Emotional Journey for an Emotion Provoking Cycling Exergame

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***Abstract*— In this work we present a novel concept for affective entertainment, which we call Emotional Journey. It provides a dynamic and adaptive story path based on a player's emotional responses and yields improved accurate recognition of the player's emotions. We conducted a case study with 25 players to evaluate our concept using our cycling exercise machine. We evaluated three different journey types and two of the three types were recognized reliably by the participants. We introduce a real time multimodal analysis method for facial expressions and electrodermal activity (EDA) measurements. This method results in significantly more robust emotion recognition rates. Therefore our exergaming system is able to provoke emotions and adapt the game play to individual emotional reactions.**

Keywords-exergame; affective gaming; multimodal emotion analysis;

I. Introduction

The field of entertainment computing advances with both content and technology to produce continually new user experiences and products. This sustained development drives the industry and creates new applications in areas including health care, learning systems and video games. The area of video gaming has long developed beyond linear storylines and static experiences using open world, nonlinear game designs and action-based character development. Modern games focus on individual and evolving narratives. Over the last decade the field of affective gaming has matured and demonstrated the physiological and behavioral effects in many commercial games [3]. Our direction is to build and investigate custom games and design emotion provoking elements. The proposed new concept of the *Emotional Journey* aims to modify the character development based on emotion responses in addition to the action-based modifiers. The term *Emotional Journey* may be found in the areas of therapy, motivational and design methods. Our use of this term is only loosely related, since we apply it to entertainment computing and game design. The Journey we envision as the emotional path a player, participant or user takes during the entertainment.

Other relevant application areas are learning or training systems, where an optimal and sustained activity is one of the great challenges for a successful automated system [6, 11]. Adaptive systems may find the optimal challenge level to enable fast progress for learning [1] and training without the pitfalls of under and over exertion based on performance.

In this work we introduce an affective entertainment application, which is able to provoke specific emotions by crafted game elements. In a case study we have shown that the system is able to take participants on an *Emotional Journey* by adapting to individual emotional responses. Furthermore the designed system is a physical cycling exergame (a portmanteau of "exercise" and "gaming") and it requires physical effort in order to progress the video game. Including physical effort allows both to increase motivation by entertaining aspects [11] and ease the transfer of findings in the health care training domain. Entertainment is able to enhance exercise endurance and can support the personal fitness program. This work is a first step towards a personalized adaptive entertaining fitness companion. Since emotions provide an interesting hook to alter: perception, memorization and engagement. Future games and applications will adapt their behavior and narrative to personal preferences.

II. Background

Interactive games enhances the experience of general exercises, which has been shown by Warbuton et al. [17]. Furthermore Biddle et al. [16] linked physical activity to mood and emotion and Lathia et al. [9] to happiness. In this work we present an exergame system, which is able to provoke specific emotions and take users on an *Emotional Journey*.

Gilleade et al. [5] described the importance of investigating user frustration in the design of video games.

in Proceedings: IEEE 4th Intl. Conference on Soft Computing & Machine Intelligence (ISCMI 2017)

Furthermore affective learning systems can be enhanced by an adequate reaction to students' frustration to increase motivation and improve learning gains, since it has been shown that affective states influences learning outcomes [6]. As a part of the *Emotional Journey* we crafted challenging game scenes with the aim to provoke frustration to evaluate the frustration recognition with facial expression recognition and physiological data.

A common used technique of affective games is to alter the game difficulty in relation to the recognized emotions [8]. Negini et al. [14] for instance used galvanic skin response to increase or decrease game difficulty. Additionally Parnandi et al. [15] introduced a game, that is adaptive to electrodermal activity (EDA) signals. In this paper we enhanced our exergame system to be able to adapt the game play in more complex ways and provide an emotional adaptive system to maintain a previously defined path through emotional reactions, in form of an *Emotional Journey*.

In this work we present a platform concept for experiments to evaluate individual emotional reactions, personal behavior or fitness conditions. Additionally we conducted a case study with 25 participants, in which we provoke specific emotions by crafted game elements. The game play is adaptive to the recognized emotions from facial expression and physiological data analysis.

