Build and Test Plan: IGV Team

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Laser Range Finder – Week 3 – Jan 29
Geoff
The laser range finder will be set-up in the lab and connected to the computer via the USB interface. The information acquired from the laser range finder will be tested for accuracy. This will involve setting up pre-defined object a certain distance from the laser range finder as a reference and comparing the data obtained from it to the reference distances. These objects will include traffic barrels, cones and barricades to get a feel for what the robot will actually encounter on the obstacle course.

LRF to XY - Week 3 – Jan 29
Geoff
Laser range finder data needs to be converted from polar coordinates to xy coordinates for integration with the rest of the obstacle detection system.

Matlab Compiler - Week 3 - Jan 29
Bill
Have the matlab compiler functioning. We should be able to run a simple matlab program using the framework.

Motor Controller - Week 3 – Jan 29
Alex
The motor controller operates via a RS232 serial interface. The goal during this phase is to have smooth communication between the computer and the motor controllers using basic functions such as connect, disconnect, setSpeed, setDirection, getSpeed, getTemp (for transistors), stopRobot, getBattery (battery voltage), and reset. These functions will be used extensively in phase 2 for following a path. This will be tested on the robot from last year in a controlled environment. A basic program will be made using every function and logging speed, temperature, and battery voltage to access at the end of the run.

Update Website - Week 3 – Jan 29
Geoff
The website should be updated from the previous year to reflect the new members and the new design of the robot. This is important for fund raising as well. The update will be complete by this point.

Camera - Week 4 - Feb 5
Bill
This is the basic interfacing of the camera to the computer. We should be able to change resolution, exposure, etc. and aquire images. This is placed in week 4 because we will be waiting for the firewire adapter card.

Camera Matrix - Week 4 - Feb 5
Bill
Once the laser pointer assembly from Mr. James is finished, debugging of the projection matrix function in matlab can be completed. This will be used to create a projection

matrix for any position that the camera is in. It may be possible to create ideal projection matrices based on the derived camera matrix and rotation and position data once the first projection matrix has been calculated. However, it will probably be more accurate to continue using the empirical method.

Emergency Distance Sensors – Week 4 - Feb 5
Geoff
The Emergency Distance Sensors will be mounted around the perimeter of the robot and will be constantly comparing the distance to a certain threshold distance. The Emergency Distance Sensors will be connected to a microcontroller which will be programmed to monitor each sensor. If a sensor's distance information reaches a programmed threshold in the microcontroller a switch will be trigger to shut the motors off. The testing will begin once the Emergency Distance Sensors are attached to a microcontroller and the microcontroller is programmed to monitor and trigger a switch at a certain threshold. The threshold will then be adjusted to a certain distance.

GPS - Week 4 - Feb 5
Alex
The GPS also operates via a RS232 serial interface. It uses the NMEA 0183 protocol to transmit data. The GPS will be interfaced to our Linux machine using either modified old code or the daemon called gpsd. Both will be tested to see which works better and the most reliable method will be used. Testing will go as follows: the GPS will be moved to an area where it can receive a signal (outside), and the position and heading will be queried at close to the maximum refresh rate while the GPS is mobile. The method that produces the most consistent and error-free data will be chosen.

Wireless E-Stop - Week 4 - Feb 5
Geoff
A circuit will be constructed by the team to receive a signal via a RF module that communicates via RS-232. This circuit will be wired to the emergency stop input on the motor controller so that the robot will come to a complete stop whenever the signal is received. The team will also make a transmitter device with a button on it that will activate this emergency stop. This device will have a transmitter RF module and a switch and will be battery powered for portability. It will also be wired up to the motor controllers and tested along with the motor control code. It will be important for the safety of the testers, so it will be tested first.

Extract Ground Plane - Week 5 - Feb 12
Bill
Once the projection matrix calculation is working, it will be possible to map the laser range finder data into the image. The next issue will be segmentation of the ground plane. At this point, we will be able to take laser range finder data and run the image through a function that will generate a new image containing just the ground plane.

Hardware Abstraction Layer - Week 5 - Feb 12
Geoff
This will be the concierge of hardware data, a simplified and standardized C++ class that will include all functions that will be needed to communicate with any low level hardware. Testing will included calling each function and comparing its output with known output to see if they are the same.

Position, Velocity, and Heading - Week 5 - Feb 12
Alex
The hardware abstraction layer will be used to determine the current speed via GPS and Encoders. The position will be determined through the GPS and the GPS's compass will be used to determine heading. These values will be checked via a handheld GPS unit. This will either be tested on the old robot or the new robot based on the status of the chassis.

