A Report On

Office ROS Enabled Assistance Robot (OTIS)

By

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Mentored by:

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Prepared in the partial fulfillment of the
Practice School II Course

AT

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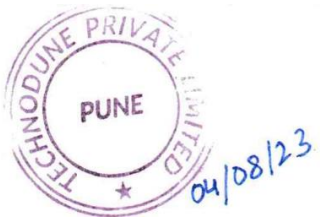
A Practice School II Station of

SCHOOL OF ENGINEERING AND TECHNOLOGY
BML MUNJAL UNIVERSITY, GURGAON
(August, 2023)

Certificate of authenticity

CERTIFICATE

This is to certify that Practice School Project of **GODAVARTHI SAI NIKHIL** titled **Office ROS Enabled Assistance Robot (OTIS)** to the best of my knowledge is a record of bonafide work carried out by him under my guidance and/or supervision. The contents embodied in this report, to the best of my knowledge, have not been submitted anywhere else in any form for the award of any other degree or diploma. Indebtedness to other works/publications has been duly acknowledged at relevant places. The project work was carried during **01-06-2023** to **28-07-2023** in **Technodune Private Limited.**

	
Signature of PS-II Faculty Advisor	**Signature of industry Mentor**
Name: Dr. Pradeep Kumar Arya	**Name:** Mr. Parth Sharma
Designation: Associate Professor	**Designation:** Co-Founder
Date	 **(Seal of the organization with Date)**

BML MUNJAL UNIVERSITY PRACTICE SCHOOL – II

JOINING REPORT

Date: 01th June 2023

Name of the Student	GODAVARTHI SAI NIKHIL
Name and Address of the Practice School – II Station	Technodune Pvt. Ltd. Address: SR.NO.74, LIFE REPUBLIC UNIT NO R2/TB/44 MARUNJI, Pune MH 411057 IN
Date of Joining PS-II station as per offer letter	01 June 2023
Actual date of reporting to PS-II station	I was informed by CDGC that offline mode is not required due to the impending investor visit to the organization.
Department Allocated	Software Developer
Name and Designation of the Industry Guide/ IndustryMentor for the Project	Mr. Parth Sharma Co-founder
Industry Mentor Contact No.	7891033994 (Parth Sharma)
Industry Mentor E-mail Address	parth@technodune.com

Acknowledgements

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My sincere gratitude to my industry mentor at Technodune, Mr. Parth Sharma for giving me valuable inputs and different types of ideas from the beginning of the project to its successful completion and the opportunity to undertake this internship. I am grateful for the guidance and support provided by my mentor from the industry and from the University. My heartfelt thanks go to:

i. Dr. Maneek Kumar – Dean of SOET

ii. Dr. Kiran Khatter- Asst.Dean

iii. Dr. Pradeep Kumar Arya - Faculty Mentor

iv. Mr. Parth Sharma – Co-founder of Technodune and Industry Mentor

Abstract

This report is on the project Office ROS Enabled Assistance Robot (OTIS) which I worked on during the two months of internship. The report discusses the systematic development and execution of the OTIS project, with a particular focus on the effective utilization of the Robot Operating System (ROS) and simulation tools. The project's roadmap addresses various phases, from establishing software prerequisites and intermediate knowledge of ROS to integrating advanced functionalities including vision, navigation, and obstacle avoidance. The project results in the development of an autonomous robot that is capable of effectively passing through work environments and avoiding obstacles through iterative procedures and intensive hands-on experience. This report provides significant insights such as the seamless integration of sensors, simulation through the Gazebo, skillful utilization of ROS controllers, and the innovative incorporation of Navigation and SLAM algorithms. This report is about the project on how the simulation of the robot approach works efficiently when it is integrated with the ROS framework.

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1. Introduction

A brief introduction to the organization’s business sector: Robotics, IoT, Drones

Some industries are the primary sources of innovation and transformation in the modern world of technological developments. The unity of robotics, IoT, and drones is one such area that has become a pillar of development in advanced technologies. This dynamic area includes a wide range of possibilities that are reshaping industries and the operation of business in the modern era.

1. **Robotics:**

   Nowadays, robotics combines technologies to develop intelligent, autonomous machines that can perform tasks that were formerly thought too risky or difficult for people. In various industries, including manufacturing and healthcare, robotics is advancing efficiency, accuracy, and scalability. Robotic solutions are being adopted by industries at an increasing rate, transforming processes and boosting productivity for anything from production line automation to surgical operations.

2. **IoT (Internet of Things):**

   The world around us has been completely taken over by the Internet of Things, which utilizes the Internet's ability to connect objects, systems, and environments. This sector can completely change how organizations operate by enabling seamless communication, data exchange, and control. IoT is changing many industries in India, including healthcare, urban planning, and agriculture. Resource management is being improved, energy usage is being optimized, and informed decision-making is being made possible through the integration of smart devices and sensors.

3. **Drones:**

   Across India, drones are quite helpful in many kinds of industries. Drones provide unique vantage points for data collecting, analysis, and action in various fields, including surveillance and agriculture. Drones have revolutionized crop monitoring, pest control, and yield estimation in agriculture. To support the development and resilience of the nation, they are also playing crucial roles in disaster management, environmental monitoring, and infrastructure inspection.

2. Overview of the organization

Official website link of the company: http://technodune.com/

Technodune is a major company within the IT Services and IT Consulting sector, which is standing as an industry expert in IoT solutions and technology services in the world of connected devices and advanced technologies. Technodune has positioned itself as an inspiration for innovation in the rapidly evolving world.
Technodune has been bringing changes by creating something that goes beyond excellency to inspire the young generations. As a result, Technodune is now positioned inside the market, where it uses technology to make people's life simpler and speed up the development of talent and skills.

2.1 Brief History:

Technodune was established in 2021 to fulfill basic and common needs through technological innovation. Technodune has been acknowledged for its outstanding solutions to problems in both the industrial and commercial environment, so it became popular by simplifying people's daily life.

The company's primary objective is on providing useful IoT, robotics, and drone solutions to companies and individuals.

2.2 Business Size:

Technodune is currently a 100% founder-owned company with a dedicated group of experts aiming for significant improvements. Due to the company's growth trajectory, a diverse team of 10–15 individuals has been hired, and they all contribute to the company's commitment to innovation and excellence.

2.3 Product Lines and Services:

The IoT, robotics, and drone industries are all being revolutionized by Technodune's wide selection of goods and services. Their product lines cover a wide range of products and services, such as

IoT solutions: Intelligent, networked equipment that offers real-time data insights to improve operations and decision-making.

Robotics: Highly developed robotic systems intended to increase efficiency, effectiveness, and precision in a variety of industries.

Drones: Modern drone technology for data collection, aerial surveillance, and other industrial uses.

2.4 Competitors:

Technodune competes against well-known companies like Corporate Serve Solutions Private Limited and Prakash Reflective Devices Private Limited in the IoT, robotics, and drone technology markets. The company works hard to set itself apart through innovation, dependability, and customer-centric solutions.