III. EMOTION PROVOKING CYCLING EXERGAME SYSTEM

Our emotion sensors consist of a Microsoft Kinect v2 camera recording facial expressions, activity sensors in the bike controller and a physiological measurement system. The wearable sensing platform biosignalsplux provides the electrodermal activity (EDA). It operates at a sampling rate of 256Hz. The EDA sensor aquires a range of 0-25µS. For data recording all client computers are loosely coupled by using a message broker. A JSON-based protocol ensures the ability to log and replay all events. The physical setup of the emotion provoking exergame system is shown in Fig. 1.

The Kinect camera is placed in front of the bicycle ergometer to record facial expressions. Our emotion provoking game is presented on a display in front of the bike. The physical cycling exergame controller a daum electronic premium8i has been enhanced by a rotatable handlebar to allow steering control of a virtual bicycle in the designed game. In addition, the game controls the physical pedal resistance in order to provide feedback, in case the virtual bicycle has to climb a virtual mountain. Furthermore we enhanced the exercise machine with a 7-Speed Shifter (shimano sl-tx50-7r) and brake controller. Both evaluated by rotary potentiometers. Our video game is designed as a fun racer and the speed of pedaling rpm is transferred into the game. Our chosen genre enables to convey a variety of interesting stories. To demonstrate and prove our concept, our exergame has been enhanced to provoke three different emotions.

Crafted scenes steer participants in controlled emotional states for experimental purposes. In the beginning of our experiment, the virtual bicycle is placed in a tunnel, which acts as a starting and ending portal to transition between scenes.

Three scenes introduced in previous works [13] are fixed for every participant: the **Night Scene**, the **Challenge Scene** and the **Teddy Scene**. These three scenes have been shown to be emotional provoking.

In this work three additional scenes are introduced in case a provocation did not work as expected to ensure the *Emotional Journey*: the **Explosion Scene**, the **Downhill Scene** and the **Glade Scene**.

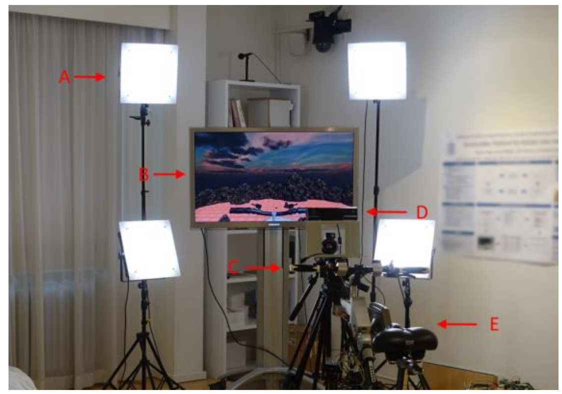

Figure 1: System Setup. A: Face Illumination, B: Display, C: Handlebar and Brake, D: Camera,
E: Physical Exergame Controller

A. Established Scenes

In the **Night Scene** the virtual bicycle is placed in a dark forest, which has to be crossed to reach the finish line. Self-illuminated coins are placed on the path to guide the participant through the dark environment. During the ride, the *Jump Scare Event* in form of zombies and shocking sound are triggered. During the ride through the **Challenge Scene** the bicycle needs to cross a booster gate to reach a sufficient speed to jump over a giant gap. The game design allows to attract or repel the player from landing on the other side, on which the goal is placed. For the player this effect is not obvious and the *Falling Event* occurs repeatedly, since when the player falls down the cliff the scene starts again. In the **Teddy Scene,** roaming teddy bears are crossing on a random path the street to the finish line. The teddy bears are very cute and it is challenging to avoid them due to their quantity. In case the bicycle hits a teddy, the teddy explodes with a bloody animation before he falls to the ground where his body remains.

B. Additional Scenes

The environment of the **Explosion Scene**, shown in Fig. 2a, is a desert containing military equipment, which suggests a war battle field. During the ride through the scene the *Explosion Event* is triggered with a very loud sound. If the virtual bicycle is located too close to the explosion center the player dies and has to start again.

