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Design and Development of a UAV Tracking System

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ABSTRACT

The goal of the "Design and Development of a UAV Tracking System" project is to develop a prototype autonomous fixed wing unmanned aerial tracking system. The prototype system is designed to be capable of autonomous flight at an altitude of 1000 feet, and utilizes a computer vision based tracking system. The aircraft system streams a video feed to a ground station in real time where a dedicated computer performs tracking operations to display the video feed with a marker over the desired object.

The aerial system is based on a Hobby-Lobby 12' Telemaster RC aircraft. Onboard is an Ardupilot Mega Arduino board loaded with accompanying open source autopilot software to control the plane in flight. Additionally, a wireless camera gimbal system is mounted to the underside of the aircraft to stream a video feed to the ground.

The tracking software uses the open source OpenCV computer vision libraries to receive the video feed and pre-determined object.

Figure 1: 5 foot Funster is used for flight training

AIRFRAME STRUCTURE

Airframe Platform Specifications	
Model Name	12' Telemaster
Wing Span	12 ft.
Wing Area	21.07 ft^2
Takeoff Weight	40 lbs.
Wing Loading	30.4 oz./ft^2
Propulsion	2-Stroke Gasoline

Figure 2: 12 foot Telemaster

TARGET TRACKING SYSTEM

Speeded Up Robust Features (SURF) and Kanade-Lucas-Tomasi (KLT) Feature Tracker form the basis for the development of target tracking the system.

SURF is a robust local feature detector used in computer vision tasks such as object recognition or 3D reconstruction. It uses an integer approximation to the determinant of Hessian blob detector, which can be computed extremely quickly with an integral image. It initializes the features of an image by using the sum of the Haar wavelet response around the point of interest.

KLT tracker is a technique intended to locate distinct frames of interest in a given image once the key features are initialized and subsequently relocate these frames in a succeeding image in an attempt to track an object

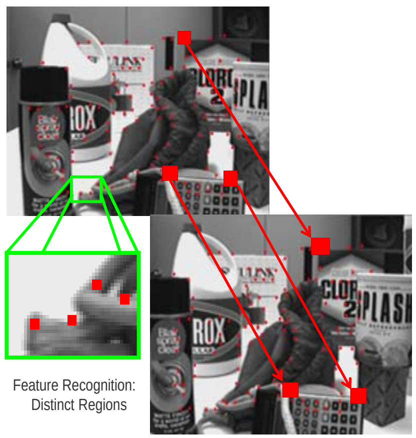

Figure 3: Corner Detection and Tracking

CONCEPTUAL OVERVIEW

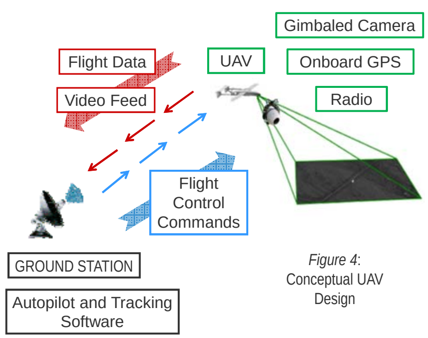

Figure 4: Conceptual UAV Design

FAIRING DESIGN

The purpose of the fairing is to enclose the camera and protect it from weather and freestream conditions in-flight. The surface of the fairing must be continuously parallel with the camera lens to reduce refraction. The fairing was designed to be easily mounted to the fuselage with minimal modifications. It was necessary to redesign the fairing to accommodate the new gimbal mount.

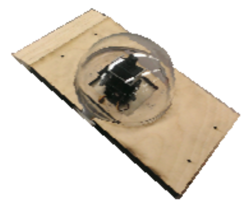

Figure 5: Camera Fairing and Fuselage Mount

AUTONOMOUS FLIGHT

To permit the autonomous flight of the UAV an Arduino Mega board was implemented to control the autopilot. A program known as mission planner was used to send and receive commands to the plane either mid-flight or as a pre-programmed mission.

Figure 6: Mission Planner Example Flight Plan [1]

Live simulations were conducted using a virtual flight simulator called "Flight Gear". This program interfaces with the "Mission Planner" software to simulate the commands sent by the user in real time.

Figure 7: Flight Gear Screen Shot [2]

RESULTS

The current tracking software is capable of reliably tracking an object without occlusions. It has been tested on tracking targets of various sizes such as full size vehicles and motorcycles, as in figure 8. Occlusions such as street posts or other nearby vehicles can potentially cause the target tracking to fail. Current development work is focused improving occlusion mitigation to improve the robustness of the software.

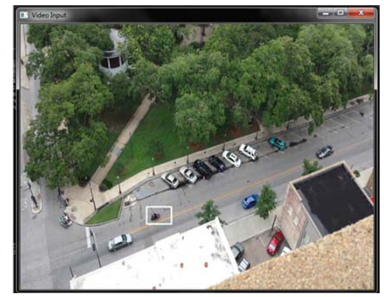

Figure 8: Camera Footage with Object Tracking

All software testing has currently been performed using prerecorded footage from a stationary, elevated point. This has avoided issues which future software iterations may have to deal with such vibrations due to the engine.

FUTURE TESTING

- Phase I: Manual flight of Funster aircraft at altitude of 100 ft with camera mounted on fuselage. Recorded video data will be used for software testing.
- Phase II: A stationary camera mounted at high elevation point will record a vehicle intentionally driven behind objects in order to test software manages occlusions. Test will then be repeated using video footage recorded from the Funster.
- Phase III: Autonomous flights will be conducted in Utica, New York. The UAV will autonomously fly in a circular pattern at a height of 1000 ft while tracking a moving vehicle on the ground. At some point a human target will exit the vehicle. The person will walk in the open and behind several object to test the robustness of software.

References

[1] "The AeroMapper UAV", 2011.
[2] Salvatore Caputo, "Flight Gear 2.10: IL flight simulator", 2013.