Line-Following Robot Challenge Technical Report

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EGB220 – Mechatronics Design 1

Abstract

This report presents the development of a line-following robot project, focusing on mechatronics design, project management, and teamwork. The project involved multiple sprints divided into key development stages: explore, design, development, and optimisation. The team successfully designed and implemented a functional line-following robot, meeting the project's specified requirements.

The report highlights the importance of mechatronics design principles, including understanding task requirements and selecting appropriate tools and components. The iterative design process allowed for continuous improvement, resulting in a reliable and efficient robot system. Accurate time estimation and effective task allocation ensured timely completion of features.

Project management followed the Scrum and Agile framework, emphasising regular meetings, collaboration, and adaptability. The team effectively managed changes and challenges, although improvements could be made in task allocation and formalised risk management practices.

Effective teamwork played a crucial role in the project's success. Clear communication, knowledge sharing, and leveraging individual expertise led to efficient collaboration. However, further improvements could be made by capitalising on individual strengths and fostering a culture of continuous learning.

The report suggests future work to enhance the product, team dynamics, and project management. Areas for improvement include enhancing the line-following algorithm, exploring advanced sensing technologies, and implementing machine learning algorithms. Team dynamics can be improved through cross-training and knowledge sharing sessions. Project management can benefit from a formalised risk management system and enhanced documentation and progress tracking practices.

Overall, this report highlights the lessons learned and provides valuable insights for future mechatronics design projects. By implementing the suggested improvements, the team can further enhance their capabilities and achieve even greater success in future endeavors.

Line-Following Robot Challenge Technical Report

1. Introduction

1.1 Problem Definition

The problem our team is addressing involves the need for an innovative solution to monitor and manage weed growth on the island of Minjerribah. Specifically, we aim to design and develop a line-following robot capable of autonomously navigating various tracks, including both straight and curved paths while adjusting its speed based on external cues. By implementing automation in the monitoring process, we aim to reduce the reliance on manual labor and enable the Quandamooka Community Rangers (QRC) to focus their skills and resources on other important conservation tasks. This project serves as an opportunity for us to demonstrate our engineering competencies and showcase our team's ability to effectively manage complex projects. The prototype we will develop represents the initial stage of an autonomous monitoring system that has the potential to significantly revolutionise environmental management efforts on Minjerribah.

1.2 Findings from the Indigenous Perspective Scoping Study

The Indigenous Perspective Scoping Study highlights the significance of the Quandamooka Yoolooburrabee Aboriginal Corporation's (QYAC) registration of a substantial portion of the Minjerribah bushland under the Land for Wildlife program. With over 40,000 years of protection by the Quandamooka People, this area holds deep historical and cultural importance. The study emphasizes the essential role of the Quandamooka Community Rangers (QCR), operating under the QYAC, in environmental land management, including weed control, invasive pest management, and cultural heritage preservation. It recognizes the profound impact of the ranger program on ecological sustainability and the transfer of intergenerational knowledge.

In terms of the purpose of the line-following robot, the study proposes the real-world concept of an advanced autonomous monitoring system that can support the QCR and significantly contribute to the preservation of the Minjerribah bushland. This future version of the robot would be equipped with advanced features, including image recognition for accurate weed identification, GPS and mapping capabilities, autonomous navigation, and real-time monitoring and communication with the QCR. By incorporating these features, the robot would serve as an invaluable tool in optimising weed detection, monitoring, and management strategies, allowing the QCR to efficiently allocate their resources and focus on other important conservation tasks.

To ensure minimal environmental impact, the study recommends designing the robot to operate quietly and slowly, minimising disturbances to wildlife. The use of biodegradable materials, such as wood, for the robot's chassis would promote sustainability and prevent litter. Additionally, the system would prioritize maneuverability by adopting a compact design with a centered center of gravity, facilitating efficient navigation and effective monitoring within the natural habitat.

For successful implementation of the robot in the Minjerribah bushland, collaboration and approval from various organisations and stakeholders are essential. Engaging with the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) to understand their specific needs and desired outcomes, as well as considering Traditional Owners and Native Title considerations, is paramount. Seeking advice and establishing access to the land would involve contacting relevant organisations, including the QYAC and local governing bodies responsible for land management and conservation efforts.

