University of New Hampshire
Department of Mechanical Engineering &
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Quad-X Swarm

Autonomous Quadcopter Missions

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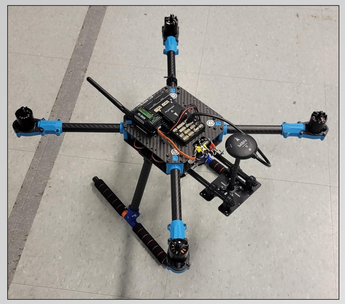
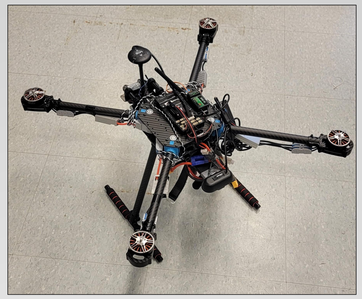
Introduction

UNH Quad-X Swarm is an interdisciplinary group comprised of students from the Kingsbury Design Lab, who specialize in the disciplines of Mechanical Engineering and Computer Science. The team has been dedicated towards the research and implementation of autonomous quadcopter missions, primarily focusing on obstacle avoidance for search & rescue applications, and package pickup & delivery. Future applications of our research would involve a swarm of interacting quadcopters all capable of completing the designated missions.

Quadcopter Models



Base X500 Quadcopter



Improved X500 Quadcopter

Upgraded Components

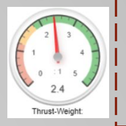
Rotors
Rotor length increase from 10" to 13"

Motors
Base

Upgraded

Original

Upgraded

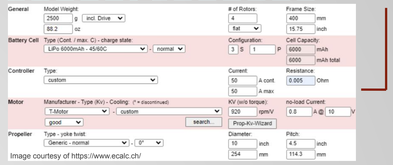


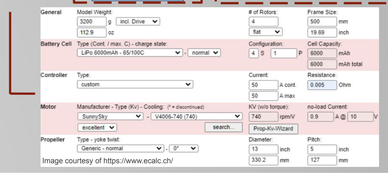
ESCs
Base

Upgraded

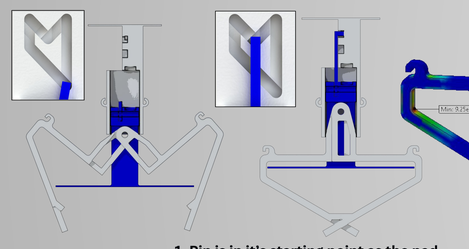
Battery
Base: 3 cell, 11.1 V

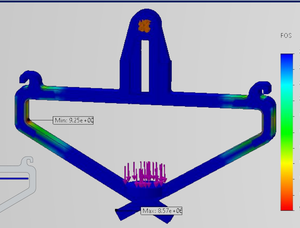
Upgraded: 4 cell, 14.8 V





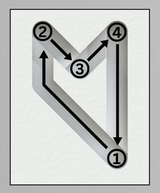
Package Pickup Mechanism



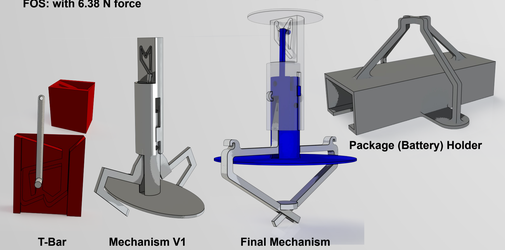


FOS: with 6.38 N force

Design Goals
1. Ease of use for autonomy
2. Consistency
3. Lightweight; no additional motors or battery needed
4. Easily attachable to quadcopter



1. Pin is in it's starting point as the pad is lowered and claws are allowed open.
2. Object pushes pad and pin upward, closing the claws around it.
3. Pin and pad drop slightly into it's resting point during transport, claws remain closed.
4. Object pushes pad and pin upward once more, allowing the pin and pad to fall back to it's starting 'open' state



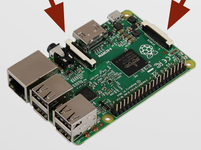
T-Bar | Mechanism V1 | Final Mechanism

Package (Battery) Holder

Added Sensors

3x LIDAR Sensors for obstacle detection and avoidance

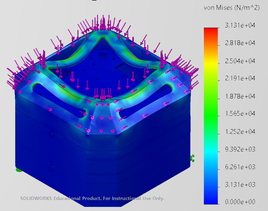
Downward facing camera for package AprilTag recognition



Processed through Raspberry PI

Protective Casing

- Modular 3 layer casing
- M3 screw attachment
- PETG material
- Bottom layer attaches
- Protects Pixhawk, GPS, transmitter, and Raspberry PI
- 20 lbf impact with a S.F. of 1.5



Flight Battery Data

Temperature vs. Flight Time Quad Data

Wind Speed vs. Flight Time Quad Data

LIDAR Mounts & Setup

The positional layout of the Lidar calls for 3 sensors to detect the front 90° field of view. The sensors have a range of 40 m with a positional accuracy of ±2.5 cm within 2 m. The Lidar sensors provide the positional coordinates of obstacles used in the obstacle detection algorithm

Screws tighten to lock rotational and linear position of Lidar on the wing

Issues with barometric sensors for altitude detection called for the reliance of Lidar. The sensor is mounted vertically facing downward to provide more accurate altitude readings which is key in automating package pickup.

Physical/Components

Connecting to the QuadCopter:

- A user for the quadcopter system SSH's into the Raspberry PI through a private network that they both share
- Through that SSH connection the user can send commands to the PI
- The PI then talks to the Pixhawk Controller, which carries out movement, taking measurements, and gives information back like GPS
- The laptop can also communicate to the Pixhawk controller to do maintenance checkups on the motors, GPS, EMC's, accelerometers, etc. This is done through QGroundControl which uses telemetry

Software Design

ROS2 and Software Design

- Flying Action Client takes in lists of waypoints from a JSON file and gives waypoints to Flying Action Server (1)
- Flying Action Server takes waypoints, gives them to the move node, then verifies that quadcopter is at that location. (5)
- Vision Node detects the package and informs the Quadcopter Control node. (∞)
- Lidar Node detects obstacles within 1m and informs the Quadcopter Control node. (∞)
- Quadcopter Control node keeps the connection alive, guides the quad to the target, manages the current mode of the quad, and begins the mission. (red hexagon)

Conclusions

The Quad-X Swarm team has successfully implemented autonomous package pickup and obstacle avoidance in simulation and is continuing working with physical testing of the missions for the remainder of the year. We hope next year's team will expand upon our work and implement a swarm of autonomous quadcopters completing the given tasks.

Acknowledgments

The Quad-X team extends our sincere appreciation to our graduate students for their invaluable expertise and knowledge throughout the year. A heartfelt thank you goes to Dr. May-Win Thein, our project mentor and advisor, for your dedication to our education and your willingness to go above and beyond to ensure our success in the field of engineering and professional lives.