

# Scenario Adaptivity in Serious Games

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## ABSTRACT

Most current serious games suffer from system inflexibility, which is responsible for stereotyped training scenarios and predictable game-play. My goal is to support adaptivity in serious games by allowing virtual scenarios to dynamically adjust to what and how players should learn. Adaptivity should give players more effective gaming and learning experiences, if it is guided by their Instructors' knowledge about both players and learning goals. I expect to enable Instructors to create adaptive scenarios through specification of: what players have to learn, how they should learn it and, afterwards, what went missing. This work focuses on embedding this sort of knowledge into objects of the virtual scenario, through new semantic modeling methods. Meaningful information on *what to learn* will be solved into generating pre-game scenarios. *How to learn* knowledge will be used to create in-game adaptable objects and events. Assessments on *what went missing* will be solved to re-generate post-game (try again) scenarios.

## 1. PROBLEM DESCRIPTION

Serious games, i.e. video games with purposes other than pure entertainment, are becoming increasingly important both in education and training environments. Considerable investments are being made and the return is already noticeable in the growing number and influence of serious games, such as Hazmat: Hotzone, Virtual U, Food Force, RescueSim, Ship Simulator and others.

Serious games are becoming increasingly established, but they are still to come of age in terms of player experience. Most serious games are developed ad-hoc and lack sound theoretical foundations, which leads to a number of drawbacks: they are predictable, impersonal and limited by stereotyped training scenarios. In particular, serious games should be designed to prevent (i) training modules from following rigid patterns, (ii) unattractive and predictable game-play, (iii) little advantage being taken of user data collected throughout the game and, worst of all, (iv) little

knowledge being employed to guide the course of the game. For example, it would not be effective if all medical trainees in a certain course would have to follow the same timed procedures, in the same standard scenarios, independently of their personal skills or difficulties; and it would be pedagogically even worse if their final scores could not be traced back to particular in-game moments. Trainees might just learn how to beat the game, instead of how to think and act in similar real life scenarios.

## 2. RESEARCH GOALS

Many researchers agree that serious games have to become more challenging, unpredictable and user-centric, to be fully embraced as an effective way of knowledge transfer [1, 2]. To prevent the shortcomings above, I believe serious games should include virtual scenarios that adapt to what and how players need to learn in a given context. This scenario adaptivity should benefit players, by providing them with more flexible challenges and a broader range of (pedagogically) meaningful ways to solve them.

The final goal of this research is to contribute with a methodology for supporting the creation of such adaptive virtual scenarios. This methodology should focus on adapting scenarios to: what players need to learn, how they should learn it and what they failed to learn. I argue that Instructors (or Trainers) already possess this specific knowledge and, as so, are in a privileged position to steer scenario adaptivity to the expected benefits. With this methodology, the Instructor will use his knowledge on what should be learned by a specific player, to automatically generate virtual scenarios that are suited to player characteristics and learning goals. The Instructor will create in-game situations where objects and events adjust, in real-time, to the player performance and the way he should be learning. After a game session, the Instructor will assess on players performance and that evaluation will be used to re-generate game scenarios where players can play again, focusing on what they failed to learn.

My research aims at embedding this knowledge, from the Instructor, into game worlds and objects, which will become more responsive to players and more meaningful to their goals. This research focuses on supporting such virtual worlds that are enriched with meaning (or semantics) about learning goals, player performance, game decisions and assessment evaluations.

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### 3. RELATED WORK

I am interested in using game world generation, adaptivity and assessment to support adaptive scenarios in serious games. Related work is scattered in each one of these fields.

Previous work for automatically generating game worlds typically relies on procedural content creation techniques, like the ones proposed by Roden *et al.* [9] or Greuter *et al.* [5] where 3D game content is generated by algorithms that progressively extrude simple generated data structures into complex geometry. On a different direction, Doran and Parberry [3] and Gain *et al.* [4] propose more controllable approaches, where generated terrains are not only influenced by the algorithms, but by features interactively defined by game designers. However, these features only relate to physic properties of the terrains (e.g. altitude for mountains, length for rivers, silhouettes of mountains).

Most in-game adaptivity research, specially in serious games, focuses on adapting behaviors and not content. Peirce *et al.* [7] propose a system for adapting non-playing characters (NPCs) behavior to enable a personalized learning experience. Westra *et al.* [12] use agent organizations to adapt the behavior of game elements, during game-play, to the skill level of players. Results in adapting game content can be found on Togelius *et al.* [10] work. The authors propose an approach for evolving racing tracks, during game-play, to match player satisfaction. However, track evolution is applied to simple 2D tracks and not complex 3D virtual scenarios.