2. Team and Report Overview

1.1 Team Strategy:

Our team adopted a strategic approach that prioritised effective collaboration, communication, and harnessing the individual strengths and expertise of each team member. We recognised the value of regular meetings and open discussions, ensuring that everyone's ideas and perspectives were actively heard and taken into consideration. By adopting an agile methodology, we broke down the project into manageable tasks and set realistic deadlines, fostering a sense of momentum and accountability. Our primary objective was to foster a cohesive team environment where we could support and complement each other's contributions, ultimately striving for the best possible outcomes.

1.2 Individual Role and Strategy:

In this project, my role as the Scrum Master was multifaceted and pivotal to the overall success of our team. I took charge of coordinating team meetings, allocating roles, and documenting progress, which helped ensure effective communication and collaboration among team members. With a strong emphasis on agile principles, I facilitated efficient sprint planning and execution while providing technical insight for demonstrations and presentations. During the development stage, I played a key role in fine-tuning PID control and motor functionality, as well as debugging through iterative process while documenting the performance of the robot. A large component of my role required me to be adaptable, make decisions, improvise, and problem-solve. By fostering open communication, tracking progress, and implementing innovative solutions, my strategy aimed to maximize our team's capabilities, deliver a high-performing line-following robot, and showcase our collective achievements at the final demonstration.

1.3 Summary of Achievements:

Throughout the project, our team achieved significant milestones in the completion of the line-following robot. We successfully designed and developed a functional prototype for the first demonstration, showcasing our ability to detect and follow a white line using a PID control system and optimised motor functionality. This milestone provided valuable insights for further refinement and set the foundation for our final demonstration. We implemented a custom PCB and sensor board, enabling the robot to detect the white line and external markers. The final demonstration marked the culmination of our efforts, highlighting the robot's impressive capabilities, including precise line following, marker detection, and adaptive speed control. These achievements demonstrate our team's commitment to delivering a high-performance solution and showcase our capacity to overcome complex engineering challenges with innovation and expertise.

1.4 Main Difficulties and Challenges:

Throughout the project, our team faced several difficulties and challenges that tested our problem-solving skills and adaptability. Budget constraints significantly influenced our choices for components and materials, requiring us to carefully balance cost considerations with functionality. The limited budget led to the use of a simple infrared LED for color detection, impacting the accuracy of determining the slow zone. Time management was also a challenge, with project deadlines and milestones necessitating efficient decision-making and prioritisation of tasks. In the design phase, we encountered complications with the printed circuit boards (PCBs), resulting in two custom PCBs to be obsolete due to routing errors. This setback forced us to find alternative solutions and adapt our project plan. The first PCB error was identified before the first demonstration, which meant that we were unable to implement our custom main PCB. Our team identified this error and aimed to print two custom PCBs for the final demonstration, a backup one correcting the initial issue and a final one implementing LEDs for the final demonstration. Although, the board intended for the final demonstration had overlaps and was unusable, and the backup board did not implement LEDs. Additionally, it was identified that incorrect resistor values on the custom sensor board were causing the board to overheat. Despite these setbacks, our team successfully presented a complete and functional line-following robot at the final demonstration, showcasing our ability to overcome challenges and deliver a high-quality result.

1.5 Outline of the Report Content:

The following sections of the report will discuss in detail the technical background of advanced line-following robots and the mechatronic design aspects relevant to our project. This report then provides a comprehensive overview of each key subdivision of the project, detailing the challenges encountered and the solutions devised to overcome them. Furthermore, it then presents our team’s proposed solution approach, discussing the system architecture, sensor integration, control strategies, and mechanical design. Additionally, it elaborates on our project management approach, outlining the breakdown of roles and tasks within the team, along with our strategies for effective coordination and communication.