2.5 Brief Summary of Departments:

Technodune operates through various departments, each contributing greatly to the success of the company:

i. **Research and Development:**

   This department is at the vanguard of innovation, always researching innovative ideas and technology to create revolutionary products.

ii. **Engineering and Design:**

   Collaboratively, designers and engineers provide strong and effective solutions for clients.

iii. **Sales and Marketing:**

   This department aims to expand knowledge of Technodune's products and services while establishing trustworthy relationships with customers and partners.

iv. **Customer Support:**

   This department is devoted to ensuring customer happiness and gives post-purchase support, technical help, and problem-solving.

v. **Operations and Manufacturing:**

   This department is responsible for logistics and production, making sure that high-quality items are delivered on time.

vi. **Finance and Administration:**

   This department supports the business's overall operations by managing the financial and administrative aspects.

Technodune's development from its starting point to its current position as a technology company focused on IoT, robots, and drones shows its commitment to innovation, empowerment, and beneficial change. The company's dedication to its fundamental principles, various product offerings, and collaborative divisions have helped it establish itself as a well-known name in the world of technology.
The key elements that they adhere to optimize their challenges for growth and potential are as follows:

- Prioritizing Talent management
- Sustainability
- Life Style Enhancement

3. Plan of my internship program

3.1 Introduction of the branch/department of internship

I joined Technodune as a software developer intern under the supervision and guidance of Mr. Parth Sharma who is one of Technodune's co-founders. The internship duration is of two months. During those two months, I have practically experienced and gained knowledge on how a software company works in day-to-day life.

As a software developer intern, the role is to create software using many types of programming languages like HTML, CSS, JavaScript, PHP, and many more and using the required type of frameworks like ROS, RViz, and tools and maintain it thoroughly so that the software gives good friendly experience to all.

3.2 Start and end dates of my internship

The internship lasted a duration of two months, started on June 1st, 2023, and ended on July 28th, 2023 with working hours starting from 9 AM until evening 5:30 PM from Monday to Friday in the online mode with regular online meetings with my mentor.

3.3 Duties and responsibilities performed

The software development team under the guidance of Mr. Parth Sharma worked on different types of projects related to software development. The projects were:

1. Designing and developing Technodune's Official website where the company can showcase its products and services to the customers and real-time alerts on the products displayed on the product's page. It has 2 tasks one is to create a user-friendly design and another is to develop it with easy navigation. This work was until 5th June 2023.
2. Later, on 6th June 2023, started working on a new project known as OTIS (Office ROS Enabled Assistance Robot), started setting up Ubuntu and learning about the ROS and its various functionalities with the key learning and designed a robot and a user-friendly interface to operate the robot so that it can be navigated in the office environment to accomplish its tasks while avoiding the obstacles in the office environment. completed on 3rd July 2023 under the guidance of my mentor.
3. From 4th July 2023, started working on a new project called the "ElecTrak" website. A website where the Company can monitor the usage of industrial energy environment. The first task is to finalize a good-looking and user-friendly dashboard template later for 1 week learned about the technologies needed and started working on the front-end part of the website and later the backend part. The project was a success and demonstrated to the mentor and completed the project and the internship at the same time.

4. Background and description of the problem

4.1 Background:

Robotics has continuously pushed the limits of innovation in technology with its goal of developing autonomous systems that can move around and perform basic tasks without the aid of humans. You need to go no further than the Office ROS Enabled Assistance Robot (OTIS) project to see examples of these efforts as it addresses a key issue in robotics how to create a robot that can navigate in challenging environments while avoiding obstacles.

By automating jobs and enhancing human capabilities, robotic devices have transformed many kinds of industries. The capacity to move around independently, however, is still a big challenge. The seamless operation of robots is frequently hindered by the failure of conventional path planning and obstacle avoidance techniques to consider the complex dynamics of real-world situations.

4.2 Description of the problem:

The main of this project is to design and develop a robot that can navigate through many complex office scenarios by avoiding obstacles. The problem covers a wide range of complexity, including the necessity for real-time mobility, dynamic obstacles, and different environments. The increasing demand for robots that can collaborate with people in shared workspaces shows the significance of resolving this problem. Safe and effective navigation is essential for both operational productivity and for creating a positive interaction between humans and robots. The OTIS project investigates multiple approaches to tackle this problem, incorporating cutting-edge algorithms, sensors, and advanced decision-making procedures. The project aims to establish the foundation for a new generation of robotic helpers that can function successfully in real-world circumstances by developing a robot capable of analyzing its environment, planning optimal paths, and dynamically avoiding obstacles. The project aims to create new opportunities for robots by converting them into valuable assets across industries and applications by successfully resolving the obstacle avoidance and navigation challenge.

5. Main Text

I took part in an immersive learning experience that focused on the Office ROS Enabled Assistance Robot (OTIS) project from June 5, 2023, to June 30, 2023, while I was a student intern at Technodune. The assumptions, experimental work, data collecting, surveys, algorithms, activities, and outcomes that were completed during this internship are all summarized in this report.

5.1 Assumptions made:

Some of the assumptions made are:

1. The simulation environment for the virtual robot can accurately reflect real-world interactions.
2. The sensors used in Virtual robot, such as the camera, lidars, map, and navigation sensors operate with a high degree of reliability.
3. The performance of the physical robot can be predicted through the behaviors and responses of the virtual robot in the simulation.
4. The virtual robot maintains constant contact and communication with other virtual systems in the simulation.
5. The algorithm used in the virtual robot for task optimization and decision-making can be adjusted to handle real-world problems.

5.2 Experimental work/ Data collection:

5.2.1 Experimental work:

The internship program was structured around the opportunity to work with the Robot Operating System (ROS), the Gazebo simulator, and related technologies. As part of the experimental work, Ubuntu and ROS were installed as requirements. I then started the process of utilizing Gazebo to build a working robot simulation. To improve the robot's perceptive abilities, this required integrating other parts including a camera sensor and a LiDAR sensor.

5.2.2 Data Collection:

Gathering the map around the robot using various virtual sensors such as camera, lidar, nav2, etc. As shown in Figure 5.2.1 the robot starts moving and collecting data around its surrounding environment in the form of a map.

