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AUTONOMOUS SECURITY PATROL ROBOT

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Abstract:

This paper focuses on designing an autonomous surveillance robot for military, institutional, and wildlife monitoring. The robot's applications include monitoring military camps, border areas, weapons depots, and tracking animal activities in forests without requiring human intervention. The project utilizes a Raspberry Pi module for multi-processing tasks such as image recognition, obstacle detection, and self-navigation. The robot's capabilities are geared towards enhancing security and surveillance efficiency, making it a valuable solution for various scenarios. The integration of advanced technologies, including artificial intelligence, enables the robot to operate autonomously in dynamic environments. This paper outlines the design, hardware components, and software architecture of the robot, showcasing its effectiveness in addressing surveillance challenges across diverse domains.

Keywords: Robotics, Self navigation robot, Autonomous surveillance robot

I. Introduction

Introducing the "Autonomous Security Patrol Robot," a project driven by our ambition to reshape the landscape of surveillance technology. Through the integration of automation and state-of-the-art sensors, this initiative pioneers autonomous patrols, incorporating self-mapping capabilities with LIDAR, real-time image recognition, GSM alerts, and a self-charging mechanism. Its applications extend beyond conventional surveillance, spanning military operations, institutional safety, wildlife tracking, and institutional monitoring. This vehicle excels in proactive security measures, environmental monitoring, and rapid hazard detection, representing a significant leap in technological achievement. It reflects our steadfast commitment to enhancing safety and security across diverse contexts.

II. METHODOLOGY

2.1Existing system:

The current surveillance methodology relies on a combination of manual surveillance personnel, strategically positioned CCTV cameras, and remote-controlled robots for aerial and ground surveillance. Human security staff play a pivotal role in monitoring and patrolling designated areas, promptly responding to security threats.

Closed-circuit cameras offer extensive visual coverage, monitored by human operators who intervene in case of suspicious activities. Remote-controlled robots enhance mobility and access to difficult terrains, capturing video footage and images. However, the existing methodology involves manual charging with human assistance to replenish the robots' power.

2.2 Proposed system:

In our proposed surveillance system, we enhance the efficiency and autonomy of surveillance processes. Human security personnel receive support through intelligent tools, refining their capacity to monitor and respond swiftly to security threats. Our CCTV cameras integrate advanced image processing for autonomous threat detection. We aim to empower robots with advanced AI algorithms for autonomous decision-making during surveillance missions. Our vision extends to a collaborative communication infrastructure with redundant systems for uninterrupted data transmission. For charging, we implement wireless power charging using primary and secondary coils along the robot's path, streamlining recharging and minimizing downtime.

2.3 Components:

Raspberry Pi 3: This essential component functions as the central processing unit, orchestrating data processing and communication throughout the surveillance system. Its versatility and computational power make it the brain behind the robot's operations.

Arduino Mega and L298 Motor Driver: The Arduino Mega, coupled with the L298 motor driver, forms the control hub for the robot's movement. These components work in tandem to manage the DC gear motors with encoders, allowing for precise control over the robot's navigation.

Battery:

Powering the entire surveillance system, the rechargeable battery ensures prolonged operational periods, guaranteeing sustained functionality during surveillance missions.

DC Gear Motors with Encoders:

These motors are the driving force behind the robot's movement. Equipped with encoders, they not only enable precise control but also provide crucial feedback on the robot's velocity, facilitating effective navigation.

LiDAR Sensor:

Employing Simultaneous Localization and Mapping (SLAM) technology, the LiDAR sensor maps the robot's surroundings in real-time. This data is vital for spatial awareness, enabling the robot to navigate autonomously and make informed decisions.

Primary and Secondary Coils:

Integral to the wireless charging system, these coils facilitate contactless recharging. The primary and secondary coils play a crucial role in ensuring the robot's autonomy by simplifying the charging process.

2.4 Working Mechanism:

Chassis Movement: Two gear motors, seamlessly integrated into the robot's chassis, are intricately controlled by the Arduino Mega and L298 motor driver. This sophisticated setup ensures smooth and precise movement, a fundamental aspect of effective surveillance.

kinematic movement of a wheel can be described using the formula:

$$v = \omega . r$$

Where:

v is the linear velocity of the wheel,

ω is the angular velocity (angular speed) of the wheel,

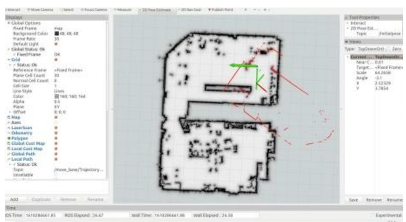
r is the radius of the wheel.

