University at Buffalo The State University of New York | REACHING OTHERS

Design and Development of a UAV Tracking System

Zachary Fisher, Andrew Lyons, Brian Bergh, Joe Groele, Alex Elhage, Nathan Guterry, Frank Repetti, Bradley Bridges, Maureen West, Varun Vruddhula, & Jimmy Lam

Advisor: Dr. Manoranjan Majji

Department of Mechanical and Aerospace Engineering

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

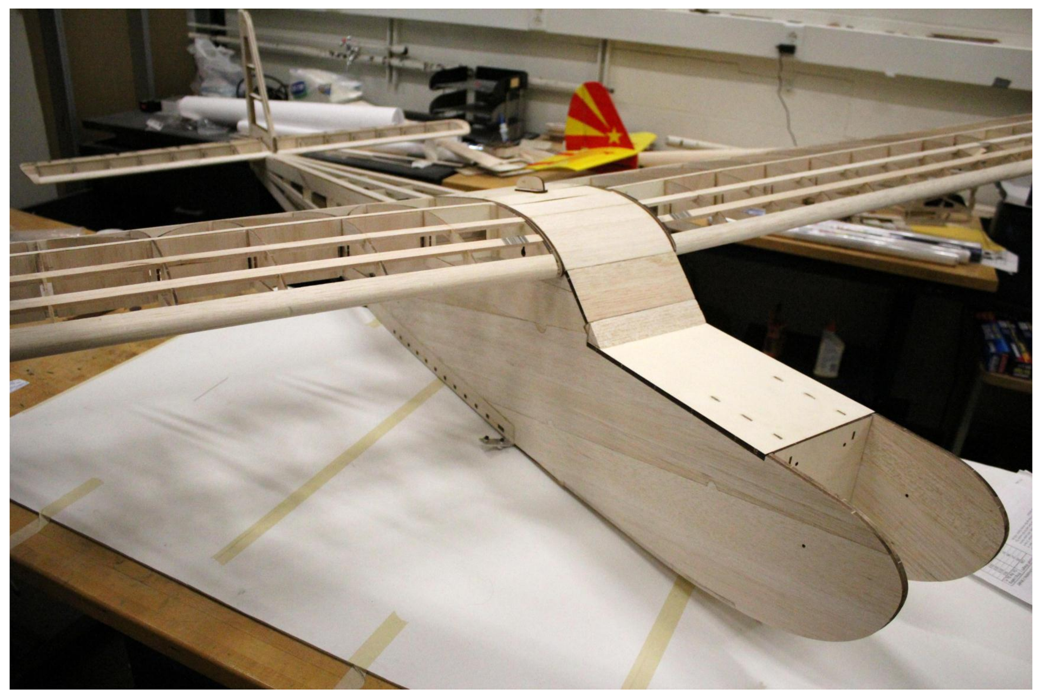


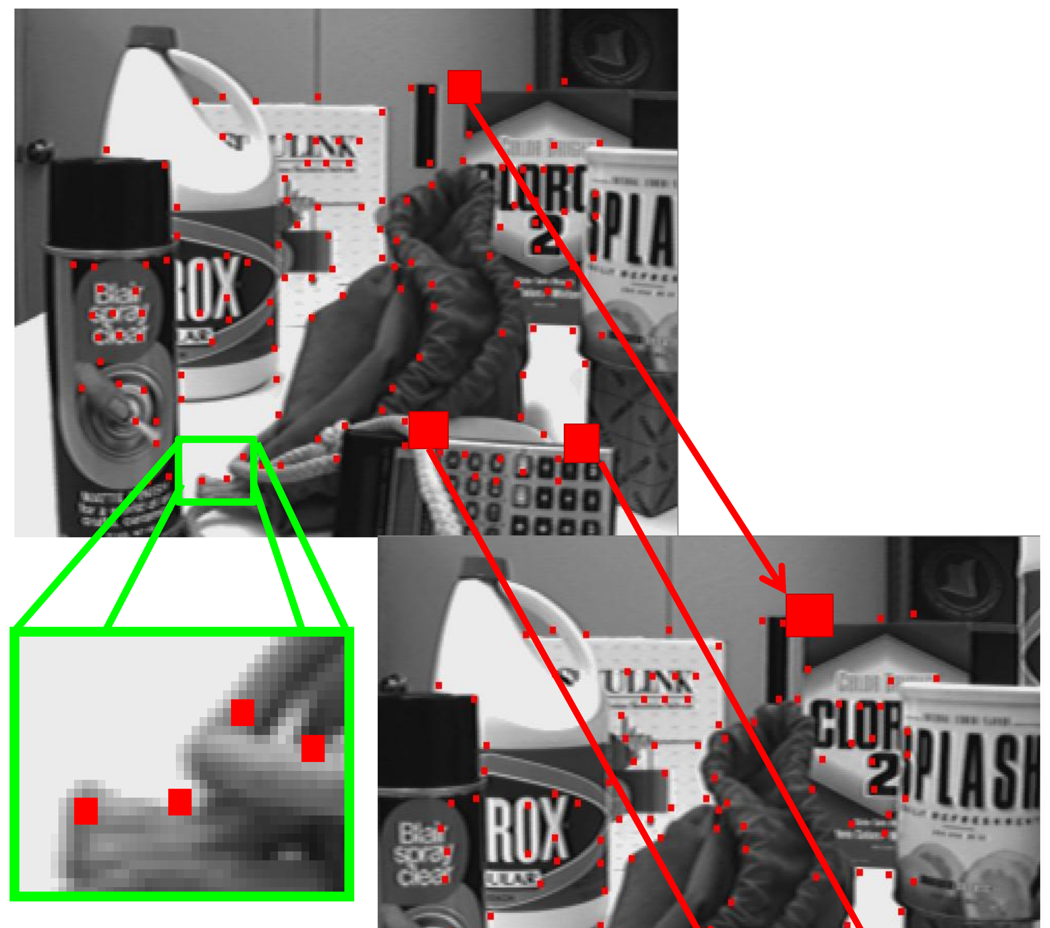
Figure 2: 12 foot Telemaster

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



Feature Recognition: Distinct Regions

Figure 3: Corner Detection and Tracking

CONCEPTUAL OVERVIEW

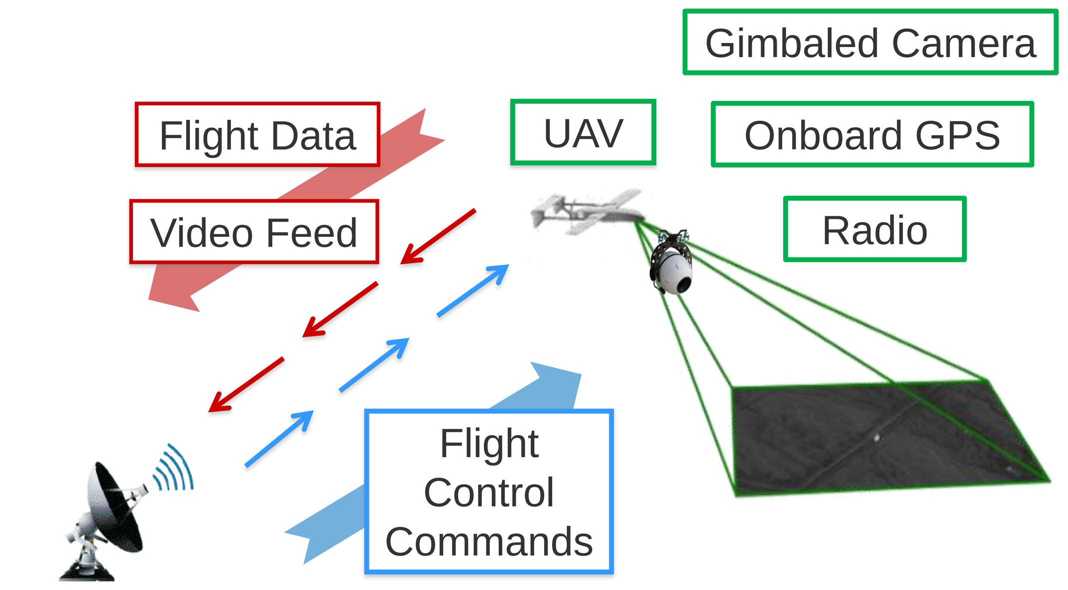


Figure 4: Conceptual UAV Design