2. Literature Review / Technical Background

In the context of developing an autonomous monitoring system, it is important to draw insights from advanced robotic systems that have successfully employed certain architectures and control methodologies. One such example is the Sense, Think, Act (STA) architecture, which has been widely adopted in robot control systems (Sivitilli et al., 2022). This architecture consists of three key components: sensing the environment, processing sensory information, and taking appropriate actions based on the processed data. For example, the RangerBot AUV (Autonomous Underwater Vehicle) is an excellent illustration of an STA-based robot. By utilising a variety of sensors such as sonar, cameras, and depth sensors, the RangerBot gathers data about its underwater surroundings. Subsequently, its onboard processing system analyzes this sensory information, allowing the AUV to make decisions based on predefined rules or algorithms. Consequently, the RangerBot can effectively carry out tasks such as reef monitoring and marine biosecurity (RangerBot - QUT Centre for Robotics, 2020).

In the realm of control theory, the Proportional, Integral, and Derivative (PID) control framework plays an exceptional role in achieving effective control in many robotic systems (Sluka, 2013). PID control involves calculating an appropriate control signal using three control components: proportional, integral, and derivative. The proportional component considers the current error between the desired and actual states, the integral component accumulates past errors to reduce steady-state errors, and the derivative component considers the rate of change of the error to enhance response and stability. While the Bang-Bang control approach, which involves switching between extreme control values based on a predefined threshold, can be effective in certain cases, it often leads to jerky and unstable movements. To enhance control performance, the Ziegler-Nichols method provides a more sophisticated and optimised version of PID control (Goodwin, 1988). This method involves systematically tuning the PID parameters to achieve desired control behavior. By measuring the system's response to a step input and analysing resulting oscillations, the appropriate proportional, integral, and derivative gains can be determined. The Ziegler-Nichols method enables more precise and stable control, resulting in smoother and more accurate robot movements.

Taking inspiration from real-world robotic systems, the CSIRO's autonomous LHD stands out as an exceptional example of a robot designed for autonomous navigation in challenging environments like tunnels (CSIRO, 2004). Equipped with laser range finders, cameras, and inertial measurement units, this truck utilizes advanced sensor fusion techniques to perceive its surroundings. Real-time processing of the sensor data enables the creation of a 3D map of the tunnel, facilitating obstacle identification and hazard avoidance. Through the application of advanced algorithms, the truck's control system can plan and execute precise trajectories, successfully navigating complex tunnels (Duff et al., 2017).

In the specific context of the line-following robot challenge, the utilisation of the Sense, Think, Act architecture proves highly relevant. By employing sensors to detect the robot's state, implementing logical processing to interpret the sensor data, and generating appropriate actions based on the current state, the line-following robot can effectively navigate its environment. Within the project, my individual role focused on mechatronic design and operational management. As the Scrum Master, I oversaw project coordination, ensured adherence to Agile principles (Atlassian, 2023), facilitated effective communication among team members, organised regular meetings, and managed the project backlog. By actively applying Scrum methodologies, I streamlined the development process and fostered collaboration within the team.

In terms of mechatronic design, my responsibilities encompassed coordinating the integration of electronics, software, and mechanical components. Working closely with the electrical and mechanical engineering teams, I ensured the seamless integration of these subsystems. Additionally, I actively participated in optimising the PID control and motor functionality of the line-following robot. Drawing upon the concepts of PID control theory (Sluka, 2013) and the real-world examples of autonomous systems, I derived and fine-tuned the PID control parameters using the Ziegler-Nichols method (Goodwin, 1988) to achieve desirable control behavior, resulting in smoother and more accurate robot movements.

Furthermore, I took charge of developing user stories, documentation, and facilitating effective team communication. These operational management responsibilities ensured a clear definition of project requirements and a shared understanding of tasks and deliverables within the team. Through collaboration with team members, I made significant contributions to the overall efficiency and productivity of the project.

3. Presented Design and Solution Concept

3.1 Team Solution:

The integration of the components and features in our line-following robot design results in a cohesive and functional system that fulfills all the design specifications and requirements of the challenge in the final demonstration. Throughout development, we took a holistic approach that considered cultural, environmental, and community aspects. Incorporating indigenous perspectives, we aimed to create a robot aligned with cultural values of the land. The sustainable HDF chassis design prioritised stability and agility while minimising environmental impact. Treaded tires were chosen to navigate diverse terrain in the Minjerribah bushland, ensuring traction and adaptability. A rechargeable battery system was implemented to promote sustainability and reduce waste. These design choices reflect our commitment to responsible resource management and minimising environmental impact.

