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Using Affective Loop as Auxilliary Design Tool for Video Games

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Abstract. As modern technologies become more apparent and persistent, human-computer interaction becomes an important research topic. With birth of affective computing, which aims at developing systems capable of detecting and processing emotionally significant data from the environment, new possibilities for applications unfold, and video games can benefit from them as well. Bringing innovative solutions to this area involves new modes of affective data collection and affect modelling of various aspects of the game experience. My research, focusing on affective game design patterns, is located on the intersection of modelling player affect and affective game design framework. In this paper, an outline of how affective computing ideas (especially affective loop) are introduced to video game design is presented. A new approach to designing video games in the form of affective game design patterns is proposed, together with research method description and summary of studies conducted so far.

Keywords: human-computer interaction, affective computing, affective loop, video game design

1 Introduction

In the times of great scientific and technological progress, almost each and every human activity is accompanied by modern technology. As computers and mobile devices become more persistent and ubiquitous, people's everyday contact with them emerge as a broad topic for discussion, improvement, and – therefore – research. With interfaces being a direct level of interaction between the user and the machine, designers and developers face a challenge to make this interaction as easy and natural as possible.

A movement taking a closer look on these problems, originating in early 1980s, is called Human-Computer Interaction (HCI). However, it was not until late 1990s that Rosalind Picard from MIT Media Lab suggested that HCI should take emotions in the interaction into consideration. She started a new approach in researched, namely – *Affective computing, AfC* [17]. It integrates psychology, cognitive science, neurophysiology, and social studies, among others, in order to make a machine a decent participator of interaction with a human.

According to Picard, an affective computer or system should be able to detect and record emotionally significant information in the environment, store the collected data, process it and generate an appropriate response. This data may come from various dimensions of interaction: from the physiological level (heart pulse, electrodermal activity, etc.), through user's behavior (facial expressions, body postures and gestures), towards more general metrics consisting of specific sequences of operations, mouse cursor paths, and so on. Depending on the context, the gathered data can be forwarded to specific algorithms and models. A notable feature of such solutions is an *affective loop* [1] – a mechanism, where data detection, collection and processing engage the user and the system in a smooth, continuous cycle of dynamic behaviors and reactions. This brings numerous challenges that were out of concern in case of models processing the data in an offline and asynchronous manner. Nevertheless, making the system behave like it understood the user's emotions greatly improves the general user experience [19].

As a domain clearly interdisciplinary in its nature, AfC needs a solid foundation in emotion theories. Currently, three main approaches to modelling emotion can be distinguished. Two of them form a dichotomy of "discreet vs continuous". With Paul Ekman's basic emotion's theory [6] as an example on one hand, the affects are grouped into separate categories. On the contrary, according to dimensional affect theories [22, 14] an emotion can be though of as a point in a two- or three-dimensional (depending on a specific model) space. However, most interesting – at least from the AfC's point of view – approach seems to be reflected in so called appraisal-based theories [21], [16]. It allows to define an emotion as a set of features, ascribe them certain numeric values, and develop mathematical models for their interpretation and simulation. Actually, one of the last of the described group of emotion theories has already been implemented in AfC, specifically in the field of video games [18].

2 Affective computing in video games

This paper focuses on how affective approach, especially the affective loop, can facilitate video game design. In creating AfC systems, two essential steps are considered: firstly, data collection (where various tools and methods for recording the player's affective state are developed), and secondly – models, where the affective loop can take its full shape. Video games, besides being a great hypothesis-testing polygon, when enhanced with an affective loop are capable of raising the player's satisfaction and engagement, thereby increasing the game's recreational, educational, and therapeutic value.