AERODYNAMIC ANALYSIS

The primary objective of the Aerodynamics team is to design an aerodynamic fairing protect the camera and camera mount from forces generated as a result of the relative free stream velocity. These forces could potentially cause moments on the camera motors that could be greater than the torque available to control the camera orientation, interfering with the camera's ability to accurately adjust its positioning to keep the target within view.

The fairing will be produced using thermoformed clear PVC plastic. Special consideration will be given to ensuring that the 3-D printing substrate used to make the thermoform mold is not affected by the heat of the thermoforming process. Analysis will be performed to determine the optimum fairing thickness that minimizes cost and weight without sacrificing structural integrity.

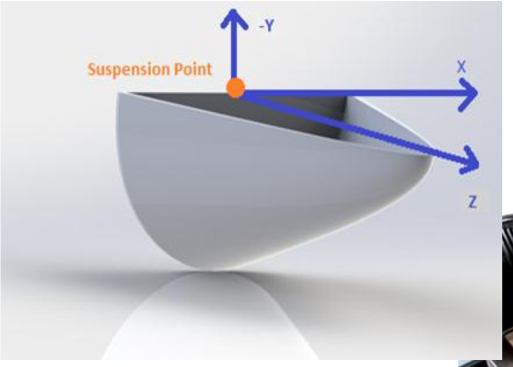


Figure 5: Geometry of the Fairing

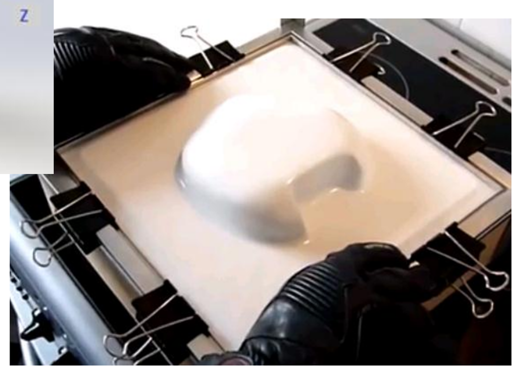


Figure 6: Thermoforming Process [1]

TRACKING CAMERA MOUNT

Attached to an Arduino is the Camera Mount. When the target moves out of the frame the camera needs to correct for this by centering the target. The design of the mount was based on a joint called the agile eye. This joint has three degrees of freedom. However, for this project the design was restricted to two degrees of freedom. This modification was performed in an attempt to reduce the complexity of the camera mount and add stability to the design.

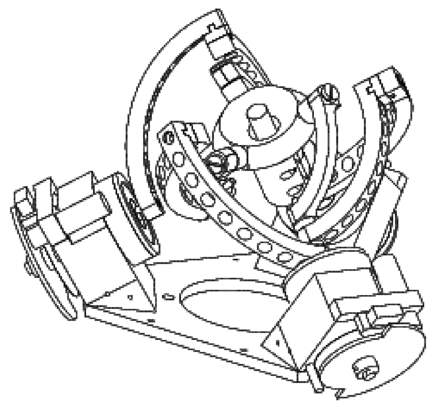


Figure 7: Agile Eye [2]

