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

Project Charter
CSE 4316: Senior Design I
Fall 2018

IGVC
AutoMav

Dario Ugalde
Awet Tesfamariam
Andrew Break
Amgad Alamin
Warren Smith

REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	10.01.2018	DU, AT, AB, AA, WS	initial draft
0.2	02.18.2019	DU, AT, AB, AA, WS	Vision and Mission revision
1.0	05.10.2019	DU, AT, AB, AA, WS	Background, Success Criteria, Roles and Responsibilities revision, updated website information

Contents

List of Figures

1 Vision

The purpose of this project is to design and construct an intelligent ground vehicle. With this vehicle we plan to go and compete in the 27th Annual Intelligent Ground Vehicle Competition (IGVC) in June of 2019. By completing this project, the team will experience designing and developing a functional product from scratch while becoming familiar with new technologies along the way. This competition will give the team a chance to showcase their work and demonstrate what the team has learned while studying Computer Science and Computer Engineering at UT Arlington.

2 Mission

Our mission is to construct a autonomous ground vehicle that will qualify and participate in the IGVC Autonomous Navigation Challenge. Qualification for IGVC requires that the vehicle meets all feature and performance constraints defined in the IGVC rules.

3 Success Criteria

For us to be successful we need to meet all the criteria we have set:

- Giving future teams a product that they can build on or otherwise use as a reference for similar projects.
- Qualify for the intelligent ground vehicle competition.
- Successfully manage the budget provided for this project.
- Meet all the necessary feature requirements for the Intelligent Ground Vehicle Competition
- Secure sponsors for additional funding for the Intelligent Ground Vehicle.

4 Background

The Intelligent Ground Vehicle Competition (IGVC) gives us an opportunity to get design experience that incorporates the latest technology. Autonomous vehicles have applications in military, industrial, and commercial areas. The goal of IGVC is for the team to construct autonomous unmanned ground vehicle. The vehicle will be tested on an outdoor course defined by painted lanes and both painted and physical obstacles. The vehicle will be given a GPS location to navigate to and must do so without crossing lane markers or striking any obstacles.

5 Related Work

Solutions that currently exist in related work to this project include the previously created vehicles at the IGVC competition. The first place winner in the 2017 IGVC competition was IIT Bombay, their design included 2 motor powered wheels with a single caster wheel in the front, with changes in torque on each wheel affecting how it turns. There sensor included, LIDAR, IMC, 2 cameras and a GSP sensor[1]. The winner of second place of that year had two front powered wheels with two caster wheels in the back. There sensors included a 3D and a 2D LIDAR camera, along with a gyroscope, GPS and omni directional camera.[2] The third place winner used a compass, GPS, Camera and LIDAR for their sensors. With these sensors, the camera data is used to detect lines, while LIDAR is used to detect the obstacles and obstacle avoidance.[3]

6 System Overview

To create a solution for the IGVC competition, the group will be handed off the hardware implementation of a robot for the competition from the previous semesters group. Given this hardware framework, the group will split the software aspect of the robot into 4 parts, these parts including way point navigation, which will comprise of the GPS navigation required to reach each checkpoint in the course. The second being in-bounds path-finding, which will guide the robot through the course on its way to the way-points, while avoiding the obstacles in the course, in staying in the lanes of the course. The third being computer vision, which is training the system to recognize the various obstacles that will be on the course, as well as recognizing the lanes and the dashed lines in the middle of the lanes. The final aspect being central data processing and handling, which will include sending instructions to the motor controller, pulling data from the sensors and sending it to the proper subsystems. The sensors used on the robot consist of a GPS, Inertial Measurement Unit (IMU), LIDAR, and 3D camera.

7 Roles & Responsibilities

- *Product Owner*: Dr. Christopher McMurrough - Responsible for defining the success criteria and maintaining project direction.
- *Stakeholders*: IGVC team, Future Sponsors
- *Software Developers*: Awet Tesfamariam, Andrew Break, Amgad Alamin, Warren Smith
- *Computer Engineers*: Dario Ugalde

8 Cost Proposal

- $1,000 - materials.
- $10,000 - travel.

8.1 Preliminary Budget

The project's budget is $800. Most of the required tools and equipment will be provided by the senior design labs.