2.1 Data collection in AfC video games

Similarly to other AfC subfields, as noticed by [9], in video game research there are several levels of interaction where player's data can be gathered. On the most fundamental level, information about affective state of the player is derived from her physiological signals, for example heart rate (HR) or galvanic skin response (GSR) [1]. A layer above comes the behavioral dimension of interaction with the game, which regards data of the player's facial expressions, body postures and gestures while playing, player character movement paths, etc. The level of stress experienced by the player can be also derived from the force used to press the button on the game controller [24]. Player's interpretation and evaluation of in-game events and objects forms yet another level where affective data can be detected. Here, information of person's affective state is derived based on models operating on numerically described features of game components and relations between them, such as the event's desirability, or its congruency with the game goal. The features and relations are defined separately for the player character, and the characters in the game (Non-Player Characters, NPC). For example, the event "the treasure is stolen" for the NPC Guard is calculated as the congruency of this event for the NPC Guard's goal ("protect the treasure", value from -1 to 1) times the utility of this goal (where utility refers to how much the NPC does or does not want the goal to happen, value from -1 to 1). Similar approach may be applied to model the player's affect.

2.2 Affect modelling in AfC games

Still following Hudlicka's suggestion [9], three perspectives on modelling the affect in games can be taken. First and foremost, one can focus on the player's emotional state, where her affects have to be detected and interpreted as reliably and precisely as possible. With regard to different levels of data collection, emotion model may be based on physiological signals [3] and behavior patterns [23]. As has been already noted, the player character may interact with in-game characters, whose emotions may be modelled too. In order to make the NPCs more realistic, their affect models have to include their goals and motivations. Finally, affective loop may be tailored into the design of the game itself, on the level of game mechanics and aesthetics. From the very beginning of affective gaming, the biometric signals of the player were used to influence the game modes and difficulty. Player's GSR and HR can be incorporated into the game engine to dynamically modify player character's speed [1], as well as interface features and monster spawning rates [5, 12]. On the other hand, there are whole architectures supporting the affective game design [25, 11].

3 Affective Game Design Patterns

My account as a researcher is situated somewhere in between modelling the player's affect and affective design framework. Coming from William James' theory of emotion [10] with Jesse Prinz's refinement [20], my team and I take a closer look on *game design patterns* [2]. We assume that a set of patterns for evoking emotional responses of the player can be distinguished, and coupled with patterns of physiological reactions of this player. Using non-intrusive sensory devices: Empatica E4 [1] and Microsoft Band 2 wristbands2 [2], as well as BITalino [3] and e-Health [4] platforms for biometric measurements, together with a simple platform game (designed specifically for research purposes, with the affective design patterns in mind, see Figure 1), we are now conducting experiments in order to test our hypothesis.

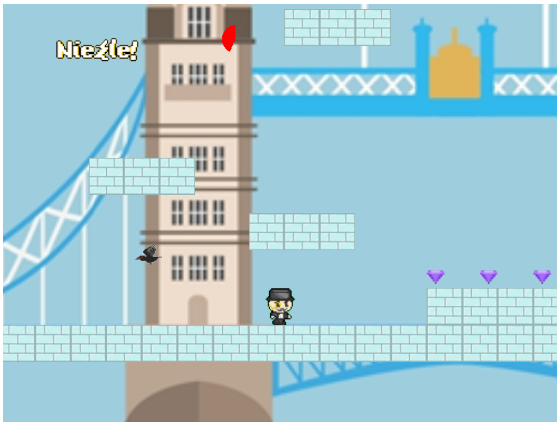

Fig. 1. A screenshot from "London Bridge", the game that was used in the discussed studies (developed with Game Maker Studio).

3.1 Method

The procedure now consists of three separate phases. Throughout the whole time of the experiment, the subject is wearing one or several of the aforementioned pieces of hardware and is seated in front of the laptop (see Figure 2). The wristbands are paired via Bluetooth with our custom smartphone app for data recording. In the beginning and between each of the phases, there is a 30-second period of inactivity, for acquiring a baseline for signals of each participant. In the first part, the task is to evaluate subjectively felt arousal in reaction to the briefly presented stimuli from Nencki Affective Picture System [13]. This steps serves as a calibration phase, to address the problem of individual differences and acquire data for developing personalized biosignals patterns. Next, the participant plays the platform game for several minutes. The affective patterns present in the game design are, among others, the Time Limit and randomly spawning Enemies. This is where the timestamps of each game event related to specific design pattern are recorder, to be included in further analysis in the light of possible correlations

[1] `https://www.empatica.com/research/e4/`
[2] `https://www.microsoft.com/en-us/band`
[3] `http://bitalino.com/en/`
[4] `http://www.my-signals.com/`

with physiological responses. In the last phase, the participant is looking at a relaxing picture, when suddenly, after roughly 50 seconds, an unpleasant sound is played – a terrified scream of a woman. Here, readings of a strong affective reaction to an unexpected stimuli are acquired.

