Player Perception Augmentation for Beginners Using Visual and Haptic Feedback in Ball Game

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Abstract

We developed *Sports Support System* that augments the perception of beginner players and supports situation awareness to motivate beginners in multiplayer sports through visual and haptic feedback. Our system provides positional relationship of the opponents using visual feedback. In addition, the position of the opponent beyond the field of view was provided using haptic feedback. An experiment of pass interception as used to compare the visual and haptic feedback. The results confirmed the effectiveness and characteristics of these feedback processes in a multiplayer ball game.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality

1 Introduction

Among the different types of sports, multiplayer ball games–such as soccer and volleyball–create a sense of unity and accomplishment that enhances the experience for the participants. However, for players with little or no experience, there is often a psychological hurdle which hinders them from trying a new ball game or resuming sporting activities [2]. It can be said that such players have lost the opportunity to enjoy sports.

Furthermore, the motivation associated with participation in sports is mainly to develop physical skills, except in the cases where physical health and social well-being are the primary objectives [1]. However, to improve the physical skill of beginners in multiplayer games, we assume that situational awareness (e.g., which player has a ball, who will receive the ball in a soccer etc.) based on perceptual skill is the main hurdle. Based on this idea, we developed *Sports Support System* (Figure 1), a system that augments a player's perception in ball games and supports situational awareness for a beginner using visual and haptic feedback. Our focus in this study is to evaluate the characteristics of the visual and haptic feedback in a ball game via experimentation.

2 Related Work

With regard to visual feedback in ball games, Itoh *et al.* proposed a system that provides trajectory prediction to support pitching action using a head-mounted display (HMD) [3]. However, it is dangerous to wear HMDs during sporting activities that involve intense movement or physical contact. Therefore, we used projection as visual feedback that does not inhibit any movement during sports.

With respect to the use of haptic feedback in sports, Kosmalla *et al.* developed a vibration device to provide real-time performance feedback while climbing. They determined that haptic feedback is more suitable than visual feedback because a user can perceive this type of feedback without gazing [4]. Shiraishi *et al.* developed a belt-type vibration device to support coaching in sports [6]. Using

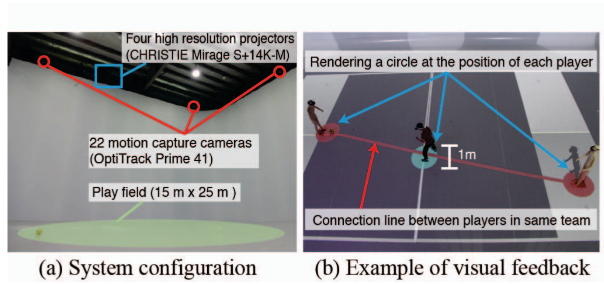

Figure 1: Overview of Sports Support System.

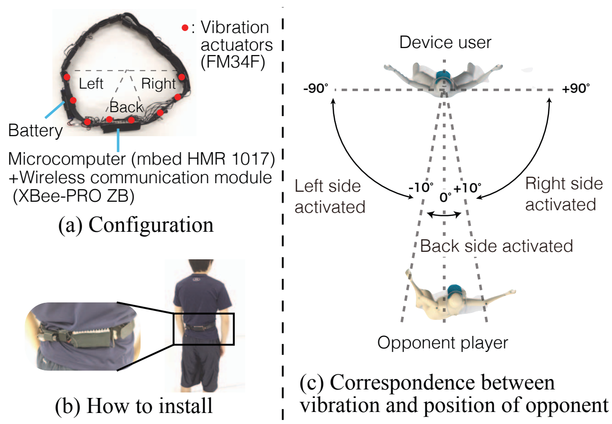

Figure 2: Vibration feedback device

this device, a coach can provide directional information to a player with arbitrary timing. Based on these studies, we assume that haptic feedback is effective for supporting player in sports by providing directional information without gazing.

However, these studies did not reveal the effectiveness of visual or haptic feedback for multiplayer sports. Therefore, in this study, we focused on soccer as an example of a multiplayer sport and implemented Sports Support System for beginners using visual and haptic feedback. We also confirmed the characteristics and effectiveness of the feedbacks in a ball game via experimentation.

3 Proposed System: Sports Support System

To design a system that supports situational awareness via visual, haptic or visuo-haptic (combination of visual and haptic) feedback, we were inspired by the following two studies. Sano *et al.* used visual feedback to augment the directional information of a ball [5]. In addition, Shiraishi et al. used haptic feedback to provide directional information from the coach [6].

Therefore, in this study, we proposed a system that uses visual and/or haptic feedback to indicate the positional relationship between opponents and teammates in real-time to support players. Figure 1 shows an overview of the proposed system.

We developed a system using a large-scale immersive display "Large Space," that includes 22 motion capture cameras to track

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the 3D position of the players and a ball. In addition, it can provide visual feedback using 12 projectors [7] (Figure 1 (a)). Figure 1 (b) illustrates an example of visual feedback in the proposed system. By connecting players in the same team to each other using lines, a player can visually recognize the positional relationship between opponents and teammates.