To enable seamless integration of subsystems, we developed a custom main PCB with a layout that maintains compatibility with the original pin layout. In the final demonstration, we utilised the built-in blue LED on the Spark processor as an indicator for curved paths, eliminating the need for an additional LED and reducing costs. This decision also resulted in a more compact board size.

In addition to the main PCB, we incorporated a custom sensor board with ten infrared LEDs. The software on the microcontroller employs a fast-polling loop to read sensor data, discard error values, and calculate the line's position using a PID controller. The markers detected by the sensors are used by a state machine to control the motor speeds. Our team's expertise in PID control, utilising the Ziegler-Nichols method, ensured accurate line position calculation and precise motor speed adjustments. Notably, the PID implementation utilised only the proportional and integral terms, omitting the derivative term.

To enhance marker detection, we implemented a sensor rejection method that ignores simultaneous detections of multiple markers, allowing the robot to continue based on the previously detected marker. This approach improves responsiveness to specific cues or instructions on the track, such as start and finish markers. Moreover, we incorporated an IR sensor to detect the slow zone, demonstrating innovative problem-solving and cost-saving measures. By utilising a state machine logic, the robot adjusts its speed and can maintain an average speed of 100mm/s in the slow zone while coming to a complete stop at the finish line.

Based on our indigenous perspective scoping study, the autonomous monitoring system implementation can be enhanced with additional features and considerations. Incorporating solar panels into the robot's design promotes sustainability and extends operation in remote areas. Traditional designs or art on the chassis celebrate indigenous cultural heritage. Integrating indigenous storytelling elements or languages fosters cultural relevance and identity. Prioritizing user-friendliness and accessibility through adjustable control settings and voice-guided instructions ensures inclusivity. Our robot design and subsystem approaches align with indigenous values, community needs, and the natural environment. The follow-up prototype should integrate traditional designs, storytelling, languages, and explore traditional navigation methods while prioritizing user-friendliness and accessibility. This comprehensive approach celebrates indigenous perspectives and cultural heritage.

In summary, our team's solution successfully integrates the design, components, and features of the line-following robot. The chassis design, the PCB layout, and the optimized P.I.D. control algorithm contribute to a cohesive system that meets the design specifications and requirements of the line-follower robot challenge. Our design choices, including material selection, utilisation of existing components, and implementation of advanced features, are justified by their positive impact on the overall functionality, efficiency, and quality of the line-following robot.

3.2 Individual Subsystem Solution:

As the engineer responsible for the PID derivation and motor control aspects of the line-following robot, I played a significant role in ensuring the functionality and performance of these features. Through iterative testing and close collaboration with the engineering teams, I contributed to the overall development of a functional line-following robot solution.

To meet the design specifications and requirements, I focused on optimising the PID control algorithm to accurately calculate the position of the line and adjust the motor speeds accordingly. I utilised the Ziegler-Nichols method to derive the PID parameters, fine-tuning the proportional and integral terms to achieve precise motor control. Through extensive testing and refinement, I ensured that the robot effectively followed the desired path and responded to changes in the track. This is represented in *figure 1* as the robot crosses the centre of the line, the PID constants adjust according to the position of the robot. This shows that as line is read from the left to the right side of the robot, the proportional and integral terms go from negative to positive to counteract the movement causing the robot and turn left towards the line. In the final demonstration I omitted the derivative component of the PID as no significant rate of change buffer was necessary to be implemented at a low scale.

