# Object Recognition and Retrieval Using an Autonomous Indoor Aerial Vehicle

**Torben Rasmussen**
**Joey Tomlinson**
Robotics Club
Oregon State University
Corvallis, OR U.S.

**Abstract**

The 6th mission of the International Aerial Robotics Competition picks up where the 5th left off, challenging teams to perform more complex navigation and object manipulation tasks using autonomous aerial robots. The 6th mission's competition arena is a security complex with an office that contains a USB flash drive which holds sensitive information. This paper describes our quad rotor platform which is designed to autonomously navigate the building and retrieve the flash drive. The platform accomplishes this task using inertial sensors, a LIDAR sensor, and a camera. Platform stability is controlled using PID algorithms which run on an embedded 8 bit microcontroller and use inertial data to maintain pitch, roll, and yaw. Navigation is accomplished using SLAM algorithms. Recognition of the flash drive is done using image recognition software developed using the OpenCV computer vision libraries. This autonomous platform caries a magnetic flash drive retrieval and replacement system.

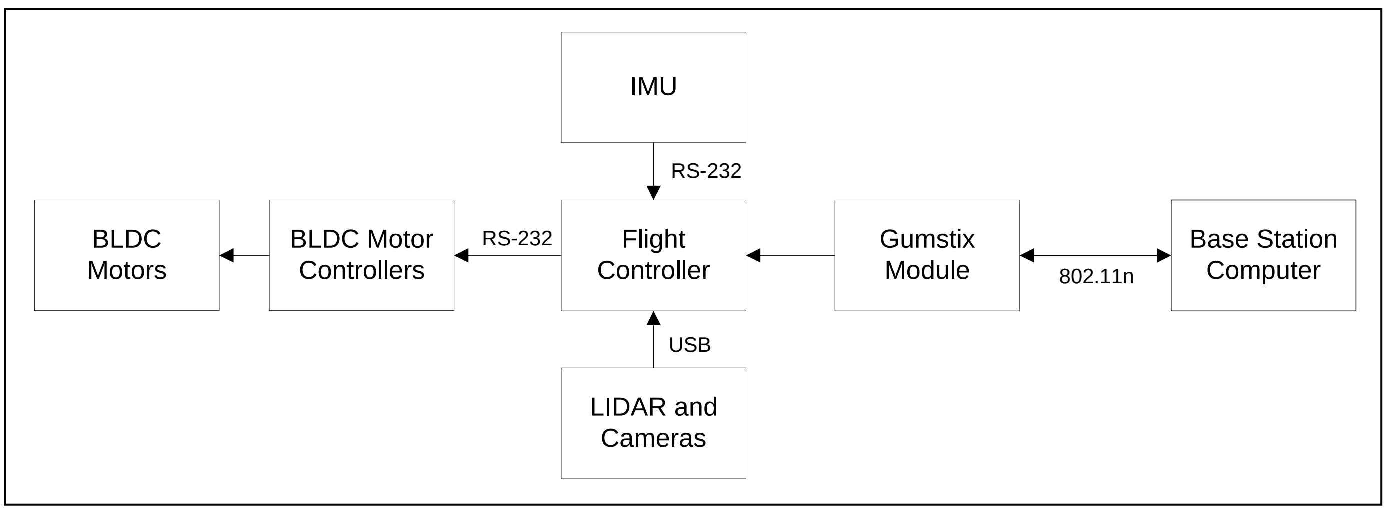


Figure 1. System Diagram

## 1. Chassis

The robot has a quad rotor chassis and propeller configuration. The chassis consists of a cross made of square woven carbon fiber tubing connected with carbon fiber plates at the center of the chassis. Counter rotating propellers at the four ends of the cross arms propel and steer the platform. By varying the speeds of the propellers, the platform can be accelerated in the pitch roll and yaw directions independently. The propellers are protected from collisions by a shroud which is made of thin carbon fiber rods and surrounds the platform and the propellers. The inertial measurement unit, LIDAR sensor and cameras are mounted to the top of the center plates. Circuitry and batteries are held under the robot. The motor wiring and motor controllers are contained within the four carbon fiber tubes which make up the cross arms.

