DroneCTRL: A Tangible Remote Input Control for Quadcopters

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ABSTRACT

Recent research has presented quadcopters to enable mid-air interaction. Using quadcopters to provide tactile feedback, navigation, or user input are the current scope of related work. However, most quadcopter steering systems are complicated to use for non-expert users or require an expensive tracking system for autonomous flying. Safety-critical scenarios require trained and expensive personnel to navigate quadcopters through crucial flight paths within narrow spaces. To simplify the input and manual operation of quadcopters, we present *DroneCTRL*, a tangible pointing device to navigate quadcopters. *DroneCTRL* resembles a remote control including optional visual feedback by a laser pointer and tangibility to improve the quadcopter control usability for non-expert users. In a preliminary user study, we compare the efficiency of hardware and software-based controller with *DroneCTRL*. Our results favor the usage of *DroneCTRL* with and without visual feedback to achieve more precision and accuracy.

Author Keywords

Quadcopter; Drone; Controller; Navigation

CCS Concepts

•**Human-centered computing → Pointing devices; HCI theory, concepts and models;** *User studies; Laboratory experiments; Haptic devices; Pointing;*

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INTRODUCTION AND BACKGROUND

Quadcopters are becoming available to the consumer market and proliferate themselves in industrial and public settings. Previously presented use cases for quadcopters include the delivery of goods [8, 13], support of activities in rural areas [12], communication of navigation instructions [1, 2, 4, 11], or availability of tactile feedback in virtual reality [10]. Depending on the usage scenario, quadcopters can be navigated manually or automatically [6]. Toolboxes [7] and design spaces are available [9] which enable industry and the general public to tailor mid-air devices for their needs. However, safety critical scenarios require an expert to fly dangerous paths or rely on an expensive tracking system which provides the necessary precision [3, 5, 14].

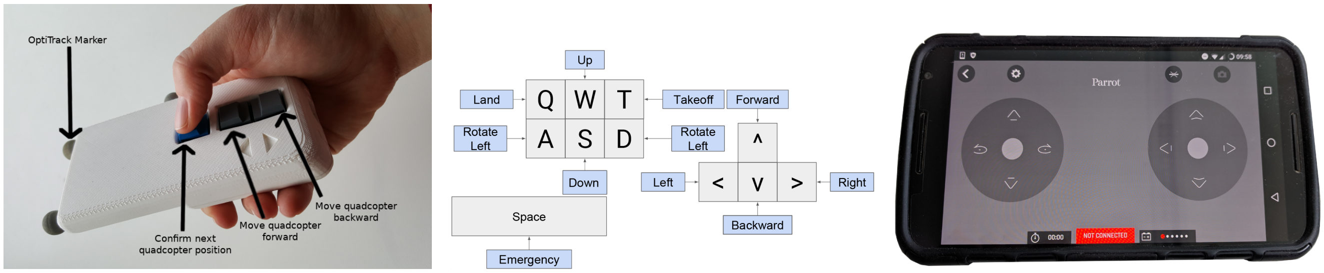
Quadcopters were either controlled by an external tracking system or were orchestrated manually. In this work, we present *DroneCTRL*, a control device for quadcopters which visually represents a simplified remote control for non-expert users. *DroneCTRL* utilizes point gestures and minimal haptic input to computationally navigate quadcopters in space. We showcase the feasibility of *DroneCTRL* compared to other control modalities.

SYSTEM

We outline the functionalities of *DroneCTRL* and describe the overall system architecture in the following.

DroneCTRL

We introduce *DroneCTRL*, a simplified tangible remote control to steer quadcopters (see Figure 1a). *DroneCTRL* consists overall of three buttons comprising a *movement confirmation*, a quadcopter *forward* request, and a quadcopter *backward* request. The quadcopter is controlled by pointing with *DroneCTRL* to a direction and pressing the *movement confirmation* button when the flight route or position is decided. The quadcopter can



(a) (b) (c)

Figure 1. Three quadcopter input modalities. (a): Remote control with a built-in laser pointer. (b): Keyboard-based controller consisting of a keyboard. (c): Software-based controller on a smartphone.

