Serious Game based on Virtual Reality and Artificial Intelligence

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Abstract: Virtual reality is a very interesting technology for professional training. We can mention in particular the ability to simulate the activity without real danger, the flexibility in the informations' presentation, or the exact control parameters of the simulation allows to reproduc specific situations. Today, technological maturity allows to plan increasingly a complex applications. However, in one hand, this complexity increases the difficulty, at the same time, to propose a pedagogical and narrative control (to ensure a given learning and narrative structure) and some freedom of actions (to promote the emergence of various, unique and suprised situations in order to ensure a learning-by-doing/errors). In other hand, this complexity makes difficult the tracking and understanding of learner's path. In this paper, we propose 1- a scripting model for training virtual environment combining both a pedagogical control and the emergence of pertinent learning situations and 2- tracking of the learner's actions, but also analysis and automatic diagnosis tools of the learner's performances.

1 INTRODUCTION

Our goal is to propose models to control the dynamic adaptation of a training system, whose objective is twofold. On the one hand, it allows learners to freely explore the Virtual Environment (VE) and learn from their errors without constraints or activity guidance. On the other hand, it allows the system to dynamically *control* the learning situations and the total coherence of the scenario.

To adapt the scenario to the learner's behaviors, it is necessary to be able to finely understand what they are doing. Therefore, we propose a learner tracking system based on plan recognition techniques. It is based on the finalized activity that contains mainly the observed procedure in situ, the compromises made by the operators and frequent errors. Our system allows to determine the task performed by the learner and committed errors, from observable actions and the effects left in the VE, based on a reference model. In return, our system scripts the VE basing on pedagogical and contextual rules and on two calculated parameters: complexity and severity. These two parameters allow us to select virtual characters behaviors. Note that the application consists of training of babysitters.

2 PROBLEM AND MOTIVATION

Our goal is to propose models to control the dynamic adaptation of a serious game, allowing one side to the learner to freely explore the VE and learn from their errors without constraint or activity's guidance and on the other hand to the system to control dynamically the learning situations and the total coherence of the scenario. In previous work (Amokrane et al., 2008c), we proposed an activity description language called HAWAI-DL, which allows to describe all the possible of reference activities. This description favors the emergence of situations and learning by errors. However, it does not ensure a precise sequence or a control of scenario consistency. Thus, in this paper we will see how we added to our system pedagogical and contextual rules based on the activity consistency to adapt dynamically the scenario according to learner progress, context and learning objectives.

The AFPA[1] has identified a set of learning situations based on the professional didactic. However, the professional didactic imposes situations precisely identified to allow the acquisition of specific skills. If the scenarios were less rich, a deterministic scripting including all possible cases and all possible interactions of the learner would have been conceivable.

In the serious games, there are several motivating

[1]http://www.afpa.fr/

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factors, the ones witch interest us are all that is related to the story. We aim to have consistent, non-boring scenarios. This point raises the problem of what motivating factors to consider in our system and how.

As we are in highly complex and dynamic systems, the learner does not have the time to understand everything that happens in real time. So, it is useful to comeback on it in debriefing, even if the trainer had all informations in real time. To do this, we added to each session a trace of performed activity. This point raises the problem of trace content and its replay.

3 CONTEXT AND RELATED WORK

3.1 Pedagogical Scenario Control in Virtual Environments

Most virtual environments designed for training purposes are used in training sessions as part of a pedagogical scenario. These scenarios are the sequences of learning activities. In some cases, several learning activities are simulated inside the VE. The transposition of the subsequence of the pedagogical scenario in the VE generally consists in branching tree structures, containing predetermined sequences of scenes (Magerko et al., 2005), or tasks the user has to execute (Mollet and Arnaldi, 2006). Yet, in order to stay within these paths, these VEs offer a strong guidance to the trainee, often stopping them whenever they deviate from the training scenario.

On the other hand, some environments are used in pedagogical scenarios as a single learning activity. These environments opt for the “sandbox” approach, letting the user act freely as the simulation evolves and reacts to their actions, like in (Shawver, 1997). However, without any real-time pedagogical control, the efficiency of the training is not guaranteed.

