DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
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SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
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TEAM TLC
ROAM_BOT

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1 Product Concept

This section describes the purpose, use, and intended user audience for the "Roam_Bot". The Roam_-BOT is a unique system that allows users to implement pathfinding algorithms to test the efficiency of their software in real time using advanced technology. Educational users will be able to evaluate the effect of different algorithms to traverse and map the surrounding areas.

1.1 Purpose and Use

The Roam_Bot should assist with learning to implement autonomous system software through real test simulations. Using an actual robotic system, software can be developed much more robustly to handle real-world obstacles.

1.2 Intended Audience

The majority of the Roam_Bot user base will be students. It will be made publicly available to the public for multiple learning institutions across the University of Texas at Arlington. Our system will be intended for the general purpose testing of navigation software.

2 Product Description

This section provides the reader with an overview of the Roam_Bot. The primary operational aspect of the product for the user is to allow the upload of path finding algorithms for testing. For the maintainers, the primary operational aspects is the functionality of the movement components and crash preventive components, and ensuring hardware is receiving provided algorithms. Key features and functions of the Roam_Bot are the navigation of a space using the provided algorithm, crash preventative feature, and a simple interface for uploading algorithms.

2.1 Features & Functions

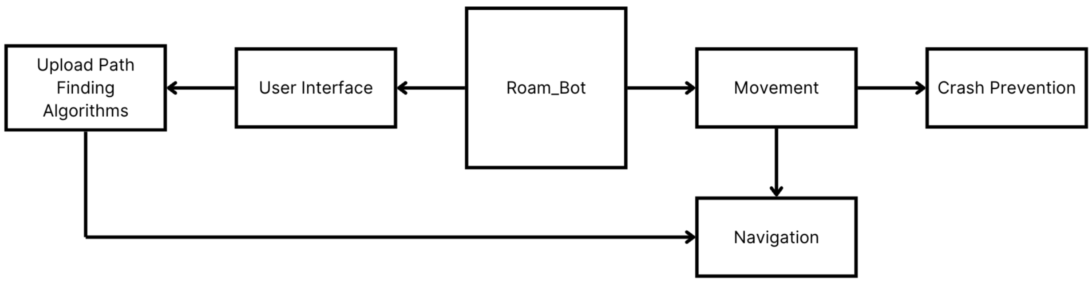

Figure 1: Conceptual Diagram of the Roam_Bot

The Roam_Bot receives and executes user provided algorithms. The algorithms are uploaded through a simple user interface. Once the start button is pressed the Roam_Bot will begin navigating using the provided algorithm. The crash prevention feature will ensure that the Roam_Bot safely avoids collision and navigates away from the obstacle.

2.2 External Inputs & Outputs

Name	Description	Use
Uploaded Path finding Algorithm	The main input that tells the Roam_Bot how to navigate	The upload is used by users to test algorithms with the Roam_Bot
Start Input	This is an input that tells the Roam_Bot to move	To ensure the Roam_Bot does not begin moving before it is intended to
Diagnostic output	Reports the status of internal components	Allows the maintainers to check that the Roam_Bot is working as expected

Table 2: Description of the critical external data flows

2.3 Product Interfaces

The simple user interface will have a simple way for the users to upload their own path finding algorithms, or the option use a default algorithm, and then start the test. The maintainers will see the same user interface but uploading the diagnostic algorithm will create a report on the Roam_Bots functionality.

3 Customer Requirements

The Roam_Bot will be fully utilized by customers who have their own path finding system or some understanding of the movement of the rover. The rover will be able to navigate through set paths as well as the option to manually control where the rover will go.

3.1 Reliable Movement

3.1.1 Description

The Roam_Bot will have motors controlling the 4 wheels of the rover. The motors are powered by a LiPo (Lithium Polymer 22.2V) battery. The power of the motors are controlled by a raspberry pi which takes in user input from our UI.

