# Requirement Analysis

## Functional Requirements

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| Basic Modular Requirements | This includes:   * powering on, * the movement capability, * functioning line sensors for line detection, * the ability to measure the distanced using ultrasonic sensors, * battery management, |
| Interfacing Requirements | This includes:   * precise speed and turning control (necessitating fine management of the H-bridge), * establish communication with the line and ultrasonic sensors. |
| Complex Microcontroller Requirements | This includes:   * Recording, storing, and analysing routes and intersection traversed by the robot. * Implementing specific criteria for stopping at certain points during navigation, * Deciding when to measure distances to objects based on predetermined conditions, * Precise control over the direction and speed of the robot. * Efficient path planning, * Safety features. |
| (Add more requirements) |  |

## Constraints

1. Voltage supply and logic level: 5V.
2. Veroboard size: 100mm x 50mm; no breadboard allowed.
3. Power source: Operates off 2 x 18650 3.7V Batteries connected in series, regulated by AMS1117-5.0.
4. Sensor placement: An ultrasonic sensor positioned at the front of the robot.
5. Line sensors: A maximum of 5-line sensors to be utilized.
6. Components: The usage of specific components is specified.
7. Time constraints: Project completion within a specified timeframe.
8. Availability of parts: Consideration of component availability during the project.
9. Mechanical specifications: Determining axle length and wheel diameter for the robot's movement.

## Possible Bottlenecks

1. Processing and sensor speed: Ensuring that the microcontroller or processing unit can handle the required computations efficiently and that the sensor response time is suitable for real-time decision-making.
2. Battery power: Optimizing power usage to ensure extended operation time and implementing mechanisms for battery charging or replacement when required.
3. High turning speed stability: Designing the robot's mechanical and control systems to maintain stability and prevent issues like tipping or skidding during high-speed turns.
4. Subsystem Design: Developing and integrating different subsystems, such as motion control, sensor interfacing, data storage, and decision-making, to work harmoniously and achieve the project objectives.

# Sub System Design

## Subsystem and Sub-subsystems Requirements

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| Power: | * Regulate the power supply to 5V to meet the system requirements. * Ensure sufficient current capacity to power all subsystems. * Implement Under Voltage Lockout (UVLO) and Reverse Polarity (RP) protection mechanisms. * Monitor and regulate current usage. |
| Microcontroller: | * Process sensor data in real-time and efficiently interpret it. * Output processed data to drive systems and control the logic flow of the robot. * Perform data processing at a faster rate than the sensor data acquisition. * Incorporate an LED indicator to signify the operation of the ultrasonic sensor. |
| Motor drive and Motors: | * Enable forward, reverse, and turning controls for smooth navigation. * Ensure speed control of the motors for precise movement. |
| Mechanical: | * Chassis is already built to house all components. * Build should be able to sustain knocks in the case of failure. |
| Sensors: | * Utilize fast and accurate line sensors to provide real-time data on the robot's position. * Ensure the ultrasonic sensor delivers quick and precise distance measurements for effective obstacle detection. |

## Subsystem and Sub-subsystems Specifications

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| Power: | * Regulate the power supply to 5V, accepting input voltages between 6V and 8.4V. * Ensure sufficient current capacity to power all subsystems. * Implement Under Voltage Lockout (UVLO) at 6V to protect the system from undervoltage conditions. * Use a Reverse Polarity (RP) protection circuit consuming less than 1mW. * Employ a current regulator to prevent the Low Voltage Regulator (LVR) from malfunctioning. |
| Microcontroller: | * Receive 5V power supply and convert the 3V3 logic level outputs to 5V using a Logic Level Converter. * Optimize calculations between the line sensors and H-Bridge output to be completed in less than 1ms. |
| Motor drive and Motors: | * Ensure the motors can rotate at a constant speed. * Power the motors with a 5V supply and ensure the system can handle up to 5A current. |
| Mechanical: | * Utilize a Veroboard with dimensions of 100mm x 50mm. |
| Sensors: | * Implement data transmission within less than 10 clock cycles to achieve high sensor speed. |

