An adaptation and personalisation methodology for Serious Games design

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Abstract: Serious games (SG) are considered to induce positive effects in the areas of learning motivation and learning gains. The use of SG in education is a large deviation from the common education standards, which usually are based on mass systems of instruction, assessment, grading and reporting students' knowledge and skills. SG encourage self-directness and independency of student, thus providing a framework for self-learning activities. But while SG can be engaging and motivating, and appealing to learners their contribution in education cannot be assessed. What is most interesting is that the assessment of the SG could help to create personalized educational material that provide the right balance between gaming and educational experience to each user. It has been suggested that SG can take advantage of Artificial Intelligence (AI) methods for automated adaptation to the learner. However, research still witnesses a lack of methodologies, guidelines and best practices on how to develop effective adaptive and personalised SG and how to integrate them in the actual learning and training processes.

In previous work we proposed a framework on adaptive and personalised SG using AI methods based on user generated data. This work extends previous work by adding a methodology for an adaptive and personalised SG design. The so far developed methodologies are usually based on a linear approach. So the adaption is usually on micro level inside this linear game developing perspective. But a non-linear approach is more flexible and provides some space for macro adaptation, meaning adapting both the game development and the learning objectives to the user. In fact, a modular approach with multiple possible routes in game development is mostly suitable since it offers best opportunities for macro adaptation and set of different learning sequences.

The development of a complex tutoring system like the one described above faces lots of challenges: Cold-start, co-adaptation and the fact that the Instructional Content adaptivity should be based on didactic models which should be based on learning theories. This paper will be used as a basis for further development of an adaptive and personalised SG.

Keywords: adaption, personalisation

1. Introduction

SG are promoted as a combination of games and education. All games are rule-based systems that attract players, with the primary purpose of entertainment (Ávila-Pesántez, Rivera, & Alban, 2017). Adding the educational factor makes it even more complicated to design the game and the critical point is the relationship between the game and the educational content (Barbosa, Pereira, Dias, & Silva, 2014). SG design relies on the incorporation of educational content, while maintaining the fun factor in the first place and even prioritising it over the regularity and frequency of learning content (Peirce, Conlan, & Wade, 2008). So, designing a SG needs elements from both game design and pedagogy. The pedagogy used is akin to problem-based learning where the structure and narrative of the game provide the purpose of learning and an immediate motivation for pursuing the knowledge required (Barbosa, Pereira, Dias, & Silva, 2014). However, only a few methodologies, frameworks and models have been proposed to guide the design and development of SG. In this paper we intend to promote a new approach on the SG design methodology based on an adaptive scheme.

The most common approach is the Task Based Learning (TBL) theory. That theory is based on tasks that are characterized by an ability to engage the learner's interest, a primary focus on meaning, a need to be completed, an outcome in terms of which the success is judged, and a clear relationship with real-world activities (Willis, 1996). The simplest form of organizing those tasks to create a game story is the linear approach (figure 1) where the stages of the game form a one-directional linked list. In that case the game designer has full control of the game story and it is quite easy to implement that approach from a game developer's perspective (Göbel, Mehm, Radke, & Steinmetz, 2009). But this linear approach is not suitable for adaption since it lacks flexibility because it is sequential. A branching approach (figure 1) based on a directed graph (not necessarily acyclic) is more complex and more expensive in terms of content but, however, it lacks the flexibility needed for macro adaptation.

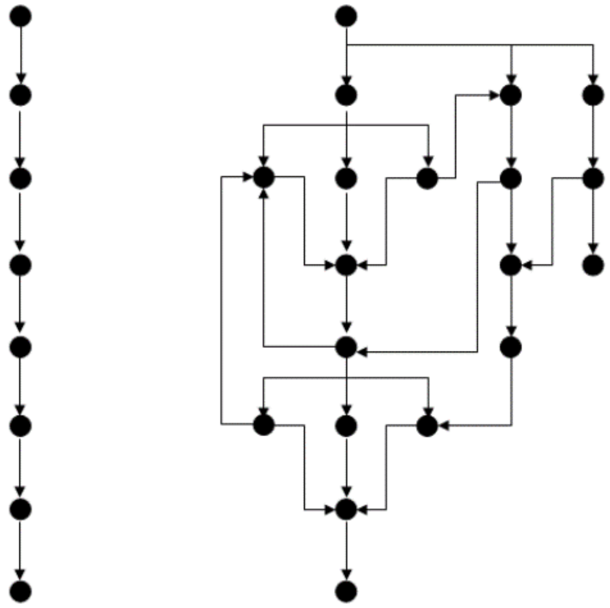

Figure 1 Linear game design (left) and Branching (right) (Göbel, Mehm, Radke, & Steinmetz, 2009)

2. Modular design methodology

It is obvious that a non-linear, modular design approach is needed in order to add adaption and personalisation in SG. The game design is highly modular allowing concurrent and continuous development process. In a modular approach (figure 2), the game designer has to provide a set of tasks units, which might be (in principle) freely connected and combined with each other. This approach builds the basis for emergent SG and offers best opportunities for macro adaptation and an almost endless set of possible storylines/paths or sequences of story modules.

