DESIGN AND IMPLEMENTATION OF A ROBOTIC TROLLEY

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CERTIFICATION

This is to certify that this project research was carried out by **AHMED, Baba Muhammed** with matriculation number **ND/23/COM/PT/0318,** has been read and approve as meeting part of the requirements for the award of National Diploma (ND) in Computer Science.

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DEDICATION

This project is dedicated to the creator of the earth and universe, the Almighty God. It is also dedicated to my parents for their moral and financial support.

ACKNOWLEDGEMENT

All praise is due to the Almighty God the Lord of the universe. We praise Him and thank Him for giving us the strength and knowledge to complete my ND programme and also for my continue existence on the earth.

We appreciate the utmost effort of our supervisor, Dr. (Mrs.) Dada, O. M., whose patience support and encouragement have been the driving force behind the success of this research work. She gave useful corrections, constructive criticisms, comments, recommendations, advice and always ensures that an excellent research is done. Our sincere gratitude goes to the Head of the Department and other members of staff of the Department of Computer Science, Kwara State Polytechnic, Ilorin, for their constant cooperation, constructive criticisms and encouragements throughout the programme.

Special gratitude to our parents who exhibited immeasurable financial, patience, support, prayers and understanding during the periods in which we were busy tirelessly in our studies. Special thanks go to all our lovely siblings.

Our sincere appreciation goes to our friends and classmates.

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ABSTRACT

This project focuses on the design and implementation of a robotic trolley, which aims to enhance efficiency and automation in various industries, particularly in logistics and manufacturing. The robotic trolley is designed to autonomously navigate through predefined paths, carry payloads, and interact with its environment using sensors and actuators. Through a combination of mechanical, electrical, and software engineering principles, the robotic trolley promises to streamline operations, reduce human intervention, and improve productivity. This project outlines the methodology, design considerations, implementation challenges, and potential applications of the robotic trolley, offering insights into its development and deployment.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND TO THE STUDY

In today's rapidly evolving industrial landscape, automation plays a pivotal role in optimizing processes and increasing competitiveness. One area that holds significant potential for automation is the transportation of goods within facilities, such as warehouses, institutes and manufacturing plants. Traditional methods relying on manual labor or fixed conveyance systems often face limitations in adaptability, scalability, and efficiency. The emergence of robotics offers a promising solution to address these challenges by introducing flexible and intelligent transport systems. In this context, the design and implementation of a robotic trolley represent a compelling endeavor with far-reaching implications (Suryanto et. al, 2018).

The robotic trolley embodies the convergence of advanced technologies, including robotics, artificial intelligence, and sensing capabilities, to create a versatile and efficient platform for material handling tasks. Unlike conventional conveyance systems, which are constrained by fixed routes and limited adaptability, the robotic trolley can navigate dynamically in complex environments, avoiding obstacles and optimizing its path to deliver payloads with precision and reliability. By harnessing the power of robotics, organizations can achieve greater flexibility, responsiveness, and scalability in their logistics and manufacturing operations (Phule, et. al, 2022).

The adoption of robotic trolleys aligns with the broader trend of Industry, characterized by the integration of digital technologies into industrial processes to create "smart" and interconnected systems. By leveraging robotics, data analytics, and Internet of Things (IoT) capabilities, organizations can achieve unprecedented levels of efficiency, flexibility, and agility in their operations. Robotic trolleys represent a tangible manifestation of these principles, offering a tangible solution to enhance material handling processes in the era of digital transformation (Joshi, *et.al*, 2019).

Bogdan et.al, (2022) claimed that, the design and implementation of robotic trolleys hold promise not only for large-scale industrial operations but also for small and medium-sized enterprises (SMEs) seeking to improve their competitiveness. Historically, the adoption of automation technologies has been perceived as prohibitively expensive and complex for smaller organizations. However, advancements in robotics, coupled with decreasing costs and increased accessibility, have democratized access to automation solutions. Robotic trolleys offer SMEs an affordable and scalable means to optimize their internal logistics, increase throughput, and meet growing customer demands effectively.

In addition to enhancing operational efficiency, robotic trolleys contribute to improving workplace safety and ergonomics. Manual material handling tasks, such as pushing carts or carrying heavy loads, are associated with a high risk of musculoskeletal injuries and worker fatigue. By automating these tasks, robotic trolleys reduce the physical strain on human workers, mitigating the risk of injuries and creating a safer working environment. This not only benefits individual employees by reducing the likelihood of workplace accidents but also translates into tangible cost savings for employers through reduced worker compensation claims and improved productivity (Bogdan, *et al.,* 2022).

The implementation of robotic trolleys facilitates data-driven decision-making and process optimization through the collection and analysis of operational metrics. Equipped with sensors and connectivity features, robotic trolleys generate valuable data regarding their movements, payload capacities, energy consumption, and environmental conditions. This data can be leveraged to identify inefficiencies, bottlenecks, and opportunities for improvement within the supply chain and production processes. By harnessing insights derived from real-time monitoring and analysis, organizations can fine-tune their operations, minimize waste, and enhance overall performance.

