Realization of a full-body immersive VR system for READ-THE-GAME skill development

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ABSTRACT
In this paper we describe the required elements for the realization of a novel full-body Immersive Virtual Reality (VR) system, for estimating and training the ability to READ-THE-GAME of soccer players. By tracking the head rotation of the user with a Head Mounted Display (HMD), we measure the *Active Visual Exploratory Activity* (AVEA) of Amateur and Beginner soccer players, performing ball passing decisions to teammates under pressure from other rivals, and finally measuring the sense of *Presence* felt during the simulation. We analyze the Human Computer Interaction (HCI) components of our system, focusing on the user feedback for improving the VR training experience. We conclude that full body interaction achieved with kinetic mapping controller provides a better option for achieving full-body immersive VR AVEA training, and elements such as audio and form of interactivity further enhance the VR training experience.

Author Keywords
Virtual reality; User interface design; HCI design and evaluation methods; User studies.

ACM Classification Keywords
H.5.0. Information Interfaces and Presentation: General.

INTRODUCTION

A paramount element in soccer is making ball passes to teammates that are in the best position in respect to the rival players, for either creating goal opportunities, or avoiding receiving goals against. For making the best decisions in an accurate and prompt way, elite players rely on visual information. Related to this corpus, a term employed that describes the visual exploratory abilities required to make the best in-game decisions is known as the ability to READ-THE-GAME [1].

A technological solution for the realization of a system that allows the development of the skill to READ-THE-GAME, is by using Virtual Reality (VR) and Head Mounted Displays (HMD), by tracking the head rotation of the user for measuring the *Active Visual Exploratory Activity* (AVEA). With our system, we measure the AVEA of Amateur (≥2 years of experience) and Beginner (<2 years of experience) soccer players (n=10) in a VR session that recreates soccer in-game situations. The HMD rotational data is logged and saved frame by frame during the VR simulation. The Field of Regard (FoR) of the HMD is divided into three zones of interest, obtaining a measurable score from the time spent engaged in AVEA before making a pass under rival pressure.

In this paper we analyze the Human Computer Interaction (HCI) elements from the user perspective that serves best for eliciting the highest sense of *Presence*, fomenting the AVEA development while not hindering the performance of soccer players inside the Virtual Environment (VE). For doing so, we performed an experiment with ten soccer players, they experience our system while we measure their AVEA, and apply IPQ Presence Questionnaire post-session.

We analyze the user feedback, focusing on their comments after the VR session. In the experiment we used the Kinect for full body immersion and compared the user data with our previous research which used a gamepad controller instead of kinetic tracking for input [2]. The feedback from the users is gathered, identifying elements of importance for future work improvements.

READ-THE-GAME AND AVEA

The term READ-THE-GAME have been employed for explaining the ability of soccer players to predict in-game events, based in early queues from sport related occurrences, and have been linked to highly skilled performance in soccer [3].

For measuring and analyzing the ability to READ-THE-GAME of soccer players, we focused in the ability required for gathering the necessary visual information in their surroundings. Soccer players must move both their heads and bodies in order to “visually scan” the whole area surrounding them as if they were a living radar, covering the 360 degrees of their Field of Regard (FoR) with their view. This action is known as the Active Visual

Exploratory Activity (AVEA), also referred to as the Active Looking Behavior [4] and is our object of interest for the present work.

AVEA Measurement and Zonal Division

For analyzing the AVEA behavior of soccer players we divided the 360° FoR of the HMD (Oculus CV1) into three (3) referential zones. We consider that the user is engaging in AVEA when he/she executes either "Long Exploratory Activity" (i.e. visual exploration in which the player's head orientation moves away from the ball for the duration of a second or more before it is redirected towards it), and/or "180-Degree Exploratory Activity" (i.e. the player's head is oriented in the opposite direction from the ball, viewed through an axis from the ball straight through the player's body) as described in referential work [4]. The specifications of the zones measured are as follow:

Zone 1: Area right in front of the player where the eye fixations on the ball in possession are done, the area is between 45° and -45° (315°).

Zone 2: Area in which AVEA is engaged, the head/body must rotate for searching teammates and passing options, engaging in Long Exploratory Activity. The area is between 45° and 90° to the right, and -45 (315°) and -90 (270°) to the left of the player.

