Adaptable Game Experience through Procedural Content Generation and Brain Computer Interface

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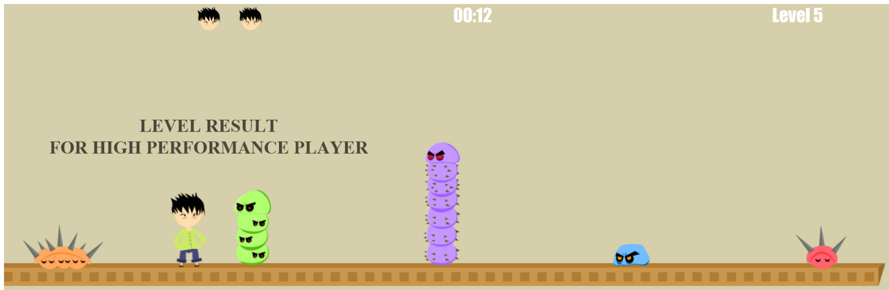

Figure 1: *A level created for a high performance player, more challenges, more difficult to clear.*

Abstract

For high skilled players, an easy game might become boring and for low skilled players, a difficult game might become frustrating. This research's goal is to offer players a personalized experience adapted according to their performance and levels of attention. We created a simple side-scrolling 2D platform game using Procedural Content Generation, Dynamic Difficulty Adjustment techniques and brain computer data obtained from players in real time using an Electroencephalography device. We conducted a series of experiments with different players and got results that confirm that our method is adjusting each level according to performance and attention.

Keywords: Game Design, Level Design, Game Development, Platformer, BCI, EEG, Procedural Content Generation, Dynamic Difficulty Adjustment, Player Experience, Neurosky, Playtesting

Concepts: •**Hardware** → *Bio-embedded electronics; Neural systems;*

1 Introduction

Players have different skills, although the case is particular for competitive games, we can see in [Cechanowicz et al. 2014] how in games where the players skill levels are not suitable for the difficulty of a game, for both types of players (high and low skilled players) the result could be an unsuitable experience. Usually this problem exists as a consequence of an unbalanced game design and can be solved changing the game rules or difficulty to make it appropriately challenging for players [Kraaijenbrink et al. 2009]. The problem with this solution is that, adapting one game for many different types of players is very complicated. Our approach is to combine methods such as Rhythm-Groups Theory (Procedural Content Generation) [Smith et al. 2009] and Dynamic Difficulty Adjustment, use an EEG device called "Neurosky Mindwave Mobile" [NeuroSky 2015] to measure the brain activity during gameplay time and finally apply them to 2D platform games, specifically changing the level design.

2 Related Work

There are some experienced researchers actively working on this field. Gillian Smith et al. are one of the most active researchers that have contributed significantly, applying methods such as Rhythm-Groups Theory [Smith et al. 2009], using PCG techniques, Dynamic Difficulty Adjustment [Jennings-Teats et al. 2010], many different game design and real-time modification techniques. In addition, there are researchers like Noor Shaker and Georgios Yannakakis who work towards personalizing the player experience automatically using PCG and Artificial Intelligence (AI) techniques [Shaker et al. 2010].

3 Method & Implementation

3.1 Game

The game is a side-scroller in which the player has to reach a goal placed on the right-most part of the level, very similar to *Super Mario Bros*. The player is also required to overcome very simple challenges such as gaps between platforms, beatable enemies and unbeatable enemies. In the beginning of each level, the player has two lives, also the game time is shown on the screen. Figure 2 shows how the game and its elements look on the screen.