This formula relates the linear velocity of a point on the edge of a rotating wheel (v) to the angular velocity of the wheel (ω) and the radius of the wheel (r). It's commonly used in robotics and mechanics to understand the relationship between the rotational motion of a wheel and its linear motion.

Li-DAR Integration: The Raspberry Pi 3 establishes a robust connection with the LiDAR sensor through USB. Leveraging SLAM, this integration provides the robot with a dynamic spatial understanding, translating into accurate linear and angular velocity for seamless navigation.

Simultaneous Localization and Mapping (SLAM) with Li-DAR for Autonomous Navigation

Our research focuses on implementing SLAM with LiDAR technology, allowing our robotic system to navigate and map unknown environments simultaneously. LiDAR generates a point cloud by emitting laser pulses, providing real-time spatial data. Through data fusion with odometry, the system achieves accurate mapping and localization. Feature extraction identifies distinctive points, contributing to continuous map refinement. Challenges like loop closure and computational demands are addressed. SLAM with LiDAR finds broad applications in robotics, autonomous vehicles, and drones, signifying a pivotal technology for advancing autonomous navigation



ROS Integration:

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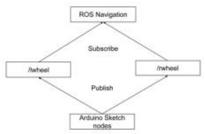


The Robot Operating System (ROS) master serves as the communication bridge between the Raspberry Pi 3 and the motors. This integration is fundamental, allowing the motors to interpret velocity commands from the ROS master and execute precise movements along both linear and angular axes.

Camera Module:

Fixed atop the robot, the camera module is a critical sensory element. Its role extends beyond surveillance to human and anomaly detection within the robot's surroundings, enhancing situational awareness.

Alert System:

In the event of human or anomaly detection, the system triggers an alert through the GSM module. This mechanism ensures that relevant data reaches a designated mobile phone promptly, enabling quick responses to potential security incidents.

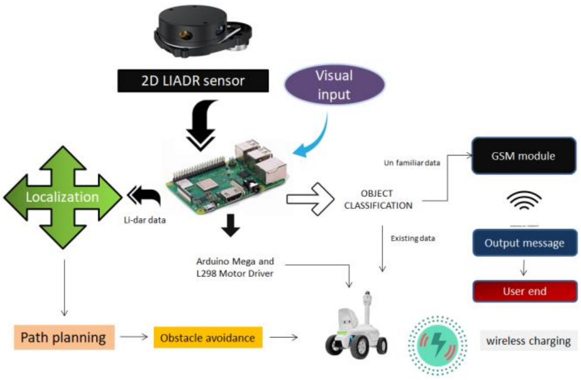
Wireless Charging:

The self-charging system relies on winding coils. This innovative approach enables contactless charging, ensuring the robot's sustained operational capability without the need for manual charging interventions

Anomaly Detection using Image Processing Integrated with GSM Module Alert System:

Our methodology centers on the fusion of image processing techniques with a responsive GSM module, offering a comprehensive solution for anomaly detection in surveillance scenarios. The image processing pipeline, comprising preprocessing, edge detection, object segmentation, feature extraction, and classification, forms a coherent framework for precise anomaly identification within captured images. This streamlined approach not only enhances computational efficiency but also ensures accurate and reliable results. Upon detecting an anomaly, the system triggers the GSM module, initiating the composition and transmission of immediate and informative alerts. These alerts, including details such as the type and location of the anomaly, are swiftly delivered to designated recipients. This integrated system, seamlessly linking image processing to GSM alert transmission, guarantees a swift and effective response to potential security threats, thereby enhancing the overall surveillance capabilities across diverse operational scenarios.

The subsequent flowchart elucidates the operation of the autonomous robot and its procedural steps.



III. Conclusion

In conclusion, our autonomous surveillance robot project represents a significant advancement in the realm of security technology. By seamlessly integrating cutting-edge components such as Raspberry Pi 3, Arduino Mega, LiDAR, and GSM modules, we have created a versatile system capable of autonomous navigation, anomaly detection through image processing, and real-time alerting. The use of SLAM with LiDAR enhances the robot's spatial awareness, enabling it to navigate complex environments with precision. The integration of wireless charging ensures sustained operational autonomy. Our innovative approach, from wheel kinematics to anomaly detection, reflects our commitment to enhancing surveillance capabilities in various domains, including military, institutional monitoring, and wildlife tracking. The successful implementation of this project underscores its potential for real-world applications, contributing to the ongoing evolution of autonomous surveillance technology.

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