8.2 Current & Pending Support

- Future sponsor-ships - $8,000.
- Redirected funding from completed projects - $2,000.

9 Facilities & Equipment

This project will require the following facilities and equipment corresponding to the IGVC Guidelines defined on October 26th, 2017:

- *Work Space*: A space reserved for project development. Facilitates project design and construction and provides storage for components and tools.
- *Physical Test Space*: The IGVC features an obstacle course that the vehicle must navigate. We require a test space that sufficiently emulates elements of the IGVC course in order to test the vehicle's performance.
- *Virtual Test Space*: Test software that allows us to analyze the performance of the vehicle's software without a physical test.
- *Software*: Various software for operating individual components of the vehicle. Development environments that facilitate the development of new software for vehicle navigation.
- *Sensors*: Cameras, lasers and/or other sensory equipment for the vehicle to collect data about its surroundings.
- *Wheel Base*: A base that facilitates vehicle mobility and can support the weight of all vehicle components and payload as defined in the IGVC guidelines.
- *Motor Controllers*: Necessary for mobility of the robot.
- *Battery*: An on-board power source that supplies power to all components for the duration of the competition.
- *Remote Control*: IGVC guidelines require that the vehicle can be manually controlled by a remote control system that includes a remote shutdown feature.
- *GPS*: IGVC guidelines require GPS Point-to-point navigation for autonomous navigation.
- *Computer*: Central computing unit that obtains and processes data from all sensors and controls automated navigation.

10 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- A suitable outdoor testing location will be available by the 5th sprint cycle.
- The majority of components acquired by the previous IGVC team will be compatible with the project's final design.

- The previous IGVC team will have remote vehicle control functional by the 4th sprint cycle.
- Software drivers for all components will be created by the previous IGVC team by the 5th sprint cycle.
- The Ross Gazebo robot simulation software will meet our requirements for virtual testing of the vehicle software.

11 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final vehicle implementation must be functional before the date of the IGVC (TBA).
- The vehicle must feature a hardware based shutoff feature, activated by both remote control and on-board control as defined in the IGVC guidelines.
- The vehicle must be designed to operate while carrying a payload defined in the IGVC guidelines.
- Total development and travel costs must not exceed the allocated budget.
- The vehicle must meet minimum and maximum length, width and height dimensions as defined in the IGVC guidelines.

12 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Debugging and error handling	0.75	20	15.0
Difficulty to integrate systems	0.50	15	7.5
Outdoor testing grounds are not available	0.30	15	5.0
Delays in shipping from overseas vendors	0.40	10	4.0
Software learning curves	0.20	20	4.0

Table 1: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

This document was delivered after the first sprint. As documentation for each system that comprises the system becomes available that will be added to this document. Furthermore, major milestones essential to the completion of the system will be added at the end of each sprint following their completion.

13.1.2 System Requirements Specification

This document was delivered after the second sprint. Requirements will be recorded into a list and included in this document. As the project develops and more requirements are identified or updates are made, the official changes will be posted at the end of the sprint where the requirements list will be reviewed by the team. The final copy will be submitted along with all documentation upon completion of the project.

13.1.3 Architectural Design Specification

This document was delivered after the third sprint of the project. This consisted of a high-level overview of the systems and subsystems that make up the entire system. Moving forward with work on the system, this document will be reviewed when connecting the various systems of the overall system and changes will be made to this document should conflicts arise between the specifications and what is proven to work.

13.1.4 Detailed Design Specification

This document will be created and delivered during Senior Design II.

13.2 Recurring Sprint Items

13.2.1 Product Backlog

Tasks based on the goal of the sprint will be created and shared with members of the team using Task Chart on Microsoft Teams. From there team members will be given the option to voluntarily take tasks with the approval of other team members and the remaining tasks will be delegated to the team. Team members must agree on the assignment of all tasks. From here each member will keep up with their time worked on each task and report back tot he team to update the backlog at each team meeting.

13.2.2 Sprint Planning

During a team meeting at the start of each sprint, members of the team will determine what the goal of the sprint is and determine what tasks are necessary to achieve this goal. All tasks will be delegated to members of the team to complete.

