Designing Affective Games with Physiological Input

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ABSTRACT
With the advent of new game controllers, traditional input mechanisms for games have changed to include gestural interfaces and camera recognition techniques, which are being further explored with the likes of Sony's PlayStation Move and Microsoft's Kinect. Soon these techniques will include affective input to control game interaction and mechanics. Thus, it is important to explore which game designs work best with which affective input technologies, giving special regard to direct and indirect methods. In this paper, we discuss some affective measurement techniques and development ideas for using these as control mechanisms for affective game design using psychophysiological input.

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Affective computing, entertainment computing, psychophysiology, game design.

ACM Classification Keywords
K.8.0 [General]: Games – *Personal Computing*; J.4 [Computer Applications]: Sociology, Psychology – Social and Behavioral Sciences.

INTRODUCTION
Traditional methods of game interaction are now including novel forms of interaction using gestural and bodily input. For example, the Konami DDR (dance dance revolution) pad allows players to use their feet while the Nintendo Wiimote is a gestural device that can be used in a number of ways. Major hardware producers are developing the next big advance in gaming input devices and have recently come up with products such as Kinect (Microsoft), and the PlayStation Move (Sony).

While gaming consoles continue to implement different forms of interactions, tangible and affective forms of interaction (i.e., physiological sensors providing information about user emotion [1] and/or cognition [6]) are becoming more popular in desktop software design as well [2]. For human-computer interaction evaluative studies, this marks a shift from analyses centering on usability to those that are looking at the full spectrum of user experience (UX). These studies focus on human aspects of interaction, such as the behavioral, perceptual, emotional, and cognitive capabilities of people [5].

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In addition to evaluating affective user responses, the use of a player's own cognitive and emotional state as input – known as affective input – is an exciting input possibility that has not been fully explored in the context of games [4]. Affective input has seen use as a direct method of control in accessibility applications, and as an indirect method of control in biofeedback training for meditation and phobia treatment. The differences between *direct* and *indirect* affective input need further exploration.

Affective Input in Games
In the context of games, some simple applications have proved the concept of affective input, but these applications are limited in terms of gameplay to a proof of concept that loses interest once the initial novelty factor has worn off. For example, Brainball [3] is an innovative interactive game that uses relaxation (sensed through EEG) to move a physical ball across a table between two opponents. The player who is best at relaxing wins by moving the ball all the way to his or her opponent's side. This game uses a direct 1-1 mapping to a game mechanic, and although it is compelling, Brainball's appeal would be limited after a few play sessions. This leaves researches to question: (1) which game mechanics work best with which forms of affective input and (2) whether direct or indirect physiological input methods are preferred by gamers.

This paper will discuss first the different possibilities of using physiological sensors for affective input. After this introduction to affective sensors, we will discuss a sample implementation of a digital game that makes use of these sensors, classified as direct and indirect sensing methods.

AFFECTIVE PHYSIOLOGICAL INTERFACES
Affective interfaces are essentially human-computer interfaces comprised of physiological sensory interfaces that can augment traditional input devices. They often require a specialist setup and are used primarily in research

environments. Some examples for physiological sensors that can be used to augment game input are the following.

Gaze Interaction with an Eye Tracker

Eye tracking is a valuable technology to provide analytical insights for studying human behavior and visual attention. Eye trackers can be easily deployed and some low cost solutions exist already (i.e., you only need a webcam and correct software). An increased interest of game hardware providers in camera tracking technology (e.g., Kinect and Move) is also likely to drive the development of tracking algorithms on these new game hardware devices, eventually leading to eye tracking to be available for gamers. Psychological data are for example the position and movement of gaze along the screen and pupil dilation. All eye tracking hardware allows to record patterns and distributions of fixations and saccadic eye motion with different levels of precision. The control of eye movement can be considered a direct form of affective input.

Electromyography

Facial electromyography (EMG) describes the measurement of subtle electrical activation of face muscles and is a good indicator of pleasant or unpleasant emotions of gamers. EMG can also be used to sense the activation of other muscles as a more direct form of input to control software [7]. Figure 1 shows an example placement of EMG sensors.

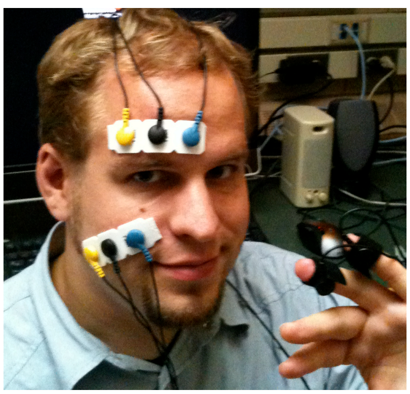

Figure 1. EMG and GSR sensors and their placement on a person

Galvanic Skin Response

Electrodermal activity (EDA, also: skin-conductance level or SCL) or galvanic skin response (GSR) is a very common psychophysiological measurement method due to its very easy application. EDA is regulated by production of sweat in the eccrine sweat glands, where increased sweat gland activity is related to electrical skin conductance level (SCL), and is associated with physical arousal. GSR can be seen as an indirect for of input to a game.

Electrocardiography or Heart-Rate Measurement

Electrocardiography (EKG) is the sensing of heart-rate through physiological sensors on the body. It is hard to control directly, but hyperventilation or physical activity often result in an increased heart-rate (HR). HR is an indirect input mechanism for a game.

Strain sensors

A strain sensor is stretched across a individual's chest to measure its strain due to breathing volume. Strain sensors can be directly controlled.