This project proposed the design and implementation of robotic trolley which represent a transformative step towards the realization of smarter, more efficient, and more sustainable industrial environments.

1.2 STATEMENT OF THE PROBLEM

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Despite the potential benefits offered by robotic trolleys, several challenges must be addressed to realize their full potential. One key challenge lies in the development of robust navigation and control algorithms capable of ensuring safe and efficient movement in dynamic environments. Navigation algorithms must enable the robotic trolley to perceive its surroundings accurately, plan optimal paths, and adapt to changing conditions in real-time. Additionally, issues related to payload capacity, power management, and system reliability pose significant obstacles to the widespread adoption of robotic trolleys in industrial settings.

1.3 AIM AND OBJECTIVES OF THE STUDY

The primary aim of this project is to design and implement a robotic trolley capable of autonomously transporting payloads in industrial environments. The objectives are to:

i. develop a prototype robotic trolley system incorporating mechanical, electrical, and software components;
ii. design and implement robust navigation and control algorithms

enabling autonomous operation in dynamic environments;

iii. evaluate the performance of the robotic trolley prototype through simulation and real-world testing; and

iv. identify potential applications and benefits of the robotic trolley in industrial settings.

1.4 SIGNIFICANCE OF THE STUDY

The successful design and implementation of a robotic trolley hold significant implications for various industries, particularly in the domains of logistics and manufacturing. By introducing autonomous and adaptable transport systems, organizations can streamline their operations, reduce labor costs, and enhance overall productivity. Furthermore, robotic trolleys offer the flexibility to accommodate changing demands and evolving production requirements, making them invaluable assets in today's dynamic business environment. This study contributes to the advancement of robotics and automation technologies, paving the way for future innovations in material handling and industrial logistics.

1.5 SCOPE OF THE STUDY

This project focuses on the design and implementation of a robotic trolley for industrial applications, with specific emphasis on autonomous navigation and payload transportation. The scope encompasses the development of both hardware and software components, including mechanical design, sensor integration, control algorithms, and user interface. While the study primarily targets indoor environments typical of warehouses and manufacturing facilities, the principles and methodologies presented can be adapted to various settings and applications. However, certain aspects such as outdoor navigation and extreme operating conditions are beyond the scope of this study and may warrant further investigation.

1.6ORGANIZATION OF THE REPORT

The project write-up is organized into five distinct chapters. Chapter one covers general introduction, which contains introduction to the research topic, statement of the problem, aim and objectives, significance of the study, scope and limitation and organization of the report. Chapter two covers literature review, which contains review of related past work, review of general text and discussions of issues related to this topic. Chapter three explains the project methodology which includes method of data collection, analysis of existing system, problems of the existing system, and the description of the proposed system, advantages of proposed system and design and implementation techniques used. Chapter four explains the design, implementation and documentation of the system which contain system design output design, input design, database design and procedure design, implementation of the system hardware and software support and documentation of the new system installation procedure, operating the system and system maintenance. Lastly, chapter five explains the summary of the research, recommendations and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1REVIEW OF RELATED WORKS

In this section some past journals related to this topic of study will be reviewed.

Phule, *et.al,* (2022) designed a fabricated remote-controlled robotic trolley. The mission is aimed at designing a remote controlled robotic trolley, which could characterize as transferring unit in isolated ward. The reason of this action is solely based on past two years where we all have been affected due covid pandemic that modified the lives throughout the globe. In this pandemic health practitioner, nurses, fitness-care employees and medical group of workers and many others. Labored as frontliners. In covid isolation ward even with social distancing observed, food water and medicinal drug supply is energetic. These offerings are being provided through our medical staffs which at once placed them into danger because of their direct contact with covid advantageous patient. And we're keen to reduce this danger by way of permitting our faraway-managed trolley to roam in the ones wards and deliver these primary services. The researchs targeted on designing and fabricating a movable trolley which can be controlled through Remote manipulate. This initiative was taken in the course of lockdown because of covid. To avoid contactless service. It can be used to hold medication, water, and meals and so forth. This faraway operation is programmed with the assist of Embedded C. An Arduino Mega is used for motion control and wheels used is Mecanum Wheels for motion in each viable direction. For actual time viewing, a camera is used. We can get admission to the actual view in front of trolley. For self-sanitization a sanitizer doling out unit is connected.

Bogdan, et.al, (2020) proposed a cooperative design of a robotic shopping trolley. The article described the design activities of enactment and reflects upon the degree of open-endedness in design. Special attention during the process of designing a robotized, multimodal shopping trolley is given to the necessary adaptation of known techniques from graphical user interface design to the area of human-robot interface design. Involving users in such a cooperative design process poses a challenge as the early design activities need to take the mobility of both users and the robotic devices into account. Discussing how video prototyping techniques can be adapted, advantages and disadvantages of various kinds of creative adjustment to traditional cooperative design methods are discussed.