Figure 2: Explosion (a) and Downhill Scene (b)

The **Downhill Scene**, shown in Fig. 2b, starts on top of a mountain and a narrow ramp is the only way down to the finish. At the end of the ramp a sharp curve without railings needs to be overcome. If the player leaves the path the virtual bicycle falls into lava, the *Player Died Event* is triggered and the scene starts again. It is difficult to make it to the finish, due to high speeds, sharp turn and disabled brakes in this scene.

In the **Glade Scene** the virtual bicycle is placed in a very nice environment designed as a glade of a forest with many plants and trees. While riding through this enjoyable environment, the player encounters a funny big rabbit.

IV. EXPERIMENT

A. *Experimental Procedure*

At the beginning of each experiment, participants were informed about the aim of our case study and about their right to abort it at any time. Before the experiment started participants were asked to fill out questionnaires about personal information, health condition, fitness level and game experience. The electrodermal activity (EDA) sensor was placed on the index and middle finger of the left hand, as described by Boucsein [2].

The journey started and ended with the assessment of the emotional and physical condition of the participants. Since every scene starts and ends in a tunnel it is our chosen place for emotion assessment. The retrospection of the perceived emotion is hence very short for the participants. During the whole procedure an independent observer was present to assess the emotions of the participants. Furthermore the observer may be perceived as a judge by the user during challenging tasks and Dickerson and Kemeny [4] have shown that social-evaluative threats are perceived as stressful. After each mandatory scene an emotion analysis was proceeded. The aim of the adaptation was to increase the successful provocation rate. In case the expected emotion was not recognized, an additional scene was started to increase the probability of a successful provocation. Thus the system allows adapting to individual emotional responses and behavior.

B. *Participants Profile*

Fifteen female and ten male persons participated in the presented case study. Their age ranged from 18 to 51 years with a mean of 29. Nine of them indicated to play video games at least two hours per week.

C. *Analysis*

In a previous work we proposed a method for facial expression analysis in cycling exergames. Thus we analyzed our data according our developed procedure [13]. In this work we applied for facial expression recognition Emotient from Imotions (https://imotions.com/emotient/). It provides the recognition of: joy, anger, surprise, fear, contempt, sadness, disgust, confusion and frustration. Furthermore it provides real-time availability in contrast to its predecessor CERT [10]. Thereby we enhanced our analysis method by a near real-time emotion evaluation, which allows the system to adapt the gameplay dynamically. In another previous work we introduced a method for the analysis of physiological data in cycling exergames [12]. We applied this method and analyzed EDA peaks in the presented work as well .Thereby we found promising results as shown in Fig. 4. Thus our analysis method was refined by a real-time analysis of EDA data and FER to support an adaptive system control. Considering that for the recognition of challenging events, a combination of facial expression recognition and EDA responses is to prefer, while jump scare events can be recognized by EDA data only and joy can be detected by facial expressions only [12].

In this work we furthermore introduce and analyze three new crafted game scenes: The **Explosion Scene**, the **Downhill Scene** and the **Glade Scene**. We enhanced our physical exergame controller by a gearshift and brake controller, which facilitates more thrilling game elements, like the **Downhill Scene**. Furthermore we analyzed the introduced novel concept of an *Emotional Journey*, in which the game play was adapted to the participants' emotional reactions in addition to player actions.

D. *Experimental Results*

In our case study we analyzed facial expressions, actions and physiological data of 25 participants. For 23 subjects we have obtained stable results, while two participants have been very nervous during the process, which may have influenced their physiological reactions. Their EDA measurements were too high to measure with the applied sensors in some of the scenes and therefore we excluded those data from the analysis.

