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REVIEW PAPER ON AUTONOMOUS ROBOT FOR INDUSTRY DELIVERY PARTS

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Abstract—: The demand for enhanced automation in industrial settings has prompted the development of innovative solutions to streamline material handling and logistics processes. This research paper presents a comprehensive study on the "Design and Fabrication of Autonomous Delivery Mini Robot for Industries." In response to the increasing need for efficient and cost-effective solutions, this project aims to design, fabricate, and validate a compact autonomous robot tailored for industrial applications. The methodology comprises four key phases. The robot design phase delves into the meticulous selection of components, materials, and mechanical specifications to ensure the robot's robustness, maneuverability, and payload capacity. Subsequently, the software development phase entails the creation of control algorithms, navigation systems, and sensor integration strategies, facilitating intelligent and autonomous operation. The fabrication and assembly phase involves the physical realization of the robot, including prototyping, manufacturing, and quality control measures. The final testing and validation phase encompasses simulation and real-world tests to evaluate the robot's performance in industrial environments, assessing its reliability, precision, and adaptability.

This research underscores the potential of autonomous mini robots as a transformative force in industrial logistics, offering improved efficiency, accuracy, and cost savings. The findings from physical testing validate the robot's practical application and its readiness to address the challenges of modern industrial settings.

1. INTRODUCTION

In the world of manufacturing, warehouses, and industries, a common goal prevails—efficiency. Picture a massive factory or a sprawling warehouse filled with endless tasks, materials, and products that need to be managed and moved. It's a world where time is money, where precision is paramount, and where the manual labor involved can be overwhelming. Amid this dynamic landscape, an ingenious solution emerges—the "Autonomous Delivery Mini Robot."

The primary purpose of this project is to design, construct, and test a compact, self-reliant robot customized for industrial applications. This robot, akin to a diligent, tireless assistant, is engineered to navigate through the intricate and bustling terrain of industrial settings, executing a multitude of tasks without requiring continuous human oversight. It is equipped with a suite of sensors for detecting obstacles, cameras for perceiving its environment, and sophisticated algorithms for making informed decisions. Be it ferrying raw materials to an assembly line, delivering finished products to a packaging area, or any other logistics operation, this mini robot can perform its duties efficiently and with pinpoint accuracy.

The motivation behind this endeavor is two-fold. First and foremost, it seeks to alleviate the load on hardworking individuals in these industries by automating tasks that are physically demanding and repetitious, thereby allowing them to focus on more creative and intricate aspects of their work. Second, the project aims to elevate the overall efficiency of industrial processes.

This research is not just about crafting a robot; it's about instigating transformative change in industrial operations. It is about streamlining processes, boosting efficiency, and introducing a new era of accuracy, adaptability, and dependability to the industrial domain. It's a vision of an industrial landscape where repetitive, labor-intensive tasks are undertaken by tireless robots, leaving humans to excel in tasks that require creativity and critical thinking.

In addition to the considerable impact on work within these industries, this research is pivotal for several reasons. The performance and efficiency of industries have far-reaching consequences, affecting our daily lives in multiple ways. Enhanced efficiency in these sectors can translate to lower production costs, which often means more affordable products for consumers. Moreover, it can lead to a reduction in waste and environmental impact, contributing to a more sustainable future.

FIG: 1 Autonomous Delivery Robot
(Source – knau.org)

The safety aspect is equally important. As robots take on physically demanding or potentially perilous tasks, the risk of workplace accidents is mitigated. Robots can also operate in conditions where human safety might be compromised, such as extreme temperatures, confined spaces, or areas with hazardous materials.