3.1.2 Source

CSE Senior Design project specifications

3.1.3 Constraints

The rover is limited by its size and the overall cost of making a similar product. The wheels of the rover does not have a function to go up or down stairs easily.

3.1.4 Standards

The speed of the motors will be limited so that it won't be a hazard when used incautiously. There will be a kill switch to turn off the rover in any situation and its function must not depend on any power source or wiring connection. The rover will meet strict cleanliness requirements to avoid contaminating samples with materials from Earth. The rover will not include any flammable, environmentally damaging, or otherwise hazardous liquids or gases.

3.1.5 Priority

Priority Level: Critical (1)

3.2 Path finding system

3.2.1 Description

The path finding algorithm finds the shortest distance to the target spot while also noting the terrain around it to avoid while moving. The path finding algorithm will take in input from LIDAR and close range sensors. With the information, it will control the wheels to go in that direction.

3.2.2 Source

CSE Senior Design project specifications

3.2.3 Constraints

Having the rover to constantly detect the path will slow processing power.

3.2.4 Standards

The factors that affect performance of the path finding system include the problem size, path length, number of obstacles, data structures, and heuristics.

3.2.5 Priority

Priority Level: High (2) (very important to customer acceptance, desirability)

3.3 Attachments

3.3.1 Description

The rover will have attachable components to help it navigate and perform different task. These attachments ranges from a water pump, a push arm, and any future attachments.

3.3.2 Source

CSE Senior Design project specifications

3.3.3 Constraints

The amount of space the rover has and the carry weight of the rover limits what can be put on the rover.

3.3.4 Standards

The rover will not include any flammable, environmentally damaging, or otherwise hazardous liquids or gases.

3.3.5 Priority

Priority Level: Moderate (3) (should have for proper product functionality);

4 Packaging Requirements

As for delivery to the user, the rover will be packaged without a battery, thus the user must plug in batteries to be able to use it. The software for the motion of the rover will be pre-loaded and shipped with the rover. The hardware in of itself will be shipped assembled, that is, completely assembled, complete with the underlying software. The user will be provided with an interface to control speed, direction and choose which path-finding algorithm to use to see their action in real time. Batteries are to be packaged separately due to their lithium content.

4.1 Fragile Packaging

4.1.1 Description

Package when shipped must be handled with care due to the circuitry within it.

4.1.2 Source

Team TLC

4.1.3 Constraints

All metal and contact points should be insulated and covered. There must also be insulating cushioning material for packing so that the circuits do not get damaged in shipping. The large size of the rover also means shipping costs will be high.

4.1.4 Priority

Priority: Moderate (3)

4.2 Lithium Battery Shipping

4.2.1 Description

Batteries will be shipped in a separate package.

4.2.2 Source

Pipeline and Hazardous Materials Safety Administration, US Department of Transportation.

4.2.3 Constraints

Lithium batteries are explosive and hence hazardous.

4.2.4 Standards

UN3480 LITHIUM ION BATTERIES [1]

4.2.5 Priority

Priority Level: High (2)

5 Performance Requirements

The Roam_Bot, is a rover that uses advanced pathfinding algorithms including Dijkstra's, Depth-First Search (DFS), Breadth-First Search, and A*. The purpose is to navigate environments autonomously. Designed for efficient navigation, the rover must meet specific operational metrics: completing path calculations within critical response times, achieving optimal setup and startup durations, maximizing battery life for extended deployment, and ensuring smooth and precise movement adjustments.

5.1 Pathfinding

5.1.1 Description

This section details the performance requirements for the pathfinding algorithms.

5.1.2 Source

Team TLC

5.1.3 Constraints

The rover should follow these constraints:

- The rover should be able to initialize calculating paths within 1000ms.
- The rover should be able to recalculate paths after reaching its LIDAR range within 500-1200-ms.
- The rover should be limited to a max speed of 1 meter per second (m/s)
- Total weight should not exceed what the motors can handle effectively.

