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DEVELOPMENT OF A MOBILE PLATFORM WITH DIFFERENTIAL DRIVE FOR INDUSTRIAL APPLICATIONS

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Abstract: *This paper presents the design and development of the CANOE mobile robot, an automated platform designed for transport in controlled industrial environments. The robot utilizes a differential traction system known for its high maneuverability and is powered by two 350W brushless motors, integrated with an advanced suspension system capable of handling minor obstacles up to 20 mm. For precise navigation, the robot is equipped with a SICK TIM 510 LiDAR sensor and a mini-PC running ROS 2 (Humble Hawksbill), an open-source platform that facilitates sensor integration and dynamic control.*

Accurate movement is ensured by encoders mounted on both the motorized wheels and independent "dead wheels," eliminating the effects of slippage. The robust, H-shaped chassis provides stability, while modular PLA panels, produced via 3D printing, protect the internal components and allow for easy assembly and maintenance. Power is supplied by a custom-built battery pack with 18650 cells and a Battery Management System (BMS) that optimizes performance and ensures safe operation.

By incorporating 3D-printed components and open-source software, CANOE offers an affordable and scalable solution that reduces initial and maintenance costs. This modular and automated platform provides a viable alternative for material handling, addressing the challenges of traditional AGV systems and enabling the adoption of automated transport technologies across various industrial sectors.

Key words: *autonomous mobile robot*, *brushless motors, encoders, LiDAR*

1. INTRODUCTION

The goal of this research was to design a cost-effective and efficient mobile platform functioning as an Automated Guided Vehicle (AGV) utilizing differential locomotion. The robot is named CANOE and stands for Computerized Autonomous Navigation Oriented Equipment, reflecting its purpose as a versatile and intelligent platform designed for automated navigation and efficient task execution in diverse environments.

The increasing demand for AGVs in sectors such as manufacturing, warehousing, and logistics highlights their role in automating material handling, improving operational efficiency, and reducing labor costs [1], [2]. However, the significant expense of current AGV systems limits their broader adoption [3].

Traditional AGVs require substantial initial investments due to their reliance on complex navigation systems and extensive infrastructure modifications, such as magnetic tracks or specialized sensors. These factors significantly drive-up deployment costs, while ongoing maintenance and operational expenses further add to the financial burden [4], [5].

To address these challenges, this research proposes a mobile platform leveraging differential traction, a simpler and more adaptable approach to AGV design [6]. By using a differential drive mechanism, the platform achieves precise and reliable movement without requiring costly infrastructure changes. Its modular design ensures easy replacement of damaged components, minimizing downtime and reducing maintenance costs [7]. Additionally, a significant portion of the platform is 3D printed, enabling low-cost manufacturing, rapid prototyping, and customization. This approach ensures that parts can be quickly and affordably produced on demand [8], [9].

To enhance the system's flexibility and usability, the platform integrates ROS 2 (Robot Operating System) Humble Hawksbill, an open-source middleware. ROS 2 simplifies robot programming through a comprehensive collection of tools and libraries, avoiding the constraints of proprietary software. This open-source framework allows for easier updates and modifications, enabling continuous improvement and adaptation to evolving requirements [10].

This design approach reduces both initial and ongoing costs, making AGVs more accessible and practical for a wider range of applications [11], [12].

2. DRIVE TRAIN

The decision to use a differential traction system for the CANOE platform was driven by its simplicity, performance, and ability to pivot around its center axis, making it highly maneuverable and ideal for navigating tight spaces. To implement this system, 6.5-inch hoverboard motors were chosen for their efficiency and suitability for the platform's requirements.

Figure 1: Used brushless motor wheel

These motors operate at 36V and provide a nominal power of 350W with a maximum torque of 13.21 Nm, making them capable of handling the robot's weight and operational needs. They are lightweight at 3.1 kg each and feature solid, tubeless rubber tires, ensuring durability and reliability. Brushless and gearless, these motors reduce mechanical complexity and maintenance, offering high reliability and efficient power transmission directly to the wheels. Additionally, they support magnetic braking, which allows the robot to stop quickly and accurately—an essential feature for safety in industrial and logistical environments.

Each motor includes internal magnetic encoders with a resolution of 90 pulses per rotation, enabling precise control. To further improve the robot's performance, the motors are mounted on a suspension system with guided rails. This suspension allows the platform to handle obstacles up to 20 mm in height or depth while maintaining stability and smooth movement. This design ensures adaptability to uneven surfaces and enhances the robot's operational efficiency in various environments.

