Bubbles: An Experiment in Aerial Robotics

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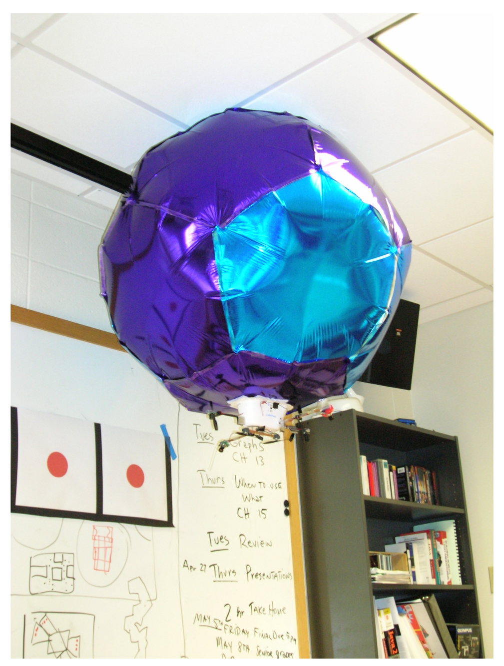
Task: To create an aerial robotic system capable of autonomously navigating a maze employing visual cues to indicate direction. Robotic system must also map the path taken through the maze. This task was designed by Drexel for the 2006 Indoor Aerial Robot Competition.

Bubbles, the blimp:



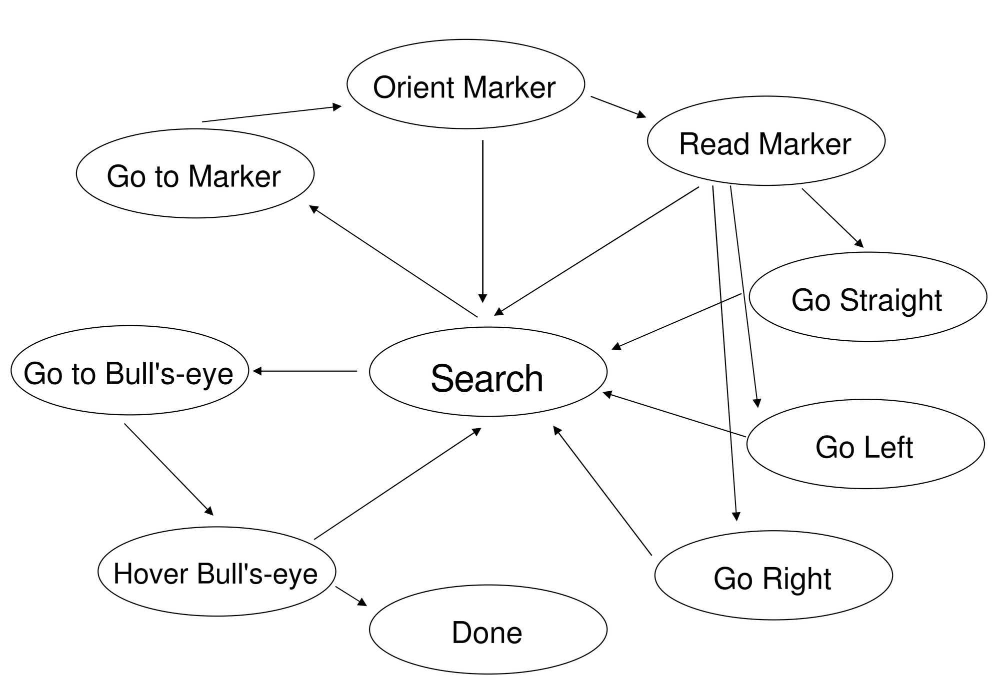
Materials: Mylar®-like balloon skin
Plastic gondola

Hardware: 3 Wireless cameras
1 Sonar
6 Fans (2 each forward, back, down)

Construction: The blimp is a dodecahedron. Helium inflation is done through a tunnel extension on one side. The gondola contains the wiring for the motors as well as the batteries for the motors and cameras.

