Dynamic Serious Games Balancing

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Abstract. The user's interest in a game is difficult to be raised and even more difficult to be maintained. The game must be addictive and correspond to the users' interest to make sure he/she doesn't feel attracted to other competing games. Therefore specific, user-adapted mechanisms are necessary to keep their interest and motivation. Dynamic game balancing (DGB) is the process of changing game parameters in real-time, according to the users' detected ability, in order to provide him/her with a tight fit challenge (neither too easy nor too difficult). A user model must be created for each player, based on data collected before and during game play focusing on interaction statistics and eventually on physiological signals. The use of identical mechanisms adjusted to the objectives of Serious Games implies changes to the design of the DGB methodology. This article presents the main theoretical aspects of this process.

Keywords: Serious Games · Dynamic game balancing

1 Introduction

Games involve mental and physical stimulation and force the player to decide, to choose, to define priorities, to solve problems, etc. Games can also be social environments, sometimes involving large distributed communities where social skills are paramount. They imply self-learning abilities (players are often required to seek out information to master the game itself), allow transfer of learning from other realities and are inherently experiential with the engagement of multiple senses. Therefore, game environments are excellent tools because they can replicate real contexts or even provide situations that occur in very specific circumstances while retaining the players' motivation.

But the user's interest is difficult to be raised and even more difficult to be maintained. Therefore specific, user-adapted mechanisms are necessary to keep their interest and motivation. Dynamic game balancing (DGB) is the process of changing game parameters in real-time, according to the users' detected ability, in order to provide them with a tight-fit challenge (neither too easy nor too difficult). A user model is individually created for each player, based on data collected before and during game play focusing on interaction statistics and eventually on physiological signals. Typical collected data (or game play metrics) can be object interaction, object trade, navigation in the environment, average playtime, damage dealt per session, etc.

Game play metrics can be subdivided into the following three categories:

- In-game: Covers all in-game actions and behaviors of players, including navigation and interaction with game assets such as objects and entities.
- Interface: Assesses all the player interactions with the game interface and menus, like setting game variables.
- System: Covers the game actions initiated to respond to player actions.

Serious Games are games that do not have entertainment as the main objective and are used to develop skills and competences related to education, government, corporate training, health and others. In fact, the main emphasis of serious games is still the educational domain with focus on learning and training and the application of new pedagogies. Nevertheless Serious Games are still games insofar they provide an entertainment-oriented, rule-based context, with clear goals. Therefore the use of DGB is still very important to keep the user motivated but should be extended to include a dimension that relates to the "serious" goals of the game which requires the collection of specific game analytics data concerned with those objectives.

This article envisages the definition, implementation and validation of a DGB methodology specially designed for Serious Games where the entertainment aspect is considered in equal terms with the serious objectives of the game, which requires special game analytics techniques. In terms of validation two different areas of application will be covered: on one side, educational games (for its importance in terms of the existing market) and, on the other side, exergames, that is games that motivate the user to have a healthier lifestyle by engaging them in physical activities.

Therefore, in the end it will be possible to obtain a methodological approach to this issue based on a set of methods for game analytics, player modeling and dynamic game balancing, instantiated for two specific areas of application: education and physical fitness. The tools developed for these two areas will be easily adaptable for other purposes in the same area (for instance, for different levels of education or professional/ amateur physical fitness).

2 State of the Art

A game is a goal directed and competitive activity conducted within a framework of agreed rules [1]. Or "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" [2]. The rules establish what a player can or cannot do, and what the behavioral consequences of actions may be within the world of the game. The game offers a structured and oriented context (meaning) to play which is a voluntary activity, intrinsically motivated, enjoyable and for recreation, in a non real context, requiring active participation. Overmars stated that "Playing a Game is about making Decisions, taking Control and reaching Goals" [3]. Prensky identified the following characteristics of games [4]:

- Games are a form of fun. That gives us enjoyment and pleasure.
- Games are a form of play. That gives us intense and passionate involvement.
- Games have rules. That gives us structure.

- Games have goals. That gives us motivation.
- Games are interactive. That gives us doing.
- Games are adaptive. That gives us flow.
- Games have outcomes and feedback. That gives us learning.
- Games have win states. That gives us ego gratification.
- Games have conflict/competition/challenge/opposition. That gives us ad adrenaline.
- Games have problem solving. That sparks our creativity.
- Games have interaction. That gives us social groups.
- Games have representation and story. That gives us emotion.

