Computer Vision “See and Avoid” Simulation using OpenGL and OpenCV

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Introduction

A major obstacle to the integration of UAVs into civilian airspace is the lack of a robust collision avoidance system. The Federal Aviation Administration (FAA) requires that all aircraft “see and avoid” other aircraft.

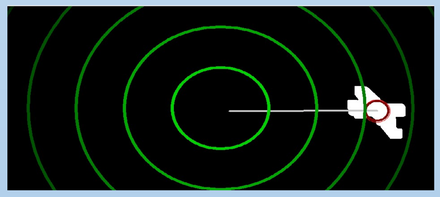
We propose a computer vision system which using a forward-facing, visual-light camera to implement a See-and-Avoid (SAA) mechanism that mimics a human pilot. The system can be used as a basic standalone collision avoidance system or as an auxiliary system in a more robust solution.

Technology

To test vision processing and collision avoidance algorithms, we first developed a test bed using the Open Graphics Library (OpenGL). Vision processing tasks were implemented using the vision algorithms in the Open Computer Vision library (OpenCV).

We used OpenGL to render a cockpit video simulation that includes a obstacle planes.

Sample image from cockpit video

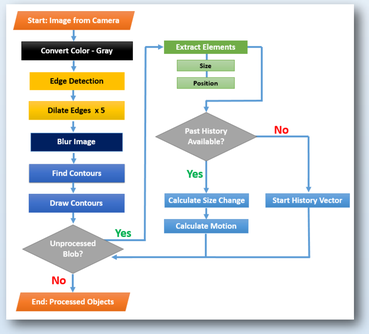


OpenCV Detection of Aircraft

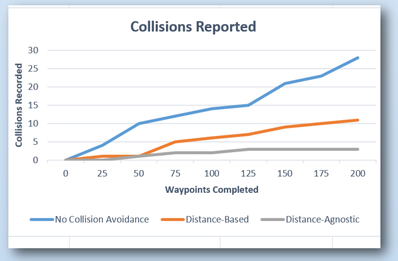
Algorithm and Results

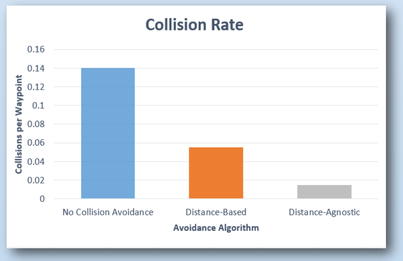
The SAA system is composed of three major components:

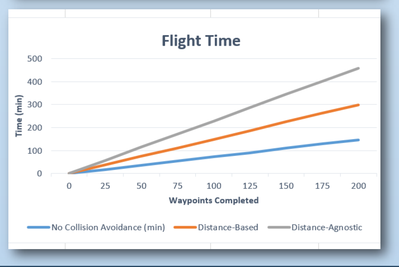
1. Obstacle Detection
   - A. Greyscale → Canny → Dilate → Find Contours
   - B. Determine bounding circle
2. Threat Analysis
   - A. Distance-based
   - B. Distance-agnostic
3. Avoidance Command
   - A. Constant Elevation
   - B. Variable Elevation

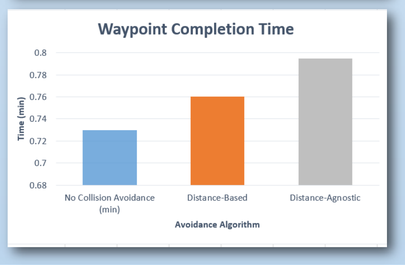


To analyze the effectiveness of the algorithm, a variety of collision scenarios were devised. The scenario would first be run without any collision algorithm. Then the scenario would be run once with distance-based avoidance and once with distance-agnostic. The results are summarized in the graphs below.









Conclusion

One of the main obstacles to integration of autonomous UAVs in civil airspace is the lack of robust collision avoidance systems. In this paper we explored a collision avoidance system based on a front-facing visible-light camera. The objective was to emulate the "see and avoid" mechanism of a human pilot.

Through a test environment rendered in OpenGL, it was possible to create a real-life airspace for collision avoidance. OpenCV object detection aided the two collision avoidance algorithms developed. Using the test environment, we found that both algorithms were able to avoid many otherwise disastrous collision events while maintaining efficient flight patterns.

We found that the vision processing algorithm is quite robust. Nearly all background noise is filtered, and collision threats are nearly always identified in plenty of time to execute an avoidance maneuver. However, the avoidance algorithms we developed are still susceptible to poor analysis of obstacles and poor choices for avoidance maneuvers.

Future Work

Future work will focus on improving the ability of the See-and Avoid system to successfully identify obstacle aircraft type, direction, and speed. Using this information, sophisticated avoidance algorithms could be used to minimize collision rates and maximize efficiency.

Acknowledgements

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