LightAir: a Novel System for Tangible Communication with Quadcopters using Foot Gestures and Projected Image

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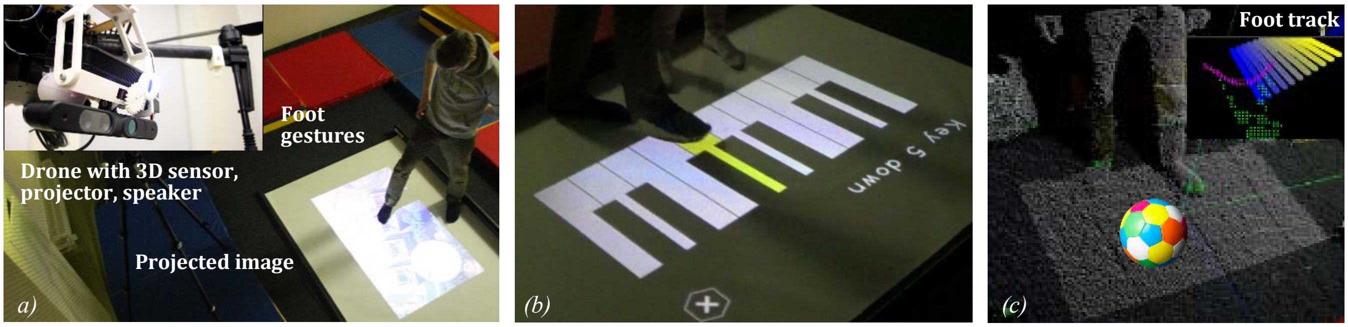

Figure 1: *(a) LightAir for human-drone communication (b) DronePiano application (c) 3D point cloud processing for DroneBall.*

Abstract

We propose a new paradigm of human-drone interaction through projecting image on the road and foot gestures. The proposed technology allowed to create a new type of tangible interaction with drone, i.e., DroneBall game for augmented sport and FlyMap to let a drone know where to fly.

We developed LightAir system that makes possible information sharing, GPS-navigating, controlling and playing with drones in a tangible way. In contrast to the hand gestures, that are common for smartphones, we came up with the idea of foot gestures and projected image for tangible interaction. Such gestures make communication with the drone intuitive, natural, and safe. To our knowledge, it is the world's first system that provides the human-drone bilateral tangible interaction.

Keywords: human-drone interaction, quadcopter control, foot gesture recognition, augmented reality, digital world, computer vision

Concepts: • **Human-computer interaction ~ Interaction devices;** *Graphics input interfaces;*

1 Introduction

Drone technology progress is extremely fast and the reason behind this is the significant interest from electronic commerce companies for parcel delivery (Amazon, Alibaba, Google, etc.), filmmakers, oil and gas industry. Nowadays, a drone is not just a device that flies but rather the device that should communicate with the human, e.g. during cargo delivery. We propose a new paradigm of human-drone interaction through projecting the image on the road in front of the user and foot gestures.

Radio controller with two joysticks is commonly used tool to hover the drone. A group of researchers from ETH Zurich demonstrated the control of quadcopter using Kinect sensor [Waibel 2011]. Hand gestures recognition lets the operator to take off, land, flip, and hover the copter. A wearable gestural interface SixthSense [Mistry et al. 2009] was designed to let user to interact with the digital world through hand gestures. In [Sugiyama et al. 2011], robot with LiDARs scans the environment and transmits the information about the obstacles to the operator through the tactile patterns. The speed and direction of the mobile robot is controlled by the torso posture of the human and, hence, the hands can be used for gesture-based interaction with the remote environment. More recently, authors [Miyoshi et al. 2014] proposed human-drone interaction with human hand tracking through camera processing the feature points. Such system enhances the level of interactivity. However, human interacting with a drone expects not only that it follows the commands but also it exchanges the digital information with us.

We developed LightAir system that makes possible information exchanging and sharing, GPS-navigating, controlling and playing with drones in a tangible way. To our knowledge, it is the world's first system that provides the bilateral digital communication.

In contrast to the hand gestures, that are common for smartphones, we came up with the idea of foot gestures and projected image for tangible interaction. Such gestures make communication with the drone intuitive, natural, and safe that is especially crucial for mid-size drones. Our experiments with LightAir revealed that drone could be an excellent communication tool between human beings and technology through the multimedia and graphic interface.

2 Principle and Technologies

The LightAir is equipped with several modules that are responsible for control and navigation: Intel NUC Kit QS77, pocket projector Optoma PK320, 3D sensor Asus, and speaker. Quadcopter DJI Matrice 100 of 1 kg payload hosts all components and flies with them robustly. Intel onboard computer processes a large amount of sensory data, such as 3D point cloud, RGB video streams, radio signals (Figure 1(a)). The designed and 3D-printed gimbal with 2-DoF moves depth camera and pico-projector jointly (Figure 2).

