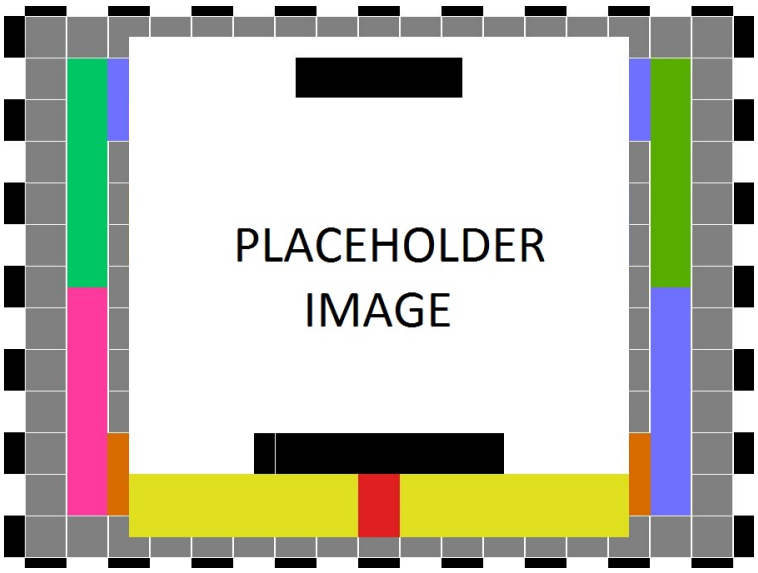
Department of Computer Science & Engineering
The University of Texas at Arlington

System Requirements Specification
CSE 4316: Senior Design I
Spring 2018



IGVC
AutoMav

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Revision History

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1 Product Concept

This section describes the purpose of AutoMav and its intended audience. Automav is autonomously controlled vehicle that can navigate itself from its current location to a point in GPS coordinates.

1.1 Purpose and Use

The AutoMav is an intelligent ground vehicle that acquires data about its surroundings using sensory equipment and uses the data to navigate itself to a location given in GPS coordinates. To do this AutoMav must recognize specific obstacles and boundaries in its path and calculate an optimal route around them while maintaining above a specified average speed.

1.2 Intended Audience

The intended audience of AutoMav are those in areas of autonomous robot research and development. Automav is intended to display an implementation of current autonomous navigation technology.

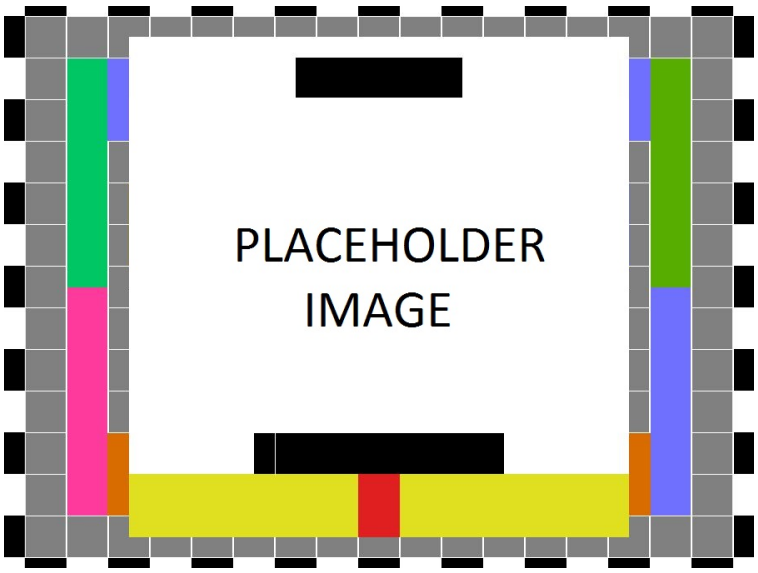

Figure 1: X conceptual drawing

2 Product Description

This section describes the AutoMav vehicle's functionality. Specifically the vehicle's features, inputs and outputs, and the product interfaces.

2.1 Features & Functions

The AutoMav vehicle is an autonomous system that contains several subsystems that allow it to collect data about its surrounding area, process the data and use it to navigate itself to a given location. The vehicle uses data from images obtained by cameras mounted around the vehicle. Other data is also gathered from a lidar laser mounted to its front. The data is then processed using computer vision techniques to classify obstacles and recognize lanes that determine the vehicles valid path to the goal location. The navigation involves path finding to navigate itself around observed obstacles.

