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A Virtual Environment Based Evaluating System for Goalkeepers' Stereopsis Performance in Soccer

Introduction

Stereopsis describes the human visual system's ability to gain depth by fusing two horizontally displaced images of the same scene acquired by each eye separately (Howard et al., 2012). The offset between the same points in two corresponding images is called disparity. It can also be used to simulate depth in stereoscopic 3D displays (Fig. 1).

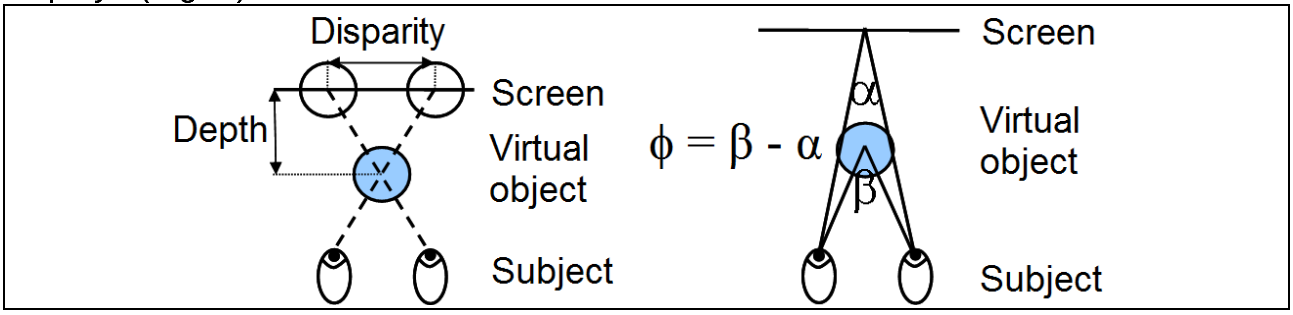

Fig.1: Left: Principle for simulating depth in a dual projection via disparity. Right: Disparity is measured as angle ϕ.

Stereopsis is an important component of human visual 3D perception, a deciding factor in sports, e.g. soccer. The sooner and more detailed a goalkeeper is able to identify the distance to an approaching ball, the sooner and more precisely he is able to react. There are three main factors describing the performance of stereopsis: Stereo acuity as a quantitative measure representing the minimum disparity that can still be correctly identified, and speed and robustness as a qualitative measure (Saladin, 2005).
Stereo acuity can be measured dynamically and statically where the definitions discriminate between moving and non-moving stimuli. Both have influence on ball based sports which has been studied and proved in the literature mainly for baseball. However, the results remain controversial. Solomon (Solomon et al., 1989) concluded that static stereo acuity does not show differences between baseball players and non-athletic subjects requiring dynamic stereo acuity tests for the sports sector. Laby (Laby et al., 1996) compared professional baseball players with non-athletic subjects and proved that static stereo acuity is only superior for far vision. Boden (Boden et al., 2009) could show a superior static stereo acuity for youth baseball players in near and far vision compared to non-ball players. These

examples show the strong need for stereopsis' performance evaluation and training systems directly connected to a particular sport.

Therefore, we propose a system for soccer that addresses goalkeepers' perceptual stereopsis' evaluation and training on dynamic stimuli for far vision (Fig. 2). It models estimates of the perception times as a function of presented disparities, thus assesses stereo acuity and speed. In this paper we describe a preliminary version of the system as well as first exemplary results for the performance evaluation part.

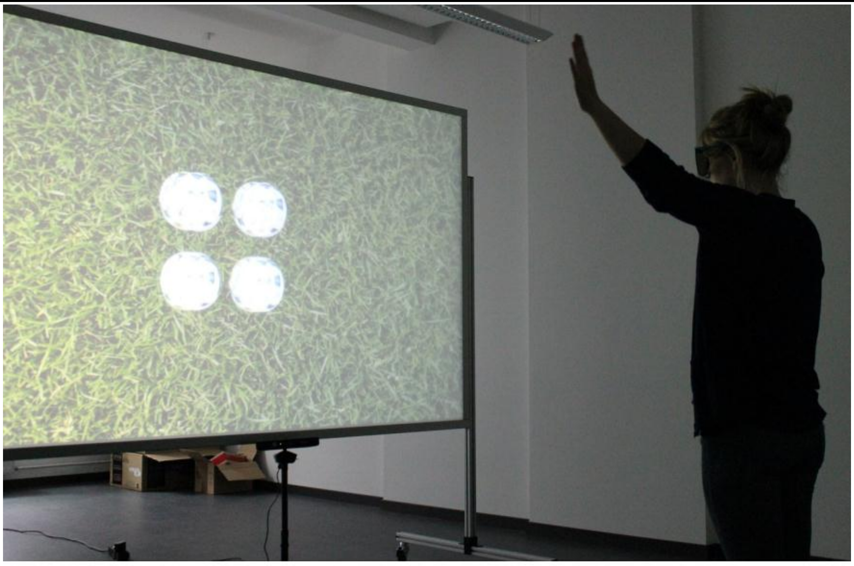

Fig. 2: A subject using our stereopsis performance system. Four balls are approaching into the direction of the subject in each iteration. The subject identifies the front ball by pointing into its direction.

Methods

Stimulus Our stimulus consists of four 3D spheres equally rendered with soccer ball textures (Fig. 2). One of the balls is chosen randomly to appear nearer to the observer. This front ball has a higher disparity than the others. The balls are rotating each in the same direction and move towards the subject simulating movement out of the screen. As the disparity of all balls is increasing during the movement also the disparity difference of the front ball compared to the other balls is increasing by the same factor. Thus, we merely measure disparity ranges. After a certain maximum disparity difference is reached the balls are set back to their initial disparities and the same movement starts again. The image generation is flexible enough for the usage on most commercially available stereoscopic displays.

