To: Professor Merz
From: Benjamin Nitkin
Subject: IGVC Progress Report
Date: September 18, 2013

Research this past week focused on computer vision, sensors, and robot architecture. On the vision front, I looked into accuracy, synchronizing cameras, and divergence depthmapping. Lafayette's IGVC robot will use the same sensor suite as other robots, but will save money by using lower-level sensors. Electrically, the robot breaks down into motors, sensors, telemetry, and central computing.

Depth mapping is a necessity for a robot navigating an unknown environment. A depthmap is far more informative than a camera because it provides a consistent map, independent of time of day or position. (Objects look very different in different lighting or from different angles with a camera.) In general, researchers use a Microsoft Kinect for indoor mapping and LIDAR outside. A Kinect would flop at IGVC because it uses an internal projector to map a space; the sun will wash out the Kinect's projection. LIDAR works for most teams, but at $5000, is out of our price range. In IGVC competition, a depthmap would show obstacles standing out of the ground plane without using heavy-duty shape recognition or color matching.

Stereo vision may allow us to generate a depthmap at a lower price point than LIDAR. Two cameras, some distance apart on the robot, take an image at the same time. A computer pores over the images, finding as many keypoints as it can in each. Keypoints are correlated between the left and right images, and their disparity (difference in location between images) is calculated. Disparity is related to depth; it's a simple conversion to transform pixels of disparity to feet of depth. There are a few constraints, though. The cameras must take simultaneous images, and the shutter must be relatively fast. The PlayStation Eye appears to match those criteria. A hardware modification allows multiple cameras to be controlled by a single master, and the camera offers very high framerates.

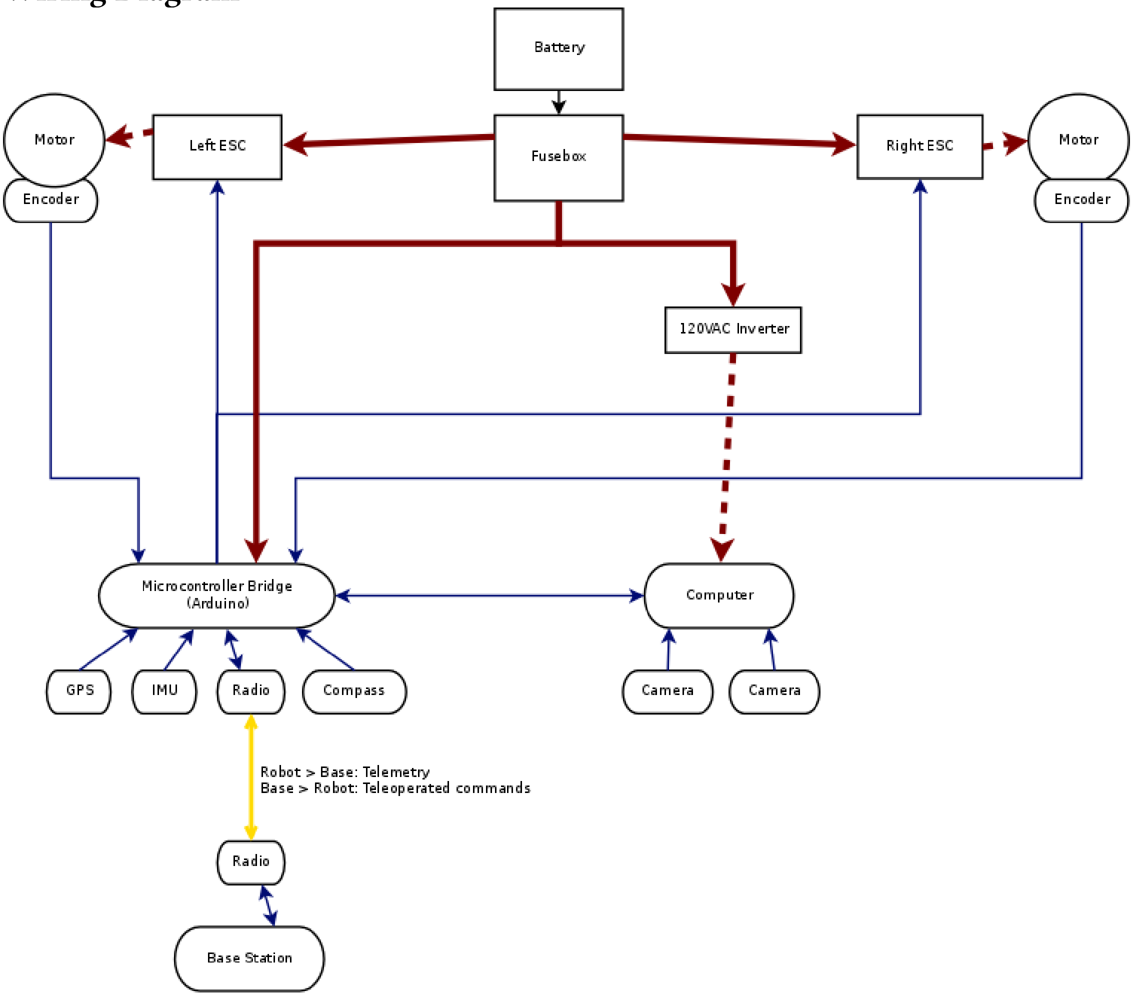
IGVC robots use a fairly standard suite of sensors: GPS, wheel encoders, inertial measurement unit (accelerometers and gyros), compass, LIDAR, and camera. Lafayette's robot will source inexpensive versions of most, and will even omit some of this standard package (LIDAR, if not others). Many teams use expensive packaged sensors that interface directly with a computer. Where possible, our robot will use serial sensors and interface them to the computer through a microcontroller (Arduino or otherwise). These serial electronics cost less than their USB counterparts. Creating a common bridge between high- and low-level electronics should reduce costs and allow us flexibility in sensors and outputs.

All of these decisions give us a fair idea of the robot's electrical structure. The nervous center of the robot is a computer. It reads data from each sensor (either directly or by polling the bridge for a particular reading). It then synthesizes the data, mapping its own little universe as it drives, and uses the map to plot a course for the next GPS waypoint. The computer sends motor powers to the speed controls over the bridge.

On the high-power side, a 12V battery powers the entire system. It runs through a fuse, then into an 120VAC inverter to power the computer. The battery also provides 12V to each of the two motor drivers. These small boxes combine the 12V from the battery with a 5V PWM signal from the bridge to produce a square wave with a variable duty cycle. By adjusting the duty cycle, the average power to the motor can be adjusted, changing the wheel velocity.

Other topics from this week
ROS, RobotRealm, and Labview: computer vision and robot management frameworks
Desktop vs laptop: laptop preferred (lower power & lighter); desktop is free from Rosenbauer

Wiring Diagram



Key:

Solid red	12V power
Dashed red	Other high current (120V to computer and 12V PWM to motors)
Blue	Signals, various formats
Yellow	Radio link
Square	Basic electric parts
Rounded	Sensors & controllers

(This is just an overview. Sensors, for instance, are missing power.)