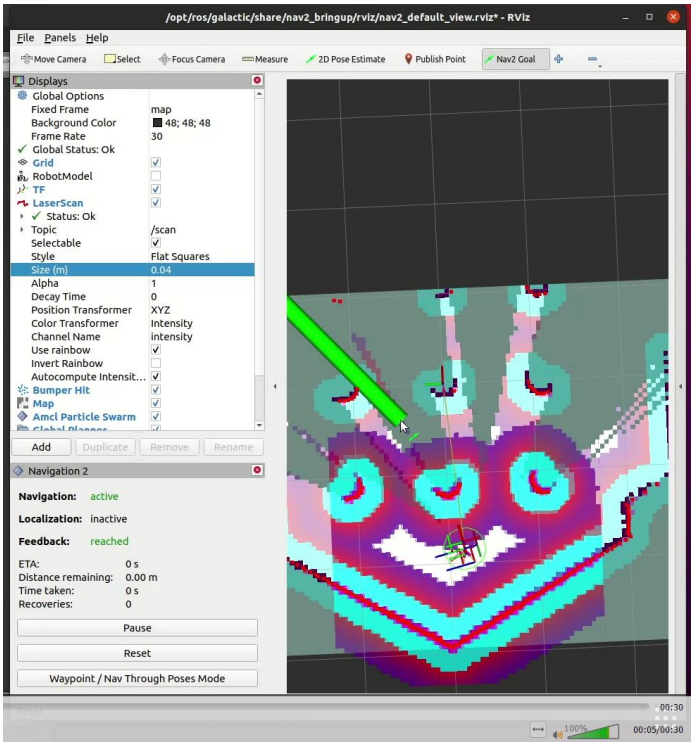


Figure 5.2.1: Robot Collecting the data.

5.3 Survey:

The basic concepts of ROS and simulation methods were researched, which helped me to provide a clear understanding of the project's scope. The comparison of platforms such as Gazebo, RViz2, and Foxglove included factors such as precision, sensor integration, and simulation capabilities.

5.4 Description of Activities and Programs Outlined:

The tasks performed as part of the internship program included everything from setting up and configuring the software to developing and enhancing a Gazebo-based virtual robot. I improved robot movement with ROS controllers, integrated SLAM for accurate mapping and localization, and put navigation algorithms into practice for autonomous path planning. The construction of a strong and effective robot was made possible by each of these steps. The following list includes the project's specifics:

1. **ROS Setup:**

   The project started with the setup and configuration of the Robot Operating System (ROS) in Ubuntu. ROS [1] provided the framework for developing and integrating the robot's capabilities.

2. **Robot Body Configuration:**

   After the installation of the ROS framework, the robot design process started with the xacro file “robot_core.xacro”.

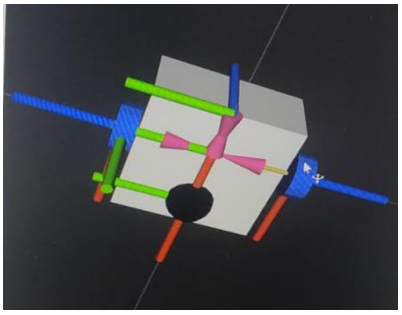


Figure 5.4.1: Body of the Robot

This step included attaching the robot as shown in above Figure-5.4.1 to the chassis and inserting left and right wheels and other essential parts required for mobility.

3. **RViz:**

The RViz2 visualization tool was carefully configured to provide a visual representation of the robot's actions and interactions with the environment around it.

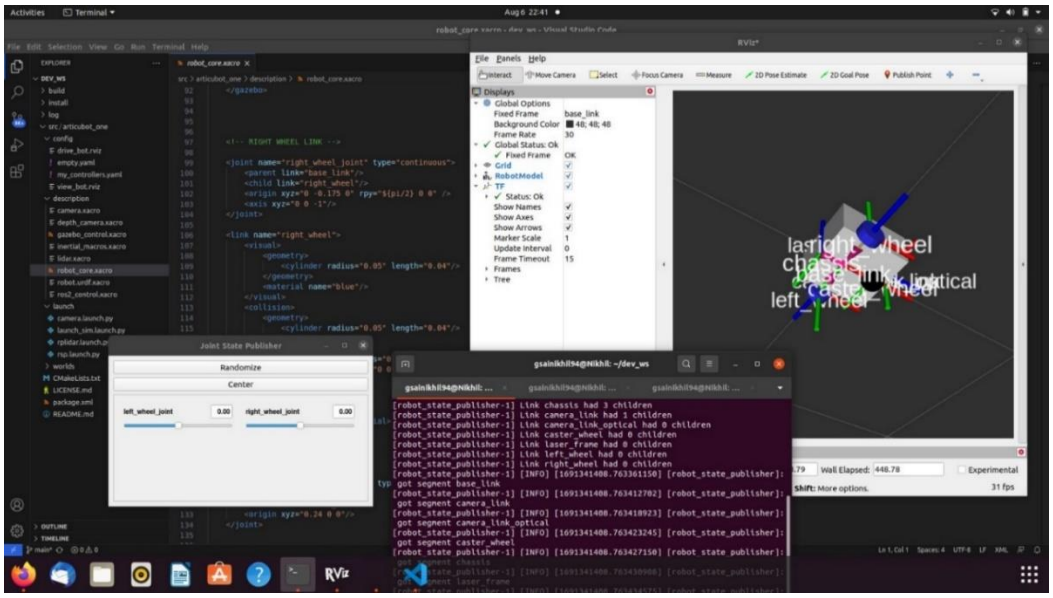


Figure 5.4.2: Spanning the robot in the RViz.

Figure 5.4.2 shows that the robot was spanned in the RViz and with the help of this we can do real-time monitoring and evaluation of the robot's movements.

4. **Gazebo Simulation:**

Gazebo, an advanced simulation platform, was created to simulate the robot's behavior in a virtual environment. To resemble real-world scenarios, the robot's model was designed and simulated in Gazebo. Firstly, I designed an environment to test the robot’s viscosity and later I designed another environment that is like the office because I do not have a current office map.

5. **Integration of RViz2 and Gazebo:**

RViz2 and Gazebo were integrated to ensure that the robot's activity was visualized in both simulation environments at the same time. This simultaneous visualization was necessary for precise measurement and analysis.

6. **Teleop Twist Keyboard:**

Using the Teleop Twist Keyboard package, manual control was enabled. This allowed for hands-on experimentation and robot moving in the Gazebo and RViz2 simulation areas.

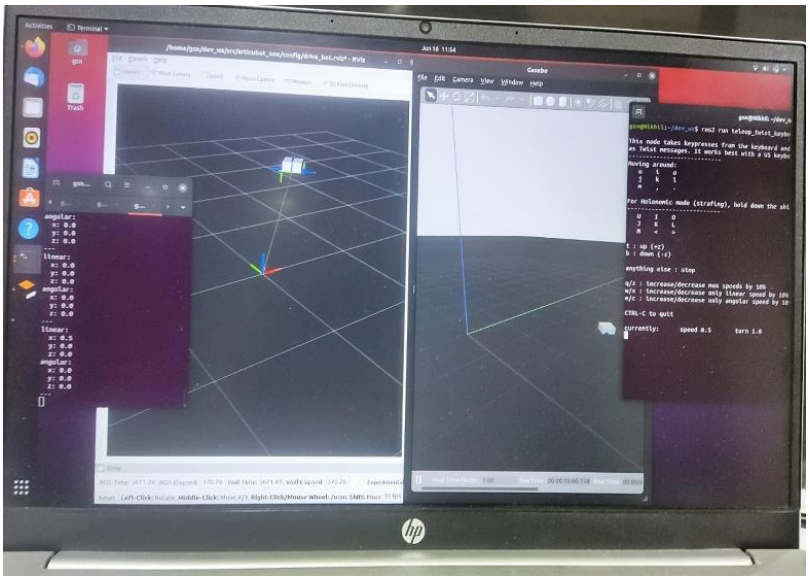


Figure 5.4.3: Moving the robot using Teleop Twist Keyboard.