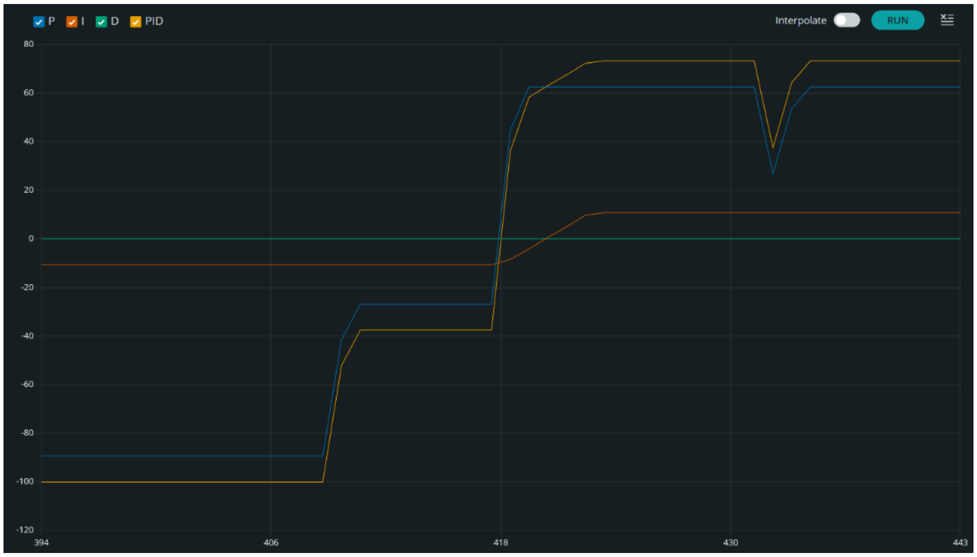

Figure 1: PID serial output

Additionally, I was responsible for implementing marker rejection functionality in our robot. This feature allowed the robot to reject simultaneous detections of multiple markers, particularly at intersections. By incorporating marker rejection logic, the robot could continue its operation based on the previously detected marker, ensuring smooth navigation along the track without any disruptions. As demonstrated in *figure 3*, the robot detects the right marker and then detects both markers simultaneously, suggesting an intersection and just ignoring the input. This problem-solving approach addressed the challenge of accurately following the intended path and demonstrated our ability to adapt to different scenarios encountered during the demonstration.

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Right Marker!
No Marker - Intersection
Right Marker!
No Marker - Intersection
Left Marker!
Left Marker!
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Figure 2: Marker detection serial output

Another crucial aspect of my responsibility was driving the robot in a straight line without relying solely on following the line. To achieve this, I introduced a calibration parameter that allowed us to alter the direction of the robot, ensuring it traveled in a straight line even in the absence of a visible line. This adjustment parameter enabled the robot to maintain its course, enhancing its maneuverability and adaptability to different track conditions.

In summary, my contributions to the PID derivation, motor control, marker rejection, and straight-line driving functionality played a vital role in the development of a functional line-following robot. Through iterative testing, problem-solving, and close collaboration with the engineering teams, I ensured that our robot met the design specifications and competition requirements. My involvement in various subsystems and consideration of the overall system demonstrated a comprehensive understanding of the problem as a whole, resulting in an efficient and effective line-following robot solution

4. System Validation Strategy and Results:

Our team employed a systematic testing and validation strategy to ensure the functionality and performance of our line-following robot system. We began by conducting unit tests on each sub-component to verify their individual functionality. Once the sub-components were validated, we proceeded with an incremental integration approach. We gradually integrated subsystems, conducting integration tests at each stage to ensure compatibility and smooth operation. This step-by-step process allowed us to identify and address any integration issues early on.

Individual sub-components of the software was experimented using the serial monitor to observe and adjust important parameters. This included observing and fine-tuning the PID coefficients, motor PWM (Pulse Width Modulation), and the sensor readings. These values were displayed through the serial monitor to either graph or observe the robot’s response while debugging and implementing the software logic. At a higher level, integrating the code required a series of tests to verify the compatibility and optimise functionality:

- Line-following test: We tested the robot’s ability to follow a predefined path accurately and consistently, integrating the PID coefficients with the motor control. This involved running the robot on different tracks with varying complexity and evaluating its ability to stay on the line. We manually diverted the robot off the line and measured its response to correcting its direction.
- Marker rejection test: We also simulated scenarios with multiple markers and intersections, ensuring that the robot successfully ignored simultaneous detections and continued following the correct path.
- Straight-line driving test: To verify the straight-line driving capability, we assessed the robot’s ability to maintain a straight trajectory without relying solely on following the line. We evaluated its performance in different track conditions and analysed its ability to stay on course.
- State-machine test: We tested the state-machine logic by conducting scenarios of different states such as sensing a stop marker, entering a curve, a straight line, and driving in a slow zone. The response of the robot was recorded using the serial monitor and then by adjusting the speed of the robot and toggling an LED.

