Intelligent Tutoring Systems for Foreign Language Learning

The Bridge to International Communication

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Introduction

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Advances in artificial intelligence (AI) in education applications have improved the potential of developing intelligent instructional systems that can actually be used in the classroom. Progress in natural language processing (NLP) has also improved the way in which computers handle natural language input. It seems propitious, therefore, that we look at these two technological advances in the application of foreign language (FL), intelligent tutoring systems (ITS). Despite these advances, the challenge of integrating ITS and NLP into one hybrid system is a formidable task. The papers in this book, and others presented at the Workshop, address that challenge and present current research in the field representing laboratories from 10 different countries (Australia, Canada, England, France, Germany, Greece, Italy, Scotland, Turkey, U.S.A.).

Intelligent Tutoring Systems for Foreign Languages

Language instruction delivered on computers is not new, but the enhancement of such instruction with AI technology in computer systems is. Computer-assisted language learning (CALL) has been used in foreign language instruction for some time with varying degrees of success [11]. This CALL approach to computer-delivered instruction generally uses predefined branching routines and static error feedback messages to guide learners. More adaptive, individualized instruction is feasible with AI techniques that model learner performance and deliver goal-based and remedial instruction to move the learner through the material [5, 13, 8]. This kind of computer-based instruction is the basis for ITS. The domains that have been most used in recent ITS development are the most pan-memorable and formally defined (mathematics, physics, electronics). Of course, not all of the problems in ITS research have been solved in these domains. Nevertheless, some very promising ITS exist that are used in training settings (e.g., the Geometry ITS [2]).

In less well-defined domains such as language learning, many important issues are emerging that were not encountered in the traditional ITS domains. Some of these issues involve (i) the representation of linguistic knowledge in the expert and learner models, (ii)

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Note 1: I would like to comment on the use of both foreign and second language learning (FLL and SLL in this book). Both terms refer to the acquisition of a non-native language. In some communities, the language is a second language (e.g., Canada with English and French) in large monolingual societies the second language is often referred to as a foreign language. We align about appropriate terminology at the Workshop, but on this occasion we were saved. One can argue that for some learners, it is time to teach language learning—such foreign language learning (FLL) needs change! On the other hand, all non-native languages can be viewed as foreign until learned adequately; this seems to be the best general term to use. This distinction is not accepted universally in the field. The reader should therefore not be confused (FLL and SLL used in the book which reflect either the multicultural definition for non-native language learning in a country or personal preference.)

Note 2: In ITS, the expert 'student' model is generally used when referring to the person acquiring some skill. We distinguish the terms ‘student’ and ‘learner’ and their relation to language skill acquisition during our working sessions. Borrowing from Seligman [12] we are term 'learners' in the 'critic' annotation context since it reflects more active participation and collaboration in the learning process on the part of the learner.
implementing parsers that must process ungrammatical input and reason about it in view of learners’ predictable interlingual productions during learning, (3) representing tutoring knowledge that is appropriate for language learning (teaching strategies and principles for language learning are different from other types of skill learning), and (4) understanding the foreign language acquisition process.

Many of these issues will involve a considerable research effort before effective FL ITS becomes a reality in the classroom; and we do not wish to claim that all these problems have to be solved before such a system is developed. Indeed, we shall not doubt be wrestling with some of these issues for some time. Nevertheless, we examined selected issues from those listed above at our Workshop and discussed their role in the development of an ITS framework for foreign language learning. This book, as a compilation of some of the papers presented at the Workshop, presents an overview of the current state of the art and recent contributions made to the field.

In order to understand the issues that face FL ITS research, the reader should be familiar with the basic architecture for an intelligent tutoring system. An ITS is made up of four basic modules: the user model, the learner model, the tutor model, and the interface or communication with the learner. The reader is referred to many excellent books that give more detailed information about ITS in other domains and ITS architectures [1, 12, 14, 16, 17, 19]. These modules are briefly reviewed below with a description of the unique requirements for developing FL ITS.

The Expert Module for a Language ITS

The expert module of an ITS provides the domain intelligence for the system [1], a model of the expert. For any given domain, one must decide what knowledge to include in the expert model, but also, how we should represent or encode it. Anderson [1] provides an overview of the three primary approaches to codifying expert knowledge: black box models, expert systems, and cognitive models; and discusses the tradeoffs for each approach in terms of implementation effort and pedagogical effectiveness. In language domains, we will find that certain approaches are more appropriate than others, given the nature of linguistic knowledge, even though the implementation costs are high.

This ITS module represents the domain-specific expert knowledge and the inference or reasoning processes involved in solving problems in the instructional domain. In language domains, this means we need some type of grammar and a lexicon for processing natural language (the expert knowledge), and a parser (the expert inference engine) to process language input.

