M-Fly Autonomous
Detect-and-Avoid System and Unmanned Ground Vehicle
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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.

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.

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

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.

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.

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.