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

Project Charter
CSE 4316: Senior Design I
Fall 2024

Team TLC
Roam_Bot

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	09.05.2024	CC	document creation
0.2	09.26.2024	CD	filled in team information
0.3	09.29.2024	AH	added to project information
0.4	10.08.2024	MG	added to project information
1.0	10.09.2024	AK, AH, CD, MG, RS	added the rest of the project information

Contents

1 PROBLEM STATEMENT

In the modern education system today, most students don't have the opportunity to engage with challenges involving autonomous navigation. As technology can provide quick answers, it is important to equip students with interactive experiences to promote critical thinking and problem solving skills.

To provide interactive learning, our team will develop the "Roam_Bot", an Autonomous Indoor Rover. This rover will navigate through complex environments without the use of GPS systems. Using advanced sensors, the rover can provide abstracted information to test pathfinding algorithms in a dynamic environment.

By creating allowing students to interact and observe with the "Roam_Bot", we can bridge the gap between theoretical knowledge and practical application. As students test their algorithms on this device, they will develop a deeper understanding of robotics and real-time systems. Overall, our robot will equip students to adapt to future technological innovations.

2 METHODOLOGY

We are building the "Roam_Bot," an Autonomous Indoor Rover designed to navigate complex environments without GPS. The Roam_Bot will use multiple sensors, including LIDAR, Sonar, Time-of-Flight (ToF), accelerometers, and gyroscopes. These devices will gather data to make real time navigation decisions. The primary task of the Roam_Bot will be to map out an indoor area and test various pathfinding algorithms. By evaluating algorithms, we can test their performance in real-world scenarios. By implementing a robust software framework, the Roam_Bot will process sensor data, identify obstacles, and dynamically adapt its route.

3 VALUE PROPOSITION

Investing in the "Roam_Bot" project offers benefits to the school, enhancing the educational experience for students and promoting the curriculum. Supporting this innovation will provide:

- Enhanced Education: The Roam_Bot project provides students with hands on experience in robotics and autonomous systems, preparing students for future careers in industry.
- Promoted Engagement: By observing real applications of theoretical concepts, the project can increase student interest. With engagement in engineering and robotics, students will achieve higher success rates.
- Institutional Reputation: Supporting innovative projects like the Roam_Bot enhances the reputation of the school.
- Research Opportunities: The data and findings generated from the Roam_Bot can be a foundation for future research projects.

4 Development Milestones

This list of core project milestones should include all major documents, demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document is listed by month.

List of milestones and completion dates:

- Access to the rover - 10/01/2024
- Project Charter first draft - 10/06/2024
- System Requirements Specification - 10/20/2024
- Architectural Design Specification - 11/2024
- Detailed Design Specification - 03/2024
- CoE Innovation Day poster presentation - 04/2025
- Final Project Demonstration - 04/2025

5 BACKGROUND

In the current educational environment, there is a gap between theoretical learning and practical application, especially in fields that rely on complex, real-world problem-solving like robotics and autonomous systems. While students are often exposed to real-time systems through textbooks and classroom exercises, most students lack hands-on opportunities to apply these concepts in dynamic, real-world settings. This limits their ability to fully grasp the intricacies of how robotic systems function in practice, from sensor integration to real-time decision-making in unpredictable environments.

The rapid advancement of technologies such as artificial intelligence, autonomous vehicles, and robotics has created a demand for engineers and technologists who not only understand these systems conceptually but can also work with them in real world contexts. In particular, autonomous navigation, a critical component in various industries ranging from logistics and transportation to search and rescue operations a skill set that is in increasingly high demand. Despite this need, many students are graduating without sufficient exposure to the challenges posed by real-time decision-making in autonomous navigation, leaving them unprepared for industry expectations.

By ensuring that students have opportunities to work directly with autonomous systems and tackle real-world challenges, educational institutions can equip them with the competence and confidence needed to succeed in advanced fields like robotics and artificial intelligence, ultimately driving innovation and growth in these key sectors.

6 RELATED WORK

Autonomous navigation systems are a rapidly advancing field, encompassing academic research, commercial products, and enthusiast prototypes. Research from the University of Michigan on LIDAR and visual sensor navigation [1] provides robust solutions but tends to be too complex and resource-intensive for educational use. Similarly, ETH Zurich's sensor fusion and mapping systems [2] primarily target advanced robotics, making them less accessible to undergraduate students.

Enthusiast prototypes like the TurtleBot [3] offer a foundation for DIY autonomous systems but often lack the robustness and structure necessary for formal education. Commercial products such as the iRobot Roomba and Starship Technologies delivery robots [4] effectively demonstrate indoor navigation but are closed-source, expensive, and challenging to modify for educational use.

Educational robotics kits like LEGO Mindstorms and VEX Robotics [5] introduce students to basic concepts but do not cover the complexity of real-world autonomous navigation.

