Flying Sports Assistant: External Visual Imagery Representation for Sports Training

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ABSTRACT

Mental imagery is a quasi-perceptual experience emerging from past experiences. In sports psychology, mental imagery is used to improve athletes' cognition and motivation. Eminent athletes often create their mental imagery as if they themselves are the external observers; such ability plays an important role in sport training and performance. Mental image visualization refers to the representation of external vision containing one's own self from the perspective of others. However, without technological support, it is difficult to obtain accurate external visual imagery during sports. In this paper, we have proposed a system that has an aerial vehicle (a quadcopter) to capture athletes' external visual imagery. The proposed system integrates various sensor data to autonomously track the target athlete and compute camera angle and position. The athlete can see the captured image in realtime through a head mounted display, or more recently through a hand-held device. We have applied this system to support soccer and other sports and discussed how the proposed system can be used during training.

Figure 1: External visual imagery capturing system: User can experience the external views captured by a camera mounted on the aerial vehicle.

Categories and Subject Descriptors

H.5.2 [**Information Systems**]: Information Interfaces and PresentationUser Interfaces[Prototyping]

General Terms

Human Factors

Keywords

Sports Assistant, Aerial Vehicle, Mental Imagery

1. INTRODUCTION

Previous studies have shown that athletes use mental imagery for improvement of sport skill performance [2, 8]. White and Hardy have defined mental imagery as: *An experience that mimics real experience. We can be aware of "seeing" an image, feeling movements as an image, or experiencing an image of smell, tastes, or sounds without actually experiencing the real thing... It differs from dreams in that we are awake and conscious when we form an image* [14].

Although the mechanism of mental imagery is still under debate [1], mental imagery serves two functions in sport because of the many possibilities of its usage [10]. One is motivational imagery, which is related to individual goals and physiological arousal emotions. The other is cognitive imagery, which includes images of specific sport skills, strategies and game plans. Athletes can imagine the execution of a skill from the perspective of an external observer as if they are watching themselves as the spectators in the stands (external visual imagery) [7].

The important point is that one's own self is seen in external visual imagery. This is because external visual imagery mediates visual and internal kinesthetic information. For example, during goal-directed reaching, visual information is an important aid for remapping sensory-detected arm positions [13]. It is easy to get visual information about motor behavior except behind oneself. Thus, athletes have to use external visual imagery for integrating kinesthetic and visual information in an environment lacks mirrors, videotapes, or coaching.

Visual imagery vividness is an important factor that contributes to effective sport skills [12]. However, it is difficult for nonprofessional athletes to vividly imagine external visual imagery due to their lack of experience. Mental imagery forms an image that arises from memories not directly from the sense organs [5]. Therefore, we have developed a representation system for gaining visual experience from an external point of view. We have adopted an aerial vehicle camera system with the capability to track and pursue a user (Figure 1). The user can see the camera vision as external visual imagery through a head mounted display or a handheld device.

2. EXTERNAL VISUAL IMAGERY

Most of the research on imagery ability has focused on processing imaginary mental visualizations, often referred to as imagery perspective [7]. Athletes can imagine themselves performing from the perspective of an external observer. For using this imagery for visual-motor adaption, it must contains the athlete's own image. One supporting subject is that visual information contributes to motor accuracy [13]. When you reach for an object within your sight, sensory information about the spatial location of the target is used to plan and initiate appropriate movements. We define "external visual imagery" as follows: It is external an vision from the perspective of others, and it contains self-image.

External visual imagery experiences are perceived by their subjects as echoes, copies, or reconstructions of actual perceptual experiences from their past. A eminent athlete can assemble vivid external visual imagery from several previous experiences, but it is difficult for nonprofessional athletes. Therefore, we have developed a representation system that facilitates the perception of external visual imagery.

We have proposed two representation methods: delayed representation(Figure 2(a)) and real-time representation(Figure 2(b)). Delayed representation is a method that shows a user his external visual imagery after capturing it. Real-time representation is a method used to show to a user his external visual imagery in real-time. The user can combine external visual information and internal kinesthetic information using a head mounted display.

3. FLYING SPORTS ASSISTANT SYSTEM

We have developed a prototype system for capturing and representing external visual imagery. This system includes an aerial vehicle with an onboard camera for capturing external visual imagery and a command and a control PC that computes its pathway. The aerial vehicle can autonomously maintain a stable flight and follow commands sent by the command-and-control PC. The command-and-control PC sends navigation commands to the aerial vehicle according to the information received from the aerial vehicle sensor and user input.

