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Poster

PhysioSense Controller: Self-Actuating Button Based on Player Physiology for Improved Avatar Control

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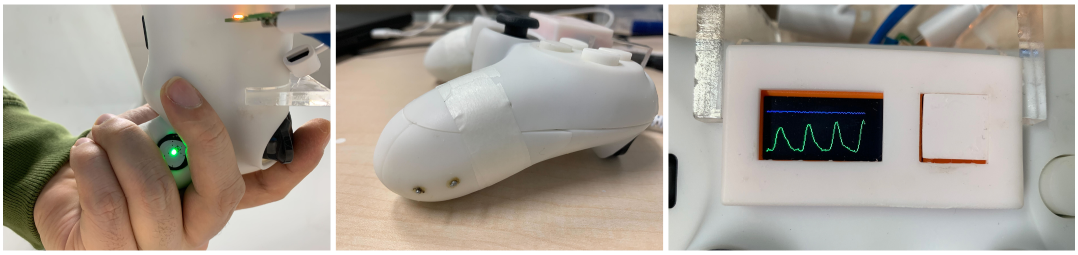

Figure 1: *PhysioSense Controller and Sensors*

Abstract

Games generally require a certain level of skill to control the avatar. However, this can also potentially lead to frustration since there is no way for a game to truly adapt to the player's skill during gameplay. We propose the PhysioSense controller, a custom designed gamepad controller that senses the player's electrodermal activity (EDA), heart rate, and motion to compute their cognitive load level in real-time and trigger a haptic feedback during key events in the game. The haptic feedback is delivered via subtle actuation on the button, allowing the player to still retain their sense of agency. We performed an initial evaluation on the PhysioSense Controller using a platforming action game with three custom difficulty levels. We found that there was a clear physiological and motion response to the presented difficulties, and that the player's behavior changes to adapt to them. We believe that our system can potentially make more players enjoy most games in the future regardless of presented difficulty.

CCS Concepts

• ***Computing methodologies*** → *Collision detection;* • ***Hardware*** → *Sensors and actuators; PCB design and layout;*

1. Introduction

Most casual game players are unable or simply do not want to invest the necessary amount of time to improve their gameplay. To adapt to this skill gap, designers have opted towards the use of dynamic difficulty adjustment (DDA) in games [Hun05]. DDA allows a player to adjust the difficulty of a game at any point during the gameplay, which changes key parameters [Hun05], machine learning [JTSWF10], and player modelling [ZR12] of the game. For example, the artificial intelligence of enemy characters can be less efficient or they deal less damage [TTT11]. There are also DDA methods that introduce features like "aim assist", which actually reduces player agency to overall perform better [VMMGB14]. This leads to our research goal that aims to let players control their in-game avatar better through the use of subtle haptic feedback. To achieve this, we sought to investigate a method to understand the player's implicit and explicit behaviour during gameplay and use this information for a novel DDA method.

We propose the PhysioSense controller, a modified gamepad controller that uses players physiological state during gameplay to provide subtle haptic feedback during key events in a game for a better experience in gaming, regardless of difficulty level. PhysioSense utilizes EDA, heart rate and motion data to compute the player's cognitive load level, which is directly affected by how they perceive a game's difficulty. Unlike controller vibration which is not localized to a button, our method sends a tactile cue to the player to press the specific button. Our contributions are therefore the following: 1) We developed a gamepad controller that reads the players physiological state to compute their cognitive load level and provide subtle tactile feedback via button actuation, 2) We evaluated the performance and perceived workload of participants under various difficulty levels, and 3) We found that our system was able

