Optimization of First-Person Shooter Game Control Using Heart Rate Sensor

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Abstract. As first-person shooter (FPS) games become highly competitive game genres, various supports are needed to improve the gaming environment. In the past, players have focused on gaming mouses and displays, which are expensive and challenging to select from. To understand the influence of the player's tension on FPS game control, we developed a system that can automatically adjust the speed of the mouse according to the player's real-time heartbeat during the game. In this study, we developed and evaluated a system to improve the FPS game environment based on the heart rate.

Keywords: game control · heart rate · emotion · sensor · first person shooter game · control optimization system · mouse sensitivity · Arduino.

1 INTRODUCTION

1.1 Background

In recent years, first-person shooter (FPS) games have become an essential part of world-class e-sports. For FPS game players, elements such as competitiveness and control feelings are vital for enhancing the gaming environment [1][2]. The most significant aspect of the FPS gamer is the speed of mouse movement [3]. Typically, players focus on their choice of the gaming mouse. If one can do it just 0.1 s faster than the person's opponent, one has a higher chance of winning [4][5]. However, if the sensitivity of the mouse is set very high, the person will be unable to react. Therefore, mouse sensitivity that matches the reaction speed of a person is desirable.

In this study, we found that a player's heartbeat changed according to the player's pressure and tension and could be used as an emotional element to influence the game control instead of physically controlling the game with a mouse and a keyboard input. A person's level of tension changes during a game, depending on the situation: the higher the tension, the higher the heart rate and ability to react [9]. We developed a system that automatically adjusts the sensitivity of the mouse according to the heart rate to improve the FPS game environment.

It is necessary to measure the real-time heart rate of the player during the game to build a system that improves the gaming environment by heart rate. Next, we link the changes in the heart rate to mouse sensitivity. The purpose of this study is to develop an FPS game control optimization system that obtains the user's heart rate and links it to the sensitivity of the mouse according to the real-time heart rate. An evaluation experiment was conducted and described.

In the work of [6], photoelectric heart rate sensors (Fig. 1) [8] exhibited the principle of heart rate measurement. The hemoglobin in the blood absorbs and reflects light differently, depending on the amount of oxygen it carries. Photoelectric sensors use this property to measure the heart rate by determining the absorption and reflection of light in the hemoglobin density change, as arterial blood flow causes the heart to contract and dilate. Photoelectric sensors are noninvasive and, therefore, easier to measure heart rates.

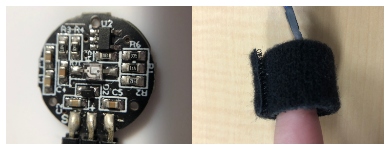

Fig. 1. heart rate sensor.

Data collection and analysis are simple and inexpensive when photoelectric heart rate sensors are utilized. Therefore, we used a photoelectric heart rate sensor to build the system.

2 FPS GAME CONTROL OPTIMIZATION SYSTEM

This system was used to controls the sensitivity of the mouse, a critical parameter for controlling the FPS game. Control was achieved by measuring the heart rate during the FPS game using a photoelectric sensor (Fig. 2).

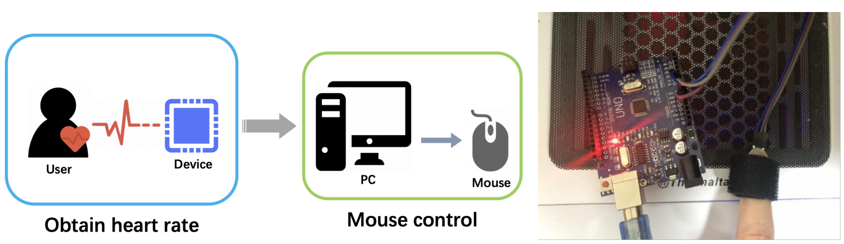

Fig. 2. FPS game control optimization system.

2.1 System implementation

Implementation overview Before the FPS game started, the player wore a device with a photoelectric heart rate sensor on the player's fingertip. During the game, the device measured the player's heart rate in real time and sent the heart rate data to the PC. The PC received the data as input and adjusted the sensitivity of the mouse according to the real-time heart rate.

Heart rate acquisition It was possible to determine the heart rate continuously using an Arduino Uno with a heart rate sensor (pulse sensor). The heart rate sensor collected electrical signals from the user's fingertips, and the Arduino program calculated the real-time heart rate. The calculated heart rate data were then continuously sent to the PC through a USB cable to obtain the user's heart rate during the game.

Mouse control The purpose of this system is to optimize the control of FPS games by adjusting the sensitivity of the mouse using the real-time heart rate data of the user. Using this system, we considered the mouse sensitivity as the speed of the mouse movement and utilized the Windows API to adjust the mouse sensitivity according to the real-time heart rate.

The Windows API MouseSpeed defines the mouse speed from 1 (slowest) to 20 (fastest). The standard value is 10.