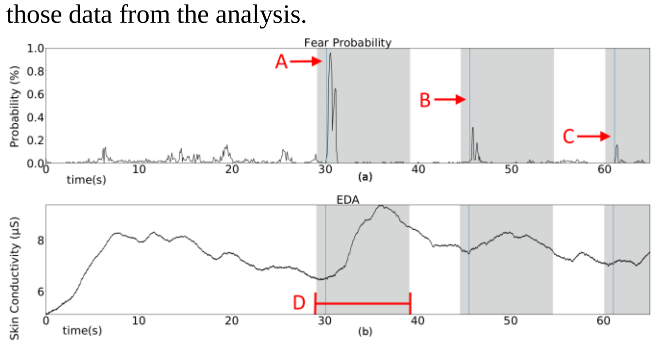

Figure 3: Typical time series for the Jump Scare Event in the Forest Scene. The data consist of a. the facial expression probability of fear and b. the skin conductivity (EDA) raw data. A, B, C: Jump Scare Event 1, 2, 3 D: Analysis Window

1) Surprise or Scare Scenes: The *Jump Scare Event* in the **Forest Scene** occurred two or three times per participant. We expected the first event to be perceived as the most scary, which is exactly what we found. Both analyzed modals show the highest rate at the first event: EDA 91,7% and the facial expression recognition of fear 62,5% or surprise 58,3%. For the second event the EDA based recognition reached only 75%. Fear could be found in 45,8% and surprise in 12,5% of the second occurrence of the *Jumps Scare Event.* Fig. 3 illustrates the decreasing effect of the repeating *Jump Scare Event* in fear probability.
The recognition of surprise is as acceptable as fear thus we applied a scene specific clustering as illustrated in Table I. The recognition rate could be enhanced to 75% for the first event and to 58,6% for all events.

TABLE I. OCCURENCE OF THREE SUBSEQUENT EVENTS BASED COMBINATION OF TWO FER CHANNEL IN THE FOREST SCENE, RECOGNITION RATES IN %

Event Occurrence	FER Surprise	FER Fear	Combined
1	58,3	62,5	75
2	12,5	45,8	50
3	13,63	50	50
All	28,6	52,9	58,6

For the same experimental scene, we combined the FER recognition with the EDA signal analysis, to further enhance the recognition rates. Table II shows that the recognition rate increased to 95,8% in the First and the Second subsequent event occurrences. The Third event could be recognized in 68,2% and thus the overall rate raised to 87,1%. Table II illustrates the beneficial effect of combining facial expression analysis and EDA peak detection. While the participant displayed surprise only for the First event, the EDA data showed peaks at the Second and the Third event as well. The small peaks of EDA data at the beginning might be related to the dark environment of the scene. In the **Explosion Scene** we found peaks in 76,1% of the triggered *Explosion Event*. Surprise was recognized in 12,7% and fear in 46,5% of the occurred events (n=71).

TABLE II. EVENT OCCURRENCE BASED COMBINATION OF THE TWO MODALITIES FER AND EDA IN THE FOREST SCENE, RECOGNITION RATES IN %

Event Occurrence	EDA	COMBINED FER / EDA
1	91,7	95,8
2	75,0	95,8
3	45,5	68,2
All	71,4	87,1

After the context specific clustering of fear and surprise the recognition rate of the FER modal increased to 47,9%, as shown in Table III. Table IV shows that the combination of the two modals FER and EDA raised the recognition rate to 78,9% for the *Explosion Event*.

TABLE III. SCENE SPECIFIC CLUSTERING OF FER CHANNELS FOR ALL SCENES, RECOGNITION RATES IN %

Scene	FER 1 Emotion	FER 2 Emotion	FER 1	FER 2	Combined FER 1/2
Forest	Fear	Surprise	52,9	28,6	58,6
Explosion	Fear	Surprise	46,5	12,7	47,9
Challenge	Frustration	Joy	24,7	90,6	95,3
Downhill	Frustration	Joy	30,6	84,7	86,7
Teddy	Joy		58,3		58,3
Glade	Joy		42,9		42,9

2) Challenge Scenes: During the **Challenge Scene** frustration is detected in 24,7% of the *Falling Events* (n= 85). With the notions that it has been shown that many people smile in frustrating situations [7]. We also analyzed joy, which was shown in 90,6% of the events. The scene specific clustering increased the recognition rate to 95,3%. The detection rate of EDA peaks was 84,7%. Additionally we found in previous works that combining FER with EDA data increase the recognition rate of frustrating exergaming events [12]. A combination with EDA raised the recognition rate in the presented work to 96,5%. Sample EDA raw data and FER frustration probability of the *Falling Events* in the **Challenge Scene** are illustrated in Fig. 4. In the **Downhill Scene** joy was found in 84,7% and frustration in 30,6% of the *Downhill Events* (n=98). The context specific clustering of both channels increased the number to 86,7%. The EDA peak detection rate was 80,6%. After integrating the EDA modality the recognition rate was 99%.

