

Serious Games Evaluation Using Eye-tracking and Affective Computing Techniques

Case Study of OSH Training Course

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Abstract—The aim of this paper is to provide theoretical and empirical assumptions of framework for evaluation of serious games. When it comes to games, whose main purpose is to train and educate, the category of “fun” is often overlooked, while the category of “education” is interpreted as “teaching how to win the game” instead of “teaching the right decision-making practice”. However, in our opinion “fun” is crucial for the success of the whole educational process. “Fun”, being a kind of user experience is a sum of player’s affects and engagement, and only the properly constructed gameplay can ensure didactic success. In our considerations, we propose pattern and DPE – based (Design, Play, Experience) model for describing and designing games enhanced by eye-tracking methods for analysis of the player’s decision-making process and affective computing techniques of evaluating player’s engagement. A preliminary case study of simple Occupational Safety and Health (OSH) training game is presented. The ultimate goal is to construct additional – affective – patterns that will ensure designer’s way to fully satisfy player’s experience in a serious play that will lead him to acquire the essential skills, from the training point of view.

Keywords—*Serious games design, Education process, Decision-making, OSH training, Evaluation methods, Eye-tracking system, Affective computing.*

I. INTRODUCTION

The aim of this study is to provide insight into serious games evaluation methods using eye-tracking and affective computing techniques.

A. Motivation

The contributed model was used to test Polish academic web browser based on OSH game entitled “Janek w opałach” (“Johnny in Distress”). We believe that it is possible to examine reception of any videogame (particularly serious) by using proper framework and tools, which provide helpful, physiological metrics of player’s concentration, perception and commitment (immersion) in the presented game world. The project is now in the course of implementation at Jagiellonian University’s Department of Games Technology. The first obtained results encourage further research.

In Section I, the problem is presented and key concepts are described. Section II is devoted to presentation of state of the art in the discipline of affective computing. Section

III is dedicated to considerate methodology of performed investigation. The last Section shows preliminary results of the conducted study.

B. Serious Games

In the book “Serious Games”, the authors D. Michael and S. Chen state: “A serious game is a game in which education (in its various form) is the primary goal rather than entertainment” [10]. The most important fact about the serious games is that pursuing “serious” purposes (most often – as in the quoted definition – educational, but also therapeutic and others) they remain all the time games – so belong to the field of pleasurable activities. Numerous studies point to the fact, that the entertainment factor – fun – has a very positive impact on the participants’ attitude to exercise, but also on the ‘breaking’ cognitive barriers to educational or therapeutic processes [2][3][4][5]. In this way, serious games are not only edutainment (the knowledge given in an attractive form), but represent something qualitatively different, an alternative form of interaction, which use brings important benefits to the user. Regardless their unique properties, serious games remain games. That means general rules governing their design and creation remain similar as in the case of “normal” games, designed for entertainment purposes only.

C. Games and Game Systems

In fact there is no good definition of game or game system. For every possible characterization, there could be a counterexample provided. In the context of affective serious games the important thing is that they are systems that have mechanics. They can be defined after M. Sicart as “methods invoked by agents to interact with game states” [9] or mention Bjork’s and Holopainen’s component framework for game systems that contains components such as “boundary” (Rules, Modes, Goals), “holistic” (Game Instance, Game Session, Play Session, Extra-Game Activities), “temporal” (Actions, Events, Closures, End Conditions, Evaluation Functions), and “structural” (Interface, Game Elements, Players, Game Facilitator, Game Time). The elements of this system provide the player with opportunity to interact with the game, overcome given obstacles and achieve goals are mechanics. Mechanics regulate gameplay and therefore are crucial elements of the whole system. Operating mechanics is also the main, distinctive source of players “fun”.

