SENIOR DESIGN PROJECT IN ELECTRICAL ENGINEERING

Autonomous Unmanned Aerial Vehicle

1/C BULONE, 1/C KIM, 1/C MCGAHEY, 1/C MEYERS, 1/C SCHELLMAN, 1/C VON BROCK

ADVISORS: CAPT HARTNETT, LT BLANCO, ET2 JOHNSON, AND DR. SWASZEK

SPONSORS: UNITED STATES COAST GUARD ACADEMY ELECTRICAL ENGINEERING SECTION

PROJECT BACKGROUND

The USCG can use unmanned aerial systems in conducting many of its missions. Currently, the only drone system in the USCG is the Boeing ScanEagle which requires a dedicated pilot and launching system. The Autonomous Unmanned Aerial Vehicle (AUAV) group aims to create a new unmanned system capable of accomplishing USCG missions without a pilot, at a low cost, and deployable from any platform. To guide the design process, the group is creating a drone that aligns with the requirements laid out in the RoboBoat Competition, a yearly contest of autonomous systems.

SYSTEM OVERVIEW

- Hardware: S-500 Frame, PixHawk 2.4.8 Flight Controller, Raspberry Pi microcontroller, ZED-F9P RTK-GPS, Xbee Series 3
- Software: PX4 v1.12.3, QGroundControl, Gazebo 11

REQUIREMENTS

1. Design and build a UAV that is capable of stable autonomous flight.
2. Enable takeoff and landing from the Autonomous Surface Vessel (ASV).
3. Deliver objects to a designated platform using a mechanical system.
4. Coordinate objectives and communicate with the ASV.

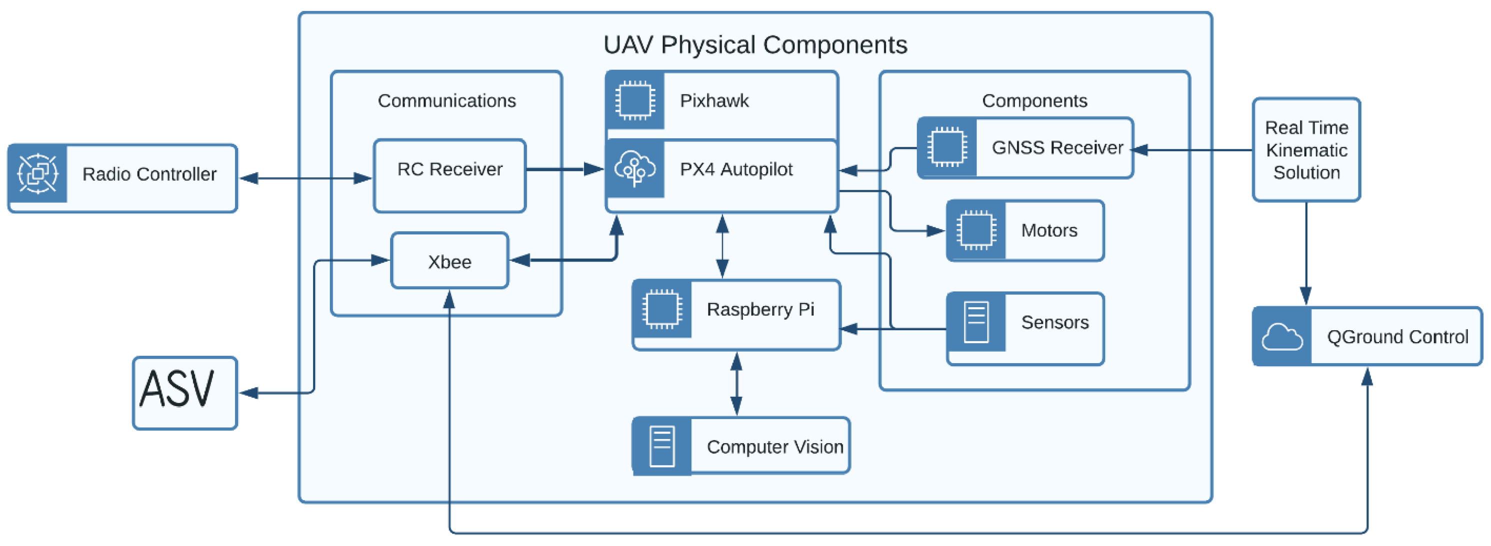

Figure 1: System Block Diagram

IMAGE PROCESSING

The AUAV utilizes an onboard Raspberry Pi 4 equipped with a standard Pi Cam module to conduct image processing. Scripts for image processing were written using the Open-Source Computer Vision (OpenCV) library, a python library with the primary purpose of support objectives in processing images and videos. The current image processing suite is designed for the detection of ArUco markers, markers containing an inner binary matric composed of white and black squares. Figure 2 shows an ArUco marker landing solution, which is a small marker inlayed on a larger marker. This was chosen due to limitations in detection of the larger marker when the vehicle flew closer to the landing platform. Figure 3 displays four stills of the image postprocessing conducted to improve ArUco detection rate. The identification of these markers provides necessary data to an onboard logic controller that autonomously lands, delivers payloads, or otherwise controls the AUAV.