Games can be instantiated for serious purposes as they involve mental and physical stimulation and they allow developing practical skills – they force the player to decide, to choose, to define priorities, to solve problems, etc. When games involve social environments, sometimes involving large distributed communities, they support the development of social competencies. Games develop the users' self learning abilities (players are often required to seek out information to master the game itself), they allow transfer of learning from other realities and are inherently experiential with the engagement of multiple senses.

Serious Games (SG) are games that do not have entertainment as the main objective. They are a "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" [5]. Serious games "are games insofar as they have rules, simulate behaviors, accept input from the player, and provide feedback within the context of the rules and behaviors" [6]. So, even if the main objective of a SG is not entertainment, it must provide the user with a context that engages and motivates him/her. Or, in the words of Csikszentmihalyi, the user should be in flow: "People are happiest when they are in a state of flow— a state of concentration or complete absorption with the activity at hand and the situation. It is a state in which people are so involved in an activity that nothing else seems to matter" [7].

Dynamic Game Balancing (DGB) is the process of real-time adjustment of game parameters so that the faced challenges and environment fit the player's ability, therefore keeping the player in *Flow*. This way the player will not be bored (if the game is too easy) or anxious (if it is too hard) and will remain motivated to play the game. DGB provides an individualized approach to a game and replaces the standard approach, common for all the players, despite their previous gaming experience, through an increasing linear difficulty approach or through a difficulty ladder (levels). DGB requires the definition of a Player Model, constructed by the collection of pregame and real-time game data. Andrade et al. present two dimensions of DGB: competence vs. performance that is the understanding and mastering of the game vs the capacity to efficiently tackle with its challenges [8].

Game analytics (GA), the set of methods designed to collect and interpret that data, are mostly related to game play metrics, that is information about the actual behavior of the user as a player inside the game: object interaction, object trade, navigation in the environment, actions and position of the player's character, results in each level, time spent, interactions with the game interface and menus, etc.

For Serious Games, DGB must include a component related to the serious objectives of the game. The entertainment aspect of the game cannot hide the skill or competence development objective (SCDO) and therefore must be tuned to include this concern. Game analytics should, at the same time, provide data that allows to assess how the player is progressing towards those serious goals.

DGB for Serious Games is a novel area without major research published unlike DGB for "normal" games where a few approaches have been used: [8] presented an approach where agents were trained to play against the human player at his/her skill level; in [9] genetic algorithms techniques the agents that best fit the user level; In [10], artificial neural networks (ANN) and fuzzy neural networks are used to estimate the parameters that provide engaging game play. None of these approaches has been extensively validated so research work is required to determine the best process to collect game analytics data and to use it for DGB but also to analyze the progress towards a DSGB Dynamic Serious Game Balancing.

Further research is also required to establish a taxonomic approach to Serious Games that delimits the DSGB methods and parameters adequate to each area of application. It is clear that serious games with educational purposes are quite different from serious games for marketing purposes, for instance. But, although it is possible to create a methodology that addresses the use of DSGB for serious games in general and develop a set of methods, data collection and analysis methods and technologies may not be, to a great extent, common. Therefore finding these specificities is a state of the art research.

3   Methods

The objectives of the project described in this article are:

- To design a methodology and corresponding methods for DSGB;
- To implement and validate the methodology with two case studies: one for educational purposes and another for fitness (personal health) purposes. Basically, two serious games will be developed, one for each area, with DSGB support.

The validation methodology is quite complex: on one side it will be necessary to evaluate the actual results of the use of the two serious games and on the other it will be necessary to assess the actual adequacy of the methodology, methods and tools. Typically Serious Games are assessed in the multiple domains of usability, game play and content (as the serious objective). Therefore the data collected must answer very different questions like:

- Is the game easy to learn and to play?
- Is the user interface (controls and navigation) adequate?
- Are the game play elements adequate to the target group.
- Is the game entertaining for them?
- Do the player decisions have a crucial role in the game result?
- Are the contents embedded in the game adequate to achieve the expected development of knowledge, skill, competence, awareness…?
- Did the player learned/developed what was intended?

- Did the player receive the message that was planned to transmit?
- Did the player changed convictions/opinions after playing the game?