One approach for ensuring both user agency and pedagogical control is to define a multilinear graph of all possible scenarios, In (Delmas et al., 2007), the set of possible plots is thus explicitely modelized through a Petri Network. However, when the complexity of the work situation scales up, it becomes difficult to predict all possible courses of actions.

3.2 Scenario Adaptation

Adaptative scenarisation is the process of reacting to users actions to provide content fitted to their need. In videogames, it might be used to adjust difficulty according to learners level without using typical discrete mode such as Easy,Hard, etc. With adaptive features, learners are always in the flow (Csikszentmihalyi, 1991): the difficulty remains high enough to propose a suitable challenge, yet, learner can overcome it so that they do not get bored or frustrated. The adaptation can be made at different level of granularity. A first approach is to have a global adaptation : a whole scenario has been written (Marion, 2010) or generated (Niehaus et al., 2011) and the outcomes of the events were scripted beforehand.

The simulation where the adaptation take place can be run with opposite approaches : the controlled approaches versus the emergent approaches. The controlled approach aims to provide a very efficient learning by orchestrating each part of the simulation : state of the object, virtual character, action possibilities of the learner, etc. It make possible Pedagogical control (Gerbaud et al., 2008). Moreover, such an approach demands an exhaustive modeling of the world functionment which handicap the evolutivity of the system. The whole modeling has to be reconsidered to avoid incoherence each time an author add new contents. By a clever modelling of small behaviors of the world, emergent approaches allow new situations to arise (Shawver, 1997). The issue with emergent approachs is the lack of pedagogical control.

3.3 Motivation’s Factors

There are several motivation models in video game. These range from expectancy/valence approaches (Mathieu et al., 1992) to Kellers (1983) Attention, Relevancy, Confidence, and Satisfaction (ARCS) model. Behavior can be intrinsically or extrinsically motivated. Most models have emphasized intrinsic motivation, focusing on the motives to perform a task that are derived from the participation itself (Malone, 1981). Malone (1981) proposed that the primary factors that make an activity intrinsically motivating are challenge, curiosity, and fantasy and specifically applied this framework to the design of computer games. Others have examined extrinsic motivation, in which someone engages in an activity as a means to an end (Vallerand et al., 1997).

4 OUR TROPOSAL

4.1 General Architectur

For each observable action or effect in the VE, a message is send to our tracking and scripting system. Thanks to task recognition technique, our sys-

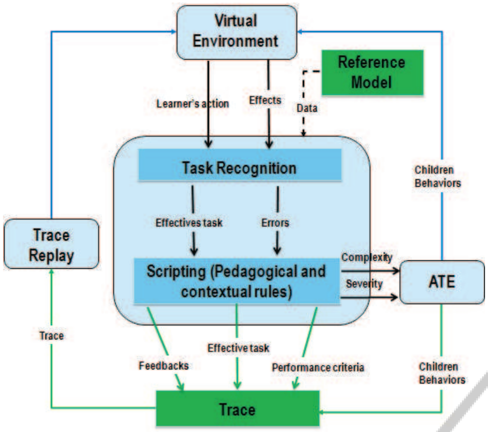

Figure 1: Global architecture of our system.

tem determines the effective task and committed errors. These last, are analyzed to determine the feedbacks, performance criteria, complexity and severity based on a set of pedagogical and contextual rules. At the laste time, a trace is recorded in xml Forme.

4.2 Task Recognition and Reference Model

Our approach consists in proposing an emergence of relevant learning situations and allows to put the learner in front of varied and controlled situations. We prefer to guide the learner through a non-intrusive scripting, to favor an exploratory approach and learning by trial and error. Therefore, the reference model must contain the finalized activity (not only the prescribed procedure but also the compromises made by the operators is situ and frequent errors).

To describe such activity, we proposed, with LATI[2] ergonomists, HAWAI-DL, an activity description language, inspired principally by GTA (van der Veer et al., 1996). Even if the activity is described previously, but thanks to the hierarchical representation of the activity and the concept of hyperonymous tasks, the learner has the freedom to choose his path to reach his goal, crossing from one branch of this tree to another or from one hyperonymous task to another. To recognize the task performed by the learner and the committed errors, we based on formal plan recognition techniques (Cohen et al., 1981). On an heuristics based approach, proposed in (El-Kecha and Desprs, 2006). This recognition system takes as input the actions or observable effects in the VE and the reference model. Our system detects several type of errors, thus, we distinguished errors and violations. The errors concern those of CREAM model (Hollnagel, 1993). The violations concern safety related errors, action errors, target object errors and condition errors (Amokrane et al., 2008b).

