Interactive storytelling in educational environments

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Interactive story-based educational environments present a conflict between the determinism imposed by the pedagogue and the freedom desired by the learner. Designing a good pedagogical experience requires adding restrictions to the interaction that may frustrate learners. This paper introduces a computational solution for addressing such problems by the application in real time of artificial intelligence algorithms of supervision and management of the plot. The proposal is based on IMS Learning Design standards and formalized Narratology theories, using a so-called Story Conductor to control the interactive storytelling process.

Keywords Interactive Storytelling; Educational Environments; Learning Design

1. Introduction

On the one hand, it is clear that web-based learning faces limitations like the lack of interactivity, little motivation or limited adaptability to the learner's needs. Given the importance of the field, there has been a great effort to minimize the impact of those limitations via standardization and interoperability procedures. But even the most prominent initiatives in that field, like ADL-SCORM [1], are unable to catch all the subtleties of more complex learning processes. That is why the main players in the field of e-learning, like the IMS Global Consortium [2] are investing a great effort in the standardization of tools that allow the formalization of more complex learning processes. One of the most tangible results in that direction is the IMS Learning Design [3] specification. It can model complex learning processes including collaborative learning procedures, participation of different roles or dynamic and alternative learning paths.

On the other hand, it should be possible to achieve high levels of motivation and learning quality by providing a truly interactive environment where the learner perceives a feeling of freedom, being able to perform different and varied actions without direct supervision from a tutor. There is a line of research that suggests that *immersive* narrative environments could provide a positive learning model [4]. However, such environments need some kind of intelligent system capable of anticipating all possible actions to be taken by the learner and guiding the interaction development.

On this paper we present a proposal based on the benefits of IMS Learning Design that employs available knowledge from the field of Interactive Storytelling.

2. Interactive storytelling as a learning process

Automatic storytelling has been a recurrent goal for many projects of Artificial Intelligence (AI) research. To build complete "artificial authors" is an extremely difficult task, to the extent that nowadays computers are not able to create plots with human-like complexity, with the exception of some theme-restricted and text-based systems like Brutus [5].

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However, it seems clear that AI systems can help in taking advantage of the expressive power of digital media for interactive storytelling. In fact, there are a number of fully-implemented projects like Façade [6] or I-Storytelling [7] that show interesting approaches for on-the-fly generation of meaningful stories. There are other projects that use interactive storytelling techniques for teaching, like JV^{2}M [8], a game-driven intelligent tutoring system to teach programming, or Fabulist [9], a story generator to teach History by means of role-playing in "historical fictions".

But, in order to apply interactive storytelling ideas to Educational Environments with the purpose of creating useful learning tools that adapt quickly to learners' profiles and dynamic decisions, designers have to face the *Interactive Storytelling Dilemma*; an inevitable conflict between pedagogues' preauthored plans and learners' free will. In order to fully catch the attention of the learner and her perception of self-guidance, the educational environment must present an intensive and meaningful interactive experience while, at the same time, it must enable and facilitate the development of a good pedagogical plot.

For this, we suggest a layered approach, in which we have a basic underlying learning process which is decorated with interactive narrative that gives the learning experience a feeling of uniqueness. The next two sections describe our approach to both the underlying script and the interactive narration of the events.

3. Modelling the script with Learning Desing

IMS-LD considers a Learning Design as a process that orders and coordinates the execution of a variety of activities by different participants in the learning process. The highest-level component of the structure is the Play, built as a sequence of Acts. During each Act, the different Actors (learners, tutors, etc.) perform a number of Activities organized in different Activity Structures. An Activity takes place in a determined Environment, simultaneously or sequentially with other Activities.

IMS-LD specification proposes a rich and complex structure consisting of three increasing levels of complexity support, each built on top of the previous one. Level A includes the aforementioned elements and yields complete learning designs with different paths between the Activities. Level B adds the notion of Conditions and thus introduces the possibility of altering the flow of the course depending on the result of certain Activities. Finally, Level C adds Notification mechanisms that allow communications triggered by the results of the Activities.

Following the parallelism between the elements of a Learning Design and the elements of an Activity Diagram [10], in our proposal we interpret each element of a Learning Design in terms of interactive storytelling. We can thus use IMS-LD as a modelling language for the global interactivity model of the system.

Therefore, the first step in the process is to formalize the pedagogue's plot and goals for the application following well-known Narratological approaches [11] and the IMS Learning Design specification. Once this has been achieved, we must add that new layer of complexity that will provide the feeling on authenticity.

4. KIIDS system

KIIDS (Knowledge-Intensive Interactive Digital Storytelling) system is an AI tool that provides meaningful interactive storytelling with a general architecture. It provides a *narrative layer* dedicated to the management of the plot. This layer of the system represents the restrictions for the Story Conductor that creates each part of the story [12]. Actually, the Story Conductor is a Case-Based Reasoning (CBR) process, a problem-solving method based on a four-stages cycle. More details about this process can be found in [13].