The grammar is used to define the legal rules for that portion of the language to be taught. This component of the expert knowledge base usually follows some syntactic theory (e.g., Definite Clause Grammar, Functional Unification Grammar, Lexical Functional Grammar, General Phrase Structure Grammar, and Tree Adjoining Grammar (TAG)) [19] used to formally represent a particular grammar. However, a linguist’s formal grammar is not the intention in the construction of this portion of the expert knowledge.

Foreign language teachers don’t teach formal grammatical, but rather some subset of the grammatical system for a language that is to be acquired by the learner for communicative purposes. Similarly, the coverage in the language ITS must be intentional in this requirement. The expert model’s grammar knowledge need not be exhaustive and adequate for the skill level (beginning, intermediate, advanced) to be addressed by the system.

A lexicon is another component in the knowledge base to provide coverage for the words to be acquired by the learner, and that will permit the learner to understand language input during various activities and learning experiences. Some type of formant is required to represent the semantics for the lexicon so that meaningful parsing can be accomplished for words used in context. Language learning is not simple vocabulary learning where an item in LI is mapped directly to its correspondent in L2 [12]. The context surrounding a word has much to do with specifying what word or idiom is used to appropriately communicate some meaning. But representing semantics and limited pragmatics in an ITS is a very hard research problem. Nevertheless, the system should identify some form of world knowledge and context to illustrate how language is used in natural settings.

The parser provides the means for the computer system to reason about and process the language, and it is the last major component in the expert module. In FL ITS, the challenge is not only to provide natural language understanding capabilities, but to allow for processing imperfect input since learners never have complete control of the L2 used. Parsing natural language in a FL ITS involves not only meaning of the learner’s attempt to use the system, but also understanding the domain skill itself that is being taught. This is a unique characteristic for NLP in language ITS implementations. The parser must be capable of accepting divergent input strings from learners and be able to identify a plausible divergence from non-native language so as to be capable of resolving properly about learners’ attempts to use the L2.

The Learner Module for a Language ITS

The learner module in an ITS includes the information that describes a learner’s knowledge about what is being learned and allows the tutor module to adapt instruction (18) and provide appropriate feedback. Self [11] refers to this model as a set of programs designed to represent a learner’s knowledge state. VanLehn [18] specifies two components that make up the learner model: the language or representation of the knowledge in the model and the process that manipulates that knowledge structure. This process is termed ‘diagnosis’ and the outcome is termed knowledge state assessment.

In order to properly model the learner and perform diagnosis, the system must have knowledge about learner errors. In traditional ITSs, these errors are stored in log files or lists of rules that get accessed when the system is engaged in learner diagnosis. While similar methods can be employed in FL ITS, the nature of the error and the way the system should handle it are different for foreign language learning (see Chapter 5).

In a foreign language domain, the representation of the knowledge in the learner model must be the same computational form as in the expert model. This is so that during the process of diagnosis, the system can cope with the two knowledge states using some acceptable modeling technique. Thus we can expect some type of formal grammar and lexicon in the learner model similar in form to those used in the expert module. The process of diagnosis has traditionally used techniques such as overlay or differential models [14] or model tracing [1, 18]. In language learning where communicative skills are stressed and situation dependent, other modeling techniques may be needed. Several papers in this book describe implementations of these and other techniques more suited to language learning.

Building and maintaining such a learner model is generally considered a difficult and costly task. Constructing a ‘deep’ model may not be a priority in certain cases (e.g., learning language for communicative purposes where the idea expressed counts more than...
the actual grammatical construction used), but in other circumstances, a deeper learner model is unavoidable (e., when diagnosing grammar errors is important). A set of design principles for bypassing some of the problems encountered in constructing a deep model [12] should help FL ITS researchers with this problem.

The Tutor Module for a Language ITS

This module represents the tutoring strategies and instructional goals used to deliver instruction in the system. The tutor module in an ITS is responsible for enabling the student to solve problems in the domain. Teaching students how to acquire a skill is difficult because the computer tutor must be able to adapt to the instructional needs of the student. This means that the knowledge base of the learning environment should provide a means for entering language input to be parsed by the system and the use of different media (graphics, animation, text, sound, video) to present language in meaningful, communicative situations. This suggests the use of some type of multimedia, multimodal design. Different media are especially important for language learning so that acoustic, semantic, and orthographic mappings to the L2 can be made.

Current advances in graphical interface and multimedia technology provide us with new, exciting tools for creating the graphical interface. Many of the papers in this book illustrate the different multimedia approaches available for foreign language ITS interface implementations.

