Project Charter: FlyNet

Autonomous Multi-rotor Mapping and Localization  
Sponsored by: United Technologies Research Center

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| Project Title: | FlyNet | | |
| Brief Project Description: | Design a team of autonomous robots consisting of multi-rotors and ground robots to map and localize in an unknown environment, while searching for known targets. | | |
| Project Manager: | Drew Ellison | | |
| Signature: |  | Date: |  |
| Machine Shop: | Matt Rhode | | |
| Signature: |  | Date: |  |
| Instrumentation Shop: | Trudy Schwartz | | |
| Signature: |  | Date: |  |
| Faculty Adviser: | Eric Frew | | |
| Signature: |  | Date: |  |
| Course Coordinator: | Joe Tanner | | |
| Signature: |  | Date: |  |

Team Organization Chart

Roles and Responsibilities

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| --- | --- |
| **Members** | **Role/Description** |
| **United Technologies Research Center**  **(Zohaib Mian)** | **Project Sponsor:** Will provide funding and academic support in technical areas in which the team lacks experience. Will confirm that the solution the team designs is to the specifications that UTRC requires |
| **Professor Eric Frew** | **Project Advisor:** Faculty advisor for your project. |
| **Drew Ellison** | **Project Manager**: In charge of managing team directive, project scope, and directly communicating with the customer regularly. |
| **Austin Anderson**  Tyler Clayton  Matt Busby | **Systems Engineer/Integration Lead:** Technical leader of the team. Works closely with the project manager to establish team goals, deadlines, and make large technical decisions. Integration team will work with Navigation team and Controls team to integrate the entire system. |
| **Steve McGuire**  Taylor Dean | **Navigation Team:** Responsible for developing and integrating mapping, localization, and navigation algorithms for 3-D, obstacle filled environments. |
| **Ed Meletyan** | **Simulation Team:** Responsible for working with the navigation and controls teams in order to develop robust MATLAB simulations of the estimation and control algorithms for proof of concept, rapid development and testing of flight software. |
| **Bryce Hill**  Prashant Ganesh | **Controls Team:** Responsible for developing robust control algorithms for multi-rotor and/or ground vehicles in order to produce reliable, autonomous indoor flight |

Scope & Objectives

**Overall**

As a whole the FlyNet team seeks to design and test a team of aerial and ground robots armed with onboard computers and sensor suites that will autonomously map an unknown building with no prior information while in a GPS denied environment. This goal requires the development and integration of real time, online autonomous controllers, state estimators, and mapping capabilities.

**Fall Semester 2015**

The deliverable for this semester is to have a *single* multi-rotor aerial vehicle that can autonomously map and navigate through an unknown territory. In order to accomplish this goal, FlyNet has identified the tasks as follows.

The Controls team will interface an onboard computer with an onboard autopilot in order to pull sensor information and to send attitude or position commands, which will take advantage of several pre-existing onboard controllers. If the existing controllers prove incapable, the team will design a position controller that will feed the onboard attitude controller. Additionally, obstacle avoidance and pattern/building searching techniques will generate desired position reference signals. Once these controllers have been developed, the team will test the algorithms using a VICON-in-the-loop position reference command in order to test the efficiency of the controllers and tune any appropriate parameters. In order to simulate realistic data rates, the VICON data stream may be artificially delayed and/or sampled.

In parallel with controller development, a vehicle state estimator will be developed in order to estimate vehicle velocity, attitude, and position. This estimator will pull sensor information from the autopilot and run Kalman filtering techniques in order to provide these state estimates. Once developed and integrated, these estimators will be tested by manually flying the vehicle in a VICON space, which provides a ground truth measurement of the multi-rotor state. The estimator performance will then be evaluated by comparison with these ground truth measurements.

The Navigation Team will develop and test an algorithm to perform Simultaneous Localization and Mapping (SLAM). Using sensor information, for example from an onboard camera or laser scanning device, SLAM creates a map of the unknown environment as the vehicle moves through it. At the same time it simultaneously determines its own location within the map/environment. For initial development, the team will develop all SLAM techniques off-board of vehicles to mitigate the risk of sensor and processor damage during flight/movement. Once SLAM has been proven to work individually, the Navigation team will integrate these algorithms onto an aerial vehicle platform.

