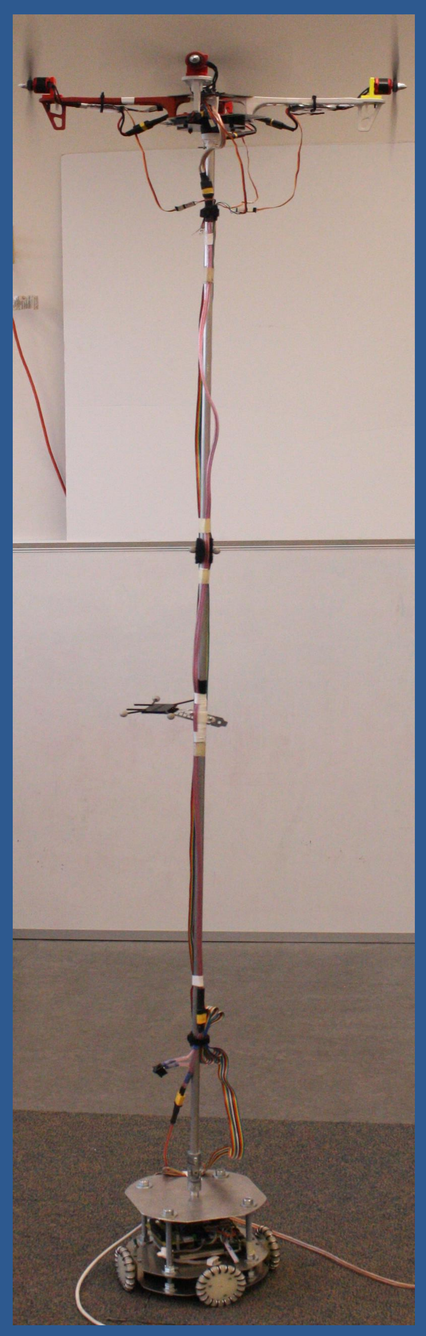
May 15-27

RADA

Robotic Agricultural Data Acquisition



Introduction

RADA is a senior design project that seeks to provide a proof of concept for a robotic tool that would take measurements of crops in a field, especially corn. The idea is to replace manpower that currently must go into a field to manually take measurements. The final system would need to traverse a corn field, which means the system must be very tall yet narrow. To achieve this we are designing a system that will balance an inverted pendulum with two degrees of freedom. We are actuating this pendulum at the top using propellers, as it would be too tall to balance from only the bottom. We set a goal of creating a proof of concept using technology that was readily available with simplified requirements so we could have a functional prototype by the end of the year. We also sought to create a reliable data measuring and logging system that could be used in the future for different projects.

Our Requirements

- Inverted pendulum needs to balance in two degrees of freedom
  - Should be able to handle disruptions reliably
- Uses a high speed camera system for measuring angle
- Uses a PID controller on a local ground robot for control
  - Should be able to be easily changed to other controllers

Resources

Man Hours: 1450

New Equipment Cost

Ground Robot: $ 350
Arm/Propellors: $ 250

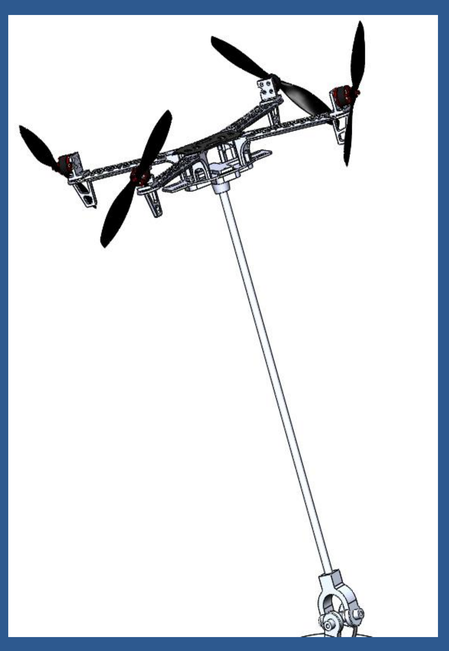
Existing Equipment

OptiTrack High Speed Camera System
Omnidirectional Robot

Propeller System and Arm

The arm is actuated via a system of propellers. This is what we are trying to balance and is where cameras and other measuring devices would be mounted in the final system.