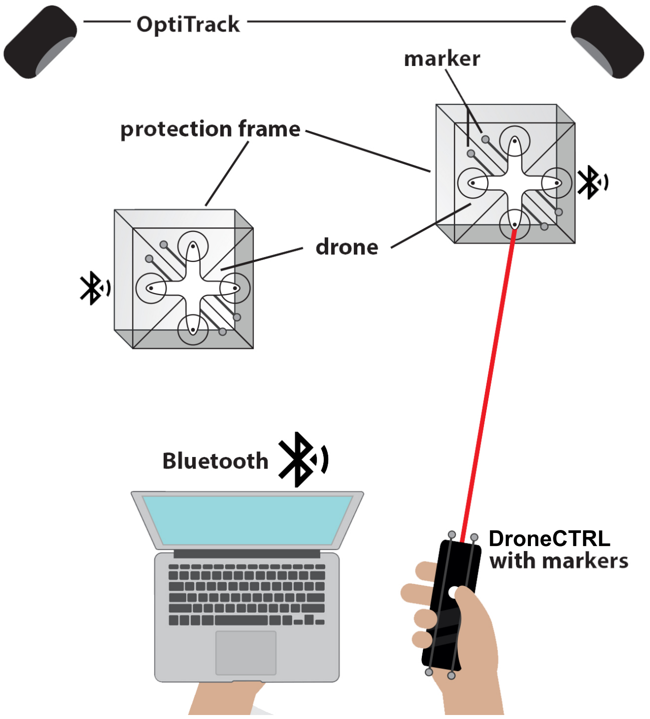


Figure 2. System description of the study setup.

be moved further towards the destination point by pressing the *forward* button and moved back from it by pressing the *backward* button. We equipped *DroneCTRL* with a laser pointer to provide visual feedback about the target position. The underlying computing units are covered in a 3D printed case.

Architecture

DroneCTRL uses an ESP8266 to send button commands via WiFi to a computer. The set of commands includes the confirmation, forward, and backward movement. An OptiTrack tracking system is used to record the position and pointing the direction of *DroneCTRL*. We use a bluetooth-equipped Parrot Rolling Spider as a quadcopter. An Optitrack system is tracking the quadcopter. A PID controller is regulating the speed towards the final position where the user is pointing to. The visual feedback is provided by a built-in laser pointer which can be turned on or off. Figure 2 illustrates the overall system architecture.

EVALUATION

We perform a user study to compare three input modalities regarding usability. We compare *DroneCTRL* with keyboard input (see Figure 1b) and input from a smartphone (see Figure 1c).

Task Description and Methodology

We conducted a user study with eight participants (3 female, $M = 24.5$, $SD = 2.45$) who had no prior experience with quadcopters. Participants had to steer the quadcopter to reach different mid-air spots in a closed room. In a within-subject design, participants used the different quadcopter control modalities in a counterbalanced order to accomplish this task with four levels.

The targets were distributed evenly in a room. We marked six different positions at three different heights as targets for the study, resulting in 18 different targets per condition. The room itself was equipped with an optical tracking system to track the precision of the quadcopter. We recorded the final quadcopter position when the participant confirmed the final position verbally. We measured the task completion time in seconds and quantified the precision using the distance in meters from the final target of the quadcopter.

Preliminary Results

DroneCTRL with no visual feedback (i.e, laser pointer off) showed the fastest task completion time ($M = 11.5$, $SD = 7.23$) when it comes to reach the targets compared to the smartphone input ($M = 12$, $SD = 9.45$), keyboard input ($M = 14$, $SD = 7.33$), and *DroneCTRL* including visual feedback ($M = 19$, $SD = 13.79$). Participants stated, that they had to find the laser pointer first before they could confirm the final position. In converse, our results show that *DroneCTRL* with visual feedback performed best when it comes to achieve a high precision ($M = 0.129$, $SD = 0.043$) compared to keyboard input ($M = 0.137$, $SD = 0.048$), *DroneCTRL* without visual feedback ($M = 0.149$, $SD = 0.083$), and smartphone input ($M = 0.157$, $SD = 0.072$).

CONCLUSION AND FUTURE WORK

In our work, we present *DroneCTRL*, a remote control for quadcopters to simplify the control of quadcopters using pointing gestures. In a preliminary study, we show that *DroneCTRL* without visual feedback provides lower task completion times compared to additional visual feedback, keyboard, or smartphone input. We found, that the precision is higher with *DroneCTRL*. Since most participants were able to reach the targets, we believe that *DroneCTRL* substitutes traditional quadcopter input modalities. For future research, we will develop an enhanced version of the current prototype which is able to communicate directly with the quadcopter, obviating the need for a tracking system.

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