Capstone Team #41

Testing and Validation Plan

For IEEE Region 5 Robotics Competition

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Testing Objectives

As with many competitions, there is a strict set of rules and regulations that a team or competitor must follow. By observing the rules, the project has clear guidelines and goals that have already been defined. Using these rules, we can create benchmarks and specifications that the robot would need to meet to compete successfully. These objectives outline every challenge the robot will face throughout the competition. By ensuring that the robot meets these specifications, the team can optimize competition performance.

To better understand the specifications chosen, one must first understand the rules and what is required of the robot. For this year's competition, teams are tasked to design and build an autonomous robot to solve a randomized maze. The competition will be conducted in rounds with the maze area and time limit increasing each consecutive round. Characters will be present on certain colored maze walls, and if recognized by the robot, the characters will add bonus points to the team's competition score. Finally in the third round, there will be obstacles in the form of speed bumps present throughout the maze.

From the brief competition description above, the team has formulated meetable specifications to ensure successful project completion:

- Reflectance Sensors with 3/8" clearance can recognize the difference between black and white with some calibration
- Proximity Sensors can recognize distinguish wall distance from 2" to 6" away
- Camera can recognize characters with 80% accuracy given a max 25 degree angle deviation from center
- Power the robot for a consecutive 30 minutes under load
- Executes turns with a minimum 0.5" clearance
- Clear a 0.5" speed bump without deviating 25 degrees from center of maze square
- Finish the maze within the time limits: 3, 4, or 5 minutes depending on maze size
- Algorithm Optimized for maximum competition score

Testing Protocols

Each of the tests outlined in this report will be performed in the IEEE robotics lab in the Engineering Research and Development building on LSU's campus. A test maze has already been constructed and the robot is nearing completion. Soon the testing plans outlined in this report will be initialized and a certain protocol must be met for each test to ensure consistent, precise data is taken.

Sensor Test

The reflectance sensors must be able to distinguish between black and white in order to ensure proper alignment in the maze square. The proximity sensors must be able to distinguish between distances from 2" to 6" away. The team will place objects of varying colors 3/8" away from the reflectance sensors and measure the voltage gathered. The team will similarly place objects 2" to 6" inches away from the proximity sensors measuring the voltages for each.

Character Recognition Test

By using computer vision to recognize characters on the maze wall. The team can gather extra points for each character recognized and reported. Due to the sensor design, the robot must never be greater than 25 degrees off center. Using this, it is reasonable to assume that while attempting to recognize a character on a wall, the robot will never be greater than 25 degrees off center at any given time. The more off center the more difficult it is to measure. So the team will place the camera on a servo motor, tilt the servo motor 45 degrees from center and run the character recognition algorithm. Recognition of at least 80% accuracy will ensure a high competition score.

Battery Life Test

There are multiple rounds in the competition. In order to assure that the robot will last long enough to finish each round, the team will run the robot in a continuous circle to simulate being under load. The team will time the robot to see how long it will be able to last without needing a recharge, with a battery life of 30 minutes indicating success.

Turning Clearance Test

Coming into contact with a maze wall will negatively affect the robot's performance during the competition. Bumping into a wall will deduct points and could potentially damage the robot or the maze, ending with disqualification. This test is to ensure the robot will be able to turn safely and efficiently. As stated in the specification, the robot should be able to freely turn up to 180° while maintaining a minimum 0.5" clearance from each maze wall. The robot will be placed in the center of a maze square and programmed to perform various 90° and 180° turns. Throughout the experiment, it will be measured how close the robot comes to passing over the tape or touching the walls.

Speed Bump test

In the later rounds of the competition, obstacles in the shape of 0.5" blocks of wood will be added throughout the course. To ensure that the robot can successfully overcome said speed blocks without deviating irreparably from the center, the team will place 0.5" blocks of wood in the path of the robot and program it to cross from one square to the next over the block. After the robot overcomes the bump it will stop and measurements will be taken. This process will be repeated until a reasonable amount of data has been taken.