Input The subject's task is to identify the front ball as fast as possible. For a simple and intuitive gesture driven interface (Paulus et al., 2012) we use Microsoft's Kinect sensor and its underlying pose estimation (Shotton et al., 2011). The subject selects the corresponding ball by pointing into its direction. In this early version the gesture simulates the goalkeeper's reaction and movement when a ball is approaching his or her goal.

Speed We measure the time from the beginning of the stimulus presentation until the subject is moving one of his hands more than 30 cm away from his shoulder indicating a ball selection. We call this the detection time and use it as an estimate for the perception time.

Performance data The final output of the test is a diagram showing the median of the correct detection times for each disparity range as well as its minimum and maximum detection times.

Preliminary experiment setup We run a preliminary study on a polarized dual projection system with a screen size of 2.4m x 1.35m and a resolution of 1920 x1080p. With a subject distance to the screen of 4.5m we obtained three disparity ranges in seconds of arc (''): 57.30''-229.20'', 343.80''-515.70'', and 573.00''-802.20''. We run each disparity range in 17 iterations where the first one was not used for the performance calculation. A disparity range was classified as detected if at least 10 out of those 16 iterations were correctly detected. This results into a probability of correctly guessing for a disparity range of lower than one percent. We measured six subjects with an age of 26.5 $\pm$ 5.4 years.

Results

In our preliminary experiment all of our subjects were able to correctly identify the stimuli for each disparity range at least 15 times out of 16 iterations. The medians of the detection times for correct detections vary from 1376.2 ms to 4318.2 ms. For most of the subjects the medians of the detection times for correct detections rise as the disparities decrease (Fig. 3).

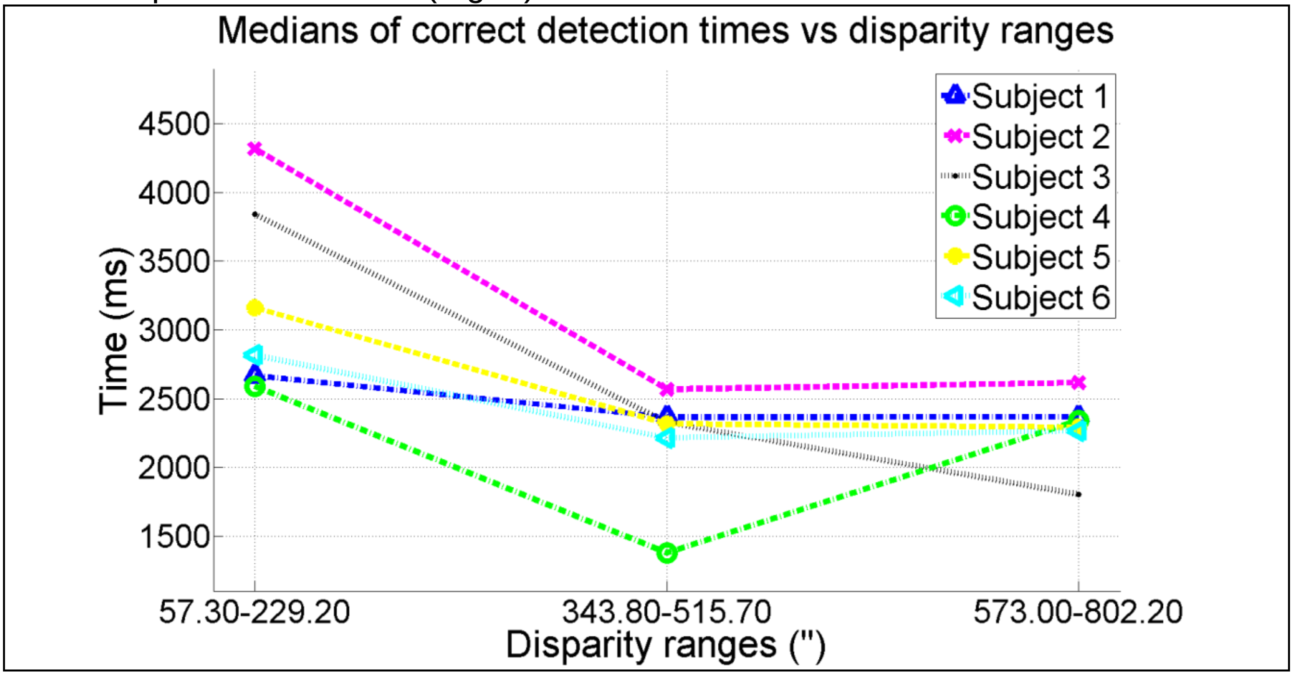

Fig. 3: Median of the correct detection times for each subject and for each disparity range. For lower disparities the detection times rise.

Discussion and Conclusion

The system shows promising potential to evaluate the stereopsis performance of goalkeepers reliably. The presented stimuli and gesture interface is a first step into the direction of simulating realistic sports impressions for precise evaluation and training of perceptual tasks. However, the project is in an early phase and needs further improvements. The Kinect's framerate of 33.3 Hz might lead to problems when evaluating professional athletes with highly trained visual abilities and thus significantly lower detection times. Therefore, it might be replaced in the future. There is also additional research required whether the system is just able to measure stereopsis performance or also to train it resulting into increased athletic performance. Nevertheless, the system is already in this early stage a powerful tool for sportive evaluation using serious games in virtual environments.

Acknowledgment

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