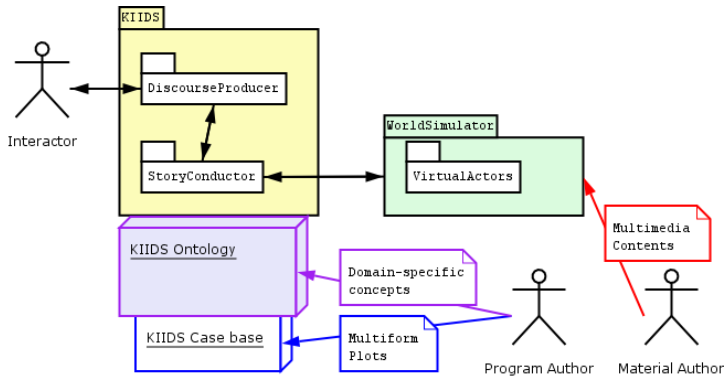

Fig. 1 KIIDS architecture overview. The Case Base stores plots and plot variations following a specific ontology (KIIDSOnto). The KIIDS system generates the interactive plots applying CBR techniques to the Case Base.

The KIIDS system provides the means for: (1) monitoring the interaction of a particular learner with the system according to the predefined learning plan, (2) allowing the learner to incur in slight diversions from the predefined plan, (3) dynamically rearrange the predefined plan to ensure that learners that have incurred in unexpected diversions still manage to traverse all the necessary nodes of the original plan. This is done by superimposing on the predefined plan a narrative structure, defined in terms of narrative events, that acts as a guiding storyline to the learning plan.

Such narrative structure or guiding storyline may at the start be a simple narrative rendition of the original learning plan. This guiding story line is presented progressively to the learner as he proceeds along the plan. However, if at some stage the learner diverges from the original learning plan, the system generates dynamically a new storyline. This storyline must satisfy the following restrictions: (1) it must match the part of the guiding storyline that covers the part of the original learning plan that the learner has already traversed, (2) it must include the divergent interaction that has lead the learner away from the original plan, and (3) it must include a new storyline that will progressively redirect the learner over the remaining activity nodes of the original learning plan in such a way that as much as possible of the original learning plan is satisfied. This is the basis of the concept of *Multiform Plot* depicted in Figure 2.

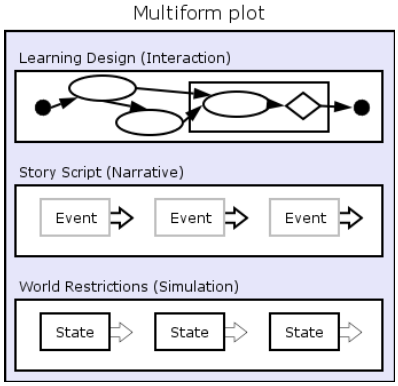

Fig. 2: Three-layer structure of multiform plots: The KIIDS system interactively builds a story over the pre-defined Learning Design. This generation is only restricted by the world's state.

Event
Paul, the ambulance driver candidate. meets Mr. Robson, the hospital manager.
Paul meets Jennifer, an attractive nurse.
Paul and Jennifer become friends.
Jennifer tries to seduce Paul during the ambulance practice.
Mr. Robson discovers Paul´s relationship with Jennifer.

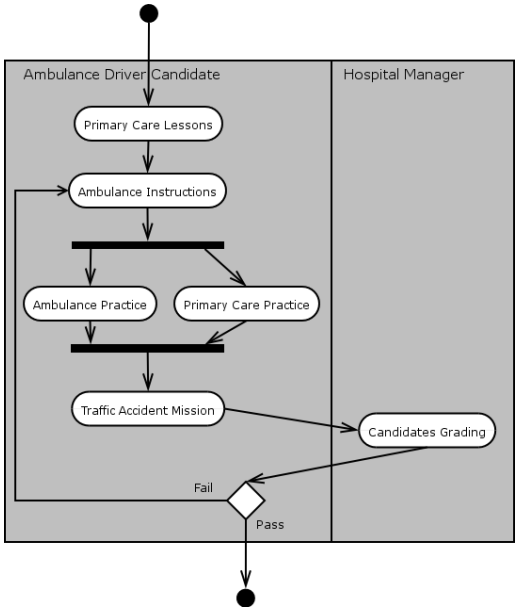

Fig. 3 Example of a basic plot structure in the form of an interactivity diagram (right) and a story generated around it (left).