3.1 Aerial Vehicle with Camera

We have used an AR. Drone[11] from Parrot Inc, as the platform for the autonomous aerial vehicle with an onboard camera. It sends sensor information, including the onboard

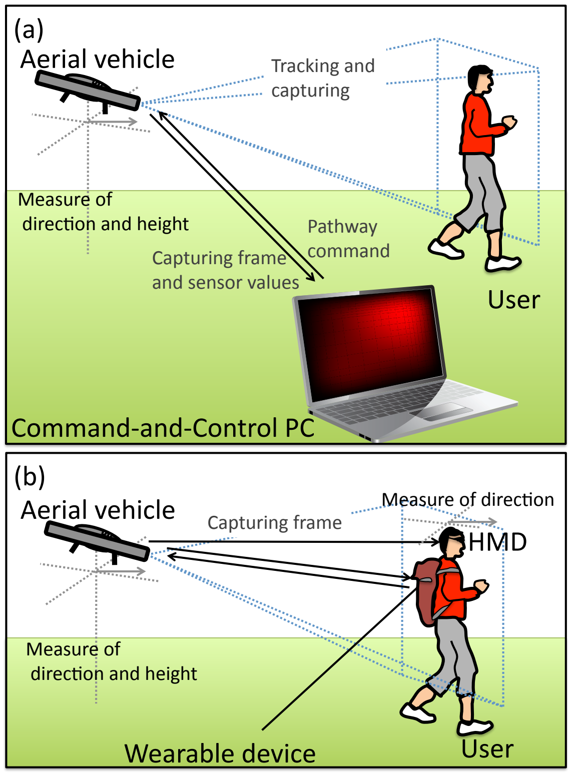

Figure 2: System configurations to represent external visual imagery:(a) Delay representation. (b) Realtime representation.

camera view and its height, through a downside ultrasonic sensor to the command-and-control PC. We have also added a digital azimuth compass to estimate the absolute directions of the aerial vehicle and the track. The command-and-control PC estimates the aerial vehicle's pathway using this information. The aerial vehicle's parameters, i.e., velocity, height, and direction are controlled by the command-and-control PC. The user can also control the state of the aerial vehicle, including its velocity, height, and relative angle using a portable device (Figure 3). For computing the relative angle *psi* between the angles of the user *theta* and the aerial vehicle *phi*, they equip each digital compass (Figure 4).

$$\psi = (\theta - \phi) \ mod \ 2\pi$$

3.2 Human Tracking

In order to visually represent external imagery, simultaneous user recognition and tracking is required. In this research, we have performed a color extraction and particle filtering algorithm for human tracking. The system requires the subject to wear a discriminative color suit (In this research, discriminative color is red). It determines and tracks the subject by recognizing only a specific color. the captured image data contains noise because of variable color. Particle filter algorithm enables noise-robust tracking by observing time-series data; further, it estimates the current and subsequent states of the tracked object [3].

We configured the system to initialize 1000 particles in a QVGA-size (320 × 240 pixel) image obtained by the on-

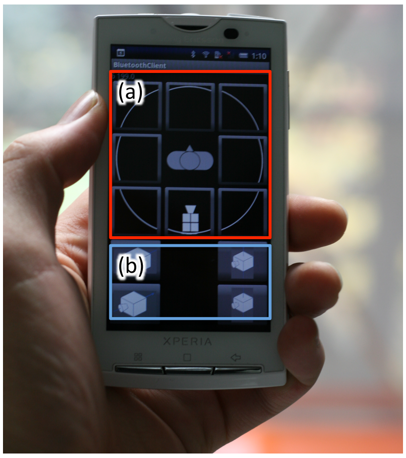

Figure 3: Portable device: (a) User can control relative angle between the user and the aerial vehicle by touch-controlling the panel. (b)User can control the aerial vehicle's state i.e., height and velocity

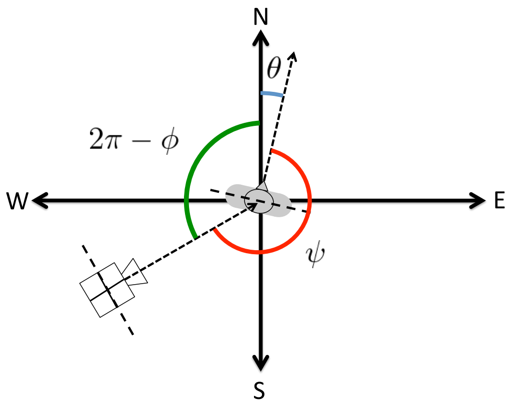

Figure 4: Relative angle ψ is calculated from the user angle θ and aerial vehicle angle ϕ.

board camera of the aerial vehicle. The system samples each particle with a dispersion of 32 pixel. Each particle's gravity is subject's area window size bounds for 10 × 10 pixel.