This paper will take you through the journey of creating and deploying this autonomous delivery mini robot. It will discuss the selection of specific components and materials, the intricate technology that drives it, and the challenges encountered during the design and fabrication process. The research findings will be shared, encompassing the outcomes of testing both in controlled simulations and real-world industrial environments, showcasing the robot's capabilities

2. LITERATURE REVIEW

Pak Daman M. et. al have innovated a path-following robot with a significant enhancement—incorporating IR proximity sensors. These sensors play a pivotal role in enhancing the precision of the robot's path-tracking capabilities. By detecting nearby obstacles or changes in the environment, the IR proximity sensors allow the robot to make real-time adjustments, ensuring it stays accurately on course. This development represents a crucial step in improving the accuracy and reliability of autonomous robots, making them more adept at navigating their surroundings and fulfilling their intended tasks with greater precision.

Priyank Patil et.al has engineered an innovative automatic voltage regulator path-following robot, which possesses the unique ability to discern voltage readings of either 0 or 1 while traversing its designated path. This functionality is achieved through the utilization of IR sensors that rely on the principles of light reflection and absorption. When the robot encounters variations in the path's surface properties, such as reflective or absorptive characteristics, the IR sensors detect these changes and subsequently relay voltage readings of 0 or 1. This groundbreaking development equips the robot with the capability to not only navigate its path but also collect valuable data based on the path's attributes, thereby expanding its range of applications and utility,

Nor Manisha Abdul Ghani et. al have introduced an ingenious two-wheel robot that utilizes infrared sensors to maintain equilibrium on inclined surfaces. This innovation allows the robot to autonomously adjust and stabilize its position when faced with inclinations, ensuring smooth navigation across varying terrains. What's more, the inclusion of remote control functionality provides an additional layer of versatility and user-friendliness, enabling operators to guide and direct the robot from a distance. The combined use of infrared sensors for balance and remote control makes this robot a dynamic and adaptable solution with potential applications in various scenarios requiring mobility on inclined surfaces

Cloak I. et. al have introduced an innovative path-following robot, uniquely designed to not only navigate designated paths but also to entertain in mall and hotel settings. What sets this robot apart is its integration of music, enhancing the overall customer experience. As it follows its path, the robot can play music, adding an element of entertainment for patrons. Impressively, this robot boasts substantial carrying capacity, with the capability to handle weights of up to 380 kg. This multifunctional robot can contribute to creating a lively and engaging ambiance while also serving practical purposes in environments where heavy payloads need to be transported, marking a versatile addition to the service industry.

Goma T. et. al have engineered a remarkable robot that distinguishes itself through its extensive control system. With an impressive array of 45-50 individual control switches, this robot offers a highly versatile and precise means of managing its movements. Operators can exercise direct control over the robot's motion, enabling it to navigate in any desired direction. Furthermore, the robot's adaptability is underscored by its

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capacity to be tested under diverse conditions. This comprehensive control system not only provides exceptional maneuverability but also facilitates rigorous testing in various scenarios, enhancing its utility for research, experimentation, and practical applications across a spectrum of settings.

Roman Osorio C. et. al have introduced a groundbreaking path-following robot distinguished by its intellectual capabilities. Equipped with magnetic sensors, this robot possesses the remarkable ability to autonomously adjust its movement based on performance modifications. These sensors detect changes in the robot's environment and effectively steer its path accordingly. The use of magnetic sensors enables the robot to make real-time decisions, ensuring it stays on course, even when conditions or requirements change. This innovation represents a significant step in the development of adaptable, autonomous robots, capable of responding intelligently to evolving performance demands, thus broadening their applicability across various industries and scenarios.

M. Zari Azharuddin et. al designed a path-following robot that incorporates mapping capabilities, utilizing a V2X sensor as a digital compass. This innovative approach allows the robot to navigate with precision. V2X (Vehicle-to-Everything) communication technology plays a crucial role, enhancing the robot's ability to understand its surroundings and follow a predefined path. The sensor functions as a digital compass, ensuring accurate directionality. Through this combination of technologies, the robot can autonomously navigate while simultaneously creating a map of its environment, offering potential applications in fields such as autonomous vehicles, robotics, and smart transportation systems.