5.1.4 Standards

The rover should ensure it complies with:

- Robot Operating System (ROS) Communication Protocols [2]
- Robot Operating System (ROS) Navigation Stack [2]

5.1.5 Priority

Priority Level: Critical (1)

5.2 Battery Life

5.2.1 Description

The battery system of the autonomous rover must deliver reliable power to support uninterrupted operation across varied terrains and usage scenarios.

5.2.2 Source

Team TLC

5.2.3 Constraints

- Battery should last at least 4 hours of continuous operation.
- Recharge time should be under 4 hours to enable quick redeployment.
- The battery must perform reliably between -10Â°C and 50Â°C, with heat management solutions to prevent performance degradation in extreme conditions.

5.2.4 Standards

- IEC 60086 [3]

5.2.5 Priority

Priority Level: Future (5)

6 Safety Requirements

The Roam_Bot is designed to avoid any hazardous materials and breakable components including glass. All electrical components will be properly protected and grounded to prevent any unwanted current discharge. If the robot's action becomes undesirable, safety protocols are implemented for an emergency stop to prevent further robot or human injury.

6.1 Laboratory Equipment Lockout/Tagout (LOTO) Procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design Laboratory Policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to the availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - Control of Hazardous Energy (Lockout/Tagout).

6.1.5 Priority

Priority Level: Critical (1)

6.2 National Electric Code (NEC) Wiring Compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design Laboratory Policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 Standards

NFPA 70

6.2.5 Priority

Priority Level: Critical (1)

6.3 Emergency Stop

6.3.1 Description

This easily accessible switch is designed to stop all power, turning the robot off immediately. This feature will disconnect the battery despite the current state of the robot.

6.3.2 Source

Team TLC

6.3.3 Constraints

Accessibility: The button is made easily accessible to all users, ensuring quick activation in an emergency.
Health and Safety: The stop is designed to protect all users by providing a nearly instant stop to all robot activity, reducing the risk of human injury.

6.3.4 Standards

- ISO 13850 (Safety of Machinery)
- ANSI/RIA R15.06 (Safety of Robot Systems)

6.3.5 Priority

Priority Level: Critical (1)

6.4 LiPo Battery Safety

6.4.1 Description

The battery is handled safely throughout its lifecycle, including its use, physical handling, and charging.

6.4.2 Source

Team TLC

6.4.3 Constraints

Environmental: LiPo batteries must be used and disposed of following industry standards to reduce their environmental impact and support the sustainability of recycling.
Health and Safety: Safety measures are followed when charging and using the LiPo batteries to prevent the release of dangerous currents.

6.4.4 Standards

- IEC 62133 (Safety for Lithium Batteries)
- UN 38.3 (Transport Safety for Lithium Batteries)

6.4.5 Priority

Priority Level: Critical (1)

7 Maintenance & Support Requirements

The Roam_Bot will require clear maintenance and support guidelines to function effectively in educational environments. This includes offering software and hardware documentation to provide users with the ability to resolve issues. Furthermore, we will also provide debugging tools to enable quick and easy detection of the issues in the robot. By implementing these measures, we aim to enhance the robot's reliability and provide a rich learning experience for students.

7.1 Diagnostics Tools

7.1.1 Description

These tools will provide an easy way to identify major problems in hardware or software that can prevent the robot from functioning safely.

7.1.2 Source

Team TLC

7.1.3 Constraints

Environmental: The diagnostics are used to ensure the health of the robot, preventing unnecessary waste from the early replacement of components.
Economic: The cost of diagnostics tools should remain within the robot budget.
Sustainability: The diagnostics should minimize the need for replacements, allowing the robot to function for longer periods of time.

