Brigham Young University

AUVSI Capstone Team (Team 45)

Design Summary

ID	Rev.	Date	Description	Author	Checked By
TW-002	0.1	12-03-2018	Created	Kameron Eves	Andrew Torgesen
TW-002	0.2	12-10-2018	Added payload delivery sections	Andrew Torgesen	[CHECKER]

Introduction

Project Description

Each year, the Association for Unmanned Vehicle Systems International (AUVSI) hosts a Student Unmanned Aerial Systems (SUAS) competition. While each year's competition has unique challenges, the general challenge is to build an Unmanned Aerial System (UAS) capable of autonomous flight, object detection, and payload delivery. This year's competition will be held June 12th to 15th, 2019 at the Naval Air Station in Patuxent River, Maryland.

The UAS's entered into the competition are judged primarily on their mission success during the competition. This year's mission begins when the team hands control of the aircraft to the autopilot. The autopilot will then initiate the takeoff and attempt to execute the following tasks.

- **Fly Waypoint Path** - Fly waypoints given to the the team just prior to the competition. In this process, and throughout the entire mission, the aircraft must avoid virtual obstacles and stay within boundaries (both horizontal and vertical).
- **Visual Target Classification** - Within a prescribed search zone there will be a number of large cardboard shapes with an alpha-numeric character on them. The aircraft must capture an image of these shaps
- **Payload Delivery** -

In general, every aspect of the mission should be completed autonomously.

For the last two years BYU has sponsored an AUVSI team to compete in the competition. The 2017 team was primarily volunteer based and placed 10th overall while the 2018 team was a Capstone team and placed 9th overall. This year's team is also a Capstone team consisting of BYU Mechanical, Electrical, and Computer Engineering students and looks to place as one of the top five teams.

Description of Design

Airframe

Visual Target Classification

This year's vision team is changing our system architecture for classifying targets which will allow for better communication and organization. Instead of downloading each image and image state onto someone's personal computer, the computer oboard the plane will send image and vehicle state data to a server on the ground. This server will have a compiled database of all images captured and will attach classification data onto each image as it is manually processed. Our autonomous detection script will also be querying the server image database and classifying images. One team member will be monitoring the autonomous output ready to kill the program if it is sending too many false positives (which cause the team to incur a penalty).

Payload Delivery

To achieve excellent performance on the key success measure of airdrop accuracy for our unmanned ground vehicle (UGV) payload, the results of our preliminary prototying and testing allowed us to converge on an uncontrolled parachute-deployed payload delivery system. The UGV will be loaded within the aircraft. Given the desired drop location, the autopilot will determine the optimal direction and speed from which to drop the payload, given airspeed conditions. A command from the autopilot will open a small hatch on the bottom of the plane and the UGV will fall out. Strings will attach the UGV to a lightweight fabric parachute with a hole in its center. The fabric parachute will be loaded onto the aircraft in a tube that will allow the UGV to pull it out of the aircraft as it falls. After exiting the aircraft, the parachute will be opened by drag. The drag caused by the fabric will slow down the system enough to allow the UGV to survive impact without damage.

Summary of Expected Performance

Airframe

Visual Target Classification

The new server system architecture is expected to perform much better for target classification that preveious year's methods. We are confident in our ability to send images from the camera to our onboard computer and down to our groundstation.

The autonomous classification system is the largest undertaking of this year's vision subteam. Each of the 6 characteristics we are required to identify could potentially be done using a different method. We expect to be able to reliable classify fifty percent of targets autonomously.

Payload Delivery

As part of the design process, we have considered multiple points of failure and used those points to inform our design. This, along with the testing documented in the *Unmanned Ground Vehicle Drop Mechanism Concept Test Procedures and Results* artifact, give us confidence that we can achieve an airdrop accuracy within 25 feet from the target drop location, as listed in our key success measures in our Project Contract. In our tests, we evaluated several different delivery mechanisms, and tested for their mass, volume, weight, drag, and drop precision in a controlled environment. These results were weighed against competition requirements for weight and volume, as well as our key success measure concerning drop precision. Our testing convinces us that our chosen payload delivery system, together with refinement and testing of the autopilot drop calculation algorithm, will adhere to the requirements of the competition and allow us to capture our key success measure criteria for excellent performance.

Status and Future Plans

Airframe

Visual Target Classification

We have already built much of the server system architecture. There is a strong framework in place for saving and accessing pictures from the server. We have also constructed a draft of the user interface that contacts the server and requests images and sends back cropped and classified images back to the server. The system for manual target recognition is already mostly complete.

We have been focusing on first achieving the ability for manual target recognition, but we have also been investing some effort into developing the autonomous target detection and classification system. As was mentioned previously, the system must be capable of detecting a target within a frame, geolocating it, and classifying its shape, shape color, alphanumeric, and alphanumeric color. Thus far, we have developed a system capable of detecting targets with around 70% accuracy. We have also modified a deep learning-based character recognition system to detect synthetic letters with over 90% accuracy. In the future, we will be working on testing the character recognizer on real images of targets. We will also be devoloping the shape classifier and color recognition systems.

Payload Delivery

At the outset, our overarching plans were to decide on a payload delivery method, build a prototype, and get last year's payload delivery system up and running. As of right now, we have converged on a method, built a prototype, and tested the software and hardware from last year's system on the ground, but not in the air. Because we have verified that the payload hardware works from last year, the only thing we were not able to do that we planned to do was test the accuracy of the autopilot drop calculation algorithm. We were planning on refining this algorithm anyway, so we will push this step to next semester without much concern. Next semester, in addition to testing and refining the drop calculation algorithm, we want to build a final version of our parachute delivery system, as well as the UGV payload itself. The majority of our work next semester concerning payload delivery will be iterating the combined payload delivery system (drop calcualtion algorithm, parachute, and UGV) with repeated simulation and hardware testing to ensure repeatability of expected performance in the face of differing environmental conditions, such as wind speed and direction.

Conclusion

From our design work outlined above and expounded upon in the artifacts below, we are confident that we will be able to construct and refine a product capable of meeting all of our key success measures and performing well in the AUVSI competition.