Body Cursor: Supporting Sports Training with the Out-of-Body Sence

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Abstract
Previous studies on sports training suggest that trainees who correctly understand their own posture, movements, and overall performance can improve their skills more rapidly. However, particularly for novice trainees, recognizing one's own posture and movement is difficult. Although some recent studies on training support attempt to display the trainee's self-image, there are limitations on viewpoints and movements. We propose a system called "Body-Cursor" that displays a copy of a trainee's body, correctly reproducing the posture and motion of the trainee in real time. This body copy is obtained through a motion capture system and presented in front of the trainee by using a see-through head-mounted display (HMD). Using this system, a trainee sees the body copy as if it were a cursor for the trainee's own body. The Body-Cursor image can be scaled to make it easier to understand the movement of the entire body. It is also possible to compare the ideal posture to the trainee's current posture and display the differences between them. Based on our preliminary experiments, copying the body and manipulating the Body-Cursor in an actual training environment appears to be a promising method for improving sport-training performance.

Author Keywords
Augmented Sports; Training Support; Mental Imagery; Mixed Reality; Augmented Human

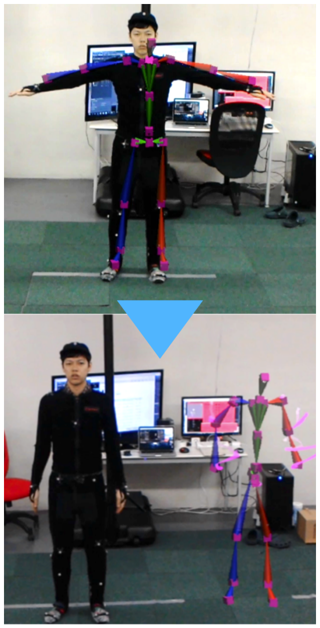

Figure 1: Body Cursor, left side of the body is red and right side of the body is blue, is displayed in actual training environment.

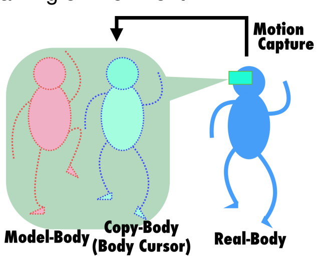

Figure 2: Following the movement of Model-Body, users operate their Copy-Body(Body-Cursor).

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous; See [http://acm.org/about/class/1998/]: for full list of ACM classifiers. This section is required.

Introduction

It is well known that athletes use mental images of their bodies in order to improve sports skills[2][5]. Self-images from an external viewpoint are also effective for performance improvement [1]. Therefore, supporting the acquisition of a self-image using various methods has been proposed. For example, there is one system that extends a face-to-face interface by using a method to view the body reflected in a mirror, and another system that uses various methods to acquire a third-person viewpoint through video recording and playback. These systems, however, face restrictions in field of view and intended use. Futhermore, previous systems using 2D displays are unable to efficiently support form-correction because they require users to understand the correspondence between 2D body images and an actual body. Thus, we propose a system that displays a copy-body of a trainee in the training environment(Figure 1). A copy-body represents the actual size and the depth ratios of the trainee's body. The user can manipulate the copy-body using their hands, similar to using a mouse cursor (Figure 2). We call the copy of the user a "Body-Cursor".

The user can view their own body from an arbitrary viewpoint and visually compare their form and movement to the Body-Cursor. Additionally, we provide tactile feedback to the user when their Body-Cursor collides with the copy-body of experts, and notify them concerning form-correction points by using vibration motors attached to their body. This functionality enables the user to recognize collisions with the Body-Cursor across the horizon, and reduce restrictions caused by the limited viewing field of the HMD. As a result, the user can acquire an external self-image without visual restrictions, and can support their own performance improvement.

Related Work

Self Image

There are various systems for supporting the performance improvement of athletes by acquiring an external self-image for evaluation. For example, there is a system which uses a flying robot equipped with a function for tracking users[4].

There is another system which provides a function similar to a moving mirror for swimmers or runners by moving with them and continuously taking and displaying pictures of their movements [6][7].

These systems are effective for viewing the movement of the athlete from the outside.

However, these systems require the user to imagine the correspondence between the displayed image and their actual body. Additionally, it is not possible to independently represent body parts with different depths on the display plane.

Coaching and Modifying

When a trainee corrects their movement to improve performance, it is common to train the body by relying on self-awareness. If a coach is present, a method for pointing out the body part requiring correction through direct contact may be used in some cases. In order to support such form corrections, there is an existing system that displays a model arm with a video see-through augmented reality using a HMD, and enables the user to visually match their arms with the displayed movement [3]. However, the application of this system is limited because it cannot display an external field of view. For example, when performing a

Figure 3: A motion capture marker attached to the top of HoloLens.