## 2. Propulsion Systems

The robot uses four Hacker brand out runner brushless dc motors connected to counter rotating propellers from Draganfly. Motor power is provided by a 5000mAh lithium polymer battery. The motors are controlled using brushless DC motor controllers from MikroKopter, a German aerial vehicle company. These controllers use back EMF sensing to control motor commutation so no external sensors are required to control the motors. They use a serial control interface which offers 8 bit speed control resolution.

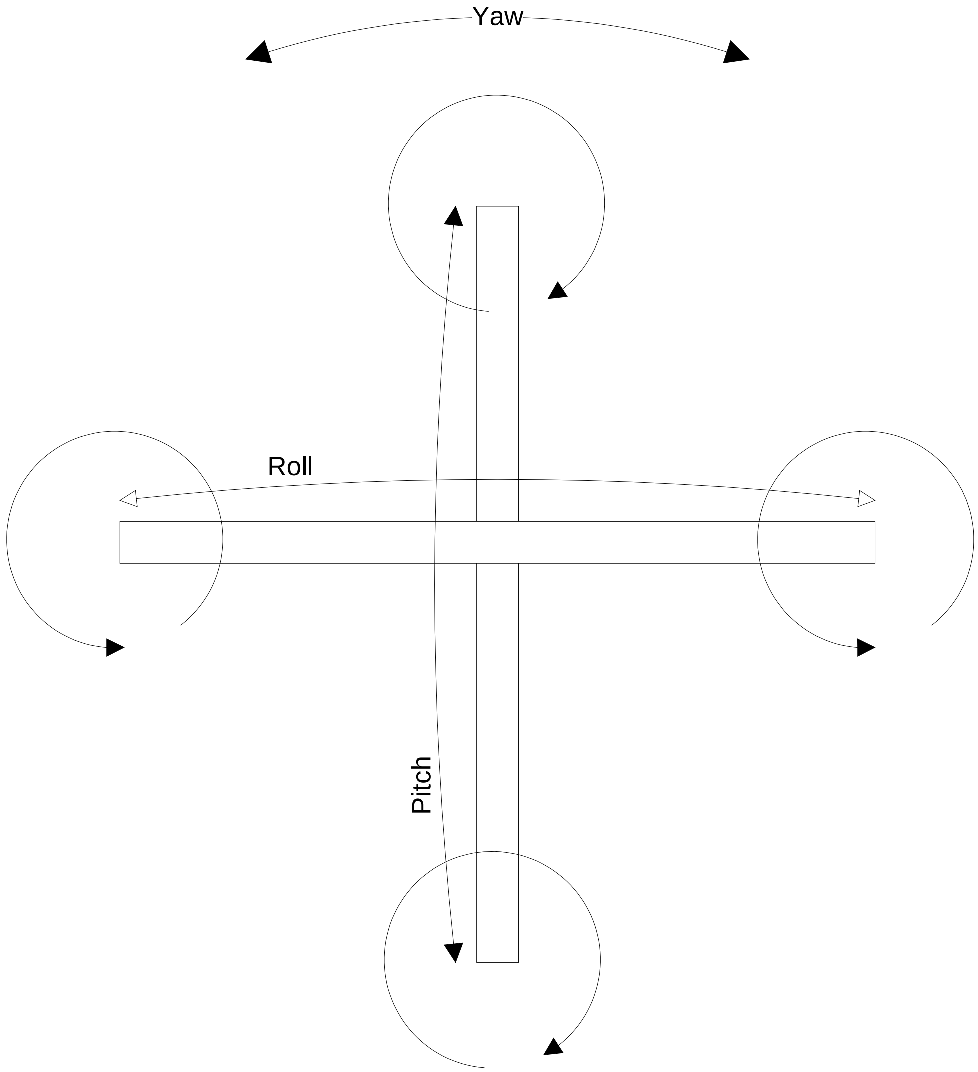


Figure 2. Aerial Vehicle Concept Diagram

## 3. Attitude Sensing and Control

The sensor responsible for obtaining attitude data is a Microstrain IMU. This data is relayed to an on-board flight controller via an RS-232 serial interface. The flight controller is an Atmel xMega128A3 microcontroller. It has an eight bit 32MHz processor, 8kB of RAM, and 128kB of program memory. It includes advanced dedicated hardware that allows for efficient interface to other devices with less CPU load. The processor controls all aspects of the vehicle's stability, and functions independently of all other systems.