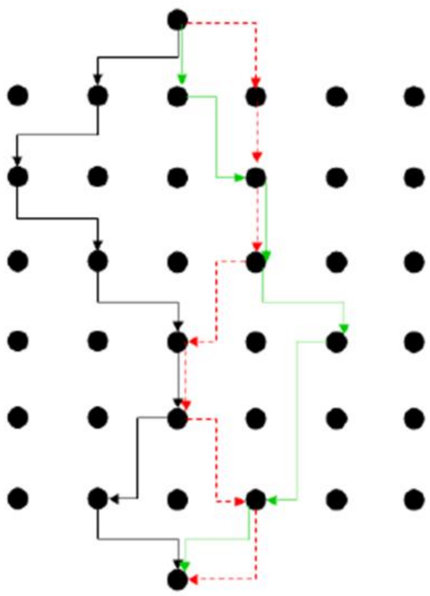

Figure 2 Modular game design (Göbel, Mehm, Radke, & Steinmetz, 2009)

On the other side, authorial control is very limited –on the contrary, the player gets more or less control over the scenario– and it becomes quite difficult to "guarantee" a suspenseful story (Louchart & Aylett, 2003).

3. A modular adaptive methodology

A previous study indicated that adaptive task selection yields more effective and efficient learning (Corbalan, Kester, & van Merriënboer, 2008). Our proposal is based on the concept of adaption of tasks from a modular task repository. So we will exploit a large availability of simple units of content, produced also according to the user-generated content (Anderson, 2006). Instead of following a limited authorial control on the gameplay we aim to dynamically place the tasks in a certain order based on the feedback from the players' answers and the learners' behaviour. In previous work we proposed a framework on adaptive and personalised SG using AI methods based on user generated data. This framework was based on the constructivism learning theory and it employed a Multi agent System consisted on a Learner Agent and an adaption and personalisation engine. The adaption engine initially creates a user model for the learner. After that, it is adapting dynamically the instructional content to the learner, using Dynamic Difficulty Adaptation (DDA). In this work we make the framework more concrete by grounding the adaption on the task sequence that the adaption and personalisation engine will create dynamically based on both system feedback and the user's behaviour (figure 3). For that reasons, is necessary to create a content database (task repository) that will contain a large set of tasks. This kind approach provides interesting features, as the following (Bellotti, Berta, De Gloria, & Primavera, 2010):

- can be easily differentiated across game sessions and may strongly motivate players to the game;
- is domain independent and can be applied to several different contexts;
- It can be continuously enriched with new tasks, without need to change the code.

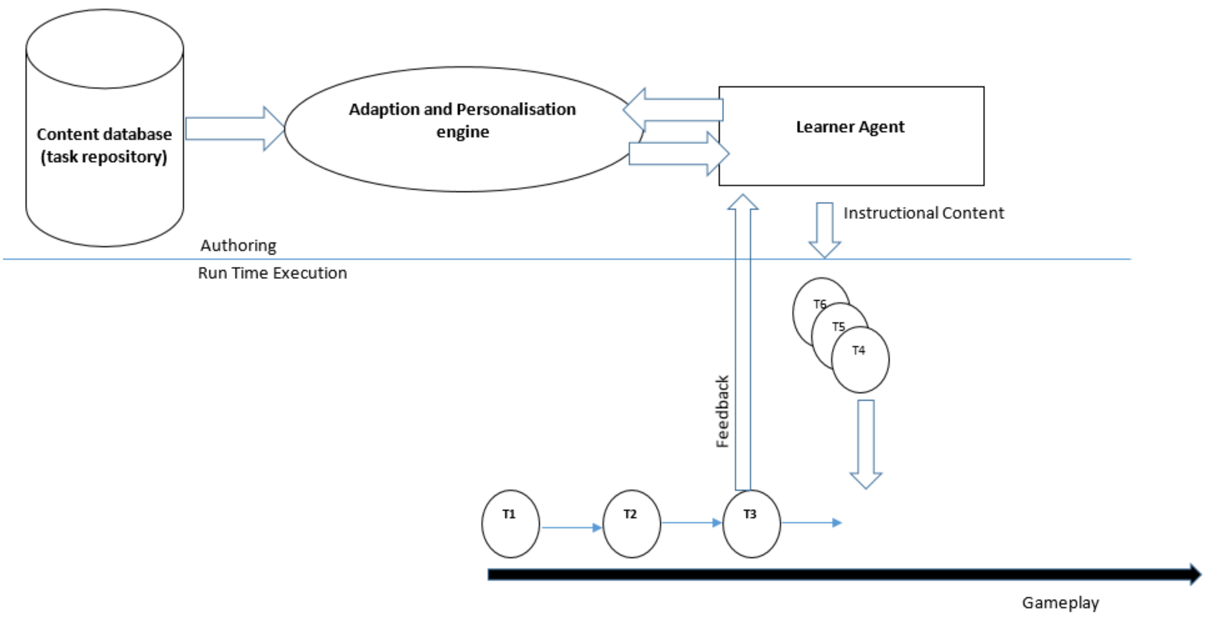

Figure 3 the proposed modular adaptive scheme

It has already being stated that prior knowledge affects the learning procedure and has marked effect on learning outcomes (Shapiro, 2004). So at the initial stage of the SG the learner will face up a series of tasks that will examine his prior knowledge and then the adaption machine will prioritise the next tasks according to his answers of the initial face. This strategy will also help to void the cold-start problem since it will feed the adaptation engine with more data in the first cycle and it will help the adaption and personalisation engine to create a more realistic user model.