Joshi, et.al. (2019) designed and developed a human following trolley. The paper represented the human following trolley using a raspberry pi. A trolley automatically avoids an obstacle, and to interact and communicate with the person trolley should follow that particular person. To achieve this target the goal of our work is to design and fabricate a robot that not only tracks the target but also move towards by avoiding obstacles while tracking. To make things simpler, a unique tag is placed on the person that should be followed by trolley. A small pi camera continuously captures the images of the unique tag and continuously compares it to the original captured image. If it is matched, then trolley moves further also it makes its way to proceed further by avoiding obstacles by using ultrasonic sensors. Tag plays essential role as per as uniqueness is a concern and makes the task easy. The trolley is mechanically designed, and electrical components are also used. All processing is carried out using a raspberry pi.

Suryanto, Siagian, Perangin-Angin, Sashanti and Yogen (2018) designed an automatic mobile trolley using ultrasonic sensors. The paper proposed an automatic mobile trolley using ultrasonic sensors. It can follow human movement automatically. It did not need to be encouraged or withdrawn. It would make an easier shopping for people as customers. The trolley controlled by a microcontroller module unit. It can stop, turn right, turn left, forward and backward. It can follow wherever they go, during they were in range.

Gunawana, *et.al* (2019) developed a smart trolley system based on Android smartphone sensors. The researcher's goal is to develop an automatic moving trolley with smart shopping devices to solve the problem. Their smart shopping trolley is based on a two-wheeled mobile robot, developed in their previous research. The paper presented the hardware and software design of a smart trolley system. Their smart trolley used IOIO microcontroller and Android smartphone as sensors and controller. The trolley was modelled as a two-wheeled mobile robot. Android smartphone will control the robot by sending a signal to IOIO microcontroller paired with a robot's actuator and monitor the situation using the smartphone camera. Furthermore, we exploited the smartphone compass for robot navigation. This system is also equipped with the indoor positioning system to detect user position using Navisens which based on gyroscope and accelerometer in the smartphone. Finally, the results of the testing on robot navigation are presented. The result is their smart trolley system based on Navisens framework can move and show its location to the user.

Akhila and Kumar (2016) implemented a smartphone based robotic arm control using a raspberry pi and Wi-Fi. In the robotic ARM, android application, raspberry pi was used. The robotic arm performs the same like human hand works. Application is built in android platform, the indication is given to raspberry pi for further process. In this technique, the delay and server problems are reduced as the Wi-Fi is used.

Morioka, Lee and Hashimoto (2020) worked on an intelligent space for human centered robotics. In the intelligent space, the achievement of the human-centred robotic system was developed. The positions of targeted objects in the iSpace was measured with multiple DINDs installed in a wide area.

2.2REVIEW OF GENERAL CONCEPTS

2.2.1Overview of Microcontroller

Microcontrollers serve as the backbone of countless embedded systems, providing compact yet powerful computing capabilities. Typically housed on a single chip, they encompass a CPU, memory, and various input/output peripherals. This integration enables them to execute specific tasks or control functions within electronic devices efficiently. Despite their modest processing power compared to general-purpose computers, microcontrollers excel in applications where real-time responsiveness and low power consumption are paramount.

Programming microcontrollers involves using specialized development environments and languages tailored to embedded systems, such as C or C++. Developers write code to be stored in the microcontroller's non-volatile memory, dictating its behavior and response to external stimuli. This programming flexibility allows microcontrollers to adapt to a wide range of applications, from consumer electronics like remote controls to sophisticated automotive systems like engine control units.

The versatility of microcontrollers extends across diverse industries, including consumer electronics, automotive, industrial automation, and medical devices. In consumer electronics, the power devices ranging from basic kitchen appliances to complex smart gadgets, providing the intelligence needed for functionality and user interaction. In automotive applications, microcontrollers control critical systems like engine management and vehicle diagnostics, ensuring optimal performance and safety on the road.

Microcontroller development is supported by a robust ecosystem of tools and resources, facilitating rapid prototyping and deployment. Development boards, programmers, and debuggers streamline the coding process, while libraries and online communities offer invaluable support and knowledge sharing. This ecosystem empowers engineers to innovate and bring new embedded systems to market efficiently, leveraging the versatility and reliability of microcontrollers (Phule *et al.*, 2022).

2.2.2 Overview of Trolley Sensor

Sensors are the lifeblood of modern trolley systems, seamlessly integrating into their framework to enhance navigation, safety, and operational efficiency. At the forefront are proximity sensors, employing a variety of technologies such as infrared, ultrasonic, or laser-based systems to detect obstacles in the trolley's path. By continuously monitoring the surroundings, these sensors enable the trolley to navigate crowded environments while avoiding collisions, ensuring both passenger safety and operational fluidity.

Encoder sensors form another vital component, meticulously tracking the trolley's position, speed, and direction of movement. By providing real-time feedback to the control system, encoders ensure precise navigation and trajectory tracking, crucial for executing complex maneuvers with accuracy and reliability. This meticulous control extends to the stabilization of the trolley, facilitated by Inertial Measurement Units (IMUs) that integrate accelerometers, gyroscopes, and magnetometers to detect motion, orientation, and tilt. IMUs play a pivotal role in stabilizing the trolley, compensating for vibrations, and maintaining its balance, particularly on uneven terrain.