**Spring Semester 2016**

The goal for this semester is to improve the above capabilities and to include target identification and target tracking. The autonomous vehicles will search for and track targets which have been pre-tagged with a unique identifier such as a colored shirt or RFID tag.

Basic Schedule Overview

* 8/25/15 – 9/29/15 – Initial Design Phase
  + Fly existing aerial vehicles manually (8/25/15 – 9/29/15)
  + Interface onboard computer with autopilot (8/25/15 – 9/22/15)
  + Design indoor flight controller architecture (8/25/15 – 9/29/15)
  + Design aerial vehicle state estimation algorithm (8/25/15 – 9/29/15)
  + Investigate existing software packages for aerial vehicle simultaneous localization and mapping (8/25/15 – 9/22/15)
  + Order possible system hardware solutions (onboard computers, cameras, sensors, etc.) (8/25/15 – 9/22/15)
  + Test system hardware and assess utility in proposed design solution
* 9/29/15 – 10/21/15 – Development and Test Phase (Preparation for Flight/Algorithm Qualification Testing)
  + Integrate flight controller and test on vehicle (9/22/15 – 10/13/15)
  + Integrate state estimator on vehicle (9/22/15 – 10/13/15)
  + Official controller FQT due (10/21/15)
  + Official estimator FQT due (10/21/15)
  + Integrate/prototype SLAM algorithm on ground robot using only aerial vehicle sensors (9/29/15 – 10/21/15)
  + Official SLAM AQT due (10/21/15)
* 10/21/15 – Mid-Semester Presentation
* 10/21/15 – 11/17/15 – Delta FQT/AQT
  + Integrate revisions/code fixes found during AQT/FQT
* 11/17/15 – 12/12/15 – SLAM-Flight Integration Phase
* 12/13/15 – Final Presentation
* 1/15/16 – 5/15/16 – Development of target ID and tracking, more robust flight control in mapped environments

Resource List

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| --- | --- | --- |
| **Resource** | **Point of Contact** | **Reason for Need** |
| Aerospace Machine Shop | Matt Rhode | Safety concerns for indoor flight testing |
| Aerospace Instrumentation Shop | Trudy Schwartz | Electronics equipment |
| MATLAB | OIT | To create simulations and prototypes of flight software |
| Previous year’s knowledge base | Drew Ellison | Will be used to aid in the decisions of hardware choices and designs of controllers and estimators. |

Budget Information

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| --- | --- | --- |
| **Source/Expense Item** | **Project Funds Available** | **Expected Expenses** |
| UTRC | $10,000 |  |
| Previous Expenditures |  | $9,000 |
| Forecast Expenditures |  |  |
| New quad-rotor platform(s) |  | $3,000 |
| Onboard Computers |  | $1630 |
| Sensors/Cameras |  | $4000 |
| Vehicle materials |  | $500 |
| Subtotal | $10,000.00 | $9,130.00 |
| Estimated Final Balance | $870.00 |  |

Communication Plan

The FlyNet graduate team will regularly meet twice a week in the Fleming laboratory:

* Tuesday : 3:00PM – 4:50PM
* Wednesday: 11:00AM – 12:50PM

All documentation and software will be kept on the team GitHub at the following address:

* [www.github.com/dme722/FlyNet](http://www.github.com/dme722/FlyNet)

In order to perform purchase orders, please contact Drew Ellison ([dme722@gmail.com](mailto:dme722@gmail.com)) or Austin Anderson ([Austin.m.anderson@colorado.edu](mailto:Austin.m.anderson@colorado.edu)), who will then contact Dr. Eric Frew ([Eric.Frew@colorado.edu](mailto:Eric.Frew@colorado.edu)) and James Mack ([James.Mack@colorado.edu](mailto:James.Mack@colorado.edu)) in order to complete purchasing.

Change Log