Sports Support System: Augmented Ball Game for Filling Gap between Player Skill Levels

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Abstract

In order to fill the gap between various levels of ball game players, we propose the Sports Support System that can reduce the difference among the skills of various players by augmenting the traditional ball game. We implemented a system that visualizes the trajectory and velocity of the ball for soccer games, as one example of ball games. This visualization and the enhancement of the player positions in the field can help beginner players recognize what they should do next and improve their playing skills.

Figure 1: Overview of Sport Support System, that is a projection-based augmented reality system for supporting ball game training, provides the trajectory and velocity of the ball and players on a marker projection on the floor.

This paper introduces the proposed system and discusses, through a user study, its effectiveness for improving reaction speed and enhancing the pleasure of playing sports. Based on the experiment results, the proposed system contributes to reaction time improvements in passing and receiving the ball, i.e., one of the most important skills in playing soccer.

Author Keywords
Visualization; Augmented Reality; Sports; Augmented Sports; Sports Support System;

ACM Classification Keywords
H.5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities

Introduction
Sports have positive effects on health, including mental, emotional, and physical benefits such as disease prevention. In addition, we can enjoy playing sports with others. Additional benefits include the fact that participating in team sports can provide players with a method for meeting new people and expanding social networks.

A sports game includes aspects of victory and defeat, tactics, and reaction speed; furthermore, some skills are very important for obtaining advantages of a game. There are large differences among the skills of various levels of players.

The purpose of this study is to develop a Sports Support System that can reduce the differences among the skills of various players by augmenting traditional sports (Figure 1). The proposed system visualizes the trajectory and velocity of the ball for soccer games, as one example of ball games. This visualization and the enhancement of the player positions in the field can help beginner players recognize what they should do next and improve their playing skills.

This paper introduces the proposed system and discusses, through a user study, its effectiveness for improving reaction speed and enhancing the pleasure of playing sports.

Related Work
Augmented reality technologies provide additional information for assisting with recognition and perception [10]. There is a study that applied an interactive projection system to help learn to play the piano fast [1]. The system provided enhanced piano roll notations and a natural leaning process with live feedback, and those interactions improved the user's performance. Augmented reality technologies are also effective in improving skills to play drums [11], climb walls [7], or other physical activities, such as dancing [2, 3].

On the other hand, an interactive augmented reality technology has been applied to basketball, table hockey, and dodgeball to create new game content [4, 9]. Those approaches indicate that the collaboration between sports and augmented reality technologies can enhance the pleasure of playing sports. Augmented reality is suitable for team games because encouragement of the social interaction among players is one of the important benefits of games [4]. However, how effective augmented reality technologies are for improving skills has not been made clear. Therefore, we focus on the skill improvement of playing sports,

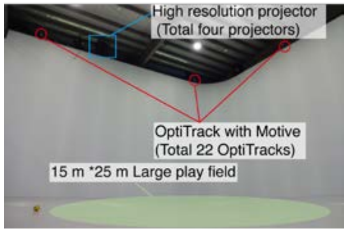

Figure 2: Large Space equipment for the proposed system, that is the world's largest immersive virtual environment with full surround and floor projections.

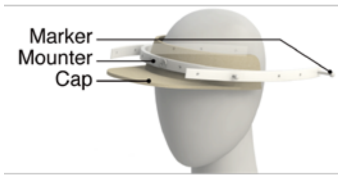

Figure 3, Mounter for infrared reflective markers that has six mounting holes to be set markers in various position combinations.

and this paper discusses the feasibility and effectiveness of the proposed system.

Sports Support System

Design

From the perspective of soccer training, the ability to pass a ball is one of the most important skills, and it consists of accuracy and timing. In particular, the goalkeeper should pay attention to the motion of four or five players simultaneously, and thus training for goalkeeping focuses on the cognition of player position and motion. Passing and receiving the ball are also required skills, as are imagining the game progress and place management [6] .

Because the standard operation of soccer training is almost always based on group practices that share the same field [5], we developed a projection-based augmented reality system for supporting soccer training, which is the Sports Support System, that allows multiple users to play in the same field at the same time. In addition, in order to support passing and receiving the ball and cognition of the ball and player movements, the Sports Support System provides the trajectory and velocity of the ball and players on a marker projection on the floor.