Incorporating global navigation capabilities, GPS receivers pinpoint the trolley's location using signals from satellites. This data not only facilitates navigation and route planning but also enables the implementation of geofencing to define operational boundaries or restricted areas. Vision systems, comprising cameras and sophisticated computer vision algorithms, further augment the trolley's perception capabilities. By recognizing obstacles, traffic signs, and lane markings, vision systems enhance safety and enable autonomous operation, empowering trolleys to navigate complex urban environments with confidence.

Moreover, specialized sensors such as load cells, temperature, and humidity sensors, along with collision detection systems, ensure optimal performance and safety in diverse operating conditions. Load sensors prevent overloading and optimize cargo handling, while environmental sensors maintain ideal storage conditions. Meanwhile, collision detection systems stand vigilant, triggering emergency measures to prevent accidents and minimize damage. Through the synergy of these sensors, trolleys evolve into intelligent, adaptive systems, capable of seamlessly integrating into urban landscapes while prioritizing safety, efficiency, and sustainability (Morioka, Lee & Hashimoto, 2020).

2.2.3 Robotic Technology

Robotic technology represents a transformative force across various industries, offering innovative solutions to complex challenges. These machines, equipped with advanced sensors, actuators, and artificial intelligence algorithms, possess the ability to perceive, interact with, and manipulate their environments autonomously. In manufacturing, robots streamline production processes by performing tasks with precision and efficiency, leading to increased productivity and cost savings. They excel in tasks ranging from assembly and welding to packaging and quality inspection, enabling manufacturers to meet growing demand while maintaining high standards of quality.

Beyond manufacturing, robotic technology is revolutionizing sectors such as healthcare, where robots assist surgeons in delicate procedures, enhance rehabilitation therapies, and automate logistics within hospitals. In agriculture, robots aid in crop monitoring, harvesting, and precision spraying, optimizing yields and reducing resource usage. Moreover, in logistics and warehousing, robots are transforming supply chain operations by autonomously moving goods, organizing inventory, and fulfilling orders in distribution centers, thus accelerating delivery times and improving inventory management.

The future of robotic technology holds immense promise, with ongoing advancements in areas such as soft robotics, swarm robotics, and human-robot collaboration. Soft robots, inspired by natural organisms, offer flexibility and adaptability for tasks in unstructured environments, such as search and rescue missions. Swarm robotics explores the coordination of multiple robots to accomplish complex tasks collaboratively, mirroring the behavior of social insects. Additionally, human-robot collaboration enables robots to work alongside humans safely and efficiently, unlocking new possibilities for enhanced productivity and creativity across various domains. As these technologies continue to evolve, the impact of robotics on society is poised to expand, driving innovation and reshaping the way we live and work Morioka, Lee & Hashimoto, 2020).

2.2.4 Robotic Trolley

Robotic trolleys are a vital component of modern automated material handling systems, designed to autonomously transport goods within defined environments. These trolleys boast diverse designs, typically comprising a mobile base with wheels or tracks, a sturdy chassis for payload support, and an array of sensors and actuators for navigation and manipulation tasks. Their flexibility in design allows for customization based on specific industry needs, whether it's navigating narrow warehouse aisles or delivering medical supplies in a hospital setting.

Navigation lies at the core of robotic trolleys' functionality. Equipped with advanced sensor suites including cameras, LiDAR, and ultrasonic sensors, they perceive and interpret their surroundings in real-time. Through sophisticated algorithms and techniques like SLAM, these trolleys construct detailed maps of their environment and determine optimal paths to efficiently reach their destinations. This autonomy enables them to adapt to dynamic environments, avoiding obstacles and optimizing routes without human intervention.

Payload handling capabilities make robotic trolleys indispensable in streamlining material handling processes. From carrying packages on shelves to manipulating objects with robotic arms, they enhance efficiency across a range of industries. In logistics and warehousing, they enable seamless movement of inventory, reducing the need for manual labor and minimizing errors in inventory management. Similarly, in manufacturing, they facilitate the transportation of parts and components along assembly lines, contributing to leaner and more efficient production processes.

Safety remains paramount in the deployment of robotic trolleys, particularly in shared spaces with human workers. These systems are equipped with comprehensive safety features, including collision avoidance sensors, emergency stop mechanisms, and fail-safe protocols. By prioritizing safety alongside efficiency, robotic trolleys ensure harmonious integration into industrial workflows, fostering a collaborative environment where humans and machines work together seamlessly to optimize material handling operations (Phule *et al.*, 2022).

CHAPTER THREE

RESEARCH METHODOLOGY AND ANALYSIS OF THE EXISTING SYSTEM

3.1RESEARCH METHODOLOGY

This robotic trolley consists of a robotic vehicle having two wheels and one freewheel mounted along with different sensors and modules, that is, ultrasonic sensor and camera. The camera is vertically adjusted and is initially mounted at the height of 4ft from the ground to enhance the visual capability and effectiveness. The user controls the trolley as it follows a particular person by a unique identification tag. Below is the block diagram of the system to be developed.