13.2.3 Sprint Goal

During the Sprint Planning meeting, the team will determine what needs to get done during the sprint to determine the goal of the sprint.

13.2.4 Sprint Backlog

During the Sprint Planning Meeting, team members will determine what tasks are necessary to achieve the goal of the sprint. These tasks will be added to the Task Chart on Microsoft Teams and delegated to members of the team to complete over the course of the sprint. Each team member is responsible for keeping track of the time worked on each task.

13.2.5 Task Breakdown

After the tasks are determined in the Sprint Planning meeting, members of the team will select which team member is responsible for the completion each task as a whole. All members of the team must be in agreement in the delegation of each task. Team members may request specific tasks pending approval of the rest of the team. Each team member should document their time spent to report for the burn down chart.

13.2.6 Sprint Burn Down Charts

During each Sprint Retrospective meeting each team member will report their final time for work on the sprint tasks and this data will be used to create the sprint burn down chart. A template table has been provide for each member to fill out and the table will be used to create the burn down chart for that sprint once all times have been submitted.

13.2.7 Sprint Retrospective

Towards the end of a given sprint, the following team meeting will consist of discussion to review the sprint and focus on what needs to be accomplished during the next sprint.

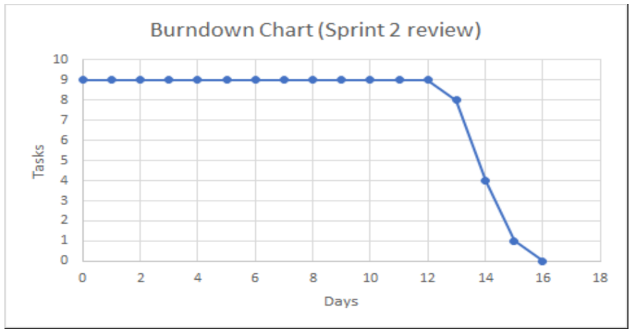

Figure 1: Example sprint burn down chart

13.2.8 Individual Status Reports

Each Friday during team meeting each team member will speak on their progress and any issues or accomplishments will be discussed.

13.2.9 Engineering Notebooks

Engineering notebooks will be handled at the discretion of each team member; however, should they require witness signatures, they can be obtained at Friday meeting for convenience.

13.3 Closeout Materials

13.3.1 System Prototype

The final prototype will be a system that adheres to all regulations specified in the rules of the IGVC competition. Prototype acceptance test will consist of necessary requirements to qualify for the IGVC competition.

13.3.2 Project Poster

By demo day, a poster of the detailing high-level operations of the system. It will serve to reinforce the demo video so the people invited to the demo day can read so basic information about the system.

13.3.3 Web Page

A public website will be provided at closeout. The website will provide a high level description of project elements such as requirements and architecture. The website will provide the final version of all documents as well as a our demo video and poster. The website will be available at:

https://blog.uta.edu/cseseniordesign/2019/03/22/igvc/

13.3.4 Demo Video

For demo day, the system can not be tested in the building, so a video demonstrating the satisfaction of the requirements for the IGVC competition will be played. This video will demonstrate the vehicle's path-finding capabilities as well as obstacle recognition.

13.3.5 Source Code

A BitBucket account has been set up for version control. Source code will be provided as specified by the IGVC rules and regulations.

13.3.6 Source Code Documentation

Source Code Documentation will be done through doxygen where functions will be commented to explain their purpose. The result will be a PDF that goes into detail about all functions for the system.

13.3.7 Hardware Schematics

Hardware Schematics will be made using Eagle to create any necessary PCBs.

13.3.8 CAD files

Any 3D printed parts will be made using STL files made in AutoCAD.

13.3.9 Installation Scripts

A sh file will be created that installs all necessary packages for the system. Any other tools that need to be manually installed will have instructions written for them.

13.3.10 User Manual

A digital user manual will be provided along with the robot. This file will detail all necessary procedures for the setup and operation of the system.

References

[1] Indian Institute of Technology Bombay http://www.igvc.org/design/2017/8.pdf
[2] Hosei University http://www.igvc.org/design/2017/6.pdf
[3] Bob Jones University http://www.igvc.org/design/2017/2.pdf