My Tai-Chi Coaches: An Augmented-Learning Tool for Practicing Tai-Chi Chuan

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ABSTRACT

Tai-Chi Chuan (TCC) is a famous physical exercise and well-known for being able to effectively promote physical well-being. Many people have been interested in learning TCC at the beginning, but eventually failed in mastering it due to the lack of a constantly accompanying master on the side. In this paper, we present an augmented-learning tool, called "My Tai-Chi Coaches", for learning TCC. By wearing an optical see-through Head-Mounted Display (HMD), the users can have their own private coaches-on-demand that will guide them in practicing TCC. To solve the "attention-sticking" problem, we propose the use of "redundant coaches" and high-lighting the primary coach at every instant. When the user wants to adjust his posture to mimic the coach's movement, he can simply suspend his motion, and then the drone will fly to a proper position to capture the images of the user's posture, and display them on an augmented mirror placed near by the highlighted or gazed coach. In addition to learning TCC, the proposed augmented-learning tool can also be used for learning dancing, yoga, sporting, and for rehabilitation.

CCS Concepts

• Human Centered Computing → Human Computer Interaction • Human Centered Computing → Ubiquitous and mobile computing → Ubiquitous and Mobile Computing Systems and Tools

Keywords

Physical Activity Learning; Mixed Reality; Drone; Augmented Mirror; Tai-Chi Chuan.

1. INTRODUCTION

In many physical exercises, keep on practicing is a key to improve the performance and ability after learning with the coach in the classroom. In Tai-Chi Chuan, the users are asked to perform a sequence of body movements with highly accurate positions. The usual way of learning is to observe the coach in the classroom, and mimic the moves from the coach. In each moves, it can be divided into several actions. Although the action has been separated, there still have lots of detail in each action and it is always hard to remember. Therefore, using recorded video as a remember tool is one of way for helping student practice back to home, e.g. smart phone. Additionally, using home console (e.g. Xbox, Wii) or smart TV (e.g. YouTube) also can be a great tool for practicing physical exercises at home. Although those assistance tools can provide the information of coach's actions via a playing system, the information was compressed to images display on a flat screen which will lose some of the details. Moreover, the information is always displayed in front of students [1,2], which they need to face to the display to receive the information including self-reflection from a physical mirror or virtual mirror. These kinds of situation may let the student ignore the face direction which is part of the standard movement in Tai-Chi Chuan. Many researches have shown the potential of displaying the coach's actions with 3D in head-mounted display (HMD) [3,4], which the student can observe the action with any direction. Furthermore, with see-through HMD, the coach's action can be imposed into the student body for providing egocentric hints to the student [3]. With those assistant tools, student can move their head accordingly to the standard movement and observe the coach action simultaneously.

Figure 1. The augmented information from our assistance tool

In this work, we propose a mixed reality system based on an optical see-through HMD for assisting TCC self-practicing. After wearing the HMD, the user can see many virtual coaches surrounding him, each with a floating ground. Also, an adaptive augmented mirror will be used to show the images captured by the drones, therefore, the student can have a self-reflection information beside the coach for adjusting their action. Moreover, our drone-enhanced approach allows the user to move the drone to the other side of the students when the action facing in different directions.

2. RELATED WORK

To provide an assistance tool for practicing Tai-Chi Chuan, many researches have influenced our work. Learning or practicing physical exercise with a flat display is the most common

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multimedia that usually seen in our houses, such as television or projector. Motokawa et al. [16] develops a support system by using a webcam and a screen for helping student learning the hand gestures of playing guitar. MotionMA [2] uses Kinect to analyze and model experts' motion. After comparing to the student movement, the feedback information will show on a screen. YouMove [1] also uses Kinect to evaluate the student performance. Additionally, they proposed an adaptive learning method with an AR mirror for learning physical activity. Physio@Home [12] uses a wearable device and setups two cameras from different angles aside the user. By the guiding information in front of a TV, this system can decrease the amount of mistakes when physiotherapy patients doing their exercises through observing from different angles. LightGuide [13] and SleeveAR [8] also show the potential of projector-based guiding system can guide the user hand movement. Those technologies can assist some physical activity (or exercise) that does not have to move around. Therefore, the guiding or feedback information from the system can always show on a fixed display that usually in front of students.