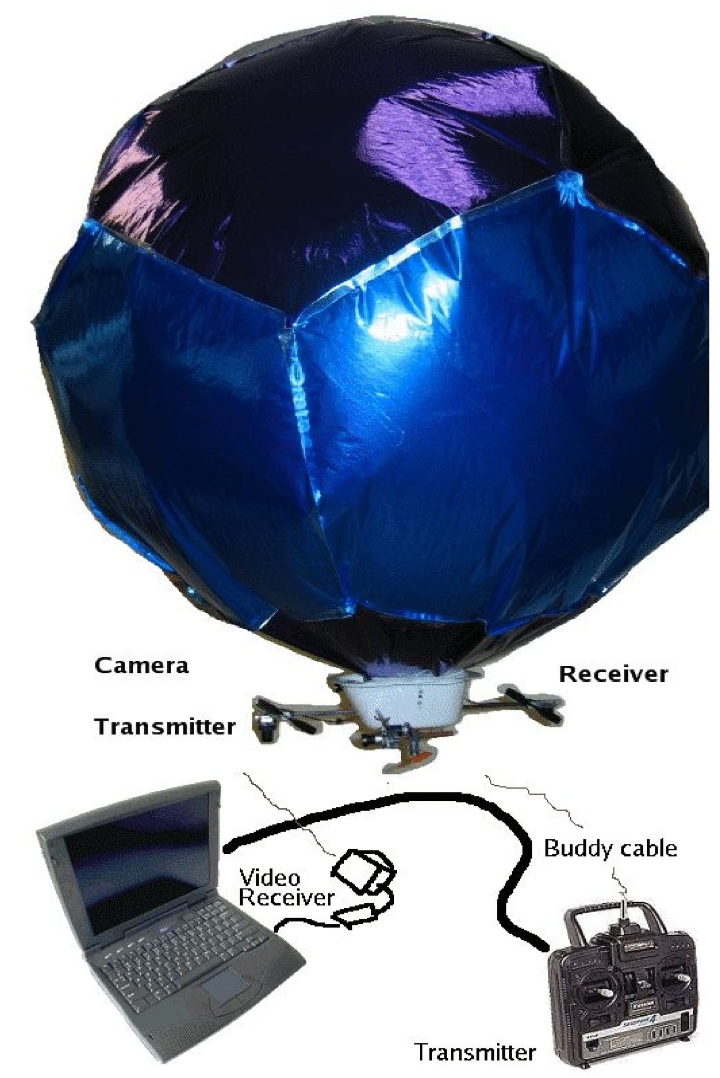
Approach: There are three cameras mounted on the gondola, one each looking forward, back and down, and one sonar to gauge distance. There are two fans each dedicated to up/down, forwards/backwards and right/left movement.

Finite State Machine:



This FSM was created to control Bubbles' movement.

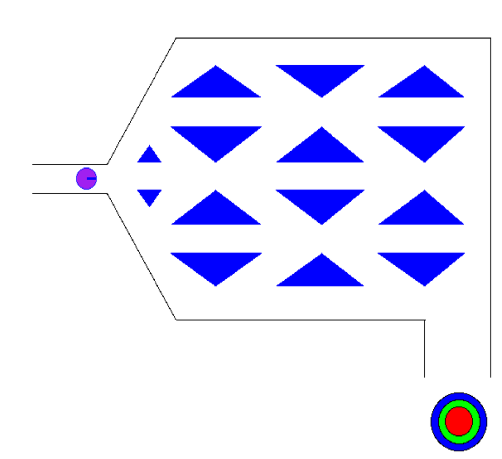
How it works:



Software:

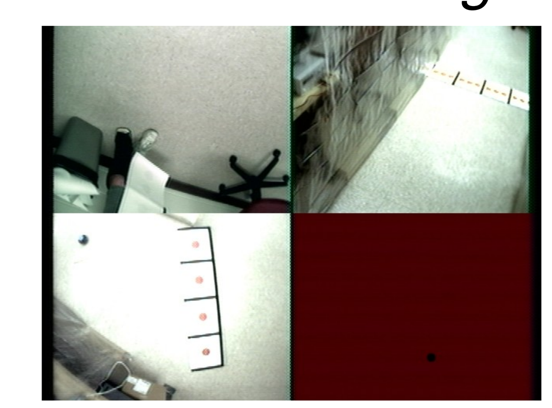
Pyro: All of our software uses Pyro Python Robotics which provides a programming environment for easily exploring advanced topics in artificial intelligence and robotics without having to worry about the low-level details of the underlying hardware. Pyro is written in python and supports several different robots such as the Sony Aibo, Pioneers and Kheperas. It is open source, and designed for students, faculty and researchers. Pyro has now partnered with Microsoft Research and Georgia Tech to form the Institute for Personal Robotics in Education (IPRE).

Mapping: A map is linked to the finite state machine, so that whenever Bubbles finds a marker, it plots it on the template map, as well as the direction it actually took. The FSM dictates the progress of Bubbles throughout the maze and plots the path taken along with the markers it encounters.



Height Control: Height is measured by a sonar device which is sent as audio through a camera. The audio is then decoded using Fast Fourier Transform as distance. The height is controlled using three coefficients to a stabilizing formula: proportional, integral and derivative. This tells the robot how much power to send to the height controlling fans.

Vision and Recognition: The vision code detects lines and the orientation of fiducial markers. It also interprets which way the blimp should go, based on the number of dots displayed on the markers. One frame-grabber reads the three cameras which come through in one signal, and then the program splits the signal back into the three separate images.



Lessons Learned:

The lab isn't the real world: The wireless signal can get scrambled by something as simple as a speaker system. When possible, try the cameras out in many different environments. Testing only for range will ignore other important issues.

Weight is a delicate issue: No matter how appealing adding six cameras may be, the robot may not be able to lift them. To carry everything on Bubbles' gondola, its balloon had to be custom made. Careful calculations went into determining the size and shape of Bubbles, but be prepared for a few false starts.

Have fun, think outside the box, push the envelope: Just because there is a kit, doesn't mean you are stuck with it. Try new ideas; do not be afraid to throw a model away. Always make it exciting!

Resources:

For more information on Pyro, please see http://pyrobotics.org

For further information on the Indoor Aerial Robot Competition, please see http://www.pages.drexel.edu/~vn43/main/IARC2006/IARC2006.html

To explore the Emergent Artificial Intelligence Laboratory, please see http://mainline.brynmawr.edu/eailab/

To learn more about the Institute for Personal Robotics in Education (IPRE), please see http://www.roboteducation.org

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