Project Quadcopter

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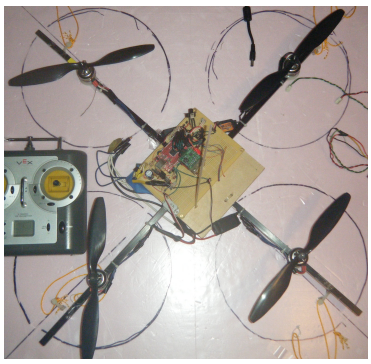
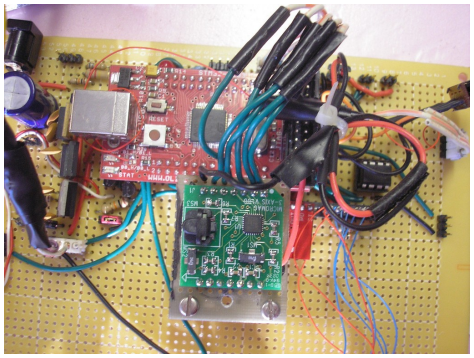
William Rolke, Jeff Hsu and I have been working on creating an autonomous quadrotor helicopter, or “quadcopter,” since the conclusion of last year's Botball season.



Our quadcopter is entirely custom designed, though we used other successful quad builds to aid our design process. It uses a 3 cell Lithium-Polymer battery, and four brushless motors and speed controllers. The perpendicular black beams are lightweight carbon fiber tubes, while the center brace and circuit mount is made of wood. At the time of this writing, we are constructing a “Quad 2.0,” featuring a larger, sturdier frame, improved power cable routing and speed controller placement, a new larger 5400 mah battery, as well as pool-noodle landing gear, and is pictured below.

The quadcopter flies similar to a helicopter, though with four fixed rotors instead of one variable pitch rotor. It can roll or pitch, producing lateral motion, as well as yaw, all by adjusting the speeds of the rotors relative to each other. Unlike a plane, a quad is a naturally unstable system, and a very slight imbalance in thrust can rather quickly cause it to flip and fall to the ground. Because of this, most successful quads contain an inertial measurement unit and a microprocessor which work in tandem to stabilize the quad and perform motions commanded by a pilot or autopilot.

Our quad's control board contains an IMU with three axises of gyroscope, accelerometer, and magnetometer sensing, as well as a 32-bit ARM processor. For autopilot usage, the board also contains an altimeter and a GPS unit. Our circuitry is an original design and has gone through several stages of prototype before the final version in the above picture. The software behind the board is also entirely custom, and has grown into a small but functional real time operating system. It keeps the quad stable by sampling the various sensors at speeds of 500hz and running a Kalman filter to combine them into a single state estimate. Individual PID loops for roll pitch and yaw produce motor corrections which are then appropriately mixed to the four rotors, enabling the quad to stay level, and perform commanded motions while remaining stable.



By GCER, we hope to have the quad be capable of executing a preloaded mission plan completely autonomously, taking off, traveling to GPS waypoints, and then landing. Failing that, it will at least be capable of flight, and we could program in simple autonomous behavior like taking off or landing. Though it seems unlikely that we will fail to achieve flight by then (we were very close in January, before having to take a hiatus for school reasons), we could still demonstrate autonomous behavior in the IMU, and demonstrate the quad balancing with two motors on a single axis, which is already functional.