Bajestani et. al have developed a sophisticated path-following robot with an emphasis on advanced technology for obstacle detection and avoidance, as well as color recognition to ensure seamless movement. The robot integrates cutting-edge sensor technologies to identify and circumvent barriers in its path, enhancing safety and efficiency. Additionally, it incorporates color recognition capabilities, allowing it to navigate in environments where color-coded cues play a critical role in movement. This combination of features enables the robot to follow a predefined path while adapting to its surroundings, making it suitable for a wide range of applications, including industrial automation, logistics, and autonomous navigation in dynamic environments.

Kazie Mahmud Hasan et. al designed a system that automatically identifies the color of a path and navigates around barriers based on this information. They've opted to replace the microcontroller with logic gates to improve the accuracy of color recognition. This innovation allows the robot to effectively discern various path colors, providing precise navigation. When the system detects a barrier, it adjusts its course accordingly. This approach ensures reliable and efficient path following, making it particularly useful in scenarios where color-coded paths and obstacle avoidance are critical, such as in automated material handling, warehouse logistics, and guided transportation systems.

Nils Boysen et. al the rise of e-commerce has led to challenges in last-mile distribution in urban areas globally. Increased parcel deliveries contribute to traffic congestion and pollution. To address these issues, new last-mile delivery concepts have emerged, including drones and autonomous robots. The paper provides an overview of both established and innovative last-mile delivery methods, with a focus on the decision-making processes involved. It offers a concise notation scheme for these concepts, discusses key decision challenges, and reviews existing operations research methods. The paper also explores potential future research directions in this field.

3. REQUIRED COMPONENTS

1. ESP 32 (Microcontroller and Wi-Fi/Bluetooth Module)
2. EM 18 RFID Reader
3. Ultrasonic Sensor
4. L293 D Motor Driver
5. Bluetooth Module
6. 5 Channel Line Follower Array
7. LED
8. Li-ion battery
9. Battery Management System (BMS)
10. Copper Clad PCBs
11. Chassis
12. 12 V 30 RPM Motors
13. Wheels
14. Connecting Wires
15. Tray
16. Capacitors and Diodes
17. Miscellaneous Items
18. 12V Adapter

1. ESP32 (MICROCONTROLLER AND WI-FI/BLUETOOTH MODULE)

The ESP32 is a versatile microcontroller with built-in Wi-Fi and Bluetooth capabilities. It features a dual-core processor and a wide range of GPIO pins, making it suitable for controlling and coordinating various functions of your robot. The ESP32 can handle data processing, sensor interfacing, and network communication. Its Wi-Fi and Bluetooth capabilities enable it to connect to networks, communicate with other devices, and provide remote control or monitoring options.

FIG: 2 ESP 32

2. EM18 RFID READER

The EM18 Card Reader is an RFID (Radio-Frequency Identification) card reader that can read RFID cards or tags. It's crucial for security and authentication purposes in your project. RFID cards or tags are commonly used for access control, allowing your robot to recognize and grant access to authorized personnel or secure areas. The EM18 reads the unique identification data on the cards, which can be validated by your robot's control system for access decisions.

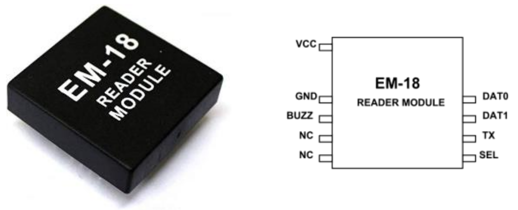

FIG: 3 EM 18 RFID Reader

3. ULTRASONIC SENSOR

Ultrasonic sensors utilize sound waves to determine distances. These sensors emit high-frequency sound pulses and measure the time it takes for the sound to bounce back after hitting an object. The data from the ultrasonic sensor helps your robot detect obstacles and avoid collisions, ensuring safe navigation. It's invaluable for applications where your robot needs to navigate through complex environments without colliding with objects.

