（様式５）

学 位 論 文 要 旨

令和 2年　　01月

08日

学位申請者

（氏　　フェルナンデス バルダ　名 ヘンリー ダニエル ）

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学位論文題目

IMPROVEMENT OF PLAYER EXPERIENCE THROUGH DYNAMIC DIFFICULTY ADJUSTMENT USING BEHAVIORAL PATTERNS AND MACHINE LEARNING

学位論文の要旨

The motivation to start this research was to find new ways to avoid the imbalance that exists in videogames when the challenges that players try to overcome are not suitable for their skills. When games are too easy, players might get bored and when games are too hard, players might get frustrated and stop playing or have a negative experience.

Several approaches were tested for different types of games and with different methods, but the overall strategy was the same for all these approaches: adapt games by changing their difficulty or game design elements dynamically, depending on how players play or how the behave while playing.

The first approach was to use Graph Grammars in 2D platformers to create levels with multiple paths automatically. A simple 2D platform game in which players had to reach a goal in the right-most part of the screen was created. After finishing, players were required to rate the difficulty of each level.

It was possible to automatically create a wide range of different levels with multiple paths to the goal with a specific degree of difficulty. Results show that there is a 0.75 of correlation between the difficulty calculated by our method and the difficulty perceived by players.

The second approach was to combine Rhythm-Group theory with levels of attention obtained from a biosensor that uses EEG data for its calculations. Performance and attention values were used to determine whether to increase or decrease the difficulty of the next level in a 2D platformer, depending on players' results.

The inclusion of the EEG component demonstrated to improve the overall results of the adaptation, a comparison against experiments without the EEG component was done to confirm the results.

For the third approach, an idea that involved behavioral patterns was implemented. Players' behavior was analyzed through the force that they applied on the button of a PlayStation 3 controller and questionnaires were designed to measure parameters such as: difficulty, fun, frustration, valence, arousal and dominance.

In order to collect as many values as possible, experiments were designed using a 2D shooting game. Players filled in a questionnaire about their experience after completing each level in the

game.

In order to analyze the data, the correlation between pressure values and the previously mentioned parameters was calculated. Dominance showed the highest correlation with pressure, which was inversely proportional; when players felt less dominant towards the game, they pressed the button harder.

In addition, results show that fun and difficulty are directly related to the pressure exerted on the button, players tended to press the button harder when they were having more fun or when the challenges they were facing were difficult.

The data collected from experiments was used to design models that could predict emotions or parameters from pressure sensitivity. Several types of Neural Networks and Support Vector Machines were designed and tested to get the best possible results when finding patterns between these parameters.

Support Vector Machines showed better average accuracy (70.69%), against Neural Networks performed (68.55%).

The best results were obtained for the parameter boredom with 83.64% of accuracy and frustration, difficulty, fun and arousal were predicted with more than 70% of accuracy.

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The motivation with this research was to find new ways to avoid the imbalance that exists in videogames when the challenges that players try to overcome are not suitable for their skills. When games are too easy, players might get bored and when games are too hard, players might get frustrated and stop playing or end up having a negative experience.

As a first approach to find solutions for this problem, the author decided to test Graph Grammars with 2D platformers to create multipath levels automatically. A simple 2D platform game in which players had to reach the right-most part of the screen and then rate the difficulty of each level after finishing was created.

It was possible to automatically create a wide range of different levels with multiple paths to the goal with a specific degree of difficulty. Results show that there is a 0.75 of correlation between the difficulty calculated by the proposed method and the difficulty perceived by players while playing, which demonstrates that the method is successful.

The second approach was to combine Rhythm-Group theory with attention levels obtained from a biosensor that uses EEG data and performance calculated in real time while playing. In this case, performance and attention values were used to determine whether to increase or decrease the difficulty of the level in a 2D platform game.

The novelty of this second strategy was the inclusion of the EEG component, which demonstrated to improve the overall results of adaptation by compensating the performance calculation with the attention values.

For the third approach, the author designed a method that involved behavioral patterns. The players' behavior was analyzed by the force they applied on the button of a PlayStation 3 controller and questionnaires designed to measure parameters such as: difficulty, fun, frustration, valence, arousal and dominance.

Results showed that dominance had the highest (inversely proportional) correlation with pressure, when players felt less dominant towards the game, they pressed the button harder. In addition, results demonstrated that fun and difficulty are directly related to the pressure exerted on the button.

Using the data collected from the experiments, machine learning methods were trained to predict

the previously mentioned parameters. Results show that Support Vector Machines had better average accuracy (70.69%) than Neural Networks (68.55%). The best results were obtained for the parameter boredom with 83.64% of accuracy. Frustration, difficulty, fun and arousal were predicted with more than 70% of accuracy.