EEG-based Emotion Recognition for Game Difficulty Control

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Abstract. Balance design taking game difficulty into account has an important role in game design. In recent years, a number of studies have tried to adjust difficulty by using various player dependent difficulty detection algorithms. But most of these methods need customizing its algorithm for each game. In this paper, we investigate the way to find adaptive game difficulty levels according to player’s emotion by analyzing electroencephalogram (EEG) signals for improving player’s emersion. A player’s EEG signals during playing a rhythm game which has three different difficulty levels were analyzed by using PAD model. We focus on the states of emotion from players EEG signals.

Keywords: Electroencephalogram, Emotion Recognition, Game Difficulty,

1 Introduction

In recent years, game becomes one of most popular form of human-computer interaction systems [1]. After inventing computer game, it is one of most major way to enjoy leisure time. Although gaming technology has evolved, there has been dissatisfaction of players with the current computer games because of their inadequacy of providing optimal challenge levels to accommodate individual player’s characteristics such as skills, capacities to learn and adapt, and emotional traits [2]. Most of game adopts static difficulty levels system that is manually selected by players. But players don’t have enough information about each levels of difficulty. Also, game designers have similar problem.

Games could derive emotion of game players. According to flow theories [3], strong involvement in a task occurs when the skills of an individual meet the challenge of a task [Fig. 1] [4]. Too much challenge would induce anxiety. Also, not enough challenge would induce boredom.

When a player plays a game, an emotional state changes to another consistently. It is occurred by two reasons. First, the increasing speed of the difficulty is faster than the increasing speed of competence of the player. Second, the increasing speed of competence of the player is faster than the increasing speed of the difficulty. In first case, emotion states would be moved to anxiety, and in second case, emotion states would be moved to boredom. Based on this theory, we focused on the state of
emotion from players EEG signals induced by different difficulty levels of a rhythm game.

Fig. 1. Flow chart and the automatic adaptation to emotional reactions [4]

2 Experiment and Implementation

2.1 Experiment

Rhythm games are suitable for this experiment because of the following three reasons: First, it is simple to control the difficulty of game by regulating the frequency of notes and changing the speed of notes. Second, it is also easy to measure difficulty. Finally, it is a widely spread and well-known genre.

A rhythm game with three different difficulty sets of notes was designed and a song named “Come to me” was chosen which has 1 minute 20 seconds play time with 125 bit per minutes. These three difficulty sets of notes have respectively 74, 159, 280 notes, and the speeds of each sets are same. This game logged all results of player with every note during experiments. Because of this character of our game, it is easy to compare between emotion states and player’s log.

This experiment implemented with eight participant (mean age is 29.3, all right handed). Each participant played game three times with three different difficulty levels of notes. A participant started from a low level and finished up high level and had 1 minute 30 second rest period between each session. To measure the EEG signals, participants were equipped with several sensors where Fp1, Fp2, Ground, Reference [Fig. 2].
2.2 Implementation

Physiological research has shown the difference in activation between the two cortical hemispheres. And the activity of alpha waves (8-12Hz) is correlated with low brain activity.

The fast Fourier Transform was used for extracting features. Frontal EEG asymmetry [5] was chosen to determine valence, and Beta/Alpha ratio was chosen to determine arousal.

3 Results and Discussion

When participants played a rhythm game with three different difficulty levels, emotion states were distinguishable. When participants played a game in easy level, valence and arousal are lower than medium level. When participants played a game in hard level, valence is lower than medium level, and arousal is higher than medium level. It means that participants were in boredom, engagement, anxiety states when they played a game in easy, medium, hard levels [Table 1]. The accuracy of emotion states is 62.5%.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Boredom</th>
<th>Engagement</th>
<th>Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Medium</td>
<td>12.5%</td>
<td>75%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Hard</td>
<td>0%</td>
<td>37.5%</td>
<td>62.5%</td>
</tr>
</tbody>
</table>

Table 1. Emotion States According to Difficulty Levels
In this paper, we investigated the possibility of dynamic difficulty control system by using EEG signals. The used algorithms for determining valence and arousal are simple to apply but do not guarantee the accuracy. Thus, it is needed to apply adaptive algorithms.

4 Conclusions

This paper used valence-arousal model, and analyzed EEG signals induced by difficulty of a game. The experimentation has been designed to gather participants’ EEG signals from different difficulty levels.

The results showed that different difficulty levels derive participants’ emotion states. Each difficulty levels are respectively involved in the anxiety, boredom, and engagement. These results could be a lead about dynamic difficulty control system by using EEG signals.

Future work will improve the detection accuracy and construct automatic process synchronization with game logs and EEG signals, for player dependant dynamic difficulty control system.

References