PROBLEM STATEMENT

While conducting agricultural experiments, researchers must take a variety of measurements of every research specimen. Currently this process is done manually by research technicians walking the fields. This process requires extra personnel, time and money for the project. Our clients wish to develop a system that could automate these agricultural measurements using a robotic platform. An automated system would then reduce the personnel required, and the time spent by researchers gathering information about their specimens.

In this project, our group is designing a cooperative robotic system containing a ground vehicle and an instrumentation arm connected at a single pivot point. This instrumentation arm will then be balanced primarily by 4 propellers located at its top, with some assistance from the movement of the ground robot. Our main goal is to design and construct a laboratory proof of concept for such cooperative system to demonstrate its feasibility.

DELIVERABLES

FIRST SEMESTER

- Spherical inverted pendulum stabilized using the propeller balancing system
  - 1-Degree of freedom (only able to rotate around the Y-axis)
  - 2-Degrees of freedom (freely able to rotate around the X-axis and Y-axis)
- Ground vehicle
  - Have a reliable ground platform
  - Ability to compile software for the platform
  - Get a stable base for mounting of pendulum
- Log and analysis of data
  - Measure flight data from quadcopter
  - Measure data from robot
  - Have a uniform format for log data from quadrotor system and ground vehicle

SECOND SEMESTER

- Cooperative system between the quadrotor system and ground vehicle
  - On-vehicle sensing to provide positional feedback
  - On-vehicle control processing
- 2-Degrees of freedom instrumentation arm balanced on a moving ground vehicle
  - Balanced primarily using the propeller system, with assistance from movements of the ground vehicle
- Control GUI for ground vehicle
  - GUI can assist with data logging

SPECIFICATIONS

The systems designed by this project will be expected to meet the following criteria.

Instrumentation Arm System

- Allow measurements above the top of the corn (up to 12ft high)
- Top-mounted balancing system to provide stabilization input
- Should automatically rebalance in response to movement
- Should balance when ground platform is not level
- Utilizes a real-time linear feedback controller

