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

Project Charter
CSE 4316: Senior Design I
Summer 2023

IGVC
Autonomous Ground Vehicle

Rodrigo Hernandez-Pleite
Tsebaot Meron
Nabeel Ur Rehman Nayyar
Jerome Siljan
Vanshdeep Singh
Jeanne Uwineza

Revision History

Revision	Date	Author(s)	Description
1	06.28.2023	RP, TM, NN, JS, VS, JU	document creation
0.2			
0.3			
1.0			
1.1			

CONTENTS

1 Problem Statement

This project is designed to create a ground vehicle that can compete in the Intelligent Ground Vehicle Competition. In which it must navigate a obstacle course autonomously without the need of human intervention.

2 Methodology

We will create a autonomous modular ground vehicle that is capable of traversing a obstacle course as efficiently and as quickly as possible. While still being bound to the rule set created by the Intelligent Ground Vehicle Competition.

3 Value Proposition

The sponsors benefit from this as it shows companies, schools and upcoming college students what the students of the College of Engineering at UTA are capable of achieving. As a result possibly leading to more companies at job fairs and more students applying to be enrolled at UTA as well as having a greater reputation amongst other engineering schools in the nation.

4 Development Milestones

- Project Charter first draft - June 2023
- System Requirements Specification - July 2023
- Architectural Design Specification - July 2023
- Demonstration of Physical layout of the rover - August 2023
- Detailed Design Specification - September 2023
- Demonstration of Remote software control - October 2023
- Demonstration of Autonomous path planning - October 2023
- Demonstration of Full Unmanned Terrain Test - October 2023
- Demonstration of Control Safety Features - November 2023
- Final Project Demonstration - November 2023
- CoE Innovation Day poster presentation - TBA
- Demonstration of <feature or implementation milestone> - November 2023

5 Background

The current status quo is limited in terms of autonomous capabilities, efficiency, and speed, necessitating the development of innovative solutions to address these shortcomings. This project aims to tackle these challenges and showcase the capabilities of the College of Engineering at UTA.

The opportunity to undertake this project lies in several aspects. Firstly, the competition itself provides a platform to demonstrate the technical expertise and problem-solving abilities of the team. By participating and excelling in the competition, the team can establish a strong reputation for the College of Engineering at UTA, attracting attention from companies, schools, and prospective students.

Additionally, the project offers an opportunity to push the boundaries of autonomous vehicle technology. By developing a modular ground vehicle that can autonomously navigate obstacle courses efficiently and quickly, the team aims to contribute to the advancement of autonomous systems. This aligns with the growing demand for autonomous vehicles in various industries, such as transportation, logistics, and defense.

The existing relationship between the development team and the customer, in this case, the competition organizers, is based on the mutual goal of advancing autonomous vehicle technology. The team aims to leverage its expertise and resources within the College of Engineering to design and develop a ground vehicle that meets the competition's requirements and surpasses the performance expectations.

6 Related Work

The field of autonomous ground vehicles has witnessed significant advancements, with several solutions existing in different forms, including academic research and review papers, as well as commercially available products.

Cheng, Yang, and Shen [3] conducted a feasibility study on utilizing Device-to-Device (D2D) communication for intelligent transportation systems. Their research explores the potential of enhancing vehicle-to-vehicle and vehicle-to-infrastructure communication for improved safety and efficiency.

Fayyad et al. [5] conducted a comprehensive review on deep learning sensor fusion for autonomous vehicle perception and localization. This review highlights the significance of integrating multiple sensors and leveraging deep learning algorithms for robust perception capabilities.

Parekh et al. [4] provide a review on the progress, methods, and challenges in autonomous vehicles. This review paper offers insights into the advancements and ongoing research efforts in the field.

Perception, planning, control, and coordination for autonomous vehicles are key aspects of autonomous driving systems. Pendleton et al. [1] discuss these crucial components and their interplay in autonomous vehicles, providing valuable insights into the state-of-the-art approaches and techniques.

