M-Fly Autonomous

Detect-and-Avoid System and Unmanned Ground Vehicle

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M-FLY

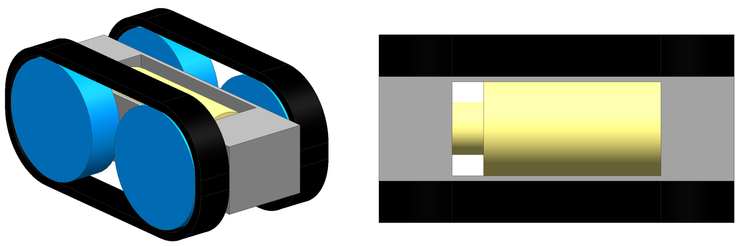
Background

- M-Fly is developing the MAT-3, an autonomous airplane for the AUVSI-SUAS competition.
- The objective of the competition is to simulate an autonomous search-and-rescue mission.
- The MAT-3 still needs a system to detect and avoid other competing aircraft during flight.
- The competition requires deploying an unmanned ground vehicle (UGV) from the air, which must land and deliver a water bottle.

The MAT-3.3 airframe, manufactured in March 2022

Objectives

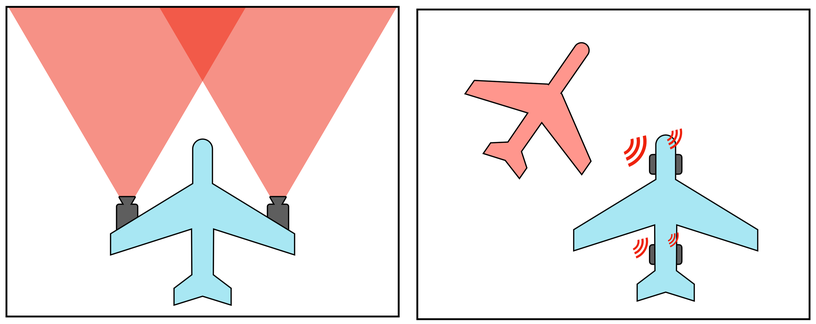
- The challenge for detecting other aircraft is choosing a cost-effective method capable of detecting another UAV.
- The system should have a range of 50-100 meters in order to give the MAT-3 sufficient time to change its trajectory.
- The UGV will be deployed from an altitude of at least 100 feet.
- The UGV should be able to land within 5 feet of specified coordinates.
- The UGV must weigh less than 4 lbs, including an 8 oz. water bottle, and fit inside the MAT-3's fuselage.



Initial concept for a UGV carrying a water bottle

Approach

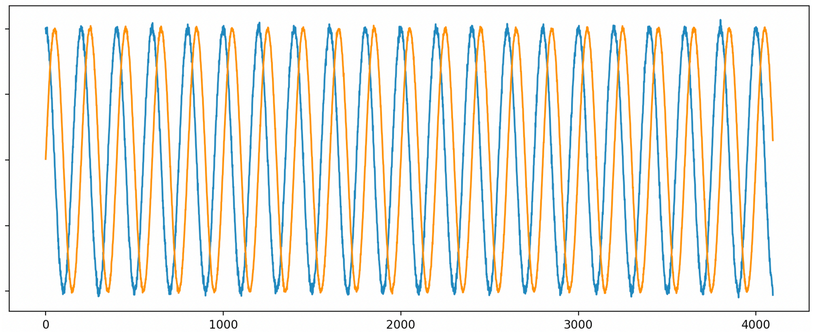
- Three broad approaches were considered for detect-and-avoid systems.
  - **Stereo cameras:** Mount a camera on each wing to create a depth map.
  - **Sound-source localization:** Use an array of microphones to localize the sound of other aircrafts' propellers.
  - **Radar:** Use an FCC-approved commercially available radar to identify the position and velocity of an oncoming aircraft.
- Two broad approaches were considered for the UGV design:
  - Passively slowing its descent with a parachute
  - Actively slowing and steering its descent with propellers



Concept for a custom stereo camera (left) and microphone array (right)

Detect-And-Avoid Results

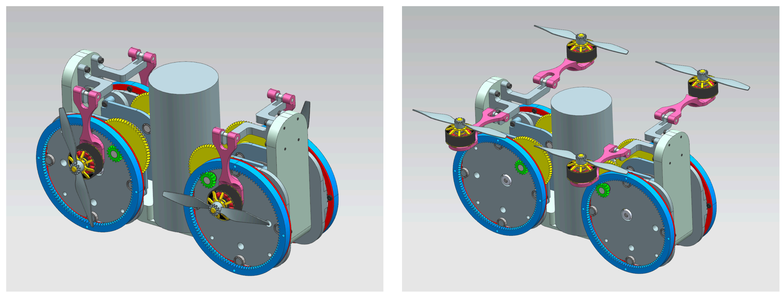
- The stereo camera did not work because stereo vision is extremely sensitive to camera misalignment, and the cameras became misaligned whenever the propellers turned on.
- Sound-source localization did not work because of a phase ambiguity.
  - The acoustic signature of a propeller is too periodic to determine whether one microphone is lagging or leading another.
- Conventional radars either only reported velocity and not position, or were not FCC approved.
- Millimeter-wave radar (mmWave) is the most viable option.
  - It uses a higher frequency with a shorter range than other radars, more easily attaining FCC approval.



Example phase ambiguity for two periodic signals

UGV Results

- An active mechanism to slow the UGV and steer its descent has been chosen.
- Spring-loaded armatures with propellers and drone motors will extend when the UGV drops out of the MAT-3.
- This method was chosen in order to increase the chance of landing within 5 feet of the target landing coordinates.
- The current design theoretically weighs 3.6 lbs including the water bottle but excluding a battery.
- There is room for further weight reduction by using plastic instead of aluminum.



Latest UGV design in collapsed (left) and extended (right) states

Future Work

- Further developing the control systems for the UGV will require more work, as this will involve adapting quadcopter controls to a vehicle with a much lower center of gravity than a typical quadcopter.
- I have already begun integrating the Texas Instruments AWR1642BOOST, a mmWave radar, into the MAT-3's onboard computer.
  - The next step is to filter out noise from objects that could be potential UAVs.