[2]http://recherche.parisdescartes.fr/LATI

4.3 Scripting using Pedagogical, Contextual and Motivation Concepts

As mentioned in the previous sub-section, our system, allows, to the learner, the freedom in the choice of his actions. However, giving the learner a total freedom in his choices makes the serious game more attractive, but it does not ensure learning. Thus, the control of situations is necessary. To do this, we added a set of pedagogical and contextual rules that are based on learning situations defined by the AFPA, according to professional didactics. But these situations are very limited and constrained; do not allow creating unexpected and surprising situations. To overcome such a limitation, we took into account the main learning situations. Then, we identified several **complexity levels** of situations and events which may disturb the main activity of the learner. So, if the learner is doing well his task, the complexity is equal to three, and then in addition to nominal task, the learner is confronted to important disturbances that require immediate reaction. If he is doing less well his task, the complexity is equal to two, and then in addition to the nominal task, the learner is confronted to some weak disturbance that do not require immediate reactions. And if the learner does not come out at all his nominal task, the complexity is equal to one, so the system let the learner doing his nominal task without any disturbance.

To create unique and unexpected game situations, we identified several **severity levels** of actions and events consequences. This severity levels depend on the historical of learner's actions and errors. So, if the learner did not do yet the scenario, the severity is equal to one, and then, even if the learner done errors, consequences are not showing. If the learner commits the same error at the second time, the severity is equal to two, and then the system show just not serious consequences. And if he commits the same error several times, the severity is equal to three, and then serious consequences of learner's error are shown.

These complexity and severity levels are recalculated dynamically during the session according to learner's activity and learning situations. These two elements allow to control the generation of virtual characters behaviors. Complexity and severity allow to increase his commitment in history and allow also to play on learners intrinsic motivation.

One of the intrinsic motivation factors on which we worked is the severity variation of situations. In order to do not loose motivation to the learner, we chose to prevent the learner from a serious danger by causing a minor accident, at the first time, that he commits the error (e.g. the child has a bump) and explain him the situation at trace replay by an attention message. The second time, the AFPA has proposed to cause more serious consequences, or irremediable: the child can have a cranial traumatism, or he can die.

Another factor of intrinsic motivation on which we worked is the dynamic adaptation of the complexity level. The goal is to create situations always unique and increasingly difficult to avoid the boredom of the learner. Even we are not in a controlled storytelling plan such as the interactive storytelling or narrative video games, and that the tragedy here is not the heart of the story, we can compare the level of difficulty (complexity and severity) progressive useful for learning at a level of dramatic tension. It concerns essentially to modulate gradually the dramatic tension by creating situations more or less complex and more or less urgent. The creation of situations with a strong dramatic tension allows the learner to learn how to react quickly but calmly in emergency situation.

Combining intrinsic and extrinsic motivation, we worked on the feeling of achievement, satisfaction and self confidence of the learner. This feeling of achievement can be created 1) by increasing his scores via the performance criteria (Figure 2), 2) by congratulations messages during trace replay when the learner is successful (Figure 2) and mostly. 3) by the success of his actions.

Figure 2: VE with congratulations messages and performance criteria.

4.4 Trace and Its Replay

As we are in the case of very complex activities, and which require to react quickly, the learner has not the time to analyze and understand in real time. Naturally, our system provides a trace which allows the trainer and the learner to go back on what have been done, to analyze it and understand all the cause and effect relationships. To model these relationships, we based on Bayesian networks, that allows to represent the causal relationships between human errors, environmental conditions and risks as well as risks propagation and compute the occurrence probability of potential risks in real time (Figure 3) (Amokrane and Lourdeaux, 2009).

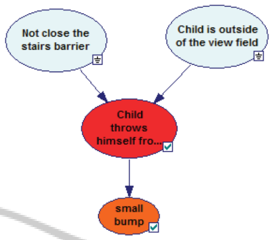

Figure 3: Exemple of Bayesian netWork.