Zone 3: The area requires 180-Degree Exploratory Activity. The area is between >90° and <270° clockwise, including the area behind the player, requiring a full rotation on the pivotal point in order to explore visually. The AVEA score is calculated by measuring the total percentage of frames in which the player enters zone 2 and 3. A figure depicting the zonal division may be seen in figure 1.

Figure 1. AVEA zonal division.

FULL BODY IMMERSION AND KINECT

Research in HCI proposes the concept of natural mapping, which refers to movement in the mediated world being in synchrony with the real one, being mediated motion a one to one representation of the user body actions. The four subtypes of natural mapping are directional natural mapping (i.e. keyboard or gamepad based directional movement), incomplete tangible natural mapping (i.e. Nintendo Wii and Sony PlayStation motion controllers), kinetic natural mapping (i.e. Microsoft Kinect) and realistic tangible natural mapping (i.e. a real bat in representation of a virtual one in a VR batting simulator) [5].

For the realization of full body immersive VR soccer simulator, we chose Microsoft Kinect motion controller as the input of choice. We chose it considering the numerous cases available of scientific research applications with this device in computer vision-based human motion tracking and recognition [6]. To confirm if the aforementioned choice is the most suitable one for our proposal, we made a comparison with a directional natural mapping input device, the old tried and true gamepad controller.

SYSTEM OUTLINE AND EXPERIMENT

The system integrates a commercially available HMD (Oculus CV1) and Kinect motion controller for gesture detection, connected to a laptop pc, powered by an Nvidia GTX 980 GPU, an Intel Core i7 6700K CPU, and 8 GB of RAM. The setup is shown in Figure 2.

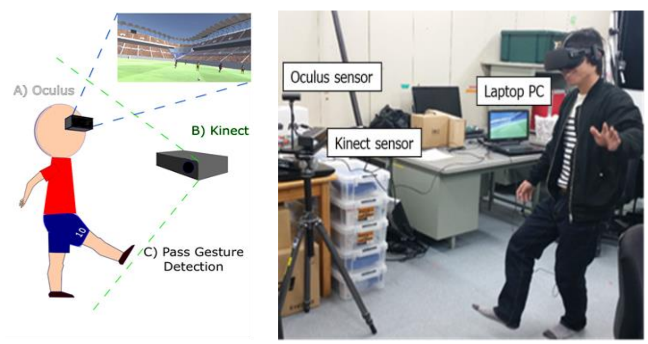

Figure 2. System Setup. Left: reference system configuration: A) The user experiences the VE through Oculus CV1. B) Kinect tracks the user's body. C) When a passing gesture is detected, the passing action occurs inside the VE as well. Right: A user experiencing the VR soccer simulation.

For the experiment we created inside the VE three (3) scenes and one (1) navigational menu. The navigational menu and two tutorial scenes are to be accessed before the main test scene, this is to facilitate to the user to get accustomed to the VE and the passing mechanics during the experiment. The test scene itself, is based on a training drill set play extracted from the coach manual provided by FIFA [7].

In this set play, the user finds himself in possession of the ball under pressure of a rival and must make a quick passing decision before a rival tackle him/her, robbing the ball as a consequence. The user gazing direction is extracted from the HMD rotation frame by frame, and the AVEA score is obtained from the total percentage of the time spent looking at Zone 2 and Zone 3 before passing the ball. After the VR session, the user answers the IPQ questionnaire and provide feedback to the experimenter from a soccer player perspective. A figure depicting the view of the user while making a pass together with the passing gesture as perceived by the Microsoft Kinect may be seen in figure 3.

Figure 3. Passing Gesture Action. Left: the image detected by the Kinect of a user performing the passing gesture. Right: the ball pass is triggered as a result inside the VE.

RESULTS

Although an in-depth analysis of the IPQ questionnaire results in relation to the sense of Presence and components is out of the scope of the present paper, we can get an overall view of the elicited sense of Immersion by our system focusing in the overall IPQ score. The questionnaire scores were analyzed as a composite measurement of *Presence*, with scores ranging from 7 to 98 obtained from 14 questions with a seven point Likert scale. The procedure for the application of the questionnaire was performed as suggested in the related research [8]. We obtained that the average value of the overall measure of the IPQ was fairly high (IPQ mean: 61.4, SD: 5.37, scale range: 7-98), meaning that the players felt "present" in the VR soccer simulation.

