Designing Learner Models for Intelligent Language Tutors

Luiz Amaral and Detmar Meurers

The Ohio State University

CALICO
May 26, 2007

Intelligent Tutoring Systems

- An Intelligent Tutoring System (ITS) is a computer program that intelligently interacts with the learner.
- Since Hartley and Sleeman (1973) an ITS is recognized as consisting of at least three components:
  - the expert model
  - the instruction model
  - the student model

The Roles of Student Models

- VanLehen (1988) presents four uses for student models:
  - Advancement
  - Offering advice
  - Adapting explanations
  - Problem generation
- In ICALL, Student Models have primarily focused on the acquisition of grammatical structures.
- ICALL systems keep track of the students' production in terms of the grammatical accuracy of their performance.

E-Tutor (Heift 2004)

- The system keeps track of a student's performance for individual so-called *grammar skills*.
- The numeric performance scores are grouped into three levels: *beginner*, *intermediate*, and *advanced*.
- When the system identifies a specific grammatical error in the student's input
  - it checks the relative level of proficiency of that student for the relevant grammar skill
  - and decides which feedback message to use on this basis.

ICICLE system (SLALOM, Michaud et al. 2001)

- Goal: capture the status of the grammatical structures of English as *acquired*, *being-acquired*, and *unacquired*.
- The knowledge units (KU) of SLALOM are grammatical concepts based on English rules and 'mal-rules'.
- KUs are grouped and hierarchically classified following stereotypical sequences of the acquisition of grammar concepts (Gass 1979; Schwartz and Sprouse 1996).
- Used to predict a student's current state of knowledge and the next grammatical structures to be acquired.

Beyond Grammar Knowledge

- Bull et al. (1995) argue for extending the scope of student models to incorporate aspects outside the boundary of the linguistic domain knowledge.
- They propose to add models of
  - learning strategies
  - analogy
- Their focus is on a general model of learning processes for different domains, not on the nature of language acquisition or linguistic modelling.

CASTLE (Murphy and McTear 1997)

Learner model consists of three components:

- the student's personal information
- the "student model"
  - student's performance per domain topic
  - proneness to commit certain errors
  - the likely causes of errors
- the "cognitive model"
  - student's preferred feedback media and exercise types
  - interest in grammar
  - the use of polite forms

What are we modelling?

1. What kind of student knowledge are we trying to model?
   - What is being acquired by the student?
   - What can we observe through analysis of the input?
2. How do we obtain information about the student knowledge?
   - How can we infer knowledge structures?
   - How do we guarantee the validity of the inferences?

Some SLA perspectives

- Ellis (2003): "the general goal of language learning is the fluent, accurate, and pragmatically effective use of the target language."
- Canale and Swain (1980): the four major types of knowledge a learner needs to acquire are
  - grammatical competence
  - sociolinguistic competence
  - discourse competence
  - strategic competence
- Bachman (1990): strategic competence is the set of non-linguistic properties to be acquired by the learner that play a role in language use.

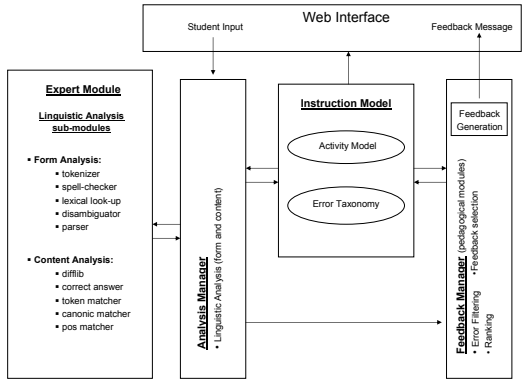
Ensuring the Validity of the Inferences

- The system's inferences about a student's state of knowledge must be valid:
  - Content Validity: "extent to which the test content forms a satisfactory basis for the inferences to be made from test performance." (McNamara 2000)
- ICALL learner modelling usually takes for granted that linguistic errors are caused solely by a lack of linguistic knowledge.
- To guarantee valid interpretations of students' performance it is necessary to add information about the task environment where it occurs.

TAGARELA

- TAGARELA can be viewed as an intelligent electronic workbook
- It offers on the spot individualized feedback on spelling, morphological, syntactic and semantic errors.
- Its exercise types are similar to the ones found in regular workbooks:
  - Listening
  - Reading
  - Description
  - Fill in the Blanks
  - Rephrasing
  - Vocabulary

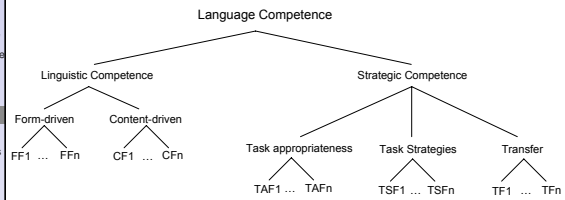
General Architecture of the TAGARELA system



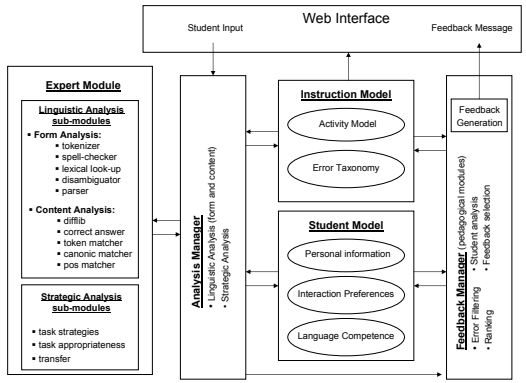
Towards a Student Model for TAGARELA

- We propose to extend ICALL student models with a representation of three aspects of strategic competence:
  - Task Appropriateness
  - Task Strategies
  - Transfer
- In line with Self (1990), we focus on modelling aspects which can be inferred based on the analyzed learner input and explicit activity models.