Research in serious games assessment is still focusing on enabling collaborative computer-enhanced after action review sessions [8, 6]. These works aim to provide and display data to support player feedback sessions. Current results show that the Instructor has the role of translating assessment data into valuable information to players.

I am interested in researching how semantics can be used (in game world generation, adaptivity and assessment) to support the creation of adaptive scenarios. Currently, I am affiliated with a research group focusing his work on semantic modeling [11]. Object semantics is defined as all information, beyond the 3D model, related to a particular object within the game world (e.g. physical attributes like mass or material, functional information like how to interact with an object). With semantic modeling, objects relationships, features and other semantic information can be used to guide the layout of a game world, whether designing it manually or generating it procedurally.

My research differs from previous approaches by using game world generation, adaptivity and assessment as an integrated methodology to build adaptive game content. My goal is to support this methodology with new semantic modeling methods and techniques. I aim to extend previous results on semantic modeling by defining new schemes to embed Instructors' knowledge about learning goals and players.

### 4. PRE-GAME SCENARIO GENERATION

Current virtual worlds are mostly created in the serious game design stage and, when the game is released, they are therefore closed to variations and can be played the same way multiple times by multiple players.

Results of my research should enable Instructors to specify learning goals and players characteristics, before each mission game-play. A new and unique scenario, suited for those

specifications and the mission, should be generated. Scenarios are defined as richer versions of virtual game worlds, comprised of world geometry, terrain and characteristics, its objects, their roles and behaviors and other available in-world events (e.g., weather conditions, traffic jams). As an example of scenario generation, consider a military training game in a specific mission where the objective is to steal secret intelligence. The learning goal, set by the Instructor, would be to practice and master stealth abilities in a slow-paced, high-visibility and open-field context. The generated scenario could include lots of wide empty space, with few hiding objects, almost non-existing events and in a day light context. For two players, assessed by the Instructor as having different expertises in stealth, the scenario could include different color schemes, vegetation and building types.

To accomplish this, I am interested in researching new methods in semantic modeling. The learning goals and player characteristics should be mapped to semantic *training specifications*. Scenarios should then be procedurally generated, influenced by such semantics. My aim is to create a new semantic scheme for specifying such *training specifications*. I expect to define how to transpose this new scheme to an object scale, i.e., how it affects the current semantic object library [11] and how it all relates to the procedural content generation level.

### 5. IN-GAME ADAPTIVITY

Currently, modifying the game scenario, during game-play, occurs typically by direct interaction either from the players or from NPCs. Some games include other (scripted) modifications, but these can only be defined in the game design stage and can not be dynamically adjusted after that.

With in-game adaptivity, serious games scenarios, i.e., its objects, events and features, should be dynamically adjusted, in real game time, to fit the players' gaming and learning experience. Instructors should be able to select or even specify (a priori) adaptable situations, where the scenario may change, during game-play, depending on what is happening in the game. At game time, when player performance matches the specified context, the scenario adapts as described. When considering the previous military training game, fog or smoke might become available in certain scenario locations, when the Instructor wants a specific player to change his strategies to using available resources.

These adaptable situations should be mapped to semantic *situation specifications* that describe a location, influenced objects and/or events, incomes (what players might do) and outcomes (what might happen to scenario). *Situation specifications* should be added to the scenario, possibly on a object level, before game-play. I aim to create a new semantic scheme for specifying such adaptable situations. I also expect to create methods that monitor player performance and match it to possible incomes (e.g., players locations, actions). For player monitoring, I am interested in new findings that take advantage of currently unused data in the game log. I will also aim at building a run-time in-game engine that, when an income occurs, adapts the virtual scenario by solving and generating outcomes. The performance and coherence of the game scenario can not be corrupted by this engine. Solving outcomes can not affect smooth game-play or generate real-life impossible situations (e.g. a tree magically changing its own size).

## 6. POST-GAME ASSESSMENT

Assessment in serious games is still too close to its counterpart found on entertainment games. Measuring completion of objectives, the actions performed to do so and mapping this to simple scores is as far as assessment currently goes. Due to the educational purposes of serious games, assessment has a stronger role than in entertainment games and, as so, it should have a stronger focus.

I am interested in researching the relations between adaptivity and assessment. I argue that repeating a game scenario, modified by the Instructor's review of the past session, is an effective tool for players to better assess their own behavior and better learn. Results of this research should allow the Instructor to decide on the need for a re-play scenario and, if so, he should be able to specify assessment evaluations and related resume points. The initial scenario should be re-generated, but adapted from the instructor assessment procedure. Still using the previous military example, consider a case where the instructor assesses that the player took too much time in stealth movements (taking advantage of the slow-pace of the scenario). The assessment on the time performance generates an identical scenario where, for example, new events are created for periodically changing the secret intelligence's location. This scenario can be played from any resume point on.