2.2 External Inputs & Outputs

The AutoMav vehicle will take in several inputs: a GPS location, video data of its surroundings, lidar data and interface inputs from the user (start, e-stop, manual control). The vehicle will output a movement action that will move the vehicle to the given location while avoiding any obstacles in its path.

2.3 Product Interfaces

The AutoMav vehicle will have a remote control with basic movement controls for the user to manually steer the vehicle while out of autonomous mode. The remote control will also feature a button to engage autonomous mode and a button to execute an emergency stop. The vehicle will also feature a button at the center rear that will also initiate an emergency stop.

3 Customer Requirements

This section describes the properties and functionality of AutoMav as specified by the customer (IGVC Rules).

3.1 The vehicle must maintain contact with the ground

3.1.1 Description

The vehicle will remain in contact with the ground at all times during operation.

3.1.2 Source

IGVC Rules

3.1.3 Constraints

N/A

3.1.4 Standards

N/A

3.1.5 Priority

Critical

3.2 The vehicle must be between 3 and 7 feet long

3.2.1 Description

The vehicle length must be between 3 feet and 7 feet.

3.2.2 Source

IGVC Rules

3.2.3 Constraints

N/A

3.2.4 Standards

N/A

3.2.5 Priority

Critical

3.3 Vehicle must be between 2 and 4 feet wide

3.3.1 Description

The vehicle width must be between 2 feet and 4 feet

3.3.2 Source

IGVC Rules

3.3.3 Constraints

N/A

3.3.4 Standards

N/A

3.3.5 Priority

Critical

3.4 Vehicle must be less than 6 feet tall

3.4.1 Description

The vehicle height must not exceed 6 feet, excluding the antenna for wireless emergency stop functionality.

3.4.2 Source

IGVC

3.4.3 Constraints

N/A

3.4.4 Standards

N/A

3.4.5 Priority

Critical

3.5 The vehicle must maintain a average speed

3.5.1 Description

During the competition, the vehicle must maintain an average speed above 1 mph throughout its time on the course.

3.5.2 Source

IGVC Rules

3.5.3 Constraints

N/A

3.5.4 Standards

N/A

3.5.5 Priority

Critical

3.6 The vehicle must maintain a minimum speed

3.6.1 Description

During the competition, there will be a section at the beginning of the course that requires the vehicle to travel at a minimum of 1 mph. This section will be about 44ft long.

3.6.2 Source

IGVC Rules

3.6.3 Constraints

N/A

3.6.4 Standards

N/A

3.6.5 Priority

Critical

3.7 The vehicle must not exceed a maximum speed

3.7.1 Description

The vehicle must not exceed a maximum speed of 5 mph.

3.7.2 Source

IGVC Rules

3.7.3 Constraints

The speed restriction must be enforced by speed restriction hardware.

3.7.4 Standards

N/A

3.7.5 Priority

Critical

3.8 The vehicle must have a mechanical emergency stop button

3.8.1 Description

The vehicle must feature a button that stops the vehicle. The button must trigger a quick and complete stop.

3.8.2 Source

IGVC Rules

3.8.3 Constraints

The button must be red and a minimum of one inch in diameter. It must be located at the center rear of the vehicle, at least two feet from the ground and less than four feet from the ground.

3.8.4 Standards

N/A

3.8.5 Priority

Critical

3.9 The vehicle must have a wireless emergency stop

3.9.1 Description

The vehicle must feature a contol that stops the vehicle with a minimum effective range of 100 feet.

3.9.2 Source

IGVC Rules

3.9.3 Constraints

The emergency stop feature must be hardware based. The vehicle must trigger a quick and complete stop. The wireless emergency stop control will be held by the Judges during the competition.

3.9.4 Standards

N/A

3.9.5 Priority

Critical

3.10 The vehicle must have a safety light

3.10.1 Description

The vehicle must have an indicator light that is solid when the vehicle is powered on. The light must begin flashing when the vehicle is put in autonomous mode. The light must return to solid when the vehicle exits autonomous mode.

3.10.2 Source

IGVC Rules

3.10.3 Constraints

The indicator must be easily viewed.

3.10.4 Standards

N/A

3.10.5 Priority

Critical

3.11 The vehicle must carry a payload

3.11.1 Description

The vehicle must be able to carry a payload weighing 20 lbs, and measuring 18 inches long, 8 inches wide, 8 inches high.