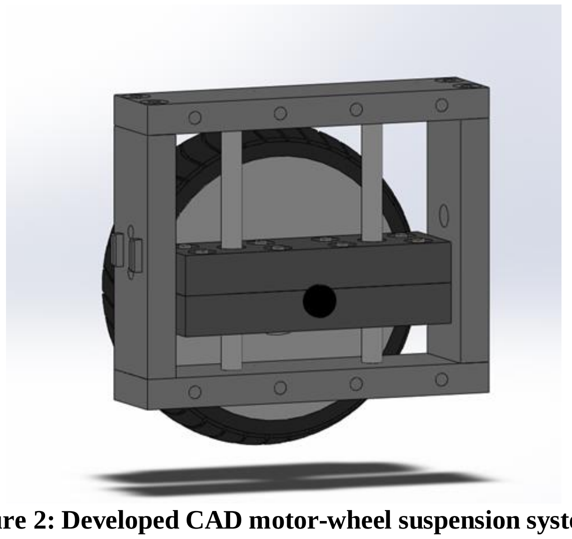

Figure 2: Developed CAD motor-wheel suspension system

To further enhance the robot's precision, dead wheel encoders are employed and mounted in the same configuration as the motors. These encoders, separate from the motor wheels, are designed to measure the exact distance traveled by the robot without being influenced by wheel slippage.

3. CHASSIS DEVELOPMENT

The chassis features a robust H-shaped design, providing a sturdy and balanced foundation for the robot. For enhanced stability, the platform incorporates four caster wheels, two located at the front and two at the rear.

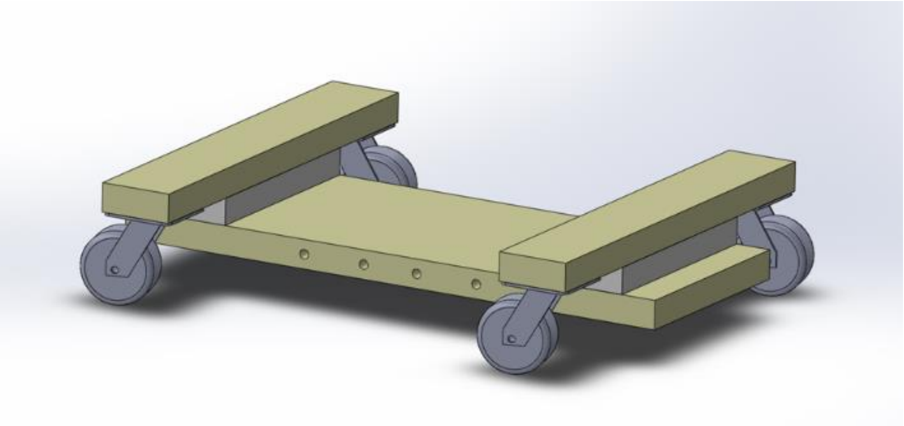

Figure 3: Chassis CAD model

Both the motor wheel suspension and the encoder wheel suspension are securely attached to the midsection of the chassis.

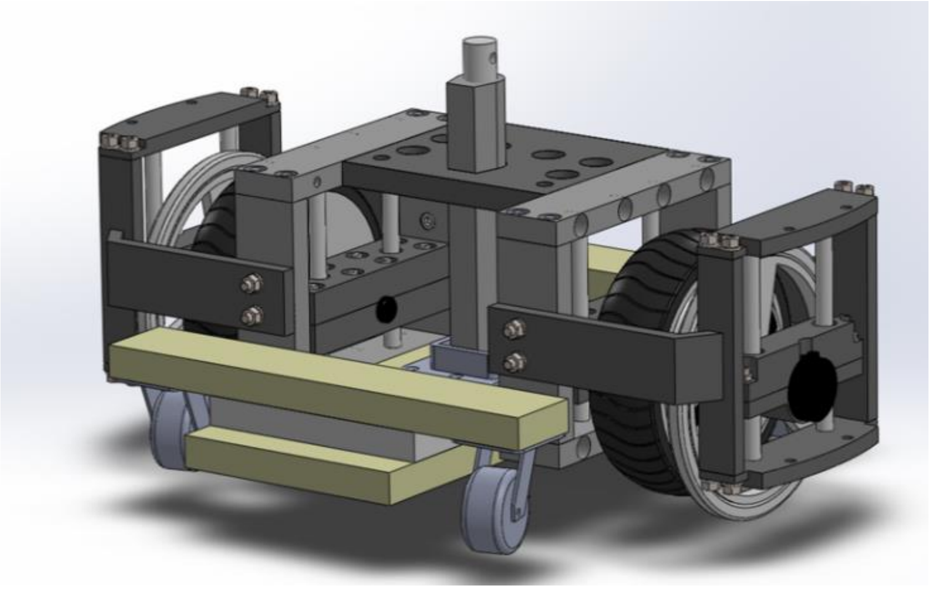

Figure 4: Robot platform after mounting the wheels on the chassis

4. COVER PLATES

The robot's chassis is enclosed with modular cover plates made of PLA (polylactic acid), which are mounted using a unique interlocking design. The plates are secured to the chassis via clips attached to two circular PLA rings, ensuring a firm and reliable fit.

