Real Time, Onboard-only Landing Site Evaluation for Autonomous Drones

by

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Abstract

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I would like to thank the Flying Spaghetii Monster and his noodly appendage.

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Chapter 1

Introduction

1.1 Problem Statement and Motivation

The goal of the proposed research is to explore the topic of autonomous, unstructured drone landing. Current autonomous landing methods have at least one of the following disadvantages: they are blind to obstacles, they require previously *known* landing sites, they depend on sophisticated ground control stations for offloading of expensive computation. This proposed research targets a gap in current autonomous landing methods. Specifically, we aim to develop a method for quickly analyzing terrain and identifying safe landing sites using only embedded computational hardware and a minimal set of sensors.

Landing is a particularly difficult aspect of drone flight, owing mainly to its risky nature and required precision. As a result, most drone landings are carried out by (or under the supervision of) a human operator, inherently limiting the applicability of autonomous drones. Some autopilot software includes an Application Programming Interface (API) for *precision landing*, which allows a drone to localize and direct itself with respect to a landing pad during an autonomous landing, according to data provided by external sensors and programs. However, there is no particular method of autonomous landing in widespread use. As autonomous and semi-autonomous drones are not able to reliably handle landings on rough terrain or in non-ideal conditions, human operators often disable autonomous control during landing (opting for full manual control), or abuse/hack the landing system by descending to a low altitude, grabbing hold of the drone, and disabling the motors, as shown in Figure 1.1. Aside from potentially exposing users to dangerous rotors, this landing technique showcases the limitations induced by a lack of autonomous landing method.

In sufficiently flat, large areas, fully autonomous drone missions can end with a GPS-based autonomous landing which is blind to obstacles in the environment. However, intuitively and demonstrably, this can lead to crash-landings at landing sites that have obstacles within the error radius of the GPS, which can be anywhere from a few centimeters to a few meters. In the available open source autopilot softwares, obstacles are simply not handled, and drones will continue their landing attempts even if fatally obstructed.

1.2 Background

1.2.1 Autopilot Software/Hardware

The most prominent, open source drone autopilot software packages are ArduPilot [1] and PX4 [3], which can integrate easily with many additional/custom software packages. DJI drones, while the most commonly used consumer-grade drones, use proprietary, closed source autopilot software that has a limited API for interacting with external software. Thus, ArduPilot and PX4 and custom drones are typically used for research on drones themselves, while DJI software

Figure 1.1: Non-ideal, human-assisted landing in the absence of an autonomous, safe landing method that considers the surrounding environment.

and drones are typically used for consumer/commercial tasks. ArduPilot and PX4 communicate using the same open source, customizable protocol - MAVLink [2] - which has APIs in many different programming languages as well as with Robot Operating System (ROS).

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[3] Lorenz Meier. Pixhawk. (accessed: 2020.6.5).