Sensor and sensor fusion technology play a vital role in autonomous vehicles. Yeong et al. [2] present a review specifically focused on sensor and sensor fusion technology in autonomous vehicles. This review highlights the advancements and challenges in utilizing sensors to gather data and fuse them for accurate perception and decision-making.

While these references provide valuable insights into the state-of-the-art in autonomous ground vehicles, it is important to note that they represent only a subset of the extensive research and development happening in the field. Additionally, there are commercially available solutions from companies like Waymo, Tesla, and Boston Dynamics, which have demonstrated advanced autonomous driving capabilities.

Existing solutions have made significant progress, but challenges such as improving perception accuracy, real-time decision-making algorithms, robustness in diverse environments, and safety under unpredictable scenarios still need to be addressed. Furthermore, factors like cost and scalability may impact the suitability of these solutions for different customers.

The state-of-the-art in autonomous ground vehicles encompasses a range of solutions, including academic research and review papers, as well as commercially available products. These solutions leverage advanced technologies and techniques in perception, planning, control, and sensor fusion. However, ongoing research and development efforts are essential to address challenges and meet the specific requirements of customers in terms of cost, performance, and reliability.

7 System Overview

For this vehicle, the team is planning to implement the IGVC starting with the outer shell such as the aluminum shell, attachment of cameras and lidar, wheels, storage for the deep learning companion computer , and the design for a carrier of 20 pound payload required in the competition rules.

Since this project was handed down from a past team , we have at our disposal a majority of the components that made up their vehicle giving us a good starting point as to what the vehicle should look like and what it takes to operate. One of the things that was given to our team was the wheel chair base used for the previous vehicle.Because of its size and weight, it ended up making it very hard for the previous team to transport it from one place to another so one of the tasks this teams plans to tackle is to find a way to make this new vehicle modular in-order to avoid any difficulties that could be faced during transportation to the competition.

On top of making the vehicle easily portable,there are also plans to make the vehicle more compact but yet powerful with things such as lidars, cameras and multi-directional wheels. As for the body of the vehicle, we will be using an aluminum shell that will hold the computing components of the vehicle and with the help of some 3D printed components, the cameras, lidar, companion computer and payload will be attached to the to this shell comfortably and insure they are protected and unmoved for the sake of correct calculations and environment reads.

For the software portion of the vehicle, the teams plans to improve the existing implementation from the previous team (A* search) but also add components of deep learning for the vehicle to learn from its surroundings as it moves. Things such as barrels, traffic cones,potholes and lanes will be included in the training set in order to get this vehicle ready to tackle the course of the competition.

8 Roles & Responsibilities

The current sponsor and point of contact is Dr.Mcmurrough from him we will be able to request his expertise. The roles of scrum master will change every sprint based on the goals that we wish to accomplish for that sprint as well as to also give everyone a chance at gaining experience at the role. All team members will have their expertise field in which they will specialize in. However, the team members are free to work on any aspect of the project that they wish too as to encourage better team cohesion.
Team Members
Rodrigo Hernandez-Pleitez - AI and ML Systems Design
Tsebaot Meron - Sofware and Integration, CAD Modeling and ROS
Vanshdeep Singh - Software Middleware and ROS
Nabeel Ur Rehman Nayyar - Hardware Design, CAD Modeling, ROS Implementation
Jerome Siljan - Hardware Verification
Jeanne Uwineza - Hardware Design

9 Cost Proposal

Since we could not meet with the sponsor to tackle the requirements needed for the project at an earlier date than 6/27/2023 we do not have an approximate budget for the project. There are many parts that we can salvage from the previous project as well, which made it difficult to assess what was needed or not. Furthermore, after speaking with our sponsor we learned that we were not limited to a 800 dollar budget. This made any original budgeting we had obsolete since we have to think of different components. The money for this project will come from the CSE department. There is pending funding that may come from Lockheed Martin but this needs approval.

9.1 Preliminary Budget

We have yet to come up with a comprehensible budget plan as per what was mentioned in section 9.

