Autonomous Quadcopter for Indoor Reconnaissance

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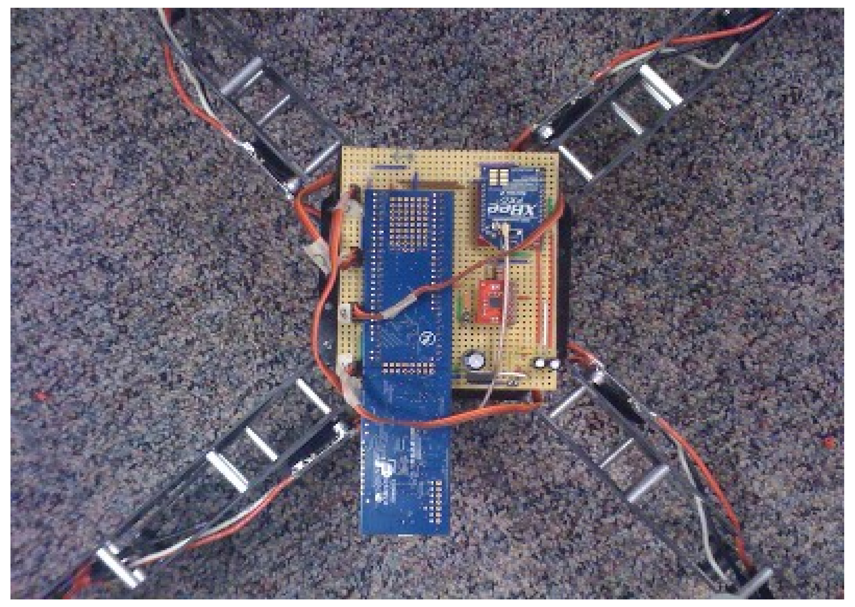
Problem/Opportunity

The worldwide UAV industry is worth $7 billion, mostly involving military applications. We are representing Portland State in the 2012 International Aerial Robotics Competition. The ten-minute mission calls for a robot to enter and navigate a building to find a supervisor's office, retrieve a flash drive from their desk, and return to the base station without being detected. No remote control is permitted.

The quadcopter frame must be small and agile to fit through a window and escape detection, but robust enough to carry the on-board sensors. Vertical thrust is provided by four motors, each controlled by a programmable electronic speed controller (ESC).

To successfully navigate the room, the onboard control system should process incoming sensor data, including some sort of visual data, and determine appropriate changes in motor values to maintain stable flight through lateral (pitch), longitudinal (roll), and vertical (yaw) axes. Using GPS to determine an absolute location is not allowed so the control system must have some way to compensate for sensor drift.

Figure 1: Protoboard with processor, wireless antenna; schematic for replacement printed circuit board.