Figure-5.4.3 shows the robot moving simultaneously in Gazebo and RViz by using Teleop Twist Keyboard.

7. **LIDAR Sensor Integration:**

As shown in Figure-5.4.4 the integration of LIDAR sensors improved the robot's ability to see its surroundings and detect obstacles. These sensors were essential to the robot's obstacle-avoidance measures.

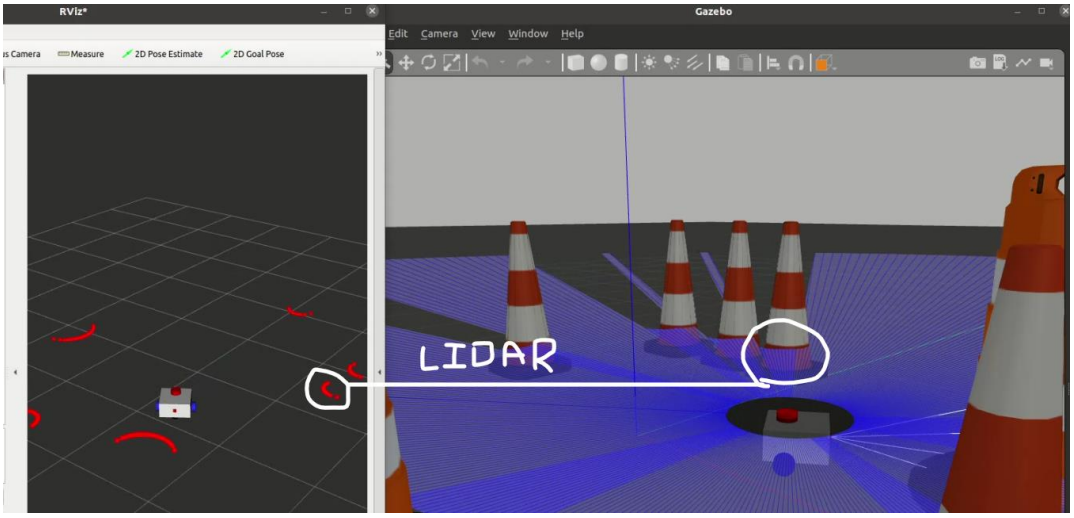


Figure 5.4.4: Visualization of LIDAR.

8. **Camera Sensor Integration:**

The integration of a camera improved the robot's perceptive abilities by supplying visual data about its surroundings. This visual input enhanced the sensor suite of the robot.

9. ROS Controller:

The ROS controller was properly integrated to ensure that RViz2 and Gazebo communicated effectively. This coordination provided that the behavior was consistent throughout both simulated environments.

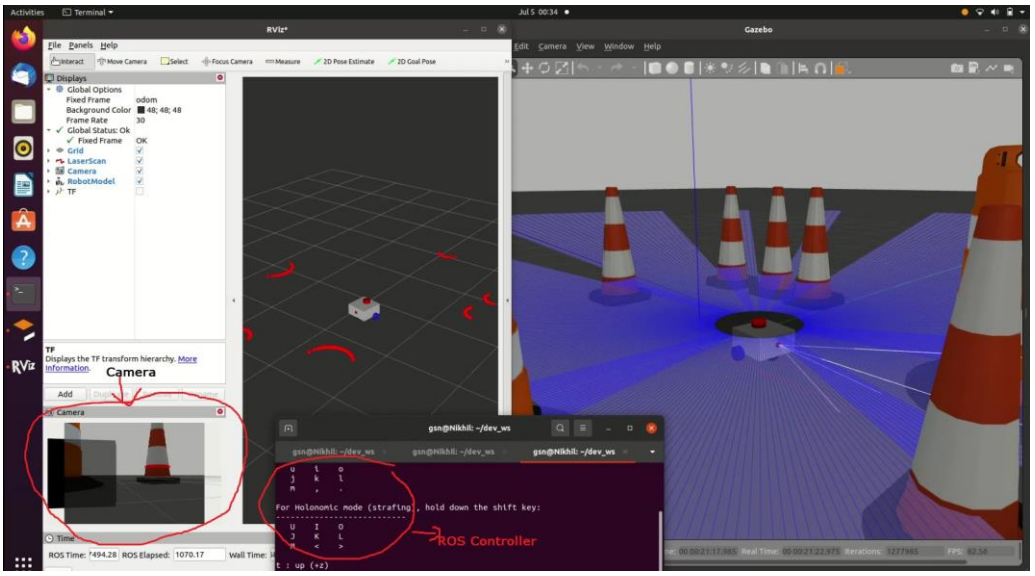


Figure 5.4.5: Integration of the ROS controller.

10. Map generation and the Navigation and SLAM:

During the project's second phase, the focus was on obstacle avoidance and path planning. This required an in-depth analysis of mapping, navigation techniques [2], and the usage of the Simultaneous Localization and Mapping (SLAM) toolkit. SLAM was used to methodically create a map, which will serve as a key guide for educated navigation decisions. The robot's navigation capabilities were increased using SLAM [3], allowing independent localization within the map and proficiently mapping obstacle-free pathways in the environment. With the help of the slam toolbox, the generated map was saved.

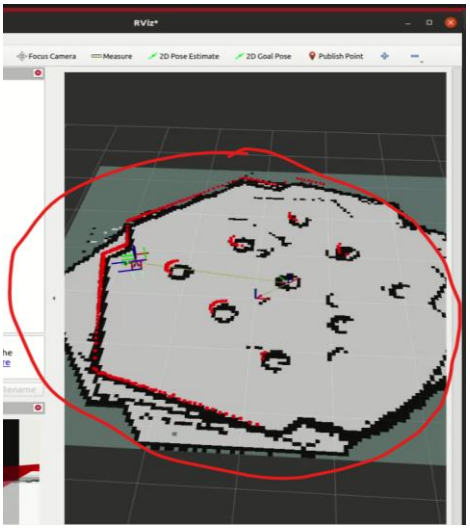


Figure 5.4.6: Generating map using Slam toolbox.

5.5 Results Obtained:

OTIS, a functional virtual robot with advanced detection and navigation capabilities, is the result of the internship work. Through camera and LiDAR sensors, the robot could effectively sense its environment, develop precise maps, localize itself, and independently plan and execute courses to desired destinations while avoiding obstacles. This has been demonstrated through effective Gazebo simulations and Rviz visualizations. Figure-5.5.1 shows that the robot is successfully moving with the help of the ROS controller. Figure-5.5.2 shows the robot moving around while avoiding obstacles.