Ground Vehicle System

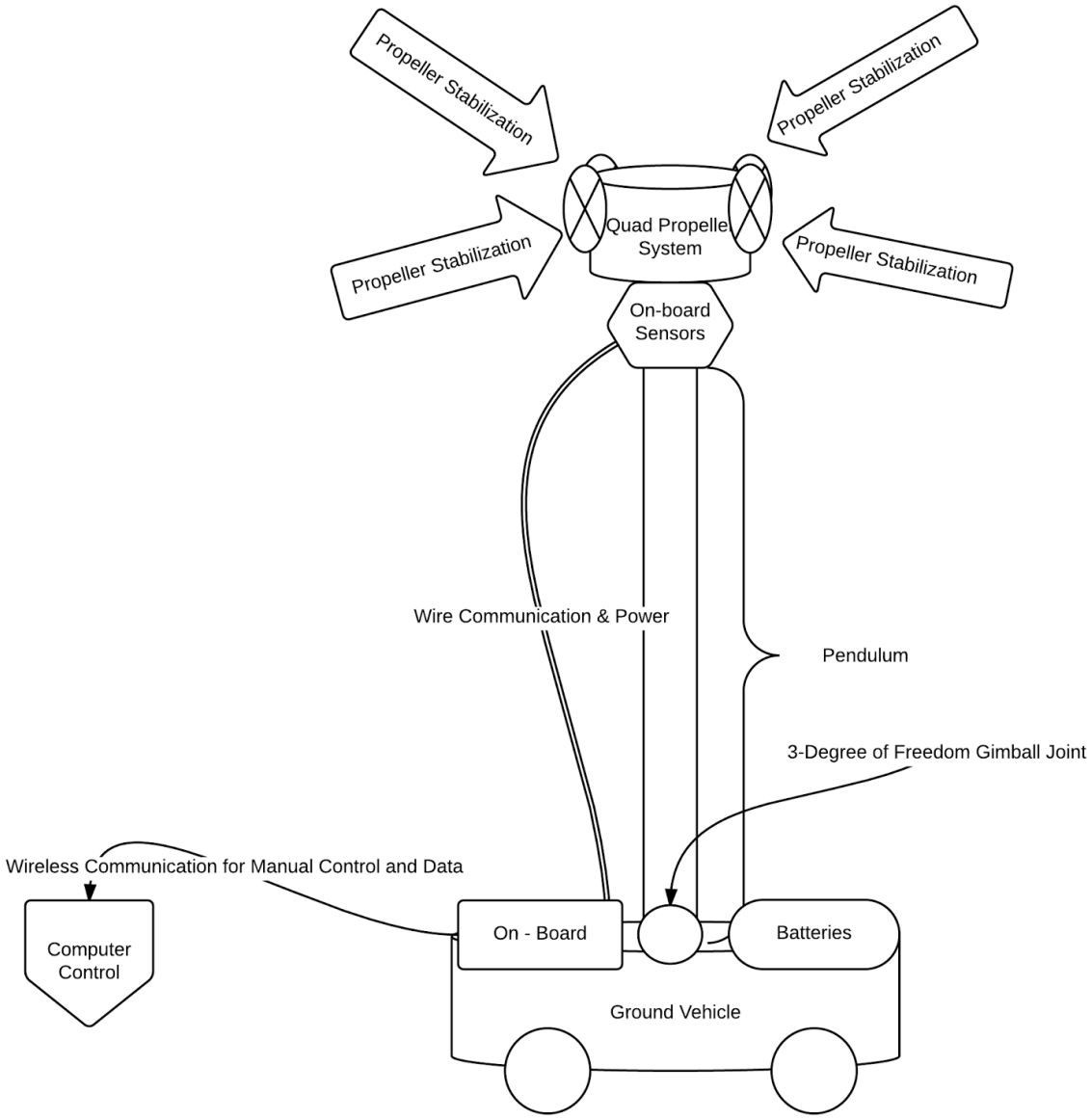
- The system should reliably receive commands and translate them into motion
- The vehicle structure should be able to provide a sturdy support base for a pendulum
- On vehicle processing should handle computing for the ground vehicle as well as the quadrotor system
- Receive commands from a user interface
- Battery powered
    - Battery provides power up the instrumental arm to the propellers as well as the ground vehicle

Data Logging and Analysis System

- Log the values of run-time parameters and variables during the experiment
    - Collect relevant data from both the quad-rotor and the ground robot
- Analyze runtime data post experiment
- System is easily reconfigurable to account for new variables or discard current ones
- Quick and simple in generating analysis to primarily serve debugging and/or development purposes

CONCEPT SKETCH/MOCKUP

Hardware Block Diagram



The system consists of a robot at the base with a long, light material stick connected to the top by a gimbal joint. This allows free motion for a quadcopter at the top which theoretically should be able to stabilize itself to be at a constant positioning above the robot.