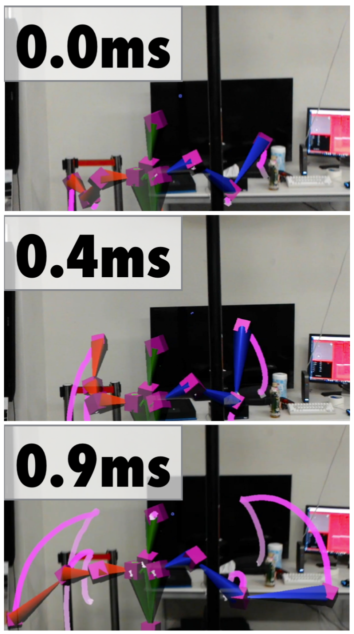

Figure 4: The purple line in the figures shows the trajectory of the joint movement of the elbow and wrist.The transparency of this line expresses the passage of time.

movement to see the fingertip of the right hand, such as in a dance, it is not possible to determine the position of the left hand or the foot. Additionally, because the indicator used to confirm consistency is simply feedback based on visual information, the user cannot determine if actual model movements can be imitated. There is a system that supports training through display of the body in a third person viewpoint in a VR space [8]. However, because the body of the user and the body of the model are arranged side by side, it is difficult to distinguish the differences between their movements. This problem cannot be solved even if the viewpoint can be freely switched.

Body Cursor System

Our system has the following features:

- To display a copy of one's body three-dimensionally in real time.
- Enable to check one's body movement outside one's field of view.
- To display the difference between the model and one's movement as visual information.

With these features, users can move their body like a mouse cursor in three-dimensional space. As shown in Figure 4, these sequential images displays the user viewpoint. This user watches their Body-Cursor from behind and waves both hands. The image(B) shows Body-Cursor after image(A) a few second later. Also the image(C) shows it after image(B) a few second later too. The purple line shows the trajectory of the joint movement of the elbow and wrist. The transparency of this line expresses the passage of time. The user can also change the viewing angle of their Body-Cursor (Figure 5). Depending on the type of movement, the best angle to view the Body-Cursor from may not be an external viewpoint from the back. Thus, our system can change the viewpoint manually or automatically.

Prototype

We obtained a user skeleton by using a motion capture system. As shown in Figure 3, alignment was achieved by attaching motion capture markers to a HoloLens. For this prototype system, the copy image is only displayed in front of the user. We also created a tactile presentation device by combining a vibration element and a motion capture marker. As a result, because the tactile system remains on the body, it can recognize differences in posture, contact with the floor, and physical contact with a third party simultaneously.

Pilot Study

For the initial trial approach, we evaluated (1) whether trainees can recognize their posture and movement their selfs in real-time, and (2) whether users can recognize other person's posture and movement from the log data which is previously captured. Therefore, we asked two users to participate two types of tests. One of the persons has over 15 years of experience in soccer, and the other person has six years of experience in baseball. The first test is displaying the body-cursor in real-time, and the second test is displaying log images.

(1)Display the Copy in real-time

We asked the user to wear a motion capture suit used each combination of scale and viewpoint for several minutes at a time as shown in Table 1. We asked the user to move freely rather than giving them specific instructions.

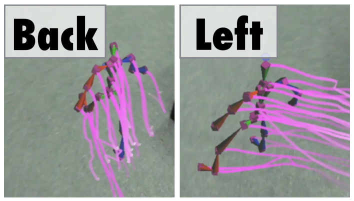

Figure 5: Images of the user's viewpoints when the user is walking around Body-Cursor. The images on the left and right show Body-Cursor viewed from the back side and the left side respectively.

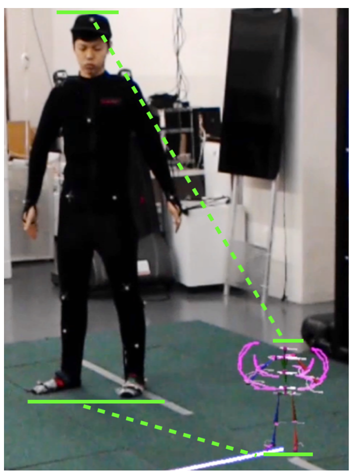

Figure 6: Body-Cursor is scalable. Body-Cursor moves following the movement of the user by measuring the positions of markers on a suit.

Table 1: Observation pattern(n = 2)

Body-Scale	1/1, 1/2, 1/4, 1/8, 1/16
Angle of View	back, side

(2)Display the Log
As shown in Figure 6, we recorded some movement data while the user was wearing a motion capture suit. We displayed this data to the user.

User FeedBack
We asked users questions such as:

- "How did the usability feel?"
- "Could you understand the movement of your body outside the field of view?"
- "How do you feel about Body-Cursor?", as well as asking for non-directed comments.

We received the following feedback from the interview: *"The body display should be smaller, I cannot see the entire body.", "It definitely shows the movement of one's body outside the field of view.", "It's cute when it gets smaller.", and "It was like playing a game."*

Improvement System
From the comments gathered in these interviews, we found both advantages and disadvantages in the proposed method. We determined that the method would be useful for training support, particularly for recognizing one's own form, because there were few critical comments regarding the form correction function of the Body-Cursor. We suspect the reason for this is that there is no delay between the actual body and the displayed body. The main disadvantage is difficulty in viewing the entire copy-body because the Body-Cursor often does not fit within the viewing angle of the HoloLens.

Discussion and Future Work

The purpose of this system is to aid trainees in checking or modifying their forms during sports training, but the system can also be used for other purposes. For example, in the case of coaching, we believe that the trainee can understand pointers given by a coach using a pen tablet in the 3D space. Additionally, it could be used as a game controller for Mixed Reality games. Because the most appropriate UI in 3D space is the human body, we believe it could become an excellent controller by providing more smooth and precise operation in 3D space.

Conclusion

We have presented the potential of a system that helps to recognize and manipulate body movements by displaying a copy of the body and operating it as a mouse cursor. From the results of pilot study, we believe that this system has a potential for assisting acquiring external self-images. We will perform continuing research on further application of this system.

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