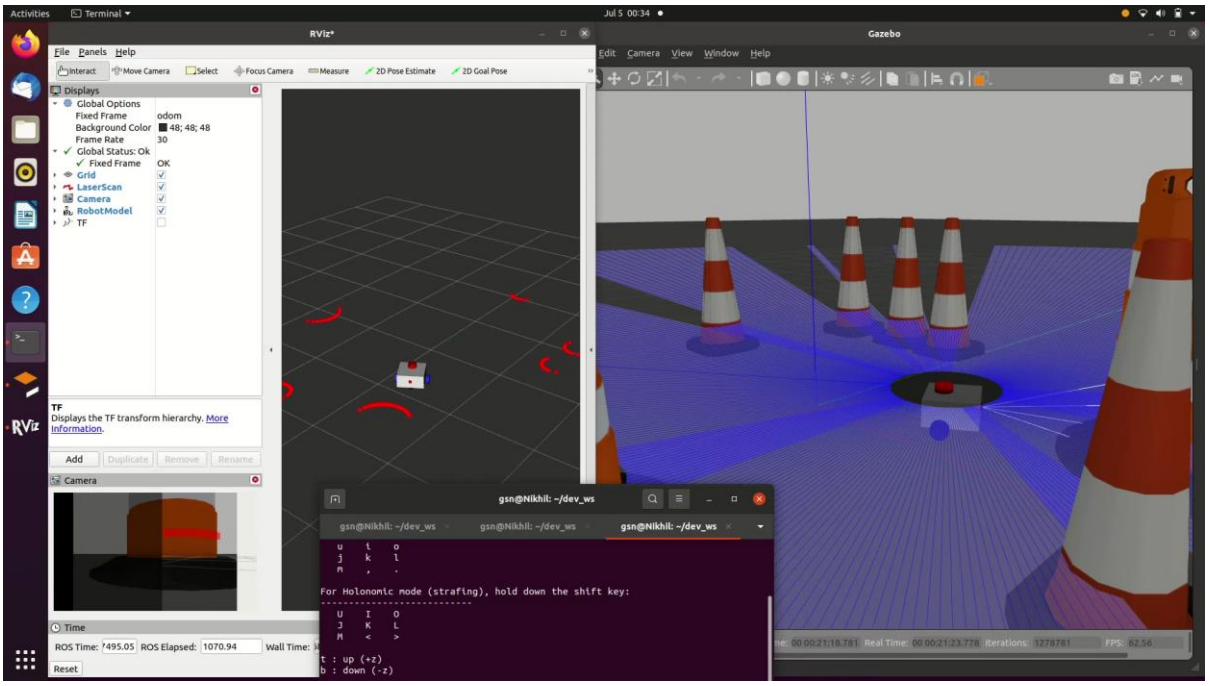


Figure 5.5.1: Moving the robot using the ROS controller.

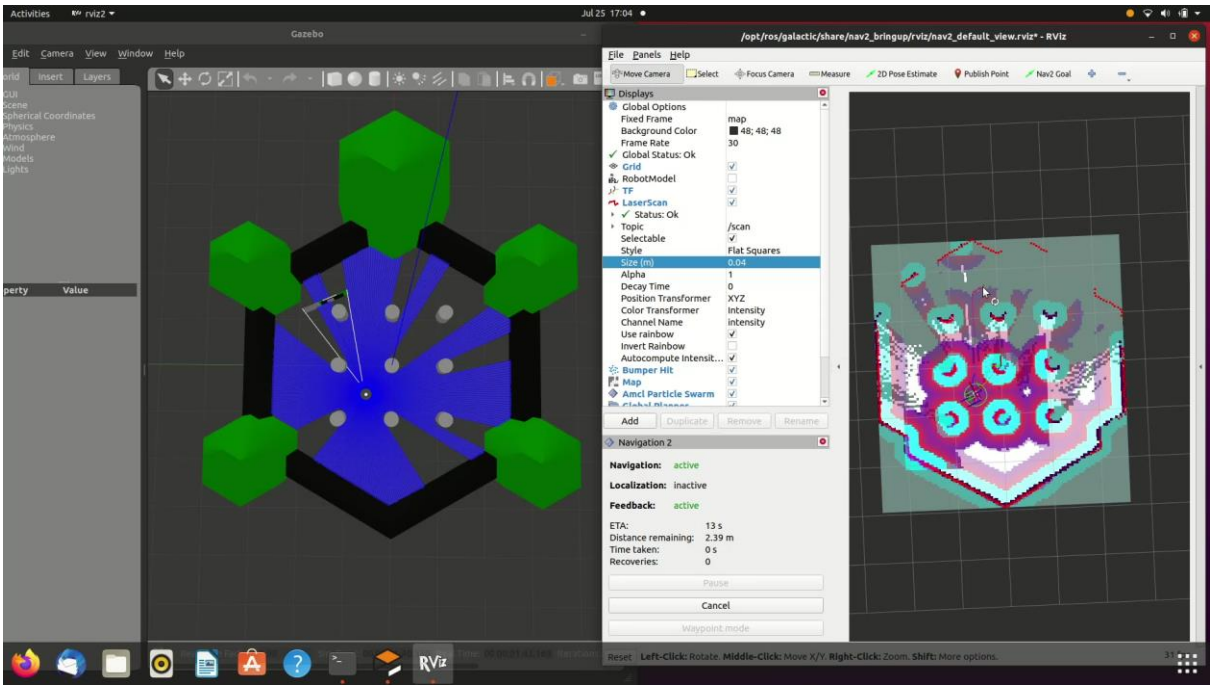


Figure 5.5.2: Moving the robot using Nav2 Goal.

6. Outcomes:

The internship achieved many key results that illustrate the project's progress and achievements:

- Successful installation and configuration of Ubuntu with ROS.
- In Gazebo, a functional robot simulation with camera and LiDAR sensors is built.
- Integration of ROS controllers for precise robot movement.
- Implementation of SLAM techniques for accurate mapping and localization.
- Development of autonomous navigation capabilities using the ROS Navigation stack and path planning algorithms.
- Thorough testing of the robot's perception and navigation capabilities.
- OTIS, an advanced robot capable of moving to specified destinations while avoiding obstacles, was developed.

7. Conclusions and Recommendations

7.1 Conclusion:

1. From June 1st, 2023 to July 28th, 2023, the internship experience provided a comprehensive platform for both technical and soft skill development, considerably enhancing my understanding of robotics and adding to my personal growth.
2. The robot was successfully implemented with an effective design and simulation to navigate through complex surroundings while avoiding obstacles.
3. Mastered the fundamentals, communication, and tools of the Robot Operating System.
4. Cameras and LiDAR sensors have been integrated into the framework of the robot.
5. Gazebo was utilized to efficiently illustrate robot actions and environments.
6. Path planning, SLAM, and mapping skills were acquired, and autonomous navigation was used.
7. Improved communication through interactions with mentors and fellow mates.
8. Improved time management skills.
9. Developed problem-solving and adaptability through overcoming issues.