3.11.2 Source

IGVC Rules

3.11.3 Constraints

The payload must be securely mounted to the vehicle

3.11.4 Standards

N/A

3.11.5 Priority

Critical

3.12 The vehicle must demonstrate lane following

3.12.1 Description

The vehicle must detect and follow the lanes of the course during autonomous navigation.

3.12.2 Source

IGVC Rules

3.12.3 Constraints

N/A

3.12.4 Standards

N/A

3.12.5 Priority

Critical

3.13 The vehicle must demonstrate obstacle avoidance

3.13.1 Description

The vehicle must detect and avoid obstacles during autonomous navigation.

3.13.2 Source

IGVC Rules

3.13.3 Constraints

N/A

3.13.4 Standards

N/A

3.13.5 Priority

Critical

3.14 The vehicle must utilize waypoint navigation

3.14.1 Description

The vehicle must be able to navigate to a 2 meter waypoint in GPS coordinates, navigating around an obstacle.

3.14.2 Source

IGVC Rules

3.14.3 Constraints

N/A

3.14.4 Standards

N/A

3.14.5 Priority

Critical

3.15 The vehicle must complete the course in under 10 minutes

3.15.1 Description

The vehicle must reach the end of the course within 10 minutes of the start of the run.

3.15.2 Source

IGVC Rules

3.15.3 Constraints

N/A

3.15.4 Standards

N/A

3.15.5 Priority

Critical

3.16 All computation, sensing and movement control must occur on board the vehicle

3.16.1 Description

Any and all computation, sensiong and motor control must be done through the vehicle's onboard systems.

3.16.2 Source

IGVC Rules

3.16.3 Constraints

The vehicle cannot utilize any outside remote control to complete the course.

3.16.4 Standards

N/A

3.16.5 Priority

Critical

3.17 The vehicle power must be generated on board

3.17.1 Description

Power for the vehicle's systems must be generated by an on board power source.

3.17.2 Source

IGVC Rules

3.17.3 Constraints

Fuel storage and operation of combustion engines will not be permitted in the team maintenance area.

3.17.4 Standards

N/A

3.17.5 Priority

Critical

3.18 The vehicle must be water resistant

3.18.1 Description

The vehicle must be able to operate in light rain conditions.

3.18.2 Source

IGVC Rules

3.18.3 Constraints

N/A

3.18.4 Standards

N/A

3.18.5 Priority

High

3.19 Autonomous navigation will initiate with a one touch motion

3.19.1 Description

The competition judge must be able to initiate a run of the autonomous navigation via a single button operation.

3.19.2 Source

IGVC Rules

3.19.3 Constraints

N/A

3.19.4 Standards

N/A

3.19.5 Priority

Critical

3.20 The vehicle shall not use tactile sensors

3.20.1 Description

Tactile sensors will not be utilized for obstacle detection.

3.20.2 Source

IGVC Rules

3.20.3 Constraints

N/A

3.20.4 Standards

N/a

3.20.5 Priority

Critical

3.21 A written report will accompany the vehicle delivery

3.21.1 Description

The vehicle will be delivered with a written report detailing the vehicle's design. The report will be a maximum of 15 pages in length.

3.21.2 Source

IGVC Rules

3.21.3 Constraints

N/A

3.21.4 Standards

N/A

3.21.5 Priority

Critical

3.22 The vehicle shall meet the requirements for the Interoperabilitiy Profiles challenge

3.22.1 Description

The vehicle design will be expanded to facilitate interoperability with other vehicles.

3.22.2 Source

IGVC Rules

3.22.3 Constraints

N/A

3.22.4 Standards

N/A

3.22.5 Priority

Future

4 Packaging Requirements

This section describes elements of the prototype's packaging at the end of development.

4.1 Software

4.1.1 Description

The vehicle will utilize ROS (Robot Operating System) that serves as the base software that facilitates all computer vision, path finding and navigation features. The software will be pre-configured such that the customer will only provide the desired GPS way points to enable autonomous navigation.

4.1.2 Source

AutoMav Team

4.1.3 Constraints

N/A

4.1.4 Standards

N/A

4.1.5 Priority

High.

4.2 Wheelchair Base

4.2.1 Description

The vehicle's base will be an electric wheelchair that has been customized to be controlled by the ROS unit.