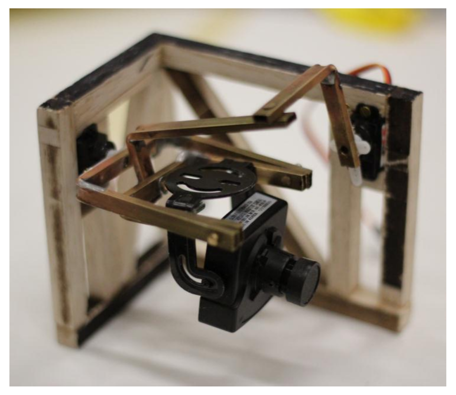


Figure 8: Completed Camera Mount

ENGINE

Owing the large physical size of the UAV and payload capacity, our research was focused on the engines in the range of 80-100cc in order to ensure safe flight. Our criteria for engine selection was primarily motivated by power to weight ratio and Mean effective pressure value. A systematic comparison of the aforementioned performance factors for different available products gave us a winner in the form of Evolution 80GX engine.

Figure 9: Evolution 80GX [3]

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.

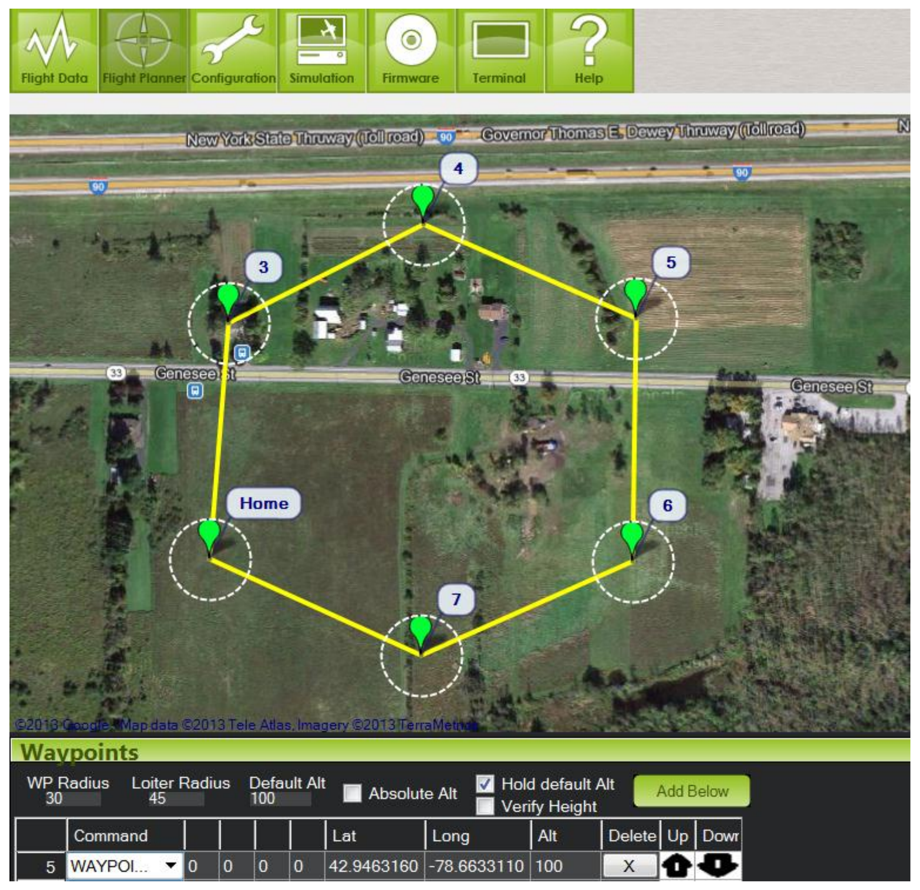


Figure 10: Mission Planner Example Flight Plan [4]

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 11: Flight Gear Screen Shot [5]

References

[1] "12" x 12" Hobby Vacuum Former", 2013.
[2] "Parallel Mechanisms: The Agile Eye", *Laboratoire de robotique*, 2013.
[3] "Evolution 80GX (4.9) Gas Engine by Evolution Engines," 2013.
[4] "The AeroMapper UAV", 2011.
[5] Salvatore Caputo, "Flight Gear 2.10: IL flight simulator", 2013.