The test results played a crucial role in improving our line-following robot system. During the serial monitor tests, we discovered unexpected error values in sensor detection on black surfaces, which were attributed to an overflow error caused by higher voltage than the reference voltage. We corrected this issue to ensure accurate readings. The motor PWM tests demonstrated that the PID value adjustments accurately affected motor performance, leading to the desired results when integrated with the mechanical system. However, we observed that the robot would occasionally mistake side markers for the line on tight corners, causing it to deviate from the track. To address this, we optimized the PID values to reduce swaying and improved manoeuvrability by reducing the robot’s size and centre of gravity.

The marker rejection test confirmed that the robot successfully ignored multiple simultaneous marker detections, ensuring it stayed on the correct path. In the straight-line driving test, we noticed a rightward bias in the robot's movement. We introduced a calibration factor to compensate for this bias and increased stability by using a single ball bearing wheel, improving the robot's ability to maintain a straight trajectory. The state-machine test demonstrated the robot's accurate response to external markers and its ability to determine the path state through the serial monitor.

We conducted electrical component tests using a multimeter and an oscilloscope to assess resistance and current flow. These tests helped identify issues with the custom sensor board, such as overheating caused by small resistors. We made necessary adjustments, replacing the resistors with appropriate values to prevent excessive current flow and ensure proper functioning of the sensor board.

Before implementing the custom PCB designs, we thoroughly analysed and validated the schematics and physical boards to ensure compatibility with the system. This validation process revealed errors in the initial PCB design, which had incorrect pin routing for the Spark processor. We printed two custom PCBs for the final demonstration, with the backup board correcting the initial issue. Although the board intended for the final demonstration had overlaps and was unusable, the backup board passed the validation and was successfully used in the system.

Through comprehensive unit and integration tests, we ensured that our line-following robot system met the specified requirements. Our systematic approach to testing and validation allowed us to identify and address potential issues, ensuring the reliability and effectiveness of our solution.

5. Project Plan and Management Review

5.1 Roles of Each Team Member:

The project was subdivided into four key sections: electronics, software, mechanical, and project management. Each team member was assigned a specific role based on their expertise and skills. This strategy enabled our team to capitalize on each individual’s specialised knowledge for efficient progress in their respective areas. Our approach followed an agile methodology, by breaking the project into a list of features to be implemented over 4 key development stages (discovery, design, development, and optimisation). Each feature was assigned a due date based on a sprint deadline which was structured around these development stages and allocated to a team member. Throughout the project, each team member had specific roles and responsibilities to ensure effective collaboration and progress. The roles assigned to each team member were as follows:

Jordan (Scrum Master and Operations Lead): I took on the role of the Scrum Master, responsible for facilitating the Agile development process. I also coordinated with the software and mechanical teams to ensure seamless integration and functionality. I also led the product testing aspect of the project, overseeing the design, testing, and integration of the motor components.

Dylan (Electronics Specialist): Dylan was responsible for the design and fabrication of the PCB. This involved creating the PCB layout, ensuring compatibility with other components, and coordinating with the electronics and software teams for successful integration. Dylan also collaborated with Jayden and Jasper to review and optimize the PCB design.

Jayden (Mechanical Specialist): Jayden took charge of the mechanical aspects of the project, including the design and upgrades of the chassis. Jayden conducted research, implemented improvements, and ensured the mechanical system aligned with the overall requirements. Jayden also collaborated closely with the electronics and software teams to integrate the mechanical components effectively.

Jasper (Software Specialist): Jasper assumed the role of the software lead, responsible for the development and implementation of the software components. This involved coding the PID control logic, sensor reading algorithms, and motor control functionalities. Jasper collaborated with the electronics and mechanical teams to ensure the seamless integration of software with the hardware components.