With the HMD system, some physical exercise need to move around in physical space can be done, because the guiding information can always show in front of students. Chua et al. [9] and Just Follow Me [14] builds a body training system in an immersive VR environment for guiding body movement with Virtual Coach. However, users cannot observe their body information in virtual space instead of using an avatar. With video see-through HMD [3,6], students can observe their body information by mounted-camera on the HMD, but the images from the camera is different than human eyes. Therefore, using optical see-through HMD as an assistance tool [4,15] may be a suitable solution for observing augmented information and body motion simultaneously.

Some researchers have tried to use external self-image as an auxiliary aid to help students refine their body posture. With extra RGB cameras or even depth cameras, the user's view could be extended in various ways. In [1,2], a Kinect-based system is proposed to generate a fixed virtual mirror in front of the user to enhance the user's movement training. However, it' not convenience because it's not portable. In [10,11], they build a movable robot with a mirror to follow the user, but the student still need to face with the mirror. OutsideMe [6] proposed a Kinect-based system that generates an augmented mirror in the video see-through HMD. Though the camera is fixed, but the virtual mirror can be placed in different directions and position in augmented environment. Parallel Eyes [5] shows a similar way for displaying the self-images by acquiring the images from the camera of other user. But both technologies cannot let the users control the shooting position of the camera. In our system, we proposed a way to show the self-images (i.e. augmented mirror) with a drone enhanced approach. The user can control the camera to shoot from the front sight or back sight, and the mirror can be displayed in different directions and position in the optical see-through HMD.

3. DESIGN

Our system comprises of two augmented visualizations for guiding user body movement: (a) virtual coaches and (b) augmented mirrors. For each design, there are several considerations need to be discussed.

3.1 Virtual Coach

We propose surrounding virtual coaches, each with his own ground, that can accompany the students whenever they want to practice TCC. With virtual coaches on the ground, students can not only observe the standard movement through coaches, but also easily recognize the foot movement of standard movement, according to the relative displacement between the virtual coach and the ground.

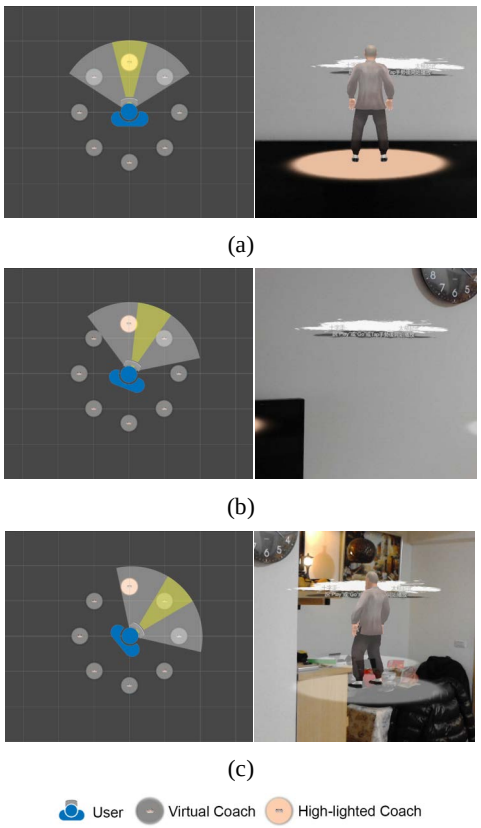

Figure 2. The placement of the coaches

The placement of the virtual coaches is one of the considerations on TCC learning due to the different observation perspective, the more different observation perspective students can have, the more completed information they can get. Due to the small augmented FOV of HMD, the augmented visualizations (e.g. virtual coaches) user can see in the line of sight is limited. This will make the user pay attention to the front virtual coach and lose sight of the surrounding coaches because users don't know where the other coaches are as shown in Figure 2, which is so called "attention sticking problem". To solve this problem, we adopt redundant coaches as shown in Figure 4. There are three different placement types which are 8, 20, 36 virtual coaches surrounding the user respectively. With the more coaches surrounding, users can easily find the other coaches they want to observe.

Another consideration is that users don't know which coach they should observe. Since the direction of the head is one of the important part in TCC movement, our purpose is to let the users face the right direction. We highlight the coach, which is in the right direction by brightening the ground of the coach as shown in Figure 2 and Figure 4. Moreover, we use some text messages to sign the user which direction they should turn.