D. Patterns in Game Design

Patterns are recurring themes that occur through the game's mechanics. Authors of the book "Patterns in Game Design" [1] perceive them as "a language for talking about gameplay" where "each pattern describes a part of the interaction possible in games, and together with other patterns they describe the possible gameplay in the game". In this framework, the provided patterns are presented through their consequences, relations and references to the gameplay. Combining different mechanics is expected to lead to the formation of emergent entitiveness

E. Serious Games Design

A popular way to represent the educational objectives is Bloom's Taxonomy. It locates the results of teaching in three areas: cognitive, psychomotoric and affective. A common way to analyze games is an MDA (Mechanics, Dynamics, Aesthetics) framework that takes into account Mechanics, Design and Aesthetic features of the entertainment systems. We would like to use its expansion – DPE (Design, Play, Experience) point of view (see [11] for more information). The basic element in the process of designing serious game is already discussed in "fun" category, as a factor characteristic of the games, yet critical to the educational or therapeutic processes. In paper, we would like to present an approach to design and evaluate affective video games that allow the player to capture (create metrics) the "fun" category for the design improvement iterations purposes.

F. Affective Patterns

The ultimate goal of work is to propose the inclusion of the concept of patterns to DPE framework and a tool for describing mechanics responsible for the "fun" factor in the games. Affective patterns would be "building blocks" from which emotional interactions with the user can be built in order to increase his/her involvement and ultimately control motivation and achieve educational and therapeutic effects.

II. STATE OF THE ART

Evaluation of games using data obtained from various sensors and trackers is very fast growing area of computer science.

A. Affective Computing

In her paradigm-establishing book, Rosalind Picard states that "affective computing is the study and development of systems and devices that can recognize, interpret, process and simulate human affects" [7]. The author of the mentioned book believes that including emotional factors in information processing systems can significantly enrich their capabilities. This can occur wherever important factors are correlated with human-computer interaction or decision making.

Within presentation the main focus are systems that recognize emotions and – to some extent – are able to react to them for the needs of creation of serious games and simulations. Intriguing and extensive subject of systems built to emulate "possession" of emotion is not the subject of our interest.

In order to build affective systems, the first thing to do would be to define affective states. This is not an easy task, but only the proper model of emotions will give possibility to set difference between emotional states, which is a crucial operation. Classification scheme needs to be developed that uses specific features from input signals to recognize user emotions.

The research involves use of biosensors (wearables) and specially treated data obtained from standard controllers (like high-resolution mouse, gamepad or motion cameras). The possibilities also include using features such as facial/gesture/pose recognition, speech/voice processing and many others. The need for theory becomes obvious after collecting any preliminary data. In common literature there is a multitude of proposals (i.e. theories by James-Lange, Canon-Bard, Schachter-Singer, etc.). Among numerous available options the James-Lange based appraisal theory by Jesse Prinz [7] was chosen. This bottom-up concept stating that basic bodily reaction is (rather) result of non-cognitive processes allows for sensible amount of intentionality in somatic feedback theory.

B. Eye-tracking

Eye-tracking is more and more often used in games, especially as a controlling device, but also as a researcher's tool for game analysis. Eye-tracker as an evaluation tool was also used in discussed inquiries to investigate the visual search patterns and heat maps describing the main area of interest on the screen [12][13]. Examinations were conducted with use of eye-tracking device to analyze search tasks [14] and measure information acquisition in educational game [18]. Due to their close relation to attentional mechanisms, eye-tracking examination can be used while analyzing the cognitive processes such as language comprehension, memory, mental imagery and decision making [16], especially for decisions based on the choice among a countable set of alternatives

III. METHODOLOGY

The main element that must be taken into consideration while designing a (serious) game is mechanics.

A. Pattern framework and DPE

In the study, they have already been considered (after Sicart, see: [9]) as elements that player can interact with in order to change state of the system, as such mechanics are main game-shaping elements. First thing to do when analyzing "Janek w opalach" would be to extract main design patterns that govern the play. It can be done through application of Bjork's and Holopainen's aforementioned framework (see: [1]). The most obvious selection includes patterns such as: Avatars,

Buttons, Clues, Collecting, Controllers, Delayed Effects, Early Elimination, Exploration, Direct Information, Indirect Information, Extra-Game Information, Game State, Overview, Guard, Helpers, Irreversible Actions, Rescue and Survive. Conducted inquiry also showed presence of some misused patterns, such as: Tension, Identification, Illusion of Influence, Emotional Immersion, Consistent Reality Logic. The detailed description of patterns and their relations and consequences is presented in [1].