4.2.2 Source

AutoMav Team

4.2.3 Constraints

The wheelchair base must be able to support the full weight of the robot frame, components and payload while being able to maintain an average speed of 1 mph during operation.

4.2.4 Standards

N/A

4.2.5 Priority

High.

4.3 Frame

4.3.1 Description

The vehicle frame will support two compartments, a lower compartment for the payload and an upper compartment for the on board computational equipment.

4.3.2 Source

AutoMav Team

4.3.3 Constraints

The frame system must be mountable to the existing mounting holes on the wheelchair base.

4.3.4 Standards

N/A

4.3.5 Priority

High.

4.4 Harware Mounts

4.4.1 Description

The vehicle will feature several sensors such as cameras, GPS and Lidar. To reduce data noise due to vibrations, the cameras will be attached using a gimble mount. The Lidar system will be mounted to the front of the vehicle based to capture data about approaching obstacles. The GPS will be mounted in a way that promotes the strongest signal. Any other cameras will be mounted such that they provide data that is consistent with other cameras on the vehicle.

4.4.2 Source

AutoMav Team

4.4.3 Constraints

All electronics must fit within the designed electronics compartment.

4.4.4 Standards

N/A

4.4.5 Priority

High.

4.5 Payload Compartment

4.5.1 Description

The payload compartment will be designed to securely transport the payload, ensuring that unexpected weight shifting does not occur during operation. The compartment will also be designed so that when the payload is present, the new weight does not affect the normal operation of the vehicle.

4.5.2 Source

AutoMav Team

4.5.3 Constraints

Must be able to carry and securely mount an 18"x8"x8" payload.

4.5.4 Standards

N/A

4.5.5 Priority

High.

4.6 Aesthetics

4.6.1 Description

The vehicle will be aesthetically pleasing, incorporating the school colors of orange, blue and white as well as any sponsorship logos on its surface.

4.6.2 SOURCE

AutoMav Team

4.6.3 CONSTRAINTS

N/A

4.6.4 STANDARDS

N/A

4.6.5 PRIORITY

Medium to Low.

5 Performance Requirements

This section includes requirements that detail specific aspects of the performance of the vehicle.

5.1 Average speed

5.1.1 Description

The average speed shall be above 1 mph, any vehicle slower than the average speed will be disqualified.

5.1.2 Source

IGVC Rules

5.1.3 Constraints

There are sections of the course in which the speed can not fall below 1 mph.

5.1.4 Standards

N/A

5.1.5 Priority

Critical

5.2 Maximum Speed

5.2.1 Description

The maximum speed of the vehicle shall not exceed 5 mph. The vehicle shall be hardware governed not to exceed this maximum speed. No changes to maximum speed control hardware shall be allowed after the vehicle passes qualification.

5.2.2 Source

IGVC Rules

5.2.3 Constraints

The speed must be hardware limited

5.2.4 Standards

N/A

5.2.5 Priority

Critical

5.3 Minimum speed

5.3.1 Description

The vehicle shall consistently travel above 1 mph in the designated zones of the course.

5.3.2 Source

IGVC Rules

5.3.3 Constraints

N/A

5.3.4 Standards

N/A

5.3.5 Priority

Critical

5.4 Lane Following

5.4.1 Description

The vehicle shall detect and follow lanes.

5.4.2 Source

IGVC Rules

5.4.3 Constraints

There shall be a minimum of five feet clearance, minimum passage width, between the line and the obstacles.

5.4.4 Standards

N/A

5.4.5 Priority

Critical

5.5 Obstacle avoidance

5.5.1 Description

The vehicle shall detect and avoid obstacles present on the course.

5.5.2 Source

IGVC Rules

5.5.3 Constraints

Competitors should expect natural or artificial inclines (ramps) with gradients not to exceed 15 percent and randomly placed obstacles along the course. The course will become more difficult to navigate autonomously as vehicle progresses.

5.5.4 Standards

N/A

5.5.5 Priority

Critical

5.6 GPS Navigation

5.6.1 Description

Vehicle shall prove it can find a path to a single two meter navigation way point by navigating around an obstacle. Two way point pairs for the course will be provided prior to competition. One way point pair will be the entrance and exit of the course in "No-Manâs Land". There will be two additional way points in "No-Manâs Land".