7.2 Recommendations:

1. To improve the robot’s decision-making abilities, further research should be done on machine learning techniques.
2. In the future we can develop a front-end design where we can operate the physical robot with more effectiveness.
3. To improve the robot’s efficiency, we need to examine its viscosity.

8. Additional Projects:

8.1 Technodune Official Website:

Objective: Improve and optimize the company's official website for better user experience and functionality.

Task Performed:

- Design and Development were done using HTML and CSS, I implemented the highlighted usability concerns and improved the website's user interface (UI). Optimized the layout, navigation, and visually pleasing features of the website to increase user experience (UX).
- The website's responsive design is completely responsive and adjusts easily to different devices and screen sizes. Implemented it using CSS media queries and flexible layouts.

Tech Stack Used – HTML, CSS, and JavaScript.

Results:

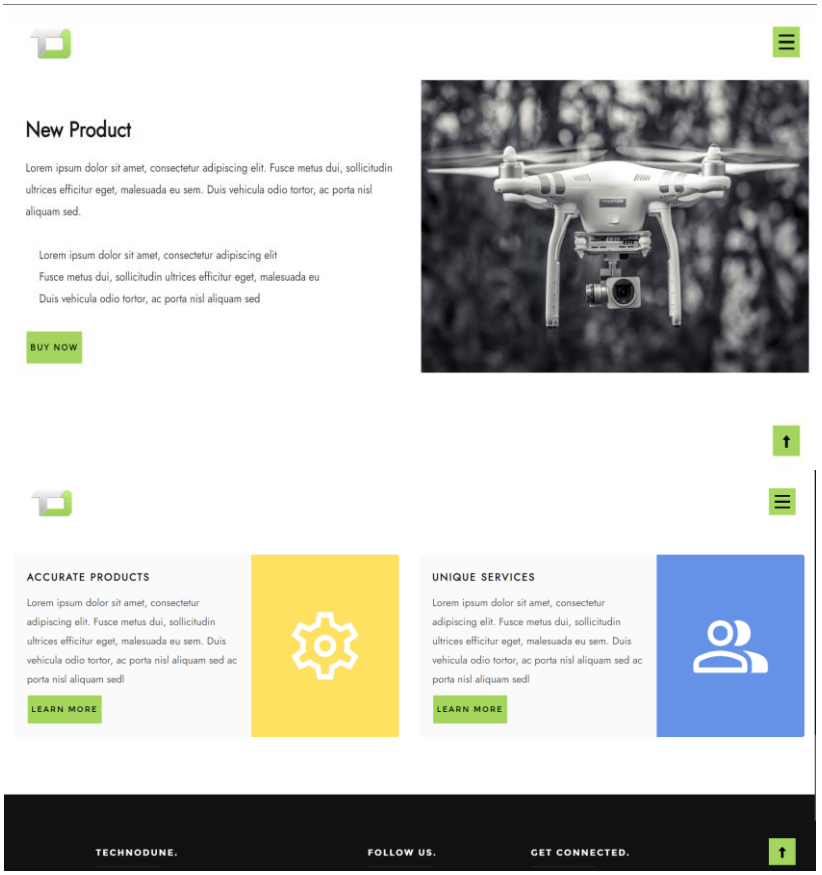


Figure 8.1.1: Technodune's Product Page

8.2 ElecTrak:

Objective: Energy Management Solution for managing and monitoring energy usage in an industrial environment.

Task Performed:

- **User Interface Enhancement:** Developed a drop-down menu that allows users to select a specific department within a particular floor under a specific block. Designed and developed the cards and focused on making the page responsive to ensure it looks good on various devices.
- **Backend integration:** phpMyAdmin was used to integrate the login page. Implemented the integration of the buttons with the associated graphs, which display the line graph of the department's energy usage over the period chosen by the users. In addition, the pie chart was implemented with the backend. And I made sure that the entire page is responsive.

Tech Stack Used – HTML, CSS, JavaScript, MySQL, and PHP.

Results:

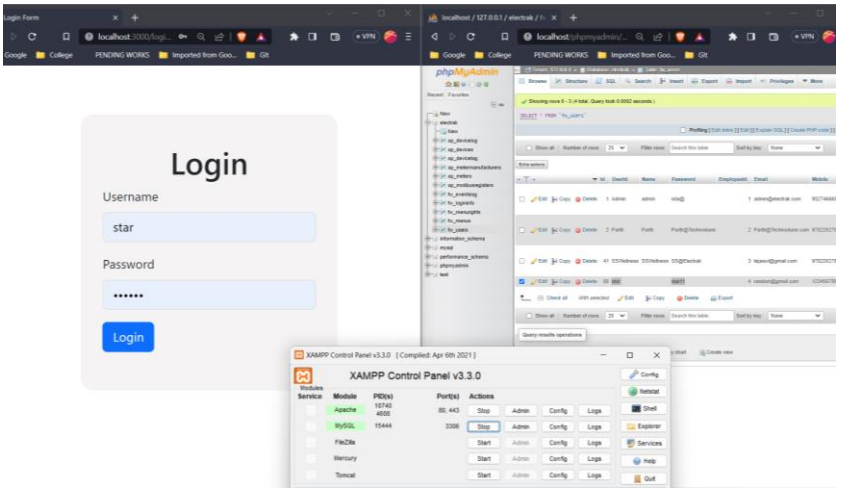


Figure 8.2.1: Before Login

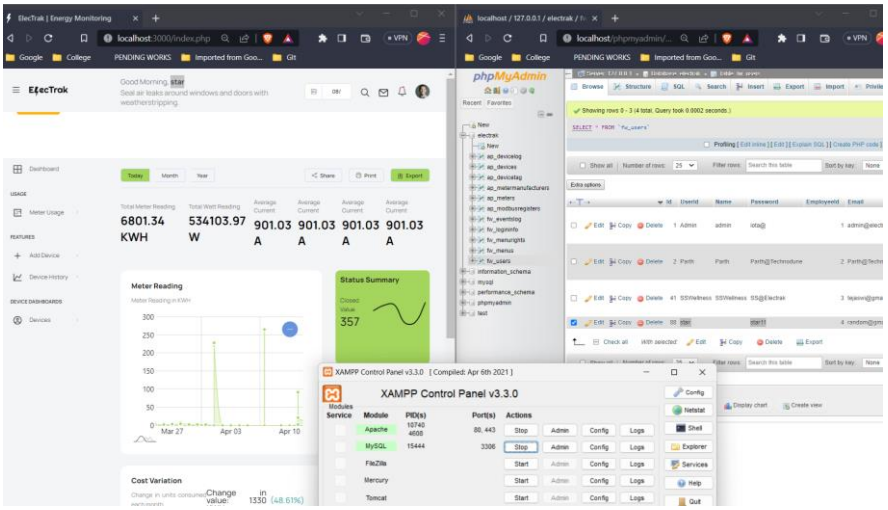


Figure 8.2.2: After Login

Figure-8.2.1 and Figure-8.2.2 show that the login was successful by using the data from the PHP.