Reconstructed gameplay overview can be interpreted in relation to DPE (Design, Play, Experience) model. It focuses on user experience seen as individual player’s game story, with accompanying affects and resulting engagement. These phenomena are associated with designer’s practice (prepared story, mechanics, user interface) and particular course of play (resulting in storytelling, dynamics – “mechanics in motion” and interactivity). When the components are duly assembled, the result can be overall experience of “fun” (see Figure 1).

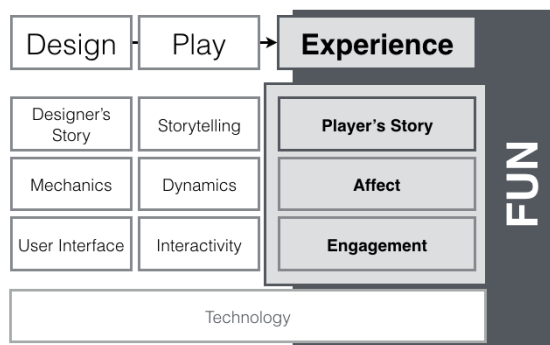


Figure 1: Design, Play, Experience model.

B. Biosensors

In the conducted preliminary experiments, various biosensor platforms such as: Empatica E4 (Developed in the Affective Computing Lab at MIT), e-Health Sensor Platform (Arduino/Raspberry-Pi shield developed by Cooking Hacks) and Microsoft Band 2 (popular fitness tracker) armed with custom made software, were used. In the paper, the results obtained with MSB2 are presented. As it is unspecialized equipment for everyday use and the long-term goal of research is to create a solution that allows obtaining feedback loop by the end users with their own equipment. Collected information were about GSR (Galvanic Skin Response) and HR (Heart Rate).

C. Eye-tracking

The approach presented in this paper is based on the dependence between the gaze direction immediately before making decision and player’s strategy. Researchers agree [17], that users have a tendency to shift their attention more towards alternatives they subjectively perceive as being attractive and thus consider to choose. In the case of serious game, the choice

is not as obvious as in the multiple-choice tasks, but every time the decision is connected with the hint visible on the screen.

Efficiency of the training can be measured using category of decision made on the base of elements of the game connected to the two game patterns featured in [1] (p. 141): “direct information pattern” (DIP) and “indirect information pattern” (IIP - see Figure 2). The first pattern is connected with gathering information about the game state from the elements connected to the game interface and game control elements. The second means collecting knowledge while interacting with others in the game and speculate using deductive or inductive reasoning. Decisions made in the game on the basis of DIP are useless in the real word situation, because of the lack of game interface indicators in the real emergency situation. Decision made on the basis of IIP shows player skills and knowledge translatable to the real

The goal of the paper is to show the repeatable eye movement schemas and correlate them with the cognitive process of making choices and making decisions to investigate efficiency of the training.



Figure 2: Game scene with indicated DIP (red line) and IIP (blue line).



Figure 3: Emergency exit sign used in the game.

From the long list of decision-making situations the one was chosen by researchers and presented below: problem of perception of emergency signs (presented in Figure 3) in decision-making process. The reasons making this example representative to the general problem of serious games are:

- The game situation is relevant to the real world problem: way choosing to escape the building,

- the problem is crucial from the OSH point of view and represents the core of the training,
- there are two types of hints visible in the screen during the decision making process: one connected with pattern “direct information” and the second connected with “indirect information”,
- the scene of the game during the process of decision making is immovable, so both gaze plot and heat maps are available.

IV. PRELIMINARY RESULTS

The research was based on the serious game, based on Occupational Safety and Health (OSH).

A. Case study

In this case aim of the player is to find the way out of the burning campus building. The game has been used at Jagiellonian University, as a part of the OSH training course for students and staff since 2008. The game view is in isometric perspective. The game is rather an ordinary representation of the “adventure game” genre with no time pressure or arcade skills required. The main task of the player is to navigate the areas and safety regulations related to decision-making.