Conceptualization of the Learner Model



Extended Architecture of TAGARELA



What informs the student model?

Information to draw inferences about students knowledge structures comes from two sources:

- the input analyses by the NLP modules
- the activity model, which explicitly specifies:
  - level (sequence of the material)
  - nature of input (string, phrase, sentence)
  - content manipulation required (little/some/necessary/major)
  - strategies to perform the task (reading, listening, and writing strategies)

Why Task Strategies in Student Model?

- Setting:
  - Student answers reading comprehension question requiring scanning a text for specific information.
  - A specific learner repeatedly does not include a key concept in the answers.
- System without Task Strategies in Student Model:
  - Inferences:
    - System determines that student has problems including all content words in the answer.
  - Feedback:
    - "There is a noun missing in your sentence again."
- System with Task Strategies in Student Model:
  - Inferences:
    - System determines that student has problems employing the scanning strategy required by the activity.
  - Feedback:
    - "Try to scan the text more carefully to include all the key concepts in your answer."

Why Task Appropriateness in Student Model?

(performance by type/level of activity)

- Setting:
  - A specific learner typically realizes correct subject-verb agreement in Fill-in-Blank but not in Reading Comprehension answers.
- System without Task Appropriateness in Student Model:
  - Inferences:
    - System determines that student sometimes has problems with subject-verb agreement.
  - Feedback:
    - Reporting subject-verb agreement receives the same priority no matter where they occur.
- System with Task Appropriateness in Student Model:
  - Inferences:
    - System determines that student has problems with subject-verb agreement in specific types of activities.
  - Feedback:
    - Reporting subject-verb agreement errors receives different priority, depending on activity type/level.

Why Negative Transfer in Student Model?

- Setting:
  - A specific learner repeatedly makes lexical transfer errors (false cognate).
    - E.g., Portuguese learners of English use “assume” instead of “admit” given Portuguese “assumir” = “admit”.
  - As answer to a comprehension question:
    - Student: *John assumed Bill was wrong.*
    - Target: *John admitted Bill was wrong.*
- System without Transfer in Student Model:
  - Inferences: ambiguity whether meaning or transfer error
  - Feedback: resolve somehow, e.g., report meaning error as the more general case
- System with Transfer in Student Model:
  - Inferences/Feedback:
    - The system can rule out an analysis based on the use of wrong content word/concept, in favor of reporting a lexical transfer analysis.

Summary

- We argued for extending ICALL student models to include aspects of the strategic competence of a student, representing factors outside of the linguistic competence per se.
- This makes it possible to model the learner’s abilities to use language in context for specific goals and the learner’s abilities relative to particular tasks.
- Updating the model currently requires hand-specification of explicit activity models, which however are well-motivated by the need to support valid inferences about the student’s state of knowledge.
- In future work we intend to explore deriving some of these properties via additional natural language processing and resources.

References

Bachman, Lyle F. (1990). *Fundamental Considerations in Language Testing*. Oxford, UK: Oxford University Press.

Bull, Susan, Paul Brna and Helen Pain (1995). Extending the Scope of the Student Model. *User Modeling and User-Adapted interaction* 5, 45–65.

Canale, M. and M. Swain (1980). Theoretical Basis of Communicative Approaches to Second Language Testing. *Applied Linguistics* 1, 1–47.

Ellis, Rod (2003). *Task-based Language Learning and Teaching*. Oxford, UK: Oxford University Press.

Gass, Susan (1979). Language Transfer and Universal Grammatical Relations. *Language Learning* 29(2), 327–344.

Hartley, J.R. and Derek H. Sleeman (1973). Towards intelligent teaching systems. *International Journal of Man-Machine Studies* 5, 215–236.

Heift, Trude (2004). Inspectable Learner Reports for Web-based Language Learning. *ReCALL Journal* 16(2), 416–431.

McNamara, Tim (2000). *Language Testing*. Oxford, UK: Oxford University Press.

Michaud, Lisa N., Kathleen F. McCoy and Litza A. Stark (2001). Modeling the Acquisition of English: An Intelligent CALL Approach. In *Proceedings of The 8th International Confeence on User Modeling*. Sonthofen, Germany, pp. 14–25.

Murphy, Maureen and Michael McTear (1997). Learner Modelling for Intelligent CALL. In *Proceedings of The 6th International Confeence on User Modeling*. Sardinia, Italy, pp. 301–312.

Schwartz, Bonnie and Rex Sprouse (1996). L2 Cognitive States and the Full Transfer/Full Access model. *Second Language Research* 12(1), 40–72.

Self, J. (1990). Bypassing the intractable problem of student modelling. In G. G. Gauthier and C. Frasson (eds.), *Proceedings of Intelligent Tutoring Systems ’88*. pp. 18–24. http://citeseer.ist.psu.edu/self90bypassing.html.

VanLehen, Kurt (1988). Student Modeling. In Martha Polson and Jeffrey Richardson (eds.), *Foundations of Intelligent Tutoring Systems*, Hillsdale, NJ: Lawrence Erlbaum Associates Publishers, pp. 21–54.