The interlocking design of the rings and clips allows for easy assembly and disassembly without requiring additional tools. This modular setup facilitates quick access to internal components, streamlining maintenance and potential upgrades. The use of PLA not only ensures lightweight and durable covers but also supports cost-effective and rapid production through 3D printing. This innovative mounting system enhances the robot's modularity while maintaining structural integrity and ease of use.

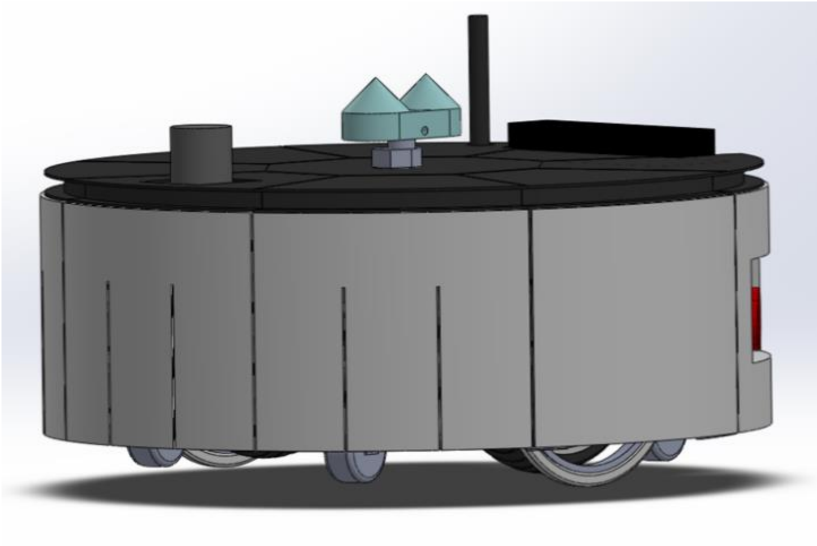

Figure 5: Robot platform after mounting the components

5. ELECTRONICS

The CANOE robot integrates several electronic components essential for its operation:

1. **Motor Drivers**: Two ZS-X11D1 brushless motor drivers control the motors, supporting magnetic braking and precise low-speed control.

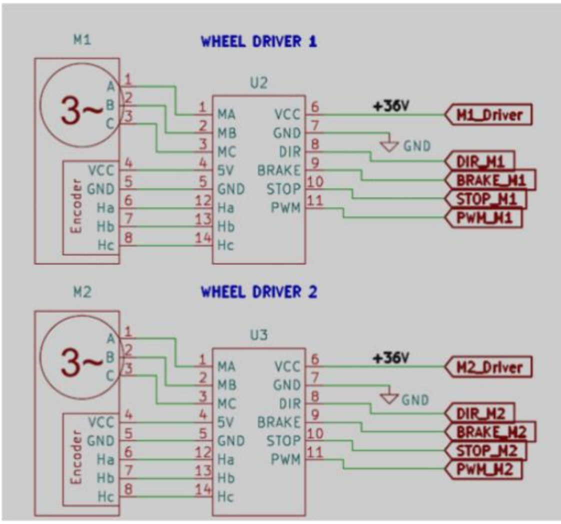

Figure 6: Motor conection to the drivers

2. **Collision Detection**: Nine KW11-3Z microswitches are used for mechanical collision detection, providing safety in operation.
3. **Human-Machine Interface (HMI)**: A control panel with an emergency stop button, on/off switch, XT-60 charging port, three customizable push buttons, and a key switch for secure operation.
4. **Microcontroller**: An ATmega2560 on an Arduino Mega board manages sensor inputs, motor control, and communication, offering sufficient connectivity and processing capabilities.
5. **LiDAR**: A SICK TIM 510 LiDAR enables navigation and obstacle detection, integrated with ROS for seamless operation.
6. **Mini-computer**: A Dell Optiplex 7050 runs ROS and processes data from the Arduino and LiDAR, allowing for autonomous and remote control.

7. **Power System**: A custom-built 18650 cell accumulator with a Dali BMS ensures stable power distribution and protection against faults. Step-down converters provide appropriate voltage levels for various components.

6. SOFTWARE

On the software side, the CANOE robot utilizes ROS 2 (Robot Operating System), Humble Hawksbill version, an open-source middleware specifically designed for robotic systems. ROS 2 provides an extensive set of libraries and tools that simplify programming, sensor integration, and motor control, making the platform highly adaptable and customizable.