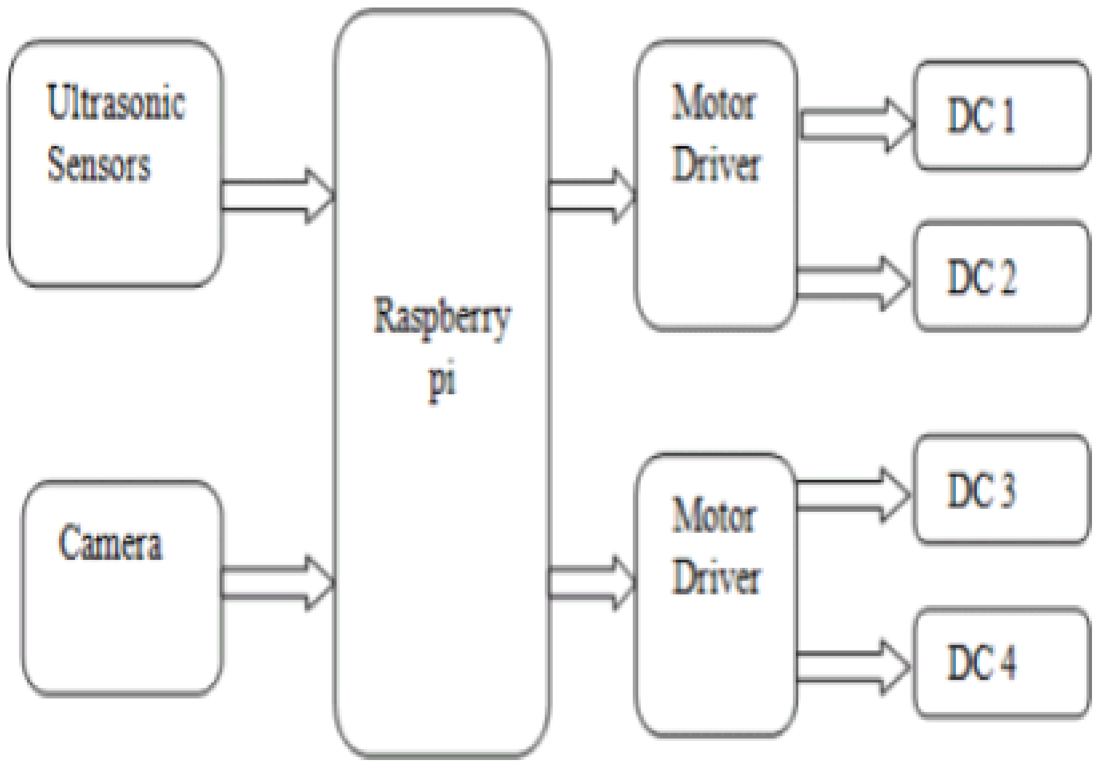

Figure 3.1: Block Diagram of the Robotic Trolley

The implemented trolley checks for the obstacles and avoids them by using an ultrasonic sensor. There are several features of the project such as design of circuit, tag identification, obstacles avoidance and human detection system.

3.2ANALYSIS OF THE EXISTING SYSTEM

The existing system of manual material handling in warehouses and industrial settings often relies on human labor for tasks such as transporting goods, which can be inefficient, time-consuming, and prone to errors. Manual trolley systems require constant supervision and are limited in their ability to adapt to dynamic environments. However, they pose safety risks to workers, especially in environments with heavy machinery or hazardous materials. The reliance on manual labor also restricts scalability and increases operational costs over time. The existing system lacks the efficiency, flexibility, and safety standards required for modern industrial operations.

3.3PROBLEMS OF THE EXISTING SYSTEM

Several problems plague the existing manual trolley system. Firstly, it is labor-intensive, leading to high labor costs and potential ergonomic issues for workers involved in repetitive tasks. Secondly, manual trolleys are limited in their ability to navigate efficiently in complex environments, leading to suboptimal route planning and congestion in warehouse spaces. Additionally, the reliance on human operators introduces the risk of human error, which can result in delays, damaged goods, or safety hazards. Finally, the lack of automation hampers scalability and adaptability to fluctuating demand, hindering overall operational efficiency.

3.4DESCRIPTION OF THE PROPOSED SYSTEM

The proposed system involves the design and implementation of a robotic trolley for automated material handling tasks in industrial environments.

This robotic trolley will be equipped with sensors for environment perception, navigation algorithms for autonomous movement, and payload handling mechanisms for transporting goods. It will integrate seamlessly with existing warehouse management systems, allowing for efficient coordination of material flow and inventory management. Additionally, the robotic trolley will feature safety features such as collision avoidance sensors and emergency stop mechanisms to ensure safe operation in shared spaces with humans and other machinery.

3.5ADVANTAGES OF THE PROPOSED SYSTEM

The proposed robotic trolley system offers numerous advantages over the existing manual trolley system.

i. It enhances operational efficiency by automating material handling tasks, reducing labor costs, and improving throughput.

ii. It improves safety by minimizing the risk of accidents and injuries associated with manual labor. Thirdly, the robotic trolley system provides scalability and flexibility, allowing for easy adaptation to changing demand and dynamic environments. Moreover, it enhances inventory accuracy and traceability through integration with warehouse management systems. Overall, the proposed system represents a significant advancement in material handling technology, offering a more efficient, safe, and adaptable solution for industrial operations.