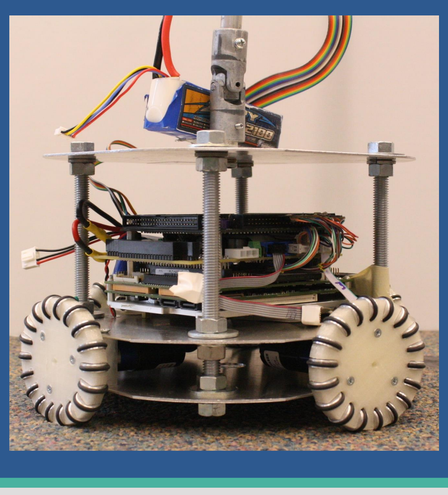
- Uses a DJI quad frame and motors
- Propellers turned 90 degrees to provide thrust outward
- Mounted to robot via base joint that rotates in pitch and roll directions simultaneously
  - Possibilities for sensing and actuating on the joint in addition to top were examined
  - Testing done, but nothing implemented
- Motor ESC firmware has ben replaced with the open source firmware BLHeli
  - Done to solve consistency issues the default firmware had
- Power and control provided via ground robot

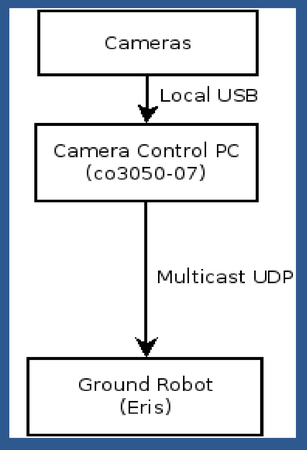


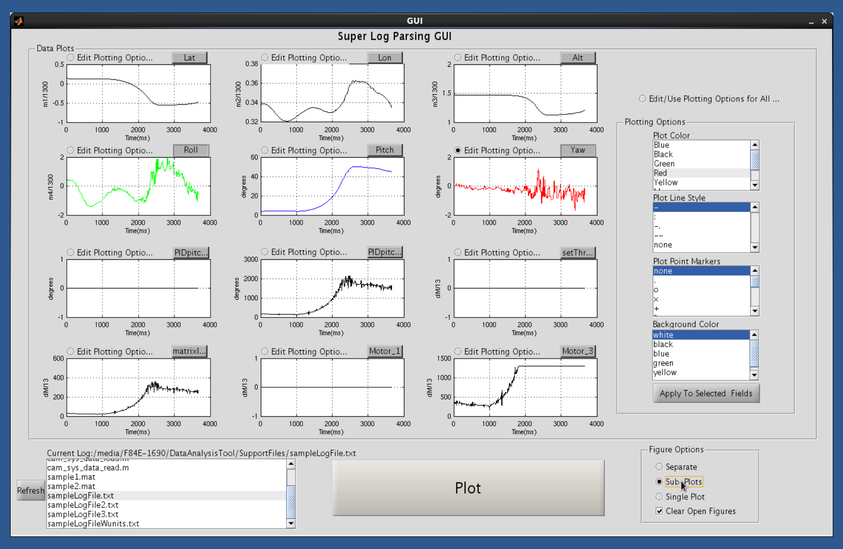
Ground Robot

The ground robot acts as the control platform for the entire system. It is an omnidirectional robot built by past teams that has been repurposed for our needs.

- A Pluto PC board running Linux and a Mesa 4i68 motor controller FPGA
- Restored from previous teams projects
- System control provided by PID controller running on Linux
  - Written in C++
- Redesigned body to support instrumentation arm system
- Receives position data via UDP from a computer that controls the cameras







Logging and Data Analysis

We designed a system for logging and analyzing data for testing purposes. This system utilizes a certain text format and a parser, such that any value can be logged.

- A MATLAB command line interface and a MATLAB GUI
- Parses specially formatted text file
- Usable for future projects
- Used for testing the system

```
#Constants      pitch_P     pitch_I     pitch_D
#PIDValues      1900        0           409
#Constants      roll_P      roll_I      roll_D
#PIDValues      1900        0           409
#Orientation:   OptiTrack-VRPN
#Position:      OptiTrack-VRPN
#Direction:     OptiTrack-VRPN
#Communication: 6-Channel Trainer
%Time   Motor_1 Motor_2 Motor_3 Motor_4 Pitch    Pitch_err
&sec    %thrust %thrust %thrust %thrust degrees  degrees
0.000000    0   1300    1300    0   -70.274537  110.266991
```

Testing

System Testing

Testing was done on each module individually as they were developed throughout the semester.

- For the arm, used an existing RC RF link and control software on a desktop
  - To test the controller while the ground robot was being restored
- The ground robot was manually tested as it was developed
- Logging was tested first with man made log files, then with log files generated by software
- PID controller tuned using logged data and plots, Simulink models, and manual testing of the system

Sensor/Actuator Testing

Sensors and actuators were tested to determine their feasibility for use on the base joint

- Used an Arduino to interface with sensors and test resolution and accuracy

Team Members

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