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SIGGRAPH '16 Emerging Technologies, July 24-28, 2016, Anaheim, CA
ACM 978-1-4503-4372-5/16/07.
http://dx.doi.org/10.1145/2929464.2932429

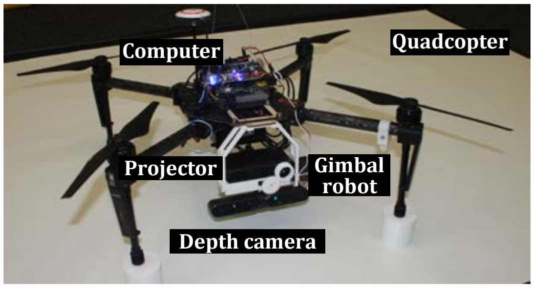

Figure 2: *Projector with the depth camera installed on quadcopter DJI Matrice 100.*

The main program sends cues to ATMega microcontroller to activate the servomotors of the gimbal robot. The gimbal features driver system for automatic adjustment of the projector focus. Program calculates the center of the virtual screen and projector focuses at that point.

The depth camera Asus Xtion determines 3D scene (Figure 1(c)). The floor is detected from the point cloud with RANSAC plane detection algorithm. Then we define the orthonormal basis of the virtual screen with the Gram-Schmidt process. The foot location on the ground is calculated from the points of the 3D cloud that arranged in predefined region above the floor. We implemented the multi-touch foot input and each press of the foot is tracked with Hungarian optimization algorithm. Secondly, we parse the orientation of the foot. The points of cloud from the depth camera are clustered into two groups representing heel and tip of the foot. Line connecting the centers of gravity of each region defines the foot orientation. We process the resulting vector using the adaptive low-pass filter.

Audio processing was realized by streaming audio data directly to the PulseAudio server. The program creates a new thread that connects to the server and streams sound for each key pressed. This way we can play simultaneously as many sounds as we want.

3 Applications and Conclusions

The proposed technology allowed to create a new type of interaction with drone, i.e., DroneBall game for augmented sport and FlyMap to let drone know where to fly. During demonstration, users will experience the following applications.

DroneBall: Football application allows users to interact with each other by kicking the ball (Figure 1(c)). Application detects the foot direction and ball responds respectively. High sensitivity makes application realistic and could be expanded in the future to the real-mode game of the player and drone. Drone will fly to the direction of the kicked ball to catch it virtually. To navigate drone autonomously we setup motion-capturing system OptiTrack Prime 13. The safety of the user during demo is secured by the net cage.

DronePiano emulates a piano keyboard (Figure 1(b)). Keys react on the user's foot as if they were real buttons: even partial appearance of the foot on the key invokes the reaction. DronePiano makes possible to press several keys simultaneously and each keypress produces its own sound. Unique music played by the drone could be generated.

FlyMap: Using image of the real-time map, drone projects it on the surface (Figure 3). The user can choose and press any point on the map and system zooms it. GPS-sensor shows the current drone position. Application calculates the approximate time along with the flight path from the given position to the selected one.

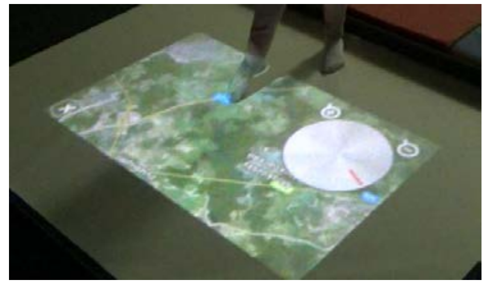

Figure 3: *FlyMap application: user can zoom in/out, and move the map to show a drone the coordinates where to fly.*

We can envision the augmented interaction with a drone while parcel delivering to check the specification and to run gadget before its unfolding (Figure 4).

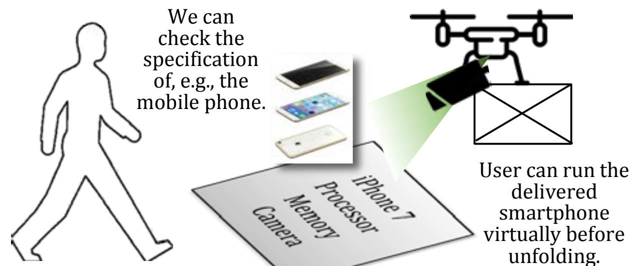

Figure 4: *Augmented parcel delivery.*

The developed technology potentially can have a big impact on the multi-modal communication and interaction with flying robots. LightAir suggests much more intimate, interactive, and immersive interaction with drones leveraging image projection and foot gesture recognition to make it tangible.

Acknowledgements

The authors acknowledge the support by Unmanned Vehicle Program, Center for Entrepreneurship and Innovation, Skoltech.

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