7.1.4 Standards

- IEC 61010 (Safety Requirements for Electrical Measurement)
- IEEE 802.3 (Wired Communication Protocols)
- ISO 9001 (Reliable Quality Measurements)

7.1.5 Priority

Priority Level: Future (5)

7.2 Software Documentation

7.2.1 Description

The software documentation will provide detailed information about packages and frameworks used to control the robot system. This includes API use and troubleshooting guides.

7.2.2 Source

Team TLC

7.2.3 Constraints

Usability: The documentation is written with clear, step by step instructions to ensure easy understanding and accessibility for any user. It includes visual aids and structured content to help users navigate through information.
Scalability: The guides can be updated, allowing the integration of new features and added frameworks.

7.2.4 Standards

- ISO/IEC 26514 (Best Practices for User Documentation)
- IEEE 24765 (Systems and Software Engineering Vocabulary)

7.2.5 Priority

Priority Level: Low (4)

7.3 Hardware Documentation

7.3.1 Description

The hardware documentation will provide detailed information about the components and controllers in the robot system. This includes specifications, configurations, and diagrams for sensors, motors, and microcontrollers.

7.3.2 Source

Team TLC

7.3.3 Constraints

Usability: The documentation is written with clear diagrams and instructions to ensure easy understanding and accessibility for any user. It includes visual aids and structured content to help users navigate through information.
Scalability: The guides can be updated, allowing the integration of new features and added frameworks.

7.3.4 Standards

- ISO/IEC 26514 (Best Practices for User Documentation)
- IEEE 24765 (Systems and Software Engineering Vocabulary)

7.3.5 Priority

Priority Level: Low (4)

8 Other Requirements

The Roam_Bot will meet various system validation requirements to make certain that it meets all design requirements and specifications. Comprehensive testing will be performed to verify the reliability and accuracy of all components in the system.

8.1 System Validation

8.1.1 Description

Validation will ensure that all parts of the robot are functioning independently and together meet the design specifications and performance requirements. This includes testing for durability, software reliability, and safety protocols.

8.1.2 Source

Team TLC

8.1.3 Constraints

Accuracy: The testing must analyze both hardware and software to ensure the design specifications are met in various environments.
Human Interaction: The system should be tested to ensure easy access and intuitive use when being operated by various users.

8.1.4 Standards

- ISO 9001 (Quality Sensor Measurement)
- IEC 61010 (Human-Computer Interfaces)

8.1.5 Priority

Priority Level: Moderate (3)

9 Future Items

9.1 Battery Life

9.1.1 Description

The battery system of the autonomous rover must deliver reliable power to support uninterrupted operation across varied terrains and usage scenarios.

9.1.2 Source

Team TLC

9.1.3 Constraints

- Battery should last at least 4 hours of continuous operation.
- Recharge time should be under 4 hours to enable quick redeployment.
- The battery must perform reliably between -10Â°C and 50Â°C, with heat management solutions to prevent performance degradation in extreme conditions.

9.1.4 Standards

- IEC 60086 [3]

9.1.5 Priority

Priority Level: Future (5)

9.2 Diagnostics Tools

9.2.1 Description

These tools will provide an easy way to identify major problems in hardware or software that can prevent the robot from functioning safely.

9.2.2 Source

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9.2.3 Constraints

Environmental: The diagnostics are used to ensure the health of the robot, preventing unnecessary waste from the early replacement of components.
Economic: The cost of diagnostics tools should remain within the robot budget.
Sustainability: The diagnostics should minimize the need for replacements, allowing the robot to function for longer periods of time.

9.2.4 Standards

- IEC 61010 (Safety Requirements for Electrical Measurement)
- IEEE 802.3 (Wired Communication Protocols)
- ISO 9001 (Reliable Quality Measurements)

9.2.5 Priority

Priority Level: Future (5)

References

[1] P. US Department of Transportation and H. M. S. Administration, "Lithium battery guide for shippers: A compliance tool for all modes of transportation."

[2] ROS, "Ros/techincal overview."

[3] IEC, "Iec 60086."