Autonomous Navigation Mobile Robot using ROS, Jetson Nano, RP Lidar, and Differential Drive Kinematics

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***Abstract*—Robots have transformed logistics, manufacturing, and exploration by automating tasks like mapping, navigation, or exploring the world. Additionally. The project is focused on creating an autonomous navigation robot that incorporates the latest technologies, including the Robot Operating System (ROS), Jetson Nano for computation, and RP Lidar for environmental scanning. Using differential drive (included in the robot) kinematics, it will be capable of real-time decision making and precise movement. Path planning and obstacle avoidance. By utilizing Simultaneous Localization and Mapping (SLAM) to navigate through unfamiliar terrain, the robot will ensure safe and reliable navigation without collisions.**

Keywords— Autonomous Navigation Mobile Robot(ANMR), ROS, RPLidar, Jetson Nano, Differential Drive Mechanics

I. INTRODUCTION

Robotics Technology has been evolving at a greater pace in these recent years, with the development of Autonomous Robots using Mobile. The non-interaction and noninvolvement of human supervision may lead to the creation of new industries in logistics, farming, healthcare, automation. Tasks like mapping, navigation and moving are performed efficiently and with reliability. By using these new advanced technologies like Robot Operating System(ROS), Jetson Nano, RP Lidar, and the differential drive mechanics, builds a solid foundation in developing more versatile and flexible autonomous systems that can interact and make decisions in real-time. The main aspect of this project is to create a robot which can be handled using a mobile and can navigate through taxing environments by utilizing these technologies. The robot's ROS, sensor data processing, and RP Lidar scanning capabilities enable it to avoid obstacles with accuracy and speed. SLAM is utilized by the robot to navigate through unfamiliar terrain and map its surroundings without any risks, while also maintaining safety. This project has broad potential applications in various industries, where automating navigation tasks can improve efficiency, safety, and operational costs. By developing a functional prototype, the project seeks to expand the research on autonomous robotics and investigate practical applications that can be developed in the future.

II. METHODOLOGY

BLOCK DIAGRAM.

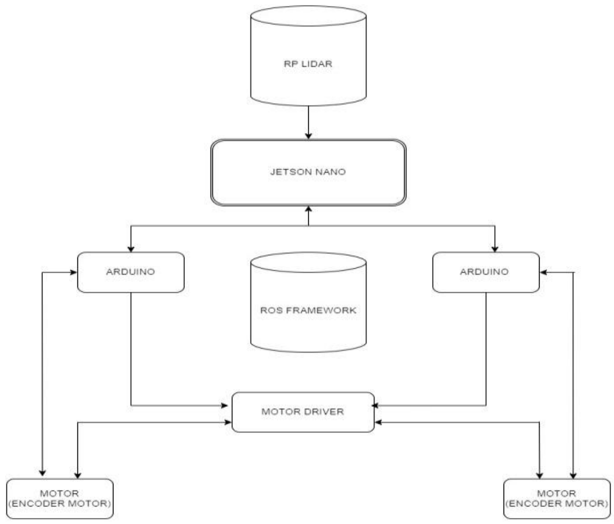


Fig 1.0 Block Diagram of Autonomous Navigation Mobile Robot

The presented a block diagram that illustrates the workings of an autonomous mobile robot. This provides a human-readable account of how the components work:

1. The RP Lidar (remote point perspective) sensor is used to scan the surroundings and provide 360 data about obstacles and surroundings. The robot's distance from objects is monitored by this sensor. What happens next?

2. Jetson Nano acts as the central point of control for the system, processing information from sensors on the RP Lidar. The implementation of advanced algorithms for detecting obstacles, mapping, and planning paths is possible. The system's communication channels enable effortless operation.