4. RESULT

We applied this system to capture playing soccer and stair climbing scenes as examples of delayed representation. It could capture the sequence of a player dribbling the soccer ball in the field and shooting it to score a goal (Figure 5). It could also capture the stair climbing scene (Figure 6).

However, the examples of delayed representation had two problems. In the soccer scene, the player had to dribble the ball slowly because he ran faster than the aerial vehicle. In the stair climbing scene, the aerial vehicle often aborted height modulation due to the measurement error of the ultrasonic sensor.

The system also captured a practice running (Figure 7 (a)(b)) and swinging of a baseball bat (Figure 7 (c)(d)) scenes as real-time representations. the user could watch

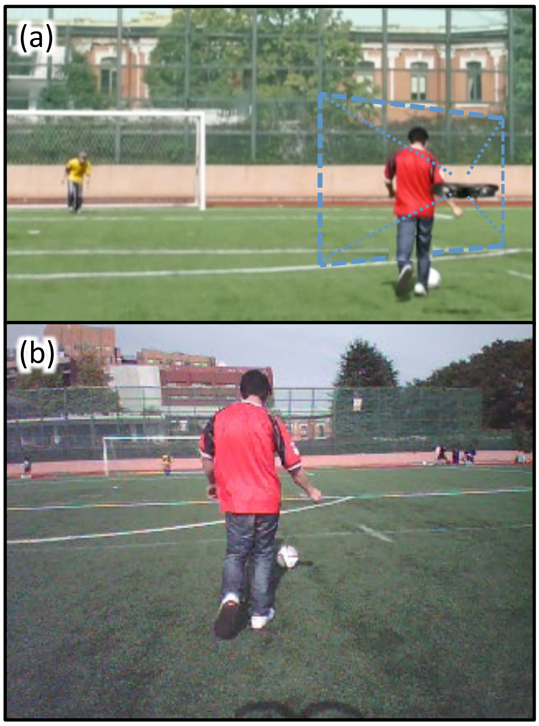

Figure 5: (a) Aerial vehicle following the user playing soccer. (b)External visual imagery obtained from the vehicle.

external visual imagery in realtime.

5. DISCUSSION

Losing Presence Identity

After several experiences of realtime external visual imagery, we found out that external visual imagery would distract presence identity. It is unusual experiences of representation both ego-centric visual information and intrinsic kinesthetic information. Surely, using a more sophisticated display, including virtual reality displays, would provide immersive external visual imagery. However, the feeling of losing reality may be natural while viewing external visual imagery. In sports psychology, self-monitoring refers to self-consciousness externalization [4]. To induce the feeling that your body is no longer yours contributes to the composition of a vivid external visual imagery.

Sports Training Application

During training, a performer uses feedback to detect errors in his performance by comparing his movements with the expected goal in order to improve the next attempt. Recent, advances in technology have made it possible to augment and improve the feedback that performers receive during training and competition [6]. For instance, for hammer throw training, Ohta et al. proposed cybernetic training using a few miniaturized sensors for biofeedback [9]. The system propose by us exhibits the possibility of facilitating real-time video feedback training for long-distance sports including marathons and cross-country skiing.

Figure 6: (a) Aerial vehicle following the user climbing stairs. (b)External visual imagery obtained from the aerial vehicle.

6. CONCLUSION

In this paper, in sport psychology, we have introduced external visual imagery derived from mental imagery. We have developed an external visual imagery representing system using an aerial vehicle. The results of the experiments performed by us have shown that our system can be applied to cybernetic training.

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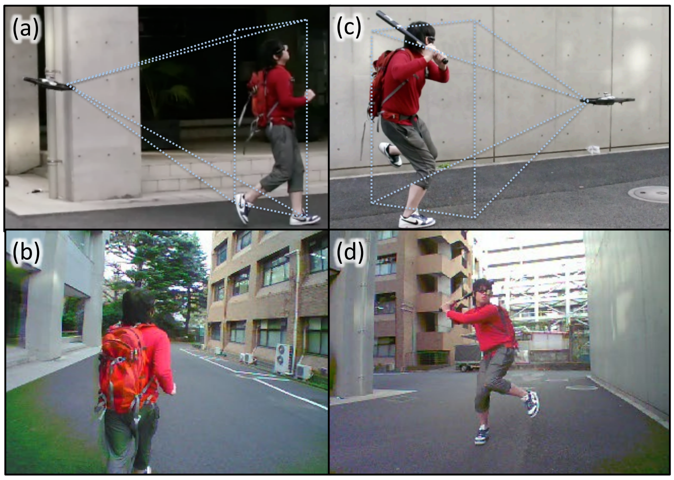

Figure 7: (a) Aerial vehicle following the user who is running. (b) External visual imagery of (a). (c) Aerial vehicle following the user playing baseball. (d) External visual imagery of (c).

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