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The Giant Experience: Visual Transfer Design to Virtually Extend the User’s Body

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Abstract

Large-scale tasks in the field, such as site investigation or civil engineering projects, require workers to have a certain level of situational awareness. However, the coverage area is too broad to investigate at once in real time because the scale of the human body is small in comparison with the size of the domain being studied. We propose the concept of experience from the perspective of a giant to virtually extend operator body size. In this study, we focus on design requirements for binocular vision, which requires a much wider pupillary distance in proportion to a much higher point of view altitude; this allows users to perceive their own bodies as being virtually enlarged.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1. Introduction

Virtually extending the human body to a giant scale can achieve remarkable performance of tasks normally beyond the ability of human operators for reasons of scale. This is shown in Figure 1. The concept of “experience as a giant” proposed in this paper is to perceive a high-altitude, first-person view as if the user has full control over a giant’s body.

This concept offers advantages in situations where large-scale tasks in the field, such as site investigation or civil engineering projects, require workers to integrate information over a coverage area too broad to investigate at once in real time because of the relatively small scale of the human body. In contrast, a virtually giant-user can easily perform these large-scale tasks. The goal is to achieve telexistence, enabling a change in virtual body geometry to fit physically large-scale tasks.

2. Related Work

While previous telexistence systems [FFK*12] have used avatars to represent the user’s body virtually, the size of the avatar was kept similar to that of the human user. Naturally, this maintains geometric similarity including eye position, head size, and height of the user relative to physical surroundings. Saakes et al. propose using a flying camera to provide a third-person view when remotely controlling vehicles [SCS*13]. The method shows that the third-person view allows for broader situational awareness around the vehicle and improved perception of the vehicle’s position relative to the remote area of operation. In contrast, Higuchi et al. use the first-person view from the flying camera to give the user a virtually extended body [HR13]. However, they use a monocular camera and the altitude of the camera is relatively low, similar to the user’s actual body height.

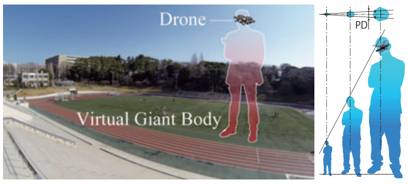

Figure 1: *Left: The concept of experience from the perspective of a giant. Right: Hypothesis on the correlation between pupillary distance and of point of view altitude.*

3. Fundamental Design and Prototype

3.1. Requirement

The goal of the virtual giant experience is to impart elements of the experience of standing while remaining grounded, furnishing a virtually extended body for the user. Therefore, there are five key requirements: (1) binocular vision, (2) extended pupillary distance (PD), (3) higher point of view

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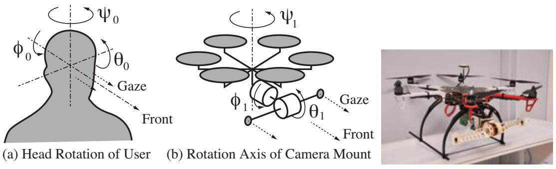

(a) Head Rotation of User (b) Rotation Axis of Camera Mount

Figure 2: *Left & Center: Corresponding head rotations for a multi-rotor vehicle. Right: Multi-rotor prototype acting as the avatar's head.*

(POV) altitude, (4) stabilization of binocular video, and (5) realization of voluntary head translation and posture.

The basic setup is as follows: user at the master side wears a head mounted display (HMD) to see a real-time video obtained by the flying camera head. This provides the user with a first-person POV situated at the virtual giant's head. The user's head position and orientation are concurrently measured and applied to the flying camera head using the algorithm described below.

3.2. Fundamental Design

First, the giant experience requires the development of a visual transfer system, which allows the surroundings to be perceived as much smaller and closer than they are in reality. For human users, the system should support binocular vision rather than monocular vision.

Second, the convergence angle creates the sensation of distance from objects. The larger the convergence angle, the closer an object appears. That is, wider PD seems to give the perception that the world is relatively smaller. Therefore, it is feasible that PD should widen for larger apparent head size if PD is kept in proportion to head size, as shown in Figure 1 (right). For these reasons, we employ wider PD than that in the case of the human body.

Third, the POV altitude is very important to the perception of body height, so POV altitude should be set in proportion to other parameters when creating the virtual, extended body image. Therefore, we hypothesize that body height is positively correlated with PD (Figure 1 (right)).

Finally, to satisfy the fourth and fifth requirements voluntary rotations and translations of the user's head must be realized at the POV of the virtually extended body. This means that the binocular camera should maintain tracking capability in the air, following the user's voluntary head movement as accurately as possible; otherwise, sensory-motor consistency is not maintained during voluntary motions such as looking around. Fuselage sway of the multi-rotor vehicle due to the wind is the dominant disturbance while in the air. Consequently, the camera platform must be designed to achieve stabilization as well as to facilitate the user's head movement. For these reasons, we employed a multi-rotor vehicle.

Assuming that translational movement of multi rotor fuselage realize the translation, the user's head rotational movement of panning, tilting and rolling $(\psi_0, \theta_0, \phi_0)$ in Figure 2(a) is assigned with the camera platform. To achieve constant performance regardless of camera platform posture, the combined center of gravity is situated on the tilting axis (θ_1) in Figure 2 (b). The rolling axis (ϕ_1) is situated orthogonally to the tilting axis. We designed a two-axis camera platform around (θ_1, ϕ_1) where the user's head panning (ψ_0) is realized by the yaw axis (ψ_1). Using the two-axis platform fixes the binocular camera with respect to the world coordinate system regardless of fuselage sway, and permits angular tracking control of the user's head posture (θ_0, ϕ_0).

3.3. Implementation of the Prototype

We built a prototype as shown in Figure 2 (right) based on the design described above. Brushless motors were installed on each roll and pitch axis. The binocular cameras are located at either end of the horizontal rod with constant PD wider than the human PD. The camera platform stabilizes roll and pitch disturbances and realizes the user's voluntary head movements. The resulting binocular vision is sent to the user using a real-time streaming protocol from Linux boards on the fuselage.

4. Conclusion

In this paper, we proposed the concept of experience from the perspective of a giant to extend the user's body size virtually. We also hypothesized a correlation between pupillary distance and point of view altitude. The demonstration prototype was developed on the basis of five requirements fundamental to the design, including binocular vision, expanded pupillary distance, of point of view altitude, tracking voluntary head movements, and stabilization of the field of view. As a next step, we will use the prototype to validate the hypothesis.

Acknowledgement

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