5.2 Product Backlog:

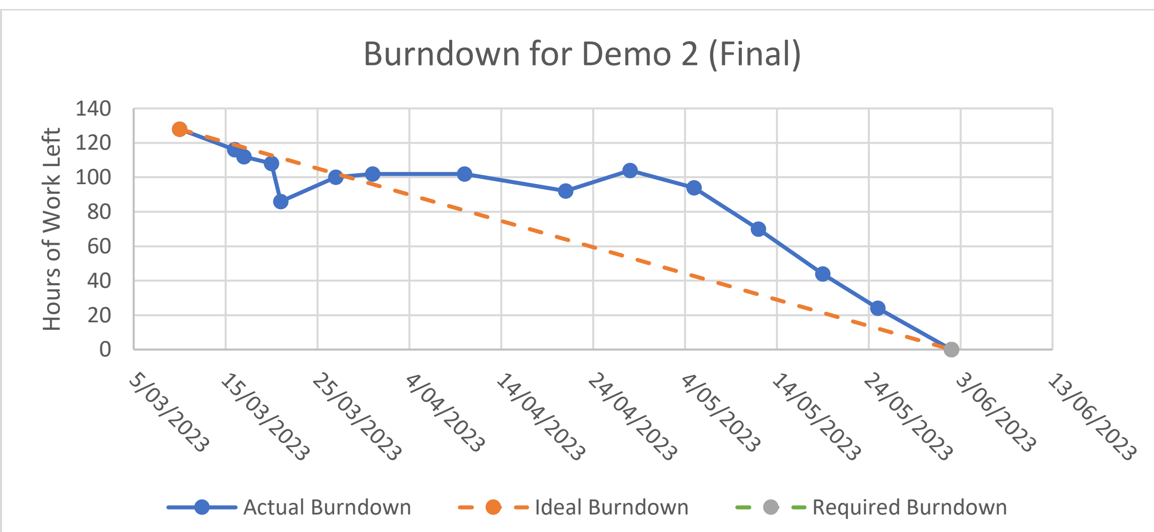
Attached as an appendix is our team’s product backlog, which divides key product sub-systems into individual tasks and allocates responsibilities to team members. The backlog includes detailed descriptions of each task, estimated time requirements, and the team member responsible for its completion. By following the backlog, we were able to prioritize tasks and allocate resources effectively, ensuring steady progress throughout the development process.

Throughout the sprints, the team members collaborated and worked on the allocated features. The backlog tasks were adapted and adjusted as needed based on the progress and feedback received during each stage. The tasks were organised to ensure a systematic development approach and to address the key components and functionalities of the line-following robot system.

The product backlog and its allocation of tasks allowed us to focus on specific areas and make progress in a coordinated manner. It provided a clear roadmap for the development stages, ensuring that each team member had a defined set of responsibilities. As a result, we were able to make significant strides in the design, development, and optimisation of the line-following robot system, leading us to the final stage of making the necessary adjustments before the project deadline.

5.3 Burn-down Chart Analysis:

The project's burndown chart illustrates the completion of the project by the final demonstration. It showcases the ideal burndown vs. the actual burndown as a visual representation of the number of hours remaining to complete the project. Throughout the project the burndown chart was continually updated and assessed to determine the rate of completion at the end of each sprint. As depicted in the burn-down chart, our team found that the original time estimates were reasonably accurate. The team managed to follow the original plan overall, with minor adjustments made to accommodate unforeseen challenges and new requirements that emerged during the development process which caused an increase in the number of hours remaining in the task. As a result, the rate of project completion significantly increased towards the late stages of the project. The burn-down chart allowed us to track our progress, identify any deviations, and make necessary adjustments to ensure that we stayed on track.



5.4 Budget Analysis:

The project budget amounted to $213.80, leaving $6.20 remaining. The product cost accounted for $138.48, leaving $4.52 worth of additional components. Throughout the project, we managed the budget effectively, ensuring that expenses were within the allocated funds. This enabled us to procure the necessary components and materials without exceeding the budgetary constraints.

5.5 Management Practices Review:

Throughout the project, we successfully completed each feature in our product backlog within the designated sprints and development stages, adhering closely to the planned timeline. Our accurate time estimates for each feature allowed us to effectively allocate resources and manage our workload, contributing to the project's progress and milestone achievement.

The team demonstrated strong adherence to the original plan, making minor adjustments and refinements within the scope of expected changes. Effective communication, regular progress monitoring, and a proactive approach to addressing challenges contributed to our ability to follow the plan.

In terms of task allocation, there were instances where certain tasks could have benefited from more allocated time or involvement from other team members. For tasks requiring attention to detail, such as PCB design and fabrication, additional time or multiple reviewers could have improved outcomes. Similarly, distributing software development tasks among team members with diverse programming skills could have increased efficiency and productivity.