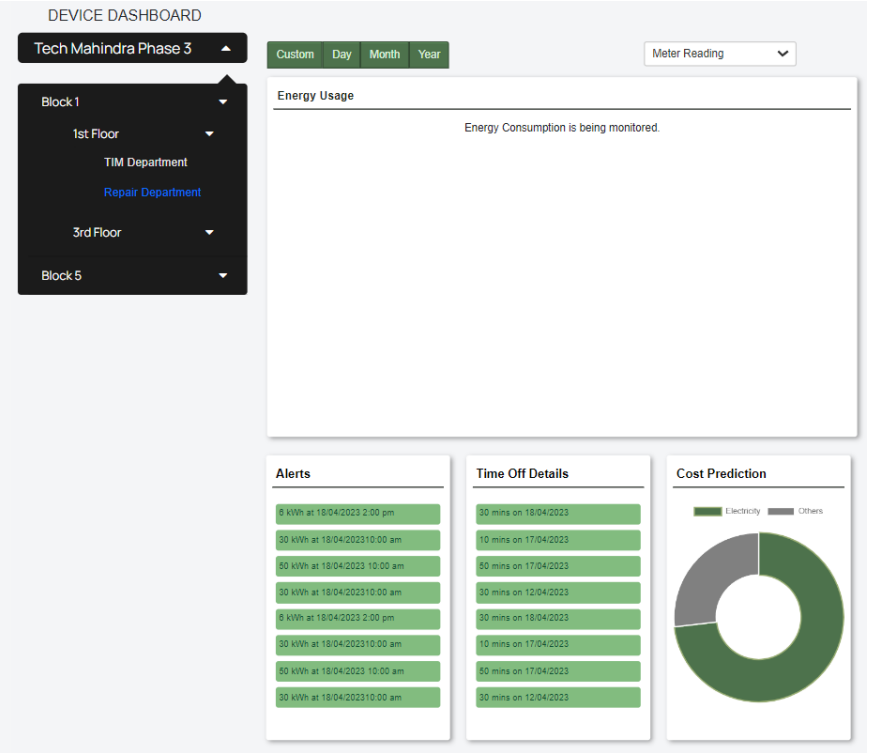


Figure 8.2.3: Device History with Frontend

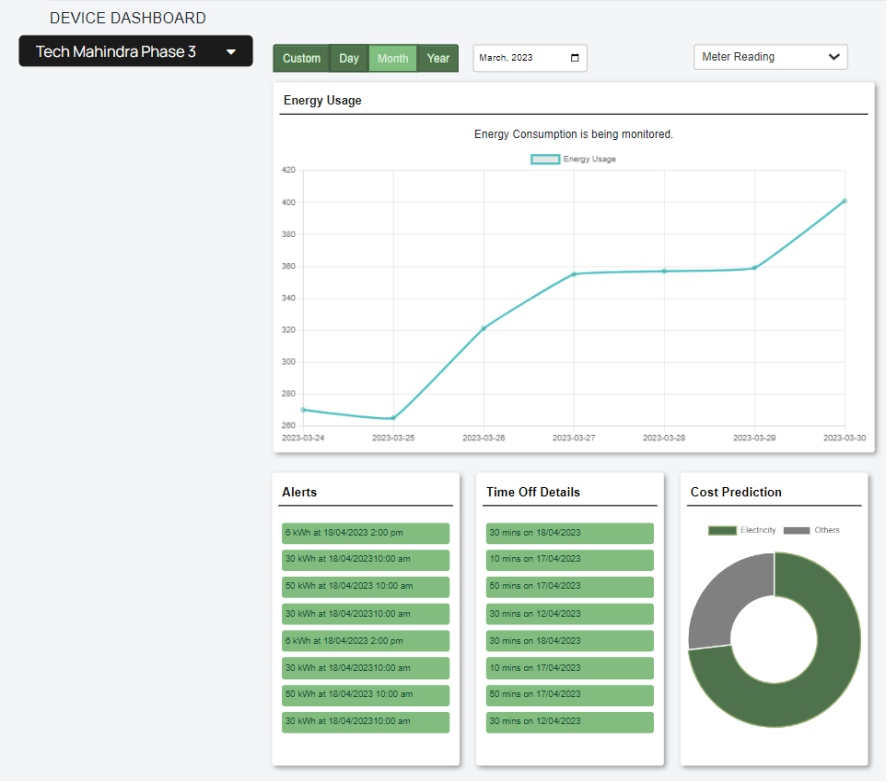


Figure 8.2.4: Device History Page after adding Backend:

9. References:

The following sources were used as research:

[1] Open Robotics, "ROS org," 2021. [Online]. Available: https://www.ros.org/blog/why-ros/.

[2] FabriceLarribe, "ROS org," 14 September 2020. [Online]. Available: http://wiki.ros.org/navigation.