Additionally, the virtual coaches need to follow the user because the student need to move around in some of the TCC motions. However, the virtual coaches which are too closed to obstacles may penetrate them. To prevent this situation, we adopt adaptive-size coaches. The virtual coaches which are too closed to obstacles will turn smaller and closer to the user.

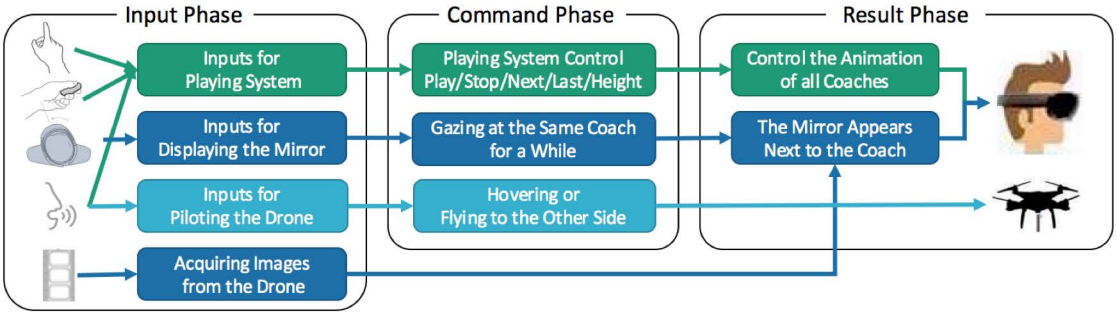

Figure 3. Overview of My Tai-Chi Coaches assistance tool

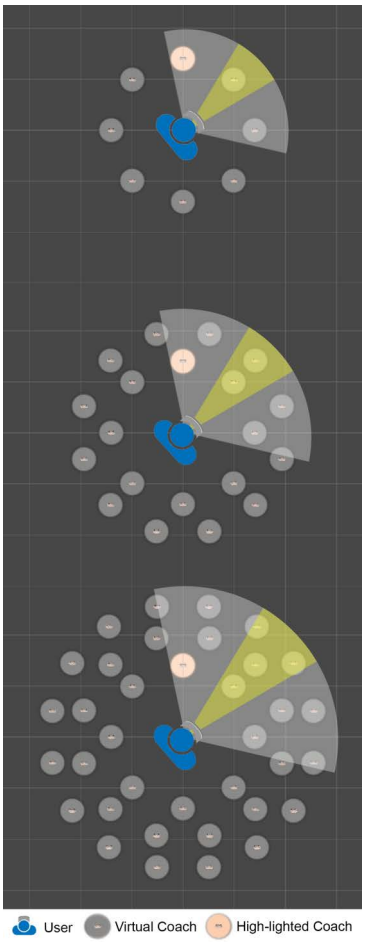

Figure 4. The placement of the redundant coaches

3.2 Augmented Mirror

In generally, mirrors are widely used for students to observe and revise their motion while practicing physical exercise. To allow the user observe and revise their motion by third person view in see-through HMD, we design an augmented mirror that shows the images the drone captured. Because the FOV of the camera on the drone is 180 degree, we define two positions (i.e. front and back of the user) for the drone to shoot at the user in order to capture the whole body shot of the user, as shown in Figure 5.

As the virtual coach, the placement of the augmented mirror is an effect need to take into consideration on TCC learning e.g. while students compare their posture in the mirror with the virtual coach. In general, the beginner of TCC cannot mimic and compare with

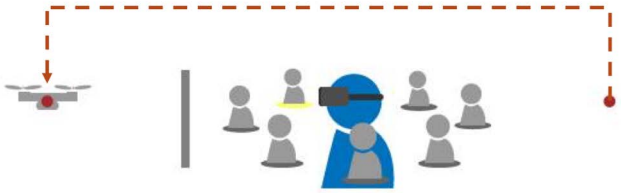

Figure 5. Two flying spot of the drone

the movement of the virtual coach via the augmented mirror simultaneously. Therefore, we design a method, “attention control drone”, to solve this issue. Users can see the mirror only when each time they gaze at the same coach for a while, which means that the user may want to pay attention to the detail of the movement at the specific time. If the coach user is gazing at is in the front sight, the augmented mirror will show the images the drone captured at the front position, and vice versa.