## Inter-subsystems Interactions

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| Power: | * Supplies regulated 5V power to all subsystems. * Includes protection mechanisms like UVLO and RP for safety. * Ensures sufficient current capacity for all components. |
| Microcontroller: | * Receives 5V power and uses a Logic Level Converter to convert 3V3 logic to 5V for interfacing with other subsystems. * Interprets sensor data and performs calculations for speed and turning control. * Communicates with the motor drive, line sensors, ultrasonic sensor, and other components. |
| Motor drive and Motors: | * Receives 5V power from the microcontroller. * Enables precise control over the motors for forward, reverse, and turning motions. * Ensures motors rotate at a constant speed for stable movement. |
| Mechanical: | * Hosts all components. * Provides protection and robustness to internal components. |
| Sensors: | * Delivers fast and accurate data from the line and ultrasonic sensors. * Transmits data to the microcontroller within short intervals. |

## UML Diagrams were possible

# Acceptance Test Procedure

## Figures of merits based on which you would validate your final design.

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| Power On, | Verification that the robot powers on and initializes successfully. |
| Interconnectivity, | Ensuring that all subsystems and components communicate effectively with each other. |
| Movement, | Validating that the robot can move autonomously as intended. |
| Speed and turning control, | Verifying precise control over speed and turning during navigation. |
| Line following, | Confirming that the robot can accurately follow a line on the designated path. |
| Intersection resolution, | Ensuring that the robot can correctly resolve intersections and continue its path accordingly. |
| Path mapping, | Validation of the robot's ability to map paths and keep track of the routes taken during navigation. |
| Stop and measure distances, | Verifying that the robot can halt at specific measuring points and accurately measure distances to objects. |
| Termination, | Confirmation that the robot terminates its movement when it reaches the designated stop point or the end of the maze. |

## Experiment design to test these figures of merit.

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| Check Power System and LEDs, | * Ensure all power connections are secure and within the specified voltage range. * Verify that the LEDs used for indicators (e.g., power on, ultrasonic sensor running) function correctly. |
| Check Microcontroller Communication with Components, | * Test communication between the microcontroller and all subsystems/components to confirm interconnectivity. |
| Test Basic Movement, | * Input a simple move command to the microcontroller and verify if the robot moves accordingly. |
| Test Advanced Movement, | * Input specific move commands with varying speed and turning parameters to validate precise control over movement. |
| Line Following Test, | * Run the robot on this path to ensure it accurately follows the line. |
| Intersection Resolution Test, | * Verify that the robot correctly chooses and traverses each possible path at the intersection. |
| Path Mapping Test, | * Allow the robot to navigate a complex maze while recording its path. * Analyse the recorded data to ensure the robot successfully maps the paths it took. |
| Stop and Measure Distance Test, | * Incorporate a measuring point with an object placed at a specific distance. * Verify that the robot halts at the measuring point and accurately measures the distance to the object. |
| Termination test, | * Set a designated stop point or end of the maze. * Confirm that the robot terminates its movement upon reaching the stop point. |

## Acceptable performance definition

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| Power On, | The robot must consistently power on and initialize its systems without any failures. |
| Interconnectivity, | All subsystems and components should establish and maintain reliable communication to ensure seamless operation. |
| Movement, | The robot should be able to move smoothly and consistently, responding appropriately to navigation commands. |
| Speed and turning control, | The robot should exhibit precise speed control and turning capabilities for accurate manoeuvring. |
| Line following, | The robot should accurately follow the designated line path, keeping within acceptable deviations. |
| Intersection resolution, | The robot must correctly identify and traverse all possible paths at intersections. |
| Path mapping, | The robot's path mapping should be accurate, capturing the routes taken during navigation effectively. |
| Stop and measure distances, | The robot should halt precisely at measuring points, and its distance measurement to objects should have acceptable accuracy. |
| Termination, | The robot should terminate movement upon reaching the designated stop point or the end of the maze consistently. |

# Development Timeline

# References