3. The Robot Operating System (ROS) is an open-source framework that provides different set of tools, libraries for facilitate development of a robotic software with seamless integration with different hardware and software components. Different modules can use libraries and tools provided by ROS to communicate, allowing for the implementation of more complex algorithms.
4. The system is composed of two Arduino boards. By converting Jetson Nano commands into high-level commands, they serve as the intermediary between the ROS framework and motor drivers.
5. Arduino boards, controlled by ROS and Jetson Nano, provide instructions to the motor driver that directs the movement of the components. It ensures that the motors are supplied with voltage and current to allow robots to rotate, move, or pivot.)
6. The encoder motors are the driving forces behind the robot’s movement. The system is informed about the degree of rotation of the motors by encoders that are linked to them. This feedback allows for the precise control of movement and speed in the robot.

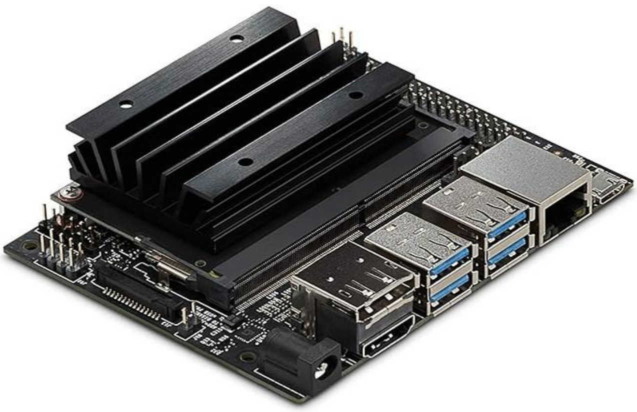
Summary: The environment is scanned by the RP Lidar and transmitted to Jetson Nano for analysis. By utilizing the ROS framework, Jetson Nano processes the data and sends it to its respective Arduino boards. These boards control the motor drivers and, once activated, move encoder motors that provide feedback to guide the robot. By using this system, the robot can steer itself and avoid obstacles.

Listed below are the key components.

1) RP Lidar A1-M8.

Designed for 2D mapping and obstacle detection, the new RP Lidar A1-M8 is a powerful LiSAR sensor that also consumes less power. It has a 360-degree scanning range that allows it to measure measurements from 0.15 to 12 meters and an impressive accuracy of 1% in 0.5m to 6 meters. The sensor's real-time environmental mapping and localization capabilities make it a popular choice for robotics, autonomous vehicles, and drone navigation. By using a serial interface, the A1 M8 is easily able to communicate with various microcontrollers and computing platforms. This makes it ideal for integration into robotic systems.

2) Nvidia Jetson Nano.

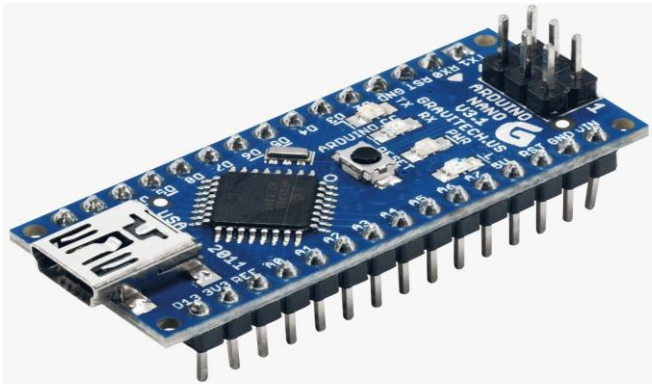


It is designed for AI and robotics, the Nvidia Jetson Nano is a computing platform is both powerful and compact. Featuring a quad-core ARM Cortex-A57.

Featuring a Maxwell processor with 128 cores, the device excels in deep learning and computer vision applications. The Jetson Nano is a powerful AI tool that can create autonomous and multi-dimensional systems, as it supports parallel multiple neural networks and TensorFlow and PyTorch.

Its vast ecosystem of peripherals and libraries, which caters to a wide range of applications from robotic devices to IoT systems, makes it primarily used by hobbyists or developers.

3) Arduino Nano.

