Entertainment Computing 14 (2016) 1–13

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: ees.elsevier.com/entcom

Video game scenery analysis with eye tracking ☆

Samuel Almeida *, Óscar Mealha, Ana Veloso

Department of Communication & Art, University of Aveiro, Portugal

ARTICLE INFO

Article history:
Received 15 June 2012
Revised 13 October 2014
Accepted 30 December 2015
Available online 22 January 2016

Keywords:
Video game levels
Eye tracking
Player behavior
Gaming experience
Data representation and visualization

ABSTRACT

Information regarding player behavior can provide valuable insight for game development and evaluation purposes. In a game level, player behavior may shed light regarding several aspects of the overall design of the level. This paper presents a method proposal for player behavior analysis within a game level, based on interactive (player movement) and visual (eye movement) behavior data. The proposed method is demonstrated within a specific context, using a popular first-person shooter video game and a predefined group of players. The data collected during the demonstration was represented with an information visualization technique and is further discussed. The representation technique applied uses game level maps to represent areas that were explored by players with greater or less intensity. The concept of efficiency according to game/level designer and players is also discussed, considering collected data. With the results of this work and method proposal, game and level designers can better grasp how players visualize and interact with video game level scenery.

1. Introduction

Since video games emerged back in the 1950s [1], this new source of entertainment has strived to challenge and entertain its audience: video game players. In a video game context, adding barriers, difficulties or challenges in a game level that might somehow motivate/frustrate a player does not make it more/less efficient, but rather, is an important and even an expected element in measuring a game's playability. Furthermore, understanding players' attention towards essential gameplay elements of a level can also help measure a game's playability. In this sense, the concept of efficiency – typically associated to usability evaluation frameworks – must be revisited and validated in the context of video game analysis.

According to the ISO9241 (part 11 – Guidance on Usability Specifications and Measures) norm, the three usability measures – efficiency, effectiveness and satisfaction – must be analyzed in a specific context of use. Here, the relation of efficiency and effectiveness must be understood in the context of video games. The hypotheses of this work are sustained on the possibility that efficiency in video games can be analyzed according to two perspectives: the game/level designer's perspective and the player's perspective. In the first perspective (i) a game/level designer expects players to explore and use all the game features and sceneries essential to gameplay in order to attain optimal game experience in a specific game context. In the second perspective (ii) players can feel optimal game experience (complete satisfaction) [2] in a game context [3,4], without having explored the game scenery as a whole. For example, a mission in a specific game level can lead players to achieve the mission goals and game objectives without completely exploring the level scenery. In such a case, high game mission effectiveness can be related to low efficiency in exploring/using scenery and game elements conceptualized by game designers without loss of player's optimal game experience.

In addition, it is common for player input to be overlooked in game level efficiency questions. Rather, playability and gameplay analysis is regularly done through other game related methods [5–8]. Although there are some evaluation methods [9,10] that do consider player opinions, it cannot be guaranteed that the information they provide is genuine.

This work proposes a method for player behavior analysis within a game level, based on the direct registration of interactive (player movement) and visual (visual exploration) behavior data. Visual behavior in the game level is acquired with an eye tracker, a non-intrusive technology that measures the position of the *Point of Regard*[1] *(PoR)* of the player's eye in space. Eye tracking generates

☆ This paper has been recommended for acceptance by Matthias Rauterberg.

* Corresponding author at: Departamento de Comunicação e Arte, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Portugal. Tel.: +351 911 980 388.

E-mail addresses: sja@ua.pt (S. Almeida), oem@ua.pt (Ó. Mealha), aiv@ua.pt (A. Veloso).

[1] Point of Regard: The place in the (game) world where a subject is looking at or the orientation of the eye in space.

http://dx.doi.org/10.1016/j.entcom.2015.12.001
1875-9521/

quantitative data from user interaction and can be used to characterize usability or other game problems.

The proposed method was demonstrated in a specific context using a game level map from the popular First-Person shooter 'Call of Duty 4: Modern Warfare'. A focus group of 12 hardcore players played a game level map with specific objectives while their interactive and visual behavior was registered. This data was later represented using an information visualization technique for analysis purposes.

With the results of this work and proposed method, a greater understanding of how players interact and visualize game level scenery (within a defined context) is possible. For game level and art designers, the application of this method can help them better understand and analyze how players interact within their game level; they can understand if player interaction patterns are those that are expected, if players are moving through the level, interacting and visualizing game and level elements that are important to gameplay, which can ultimately define the quality of their gaming experience.