System Configuration

Figure 2 shows a system overview of the Sports Support System. The system uses 22 motion capture cameras and four projectors within the Large Space. The Large Space is the world's largest immersive virtual environment with full surround and floor projections. It covers a space of 7.7 m in height, 25 m in width, and 15 m in length.

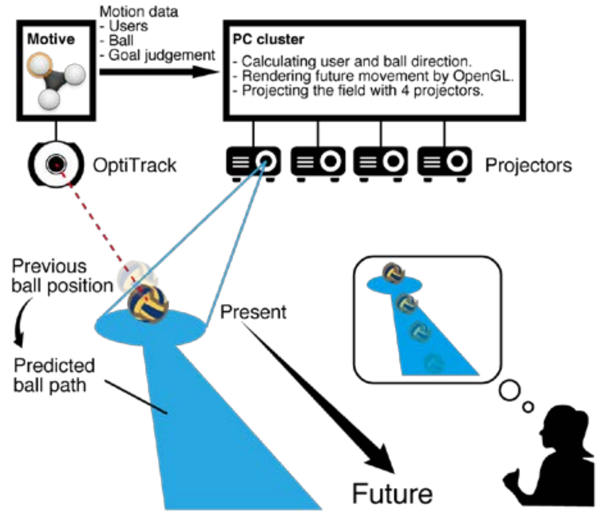

Figure 4: System Configuration of Sport Support System that have 22 motion capture cameras for tracking the ball and users at very high accuracy less than 1mm and four FHD projectors for projecting ball path and players position.

Tracking System

We use the motion tracking system (Optitrack with Motive) to detect the position and direction of the ball and players with infrared reflective materials. In order to distinguish each player, we made a 3D-printed mounter (Figure 3) that has six mounting holes for infrared reflective materials to be set in various position combinations.

Projection System

We developed a projection system for visualizing the position and direction of the ball and players in order to enhance predictions of ball path (Figure 4). This system renders on the floor a predicted path calculated by the

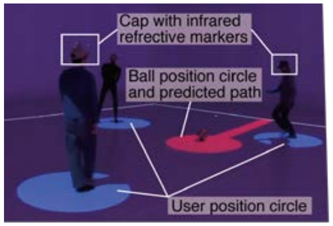

Figure 5: Implementation results for Sports Support System for soccer, the proposed system can track six of players and the ball and visualize those positions and predicted direction.

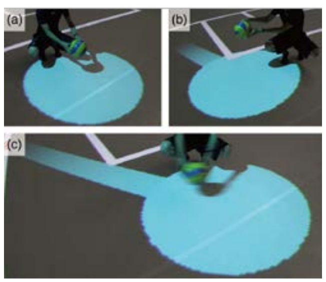

Figure 6, Predicted path of a ball (a) stopping, (b) moving slowly, (c) moving quickly, the length of predicted path scales linearly with the velocity.

previous ball position; it also renders player directions in the same way as the ball. The rendering task is managed by OpenGL, and four PCs (CPU: Intel Core-i7 4790K, GPU: NVIDIA Quadro K5000) in a PC cluster run the OpenGL program. Each computer calculates the ball path on the floor allocated to each projector. A player would predict not only the ball path, but also the velocity. The length of the ball path represents the velocity of the ball.

Implementation Results

Six players can simultaneously play a mini-soccer game in this space (Figure 5). Figure 6 shows the difference in the length of the predicting path based on ball velocity. The tracking error is less than 1 mm according to the system datasheet.

Experiment

Purpose and Procedure

The purpose of this experiment is to clarify the effectiveness of the proposed system for improving skills. We assume that the gap among the various player levels can fall into two categories: the skill of ball-path-prediction and width of the field of view. The skill of ball-path-prediction can be confirmed by comparing the cases with or without the proposed system, and width of the field of view can be confirmed by comparing the cases of passing the ball from the front or from out of view.

In order to evaluate the effectiveness of the proposed system for these factors, we recorded reaction times from the moment of passing the ball to the participant's initial reaction in the case of passing from the front or from out of view, and with or without the system.