FIG: 4 Ultrasonic sensor

4. L293 D MOTOR DRIVER

The L293D is a popular integrated circuit used to control DC motors and stepper motors. It is designed to provide bidirectional control for two motors, making it a suitable choice for your autonomous delivery robot, which likely requires the capability to move forward, backward, and turn.

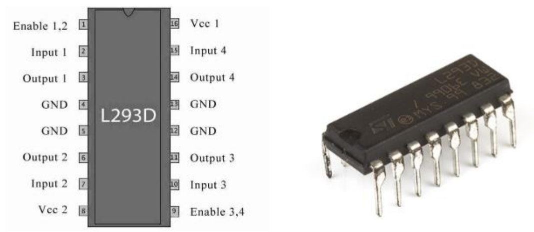

FIG: 5 L293D Motor Driver

5. BLUETOOTH MODULE

The Bluetooth module provides wireless communication capabilities for your robot. It allows for remote control, monitoring, and reprogramming via Bluetooth connectivity with other devices, such as smartphones or computers. This feature enhances user-friendliness and provides options for real-time control and diagnostics.

FIG: 6 Bluetooth Module

6. 5-CHANNEL LINE FOLLOWER ARRAY

The 5-channel line follower array is a sensor system designed for tracking lines or paths on the ground. It consists of multiple infrared sensors that can detect changes in reflectivity. In industrial settings, this is useful for line-following tasks where your robot must follow a predefined path, such as on factory floors or warehouse aisles.

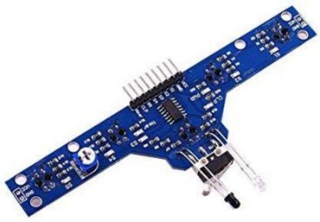

FIG: 7 5-channel line follower array

7. LED

LEDs serve as visual indicators on your robot. They can be used to display various information, such as power status, connectivity, or error states. LEDs provide a straightforward way to communicate the robot's current state and help with debugging and maintenance.

FIG: 8 LED

8. LI-ION BATTERY

The Li-ion battery serves as the primary power source for your robot. It supplies the energy needed for all components to operate. The choice of battery capacity and voltage is crucial to ensure that your robot can operate for an extended duration without frequent recharging, which is particularly important in autonomous applications.

FIG: 9 Li-ion Battery

9. BATTERY MANAGEMENT SYSTEM (BMS)

The Battery Management System (BMS) is responsible for monitoring and safeguarding the Li-ion battery. It manages the charging and discharging processes, preventing issues such as overcharging, over-discharging, and overheating. A reliable BMS ensures the safety and longevity of the battery, which is essential for the long-term operation of your robot.

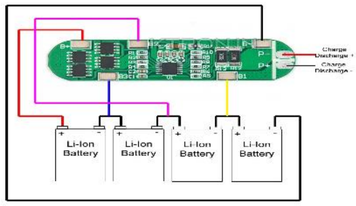

FIG: 10 Battery Management System (BMS)

10. COPPER-CLAD PCB

Copper-clad PCBs provide a stable and organized platform for creating the electrical circuits of your robot. They allow you to solder components, create custom circuitry, and interconnect various parts of the robot's electronic system. Designing the PCB effectively is essential for efficient and reliable electrical connections.

FIG: 11 Copper-clad PCBs

11. CHASSIS

The chassis is the structural frame of your robot, providing support for all the robot's components. It houses the electronics, motors, and wheels, determining the robot's overall size, shape, and strength. The choice of a sturdy and well-designed chassis is vital to ensure the structural integrity of your robot, especially in an industrial environment where robustness is crucial.

FIG: 12 chassis

12. 12V 30 RPM MOTORS

The 12V 30 RPM motors are responsible for propelling your robot. Their speed and torque characteristics make them suitable for driving the robot's wheels. These motors play a central role in the robot's mobility and are essential for precise control of its movement.