This paper is organized into four main sections. First, a conceptual framework that supports this study is explored, focusing on issues related to game evaluation and analysis, eye tracking, game levels and data representation and visualization. Second, the analysis method that was developed is described and then demonstrated in a specific study. Third, results acquired from the method demonstration are presented and discussed. Lastly, conclusions related to the validity of the method and final notes are presented.

2. Conceptual framework

2.1. Video game evaluation & analysis

Commonly, usability research is framed within the ISO 9241-11 standard which defines usability as the "*extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use*" [11]. Effectiveness deals with the accuracy in achieving a goal; efficiency is related to the resources used to complete a goal; satisfaction involves the user's attitude. However, this definition is normally associated to computer mediated services/applications or electronic products/devices.

Video games, on the other hand, present characteristics that make them unique. There is a general idea, supported by several authors [3,12] that video games are designed for enjoyment and to entertain players rather than to obtain maximum user efficiency in achieving goals. Consequently, these concepts must be analyzed through a different perspective. Federoff [8] characterizes 'efficiency' in games as "*expending the least amount of resources to complete an end goal*". Federoff explores the idea of users playing games to achieve a goal and, in the lack of challenges while playing, the game itself becomes boring. As a result, if players can complete their goals with few resources (great efficiency) and without great challenge, one can consider that the game failed to entertain. Another study explored the (game) usability question through a different perspective. Pinelle et al. [7] consider interaction as a key factor in video games and believe that usability is important. They define game usability as "*the degree to which a player is able to learn, control, and understand a game*" [7]. They also argument that even though video games and other products share usability issues, video games present usability questions uncommon in everyday products. For example, many video games are designed to include problems and challenges to lead the players to develop skills so that game objectives are completed with engagement. Despite differences between these perspectives, it is plausible to suggest that in certain contexts, a game with low efficiency can be an entertaining game; i.e. if a player has to explore more of the game (level) and use more resources, he can in fact have a more enjoying gaming experience. Ultimately, the relation between game efficiency and effectiveness depends on the objectives and overall design of a game.

To understand and evaluate these and other game related issues, video game developers rely on methods that can identify game problems in the beginning of the development stage or throughout the development process [10]. Methods like 'Playtesting', which are used throughout the design process to acquire information on how players are experiencing the game [13], require a playable prototype that may only be available in an advanced phase of the development process [7].

Usability inspection techniques, however, can assist in the game evaluation process. These techniques do not require user participation and can be used at various moments of the development process. According to several authors [7,14] when these techniques are carried out by trained evaluators, they are more *cost-friendly*, and can be accomplished with faster sessions. A 'Heuristic Evaluation' can be described as an informal method of usability analysis where a number of expert evaluators are presented with an interface design and asked to comment on it according to a list of guidelines [14]. Several authors [7,8,10,15,16] have focused on developing guidelines for video game development and evaluation. Their heuristics focuses on a variety of game issues such as engagement, fun and other game usability problems in general. Other empirical evaluation instruments such as '*TRUE – Tracking Real Time User Experience*' [9] can also be effective at uncovering usability issues. 'TRUE' combines the analysis of user initiated events (UIE) – gameplay metrics – with other HCI methods. Kim et al. [9] elaborate on the value of logging UIE (e.g. number of errors) and other data so that errors can be analyzed. This approach results in a greater understanding of how users experience products, games included. The use of metrics has also been applied in other game studies [17,18] focused on understanding gameplay behavior.

2.2. Eye tracking in video games

Despite the value and potential of the referred studies, some of which deal with game level questions; none of the studies explore evaluation or analysis options to achieve a better understanding of exactly how players interact or move within game levels. This information is important in understanding if players are interacting with gameplay elements embedded into the level that might be of importance for successful gameplay. Furthermore, none have explored the possibility and value of an additional quantitative dimension, directly related to a player: eye movement. The tracking of eye movement – eye tracking – can be defined as "*a technique where (...) eye movements are measured so that the researcher knows both where a person is looking at any given time and the sequence in which their eyes are shifting from one location to another*" [19].

Current research addressing eye tracking as a means of video game evaluation is limited [20,21]. Additionally, concerns regarding its limitations (e.g.: calibration difficulties, user-related limitations, precision inaccuracies) may have delayed its affirmation as an evaluation tool. However, modern eye tracking equipment is more efficient and provides an additional accurate non-intrusive recording of a person's eye movements, promoting research in diverse scientific areas [19,22–24].

Regarding video game evaluation with eye tracking studies, only El-Nasr and Yan [20] focus to some extent on issues related to the game level and scenery issue. El-Nasr and Yan state that understanding visual search patterns in three-dimensional environments could improve game and level design; secondly,