Modeling Player's Enjoyment in Video-Games Using Physiological Measurements

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***Abstract*—Analyses of user experience in electronic entertainment industry currently rely on self-reporting methods, such as surveys, ratings, focus group interviews, etc. We argue that self-reporting alone carries inherent problems - mainly the subject bias and interpretation difficulties - and therefore should not be used as a sole metric. To deal with this problem, we propose a possibility of creating a model of consumer experience based on psychophysiological measurements and describe how such model can be trained using machine learning methods. Models trained exclusively on real-time data produced by autonomic nervous system and involuntary physiological responses is not susceptible to subjective bias, misinterpretation and imprecision caused by the delay between the experience and the interview. This paper proposes a potentially promising direction for future research and presents an introductory analysis of available biological data sources, their relevance to user experience modeling and technical prerequisites for their collection. Multiple psychophysiological measurements (such as heart rate, electrodermal activity or respiratory activity) should be used in combination with self-reporting methods to prepare training sets for machine learning models.**

***Keywords*—User Experience, Enjoyment, Psychophysiological measurements, Electronic entertainment, Correlations, Time-series data**

I. Introduction

Electronic entertainment (EE), especially video-games, has undergone an extensive growth over the past decade. The global value of video-game industry is estimated to reach $120 billion by 2019 [1]. Yet the assessment of user experience in video-games is still done using old-fashioned self-report techniques, such as questionnaires and interviews.

We propose an approach to assessing player experience more effectively while eliminating some disadvantages of self-report techniques, such as untruthfulness or emotional bias.

Based on the assumption that psychophysiological measurements correlate with user experience, we suggest combining them with the player's self-reports to create machine learning-based model of the player's experience. Such model may help developers predict how players will react to particular in-game events in the future.

II. Problem domain

We feel that electronic entertainment development process might benefit largely from evaluating particular sections of the product (be it levels in video-games, or segments of movies) in a reliable way. As stated above, questionnaires in focus groups have several drawbacks regarding reliability, such as personal bias or untruthfulness of subjects. We propose a solution taking advantage of the autonomous nervous system (ANS), which functions automatically.

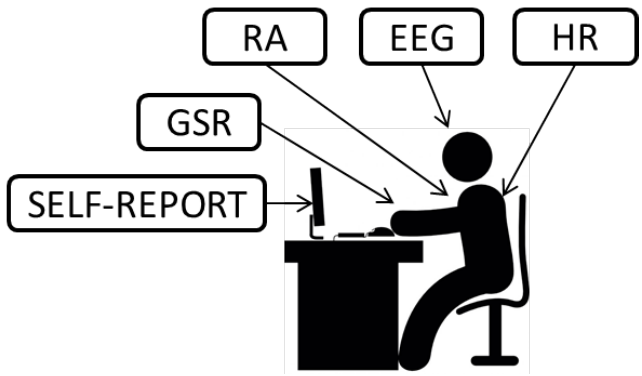

Fig. 1. List of measurements used in our experiments.

III. Psychophysiological Measurements

Any research method in which the dependent variable is a physiological measure and the independent variable is behavioral or mental (such as memory) is a psychophysiological method. Physiological measures take many forms and range from blood flow or neural activity in the brain to heart rate variability and eye movements. These measures can provide information about processes including emotion and cognition, as well as interactions between them. Physiological measures thus offer a very flexible set of tools for researchers to answer questions about behavior, cognition, and health [2]. All the measurements used in our research are parts of the human nervous system, more specifically the autonomic nervous system (ANS), which controls involuntary physiological responses. Measures controlled by the ANS function automatically - therefore, they can not be affected or controlled consciously, which reduces the risk of unsuccessful experiments or imprecise results. We believe that a combination of traditional techniques with psychophysiological measurements will provide a reliable insight into player experience. In our research, we collect precisely 10 sets of physiological data using 3 sensors:

1) **Heart Rate + Heart Rate Amplitude** is a measure of cardiovascular activity which reflects emotional state.
2) **Respiration Rate + Respiration Amplitude** is measured as the rate of volume at which an individual exchanges air in their lungs.

3) **Electrodermal Activity (EDA) - Resistance & Conductance** measures the activity of the eccrine sweat glands and is said to correlate linearly to arousal [3].
4) **Electroencephalography (EEG) - Attention & Meditation** provides data about the brain's electrical activity with millisecond accuracy.