5.6.2 Source

IGVC Rules

5.6.3 Constraints

N/A

5.6.4 Standards

N/A

5.6.5 Priority

Critical

5.7 Wireless drive

5.7.1 Description

The device shall be able to be driven remotely using an RF based transmitter receiver combination. This will allow for easy transportation and navigation of the vehicle when not on the actual competition course.

5.7.2 Source

Team Discussion

5.7.3 Constraints

Must be able to be used without the need for ROS or any software components.

5.7.4 Standards

N/A

5.7.5 Priority

Medium

6 Safety Requirements

This section includes safety requirements for the AutoMav vehicle.

6.1 System Wiring

6.1.1 Description

Any wires used by the system must be properly packaged and grounded in accordance with existing safety standards to prevent risk of electrocution.

6.1.2 Source

IGVC Guidelines

6.1.3 Constraints

N/A

6.1.4 Standards

UL-1740

6.1.5 Priority

Critical

6.2 Sharp Objects

6.2.1 Description

There must be no sharp objects protruding from the system, should any be found they should be handled appropriately and removed or padded to prevent harm to any individual.

6.2.2 Source

IGVC Guidelines

6.2.3 Constraints

N/A

6.2.4 Standards

UL-1740

6.2.5 Priority

High

6.3 Emergency Stop

6.3.1 Description

The system shall have two emergency stops: one on-board button that should be bright red and easily visible and the other should be remote and able to turn off the system from a distance

6.3.2 Source

IGVC Guidelines

6.3.3 Constraints

N/A

6.3.4 Standards

UL-1740

6.3.5 Priority

High

6.4 Safety Lights

6.4.1 Description

The system shall have LED light that indicates the system is in autonomous mode. It shall be easily visible on the system.

6.4.2 Source

IGVC Guidelines

6.4.3 Constraints

N/A

6.4.4 Standards

N/A

6.4.5 Priority

Medium

6.5 Fragile Materials

6.5.1 Description

The system shall not be made using fragile materials. For example, the main support frames of the system should not be made of glass or any other fragile material

6.5.2 Source

IGVC Guidelines

6.5.3 Constraints

N/A

6.5.4 Standards

List of applicable standards

6.5.5 Priority

High

6.6 Battery Handling and Disposal

6.6.1 Description

Caution should be used connecting the system battery as there is risk for electrocution. Once the system battery is no longer of use it should be disposed in accordance with local waste management policy to protect the environment from the harmful chemicals found with them.

6.6.2 Source

AutoMav Team

6.6.3 Constraints

N/A

6.6.4 Standards

UL-1740

6.6.5 Priority

Medium

7 Maintenance & Support Requirements

This section includes requirements involving the maintenance and support of the vehicle after the end of development.

7.1 Hardware design documentation

7.1.1 Description

The provided system documentation shall include diagrams of hardware components, as well as overall mechanical design in order for future teams to fully and easily understand the existing hardware system.

7.1.2 Source

AutoMav Team

7.1.3 Constraints

N/A

7.1.4 Standards

N/A

7.1.5 Priority

High

7.2 Software design documentation

7.2.1 Description

The provided system documentation shall provide documents detailing the architecture of the overall software system, as well as the individual subsystems.

7.2.2 Source

AutoMav Team

7.2.3 Constraints

N/A

7.2.4 Standards

IEEE 26514

7.2.5 Priority

High

7.3 Sensor calibration

7.3.1 Description

Calibration of sensors and cameras shall be performed on use of the system to insure that accurate and proper data is being acquired.

7.3.2 Source

AutoMav Team

7.3.3 Constraints

N/A

7.3.4 Standards

N/A

7.3.5 Priority

Medium

7.4 Component specifications

7.4.1 Description

The provided system documentation shall include component lists, that specifies the exact components used, and the specifications of the components.

7.4.2 Source

AutoMav Team

7.4.3 Constraints

N/A

7.4.4 Standards

ISO 7573:2008

7.4.5 Priority

Medium

8 Other Requirements

This section includes any requirements not covered in any previous sections.

9 Future Items

This section includes features that will not be implemented in the initial prototype. These features could be implemented with further development time and resources.

9.1 The vehicle shall meet the requirements for the Interoperabilitiy Profiles challenge

9.1.1 Description

The vehicle design will be expanded to facilitate interoperability with other vehicles.

9.1.2 Source

IGVC Rules

9.1.3 Constraints

N/A

9.1.4 Standards

N/A

9.1.5 Priority

Future

REFERENCES