The IMU collects data from a triple axis accelerometer, triple axis gyroscope and triple axis magnetometer. Data fusion and filtering algorithms running on board the IMU process this data and report estimated platform Euler angles to the flight controller. Three independent PID control loops run on the flight controller to control each rotational axis of the arm: pitch, yaw, and roll. The PID control loops were tuned using an educated trial and error method.

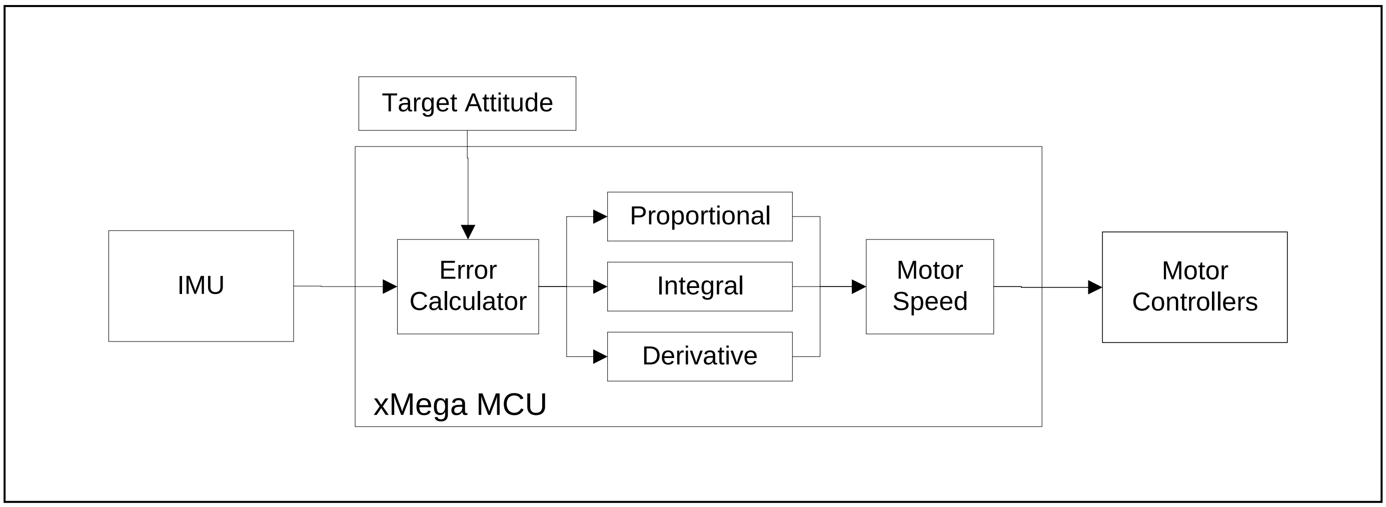


Figure 3. Attitude Control Diagram

## 4. Navigation Systems

The robot uses SLAM algorithms to map its surroundings and determine its position within indoor environments. Path planning algorithms are used to guide the robot around obstacles in order to search the building for the USB drive.

### 4.1 LIDAR Driven SLAM

Simultaneous Localization and Mapping (SLAM) algorithms use rich spatial data sets to map the surroundings of a vehicle and determine the location of the vehicle within its surroundings. Our vehicle uses a LIDAR sensor in conjunction with acceleration data from the IMU. We are using SLAM algorithms which are integrated with the Mobile Robot Programming Toolkit (MRPT) to accomplish mapping on our robot.

### 4.2 Obstacle Avoidance

Once a spatial map of the robot's surroundings is constructed and the position of the robot within its environment is know, path planning and search algorithms are used to navigate through the building and search for the flash drive while avoiding obstacles.