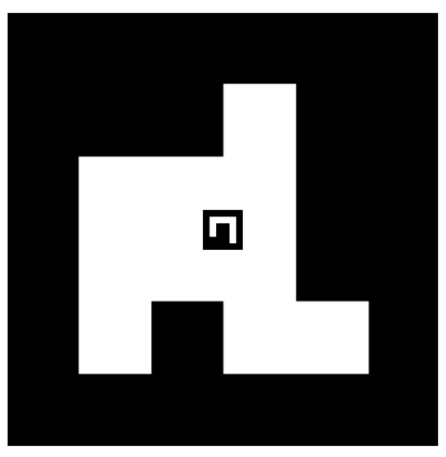

Figure 2: ArUco marker

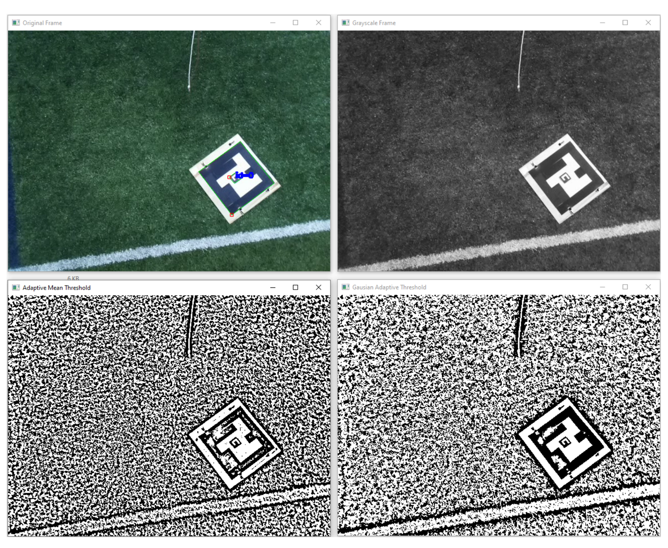

Figure 3: Imagine Refinement

AUTONOMOUS FLIGHT

A key performance parameter of the AUAV is support of autonomous flight. PX4, the autopilot software, features several flight modes including command-driven flight. GPS controlled autonomous flight demonstrates the ability to fly predetermined paths and simulated search patterns. An offboard vision-enabled controller further enables autonomous landing, payload delivery, and localization. In all stages of flight and flight testing, the AUAV demonstrates stable flight characteristics.

Figure 4: Image of Final UAV Design

PAYLOAD DELIVERY SYSTEM/LANDING

The AUAV is required to transport a ping-pong ball sized object. This has been accomplished with the scoop mechanism in Figure 5, actuated by a micro-servo motor. To secure the drone while landing on a moving platform, a Velcro ArUco marker was created. The Velcro creates enough friction to prevent movement of the drone while still allowing for take off.

Figure 5: Payload Delivery System

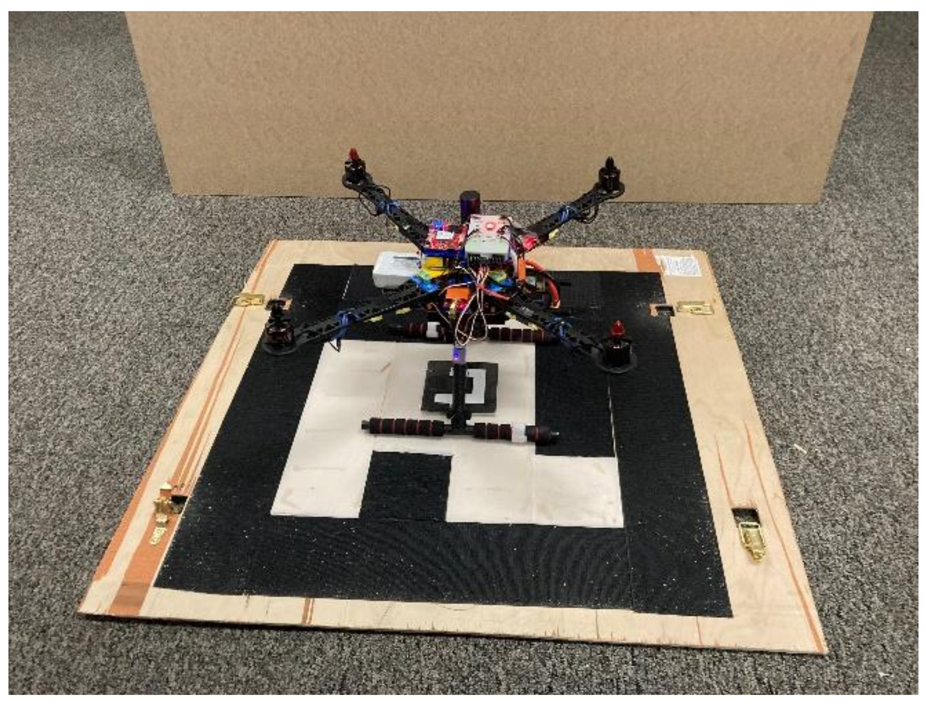

Figure 6: Velcro Landing Solution

RESULTS

An Autonomous Unmanned Ariel Vehicle (AUAV) has been designed and completed according to the requirements imposed by the RoboBoat Competition alongside several self-imposed constraints. The weight, flotation, and component requirements of the RoboBoat Competition have been satisfied. A mesh communication network has been established to facilitate broadcast and direct transmission of critical telemetry and other data. Autonomous flight, landing, search, and payload delivery have been validated in accordance with testing procedures. The AUAV Capstone is positioned to fulfill the requirements of the Autonomous Surface Vessel (ASV) in the RoboBoat Competition. Further work is required to begin adjoining the distinct AUAV and ASV systems.