Temperature sensors

A temperature sensor can be used as a physiological sensor when applied to a person's skin. It can otherwise be directly controlled by a person.

Electroencephalography

In EEG, electrodes are placed in standard positions on the scalp adhering to the international standard 10-20 system. The neural signals recorded with an EEG are just a rudimentary representation of neural activity, since the electrodes only register the attenuated signal of neuronal activity near the brain's surface. Thus, signals need to be appropriately filtered before analysis to be distinguishable from for example muscular scalp activity. The signal is then typically referenced to another electrode (i.e., ground or average) before any further analysis. EEG is an indirect form of affective input.

DEATH TRIGGER – AN AFFECTIVE INPUT GAME

With the goal in mind to investigate the optimal game mechanics and designs for using players' cognitive and/or emotional state to control a game, we tested some ideas for an affective gaming prototype, which is still in a very early stage of development. Figure 2 shows the standard controller scheme that was used for the game, we developed. These controls were later augmented with affective input to control certain game mechanics.

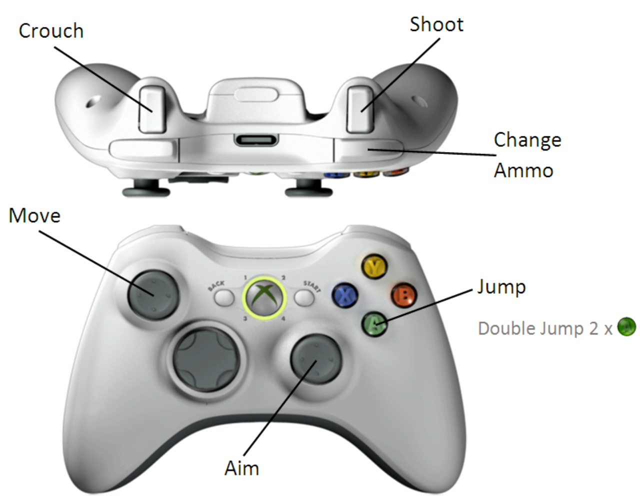

Figure 2. Basic controls of the Death Trigger game

The Death Trigger Game

In this side-scrolling, single-player shooter game, the main character holds a weapon that is able to fire three different ammunition types (2 bullet types and a flamethrower). The player begins the game with only the weakest form of ammunition and is able to collect more powerful ammunition by exploring the level and killing enemies. The game features obstacles including marines, a yeti, and other hazards such as burning wreckage and bottomless pits. To be successful, a player needs to strategically navigate the environment and carefully manage their resources.

When brainstorming ideas for affective input mechanics for games a concern was that they should positively reinforce player experience or UX. Thus, rather than using affective feedback for penalizing the player, we wanted to reward the player for physiological control.

The following mapping of affective input to control schemes was tried in the game:

- GSR to indirectly control the size of the enemies in the game. Higher GSR will result in enemies increased in size. It also means that enemies will be easier to fight due to a bigger surface.
- EKG was used as indirect control of the snow particles in the game, which also triggered how fast the final game boss enemy (a Yeti) would attack the player. Increased EKG activity would result in lower precipitation
- Strain was used as a direct control sensor of the flamethrower weapon. Thus, breathing in deeply through your chest and exhaling would result in an increased flame length.
- EMG was used as a direct input sensor on the *tibialis* leg muscle, which had to be flexed to control the speed of the player and her jump height.
- Finally, a special pick-up item in the game would trigger a special ability steered by the eye tracker, which was dubbed "Medusa's Gaze." Looking at enemies in this condition freezes them for a given amount of time. In addition, this ability is only available for a short timespan.

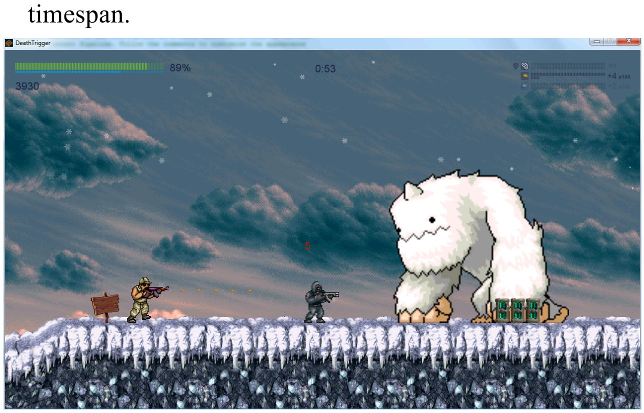

Figure 3. Screenshot of the Death Trigger game.

As shown in Figure 3 on the top right, the player manages one large health bar representing the amount of total health available to the player and one smaller health bar representing the biosuit feature, which allow recharging health whenever the player is not attacked. When the large health bar is depleted, the player is dead.

The game uses Microsoft .NET XNA technology and physiological input sensors provided by Thought Technologies.

Initial Pilot Study Results for Evaluating Affective Input

When the game features were evaluated in an initial pilot study, we interviewed 5 players for their preferences in the game. Four out of five players liked the strain sensors and the eye tracker best as forms of direct input. Many complaints were given on the control of the EKG and temperature sensors. In general, the initial pilot study revealed a preference for the direct form of physiological input.

CONCLUSION

In this paper, we have presented affective input mechanisms and some initial ideas of mapping these to subtle game mechanics. In addition, we are currently developing a game prototype that will incorporate these game mechanics to demonstrate affective gameplay interaction. We are also working with our project champion, Thought Technologies, to integrate physiological sensors into game controllers

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