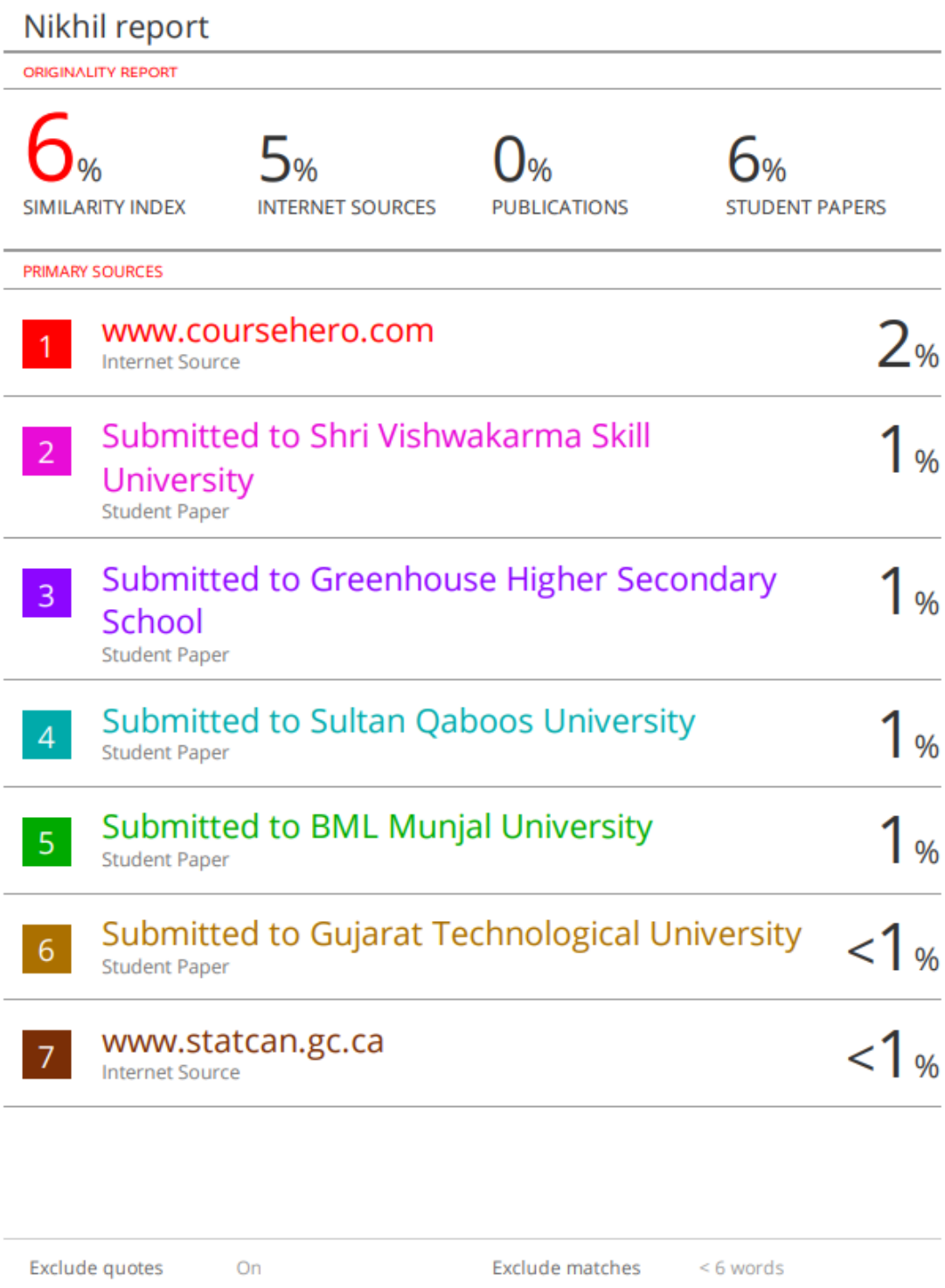
[3] J. I. Steve Macenski, "ROS.org," 16 December 2021. [Online]. Available: https://wiki.ros.org/slam_toolbox.

[4] T. F. B. G. C. L. W. W. Macenski, "Robot Operating System 2: Design, architecture, and uses in the wild," 7 May 2022. [Online]. Available: https://docs.ros.org/en/galactic/Installation/Ubuntu-Install-Debians.html.

[5] M. Delisle, "phpMyAdmin," 2001. [Online]. Available: https://docs.phpmyadmin.net/en/latest/.

[6] jennifer, "rkimball," [Online]. Available: https://www.rkimball.com/how-to-connect-html-to-phpmyadmin-database/.

10. Plagiarism Report:



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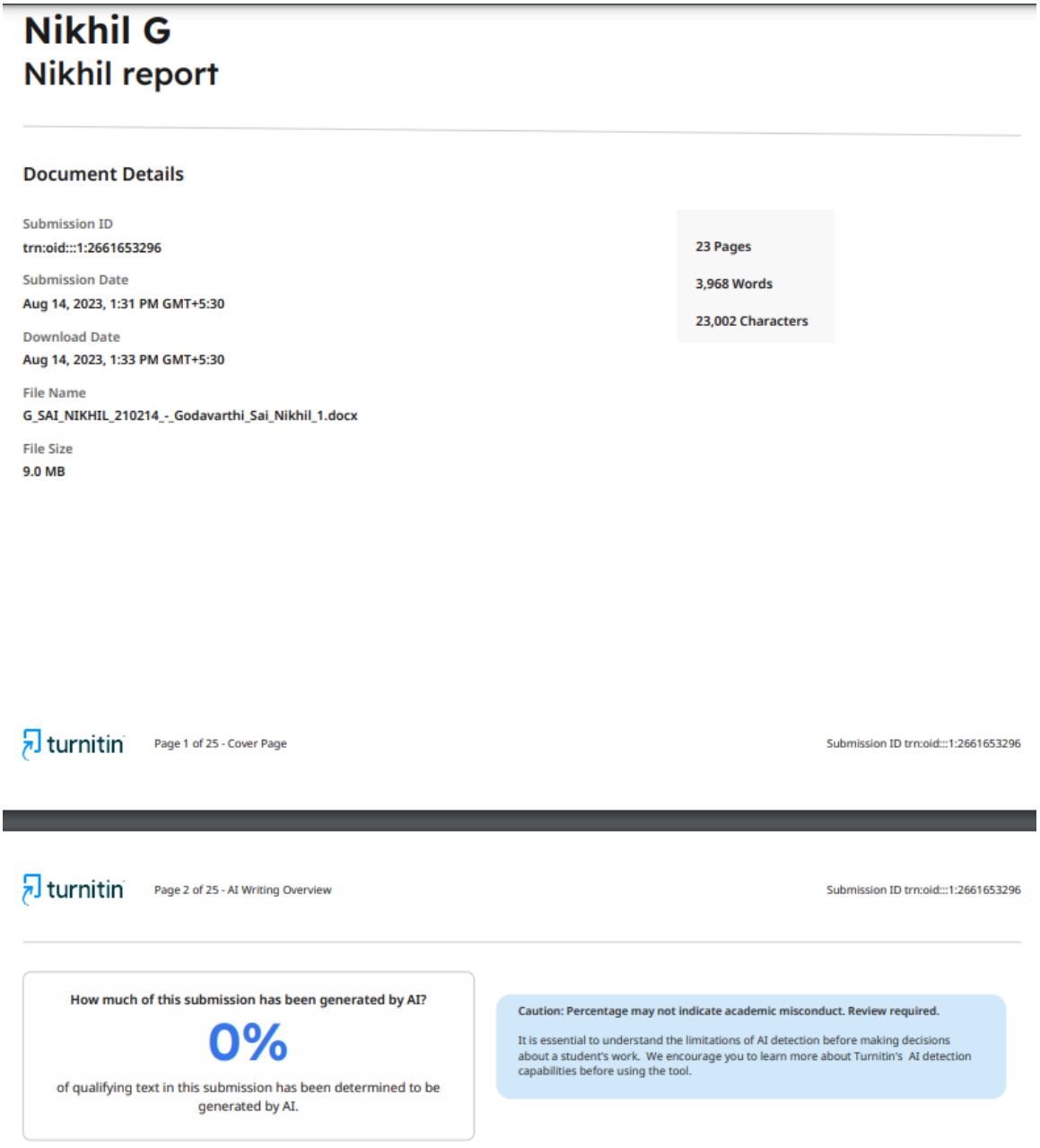

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