CHAPTER FOUR

DESIGN, IMPLEMENTATION AND DOCUMENTATION OF THE SYSTEM

4.1DESIGN OF THE SYSTEM

The design of the robotic trolley system integrates a sturdy chassis with motorized wheels for mobility, a microcontroller for processing and control, sensors for obstacle detection and navigation, a power management system for efficient energy use, and a user interface for real-time monitoring and control, ensuring seamless and autonomous operation in various environments.

4.1.1OUTPUT DESIGN

The output design of the robotic trolley includes a user-friendly interface displaying real-time status updates, navigation controls, and load capacity indicators, along with a robust framework supporting efficient movement, precise obstacle avoidance, and autonomous operation within defined parameters. Things taken into consideration in determining the output are represented below:

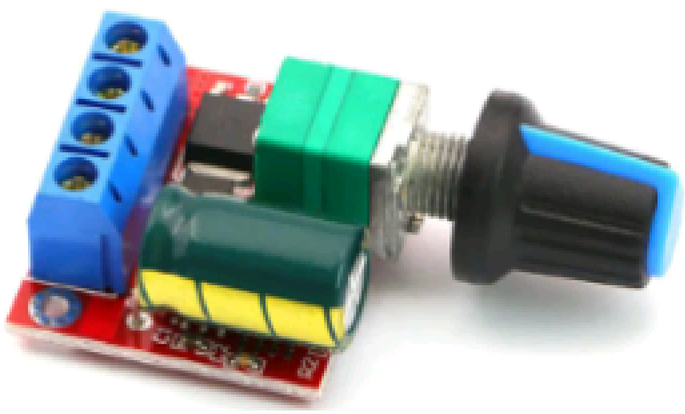

Figure 4.1: 12V 5A DC motor

A 12V 5A DC motor is designed to operate efficiently at 12 volts DC while drawing a maximum current of 5 amps. It is suitable for a wide range of applications requiring moderate power and torque, such as robotic platforms, small vehicles, conveyor systems, and various industrial and DIY projects. This motor's specifications make it versatile for tasks that demand reliable performance and precise control over speed and direction, facilitated through compatible motor drivers or controllers. Efficient heat management is crucial due to its potential for generating heat during operation, necessitating adequate cooling measures to maintain optimal functionality and longevity.

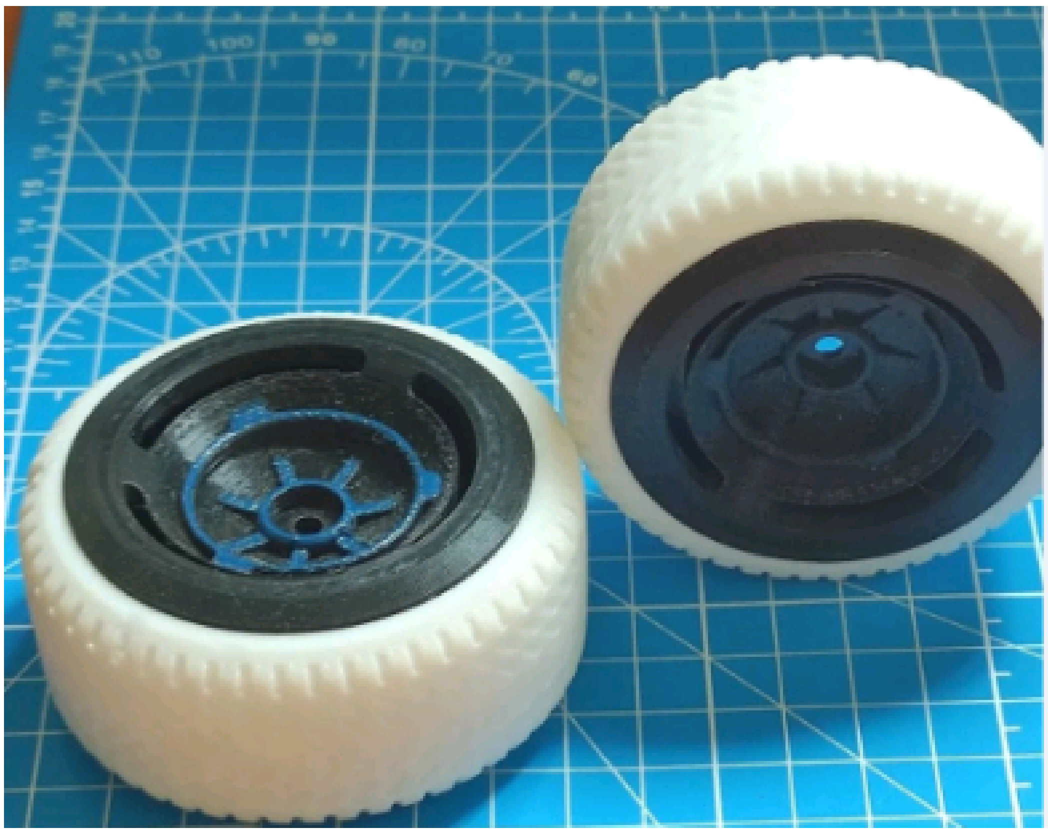

Figure 4.2: 5mm x 4 free wheel

A 5mm x 4 free wheel refers to a component typically used in mechanical assemblies where rotational freedom in one direction is desired while restricting motion in the opposite direction. It features a 5mm diameter axis and contains 4 elements that enable smooth rotation in one direction and lock against rotation in the opposite direction, providing efficient motion control in various applications such as conveyor systems, mechanical linkages, and automotive components.

