

2.017 Design of Electromechanical Robotic Systems, Fall 2009

Field Robotics Projects

Final report and presentation due: 12/07/09

1 Project 1: Autonomous Air Vehicle Navigation

1.1 Objective

Design and implement an integrated navigation system for a rotorcraft that is capable of taking off, flying through a preset course, collecting data at several waypoints, and landing on a marked target location autonomously.

1.2 Description

A modern navigation system generally includes a Global Positioning System (GPS) receiver to determine the position and motion of a vehicle. However GPS alone sometimes cannot provide the required accuracy and robustness of Position Location Information (PLI) due to the following limitations.

- Position error
Typical position accuracy of a commercial GPS receiver (such as the USGlobalSat EM-406A that we have) is about 10 meters while the velocity accuracy is about 0.1 m/s. (Note that a military grade GPS can provide a position accuracy of a few centimeters.) As you can see the position accuracy of the GPS may not be good enough to navigate a small vehicle to a specific location or to land it on a tight spot reliably. This is important if we want the vehicle to inspect a small target or to re-fuel automatically at a re-fueling station.
- Operating conditions:
The vehicle may have to operate in conditions where GPS signal is unavailable, such as a GPS denied battlefield, under foliage, in and around natural mountains/canyons, or urban conditions.

For the above reasons, a GPS-based navigation system needs to be augmented by adding an Inertial Measurement Unit (IMU) with three mutually orthogonal gyros and accelerometers. Alternatively, a vision-based system can be used in conjunction with the GPS receiver to provide improved position accuracy and reliability.

The purpose of this project is to develop an integrated navigation system that includes a GPS receiver and an IMU or a camera that will provide accurate PLI to the ob-board computer on a rotorcraft for unmanned operations.

1.3 Themes

The project is designed to learn the following aspects in robotic system design:

- Complex system modeling, analysis, and design
- Design for RC rotorcraft operations in uncertain wind conditions
- Microcontroller programming and communication
- Signal and image processing
- Navigation and feedback control
- Autonomy

1.4 Equipment

Two rotorcraft will be available to you as the test platform:



Ascending Technologies “HummingBird” quadrotor aircraft.
(<http://www.asctec.de/main/index.php?id=4&pid=2&lang=en&cat=pro>)



E-Flite Blade CP Pro 2 RTF Electric Micro Helicopter.
(http://www.redrockethobbies.com/E_Flite_Blade_CP_Pro_2_RTf_Electric_p/eflh1350.htm)

All the sensors, equipment, and parts in the lab are available for the project. Additional components, sensors, and supplies will be acquired as justified by design needs.

1.5 Tasks

1. Fly the aircraft to a preset coordinate and regulate the aircraft to maintain position based on GPS reference.
2. Take one or more pictures at that location.
3. Fly a planned GPS reference path.
4. Take pictures along the path.
5. Position control using both GPS reference and camera feedback.
6. Precision landing on a small marked target.

2 Project 2: High Speed River Navigation with Energy Constraint

2.1 Objective

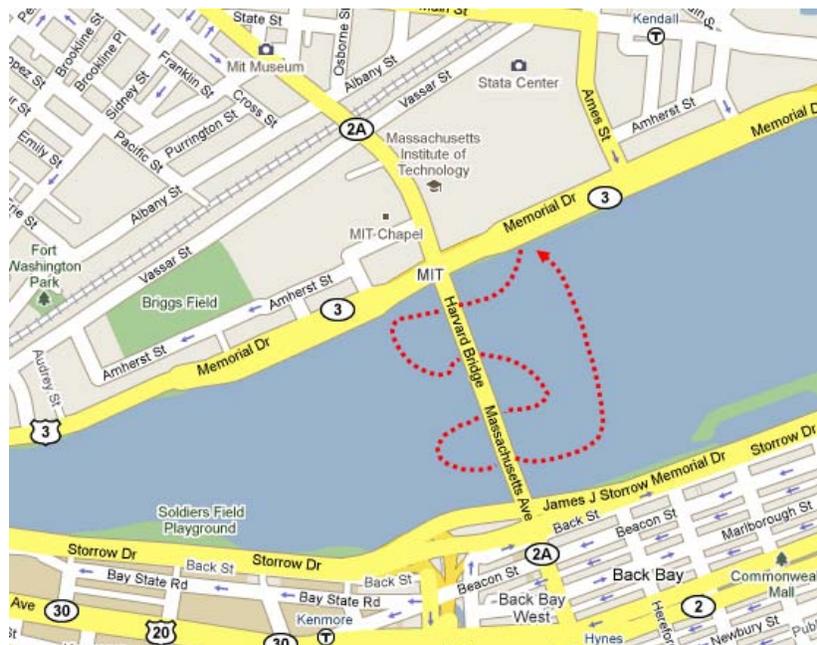
Design and implement an autonomous surface vessel that is capable of navigating around and under the spans of a bridge with minimum energy consumption and time.

2.2 Description

High speed river or ocean navigation with an unmanned vessel is of great interest to the scientific community as it enables researchers to survey a vast area without a human operator. One example of such application is the development of an automated bridge inspection vessel that can take multiple perspective photos of a bridge footing. However there exist several challenges that require further research and development, such as energy harvesting so that the vessel can operate for a prolong period of time without refueling or recharging.

For this project your team will design and implement an autonomous surface vessel that meets the following requirements:

- Survivable and rugged enough to host sensors that can inspect the Harvard Bridge on the Charles River as shown below
- Scavenge wind, solar, or wave energy from the environment for vehicle propulsion and electronics, to complement the on-board batteries



2.3 Themes

The project is designed to learn the following aspects in robotic system design:

- Complex system modeling, analysis, and design
- Design for RC vessel operations in uncertain wave conditions
- Microcontroller programming and communication
- Navigation and feedback control
- Inspection and data collection
- Energy harvesting and optimization
- Autonomy

2.4 Equipment

Platform:



Pro Boat Miss Elam 1/12 Brushless Electric Hydroplane
(<http://www.redrockethobbies.com/ProductDetails.asp?ProductCode=PRB3550>)

All the sensors, equipment, and parts in the lab are available for the project. Additional components, sensors, and supplies will be acquired as justified by design needs.

2.5 Tasks

1. Control the hydroplane to fly a planned GPS path.
2. Fly parallel to a wall using a laser range finder.
3. Photo survey on a bridge footing using both GPS and laser information.
4. Quantitative assessment and/or experiment on solar power charging strategies for the instrumentation.

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