SOFTWARE & CONTROLS

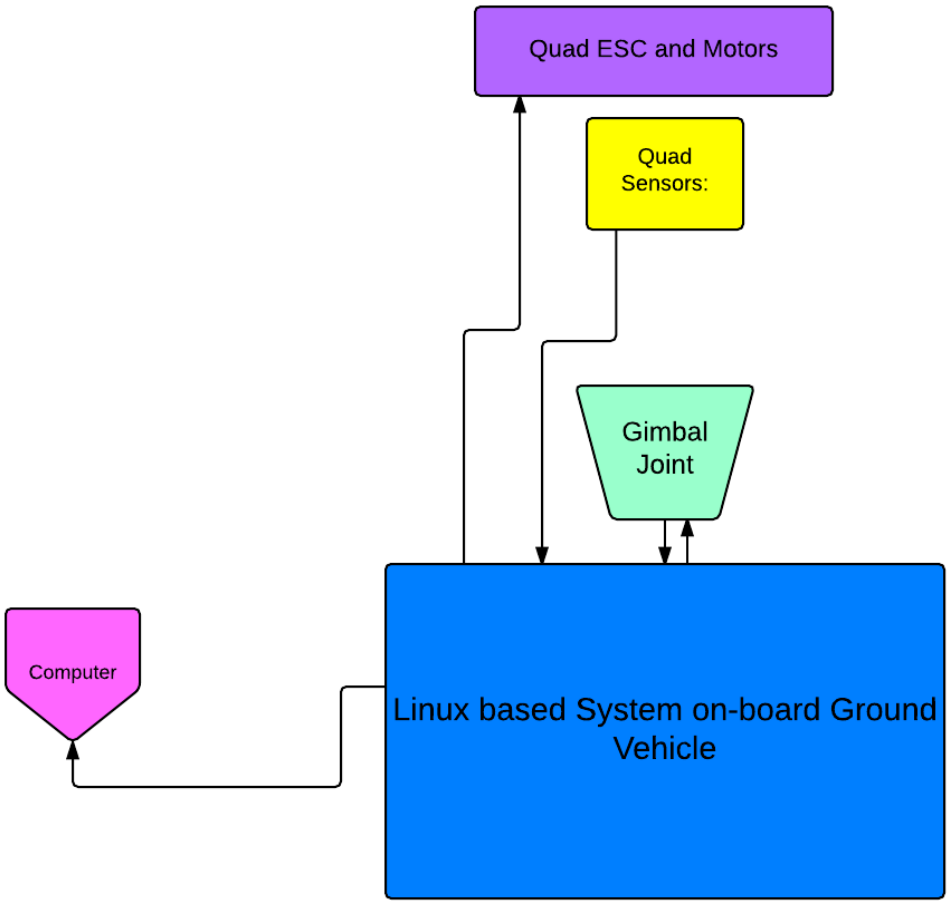
The cooperative system will be designed so that the propeller system will follow the movements of the ground vehicle in order to keep the instrument arm balanced. The commands to move the entire system will come from a GUI that transmits them to the ground vehicle.The ground vehicle will then handle the computation of the entire system and send commands to the stabilizing propellor system.

DATA LOGGING & ANALYSIS SYSTEM

This system consists of log files that hold runtime data of individual experiments. A MATLAB environment reads the logged data and generates data in the form of graphs and matrices for analysis and computational purposes.

USER INTERFACE DESCRIPTION

HARDWARE



SOFTWARE

The software will have a graphical user interface which will be used to send commands to the ground vehicle. These commands can be to move, stop, send data, etc. The GUI will also be a point that can be used to access important logger data.

FUNCTIONAL REQUIREMENTS

- Cooperative system between ground vehicle and quadrotor system
    - All processing should be completed on the ground vehicle
    - Should be independent of outside monitoring systems (camera system will act as a stand in for advanced gps sensors used in the final version)
- Quadrotor system balances pendulum while moving above the ground vehicle
- Data logging system that can export data to matlab for quick and easy analysis
- GUI to control the movement of the cooperative system

NON-FUNCTIONAL REQUIREMENTS

- Reliable system that performs commands in real-time
- Efficient power consumption
- Failure Management
- Upgradable hardware & control system

WORK BREAKDOWN STRUCTURE

Every member of our team is expected to work closely and cooperatively even when working on different tasks. In order to ensure continuous progress as well as a well structured team format, we designated a team role for each member to better organize us.
Robert Larsen: Team Leader/Project Manager
Ian McInerney: Team Key Concept Holder/Tech Lead
Dylan Gransee: Webmaster
Alberto Di Martino: Webmaster
Aaron Pederson: Team Communications
Fengxing Zhu: Team Communications
Rohit Zambre: Data Logging and Analysis Lead