Figure 4.3: Mq99a steel servo motor

The MQ99A steel servo motor is selected for its robust design and precise control capabilities, ideal for the design and implementation of a robotic trolley. With its durable steel construction, this servo motor offers reliable performance and high torque output, essential for powering the movement mechanisms of the trolley. Its integrated control features allow for accurate positioning and smooth operation, crucial for navigating diverse environments and handling varying loads efficiently. The MQ99A servo motor enhances the trolley's responsiveness and stability, ensuring consistent performance in automated tasks such as navigation, load handling, and obstacle avoidance, making it a suitable choice for robust robotic applications.

4.1.2INPUT DESIGN

The input design of the robotic trolley includes a set of sensors for obstacle detection (such as ultrasonic, infrared, and LIDAR), user input through a mobile app or onboard controls, and GPS for navigation, enabling the trolley to receive and process environmental data, user commands, and location information for accurate and efficient operation.

Figure 4.4: U shaped casted chromium steel

U-shaped casted chromium steel is chosen for its high strength, durability, and resistance to corrosion, making it ideal for structural components in demanding applications. This material's properties ensure reliable performance and longevity in environments exposed to stress, wear, and varying conditions. In the context of designing and implementing a robotic trolley, U-shaped casted chromium steel can be used to construct the frame or chassis, providing a robust and stable foundation that supports the mechanical and electronic components, while also withstanding the operational demands and loads, ensuring overall structural integrity and durability of the robotic system.

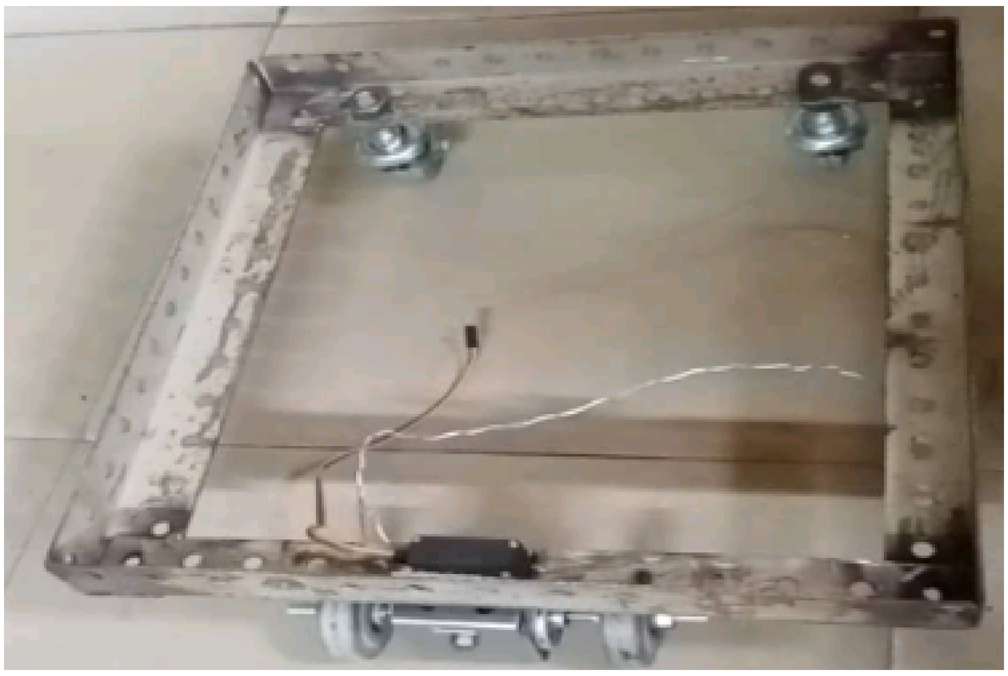

Figure 4.5: Bottom Frame

This this robotic trolley bottom frame that consist of wheel for movement/ navigation

4.1.3PROCEDURE DESIGN

The procedure design for the robotic trolley involves initializing the system, calibrating sensors, processing user inputs and environmental data, executing movement commands via motor control, continuously monitoring and adjusting for obstacles and path deviations, and providing feedback through the user interface to ensure efficient and autonomous operation.

4.2IMPLEMENTATION OF THE SYSTEM

The implementation of the robotic trolley system involves assembling the hardware components, programming the microcontroller with navigation and control algorithms, integrating the sensors for real-time data acquisition, developing the user interface for monitoring and commands, testing the system in various scenarios, and refining the software and hardware to ensure reliable and efficient performance.