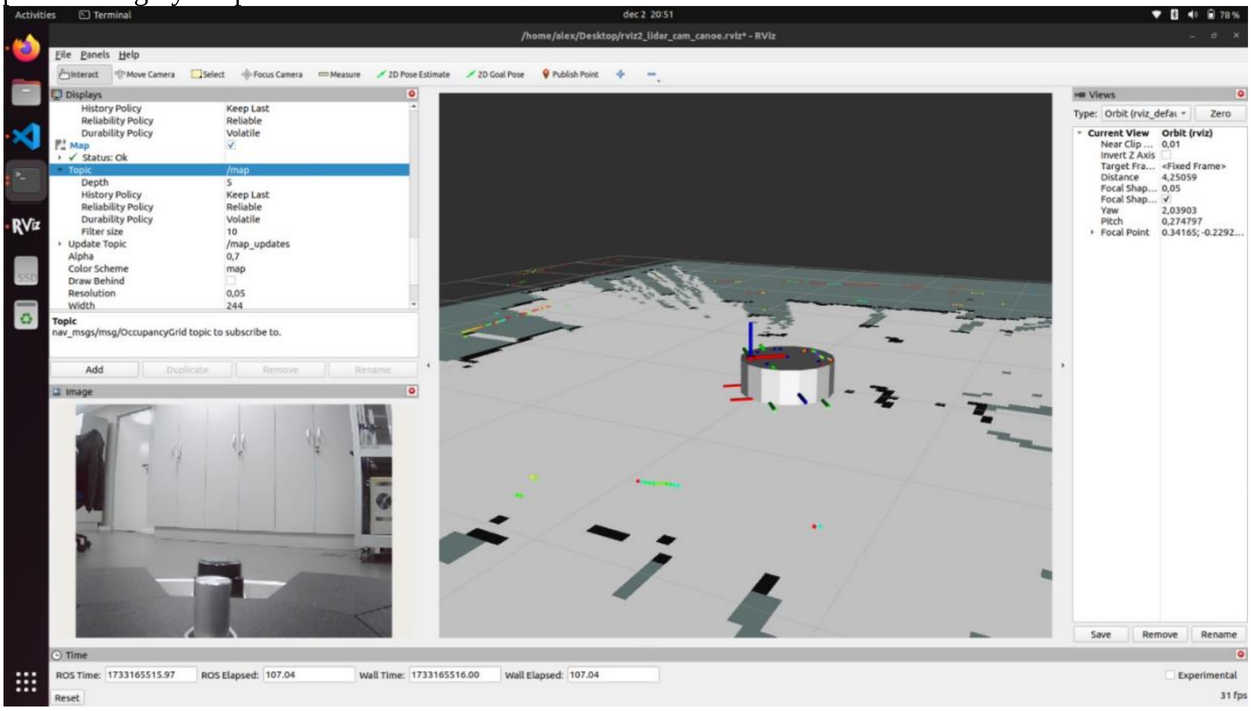

Figure 7: RVIZ2 robot mapping

For controlling the motor drivers and processing input from sensors and buttons, the robot utilizes the ATmega2560 microcontroller, integrated on an Arduino Mega board. This microcontroller handles all low-level operations, including managing PWM signals for the motor drivers, reading data from encoders, and responding to inputs from the collision detection microswitches and HMI panel buttons. The ATmega2560 is connected to the mini-PC via serial communication, enabling seamless data exchange. The mini-PC sends high-level commands to the microcontroller, while the ATmega2560 processes these instructions and provides real-time feedback on the robot's operational status.

7. CONCLUSIONS

The CANOE AGV platform is a cost-effective and versatile solution for automated material handling in controlled industrial environments. By utilizing 3D-printed components and a custom-built 18650 cell battery, the platform significantly reduces production costs, making it both affordable and easy to maintain. Its modular design ensures straightforward upgrades and expansions, allowing it to adapt seamlessly to various requirements.

The system's technological capabilities are highlighted by its differential traction system and 350W brushless motors, which provide precise and reliable navigation. The inclusion of a LiDAR sensor and an Arduino Mega microcontroller further enhances its functionality while simplifying programming. Designed with robustness and user-friendliness in mind, the CANOE platform focuses on simplicity across its mechanical, electrical, and software systems, ensuring ease of troubleshooting and maintenance.

By integrating open-source tools such as ROS 2, the platform offers flexibility and supports continuous improvement, making it a practical and future-ready solution. Its adaptable design positions CANOE as an innovative and efficient tool for diverse industrial applications, combining cost efficiency with high performance and scalability.

Figure 8: CANOE robot platform

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