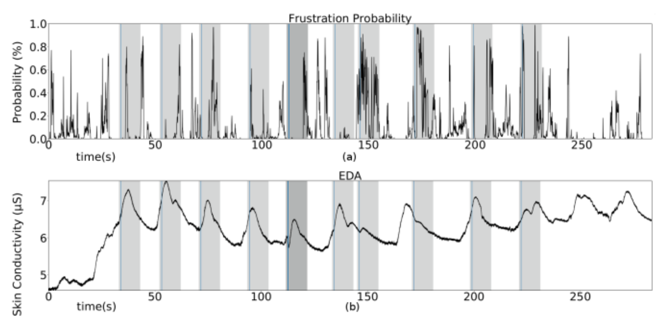

Figure 4: Typical time series for the Falling Event in the Challenge Scene. The data consist of a. the facial expression probability of frustration and b. the skin conductivity (EDA) raw data.

TABLE IV. TWO MODALITIES COMBINED FER AND EDA, RECOGNITION RATES IN %

Scene	FER	EDA	Combined FER / EDA
Forest	58,6	71,4	87,1
Explosion	47,9	76,1	78,9
Challenge	95,3	84,7	96,5
Downhill	86,7	80,6	99,0
Teddy	58,3	91,7	100
Glade	42,9	95,2	100

3) Joy Scenes: The detection rate for joy in the **Teddy Scene** was 58,3% and we found peaks in 91,7% of the EDA data analysis. The combination of both increased the number up to 100%. An interesting finding was the recognition rate of fear with 45,8%, since the scene is full of cute teddy bears. Similar results we found in the **Glade Scene**. The EDA data analysis showed peaks in 95,2%, while joy was detected in 42,9%. Combining both modalities increased the number to 100%. An interesting finding was that the participants stated that they were scared by the big rabbit because they expected harm, though we also analyzed the results of fear and we found a very high fear detection rate of 52,4%.

4) Emotional Journey: After the experiment the participants took part in several questionnaires concerning the game concept, their experience and a detailed self-assessment. In this qualitative analysis we evaluated the concept of the Emotional Journey with participants' ability to recognize and resonate the in-scene provocation. The participants' recognition rate of the designed Emotional Journey was 89,3%. In more detail the *Jump Scare Event* and the *Challenge Event* was recognized by 100%. The aim of the **Teddy Scene** and the **Glade Scene** was to provoke joy, which has been stated by 68%. This finding is interesting since the game elements has an opposite effect to the participants than expected. Many participants stated they apprehended danger from the allegedly funny rabbit.

V. CONCLUSION

In this work we introduced a novel concept for affective entertainment, the *Emotional Journey*. The *Emotional Journey* provides a dynamic and adaptive story path for a player based on emotional responses and leverages combined modalities to achieve improved accuracy of emotion recognition. We demonstrated this concept in a case study using a cycling exergame system. The empirical results showed a recognition rate of 100% for two of the three journey parts by the participants. The third part of the journey did not resonate with the subjects, hereby did not trigger the expected emotions.

Since the presented journey implies emotions like frustration, our findings are interesting for building emotional adaptive learning applications. Furthermore the presented exergaming concept allows studying motivational aspects due to its possibilities of enhancing exercise endurance and intensity.

We extended an exergame controller with a brake and gearshift to enable a more immersive and natural cycling game experience. Furthermore we applied our real time multimodal analysis method for facial expressions and EDA measurements. We found for the analyses, that combining different facial expressions and combining facial expressions with EDA output results in significantly more robust emotion recognition rates. We implemented and evaluated our multimodal emotion analysis within a virtual cycling simulation. Our cycling simulator contains six emotion provoking and parametrized signature scenes that are chained together resulting in a dynamic game experience. In our nonlinear gameplay concept individual emotional reactions can lead to different and individual experiences.

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