4. SYSTEM OVERVIEW

Figure 3 shows the system overview. There are three phases in our system, input phase, command phase and result phase. Users can use different inputs to control the animation of the virtual coaches which play the motion data we captured from the TCC master, control the augmented mirror or pilot the drone. Finally, all the result will display on the HMD.

4.1 Implementation

For the core of our system, the main app running on HMD, continually receives the images from the fisheye camera of the drone through wireless communication, and the motion data is applied to the surrounding coaches.

We design a playing system to present the motion data on the virtual coaches, which can be controlled by gesture, clicker or voice command. When the user says “play” and “pause” or use tap gesture, or even click the clicker, it can switch between “play” and “pause”. The user can also adjust the playing speed by saying “fast” or “slow”, and adjust the current form by saying “next” or “Last”. Due to the limitation of HoloLens FOV and the difference of each user, some users may see the virtual coach out of the projection area. In order to solve this problem, the user can adjust the height of the virtual coach by dragging the coach after saying “height”.

In the part of the augmented mirror, the user can see the mirror only when each time the user gazes at the same coach for a while. The mirror will appear next to the coach which the user is gazing at and will show the images acquiring from the drone. Besides, due to the wide FOV of the drone, we define two positions (i.e. front sight of the user and back sight of the user) where the drone will hover at and photo the user. The user can pilot the drone to these positions by saying “front” or “back”.

4.2 Hardware Configuration

The optical see-through HMD we used is Microsoft HoloLens. It offers 30*17 degrees FOV of holographic and 120*120 degrees FOV of depth sensor. The overall rendering performance is 30 fps. The drone we used is Parrot Bebop2. It is equipped with a 180 degrees FOV camera which is stabilized, and the video fps is 30. The entire software system is developed based on the game engine Unity3D 5.5.0f3 with the Microsoft HoloLens SDK.

5. EXPLORATORY OBSERVATION STUDY

To understand how this enabling visualization can be applied to design training system for the Tai-Chi Chuan self-practicing, we demonstrate in two exhibition events, 60 participants were interviewed after experiencing our system.

5.1 Procedures

First, we introduce the function on the optical see-through HMD and the usage of the drone. Then, the user is asked to follow the first section of 108 forms of Yang-style Tai-Chi Chuan. In the end, a 5-10 minute interview was taken.

5.2 Results and Discussions

During the two exhibition events, various feedbacks were gathered. We divided those feedbacks into two categories, which were visualization of standard movement and self-reflection.

5.2.1 Visualization of standard movement

Most of the user focus on the virtual coach at the front, which we called attention-sticking problem. They follow the movement from the coach until they cannot see the coach anymore. Then, they move their head to find the other coach, which is in front of the user. During the different directions of the movement, the users report that the field of view (FoV) is not wide enough. Therefore, while the user face between the coaches, there was no virtual coach in the FoV. This may be improved by providing more virtual coach surrounded by user (as Figure 4), or the FoV from the HMD can be wilder. SpiderVision [7] has shown an example about what human can do with extended FoV.

5.2.2 Self-reflection

The augmented mirror is used to provide the reflection of student posture. Many users mentioned that this tool can be used in many physical activities such as dancing or yoga. To compare their self-image to the standard posture, we found that there have two kinds of situation for the users. Most of the users put the augmented mirror next to the virtual coach, but some of the users put the augmented mirror behind the coach, which is more like overlapping the self-image with the virtual coach at the user perspective. Additionally, although the augmented mirror can be always shown on the HMD, many users would ignore the head movement of the virtual coach and tended to use their head to control the mirror. In fact, the head movement is part of the TCC which needed to be learned. Therefore, to avoid such situations, we suggest that the placement of the augmented mirror could be fixed in the environment, instead of fixing in the middle of the HMD, e.g. fixed beside the gazed virtual coach.

6. CONCLUSION AND FUTURE WORK

In this paper, we propose an augmented-learning tool for practicing Tai-Chi Chuan after learning with the coach in the classroom, which provides surrounding virtual coaches with adaptive augmented mirror. Additionally, this system can let students observe their actions via the first-person views and self-reflection simultaneously with a see-through HMD and a drone. For future work, we will enhance the control of the drone, so the drone can automatically move and recalibrate to the proper position for shooting the video of the user's action, and a further user study will be investigated.

7. ACKNOWLEDGEMENTS

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