The current solutions in the market whether academic, enthusiast driven, or commercially available do not fully address the needs of students seeking a comprehensive, hands-on education in autonomous navigation. Academic research is often too advanced and resource intensive, enthusiast prototypes lack educational integration, and commercially available products are either too expensive, too simplified, or proprietary. These limitations highlight the necessity of a custom built solution like the Roam_Bot, which offers students the ability to work directly with real world navigation challenges in a controlled, affordable, and educationally driven platform.

7 System Overview

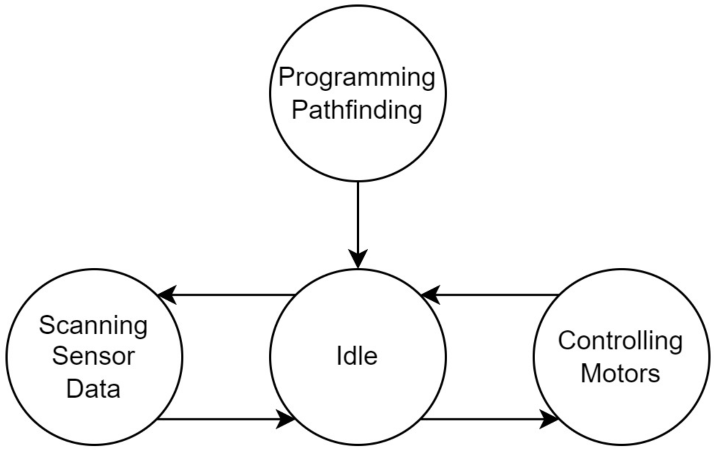

Figure 1: Roambot System

As the diagram shows, we will keep the rover idle while scanning data. Once the path finding program is implemented, it will then go from idle to scanning where it needs to go and then power the motors till it reaches it's destination.

8 Roles & Responsibilities

As of now, Raya Sultan is assigned as the SCRUM master. These are subject to change over time. Our point of contact from the sponsor side will be Christopher Conly, from the team side it is Andrew Howard. At present, the university is the stakeholder of the project, given it is an educational project to aid other students in their real-time understanding of different navigation algorithms. Our sponsor is Christopher Conly.

Abubakar Kassim, due to his experience in software engineering, is responsible for programming and simulating various navigation algorithms.

Madison Gage, due to her experience building an indoor rover, focus on designing and assembling the indoor rover.

Christopher Davis, due to his experience with embedded systems will focus on designing and assembling the indoor rover.

Raya Sultan, due to her graphics as well as engineering skills, will focus on drawing up schematics and diagrams, as well as assist in assembling the motor.

Andrew Howard, with his experience in digital systems, will focus on interfacing the hardware of the indoor rover with abstract software.

9 Cost Proposal

This section contains the approximate budget for the project, where that money will come from, and any other support. The money will be provided by the University of Texas at Arlington CSE department. The circuit boards for a rover to function would cost over the amount the University is providing so we will be reusing boards that were part of previous rovers which would be used to cut down on overall cost.

9.1 Preliminary Budget

- Any circuit components that needs to be replaced.
- 3D printing components to add onto the rover
- Software licensees for navigational systems

9.2 Current & Pending Support

University of Texas at Arlington CSE department is funding our project with $800.

10 Facilities & Equipment

Our team will need lab space in order to work on our rover. We will also need access to a rover/drone cage for safe testing of the rover. This testing ground is already present in the senior design labs we are provided.

We will require hardware components necessary for building an indoor navigation rover. This includes and is not limited to processors, power supplies and sensors. Furthermore, our team needs a place to store our rover, components, and related tools. There are black bins located in the senior design labs already that can be reserved, which covers tools and components. However, the rover is too large to be stored in the bin.

Already present in the lab are the retired UTARI rovers. This provides our team with a lot of starting materials. The rover will still require some components we do not have and these we will have to be purchase. Cannibalizing the UTARI rover and assembling the new rover will require tools, such as screwdrivers, wire cutters, soldering iron, wires, and more. Most of these tools are available to us in the senior design labs. Our team might need access to a MakerSpace to 3D print parts to hold or support components inside the rover. Further needs and and other equipment will be put here.

11 Assumptions

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

- Getting the rover to move in one direction by the 2nd sprint cycle
- A path finding system developed by the team coders will be done by the 4th sprint cycle
- Controlling the direction of the rover will be done by the 4th sprint cycle
- Testing the path finding system with the rover indoors will be done in the 4th sprint cycle
- Adding different parts that can be attached will be done after the 4th sprint cycle.

12 Constraints

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

- The base robot was not initially designed by our team.
- Limited to certain components that would be out of budget to replace.
- Limited range of motion due to design of robot wheels.
- Total development costs must not exceed $800.
- Limited to the sensors, such as limited to the range of the LiDAR.

13 Risks

This section lists 5 of the most critical identified risks that may hamper the progress and success of the project. Mitigation strategies will be discussed further in future meetings.

Risk description	Probability	Loss (days)	Exposure (days)
Vital components being proprietary	0.25	5	1.25
The retired rover not being salvageable	0.20	14	2.8
The rover being damaged in transport	0.30	10	3
Delays in shipping from overseas vendors	0.10	20	2.0
Reordering damaged components	0.10	10	2.0

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

This document will be updated once every week, unless any major change or update occurs. The initial document is set to be submitted on 10/09/2024, Wednesday, and the final document is to be submitted in April 2025.