The Structure of the Book

The papers in the book represent a selection of those presented at the Workshop, and are organized into five different sections to reflect a conceptual focus for each group of papers. We used the Workshop topics to organize our presentations and focus our discussions (computational and theoretical foundations, learner modeling and error diagnosis, tutoring strategies and learner control). We found that some of the papers addressed other areas not explicitly covered by these topics. The foreign language experts we invited to the Workshop were most concerned about identifying language learner characteristics and discussing practical issues related to using computers in the classroom. Since understanding these issues is a fundamental prerequisite to foreign language ITS research, we grouped those papers that explore some of the research problems we face in the development of the three principal ITS modules. The next three sections of the book present papers that explore some of the research problems we face in the development of the three principal ITS modules. These sections propose methods for solving some of the knowledge representation, computational, theoretical, and modeling problems we face. The papers presented in Section Two deal with the first topic. Here we grouped those papers that described theories of foreign language acquisition and processing, and computational formalisms for representing linguistic knowledge, as a theoretical basis for understanding foreign language ITS requirements. Section Three includes papers that describe modeling techniques for understanding what the learner knows about the L1 and methods for constructing learner models. These papers deal with the computational aspects of the second topic, but also depend on an understanding of learner characteristics and errors presented in Section One. Section Four presents papers that describe approaches to tutoring language and ITS. These papers focus on using principled techniques and environments for presenting communicative foreign language tutoring with innovative use of multimedia. Section Five presents descriptions of working intelligent CALL prototypes. These papers present recent accomplishments and the technology promise in FL ITS research.

All of the Workshop participants are gratefully acknowledged for the lively discussion and critiques of the work presented during the Workshop, and their consideration of the research problems that remain to be solved. Their many fruitful ideas and contributions that arose in the working group sessions are reflected in the introductory comments for each section of the book.
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The papers cover many different technical domains and therefore can be read in a modular fashion. We assume that our readers will come is familiar with certain sections or papers in the book depending on your background and interest. But we hope that you will read those other sections whose work is less familiar to you in order to understand the interaction between different fields in a multidisciplinary effort such as FL ITS development. We also hope that the readers will be able to gain from the work presented in this book and use it as a guide for continued research in the field.

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Section One

Teaching Practice: Understanding Technology and Language Learners

One of the first steps in the development of a foreign language ITS is to understand the characteristics of language learners and language teaching practice. In this section we present a group of papers that were prepared by foreign language teaching experts invited to our Workshop. In this introduction, we borrow from an essay presented at the Workshop by Alex Gogos, English professor, Aristotle University, on the practical perspective of computer-assisted language learning (CALL) in the classroom.

As a foreign language teaching expert, Dr. Gogos elaborated on two interesting views for CALL. One view embraces all the possible aspects of CALL, new technology, automated instruction, and instructional support for the teacher. Where previously the language teacher had relied on record and audiotape players, videos and filmstrips, and the language laboratory, we are now seeing the language laboratory concept encapsulated in one system: CALL. These systems provide multimedia presentations of language material with sound, animation, and online exercises. This is exciting, but we must not be seduced by more technology; high-tech toys will not in and of themselves perform miracles in the classroom.

The other view for CALL begins with an admission that foreign language learning is very different from learning other subjects. Everyone agrees that to become a graduate in nearly any subject (math, economics, or computer programming), one follows a four-year program of study and then gets a diploma. This degree assures us that the graduate is knowledgeable in the subject, indeed a specialist or expert in the field. However, with language learning, the situation is somewhat different. After four years of study, the graduate may be considered a specialist in the field, but there is no guarantee thatthis individual will be comparable with a native speaker (an expert in the field). This is especially true if the individual started the program with no prior knowledge in the language or if the program of study is in their native language environment.

Nevertheless, CALL has entered the classroom and there it shall stay. To use it effectively in the classroom, and to develop it into a more sophisticated intelligent tutoring system, we must first come to understand the language learner, the acquisition process itself, and how to best utilize this new technology for instructional purposes.

Chapter 1 expands on this practical perspective with a description of an evolution of a CALL system presented at a German university. We show how CALL can be used to promote communicative interactions which between learner and system. The authors have also present a good description of learner characteristics from a psycholinguistic view of language acquisition. Their view of the learner as an 'experimenter' provides a good introduction to more detailed theoretical frameworks on foreign language acquisition presented in Section two of the book.

Chapter 2 in this section discusses language learner's errors and misconceptions that arise during learning. The authors have developed an analytic approach to extract diagnostic information about an individual's errors during a lesson. This approach uses an interactive dialogue where questions are used to probe learners' 'intuitions' regarding novel linguistic phenomena. Such empirical data along with other important role in error diagnosis in ITS research. We will revisit similar issues in error knowledge acquisition and the computational formalism derived from this analysis in the sections on Modelling the Language Learner presented later.