Our management practices facilitated collaboration and progress through regular meetings, both formal and informal, promoting open communication and knowledge sharing. The use of the Scrum and Agile framework provided structure and direction to task management. However, task allocation based on individual strengths and skills could have been improved to leverage expertise and enhance execution.

To enhance our management practices, implementing more frequent progress tracking and documentation would have ensured consistent project status updates for all team members. Establishing a formal system for capturing and addressing risks and challenges could have improved our ability to anticipate and mitigate potential issues.

In conclusion, our team's management practices were generally effective in driving the project forward and achieving objectives. Adherence to the original plan, good communication, and collaboration were notable strengths. Opportunities for improvement lie in task allocation based on individual strengths, increased documentation, and a formalized risk management system. By leveraging strengths and implementing these improvements, we could have further enhanced our project management practices and overall outcomes.

6. Conclusion

In conclusion, this report has provided a comprehensive overview of our line-following robot project, highlighting key aspects such as mechatronics design, project management, and teamwork. We have successfully developed a functional robot system that meets the specified requirements, demonstrating our effective collaboration as a team.

Throughout the project, we gained valuable insights into mechatronics design, emphasizing the importance of understanding task requirements and carefully selecting tools and components. Our iterative design approach allowed us to refine the robot's functionality and optimize its performance, resulting in a reliable and efficient system. Accurate time estimation and effective task allocation were vital in ensuring steady progress and timely completion of features.

In terms of project management, adopting the Scrum and Agile framework proved beneficial, providing structure, task prioritization, and fostering communication. Regular meetings and collaboration enabled us to adapt to changes and challenges effectively. However, we acknowledge the need for improved task allocation based on individual skills and formalized risk management practices to anticipate and address potential issues.

Teamwork played a crucial role in our project's success. Clear and open communication, knowledge sharing, and leveraging individual expertise were key factors. By capitalizing on each team member's strengths, we could have further enhanced efficiency and quality in specific areas.

Looking ahead, future work should focus on improving the line-following algorithm to enhance accuracy and response time. Exploring advanced sensing technologies or implementing machine learning algorithms could further enhance the robot's performance and adaptability.

In conclusion, our line-following robot project provided valuable learning experiences in mechatronics design, project management, and teamwork. By reflecting on lessons learned and implementing suggestions for future work, we can continuously improve both our product and our team's capabilities, paving the way for future successful projects.

7. Reflection

Participating in EGB220 has significantly enhanced my understanding of mechatronics design and equipped me with the necessary technical skills for effective engineering teamwork. Throughout the course, I developed competencies in team membership and leadership, gaining valuable insights into effective communication, role allocation, and project management.

Engaging in group discussions and project work, I recognised the importance of clear communication in driving team performance. Interacting with my peers, I honed my active listening skills, effectively expressed my ideas, and embraced diverse viewpoints. Moreover, the course structure emphasised outlining team member expectations from the outset of a project. By clearly defining roles and responsibilities, we established accountability and efficient task allocation. Leveraging each team member's strengths and expertise, we synergised our skills to achieve project objectives effectively. EGB220 also provided opportunities for me to assume leadership roles and responsibilities. Leading diverse engineering teams, encompassing individuals from various levels, disciplines, and cultural backgrounds, allowed me to develop my leadership abilities in an inclusive and challenging environment.

Throughout the course, project management played a crucial role in ensuring successful task execution. I was involved in an agile framework and practiced developing project plans, setting clear objectives, and establishing realistic timelines. Skillfully managing tasks, monitoring progress, and proactively addressing obstacles, I gained invaluable experience in project coordination and delivery.

In conclusion, EGB220 provided me with a comprehensive understanding of mechatronics design and equipped me with the skills essential for effective team membership and leadership. Through effective communication, role allocation, and project management strategies, I can contribute positively to team dynamics and achieve successful outcomes. The course’s collaborative projects and practical experiences have shaped my learning journey, allowing me to apply these competencies in real-world scenarios. I am confident that the knowledge and skills acquired through EGB220 will continue to benefit me as I progress in my engineering career.

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Appendix

Figure 3 Product Backlog