Chen, W. et al. (Eds.) (2017). Proceedings of the 25th International Conference on Computers in Education. New Zealand: Asia-Pacific Society for Computers in Education

Proposal of an Intelligent Tutoring System for Procedural Learning with Context-aware Dialogue

José PALADINES[ab*] & Jaime RAMÍREZ[b]
[a]*Technical Sciences Faculty, Universidad Estatal del Sur de Manabí, Ecuador*
[b]*Computer Science School, Universidad Politécnica de Madrid, Spain*
*jose.paladines@unesum.edu.ec

Abstract: This poster presents a proposal for an ITS for procedural training in a 2D/3D virtual environment in what each student will be trained through a dialogue in natural language that takes into account his/her specific features, his/her progress in the development of the task and the environment where the task is performed. To support the dialogue, we will use a dialogue manager built on some of the platforms for creating dialogue managers currently available.

Keywords: Intelligent tutoring system, Natural language processing, Context-aware dialogue, Graphic virtual environment.

1. Introduction

Intelligent Tutoring Systems (ITS) have been developed for very varied environments and different purposes. However, there are very few ITSs for procedural training in which the student can interact with the system through an avatar in a 2D/3D virtual environment, and can dialogue with the system by using natural language.

Therefore, we present a proposal for an ITS for procedural training in a 2D/3D virtual environment with the capacity for dialoguing based on the context, that takes into account his/her specific features, his/her progress in the development of the task and the environment where the task is performed. So, tutoring feedback will be the result of a context-aware dialogue.

The dialogue manager will be built on some of the well-known platforms that have reached a remarkable degree of maturity for their facilities to interpret and process natural language in different application domains.

2. Related Work

Next we will present some of the most remarkable ITSs with Natural Language Processing (NLP) for 2D/3D virtual environments oriented to teaching. **Why2-Atlas** (VanLehn et al., 2002) supports that students write long explanations of simple mechanical phenomena, and uses a symbolic analysis (CARMEL) to discover their misconceptions. **Autotutor** (Graesser & et al., 2005) maintains mixed initiative dialogue in interactions in which students can explain concepts, and then their explanations are compared with a set of expectations and misconceptions by using Latent Semantic Analysis. **Beetle II** (Dzikovska, Steinhauser, Farrow, Moore, & Campbell, 2014) implements an approach based on task-oriented dialogue systems, and uses an ontology to represent domain knowledge.

On the other hand, the only ITSs with NLP for procedural training are Paco and Jacob. **Paco** (Rickel, Lesh, Rich, Sidner, & Gertner, 2002) supports tutoring actions as part of a collaborative dialogue system (built on Collagen) that uses rules based on a task model, a student model and the interaction with the student. **Jacob** (Evers & Nijholt, 2000) teaches to solve the problem of the Towers of Hanoi in a 3D virtual environment, and the interaction with the user is given by performing actions concerning the task. However, both Paco and Jacob suffer from many limitations regarding natural language dialogue.

3. Platforms for Creating Dialogue Managers

There are several platforms for the management of dialogue in natural language, between the most well-known are Api.ai from Google, Wit.ai from Facebook Messenger, Bluemix from IBM and LUIS from Microsoft. In general, these tools perform NLP within a workspace where the intentions, entities and the dialog flow are defined.

- Intentions represent the purpose of a user's entry (request).
- Entities represent a term or object that is relevant to intentions and provides a context for intention. Most platforms have predefined intentions that give a greater robustness to the application.
- The dialog is a logical tree-like conversation flow that defines how the application responds when it recognizes defined intentions and entities. Dialogue can be dynamically adjusted to the situations of a certain scenario by means of the context variables.

4. Features of an ITS for Procedural Training in a 2D/3D Virtual Environment with NLP

The dialogue manager has to implement a context-aware dialogue. To achieve this, the context should contain information on the virtual environment (static and dynamic), the student's knowledge and progress in the activity to be performed. With this information it will be possible to provide a personalized tutoring through a context-aware dialogue adapted to: what the student knows; his/her avatar location in the virtual environment at the time of the dialogue; and the phase of the procedure in which the student is. Some examples of personalized tutoring feedbacks would be the following ones:

- Answer questions about the location of an object in the virtual environment or how to reach it, even when this object is far away from the student's avatar.
- Answer questions about the next action to be done.
- Recommend learning activities to bridge knowledge gaps.
- Provide proactively hints to guide the student with the execution of a task.
- Encourage an affective dialogue in the face of student inactivity or moments of uncertainty.

5. Proposed Approach

In Figure 1 we show the architecture composed by three main components, which would provide a personalized tutoring centered around the virtual environment where the training is performed.