RESOURCE REQUIREMENTS

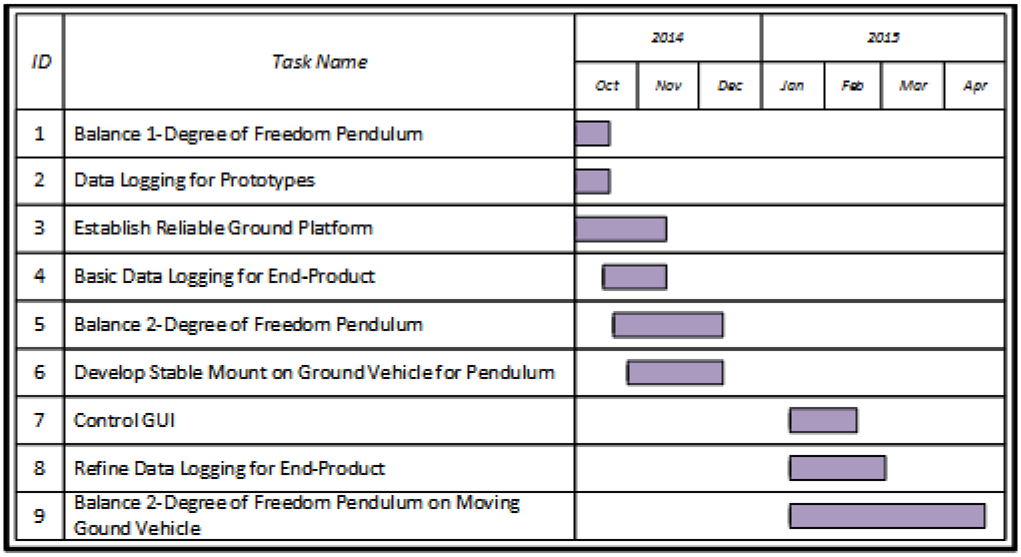
Resource	Provided by	Estimated cost
Gimbals	Provided by Client	$100
Gyroscope/Accelerometer	Provided by Client	$50

Brushless motors, Propellers, Electronic Speed Controllers	Provided by Client	$300
Photo Tachometer	Provided by Client	$200
Spektrum Transmitter & Receiver	Provided by Client	$250
Spektrum Transmitter & Receiver	Provided by Client	$250
OptiTrak IR Camera System	Provided by Client	$15,000
Digital Scale	Provided by Client	$50
Omnidirectional Robot System	Provided by Client	$3,000
FPGA system	Provided by Client	$500
2-cell lipo batteries	Provided by Client	$50

PROJECT SCHEDULE

We will make a Gantt chart once dates are finalized (we can finalize the dates when we discuss specs more in depth at our meeting).

Mid-October - Balanced 1-Degree of freedom inverted stationary pendulum system using propellers
Mid-October - Data Logging and Analysis system for prototypes
Mid-November - Get a reliable ground vehicle with system backups
Mid-November - Basic Data Logging and Analysis System for end-product
December 5th - Balanced 2-Degree of freedom inverted pendulum system using propellers
December 5th - Get a stable base on the ground robot for a pendulum to be mounted
Mid-Feburary - Control GUI
Mid-February - Complete Data Logging and Analysis System for end-product
April 17th- Balanced 2-Degree of freedom pendulum system on a moving robot



RISKS

RISKS TO THE PROJECT TIMELINE

Our project relies upon a past senior design project that requires some work to get back in shape. If we are unable to resurrect that project efficiently, then we must purchase a new ground vehicle. Since this project is a proof of concept, it may not work the way we are expecting, so our project could take a sharp turn at any time.

PHYSICAL DANGERS

The main risk is with testing the propeller system. If it is not secured properly, there is a chance that it could break free and hit somebody.

MARKET/LITERATURE SURVEY

This project is mainly focused on developing a research system to prove if the propeller-based balancing system is able to stabilize the instrument arm (which behaves similar to a spherical inverted pendulum). Other universities have conducted research and successfully balanced 1-degree of freedom spherical inverted pendulums on stationary objects. No current work on balancing a spherical inverted pendulum with 2-degrees of freedom using a propeller-based balancing system is known.