Summarization of Journal Paper for AUVSI SUAS 2022

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1 Aircraft

- the aircraft we selected is the Hangar 9 3.1m Sukhoi ARF. The aircraft labelled diagram is shown in figure 1.

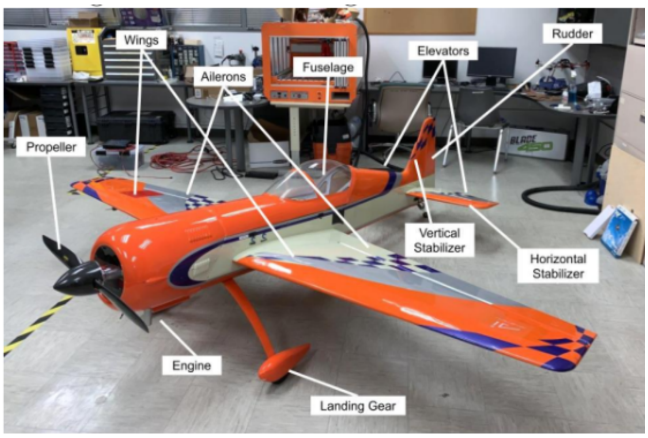

Figure 1: Labelled Diagram of the Aircraft

2 Air Drop

2.1 Payload

- They used a two wheel payload system using an Arduino micro controller to control the all motors in the system.

2.2 Drop Mechanism

- They used a set of bay doors installed into the belly of the plane linked with Smartfly and Pixhawk 4 to drop the payload and deceided to drop the load when its above the target.

3 Autopilot

3.1 Autopilot Software

- The aircraft is controlled by a Pixhawk 4 autopilot running the PX4 software.
- It can receive the mission in preflight but also allows mid-flight modifications of the mission.
- PX4 is capable of waypoint navigation so the autonomous missions it receives are mainly a set of waypoints to follow along with autonomous takeoff/landing and camera/gimbal commands.

3.2 Ground Station Software

- A custom ground station software was created using Python to ensure better control using the MAVSDK set of libraries to communicate with PX4 including sending the missions and receiving telemetry.
- It also communicates Interoperability server using the API provided by AUVSI SUAS and with user using a GUI.

4 Obstacle Avoidance

4.1 Obstacle Avoidance Algorithm

- They leverage the waypoint navigation capability of PX4 by adding additional waypoints to the missions before they are uploaded to allow for obstacle avoidance and scouting areas for imaging/mapping.
- The additional waypoints are determined using a custom version of a variant of the A* algorithm called jump point search used on a 2D projection of the flight area
- The algorithm builds a path between each two mission waypoints by either connecting them directly if possible or by creating intermediate waypoints tangent to obstacles or to border vertices to allow for obstacle avoidance within the flight area.

4.2 Scouting Algorithm

- First, exploring a grid of nodes covering the search and mapping areas while minimizing turning which leads to a spiral motion.
- Second, a path is created for going around obstacles to scout under them and along the flight area border to scout outside it. This path is paired with a set of gimbal commands to point the camera into the regions of interest.
- Finally, the 2 output paths are fed to the avoidance algorithm.

5 Imaging System

5.1 Overview

- The imaging system is comprised of a camera, three axis gimbal, and software on the ground station.
- The chosen camera for the imaging system is the Blackfly S BFS-U3-120S4C-CS sensor.
- They used the Pixy-U tri-axis gimbal that ensures the ability position the camera straight down to image the map even when the attitude of the plane is not level.
- The ground station software encompasses a small imaging software section that examines the current pixhawk airspeed and altitude data to create an imaging frequency.
- The ground station imaging code then performs object detection using the team's convolutional neural network, and creates a map using more code from the OpenDroneMapPy library.

6 Object Detection, Classification and Localization

- The detection and classification are accomplished via two custom convolutional neural networks, the first CNN is the standard object classifier. It classifies four dimensions: shape color, shape type, letter color, and letter type, the other network identifies emergent objects, and outputs a guess of the current activity of interest.
- Both of these networks are trained in part by datasets generated from custom dataset generation environments created in the Unity game development

  engine.

7 Mapping

- The mapping is largely accomplished by OpenDroneMap (ODM).

8 Communications

- The communication system consists of four parts: The plane's RC receiver, the plane's RF transceiver, the computer's RF transceiver, and the RC remote controller.
- On the software level, the communication between the PX4 and the custom ground station happens through MAVLink as handled by the MAVSDK set of libraries.

Illustration for the communication diagram shown in figure 2

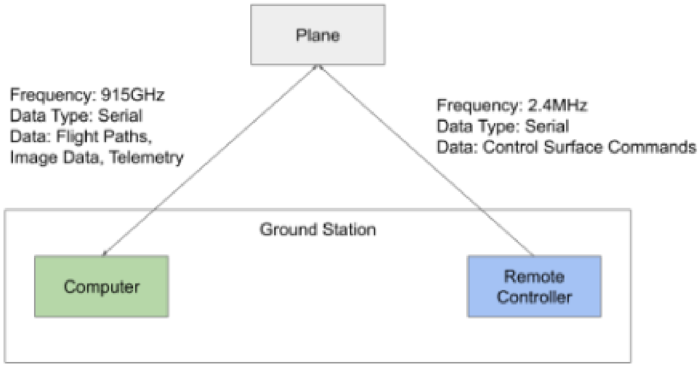

Figure 2: Communication Block Diagram

9 Alternatives

9.1 Hardware Alternatives

- Swapping from the current fixed wing plane to a VTOL plane because the air drop would be significantly easier.
- Swapping to 4-wheel ground vehicle instead of a 2-wheel ground vehicle to add extra stability and power to the ground vehicle itself.

9.2 Software Alternatives

- Not using QGroundControl as the main ground station software as there was a struggle to integrate new avionics software with it like obstacle avoidance.
- Not using grid search for path-finding as opposed to jump point search as Grid search offers paths that involves a lot of 90 degree turns which lead to overshooting from the aircraft risking collisions during turns.
- Both have object identification done in near real time via an on board computer and to beaming the images down to the ground station using the antennae were impractical. Upgrade was not possible due to budget, so the design changed to store the images on board instead.