4.2.1CHOICE OF PROGRAMMING LANGUAGE

The choice of programming language for the robotic trolley system is Python for its simplicity and extensive libraries for robotics and machine learning, C++ for performance-critical components and real-time control, and JavaScript for developing a responsive web-based user interface.

4.2.2HARDWARE REQUIREMENT

The hardware requirements for the robotic trolley system include:

i. **Chassis**: A durable frame to support all components and the payload.

ii. **Motors**: High-torque DC motors or stepper motors for precise movement.

iii.**Wheels**: Suitable for the operating surface (e.g., rubber wheels for indoor use).

iv. **Microcontroller**: Arduino, Raspberry Pi, or similar for control and processing.

v. **Sensors**: Ultrasonic, infrared, and LIDAR sensors for obstacle detection and navigation.

vi. **Battery**: High-capacity rechargeable batteries, such as Li-ion or Li-Po.

vii**Motor Drivers**: To interface between the microcontroller and motors.

viii. **GPS Module**: For outdoor navigation and location tracking.

ix. **IMU (Inertial Measurement Unit)**: For orientation and movement tracking.

x. **Communication Module**: Wi-Fi or Bluetooth for remote control and monitoring.

xi. **Display**: LCD or LED display for status information.

xii. **Casing**: Protective housing for electronics and sensors.

xiii. **Connectors and Cables**: For power and data connections.

xiv. **Miscellaneous**: Screws, nuts, bolts, and mounting brackets for assembly.

4.2.3 SOFTWARE REQUIREMENT

The software requirements for the robotic trolley system include an integrated development environment (IDE) for coding (such as Arduino IDE for microcontroller programming and Python IDE for higher-level control), a real-time operating system (RTOS) for efficient task management, sensor data processing libraries, machine learning algorithms for path planning and obstacle avoidance, a web-based interface framework (using JavaScript) for remote monitoring and control, and communication protocols (like MQTT or HTTP) for seamless data exchange between the trolley and user interface.

4.3 DOCUMENTATION OF THE SYSTEM

4.3.1 PROGRAM DOCUMENTATION

The program documentation for the robotic trolley system includes detailed descriptions of the system architecture, hardware components, and software modules; installation and setup guides; step-by-step instructions for calibrating sensors and testing the trolley; annotated source code with explanations of key functions and algorithms; troubleshooting tips; and user manuals for operating the trolley and utilizing the user interface effectively.

s4.3.2MAINTAINING OF THE SYSTEM

Maintaining the robotic trolley system involves a structured approach to ensure ongoing functionality and reliability. This includes regular hardware inspections and repairs, updating software to enhance performance and security, calibrating sensors for accurate data acquisition, monitoring battery health and optimizing power management, diagnosing and resolving communication issues, and providing continuous user support and training. Proactive maintenance schedules and periodic system checks are essential to minimize downtime and maximize the operational efficiency and lifespan of the robotic trolley.

CHAPTER FIVE

SUMMARY CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The design and implementation of a robotic trolley system present a transformative solution to the challenges faced by traditional manual material handling methods in industrial settings. By leveraging advanced robotics technology, sensors, and autonomous navigation algorithms, the proposed system offers a more efficient, safe, and adaptable approach to material transportation within warehouses and manufacturing facilities. The robotic trolley system addresses key issues such as labor intensity, inefficiency, safety hazards, and scalability limitations associated with manual trolley systems. Through automation, integration with warehouse management systems, and the incorporation of safety features, the proposed system enhances operational efficiency, improves worker safety, and enables seamless adaptation to fluctuating demand and dynamic environments.

5.2 CONCLUSION

The development and deployment of a robotic trolley system represent a significant advancement in material handling technology with far-reaching benefits for industrial operations. By replacing manual labor with autonomous robots, businesses can achieve higher levels of efficiency, productivity, and safety in their material handling processes. The integration of robotics technology not only streamlines operations but also enhances inventory accuracy, traceability, and overall warehouse management capabilities. As such, the adoption of robotic trolley systems holds immense potential for improving the competitiveness and sustainability of industrial enterprises in the modern era.

5.3 RECOMMENDATIONS

Based on the findings of this project the following were recommended to fully realize the potential benefits of robotic trolley systems:

i. Continued investment in research and development is essential to further enhance the capabilities and performance of robotic trolley systems, including advancements in sensor technology, navigation algorithms, and human-robot interaction.

ii. Providing training programs to equip workers with the skills and knowledge needed to operate and maintain robotic trolley systems effectively. Additionally, promote workforce development initiatives to ensure a smooth transition to automation and mitigate any potential job displacement.

iii. Collaboration should be foster on among stakeholders to ensure seamless integration of robotic trolley systems with existing warehouse management systems, as well as compatibility with emerging Industry 4.0 technologies such as IoT (Internet of Things) and AI (Artificial Intelligence).

iv. Address regulatory and safety standards pertaining to the deployment of robotic trolley systems in industrial environments to ensure compliance and mitigate risks associated with human-robot interaction.

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