteen primitive relations proposed by Allen [1]. They are before (*b*), equal (*e*), meet (*m*), overlap (*o*), during (*d*), start (*s*), finish (*f*), and their inverses which indicate by an "*i*" after the relation. These relations can be graphically shown in Table 1. The disjunction of these primitive relations expressively represents ambiguity between two events when the starting and finishing points of the events cannot be clearly stated.

Relation	Symbol	Symbol for Inverse	Pictorial Example
X before Y	b	a	XXX YYY
X equal Y	e	e	XXX YYY
X meets Y	m	mi	XXXYYY
X overlaps Y	o	oi	XXX YYY
X during Y	d	di	XXX YYYYYY
X starts Y	s	si	XXX YYYYY
X finishes Y	f	fi	XXX YYYYY

Table 1. Allen's thirteen interval relations.

4.2 Temporal reasoning

In this subsection, we introduce two examples of temporal reasoning in Thai tutor. The first example shows a simple sentence when the relation between two clauses implies the proper conjunction. The second example introduces the reasoning process when there is ambiguity between three events.

Example 1: Suppose the system proposes an exercise to students in order to find a proper conjunction indicating the order of two events ("I bought some food" and "I went to the market") as follows:

ฉันซื้ออาหาร ... (conjunction) ... ฉันไปตลาด

Here the meaning we intend to train students is "I bought some food when I went to the market". The schematic description of this sentence is the following:

Sentence: S1
  Structure: C1, C2
  Part_to_solve: conjunction
Clause: C1
  Clause_type: main
  Clause_form: narrative
  Relation: (C2, *s, f, d, e*)
  Formality: 2
  Part_to_solve: none
Clause: C2
  Clause_type: subordinate
  Clause_form: narrative
  Relation: (C1, *si, fi, di, e*)
  Formality: 2
  Part_to_solve: none

Typically, a Thai sentence can be applied with more than one function word to make the sentence sound more formal and polite. This depends on the context of the sentence. Here we represent the degree of formality as an integer in order to demonstrate the natural conversation. From the intended meaning of sentence S1, we can imply that

- The starting of the interval C1 ("I bought some food") was during the time period when the clause C2 ("I went to the market") was carrying on;
- The event C1 terminated before the ending of the event C2.

Therefore, the clause "I bought some food" could start, finish, during, or happen at the same time (equal) as the clause "I went to the market". When TT verifies the answer from learners, the temporal expert matches the relation between two clauses with a conjunction table to obtain the proper conjunction.

This exercise can be simply resolved by table look up techniques. However, the significant part of this task is the construction of the table. Each entry of the table contains a Thai word (e.g., conjunctions, function words, adverbs of time, etc.) that matches the corresponding situation (e.g., tense, formality, etc.).

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In real situation, a conversation may refer to more than two events. In such cases, the temporal relationship between any pair of events may be unknown. In some cases, the system may have complete information about how the events could be related. But when new temporal information is entered, all relations will have to be revised to maintain the consistent knowledge of the overall scenario. To generate or verify an appropriate tense for a given clause or sentence, we need a reasoning process that infers the unknown relations or eliminates the inapplicable relations.

Example 2: Suppose we further know that "A friend came to my house after I left home for the market". This knowledge helps us to infer the relationship between the events "A friend came to my house" and "I went to the market" as the disjunction of relations "after (*a*)", "met by (*mi*)", "overlapped by (*oi*)", "during (*d*)", and "finish (*fi*)". However, the temporal relation between events "I bought some food" and "A friend came to my house" remains unknown. The schematic representation of the additional knowledge can be shown as follows:

Sentence: S2
  Structure: C3, C2
  Part_to_solve: none
Clause: C3
  Clause_type: main
  Clause_form: narrative
  Relation: (C2, *a, mi, oi, d, f*)
  Formality: 2
  Part_to_solve: none
Clause: C2
  Clause_type: subordinate
  Clause_form: narrative
  Relation: (C3, *b, m, o, di, fi*)
  Formality: 2
  Part_to_solve: none

The reasoning task here is to generate the unknown relation between clause C1 and C3. The new fact (the relation between C3 and C2) adds a constraint about how the two events could be related. This may in turn introduce new constraints between other events. In this scenario, there are only three events and the relation between C1 and C3 is not predefined. The consequence of the added knowledge will identify the relation between C1 and C3. To achieve the task, we adopted Allen's temporal reasoning algorithm called *Constraints (R1, R2)*, where *R1* is the disjunctive relation between clauses C1 and C2, and *R2* is the disjunctive relation between clauses C2 and C3. This algorithm was later modified to the so-called Path Consistency algorithm [8].

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Constraints (R1, R2)
    C ← ξ
    For each r1 in R1
        For each r2 in R2
            C ← C ∪ T (r1, r2)
    Return C
```

U is the mathematical union operation. T(*r1, r2*) is the transitivity function describing the inferred relations from primitive relation *r1* to *r2*. For instance, if interval *i* is during interval *j*, and the fact that interval *j* happens before interval *k* is added, then the transitivity function infers that interval *i* must be before interval *k*.

In our scenario, *R1* is the set {*s, f, d, e*} and *R2* is the set {*b, m, o, di, fi*}. After the reasoning process, the relation between clauses C1 and C3 may be any of the possible thirteen relations. Therefore, we cannot strictly

specify the order of the two events (C1 and C3). In other words, all conjunctions are possible to conjugate the clauses. Until more new knowledge about temporal relation is provided, relation between the intervals can be further restricted.

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5. Related works

Several ITSs for teaching languages have been proposed. A system for teaching English as a second language presented by Fum, et al., concentrated on generating in a cognitively transparent way, the right tense for the verb(s) appearing in exercises [4]. A related work by Fum, et al., [5] focused on the relationships between naive grammar (knowledge derived from textbooks and school grammars), and formal grammar (developed by theoretical and computational linguists). Another ITS, called *Tutor Assistant*, is designed to be an authoring tool for English language instructors to create their own lessons and exercises [11]. This study also evaluated the degree to which instructors can author good quality content for an *English Tutor* and established benchmarks for development times. ALICE uses Natural Language Processing (NLP) as a basis both for assisting instructors in preparing exercises and for evaluating student responses [9]. Finally, a *German Tutor* was developed by Heift and Nicholson [6]. This attempted to implement generality, interactivity and modularity into the system with an emphasis on efficient and adaptive hypermedia.

As for the Thai learning system, there are several Thai courseware either on a stand-alone machine, or publicly on the Internet. However, they are conventional Computer Assisted Instruction (CAI) setups.

6. Conclusion and ongoing research

Verbs in Thai sentences are not modified according to the chronological order of events. They need additional words (e.g., adverb of time, function words, conjunctions, etc.) to express the tenses. This paper presented a web-based ITS for teaching Thai as a second language, called *Thai Tutor*. The system is able to handle the temporal information when tenses are involved. A module, called *Temporal Expert,* is devoted to represent and reason the temporal knowledge by using Allen's interval-based temporal logic. The temporal expert provides information about the order of events so as to convey the intended meaning of the sentence. The long-term project for a fruitful *Thai Tutor* requires developing the ability to recognize and diagnose learners' pronunciation when speeches are emphasized. Unfortunately, current technology does not yet practically support this requirement.

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