FIG: 13 12V 30 RPM motors

13. WHEELS

Wheels are the components that enable your robot to move. The type of wheels you choose, whether omni-wheels for enhanced maneuverability or standard wheels for simplicity, greatly affects the robot's mobility and performance. The choice of wheel material, size, and design should match the robot's intended tasks and environmental conditions.

FIG: 14 Wheels

14. CONNECTING WIRES

Connecting wires serve as the "nervous system" of your robot, transmitting power and data between components. Properly sized and connected wires are vital for reliable and efficient electrical connections, ensuring that your robot's subsystems function harmoniously.

FIG: 15 Connecting wires

15. TRAY

The tray provides a platform for transporting items or payloads. In the context of an autonomous delivery robot, it's the space where packages or goods are loaded for transport. The tray's design should consider the size and weight of the items it will carry, ensuring stability and safe transport.

FIG: 16 Tray

16. CAPACITORS AND DIODES

Capacitors store electrical energy and can help stabilize power supply voltage, reducing voltage fluctuations. Diodes allow current to flow in one direction and are used in various electrical applications. Both components are vital for maintaining a stable electrical system within your robot.

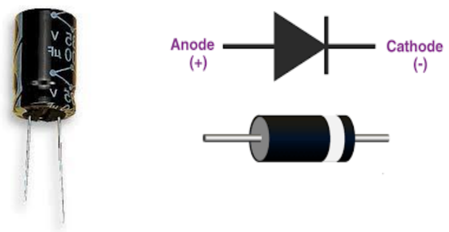

FIG: 17 Capacitors and Diodes

17. MISCELLANEOUS ITEMS

Miscellaneous items like soldering wire, glue sticks, bolts, and other hardware are essential for assembling, maintaining, and customizing your robot. Soldering wire is used to create strong and durable electrical connections, while bolts and glue sticks are necessary for securely attaching various components and structural elements..

FIG: 18 Miscellaneous items

18. 12V ADAPTER

The 12V adapter provides an external power source for your robot, allowing you to charge the Li-ion battery and power the robot during maintenance or when it's not in operation. It ensures that your robot remains operational and ready for use at all times.

FIG: 19 12V adapter

4. WORKING

Working of the Autonomous Delivery Robot:

1) Robot is at original starting location with unload condition

2) Load the Robot with goods and power on the circuit

3) Check all the peripheral connection and indications led's established the connection between Bluetooth module

4) Now Gives command from phone to robot for going to desired location ex. Godown 1

5) Robot starts Following the path and stop at cross junction to scan the RFID tag

6) After scanning it cross check itself with given location and right direction and take accordingly and move on.

7) Once it reach to the Godown ultrasonics sensor sense the action of unloading the goods it wait till the robot can not get fully unload

8) Once everything was done it comes to its original starting position by reversing the algorithms

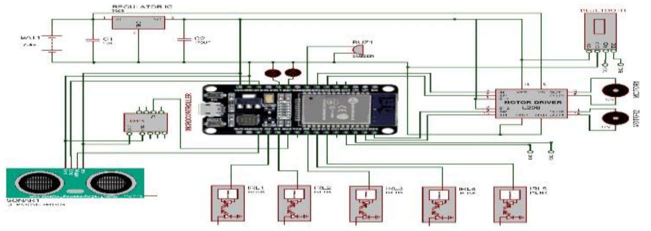

FIG: 18 Circuit Diagram of this Project

5. RESULTS AND DISCUSSION

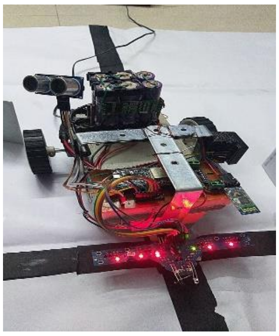

FIG: 19 Project Model

The autonomous delivery robot, as described in the working hierarchy and circuit diagram, demonstrates a practical and effective solution for optimizing logistics and goods delivery. The process begins with the robot at its original starting location, in an unloaded state, ready to be loaded with goods. The use of an ultrasonic sensor allows the robot to detect when materials are placed in its container, signaling the start of its operation. The robot proceeds to follow a predefined path, guided by the line following array, which detects the black line path on the white reflective surface. This path navigation system is an essential component for efficient and accurate movement within a warehouse or distribution center.