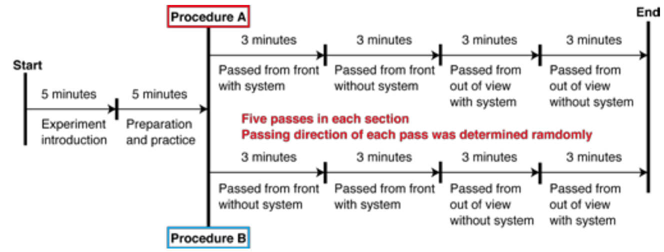

Figure 7: Experiment procedure for evaluating effectiveness of proposed method for improving reaction time

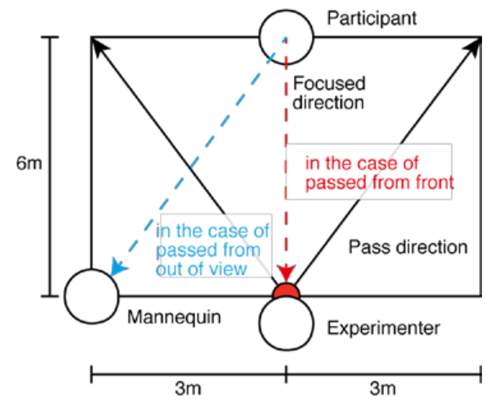

Figure 8: Experiment environment and position of each mannequin, participant, and experimenter

The experiment procedure is shown in Figure 7, and eight university students (22-25 years of age) participated in this experiment. The students were divided into two groups, and they were subjected to the experiment in different order, starting from the case with the proposed system or from the case without the system, in order to avoid an order effect.

The experiment was divided into four sections in each procedures, and the experimenter randomly passed a ball to the participant's left or right side from 6 m away in each sections (Figure 8). In the case of passing from out of view, in order to create a situation where the participant received the ball passed from out of view, we set a mannequin 3 m to the left of the experimenter, and required the participant to focus on the mannequin.

Results

We focused on the differences in reaction time between the cases of passing from the front or from out of view, with or without the system (Figure 9). A two-way factorial repeated-measures ANOVA indicated a significant main effect for both with or without the system ($F(1,1) = 113.7$, $p < 0.01$) and the focused direction ($F(1,1) = 42.53$, $p < 0.01$). Their interaction showed no significant difference.

The average reaction time in the case of passing from out of view is longer by 114 ms compared with the case of passing from the front for all participants, both with and without the system. On the other hand, the proposed system improved the reaction time by 88 ms on average. Note that the difference of ball speed between each trial was so small that there was weak correlation between the ball speed and the reaction time in this experiment.

Discussion

The results of ANOVA indicate that the proposed system contributes to improvements in reaction time when passing the ball; therefore, the proposed system can improve the skill of passing and receiving the ball, i.e., one of the most important skills in playing soccer.

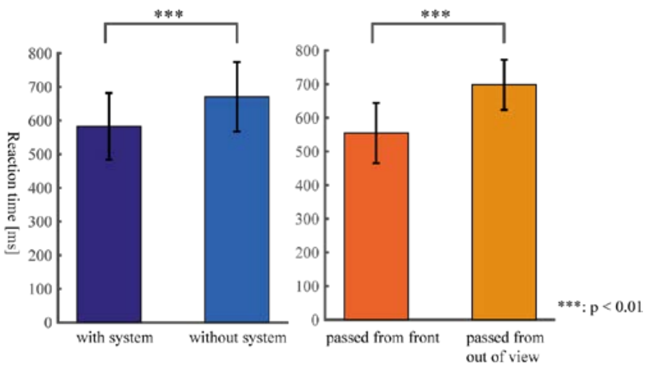

Figure 9: The reaction time between in the case of whether passed from front or from out of view, with or without the system.

In addition, the proposed system might be effective for low-skilled players because none of participants exercise actively in their daily life. On the other hand, the proposed system does not support the player's field of view because there is no significant difference between the cases of passing from the front or from out of view. From this result, in order to improve the proposed system, we plan to implement a function that can visually suggest the moving path for the player to receive the ball.

Conclusion

We focused on the gap among various levels of ball game players, and proposed the Sports Support System. We realized the idea of reducing this gap by helping with the cognition of what a player should do next. For implementation, the proposed system provides the trajectories and velocities of the ball and players as projections on the floor of a soccer game.

As demonstrated by the experiment results, the proposed system contributes to reaction time improvements when passing the ball. Our approach found that the interactive visualization in sports could help various levels of players to improve their skills.

For future work, because the results of the experiment also showed only the effect of short-term skill improvement, we plan to clarify the effectiveness of the proposed system for long-term skill training.

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