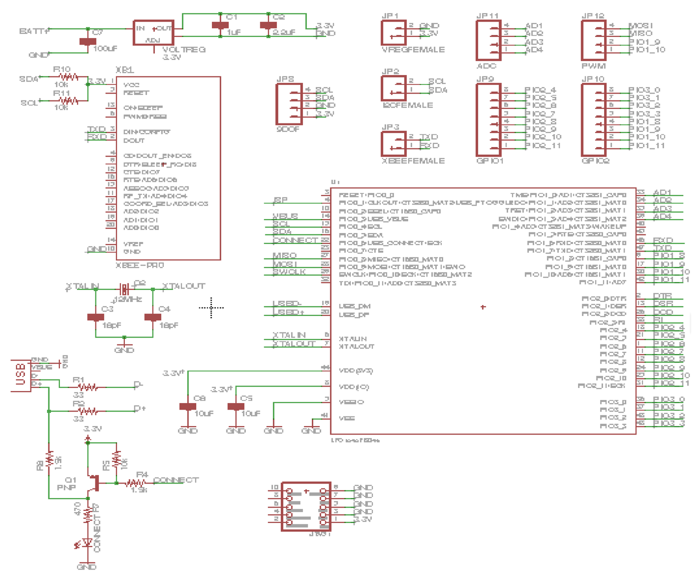
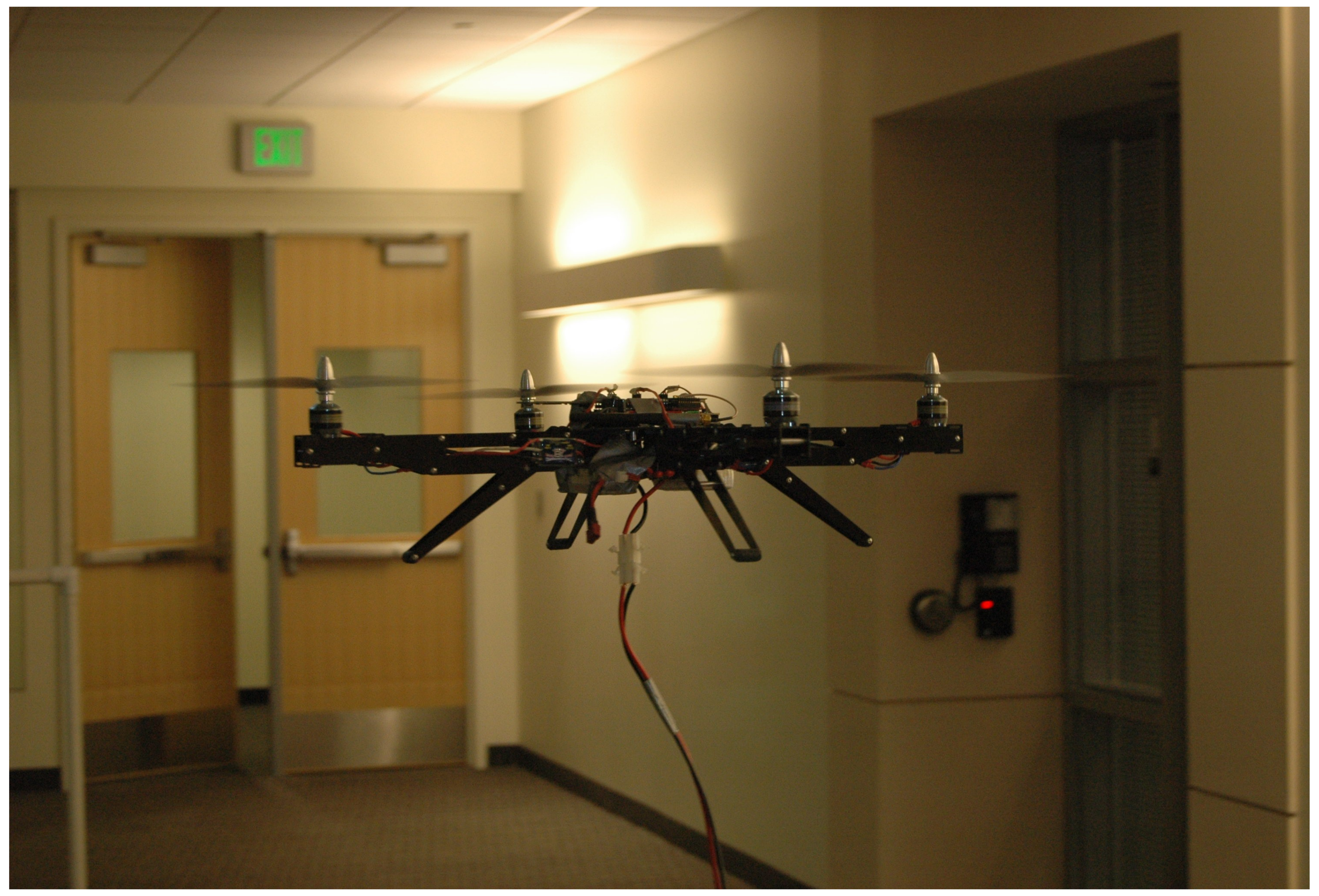


Figure 2: Tethered quadcopter holding a hover.



Key Observations and Learnings

The initial phase focused on development of the onboard embedded sensor and control system. Our high-level onboard processor, the Neocortex, is an off-the-shelf Pandaboard which runs headless Ubuntu Linux for OMAP4 and serves as a message bus between Wireless N (base station communications), the control board, and the Hokuyo laser range finder

We use an LPCXpresso microcontroller for stabilization and ESC control. The current sensor package includes a gyro, accelerometer, and magnetometer. We use a direction cosine matrix updated with rate gyro data to estimate our attenuation in earth fixed frame. Our PID loops then operate on the euler angles obtained from this matrix. Two separate loops comprise the control system. One loop running at 200hz estimates our attenuation (roll-pitch-yaw). A second loop runs at ~50hz and sets motor outputs based on the current state error.

Results

The quadcopter is capable of several minutes' flight without the tether. It stabilizes automatically when its attitude is upset and it is capable of maintaining a given state, but it is not yet able to navigate or react to visual input.

Lithium polymer batteries fully charged will last the required ten minutes. We built a test stand for controllable flight test. Languages used are Python and C.

Conclusions

The intensive data processing for a vision system requires a remote link to the base station. Using a Hokuyo laser rangefinder to generate the necessary data, we will implement Simultaneous Localization and Mapping (SLAM) which will generate an internal map for the quadcopter as it explores the building.

The next phase will give the quadcopter enough sensor data, including vision, for it to make decisions during the mission.

Figure 3: Construction of the Hoverthings frame.