To accomplish this, assessment evaluations should be mapped to semantic *assessment specifications* that affect (new or old) objects and events in the initial scenario. My goal is to create a new semantic scheme for assessment, that is described in terms of fulfillment of learning goals and refinement of player characteristics. Therefore, the new scheme can be integrated and take advantage of the previous semantic scheme for scenario generation. I also expect to contribute with the definition of tools that support the assessment procedure. I aim to research on multiple alternatives for creating performance logs that report player performance. Videos, text reports and reusing player monitoring methods (from section 5) are initial ideas that should be investigated.

## 7. RESEARCH PLAN

So far, I have been focused on defining the goals and expected contributions of this research, as outlined by this document. Currently I have been reviewing literature to specify the requirements of this methodology. In the near future I will continue on this literature review, namely on customized content generation, on-line adaptivity, assessment methods, player monitoring, semantic modeling and other methods for embedding meaning into virtual worlds.

I will then focus on designing and implementing a semantic layer for embedding knowledge about learning goals, player performance, game decisions and assessment evaluations, into objects and events of virtual worlds. To sustain such implementation, I will organize workshops with serious games domain experts to determine what knowledge to capture from Instructors and how to do it. I will validate this semantic layer, by solving prototype scenarios and testing them with players and Instructors.

Afterwards, I will develop two complete case studies where my methodology will be integrated into two distinct serious games. On such case studies, I expect to collaborate with several experienced partners in the serious game industry

and research community. At this stage I will focus on designing and implementing the remaining requirements for this methodology: a run-time procedural solver engine and techniques for monitoring players. At completion of this work, my research will be validated by players and Instructors, through these two case studies.

## 8. REFERENCES

- [1] C. Aldrich. A field guide to educational simulations. *Learning Circuits*, 2002. American Society for Training and Development.
- [2] S. Blackman. Serious games...and less! *SIGGRAPH Comput. Graph.*, 39(1):12–16, 2005. ACM.
- [3] J. Doran and I. Parberry. Controlled procedural terrain generation using software agents. *IEEE Transactions on Computational Intelligence and AI in Games*, 2010. (To Appear).
- [4] J. Gain, P. Marais, and W. Strasser. Terrain sketching. In *I3D '09: Proceedings of the 2009 Symposium on Interactive 3D Graphics and Games*, pages 31–38. ACM, 2009.
- [5] S. Greuter, J. Parker, N. Stewart, and G. Leach. Real-time procedural generation of 'pseudo infinite' cities. In *GRAPHITE '03: Proceedings of the 1st international conference on Computer graphics and interactive techniques in Australasia and South East Asia*, pages 87–94, Melbourne, Australia, 2003. ACM.
- [6] D. R. Lampton, J. Bliss, and G. A. Martin. Performance measurement and training feedback in a military collaborative virtual environment. In *First International Conference on Virtual Reality*, Las Vegas, Nevada, USA, July 2005.
- [7] N. Peirce, O. Conlan, and V. Wade. Adaptive educational games: Providing non-invasive personalised learning experiences. In *Digital Games and Intelligent Toys Based Education, 2008 Second IEEE International Conference on*, pages 28–35, Banff, Alberta, Canada, Nov. 2008.
- [8] E. M. Raybourn. Applying simulation experience design methods to creating serious game-based adaptive training systems. *Interact. Comput.*, 19(2):206–214, 2007.
- [9] T. Roden and I. Parberry. From artistry to automation: A structured methodology for procedural content creation. In *Entertainment Computing - ICEC 2004, Third International Conference, Proceedings*, volume 3166 of *Lecture Notes in Computer Science*, pages 151–156, Eindhoven, The Netherlands, 2004. Springer.
- [10] J. Togelius, R. De Nardi, and S. Lucas. Towards automatic personalised content creation for racing games. In *Computational Intelligence and Games, 2007. CIG 2007. IEEE Symposium on*, pages 252–259, April 2007.
- [11] T. Tutenel, R. Bidarra, R. M. Smelik, and K. J. D. Kraker. The role of semantics in games and simulations. *Comput. Entertain.*, 6(4):1–35, 2008.
- [12] J. Westra, H. Hasselt, F. Dignum, and V. Dignum. Adaptive serious games using agent organizations. *Agents for Games and Simulations: Trends in Techniques, Concepts and Design*, LNCS 5920/2009:206–220, 2009.