9.2 Current & Pending Support

After speaking to our sponsor Dr. McMourrough, we have been promised additional funding from the CSE department on top of the eight hundred dollars we will be receiving from the department. As for the extra amount we are to receive we did not receive an exact answer. Another possible funding support may come from a Lockheed Martin grant but this is under process of approval, as per Dr. McMurrough.

10 Facilities & Equipment

Since the project involves working on heavy hardware, we have been given the choice of our lab space we to either be ERB 203 or ERB 335 depending on what part of the project we will be working on. We can do a lot of the testing in ERB 335 as it has a lot of room. We would also need space in an outdoor area preferably a parking lot or a place with concrete roads for testing. Another location we will need access to is the engineering fab lab in Nedderman Hall because we will need to do 3d printing and there are many tools there that could be helpful for building the vehicle, We will be requiring equipment to solder, power tools, 3d printers, a computer for our development station, and workstation to place the vehicle base. We may need more equipment in the future but it is hard to asses at the moment for specific tools we would need. We plan to obtain most of the equipment from the CSE department, either by the equipment itself being in the lab or by doing requests. For the 3d printer we plan to gain access to the engineering fab lab for that tool. We are going to ask the CSE department a request for a development station computer that we can work on from the ERB 335 or ERB 203 lab. A workstation where we can work safely on the vehicle can be found in ERB 335. More specific item needs may be added depending on our needs as they arise.

11 Assumptions

To realize the Hardware and Software designs, certain assumptions were made which were strongly based on the project requirements, physical limitations of the design implemented, facilities available, and most importantly the funding for the project. 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 3rd sprint cycle and expected to not have a climb over 40 degrees vertically.
- System to be functional till temperature range between 0-80 °C
- Have a working vehicle prototype from old parts by the 3rd sprint cycle.
- Have a concrete design of the modular vehicle by sprint 4 or 5
- Have a suitable test environment by sprint 3
- A working development station set up for the team by the end of sprint 2
- Have a cohesive data set

12 Constraints

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

- Final prototype demonstration must be completed by December 1st, 2023
- The final product should have omnidirectional movement done by the wheels.
- The final product must be built in modularly for easy transportation and reassembly of the vehicle.
- Total development costs must not exceed $2500. (This is bound to change)
- Our vehicle design must follow the specifications set by the IGVC ruleset.

13 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)
Hardware delays	0.25	15	3.75
Hardware Malfunction	0.13	7-8	5-6
Incompatible wheels	0.20	10	2
Biased data	0.40	8	3.7
Fluctuating outdoor testing times	0.45	15	6.75
Defective parts purchased	0.25	10	2.5

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The Project Charter will be maintained by the current team and will be updated whenever major design changes are requested by the sponsor. The initial version of this document will be provided on June 28, 2023 and the final version will be delivered on November 1, 2023

14.1.2 System Requirements Specification

We hope to update the SRS document once every month for the duration of the project. The initial version needs to be delivered by July 12, 2023 and the final version should be delivered by December 2023.

14.1.3 Architectural Design Specification

The Architectural Design Specification should be updated monthly. The initial version initial delivery is not known but we expect it by the end of July 2023 and the final version should be delivered by December of 2023.

14.1.4 Detailed Design Specification

The date for this document is currently unknown but will be updated when available.

14.2 Recurring Sprint Items

The SRS will be updated as need based on the demands of the sponsors and team.

14.2.1 Product Backlog

Items will be added to the product backlog based on priority from the team and the sponsors if possible. These decisions will be made as a team on what we believe hold the most criticality. At that point the product backlog will be held on our SRS.

14.2.2 Sprint Planning

The sprint plans are planned in our weekly discord meetings where we separate the work load amongst the group. There are 4 total sprints for this summer semester.

14.2.3 Sprint Goal

The sprint goal is influenced by the team itself and what we believe the most critical parts of the project are at the time of the sprint. The sponsor/ customer is involved through meetings on a weekly basis if possible so their input will also influence the sprint goal.