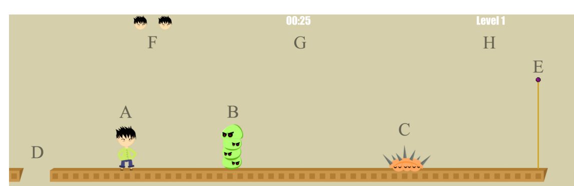

Figure 2: ***Game Elements***. *A: Player; B: Beatable enemy (jump over its head); C: Unbeatable enemy (avoid it); D: Gap; E: Goal; F: Player's lives; G: Game Time; H: Current Level.*

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3.2 System

When the player is playing the game, the average attention is calculated using the whole gameplay time, also, while playing, a performance value [0,1] (0 meaning poor performance, 1 meaning excellent performance) is calculated based on level clear time and how many times was the player hit or died.

The calculated data (performance and attention) in one level is used in the next level as input parameters to create it. Player performance and attention values are input into the DDA system that is in charge of deciding the right parameters for a Rhythm-Group system that will finally decide how the shape of the level will be created.

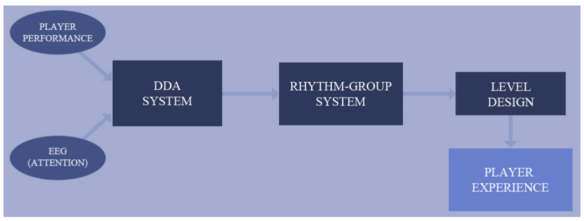

Figure 3: ***General design of the system created***. *This figure represents the overall system and how each subsystem is related to each other.*

3.3 Dynamic Difficulty Adjustment

One of the parameters used to calculate performance is gameplay time, it means, the less time it takes for the player to complete a level, the better the performance will be; also, the other import factor here is being hit by an enemy or falling to death on a gap, the less the player is hit or dies, the higher the performance will be. If a player is concentrated in a task, he or she would perform better than if concentration levels were poor [Moran and Murphy 2012].

3.4 Rhythm Generation System

This system is in charge of creating a full rhythm for the geometry system to interpret and decide how the final level will be created. A set of parameters are important to take into consideration to construct a rhythm, these are: rhythm type, rhythm density, action types, number of actions.

4 Experiments & Results

We conducted a series of experiments with 25 different types of players. While they were wearing the Neurosky EEG device to capture brain data, they played and cleared 5 levels created automatically by the method that we designed.

Since our method involves using previous results to create a new level, for the first level that players played, we set all parameters to 0.5, difficulty was set to 0.5 too. Depending on the results of the first level the second level is created to adapt it to the player's performance and brain data status. Same process is repeated until the player clears 5 levels.

In figure 4 we can see how the difficulty curve and "Att.& Perf." curve are getting closer to each other level by level. This shows how the method adapts the level difficulty to the player skills.

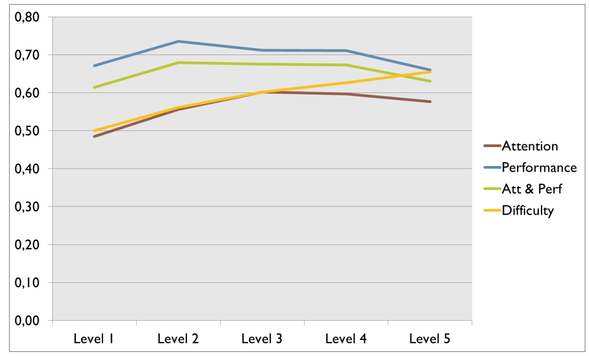

Figure 4: ***Experiment Results***. *After gathering results from 25 players, we calculated average attention, performance, a combination between attention and performance and finally difficulty. The graph shows how these values change from level to level.*

5 Conclusions & Future Work

We created a new technique that combines methods from previous work (PCG, DDA) with modifications and add a new component (EEG), conducted experiments with players, gathered results, analysed them and have prove that it's being successful. Results show that our method is capable of adapting the difficulty for high and low performance players in a smooth way.

We have plans to improve our current work, expand it and be able to obtain meaningful results. We would like to enhance the method, add more features to the game and perform experiments again. Finally we are considering to use the created method for improving playtesting in videogames and support game development companies on the level creation process.

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