Figure 3 presents an example course (ambulance driver). The main narrative elements are reflected in a Learning Design. On top of, there is an example story about Paul, an ambulance driver candidate. His supervisor is Mr. Robson, the hospital manager. One of the layers of the plot is related to primary care learning and training in ambulance driving, the second layer is about a love story involving three characters, two of them playing roles in the interactivity diagram. Figure 3 introduces the abstract description of the plot structure and the interactivity diagram of the example. The system lets the learner play with the environment but only actions that are meaningful for the development of the story are considered.

For instance, given the learning plan from Figure 3, it may occur that a learner, taking advantage of the freedom provided by the interaction mechanisms, attempts to jump to Primary Care Practice without first completing the Ambulance Instructions activity. The KIIDS system can automatically generate a small story fragment to redirect the errant learner, either by allowing him to carry out the Primary Care Practice and then prompting him to go back ("During his first attempt at Primary Care Practice, Paul is questioned by the exercise supervisor about his Ambulance Instructions, rebuked for not having attended, and asked to go back") or by insisting that he first completes the Ambulance Instructions ("Jennifer suggests that they attend together Ambulance Instructions so that they can later do their Ambulance Practice together").

The choice that the system has to make (between allowing a transgression or forcing strict adherence to the original plan) is governed by meta-level restrictions encoded by the designer of the original plan as constraints either in the KIIDS ontology or in the KIIDS case base, which are the two sources of knowledge to which the system resorts in making its decisions.

5. Conclusions

The KIIDS system provides the means for course designers to generate an original learning plan together with specific constraints encoding a number of divergences from it, as well as a number of restrictions on the form that those divergences may take. The knowledge resources of the KIIDS system, including its knowledge base of narrative material and narrative theory, allow it to construct dynamically and

automatically short guiding storylines that enforce the designer's will on the learner even over an interface that allows great freedom of choice. Although the learner has little "real" freedom, in the sense that the system will ensure that all the necessary activities are covered, the solution proposed here may give him a certain "apparent" freedom, by allowing him a small number of free choices that are then redirected by the system to accomplish the designer's goals. This constitutes an interesting compromise between traditional inflexible interfaces to learning options and totally open solutions where little guidance is provided.

There is a long way to go before the full implementation of a complete environment built over a fully functional system supporting IMS Learning Design Level C for Interactive Pedagogical Storytelling, but this paper presents a first approach of what seems to be an AI-based solution for the complex issue of "edutainment".

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References

[1] Advanced Distributed Learning Initiative. http://adlnet.org
[2] IMS Global Learning Consortium, Inc.http://www.imsglobal.org
[3] IMS Global Learning Consortium, Inc. IMS Learning Design Best Practice and Implementation Guide. Version 1.0 Final Specification (2003). http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html
[4] J. P. Gee, in: What Videogames have to teach us about learning and literacy? (MacMillan, New York, 2003).
[5] S. Bringsjord, D. Ferrucci. Artificial Intelligence and Literary Creativity: Inside the Mind of Brutus, a StoryTelling Machine. Hillsdale, NJ: Lawrence Erlbaum Associates (1999).
[6] M. Mateas, A. Stern. Architecture, Authorial Idioms and Early Observations of the Interactive Drama Facade. Technical Report CMU-CS-02-198, School of Computer Science, Carnegie Mellon University, Pittsburgh, PA (2002).
[7] M. Cavazza, F. Charles, S.J. Mead. Character-based Interactive Storytelling. IEEE Intelligent Systems, special issue on AI in Interactive Entertainment, **17**, 4 (2002) pp. 17-24.
[8] M.A. Gómez-Martín, P.P. Gómez-Martín, P.A. González-Calero. Game-Driven Intelligent Tutoring Systems. Proceedings of the 3rd International Conference on Entertainment Computing, Lecture Notes in Computer Science, **3166**, Springer (2004) pp. 108-113.
[9] M.O. Riedl, and R.M. Young. A Planning Approach to Story Generation for History Education. Proceedings of the *3rd International Conference on Narrative and Interactive Learning Environments* (2004).
[10] I. Martínez Ortiz, P. Moreno Ger, J. López Moratalla, B. Fernández-Manjón. Towards the Implementation of IMS Learning Design in the <e-Aula> LMS. Proceedings of the 4th IASTED-Web Based Education Conference. Grindelwald, Switzerland (2005)
[11] S. Chatman. Story and Discourse : Narrative Structure in Fiction and Film. Cornell University Press (1986).
[12] P. Gervás, B. Díaz-Agudo, F. Peinado, R. Hervás. Story Plot Generation based on CBR. 12th Conference on Applications and Innovations in Intelligent Systems, Springer WICS series (2004).
[13] F. Peinado, M. Ancochea, P. Gervás. Automated Control of Interactions in Virtual Spaces: a Useful Task for Exploratory Creativity. In 7th European Conference on Case Based Reasoning. First Joint Workshop on Computational Creativity. CERSA, Madrid, Spain (2004) pp. 191-202.