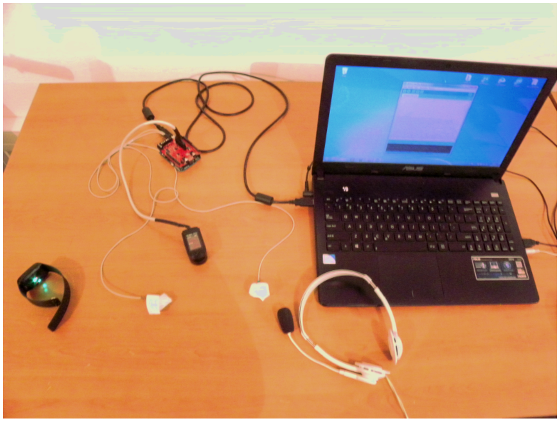

Fig. 2. Experimental setup, including of e-Health's GSR electrodes and pulsioximeter for HR readings, as well as Empatica E4 wristband. In the latest studies conducted, either one of the e-Health of Bitalino platforms were used.

3.2 Results and Discussion

So far, several studies have already taken place. From each of the experiments conducted, readings of participant's HR and GSR responses from each of the three phases were recorded and stored in CSV files. Additionally, timestamps of each time a visual stimuli or affective event occurred are kept in separate files, for each individual. In April 2017, only the calibration phase was conducted, with participation of 6 subjects, in Eurokreator Lab in Cracow. This first attempt allowed to verify that pictures with higher arousal values are reacted to with stronger affective responses, as indicated by increased participants' HR and GSR measurements. Tentative findings of the first experiment have been described and published in [15]. Second experiment in June 2017 included both calibration phase and gaming phase, with 9 participants – AGH UST students.

In order to test the reliability of our experimental setup and explore other possible directions of applicable hardware, experiments conducted in January 2018 and March 2018 were aided with e-Health and BITalino sensory platforms. Moreover, in January we also used Neurobit Optima equipment, a reputable system intended for neurofeedback and biofeedback training, as a reference device. That time, all three phases (including the last one, with the audio stimuli) were conveyed. 107 AGH UST students in total took part in the experiment. In brief, as a result of those two studies we have confirmed that e-Health and BITalino provide best HR and GSR measurements. However, in the future other forms of sensors need to be considered, as fingertip-attached electrodes significantly disrupt the player's comfort. This should not pose that much of a challenge, though, as for example BITalino sends the acquired readings using Bluetooth, so the sensors can be compressed into 3D printed wristband.

Close examination of data in search of specific correlations are still in progress, but nevertheless some observations can be made. Our studies indicate that Empatica E4 wristband and BITalino platform may serve as reliable biometric measuring platforms for AfC purposes. Whether they can be successfully applied to games with affective loop, so that our requirements for non-invasiveness and undisturbed gaming experience are satisfied, is still to be determined. We also confirmed that out custom application for recording data from the wristbands works impeccably, and is a useful asset for further studies. On the other hand, unfortunately we had to withdraw from further using the Microsoft Band 2 wristband due to its poor raw data quality.

4 Conclusion

Modern technologies are becoming increasingly pervasive in everyday life. Interaction between human and computer has rightfully received much attention within previous decades, but nevertheless there is still much to be done. Affect-aware systems, though already studied and developed, are rather crude and are facing a lot of difficulties. The need for new methodologies and frameworks for implementing AfC into existing and new applications is evident. One of the areas in need of such concern is video game development.

As for future objectives, we aim at creating a new game, this time with an affective loop incorporated, and with respect to the conclusions from the analysis of our previous studies. We predict that the outcomes of our research will have a significant impact on the how the affective dimension of games is designed. This will be beneficial both for video games as an entertainment industry, and as a medium for tutoring and therapy. Realistic emotional behavior of in-game characters together with accurate player affect models will undoubtedly raise credibility of NPCs and make players more engaged in the experience, hence increasing educational value [8] and effectiveness of various psychological treatments [7, 4].

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