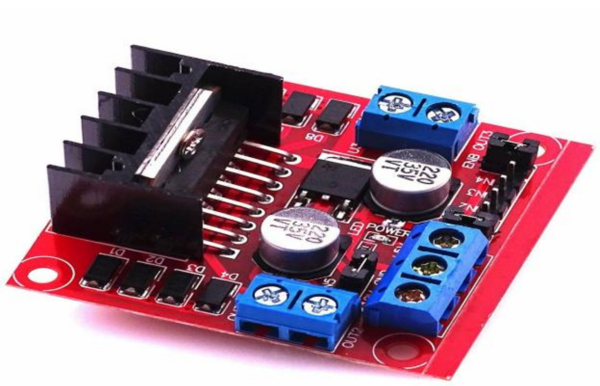


Using the ATmega328P microchip, the Arduino Nano is a small and easily breadboard-compatible microcontroller board that uses circuit breakers.

With 14 digital input/output pins, 8 analog inputs and a USB connection for easy power programming, the device is versatile. Both hobbyists and professionals favor the Nano due to its compact size, ease of use, and compatibility with the extensive Arduino ecosystem.

Small form factors are the determining factor for projects like robotics, wearables and home automation systems. Prototype and development of various kinds can be easily achieved by users with the help of a wide range of libraries and community support.

4) L298N 2A Based Motor Driver Module.



With the L298N motor driver module, a dual H-bridge driver is available that can handle up to two DC motors or one stepper motor with an output current of 2A per channel.

It has built-in diodes for back EMF protection and operates at voltages of 5V–35V. By enabling forward and reverse movement, the L298N motors can be controlled in both directions, making it a key element in robotics/automation projects. Interface: The module is easy to use with microcontrollers like Arduino and Raspberry Pi, and speed control via PWM signals.

5) Rhino GB37. The Servo Motor is an encoder that operates on a DC geared encodement, 12V 60RPM, and 10.4Kgcm.

A 12V DC geared, gear ratio Rhino #37 with a speed of 60 per cent is incredibly powerful. With a 10.4-place torque, you get 10,000 RPM.

What's the difference? Kgcm. An encoder-equipped motor is ideal for precise control of position and speed, making it suitable for applications that require precise motion control, such as robotics and automation.

It reduces speed but increases torque, creating power and efficiency. This is an independent design. It is a reliable and long-lasting solution for demanding tasks.

6) Wheels.

Mobility: Wheels are used in mobile robotic systems, which enable them to move around different terrains. The robot's size and material choice are determined by its intended application. Typically, wheels are constructed to decrease friction and increase traction in robotic applications.

Choosing the right type of wheels for the robot is crucial to its desired outcome, as these wheels will impact its mobility, balance, and control characteristics. Combined motor drivers with wheels allow for precise control of the vehicle's motion.

7) Ball Caster Wheel.

Essentially, it's the equivalent of a ball in tires that is mounted inside an otherwise stationary object to move smoothly through its surroundings.

This wheel is often used in robotics and automation systems because it can pivot freely in any direction.

This design also helps mobile robots navigate around tight spaces or sharp turns. Ball caster wheels offer greater stability, reduced weight, and resistance, making them ideal for balancing and mobility applications in robotic systems.

III. FINDING FROM LITERATURE SURVEY

From the literature survey following gaps are identified:

1) SLAM algorithm and LIDAR sensors enable the robot to map out and detect obstacles in areas it has not been exposed to before, providing real-time obstacle detection. It is effective even in chaotic and active settings.

2) The use of differential drive kinematics is effective for autonomous robots in controlled environments, such as warehouses or hospitals, but extra sensors or balance mechanisms are necessary for rough terrain or outdoor applications.

3) AI algorithms for navigation and decision-making can be powered by the Jetson Nano due to its ability to handle real-time image processing and sensor fusion. Researchers are actively working on optimizing power consumption and heat management.

4) An open-source and modular framework called ROS Framework, it is widely used to incorporate a variety of sensors and actuators. This allows for flexibility in experimentation with different robotic systems and navigation issues.

5) Combining advanced sensors like LIDAR with computational frameworks like Jetson Nano and ROS to create robots that can navigate and avoid obstacles in real time.

