Telexistence Drone: Design of a Flight Telexistence System for Immersive Aerial Sports Experience

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ABSTRACT

In this paper, a new sports genre, "Aerial Sports" is introduced where the humans and robots collaborate to enjoy space as a whole new field. By integrating a flight unit with the user's voluntary motion, everyone can enjoy the crossing physical limitations such as height and physique. The user can dive into the drone by wearing a HMD and experience the provided binocular stereoscopic visuals and sensation of flight using his limbs effectively. In this paper, the requirements and design steps for a Synchronization of visual information and physical motion in a flight system is explained mainly for aerial sports experience. The requirements explained in this paper can be also adapted to the purpose such as search and rescue or entertainment purposes where the coupled body motion has advantages.

Author Keywords

Aerial Sports, Drone Telexistence, Flight Experience, Augmented Sports, Virtual Reality

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces:Interaction styles

INTRODUCTION

Humans enjoy sports everyday in their daily life. But these sports are rather limited in space and the players only have limited freedom. Sports like Skydiving, Sea Diving gives much immersive experience to the player by merging the 3D space in to their sports boundaries. However, these extreme sports are rather difficult and dangerous to try by many people at once. If we can provide an unlimited space for the players with safety, there could be many interesting new sports and even humans could see the potential of getting supernatural powers during sports. If there was a robot that could fly in the space and we could experience being that robot in the sky, what would we do?

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Figure 1. Telexistence Drone System Overview

As the applications, we can think of a race through a course created in the space, where humans and robots can cooperate. In this paper, we call this kind of sports "Aerial Sports". In previous research about telexistence [4] the authors mention that to provide a sense of presence in a remote environment, there should be visual, auditory and kinesthetic sensation coupled with the body. TELESAR V [1], shows the quality of awareness that a person can experience through synchronous visual, auditory, haptic and kinesthetic sensations. The significance and diversity of sport using the air [2] [**?**] explains new kinds of sports in air. However, flight telexistence or immersive aerial sports are not realized. Therefore, in this research, we use visual, auditory and kinesthetic sensation to achieve being in a flight experience and further to find out the requirements of a flight telexistence system for immersive aerial sports experience.

Virtual reality contents such as Birdly [3], allows the user to experience the feeling of flight with a HMD and the control unit. But it has no effect on the real world and therefore could not be used for creating a real-time sports experience. As shown in Figure 1, by integrating the flight unit with the user and thus crossing physical limitations such as height and physique, anyone can become a player and enjoy space as a new field of sports while staying on the ground.

SYSTEM DESCRIPTION

Unlike FPV Drone (First Person View) systems commercially available where the latency is not a critical issue, to experience of flying inside the drone, captured 3D stereoscopic visuals has to be streamed back to the ground user in real-time. Secondly, the ground user's head position and orientation has to be exactly matched with the drone's motion so that the user could feel the sensation of controlling the drone

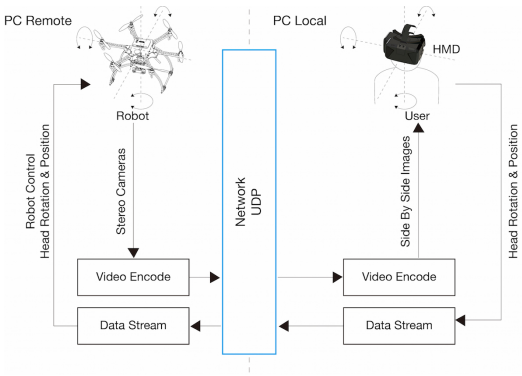

Figure 2. System Block Diagram

with his voluntary motion. The aim of the visual information transmission (streaming) system is to provide equivalent visual sensation to the ordinary human vision such as active viewpoint, motion parallax, binocular stereoscopy.

Figure 2 shows the overall system structure of the flight telexistence system. A 1 DoF (Tilt) Robotic head is attached to a Hexacoptor Drone system (Model No: DJI F550 Flame Wheel ARF). Two USB 2 Cameras (Model No: Logitech C615) with a Wide Conversion (x0.5) lens fixture is used to capture a wide field of view (HV: 128 $\times$72) from the sky. The visual frames were grabbed at a rate of 30FPS by the On Board PC (Intel NuC D53427RKE), encoded with H.264 and sent back to the ground player with GStreamer pipeline. The end to end video latency is measured to be 150ms when the distance is within the range of 100m. Players motion is captured from the Oculus DK2 (position, orientation) and sent to the drone as a PPS (Pulse Per Second) signal to control the altitude, roll, pitch, pan and tilt (1 DoF Robot). A commercial high power Wireless LAN router (Model No: WZR-1750DHP, IEEE802.11ac ch110, BW: 40MHz, Burst: 600Mbps) is used to receive the transmitted data from the two collinear 5GHz antennas mounted at the Drone.

To carry the onboard PC, battery for 25min of flight and Power supplies, the system was modified with special motors, carbon fiber propellers etc... The system is capable of lifting a payload of 4.0kg and the current total payload of the system was measured to be 3.3kg.

AERIAL SPORTS EXPERIENCE

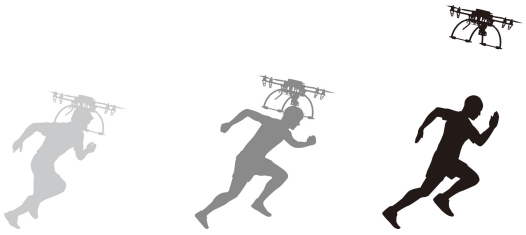

Figure 3. Aerial Sports Concept, Earthlon constituted by run and flight

As explained in the system description, the flight unit can follow the user according to his motion. For example, similar to the concept of triathlon, as shown in Figure 3, we can think of Aerial Sports "Earthlon" where human and drone collaborate to run and fly in different stages in the game. In the first part the user run like in a normal race and then he uses his telexistence drone to fly to the goal in the second part. It suggests that, Aerial Sports not only could expand the possibilities of play but also the playing tactics that were normally impossible so far.

The system is in early stages. However, as shown in Figure 4 full flight tests were conducted to evaluate the system performance as well the drone flight experience. During the test flights, users were able to control the drone with their natural movements and drive the drone in a desired path.

Figure 4. Telexistence Drone Mobile System Installed on a Park

CONCLUSION

In this paper, a new sports genre, "Aerial Sports" is introduced where the humans and robots collaborate to enjoy space as a whole new field. The effectiveness of the system has been realized by implementing "Telexistence Drone" a Hexacoptor with onboard robotic camera head with stereovision. Several test flights has been conducted to evaluate the system performance and enjoyment of crossing physical limitations such as height and physique through voluntary motion. In the future, the validity of flight type Aerial Sports has to be conducted.

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