Another problem to face up is the co-adaptation. In real prolonged use of any serious game, the player capabilities and needs are not only complex and multivariate, they also change (adapt) over time in a nonlinear fashion; the user adapts to changes in the adaptive system. This can lead to situations where a system adapts settings in a specific way and the user adapts to handle these settings even though they are not objectively optimal, and in worst-case scenarios may even lead to harmful interactions. (Streicher & Smeddinck, 2016).

4. Modelling the tasks

Tasks could be of various types. For instance a task could be a puzzle, or an action scene or even a combination of types. The type of tasks is usually defined by the author. In order to create a balanced SG the author should give each task an entertainment value, a quality value and an expected length. All those values are usually normalized to the interval from 0 to 1. Some parameters can also be left as adaptive: the system can update their values at runtime, according to proper heuristics that evaluate the actual gameplay (Bellotti, Berta, De Gloria, & Primavera, 2010). The author should also predefine a list of skills/subjects relevant to the task (Brooks & McCalla, 2006) and learning styles. Finally the author has to create for every task a list of dependencies. All of the above values will help the adaption engine to calculate the difficulty of the task and also match it with the Difficulty Curve that the author specified for the task sequence.

5. Conclusion and future work

In this paper, we proposed methodology design mechanisms for an adaptive and personalised SG and we described how to implement them. This has been achieved by reviewing existing literature on SG design methodology. That new approach follows the constructivism pedagogic approach for the instructional content adaption and is using a totally adaptive framework based on task based learning and a task adaption engine. The next steps will be the creation of a SG in order to implement our adaptive design mechanisms and to test them. We also plan to explore the different adaptive game mechanics. Implementing these models could help the design process for a new generation of serious games that are fun but also educating.

References

Anderson, C. (2006). The Long Tail. How Endless Choice is Creating Unlimited Demand. New York: Random House.

Ávila-Pesántez, D., Rivera, L. A., & Alban, M. S. (2017, SEPTEMBER). Approaches for Serious Game Design: A Systematic Literature Review. COMPUTERS IN EDUCATION JOURNAL, 8(3).

Barbosa, A. S., Pereira, P. M., Dias, J. F., & Silva, F. G. (2014, June 1). A New Methodology of Design and Development of Serious Games. International Journal of Computer Games Technology, 2014.

Bellotti, F., Berta, R., De Gloria, A., & Primavera, L. (2010). Adaptive Experience Engine for Serious Games. Computational Intelligence and AI in Games, IEEE Transactions, pp. 264 - 280.

Brooks, C., & McCalla, G. (2006). Towards flexible learning object metadata. Int. J. Cont. Engineering Education and Lifelong Learning,, 16(1/2), pp. 50-63.

Charles, D. (2003). Enhancing Gameplay: Challenges for Artificial Intelligence in Digital Games. DiGRA Conference. Utrecht .

Corbalan, G., Kester, L., & van Merriënboer, J. G. (2008, October). Selecting learning tasks: Effects of adaptation and shared control on learning efficiency and task involvement. Contemporary Educational Psychology, 33(4), pp. 733-756.

Göbel, S., Mehm, F., Radke, S., & Steinmetz, R. (2009). 80Days: Adaptive Digital Storytelling for Digital Educational Games. Proceedings of the 2nd International Workshop on Story-Telling and Educational Games (STEG'09).

Louchart, S., & Aylett, R. (2003). Solving the narrative paradox in VEs - lessons from RPGs. 4th International Workshop Intelligent Virtual Agents (pp. 244-248). Kloster Irsee, Germany: Springer.

Peirce, N., Conlan, O., & Wade, V. (2008). Adaptive Educational Games: Providing Non-invasive Personalised Learning Experiences. Second IEEE International Conference on Digital Games and Intelligent Toys Based Education, (pp. 28-35).

Shapiro, A. M. (2004). How Including Prior Knowledge As a Subject Variable May Change Outcomes of Learning Research. American Educational Research Journal, 41(1), pp. 159–189.

Streicher, A., & Smeddinck, J. D. (2016). Personalized and Adaptive Serious Games. In R. Dörner, S. Göbel, M. Kickmeier-Rust, M. Masuch, & K. Zweig, Entertainment Computing and Serious Games: International GI-Dagstuhl Seminar (pp. 332-377). Dagstuhl Castle, Germany: Springer.

Willis, J. (1996). A Framework for Task-Based Learning. Harlow, U.K.: Longman Addison- Wesley.