Maze Completion Test

The competition consists of three maze variants 5"x5", 6"x6", and 7"x7". These three variants have minimum completion times of 3 min, 4 min, and 5 min respectively. In order to ensure that the robot will be able to meet this minimum times, the team has devised a test where the robot will be placed in a test maze under various conditions and tasked with solving the maze. Various algorithms will also be tested and compared against previous runs to ensure optimal competition score.

Instrumentation

Sensor Test

- QTR-1A Reflectance Sensor - Sensor under test
- QTR-3A Reflectance Sensor - Sensor under test
- SHARP GP2Y0A41Sk0F Proximity Sensor - Sensor under test
- Multimeter - To measure voltages
- Power Supply - To power sensors with 5V

Character Recognition Test

- Raspberry Pi Camera Module - Camera under test
- Raspberry Pi B+ - Processor under test
- Servo Motor - To simulate being off center
- Character Stickers from Competition Committee - to simulate characters

Battery Life Test

- Integrated Robot with NiMH battery attached - Battery under test
- Test Maze - To run under load
- Stop Watch - To time how long the robot is able to run on one charge

Turning Clearance Test

- Robot – Completed functioning robot
- Electrical tape boundary – To mark where the 0.5” boundary is
- Measuring tape – To measure clearance

Speed Bump test

- Robot – Completed functioning robot
- Test Maze – Completed test maze and walls
- 0.5” Block – Simple 0.5”Hx0.75”Wx10”L block of wood
- Protractor – Store bought protractor to measure the angle offset after the robot overcomes the speed bump

Maze Completion Test

- Robot - Device Under Test
- Test Maze - To simulate competition scenario
- Stop Watch - To record time to completion of maze

Data Acquisition/ Processing

Sensor Test

Voltages will be plotted to ensure they are monotonic functions and to generate effective thresholds.

Character Recognition Test

Each character will be put through the character recognition algorithm ten times with the percentage of correctness for each character plotted to mark problem areas.

Battery Life Test

The robot will be run under load 10 times until the charge on the battery has been depleted. The average amount of time to depletion for the ten runs will be used for evaluation

Turning Clearance Test

For this test the distance between the edge of the robot and the 0.5” clearance boundary will be measured and recorded. Each measurement will be put into an excel sheet and an average will be produced for both 90° and 180° turns.

Speed Bump test

By measuring the angle offset after overcoming an obstacle, the robot can be programmed to compensate in order to stay on track. Each measurement will be recorded and entered into a spreadsheet, producing an average. If the angle is under 25° the sensors will be able to correct the path on its own.

Maze Completion Test

Each algorithm will be run on a set of five mazes for each maze variant. The averages for each algorithm per maze variant will plotted against each other putting special emphasis on algorithms that perform well on later round variants.

Data and Statistical Analysis

Sensor Test

By ensuring that the sensors output a monotonic function and that effective thresholds can be met. The team will be able to determine whether the sensors meet the desired functionality. If the current sensors fail, new sensors can be purchased until the specifications are met.

Character Recognition Test

With the data gathered on character recognition percentages, the team can evaluate the effectiveness of the character recognition algorithm. If the data does not pass, the algorithm can be tuned by training with more data and pruning bad data.

Battery Life Test

With the data gathered on battery life, the team will be able to decide if the battery will meet the needs of the competition. With this analysis we can determine if a larger battery should be chosen.

Turning Clearance Test

With this data, the team can make adjustments to the positioning of the treads or other various pieces of the robot to facilitate a tighter and more accurate turning radius.

Speed Bump test

The data acquired by the speed bump test will be used to ensure that the robot will not deviate over 25 degrees from center. The data can be used to tune the tread tightness.

Maze Completion Test

By comparing algorithms based on score and completion time. The team will be able to adjust the maze solving algorithm for maximum competition score.

Testing Timeline

	3/16 - 3/20	3/23 - 3/27	3/30 - 4/03	4/06 - 4/10	4/13 - 4/17
Sensor Test					
Camera Test					
Battery Test					
Turning Clearance Test					
Speed Bump					
Maze Completion Test					