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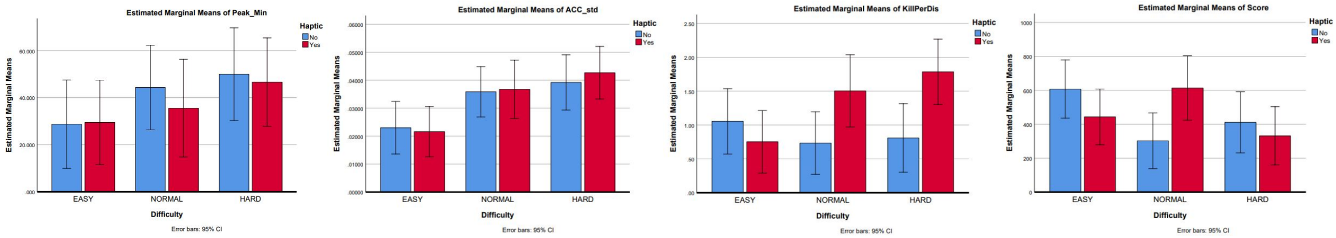

Figure 2: *Plot of Peak per Minute, standard deviation on accelerate value, KpD, and Score, from left to right*

to change the player behavior when playing the game depending on the different difficulty levels.

2. PhysioSense Design

As the player typically needs to press a button to execute an action, a subtle button actuation acts along this action, possibly making it less perceivable. We aim to actuate the button only slightly; the trigger still needs the player to bottom out the button themselves. To achieve this, we use a simple electromagnet solenoid and pulley mechanism. The string goes through a circuit board and finally connects to the bottom of the button. When power is provided to the electromagnet, the button is pulled downwards for a subtle tactile feedback on the finger resting on the button. The sensors integrated into PhysioSense are the heart rate, EDA and acceleration sensor. To ensure that the physiological sensors receive skin contact from the player, the heartbeat sensor is placed at the bottom of the left grip where the left middle finger rests. The EDA sensor is on the right grip where the palm is naturally in contact. M5StickC has a built-in inertial measurement unit (IMU) chip, which uses a combination of accelerometers, gyroscopes, and magnetometers. The sensors and display are shown in Figure 1.

3. Initial User Study and Results

The goal of the study is to collect the participant's physiological data, evaluate the performance and perceived workload. We developed a game where the player's avatar have a health score of five points and need to jump between platforms. The game's difficulty level ranges from 0 to 30, where the distance between jumps, platform size and enemy spawn rate directly correlate with the difficulty.

We then determine the participant's baseline difficulty level (BDL). When a player dies , the current difficulty level of the game at the time of death will be recorded. This difficulty is used as the participant's baseline (*medium* difficulty). Three game difficulty levels will be set for each participant: *easy* (medium level minus two), *medium*, and *hard* (medium level plus two). The order is counter-balanced for each participant. Twelve participants took part in this experiment (3 males, 9 females).

The results are shown on Figure 2. Simple main effects analysis showed that in *easy* mode, peak per minute were significantly larger than in *hard* mode ($p = .046$). This means that the selected difficulty modes were reflected well through their cognitive load level, though the haptic feedback is not reflected here possibly due to the subtleness of it. There was also a statistically significant interaction between the effects of difficulty on std. deviation, $F = 8.85$, $p = .002$. Simple main effects analysis showed that in *easy* mode, holding controller were significantly stable than in both *medium* mode ($p = .004$) and *hard* mode ($p = .000$). This makes sense since the harder the game is, the more motion is present. We use "*Killing per Distance*" value (KpD) for evaluating player's behaviour in the game. Higher *KpD* value shows that player prefer to kill the enemy rather than avoid them. It is evident that with the actuated button, the player prefer to kill enemies. Additionally, there was a statistically significant interaction between the effects of difficulty and haptic feedback on KpD, $F = 3.581$, $p = .033$. We also examined the effect of difficulty and actuated button on score. There was a statistically significant interaction between the effects of difficulty and haptic feedback on total score, $F = 4.209$, $p = .02$. Simple main effects analysis showed that the value of KpD in haptic mode were significantly higher than non-haptic mode ($p = .019$). Therefore, the button actuation on PhysioSense changes the overall gameplay behavior of the participants.

4. Conclusion and Future Works

Participants performed overall better with PhysioSense. Yet, physiological response and skill levels are very dependent to each player, and this work offers a preliminary glimpse on a method to assist players, though we would like to assess their perceived agency towards their avatar as well.

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