

SYSTEMS ENGINEERING AND PROTOTYPING COURSE

Prototyping Technical Report: The Design and Construction of Autonomous Vehicle

Significant Challenges and Resolutions:

Throughout the development and testing of the autonomous vehicle, several technical and practical challenges were encountered. These challenges provided valuable learning opportunities and required iterative problem-solving, adjustments to the hardware and software, and fine-tuning of system performance. Below is a summary of the key challenges faced during the project and the solutions implemented to overcome them.

Sensor Inaccuracy and Interference

- **Challenge:** The IR and ultrasonic sensors sometimes gave inconsistent or false readings, especially in bright lighting or when objects were at awkward angles.
- **Resolution:** Implemented multiple readings and averaging (for color sensor), timing intervals for ultrasonic checks and added logic to ignore clearly invalid values.

Obstacle Avoidance Complexity

- **Challenge:** Designing an effective obstacle avoidance routine that didn't cause the robot to get lost or stuck after detouring.
- **Resolution:** Created a step-by-step avoidance sequence including reverse, pivot, bypass, and line recovery with fail-safe search patterns - ensured the robot could return to the line reliably.

Line Loss and Path Recovery

- **Challenge:** When both IR sensors lost the line (e.g., at junctions or sharp curves), the robot didn't always know which way to turn.

A pre-requisite report for completion of Prototyping and Systems Engineering Course:

To: Professor Stephen Henkler

By Group B 4 students :

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- **Resolution:** Tracked the last seen position of the line using lastSeenLine logic and implemented directional searches (pivot left/right) to regain the path.

Color Detection Reliability

- **Challenge:** Colours were sometimes misclassified due to ambient lighting or variations in surface tone.
- **Resolution:** Collected calibrated colour ratios (RG and RB) and added a differential comparison strategy instead of relying on raw RGB values - improved classification accuracy between Colour A and B.

Tuning PID Controller

- **Challenge:** The robot either over-corrected or didn't respond well to line deviations during movement.
- **Resolution:** Tuned the PID constants (Kp, Ki, Kd) through trial and error to achieve smoother turns and better line-following stability.

Code Integration and Timing Conflicts

- **Challenge:** Running multiple sensor routines (IR, ultrasonic, colour) caused timing conflicts and delayed responses.
- **Resolution:** Used timing intervals (millis) instead of delay() for obstacle checks and optimized sensor polling frequency to balance responsiveness and stability.

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