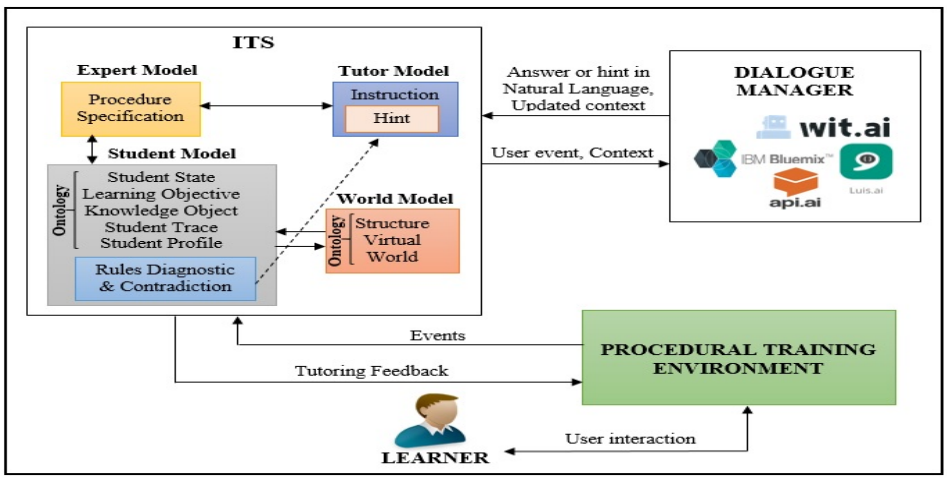

Figure 1. Architecture of ITS with NLP for procedural training

The **procedural training environment** is the scenario that simulates the real world where the training activities are carried out. The user will be able to interact with the environment generating events such as performed actions, actions attempts, questions, etc., which will be provided to the ITS throughout an exercise.

The **Intelligent Tutoring System** will integrate the modules corresponding to a classic ITS such as the student model, tutoring model, expert model, communication model.

Additionally, a world model will be added to the ITS to represent the characteristics of the training environment, this model will represent the physical structure of the scenarios and their content so that the system can answer a question regarding the situation of an object or how to go from one place to another.

Within the student model, the user's request will be evaluated through rules, which will determine what the student knows and doesn't know and begin to structure the context. To this end, we will adopt the student model proposed in (Clemente, Ramírez, & de Antonio, 2011).

The context will be defined in terms of an ontology and it will be populated with information coming from the student model (knowledge state, activity progress, student trace), the expert model (correct plan, next correct action) and the world model (virtual world structure, student avatar position, object descriptions). Then, before passing the context to the dialogue manager, the ontological representation of the context will be translated into another representation understandable by the dialogue manager.

The **dialog manager** will contain the definition of the dialog structure, intentions and entities specifically intended for the training environment to be able to control the branching mechanism of a conversation. This component will be responsible of the communication with the user taking into account the contextual information provided by the models that integrate the ITS. Therefore, the hint given to the student will be adjusted to his/her current knowledge. Additionally, dialogue manager will be able to update the context after inferring the student knowledge from his/her utterances. This updated context will be sent back to the ITS.

6. Future Work

This is an ongoing work of a PhD thesis. In addition to what we have presented, in the future we plan to refine the presented architecture by: deepening in the concept of "context"; and designing a dialogue structure that leverages the context information to provide natural language messages properly adapted to the student and his/her situation in the virtual environment.

Acknowledgements

Paladines would like to acknowledge financial support from the Universidad Estatal del Sur de Manabí.

References

Clemente, J., Ramírez, J., & de Antonio, A. (2011). A proposal for student modeling based on ontologies and diagnosis rules. *Expert Systems with Applications*, *38*(7), 8066–8078. Retrieved from http://www.sciencedirect.com/science/article/pii/S0957417410015095

Dzikovska, M., Steinhauser, N., Farrow, E., Moore, J., & Campbell, G. (2014). BEETLE II: Deep Natural Language Understanding and Automatic Feedback Generation for Intelligent Tutoring in Basic Electricity and Electronics. *International Journal of Artificial Intelligence in Education*, *24*(3), 284–332.

Evers, M., & Nijholt, A. (2000). Jacob - An Animated Instruction Agent in Virtual Reality. In T. Tan, Y. Shi, & W. Gao (Eds.), *Advances in Multimodal Interfaces --- ICMI 2000: Third International Conference Beijing, China, October 14--16, 2000 Proceedings* (pp. 526–533). Springer Berlin Heidelberg.

Graesser, A., & et al. (2005). AutoTutor: An Intelligent Tutoring System With Mixed-Initiative Dialogue. In *IEEE Transactions on Educatiion, 48* (pp. 612–618).

Rickel, J., Lesh, N., Rich, C., Sidner, C., & Gertner, A. (2002). Collaborative Discourse Theory as a Foundation for Tutorial Dialogue. In *Proceedings of Sixth International Conference on Intelligent Tutoring System* (pp. 524–551). Springer-Verlang.

VanLehn, K., Jordan, P. W., Rosé, C. P., Bhembe, D., Böttner, M., Gaydos, A., … Srivastava, R. (2002). The Architecture of Why2-Atlas: A Coach for Qualitative Physics Essay Writing. In S. A. Cerri, G. Gouardères, & F. Paraguaçu (Eds.), *Intelligent Tutoring Systems: 6th International Conference, ITS 2002 Biarritz, France and San Sebastian, Spain, June 2--7, 2002 Proceedings* (pp. 158–167). Springer Berlin Heidelberg.