The robot's ability to reach its desired location at cross junctions, guided by RFID tags, showcases the integration of technology for precise direction control. The Bluetooth module allows for remote command input, enabling users to direct the robot to specific destinations, such as "Godown 1." The robot scans RFID tags at cross junctions, collects data, and cross-references this data with the given location, ensuring it moves in the correct direction.

The inclusion of an ultrasonic sensor at the "Godown" location is a crucial element of the system. It senses the presence of goods, and the robot waits until the unloading process is complete before returning to its original starting position. This level of automation and accuracy reduces the need for human intervention in the logistics and warehousing process.

The described working and circuit diagram of the autonomous delivery robot presents a practical and efficient system for goods delivery in industrial settings. It demonstrates the seamless integration of various technologies, from sensors and microcontrollers to Bluetooth communication and RFID, to create a cohesive and reliable system. This innovation holds the promise of significantly enhancing efficiency, reducing errors, and increasing the level of automation in logistics and warehousing, aligning with the evolving needs of the modern supply chain. With further advancements and refinements, such robots have the potential to revolutionize logistics and warehousing, making operations more precise, efficient, and cost-effective.

6. CONCLUSION

In conclusion, the introduction of goods delivery robots has heralded a revolutionary era in the logistics and warehousing sector. These innovative machines are far from mere novelties; they represent a practical and profoundly impactful solution to the challenges encountered in today's modern supply chain. By automating the delivery of goods within warehouses and distribution centers, these robots have not only significantly reduced the need for human labor but have also minimized errors while simultaneously enhancing safety and scalability.

What is more, goods delivery robots have showcased their remarkable adaptability in various industries, from e-commerce giants to manufacturing plants, rapidly evolving into indispensable assets for managing the ever-increasing demands of a globalized market. Their ability to seamlessly collaborate with human operators, learn from their surroundings, and adapt to changing environments positions them as powerful allies in the realm of logistics.

As technology continues to advance, we can look forward to even more sophisticated and capable robots that will further redefine how goods are handled and transported. This evolution promises to drive the logistics industry to new heights of productivity and innovation. It is a future where precision, efficiency, and cost-effectiveness reign supreme, ensuring that goods delivery robots will continue to play a pivotal role in shaping the logistics and warehousing landscape for years to come.

7. FUTURE SCOPE

The future scope of autonomous delivery robots is filled with promise and opportunities for advancements in logistics and warehousing. These robots, as outlined in their working and construction, have the potential to shape the future of how goods are transported and delivered within industrial settings. Looking ahead, several avenues for development can be explored to enhance their capabilities. This includes the integration of advanced navigation and localization technologies like simultaneous localization and mapping (SLAM) and computer vision, enabling robots to adapt to dynamic environments and intricate routes. Incorporating artificial intelligence and machine learning can make them more adaptive and efficient, improving decision-making and route optimization. The future also holds the potential for multi-modal transport robots that can switch between different modes of transportation, from wheels to tracks, depending on the specific requirements. Collaborative robots (cobots) that work harmoniously with human operators are poised to become a significant part of future industrial settings. Moreover, the integration of the Internet of Things (IoT) devices will offer comprehensive monitoring of environmental conditions, security, and quality control. Fleet management solutions, energy-efficient components, human-robot interaction interfaces, regulatory standards, and industry-specific customization further contribute to the expanding role of these robots in revolutionizing the logistics and warehousing landscape. As technology evolves, autonomous delivery robots are set to play a pivotal role in driving efficiency, cost reduction, and safety in logistics and warehousing across diverse sectors.

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