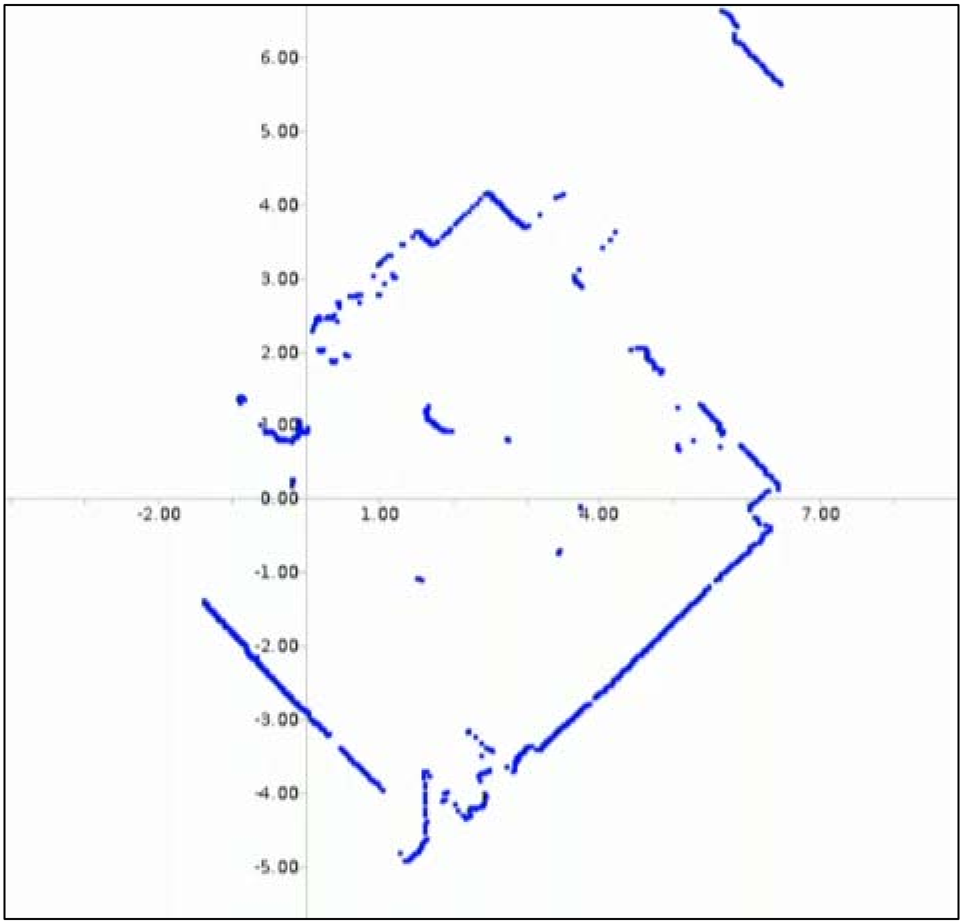


Figure 3. LIDAR Data Used for SLAM

### 4.3 Security Avoidance

The aerial vehicle will be capable of continuous flight in order to not trip the ground pressure sensitive alarms. It will use a camera to detect security camera activity LEDs. When the blue LED is off, the robot will be able to enter through the window undetected.

## 5. Communications

There are several communication protocols in use on the system:

- 802.11n Wi-Fi Using TCP/IP Sockets
  Used for issuing high-level commands between base station and on board computer
- RC PPM Controller
  Used for direct manual control of the flight controller. When activated, this overrides computer control of the robot and can be used to immediately shut down all propulsion systems in an emergency situation.
- RS232 Serial Communication Between Onboard Devices
  Used for communication between the on board computer, flight controller and motor controllers.

## 6. USB Drive Identification

The USB drive will be detected using cameras onboard the vehicle. Camera data is sent off board to be analyzed by the base station computer. Computer vision algorithms developed using the OpenCV computer vision libraries use feature matching to attempt to locate the flash drive within an image.

## 7. USB Drive Retrieval and Replacement

The USB drive, once identified will be retrieved by the aircraft using a permanent magnet attached to an arm. This mechanism will attach to the metal USB connector on the USB drive and allow the aircraft to pick it up. The aircraft will be carrying a dummy USB drive which is secured to the robot by a thin copper release wire. When the dummy USB drive is to be released, the robot melts the wire by passing current through it. When the wire breaks, the drive is released.

## 8. Obstacle Avoidance

The on board computer gathers LIDAR and camera data and sends them to the base station computer over an 802.11n Wi-Fi link. The base station simultaneously runs SLAM and path finding algorithms to map the robot's environment and steer the robot around obstacles and through hallways.