IV. GAP IDENTIFICATION

1) The sensitivity of differential drive kinematics is optimal for indoor environments with smooth surfaces, but not as effective in outdoor terrains with uneven surfaces. To overcome this issue, additional balance systems or alternative methods of locomotion like omnidirectional wheels or advanced suspension systems are necessary, as it can aid in navigation on uneven terrain.

2) Jetson Nano has strong AI and sensor fusion capabilities, but running computationally intensive algorithms like SLAM in real time can cause significant computational overhead. Processing delays may occur as environments or tasks become more complex, resulting in the robot's performance being compromised and potentially unwieldiness.

3) Discrimination and miscommunication may occur in environments where surfaces are reflective, transparent, or absorptive, making it difficult to use RP Lidar. Although the RP Lidar is suitable for many applications, adding complementary sensors (such as cameras or depth sensors) may make it more capable of handling these limitations and providing greater accuracy when used with other materials.

4) Managing Power and Heat: High power consumption and heat buildup in the Jetson Nano can severely affect the robot's performance when working for extended periods. The resolution of this shortcoming would entail more effective hardware design or optimization methods that optimize energy usage and heat dissipation, making it crucial for self-driving robots to function continuously without manual intervention.

5) Scalability is crucial for complex and dynamic tasks, as the system is designed to function autonomously in structured environments, but scalability becomes problematic when applied to more dynamic and unstructured environments. Changing conditions, such as those caused by multiple moving obstacles, may pose challenges for the adaptive algorithms and sensor systems required to accommodate real-world scaling.

Managing Real-Time Decisions: The robot's real-time path planning and obstacle avoidance mechanisms may face challenges or delays when working in highly active or dense environments. This may have to do with limitations on algorithms or computational resources at present.? Accuracy and speed of decision-making could be enhanced by implementing more efficient algorithms, such as predictive modeling or machine learning.

Integrated Data Fusion: The current system relies on navigation (Lidar) but accuracy could be greatly improved by using data from various sensors (cameras, IMUs etc.). Better decision making and overall robustness would be achieved by utilizing advanced sensor fusion techniques that enable the robot to operate more efficiently in complex environments or when visibility is reduced.

V. FUTURE SCOPE

The future prospects for this project are promising, thanks to significant progress in AI and robotics. These robots can perform tasks that require human coordination, real-time decision-making, and manipulation of objects in order to function properly due to ongoing advancements in Artificial Intelligence and Machine Learning. By utilizing advanced battery technology and energy efficiency, these robots can be utilized for disaster recovery and agricultural monitoring, which will enable them to perform tasks in remote areas with extended coverage time. Furthermore, 5G and edge computing could enable better communication between robots to central systems, allowing collaborative robotics and large-scale automation in logistics, healthcare, urban infrastructure. It also has scope to include self-driving vehicles, smart cities and the Internet of Things (IoT), in which mobile robots will be a key player in intelligent, interconnected systems

CONCLUSION

1) In conclusion, our UTV design will reduce human involvement in hazardous environments, will control the rover using radio-controlled devices or 4G based communication link, which gives user the ability to choose between preferred method.

2) Will perform the use of mobile rovers as UAV detection systems, as agricultural systems using machine learning and open cv, using AI model as per the use case, and providing flexibility to the user to choose the task as per the requirement and on the go.

3) Designed robot will carry 100+ kgs of weight through rough terrain and perform rescue and payload carrying tasks and perform surveillance operations. Multi model object movement tracking using sort algorithms and assigning unique ids so it can systematically target the targets.

4) It also allows wide range of drones to be carried for various purposes such as surveillance, target destruction, payload carrying via air etc., because of the tube launched drone feature, which allows and proves the concept and ability of a UTV to act as unmanned drone carrier which can house up to 4 tube launched drones without the need of human operator.

5) Improving efficiency in agricultural lands by allowing selective targeting of weeds, pests or even simple tasks such as watering the plants, etc. via user selectable modes of AI model, and a dedicated 100+ kg payload bay to store payload

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