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学位（専攻分野）　　博士(情報学)

学 位 記 番 号　　総研大甲第 1725 号

学位授与の日付　　平成26年9月29日

学位授与の要件　　複合科学研究科　情報学専攻
　　　　　　　　　学位規則第6条第1項該当

学 位 論 文 題 目　　Narrative Balance Management in an Intelligent Training
　　　　　　　　　Application with User Task Recognition for Enhancing User
　　　　　　　　　Interest and Performance

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論文内容の要旨
Summary of thesis contents

Narrative Balance Management in an Intelligent Training Application
with User Task Recognition for Enhancing User Interest and Performance

The use of three-dimensional virtual environments in training applications allows the simulation of complex scenarios and realistic object behavior. These environments offer an ideal setting to develop intelligent training applications; yet, their ability to support complex procedures depends on the appropriate integration of knowledge-based techniques and natural interaction. However, while these environments have the potential of providing an advanced training experience to students, it is difficult to design and manage a training session in real time due to the number of parameters to pay attention: timing of the events, difficulty, user's actions and its consequences or eventualities are some examples.

In this work, we describe the implementation of an intelligent application for biohazard training: Bio-safety Lab, which serves as a virtual training environment for medical students (Prendinger et al., 2013), developed in collaboration with the National Institute of Infectious diseases in Tokyo. The application emulates a scenario in which users must handle a critical biohazard situation involving the spill of a contaminated blood sample from a broken bottle. The system has been tested 'in the field', i.e., with students from the medical faculty in Kyushu University, another collaborator, who are the target users of the system. In order to test our hypothesis we developed a novel Narrative manager system (Alvarez et al., 2014) that controls the dramatic flow in a virtual training scenario aimed at practicing biohazard procedures. The environment targets the training of protocols in response to an accident in the laboratory. These protocols are too dangerous to train in the real laboratory, and paper tests do not cover all the unexpected problems that can arise during the clearing of the accident. For this reason, a virtual application (in this case a virtual laboratory) can be a very good solution to this real need in medical teaching. Bio-safety Lab acts as a virtual tutoring system via user's task recognition and has been tested already in two field experiments.

We present also the results of two experiment testing different aspects of our application. The first one with students from the Faculty of Medical Sciences at Kyushu University where we investigated the effect of real-time task recognition on recovery time after user mistakes and the usability aspect by comparing interaction with mouse and Kinect devices. In the second one, in the National Institute of informatics in Tokyo we finally tested if users using our Narrative Manager improve their learning output. Our hypothesis is that the Narrative Manager allows us to increase the number of tasks for the user to solve but keeps the user interested in the training due to balancing difficulty and intensity. When evaluating our system we observed that the Narrative Manager effectively introduces more tasks for the user to

solve, and despite of that, is accepted by the users as more interesting and not harder than an identical system without Narrative Manager. Also, by observing the knowledge test results we saw that the learning output increases, being a consequence of solving more tasks.

The main contribution in this thesis is listed in the next points:

- First, we developed a novel control system which manages the events in a training session using narrative techniques with the goal of enhancing the user experience by balancing the difficulty of the session. This model is the first narrative system with this kind of goal. The system maximizes the number of events for the user to solve, but instead of becoming more difficult of boring as a consequence, we obtain the opposite effect, creating an interesting experience for the users.

- Our system not only enhance the learning output and interest levels of the training subjects, but also saves time and efforts to the scenario design: is not necessary anymore to redesign again the whole session when we want to create a different arrangement of events, because the Narrative Manager generates a different session each time the user plays it.

- Finally, we test and confirm our hypothesis: our narrative management increases the learner interest in the training and as a consequence his learning output increases as well. The users of our system perceive it as more interesting and challenging than a system without narrative management, and at the same time is not perceived as more difficult. Also the learning output of the users improves in comparison with the system without Narrative Manager.

This work also presents a number of secondary contributions:

- Also, the real-time instantiation of hierarchical task models to prompt the user on incorrect actions using descriptions about high-level goals, rather than concrete actions. We confirm that this method diminish the recovery time of the subjects in correcting mistakes (but it doesn't have much impact in the knowledge acquisition compared with other methods).

- Next, we integrate in our system a gesture-based interaction and present an experimental comparison of two types of control interfaces: gestural based and a classic mouse and keyboard control, studying the benefits of each one.

- Finally, we present a high level authoring tool for designing the narrative flow of the session.

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博士論文の審査結果の要旨

Summary of the results of the doctoral thesis screening

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Mr. Nahum Alvarez presented his research on a narrative method for controlling events in a virtual training application in real time. The hypothesis of his work is a method that improves the user's knowledge acquisition from the virtual training.

The presentation was structured as follows:

- The motivation of the research is to improve the performance of virtual training systems users by using narrative techniques in order to balance the difficulty of a training session.
- There were two types of related work reviewed: first, a comparison of the presented system with other training applications highlighting aspects like the scalability of the systems or the type of training used in them. Then there was a review of other narrative works with an emphasis in research about narrative conflict in this part of the review.
- The system architecture consisting of following modules: Gestural Processor, Task Recognition System and Narrative Manager, being the Narrative Manager the core novel technology of the system and the main focus of this part of the presentation. The Narrative Manager is in charge of triggering events in the training session in order to maximize user's interest and balancing the session difficulty. It uses a knowledge structure for storing the domain knowledge called task trees that were described in detail, as well as the set of parameters used for the event management: Impact, Balance, Intensity and Global Balance. Two of them are static and given by the domain expert and the other two are managed in real time by the Narrative Manager. An example of how the Narrative Manager works was given with a training session sample, and also an authoring tool for limiting the intensity levels in the session.
- The first experiment described was carried out in the Kyushu University Medical Faculty, and its goal was to test the impact the Task Recognition System (without the Narrative Manager) has in the users, as well as to evaluate the two types of user interface: Kinect and mouse. The results showed that the Task Recognition System improves significantly the users' error correction times and slightly the users' presence levels, but it does not significant impact in knowledge acquisition.
- Then a second experiment (in the NII) was carried out where the impact of a system with the Narrative Manager was evaluated, comparing it with a system only with Task Recognition System. The results of this experiment showed how the users' behavior proceed when solving the main task of the training in the two systems thanks to a series of burn-down graphs and in the case of the

Narrative Manager's users it was shown how the difficulty fluctuates over the time in a balance graph, effectively balancing it. Also, the results of the questionnaires showed that the Narrative Manager users got better results in interest, perceived learning and knowledge acquisition.

- The conclusions of the presentation were that the results of the second experiment confirmed the hypothesis of the thesis, i.e. that the Narrative Manager improves the user's knowledge acquisition via difficulty balancing and improving user's interest.

The evaluation committee asked some questions, which Mr. Alvarez could answer to their satisfaction.

The main paper was accepted in the International Journal of Artificial Intelligence in Education.