Sense-and-Avoid Based on Computer Vision

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Background
This project draws inspiration from the now defunct NASA UAS Airspace Operations Challenge (AOC). It intended to find simple, yet efficient solutions to the ongoing safety concerns of UAS operating in complex environments. Several technologies already exist to track airborne aircraft, such as ground-based radar, TCAS, and ADS-B. Specifically, this project considers the sense-and-avoid issue in the presence of uncooperative UAS that do not broadcast their location. We propose the use of computer vision to sense such vehicles, and execute avoidance maneuvers whenever there is a risk of collision. However, we use an indoor ground vehicle instead, in order to simplify the exploration and verification of these concepts. To address this problem, a multidisciplinary team of 6 individuals from electrical and computing degrees was formed. There is a team leader and project manager to oversee team progress, and all members have been assigned a specific subsystem to focus on during project development.

Purpose
Using several of the rules laid out by the NASA UAS AOC organizers, the purpose of this project is two-fold: first, to verify the feasibility of computer vision for sense-and-avoid and second, to navigate using time of arrival principles with ultrasonic beacons. The project will consist of: a) a ground station for operation and monitoring, b) a navigation system based on ultrasonic technology and wireless communications, and c) an autonomous robot with cameras for object sensing and avoidance.

Design/Method
A set of 5 subsystems were defined to tackle the various primary functionalities required for the vehicle:

1. Communication: provides a wireless network for subsystems to exchange information.
2. Control: coordinates vehicle waypoint navigation, and speed-based collision avoidance.
3. Ground Station: provides monitoring and operation features to the system user.
4. Localization: robot-controlled system to wirelessly operate ultrasonic beacons around test area to assist in vehicle positioning using time of arrival math (based on VOR/DME technology).
5. Processing: analyzes data received from ground station, localization calculations, and onboard cameras to advise control subsystem of course corrections or nearby obstacles.

Results
Tests have demonstrated the capability of this system to identify and accurately track nearby obstacles using onboard cameras. The system is also able to calculate the location of our stationary robot within the test area. Team efforts are now focused on adapting these implementations to work correctly on a moving vehicle, while safely following a pre-defined waypoint path.

Conclusion
This project employed an ultrasonic, aviation-inspired means to determine the robot’s position at any time and allow it to properly navigate a defined waypoint path. However, the focus of the NASA competition was the ability to identify and track non-reporting aircraft while operating. Our project demonstrates the promise of using computer vision solutions to locate such hazards to UAS operations.