With respect to haptic feedback, Figure 2 (a) shows the belt-type vibration feedback device. In the proposed system, the vibrators attached to the belt worn on the waist of the player (Figure 2 (b)) provides the direction of an opponent onto the player's back via haptic feedback based on the positional information of each player. As shown in Figure 2 (c), the direction of players outside a user's field of view is divided into three directions. The device relays the directional information to the user using 2 Hz vibration feedback, and consists of a micro-controller, a wireless communication module, a battery, and eight vibration actuators at the back half of the body.

4 Experiment

We conducted an experiment based on pass interception to evaluate the effectiveness of the proposed system, based on the assumption that intercepting an opponent's pass is an important aspect of playing soccer.

A total of 18 healthy participants (23.0 ± 1.6 years old, 17 males, 1 female) took part in the experiment. In this group, 16 participants were beginners without experience and two participants had previously played soccer, but were playing after a long break (> 10 years). At any given time, three participants were involved in the experiment and we assigned three types of roles to each participant: role A involved passing the ball, role B involved receiving a pass, and role C involved intercepting a pass. Figure 3 (a) shows a layout of the experimental environment.

Figure 3 (b) outlines the experimental procedure. Four conditions were used for comparison; no feedback, visual feedback, haptic feedback, and visuo-haptic feedback. The visuo-haptic feedback was used to check for defects. To eliminate the order effect, we counterbalanced the trial order for the four conditions. It was a within-subject design. After participants each completed 20 pass interception exercises for the four conditions, they were assigned to the another role (A->B->C->A). After all member of a group participated in all the roles and conditions, we interviewed them based on the following items for both visual and haptic feedback on a scale of one (low) to seven (high):

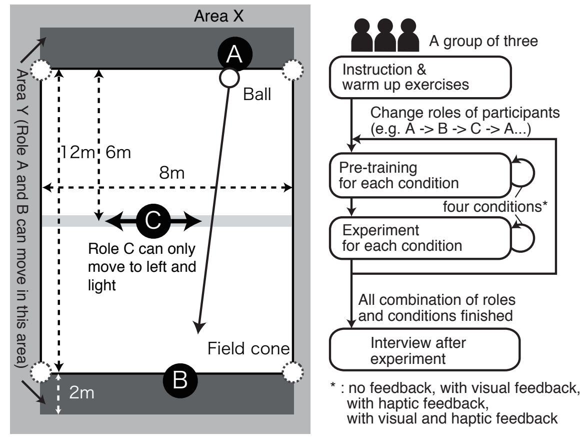
- Q1, Was it easy to recognize the position of the opponent visually | haptically relayed by the system? (For role C)
- Q2, Was visual | haptic feedback useful for pass interception? (For role C)
- Q3, Was visual | haptic feedback useful for receiving a pass? (For role B)

5 Results

For the recognition of the position of the opponent (Q1), visual feedback was significantly easier to recognize compared to haptic feedback (visual: 6.67 ± 0.49, haptic: 5.17 ± 0.98, $p < 0.005$). Similarly, with respect to the usefulness of pass interception (Q2), visual feedback received significantly higher scores than haptic feedback (visual: 6.22 ± 1.00, haptic: 5.39 ± 1.54, $p < 0.05$).

Based on these results, it can be concluded that visual feedback is easy to recognize and intuitive. Moreover, it is useful for pass interception compared to haptic feedback. It is possible that haptic feedback was a unique experience for the participants, as they were required to recognize the position of players based on the vibrations of the actuators.

Regarding the comments about the visuo-haptic feedback, three participants commented that it was more difficult to recognize the haptic feedback in the experimental environment compared to the visual feedback. According to these comments, visual feedback also appears to be easy to recognize in the visuo-haptic feedback condition. With regard to haptic feedback, the feedback pattern or strength should be modified to facilitate ease of recognition.



(a) Experimental environment (b) Experimental procedure

Figure 3: Outline of the experiment.

In terms of usefulness in pass receiving (Q3), there was no significant difference between the visual and haptic feedback (visual: 3.39 ± 1.50, haptic: 3.61 ± 1.29, $p = 0.44$).

One of the role B participants commented that the haptic feedback was less stressful to use because the movement was invisible to role C. In another comment, three participants noted that the visual feedback could be used as a feint for role C. Based on these comments, it can be inferred that the reason why there was no significant difference for Q3 is that the advantages of both feedbacks were counterbalanced.

6 Conclusion

We proposed Sport Support System that supports a player's situational awareness via visual and haptic feedback for multiplayer ball games to motivate beginners to participate in sports. We confirmed that the characteristics and effectiveness of visual and haptic feedback in a ball game via an experiment. From the results, it can be concluded that the visual feedback is easy to recognize and intuitive. Moreover, it is useful for pass interception compared with haptic feedback. We also clarified the advantages of visual and haptic feedback based on the comments of the participants.

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