Chassis - Week 6 - Feb 19
David and Diego
The chassis will be constructed out of 6063 aluminum. The design, which is currently in Solidworks, will be exported into a metal cut sheet. The ME students will practice TIG welding on small lengths, until they feel that they are proficient enough to conquer the actual chassis construction. The chassis will be tacked together for fitment then fully TIG'ed at every seam. This should provide for an extremely strong, lightweight chassis.

Match LRF to Obstacles - Week 6 - Feb 19
Bill
This milestone involves the segmentation of obstacles. Once the obstacles are distinct areas, they can be matched to the laser range finder data in preparation for the obstacle characterization.

Parameterize Lines - Week 6 - Feb 19
Bill
Building on the previous week's ground plane extraction, the lines on the ground should be detected and parameterized at this point.

A-Star - Week 7 - Feb 26
Alex
This phase will consist of developing the A-Star algorithm which will be used for following the map that is in place. A weighted grid will be taken in, and the lowest weight path will come from it. Optimizations will be made for smoother turns. This will be tested using multiple grids and confirming the results by hand.

Assembly - Week 7 - Feb 26
David and Diego
The team will be assembling the robot at this time. This includes mounting all of the components to the chassis and implementing any extraneous systems such as the access drawers and humidity reduction heat vent. This stage also includes neatly wiring the

robot and ensuring full functionality of all previously working systems. The robot will be made such that the sensors can be removed easily and the camera mount can also be removed for possible shipping of the robot.

Parameterize Obstacles - Week 7 - Feb 26
Bill
Once the laser range finder data has been matched to color regions in the image, we can estimate the depth and area of the obstacles using our assumptions. This function should be operational at this time.

Motor Controller Tuning - Week 8 – Mar 4
David and Diego
The feedback constants (kp, ki, kd) will be adjusted to get the robot to follow the path smoothly. Turns should be smooth, and acceleration should not be jerky.

Potholes - Week 8 - Mar 4
Bill
Potholes will be a difficult task in themselves. At this point, we should be able to detect them in the ground plane.

Overlay Multiple Maps - Week 9 - Mar 11
Geoff
As the vehicle moves through the course, it will be necessary to combine the information from maps generated at various positions and angles. At this point, the algorithm for doing so will be finished, and the code will be written and tested.

Path Following - Week 9 - Feb 11
Alex
The robot must be able to follow a path and use sensor data to calculate the error in this path while correcting it. In order to do this, a PID motion control system will be implemented at this stage. A test path will be made with GPS coordinates and the robot must be able to follow the path as close as possible.

Spring and Tires Tuning - Week 9 - Mar 11
David and Diego
In order to accurately predict and control the vibrations of the vehicle, the characteristics of the tires and casters must be determined. In particular, the spring rate and possibly the damping coefficient can be estimated experimentally. The wheels will first be mounted to the 2007 vehicle frame or some other rigid testing rig which will allow for vertical movement as the tires are loaded. Next, incremental weights will be added and the deflection will be measured. This experiment will be repeated under multiple tire air pressures. In a similar fashion, the caster spring rate will be estimated for multiple spring designs. This information can be used to properly model the movement of the vehicle. We will also attempt to estimate the damping coefficients associated with each air pressure and spring by measuring the response of each to a given set of initial conditions. Plots of the displacement response will be acquired from the accelerometer plot.

Terrain - Week 9 - Mar 11
Bill
The vision system should be able to ignore terrain features such as ramps and sand pits. This should be operational at this point.

Final Map - Week 10 - Mar 18
Bill
This represents the final functioning stage of the obstacle detection system. All core functions should be written and the robot should be able to execute the algorithm as designed. The result will be a map of the area visible to the sensors.

Emergency Stop Handling – Week 11 – Mar 25
Geoff
The emergency distance sensors will need to be incorporated into the motor control and locomotion functionality. At this point, the two systems will be interacting reliably. An object coming within range of the distance sensors should stop the robot or initiate avoidance algorithms.

Nav Operation - Week 11 – Mar 25
Alex
This step processes the GPS coordinates and determines the shortest path between them. This will be done via brute force. This path will determine a general direction and the robot will use this direction to create a weighted grid with the obstacles found by the sensors in the path.

Following and Planning Code - Week 12 - Apr 1
Bill
At this point, the timing for the transition and interaction between following and planning modes should be finalized and functional.

Autonomous Operation - Week 14 – Apr 15
All
At this point, the autonomous operation should be finished.

Final Debug - Week 15 - Apr 22
All
The final debug stage is a final run through of all the possible situations that we will encounter in the competition. We will start with the most basic problems without any obstacles to verify simple operation. We will add obstacles in degrees, verifying performance with each new configuration. Finally, we will conduct “torture tests” that will pit the robot against the most difficult situations conceivable. Any bugs found will be fixed as they arise.