In addition, we measure subject's physical activity and blinking frequency per minute during the experiments.

IV. Methods

In order to determine an overall experience of the subject we need to be able to model relations between changes in psychophysiological measures and the subject's emotional states. Our experiments produce simple time-series data (see Fig. 2) which should prove straight-forward in order to model such relations. Furthermore, possibility of previous states affecting subjects' present emotional state procure the need to take these into account. This means using methods that are able to take such specifics into account, such as:

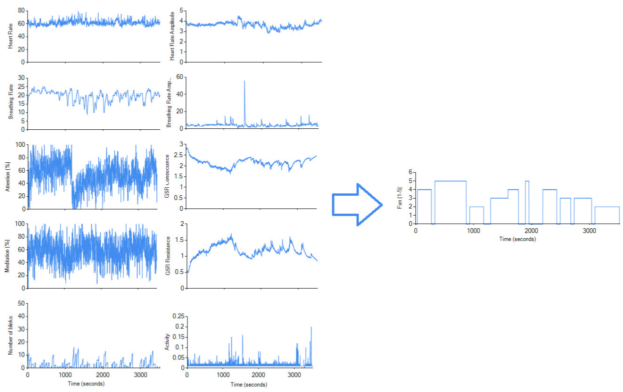

Fig. 2. Data from one of our experiments, with enjoyment data added.

1) **LSTM Neural Network** should be able to exploit possible dependencies of consecutive PPM values in our data [4].
2) **Hidden Markov Model** may provide some hidden (unobservable) patterns in time-series data we will gather during the experiments [5].
3) **Random Forest** should allow us to extract knowledge from successfully trained model represented in rules [6].

After collecting the data from sensors, subject participates in an interview, labeling his enjoyment level throughout the session on the scale from 1 to 5 (see Fig. 2).

V. Proposed Apparatus

The apparatus our experiments consists of a simple setup: We use a Bioharness[1] sensor for measuring heart rate, respiratory and activity data (5 features). Measuring EDA (GSR) is done using fingertip-worn, low-cost sensor combined with Arduino. Additionally, we measure EEG data in combination with blinking rate of the subjects using NeuroSky Mindwave[2] sensor and capture both the subject's screen and video of the subject during the experiments. Screen capturing in combination with video recording is necessary in said interview, to label particular times of session based on subject's enjoyment level. These enjoyment data pose as a key feature for our model.

[1] http://www.zephyranywhere.com
[2] http://neurosky.com/

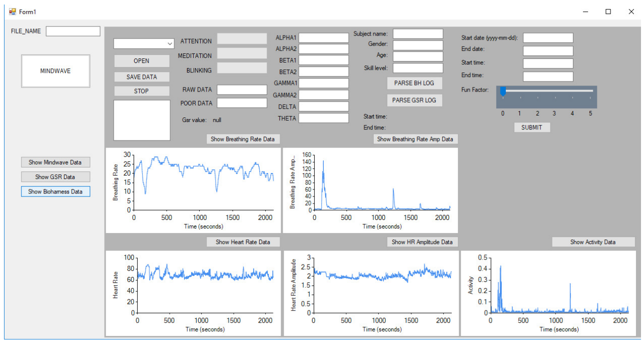

Fig. 3. Software for physiological data collection.

VI. Experiments & Future Work

We have already published results of some initial experiments that have been done in our research [7],[8]. These experiments were done using simpler version of setup than the one described in this paper (measuring only heart rate of one subject during approximately 20 hours of Dota 2 gameplay). Several interesting patterns were exposed, concerning both game-specific events as well as overall useful facts about the measurements. We repeatedly detected increased HR in specific game situations (deciding fights, first contact with opponent) or decreased HR in times subject waited for his character to respawn after death. However, as stated in Sec. I, for successful training of fun factor model, simply measuring psychophysiological states of subject is not sufficient.

Later, we conducted new set of experiments using the described apparatus, measuring 10 physiological signals shown in figure 2. Up until this point, 10 subjects have participated. We plan to conduct another 20-30 experiments before applying described machine learning methods on collected data. As stated in III, to create the model, we have to rely initially on the said questionnaires and interviews. With this information, experiments will pose as a training set for our model, with the goal to predict the enjoyment of players in the future.

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