Regarding the AVEA results, the total percentage of video frames engaged in AVEA (i.e. HMD center eye is looking at either Zone 2 of Zone 3) before making a passing decision is assigned as the AVEA score. Beginner players exhibited a lower AVEA score (mean score: 30, SD: 26.53) in comparison to the Amateur players (mean score: 53.2, SD: 19.54). But the conclusions can be mainly inferential, since the sample size was not big enough to offer statistically significant differences. A graph representation regarding the AVEA score of both sample groups is shown in figure 4.

In future studies, we want to test our system by comparing elite and amateur soccer players instead, in order to test our hypothesis which suggests that is probable to find a bigger difference in the AVEA score. This hypothesis is grounded in the related research that found that less experienced players showed lower visual exploration in comparison to more experienced players [9].

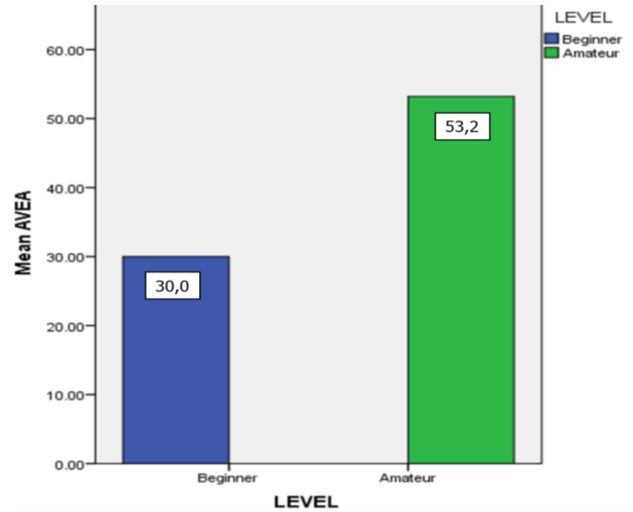

Figure 4. AVEA scores of beginner (blue) and amateur (green) soccer players.

USER FEEDBACK

User feedback is the focus for us in this stage, since we want to identify which elements are considered necessary and desirable from the soccer player's perspective. So far, the system has been designed by taking as a priority the technological completeness, so now we want to aim for a user-oriented design, with the requirements and opinions from the athletes in mind.

When comparing comments received from our system with the gamepad controller configuration in our previous research [2], we see that the users felt that it was in overall more "natural" to them. One of the most experienced players of the group, that had the chance to experience the system in both configurations commented:

"I felt rather distracted by the controller, which forced me to constantly focus on elements that were not natural to the game, with gesture detection I just could behave as I usually do in a match or practice."

This goes in line with the conception that the increased interaction of motion-based systems like Kinect *"increases feelings of spatial presence, perceived reality, and enjoyment* [10]*"*.

Another element of the simulation that seemed to impact more than expected the experience was the sound. Three (3) players commented in similar fashion on this matter, being one as follows:

"The sound of the public really helped to make me feel in the stadium, the adrenaline rush effect of the public was there to some extent."

For the sound we used recorded audio from a crowded soccer match, chanting in support of their team. This seemed to trigger some significant cognitive effect on the players, so we want to further explore the possible connections of sound with players AVEA performance.

Finally, the CG model of the rival player used for the simulation seemed to be effective on exerting the sense of pressure as a real player would do. A player commented:

"The rival player really made me feel stressed, as it normally occurs when I am facing marking defenders."

Even though the player model was not a photorealistic one, it effectively served the purpose of eliciting in-game pressure to the players. This support the conception that real immersion can be achieved with non-photorealistic graphics in the VE by focusing on the level of interactivity.

CONCLUSION

We successfully tested the capacity of our system for estimating the skill to READ-THE-GAME, specifically by measuring the Active Visual Exploratory Activity (AVEA) of soccer players while providing a high sense of Presence. We proved that full body interaction with a kinetic controller offer a better option for AVEA development. Also, we got positive feedback from soccer players, discovering key aspects that could further increment their sense of Immersion, such as audio from the cheering crowd. Finally, we received evidence that the CG soccer game simulation can be highly immersive without aiming for photorealistic graphics.

ACKNOWLEDGMENTS

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