The DSGB methodology, although roughly following existing DGB approaches, is still innovative and new. Therefore, the complexity of this goal requires that strong and careful steps for analysis, design, development, validation and testing are in place. This methodology is concreted in the following set of tasks:

- Project Management and Quality Assurance: Integrates project planning and monitoring to ensure a full quality assurance approach. This task deals with project planning, monitoring and quality assurance and it will be led by the IR. This task will also deal with the process of quality assurance of the project methodology and results of the project. It will be accomplished through a continuous process of monitoring, internal and external evaluation and methodology, methods and tools validation. Therefore it will have a component of formative evaluation (during the project) and summative evaluation (at the end) of the Project, and will focus on Activities and Products. The methodology adopted includes the analysis of quantitative and qualitative data, focusing as much on processes / methodologies as products / results.
- Specification and Analysis: This task will handle the identification of the state of the art in the multiple domains addressed by the project and the specification of the methodology. This task will produce a set of publishable deliverables like a survey on DGB methods and tools, a survey on game analytics, a survey on game development tools and an article about the definition of the Player Model (PM). This task will also handle the identification of the state of the art in the multiple domains addressed by the project and the specification of the methodology. This task will produce a set of publishable deliverables like a survey on DGB methods and tools, a survey on game analytics, a survey on game development tools and an article about the definition of the Player Model (PM). Therefore it includes the conceptual aspects but also the technical aspects related to the tools. The design and specification will be lead by the PhD researchers experts in their specific areas. External consultants will be involved to provide their expertise.
- Design of the DSGB methodology: This task relates to the design of the SGDBG methodology, methods and tools. It will also include the complete design of the two case studies: one for educational purposes and another for personal fitness purposes. This task is highly dependent on the results of the previous task where a comparison between the different available technologies will lead to a decision.
- Development of the serious games: This task integrates the activities related to the actual development of the games and tools (including data collection tools). A Rapid Prototyping Approach will be preferred (which implies a regular involvement of the users).
- Validation and Test: This task corresponds to the implementation of the validation phase. It will start by identifying the users that will be involved in the implementation. The second task is to make a detailed plan. The next task is to actually implement all the activities, according to the project plan. All of these processes will be evaluated continuously, so that results can contribute to an upgrade of the environment, the contents and the pedagogical methodology itself.

4   Conclusions

Serious games are games that do not have entertainment as the main objective. Neverthe-less they are games, so they must keep the user motivated and interested, in "flow". Dynamic Games Balancing tries to adjust the difficulty levels of the challenges to the abil-ities of the player providing a tight fit match that prevents him/her from getting bored (when challenges are too easy) or anxious (when challenges are too difficult). For Serious Games, DGB must incorporate a new dimension related to the "serious" objectives of the game.

Dynamic Serious Games Balancing is therefore a new approach that tries to balance the challenges not only to the game play performance but also to the serious objective performance (have learning outcomes been achieved in educational games? has the advertising message caused an impact in advergames?). A Serious Player Model (SPM) based on the User Model of Adaptive Hypermedia Systems will be created incorporating all the relevant parameters of use. "Player modeling is, primarily, the study and use of artificial and computational intelligence (AI and CI) techniques for the construction of computational models of player behavior, cognition and emotion, as well as other aspects beyond their interaction with a game (such as their personality and cultural background)." [11]. The SPM extends this model into the player characteristics adequate for the serious game purpose. For instance, for an exergame the player model should incorporate phys-ical parameters of the user, for educational games the SPM has to include parameters related to the knowledge, skills and competences pre and post serious game usage. The SPM integrates with the idea of Procedural Content Generation (PCG) that is the possi-bility of realtime generation of the game challenges based on a set of parameters instead of a complete, predetermined and fixed progress route. A simple example is Temple Run, a game where the player's route is always different based on instant random selection of a path and challenges from a predetermined set of paths and challenges.

Using DSGB, based on SPM, combining with PCG it is expected to create highly motivating, adaptive and personalized skill and competence development environments (but still games) that keep users involved for a long time therefore ensuring that they are focused on the "serious" objective. This approach implies the definition of methods to collect user data (game play, interaction and content) also known as game analytics. As serious games can have quite different purposes (educational, advertising, health, awareness raising) the actual tools to implement the methods must be different and the collected data also highly depends on the actual serious game objectives.

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