6 DEGREE OF FREEDOM UAV CAPABLE OF HIGH SPEED AUTONOMOUS TRANSLATION AND LOCALIZATION

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1. Introduction

Quadrotors have surged in popularity in part due to their simple mechanical construction. They require only four rotors that are all in the same plane but, they have the disadvantage of being non-holonomic[1]. Several published designs have been proposed which add to, and rearrange, the propellers of a traditional quadrotor for holonomic control. In [1, 2, 3] hexacopter designs are proposed that employ three pairs of rotors oriented such that the normals of the planes formed span three dimensional space. Another approach is to use tilting rotors as seen in [4, 5]. A completely omnidirectional design using a novel propeller configuration is demonstrated in [6, 7]. These designs all attempt to solve the problem of achieving 6 Degree of Freedom (DOF) control for a UAV, regardless of its orientation.

We propose to achieve 6 DOF control of a UAV by mounting four side-rotors onto a quadrotor airframe. This technique is seen in [8, 9] where a single side-rotor is added so that the multicopter can accomplish a specific task[2]. The idea using four side rotors was explored in [10] however the results did not clearly demonstrate superiority or lack thereof of the design compared to a traditional design. In short, this project will not attempt to decouple orientation and translational control as seen in [1, 2, 3, 4, 5, 6, 7]. Instead this project aims to dramatically increase accuracy and speed of translational performance compared to a typical quadrotor using the side-rotors. Localization accuracy will also improve due to the drone's sensors remaining in a fixed orientation compared to the region of interest.

[1] Holonomic: controllable degrees of freedom are equal to the total degrees of freedom.
[2] Specific tasks: UAV pulls a door open, UAV holds itself against a wall

2. Goals

- Build an autonomous UAV capable 6 DOF control.
- Show viability of side pushing propellers as a 6 DOF control solution.
- Develop power distribution board to with emergency stop and power monitoring.
- Demonstrate utility for industrial, military, commercial, or domestic applications.
- Develop control system for holding positions and moving to waypoints.

3. Deliverables

- Construct a lightweight drone for the purpose of testing (Use RAS resources).
- Attach side pushers to the drone.
- Modify existing flight-controller software to allow development and prototyping of side pusher designs (will likely be completed before start of spring semester).
- Analyze drone with and without side pushers and develop plant model for both.
- Develop controller for precisely actuating the drone using plant models.
- Gather sensor data from TOF rangefinder, IMU, and optical flow sensor.
- Fuse sensor data with EKF using embedded linux system running ROS.
- Perform tests to show improvement in localization and autonomous actuation.
- **Tentative:** Gather position data from motion capture system.

4. Conclusion

6-DOF UAV technology is a promising improvement on the traditional quadrotor design. 6-DOF controls will allow future drones to demonstrate unparalleled avoidance, nimbleness, control, and autonomous flight capabilities. In particular, 6-DOF control is useful in indoor and physically constrained environments where agility is necessary, and localization is challenging when using onboard methods. This study aims to demonstrate the agility and localization improvement that a side rotor design offers. In light of recent studies, we think the side rotor design is undeservingly neglected and deserves another look.

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