14.2.4 Sprint Backlog

We decide as a team where products make it into the backlog items in order of priority for the specific sprint. The backlogs are maintained through individual notions.

14.2.5 Task Breakdown

Tasks are assigned according to individual strengths or interests and are documented through individual notions.

14.2.6 Sprint Burn Down Charts

Each team member will be responsible for at least one burn down chart through out this summer semester. Each member will share there individual times to each person so it is easier to make the burn down charts. The format for the burn down chart will be daily throughout the sprints.

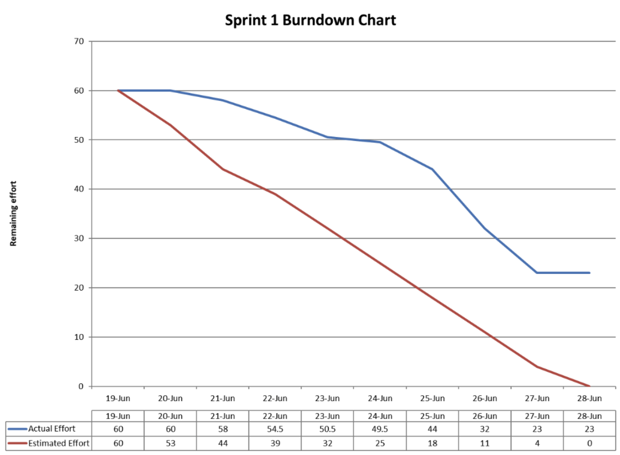

Figure 1: Example sprint burn down chart

14.2.7 Sprint Retrospective

The retrospective will be held during either the day of our presentation for our sprint review after class or on our designated meeting days.

14.2.8 Individual Status Reports

Team members will report their findings at the end of the day during a sprint period. They should talk about things they have accomplished that pertain to the backlog as well as point out any issues that may effect the ability to do a task.

14.2.9 Engineering Notebooks

We plan to update the ENB as soon as ideas are presented. As for the minimum amount of pages it may vary between sprints. We don't have a quota but we expect at the very least the team is adding pages during the sprints. We plan to present the ENB pages to the team at the end of every sprint to see what they have worked on. For this project we do not need a witness signature.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype should be modular and have a working computer vision that sends data to the main computer for computation. A demo should be held for the sponsor to show the modularity of the product, the working mecanum or omni wheels, and the show the computer vision system. Unit tests for each component must pass during the final system prototype. We are not sure whether we would have a PAT or FAT with the costumer. We do want to do the demo off site in a concrete road surface.

14.3.2 Project Poster

The poster shall consist of photos of the robot as well as our team logo and name with the words of the technologies we used to create the robot. It will be delivered in October 2023.

14.3.3 Web Page

The project web page will be available to the public with documents such as the project charter. However it will only be updated at closeout with the remaining documents.

14.3.4 Demo Video

The demo video will consist of footage we have captured doing the current sprint consisting of new things that we were able to accomplish. In terms of length the video can be anywhere from 30 seconds to 10 minutes based on what was accomplished during the sprint.

14.3.5 Source Code

Our code will be maintained on GitHub in which a private repository will contain all of our source code. At the end of September 2023 we will provide the Senior Design 1 team access to the GitHub repository.

14.3.6 Source Code Documentation

What documentation standards will be employed? Will you use tools to generate the documentation (Doxygen, Javadocs, etc.). In what format will the final documentation be provided (PDF, browsable HTML, etc.)?

14.3.7 Hardware Schematics

For all wiring diagrams a png file of schematics will be provided

14.3.8 CAD files

All CAD files used to create the robot will be provided in the closeout materials as well as what resources we used in order to create those items such as the 3D components.

14.3.9 Installation Scripts

The software will have already been deployed to the ground vehicle. However, instructions on how the software was complied will be provided for the next teams.

14.3.10 User Manual

A digital manual will be provided which would contain items such as wiring and hardware diagrams as well as a basic quick start guide.

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