14.1.2 System Requirements Specification

This document will be updated once every week, unless any major change or update occurs. The initial document is set to be submitted on 10/09/2024, Friday, and the final document is to be submitted in April 2025.

14.1.3 Detailed Design Specification

This document will be updated weekly based on progress with the rover and the navigation system. The initial version will be delivered on 10/09/2024 and the final document is to be submitted in April 2025.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

The product backlog will be decided as a group vote and will prioritized based on how important it is toward goal of having a educational robot. Github will be used to share the code for the rover. Overleaf and Discord will be used to discuss the rest of what is needed for the rover to function.

14.2.2 Sprint Planning

There will be 9 sprints. Each sprint will be planned based on sprint backlog items and future goals for the rover.

14.2.3 Sprint Goal

The sprint goal will be decided by the group and be discussed as the rover gets built.

14.2.4 Sprint Backlog

The sprint backlog will be decided as a group and will be organized with hardware task and software task. We use github to collaborate on the software and use overleaf and discord to discuss what hardware to focus on.

14.2.5 Task Breakdown

Tasks will be assigned to team member who volunteer and for the task that are not picked will be given to the members that have enough time and willing to take on the task.

14.2.6 Sprint Retrospective

The sprint retrospective will be due on 10/21/2024. We as a team will discuss this after each week on Friday to pull all of our information.

14.2.7 Individual Status Reports

Each member will submit a report about their perspective about how the project is going and how each member is contributing. This will be reported after every sprint.

14.2.8 Engineering Notebooks

The engineering notebook will be updated each week by each team member when they are in lab and at the end of each sprint each member would have to have an entry in the notebook. The minimum amount of pages per sprint would be 5 pages. Professor Conly will be the witness for each ENB page. Each member will be held accountable for their own entry.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will include a navigation system as well as different components like a pushy arm, sensors and a speaker. The rover will be demonstrated at the end of the spring semester.

14.3.2 Project Poster

The poster will include the rover as well as the many different functions it can do. The dimensions will be 24x32 and will be done by the end of the 4th sprint.

14.3.3 Web Page

The project webpage will serve as a key communication tool, showcasing the evolution of our pathfinding algorithms through detailed simulation videos. These videos will demonstrate various versions of our algorithms in action, alongside comparisons to the physical model, providing a clear visualization of performance and accuracy. This will allow users to assess how well the algorithms perform in real-world scenarios and how they improve over time. The webpage will also include a GitHub link, granting access to the project's source code and version history, promoting transparency and enabling collaboration. It will be accessible to the public, allowing stakeholders, potential collaborators, and the wider community to engage with our progress.

14.3.4 Demo Video

The demo videos will cover a wide range of topics related to the rover. Such as the key components that allow for different navigation algorithms to be tested on the rover. How to program the rover and what languages are used to do so. The demo video will include b-reel of the rover in action demonstrating different navigation algorithms. Should ideally take around 3-5 mins.

14.3.5 Source Code

Our source code will be maintained using GitHub. The project will be open-source under the GPL (GNU General Public License), as many of our pathfinding algorithms (A*, Djikstra, Depth First Search, etc.), are open-source software, to promote transparency.

By adopting the GPL public license, we ensure that the derivations of our source code are open source. The source code including the binaries, will be provided to the customer, to ensure full control over the implementation. The customer can locate the source code via Github, where they have direct access to the repository. All information containing our licensing will be contained within a readme file at the root of the repository.

14.3.6 Source Code Documentation

For code documentation, we will primarily utilize GitHub to ensure version control and collaborative efficiency. In addition, we will use Overleaf for generating our project documentation, which will be published as a downloadable PDF for easy access and distribution.

14.3.7 Hardware Schematics

We will be documenting the connections between the PCB, Sabertooth motor drivers, DC converters, Signal Controllers, and any other component that is added in future sprints.

14.3.8 CAD files

We plan to use 3D printed parts to add on to the rover. We would be using Blender, Plasticity, or any of the available 3D modeling software.

14.3.9 Installation Scripts

The customer will be able to deploy their own navigation system through flashing onto the device by connecting it to the main board. We will provide a basic navigation system to demo the rover's capabilities.

14.3.10 User Manual

The customer would either need a digital user manual or a physical copy to understand what buttons do what and where extra additions can be placed.

References

[1] A. Howard and J. Smith, “Indoor autonomous navigation using lidar and vision sensors,” *Journal of Robotics*, vol. 22, no. 3, pp. 55–67, 2023.

[2] B. A. et al., “Sensor fusion techniques for autonomous systems,” *IEEE Transactions on Robotics*, vol. 34, no. 1, pp. 15–27, 2022.

[3] O. S. R. Foundation, “Turtlebot: An open-source autonomous robot for learning and research,” 2021.

[4] S. Technologies, “Autonomous delivery robots: Navigating urban environments,” 2022.

[5] L. Education, “Lego mindstorms: Robotics for learning,” 2020.