The trace does not only contain the activity performed by the learner, but also all the committed errors, feedbacks and all Performance Criteria (PC) and their values. For each session, a trace is saved and at the trace replay time, the learner can revise everything he did during a session (Amokrane et al., 2008a).

4.5 The Childern's Generation Behaviors

The learner shares his universe with virtual characters, which represent in our case children between 6 months to 7 years. These children represent either the disturbing elements or support elements for the learner, depending on his activity (if he does well or not, if he commit a lot of errors or not, etc.) and depending on the world state.

For the generation of children's behaviors, we integrated a module named ATE based on rules. It in input the complexity and severity calculated by our learner tracking and scripting module and the state of the world to determine the children's behaviors. Among a set of possible situations, ATE eliminates situations / responses that are not valid according to the context, eliminating those that have already occurred, and determined, basing on severity and complexity, those that are more appropriate. If still more, it chooses one at random. For example, if the complexity is 2 (commits errors that are independent on the main learning situations), and severity is 2 (scenario already done, and the learner forgot to close the stairs barrier for the first time), and the child is outside of the view field of the learner, the child throws himself from the stairs and as a result he will have only a small bump. on the other hand, for the same example, if severity is 3 (scenario already done, and the learner forgot to close the stairs barrier for the second time) the child throws himself from the stairs and as a consequence he will have a cranial traumatism.

5 RESULTS

The evaluation of our approach is performed by AFPA learners for real training sessions. The tests were performed in two sessions, with 14 learners for each and during one week. The methodology used is the one which compares two groups: one used our system to learn (experimental group), another learn without our system (Control group). The evaluation considers principally the usability of the feedbacks that we proposed and the PC. At the end of the experiments, a satisfaction questionnaire is filled out by each learner of the group.

Figure 4: PC evolution (pres test).

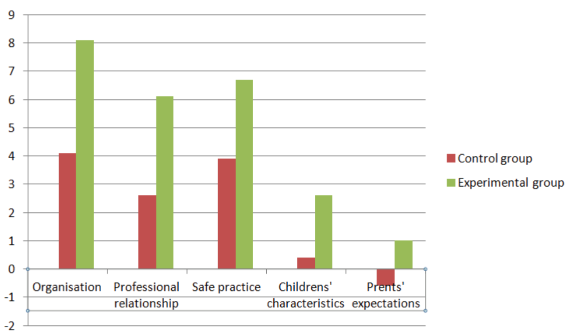

Figure 5: PC evolution (post test).

The Figure 1 and 2 summarize some comparison results between the two groups regarding the evolution of PC before and after using our system by experimental group and the results of control group, respectively. The results of this experiment show positive effects after the use of our system for learning skills related to child safety. If we consider the differences between the pre-test and post-test results, which means the learning gain at the end of the training week, positive tendency appears in the experimental group. This last gets a larger learning gain for all the criteria and a significant difference occurs on the ”Safe Practice” criterion which is fundamental to the child Safety.

The questionnaire shows that learners are very satisfied by using our system to learn. They testified to the fact that: our system allow them to make errors without repercussions; that the virtual allow to project them into the reality; the replay mode allows them to see their errors, and feedbacks (comments) are useful to understand these errors in order to not do it again; our system allows to confront them to various and changing situations,and to understand new situations

6 CONCLUSIONS

In our work, we proposed a serious game equiped with a learner tracking and dynamic scenario adaptation system, which allows to: 1) infer the task performed by the learner, 2) determine committed errors and necessary feedbacks (consequences and scenario adaptation), 3) calculate the Performance Criteria, and 4) produce the trace.

Our reference model is tree-based one, which gives the learner the freedom to choose paths to achieve his objectives. Furthermore, we added a set of pedagogical and contextual rules based on the professional didactic, which represent key points of our system. To maintain the motivation of the learner, we added two concepts: complexity and severity. Dynamic adaptation of the complexity allows to learn concepts in a progressive manner. Thus, the dynamic adaptation of the severity level allows to prevent consequences and to punish the learner if he committed this error previously.

For the generation of children's behaviors, our system relies on the world state, the complexity and severity. To allow the learner and the trainer to go back on what have been done, a replay of the trace of each session is possible. During this replay, feedbacks and Performance Criteria are displayed.

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