2.2 Sensing devices for meansuring heart rate

We used Arduino Uno in this study. The program was written in the Arduino language based on the C language. It can control lamps, switches, and motors connected to boards, thus assisting people with less experience in electronic construction to develop unique creations. To measure the electrical signals of the heart rate, we used a heart rate sensor in Arduino. By attaching this sensor to the user's ear or fingertip, we easily measured the electrical signals of the heart rate (Fig.2). Logitech G502a gaming mouse with a high-precision sensor and high customizability was selected. The weight (up to 5×3.6 g) and balance could be tuned to suit the user's playing style.

We used the Arduino program to calculate the heart rate in real time. The mouse control part was used to link the real-time heart rate and the mouse sensitivity. Therefore, we wrote a program using Python software; with this program, we could control the mouse using the real-time heart rate. Pairs of heart rate segments ranging from lower than 80 to higher than 120, and MouseSpeed segments ranging from 10 to 20, were adopted (Table. 1).

When the user's heart rate increased, MouseSpeed increased, and when it decreased, MouseSpeed decreased. These actions were performed using a program written in Python.

Table 1. Pair of the heartbeat interval with the MouseSpeed interval.

heart rate	≤ 80	80-90	90-95	95-100	100-105	105-110	110-120	≥ 120
MouseSpeed	10	12	13	14	15	16	18	20

3 EVALUATION OF PROPOSED METHOD

3.1 Experimental method

The Aimbooster shooting training software (Fig. 3) [7] was used to simulate game-like situations to test the system. In concrete terms, 10 subjects were tested five times using the device and five times without the device. The mean and variance of the results (accuracy) for each of the five tests were calculated, and the calculated data were analyzed.

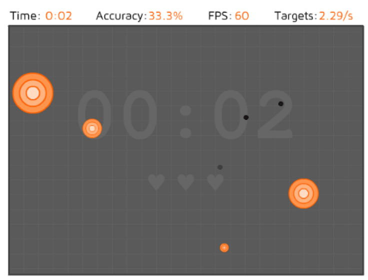

Fig. 3. Aimbooster.[7]

All subjects were tested in a random order under the exact same device conditions (mouse weight, brand, etc.). The setting of the target pattern was also random. The average age of the 10 subjects (9 males; 1 female) was 20-25 years old. All subjects are FPS gamers.

3.2 Experimental results

The following are the results of our tests on this system using Aimbooster. The mean and variance of the accuracy of the 10 subjects without the device (Table. 2) and with the device (Table. 3) were determined.

Table 2. Average values without the device (10 people).

	A	B	C	D	E	F	G	H	I	J	Average
Mean	82.2	74.2	82.4	76.0	83.8	73.2	75.4	87.8	82	77.8	79.48
Variance	6.96	58.56	5.44	8.00	16.96	19.76	31.04	4.16	17.6	10.96	17.94

Table 3. Average values with the device (10 people).

	A	B	C	D	E	F	G	H	I	J	Average
Mean	89.2	79.2	87.2	86.6	89.2	81.8	78.4	88.4	88.4	78.2	84.66
Variance	2.96	26.56	21.76	6.24	8.96	14.96	13.04	13.84	3.44	23.36	13.51

A t-test was used to evaluate the system. We observed the following:

- The system improved the average hit rate by 5% compared to the method without the device.

We formulated the following t-test hypotheses.

- Null hypothesis: The method with the device in this system was significantly less effective than the method without the device at the 5% significance level. The mean value of the hit rates of the method with and without the device were equal.
- Counter-hypothesis: The method with the device was significantly more effective than the method without the device at the 5% significance level. The mean of the hit rates of the method with and without the device were different.

The degrees of freedom followed a t-distribution pattern, and the significance level was set at 5% (two-tailed test).

According to statistical analysis, the value of t is 2.43 and the value of p is 0.026. When the degree of freedom is 18, the critical value of t is 2.101, and the rejection region is $t \leq -2.101$ or $t \geq 2.101$. The test results confirmed that the system with the device was significantly more effective than that without the device at the 5% level of the mean hit rate. In other words, the system improved the mean score by 5% compared to the method without the device.

3.3 Discussion

In this experiment, we only assumed the situation of shooting in an ideal environment. Therefore, it was reasonable to use Aimbooster for the experiment. The t-test revealed some validity of the effectiveness of the FPS game control optimization system. In addition, there were several possible reasons why the results were not good for the test. First, we found that individual differences in the human constitution influenced the change in the heart rate. Thus, it is necessary to adjust the threshold for individual differences in advance to obtain valid test data. Second, if the same test is performed more than once, the subject may become accustomed to the test pattern, and the heart rate variations may become smaller.

4 CONCLUSION AND FUTURE WORK

In this study, we implemented and evaluated an FPS game control optimization system using a heart rate sensor and found that the FPS game environment could be improved using heart rate data. This study demonstrates the possibility of using the biometric information of a player's heart rate to improve the game environment, as opposed to the conventional method of using a gaming device to improve the game environment.

In a future study, we aim to investigate the influence of individual differences mentioned in the discussion section and set reasonable thresholds for individual differences in each player. We also want to investigate the possibility of using other biometric information, in addition to the heart rate, to enhance the game environment.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Numbers 20K11780 and 19H01719.

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