Data was collected from 30 voluntary participants (students of the Jagiellonian University) during the sessions of gameplay. The used equipment was: The Eye Tribe (specification in [15]) – for eye tracking and Microsoft Band 2 for bio-signals (GSR, HR). After finishing the game (usually after 10-15 minutes), the participants were asked to fill custom made questionnaires with two one-dimensional axis (Was experience “unpleasant – neutral – pleasant” and “boring – neutral – fascinating”). The questionnaire also included the “cloud” text with emotional keywords, where participants could mark expressions describing their feelings about the game (i.e. sadness, joy, rage, fear...).

B. Results

Both the eye tracking and affective preliminary data seem to suggest the grouping pattern which can be a base to make the general picture of “Janek w opalach” as a serious game. Although the presentation of the full result will need to be confirmed in additional studies.

In the category of “decision-making” there was one problem taken into consideration: choice of the direction to get out of the building. There were two types of hints, each connected with one game pattern. For OSH training, the essential part is the decision made on the basis of “indirect information pattern”.

The results were unexpected and worrying. This educational game does not teach users to pay attention to emergency signs during the evacuation from fire, as there are very attention-grabbing yellow arrows showing possible movement on the stage (elements of Heads Up Display, not the scenery) and they were the only noticeable tips. In 90 percent cases, the

players chose the one of the top-left yellow arrow. No one gave a single look to emergency signs.

In the category of “fun”, the general attitude to the game was taken into consideration. The second problem was that game was generally considered very dull. In participants’ reports, most of them marked “neutral” on “pleasant-unpleasant” axis and “neutral” to “boring” on “arousal” axis. Greater part of respondents did not choose any keywords from the “affective cloud” or chose “irritation”. It can be observed on averaged graphs showing trends in changes in GSR and HR (see Figure 4 and Figure 5). Note: there are no markers of concrete values or precise timeline on graphs on purpose – the core interest were changes in tendencies, attaching to specific numbers obtained with device of such low precision, as MSB2 can be delusive and lead to false conclusions.

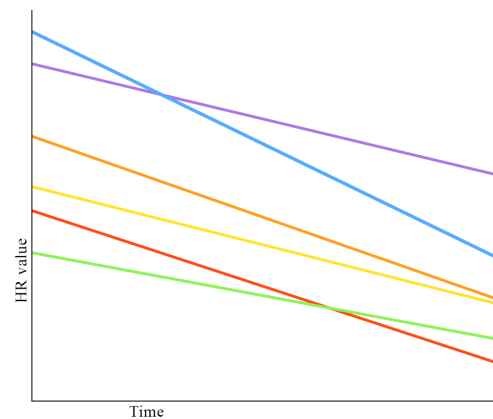


Figure 4: Averaged tendencies in changes in HR.

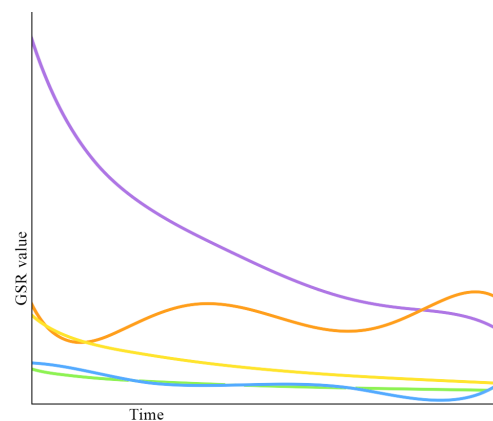


Figure 5: Averaged tendencies in changes in GSR.

V. CONCLUSION AND FUTURE WORK

We believe that above results should be taken into consideration while preparing “Janek w opalach 2.0”.

The authors would like to emphasize that presented tests are work in progress but we are confident that the combination of

affective computing techniques and eye-tracking is a promising direction of research on the evaluation of serious games. Another step is to prepare and conduct further study with more accurate custom-made sensors and dedicated application that will allow to examine gameplay variants.

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