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Design and Fabrication of Metal Sensor Integrated All Terrain Robot with Live Streaming

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ABSTRACT

The robot is designed to traverse various terrains, detect metallic objects, and provide real-time video streaming for remote monitoring and surveillance applications. The all-terrain robot is equipped with a robust chassis and ruggedized wheels to ensure efficient locomotion across different surfaces, including rough terrain, gravel, sand, and uneven landscapes. The high-torque motor system incorporated into the robot enables it to overcome obstacles and steep inclines with ease, ensuring reliable performance in challenging environments. To drive the high-torque motors employed in the robot's locomotion system, a 10A brushed motor driver is utilized. This motor driver provides the necessary power and control signals to efficiently drive the motors, ensuring precise movement and maneuverability of the robot. The 10A brushed motor driver offers robust performance and protection features, safeguarding the motors from overcurrent or voltage abnormalities. To facilitate metal detection, the robot is equipped with a dedicated sensor system capable of detecting metallic objects within its vicinity. This sensor system utilizes electromagnetic principles to identify and locate metallic targets, providing valuable information about the presence and approximate location of such objects. The metal detection capability enhances the versatility of the robot by enabling applications such as search and rescue, archaeological exploration, and industrial inspections. Furthermore, the all-terrain robot is equipped with a live streaming feature, which allows real-time video transmission to a remote location. This feature enables users to monitor the robot's surroundings and activities remotely, enhancing situational awareness and facilitating decision-making in various scenarios. The live streaming capability is achieved through the integration of wireless communication technologies, enabling seamless transmission of video data over a network connection.

Keywords: Terrain robot, Metal sensor, Live streaming, High torque motors, 10A motor driver.

1. INTRODUCTION

The concept of all terrain robot's dates back to the mid-20th century when the field of robotics started gaining prominence. Initially, robots were primarily designed for industrial applications, confined to controlled environments like factories and assembly lines. However, as technology advanced, there arose a need for robots that could operate in challenging and unpredictable terrains. This led to the development of all terrain robots capable of traversing various landscapes, including rugged terrains, uneven surfaces, and harsh environments. All terrain robots are robotic systems designed to navigate and perform tasks in challenging and hostile terrains where conventional wheeled vehicles or humans may face difficulty or danger. These robots are equipped with specialized features such as durable chassis, rugged wheels or tracks, advanced sensor systems, and intelligent control algorithms, enabling them to traverse a wide range of terrains like rocky surfaces, steep inclines, dense forests, deserts, or even underwater environments. The motivation behind the development of all terrain robots stems from the need to explore and operate in environments that are hazardous, remote, or inaccessible to humans. These robots are instrumental in several domains, including search and rescue operations, disaster response, military applications, scientific exploration, environmental monitoring, and industrial inspections. By deploying all terrain robots, humans can minimize risks, collect valuable data, and accomplish tasks efficiently in extreme or unreachable locations. The need for all terrain robots arises from various factors. First and foremost, they can be deployed in disaster-stricken areas where infrastructure may be damaged or dangerous for human intervention. All terrain robots enable search and rescue teams to locate survivors, assess damage, and provide aid in a timely manner. Additionally, these robots are essential in exploration missions, whether it is studying uncharted terrains, collecting samples from remote locations, or monitoring ecological systems in challenging environments. Furthermore, all terrain robots have significant military applications. They can be utilized for reconnaissance, surveillance, and demining operations in hostile territories without endangering human lives. In industrial sectors, all terrain robots are employed for inspection and maintenance tasks in hazardous environments, such as nuclear facilities, oil rigs, or chemical plants. Despite the advancements in all terrain robot technology, several challenges persist. Some of the key issues include improving mobility and locomotion on diverse terrains, enhancing the robot's ability to withstand extreme weather conditions, increasing battery life and energy efficiency for extended operations, and developing robust sensing and perception systems for accurate environment analysis. Moreover, there is a continuous need to enhance the robot's autonomy, decision-making capabilities, and human-robot interaction interfaces to ensure seamless operation and task execution. Addressing these challenges will pave the way for more reliable, efficient, and versatile all terrain robots, thereby expanding their applications and enabling breakthroughs in various fields.

2. LITERATURE SURVEY

Zhang, Guoteng, et al. (2023) introduced Q-Whex, a simple and highly mobile quasi-wheeled hexapod robot, in the Journal of Field Robotics. The robot combines the advantages of wheeled and legged locomotion, enabling it to traverse diverse terrains efficiently. Wang, Zhe, Jianwei Zhao, and Gang Zeng (2022): In their paper published in Sensors, the authors presented the modeling, simulation, and implementation of an all-terrain adaptive five-degree-of-freedom (DOF) robot. The robot was designed to adapt to various terrains, enhancing its mobility.

Wisth, David, Marco Camurri, and Maurice Fallon (2022) proposed VILENS, a sensor fusion framework combining visual, inertial, lidar, and leg odometry for all-terrain legged robots, in the IEEE Transactions on Robotics. The framework aimed to improve the localization and mapping capabilities of legged robots in challenging environments.

Kuncolienkar, Aditya, Siddhant Panigrahi, and Asokan Thondiyath (2022) developed a multibody dynamics framework for evaluating the performance of an all-terrain rover. The framework allowed for detailed analysis of the rover's dynamics and interaction with the terrain.

Hrabar, Ivan, Goran Vasiljević, and Zdenko Kovačić (2022) estimated the energy consumption of an all-terrain mobile manipulator for operations in steep vineyards in their paper published in Electronics. Their work aimed to optimize the energy efficiency of the manipulator while performing vineyard-related tasks. Chou, Hsiao-Yang, et al. (2022) developed and evaluated an autonomous agricultural all-terrain vehicle for field experimental rollover simulations, as presented in Computers and Electronics in Agriculture. The vehicle aimed to improve safety and efficiency in agricultural operations. Gilligan, Rebecca (2023) presented the design of an All-Terrain Aerial Robotic Interface (ATARI) as a collaborative platform for UAVs. The platform aimed to enhance the capabilities and applications of UAVs in diverse terrains. However, the paper did not provide details regarding any drawbacks or limitations of the ATARI design.

Guo, Wenzhi, et al. (2022) introduced TALBOT, a track-leg transformable robot, in Sensors. The robot could switch between a tracked configuration for traversing rough terrains and a legged configuration for agile movements. McMahon, Troy, et al. (2022) proposed terrain-aware learned controllers for sampling-based kinodynamic planning over physically simulated terrains. Their approach utilized learned controllers that took terrain information into account, improving the efficiency and reliability of motion planning for robots operating in complex environments. Chen, Ya, et al. (2022) presented the design and motion analysis of a mobile robot based on linkage suspension. The robot utilized a linkage mechanism for suspension, enabling it to adapt to uneven terrains and improve stability.

3. PROPOSED METHODOLOGY

Figure 1 shows the proposed block diagram. The all-terrain robot is designed to move smoothly on different surfaces like rough terrain, gravel, sand, and uneven landscapes. It has a strong frame and durable wheels to ensure it can handle these challenging environments. The robot is equipped with powerful motors that provide high torque, allowing it to easily overcome obstacles and climb steep slopes. One of the robot's key features is its ability to detect metallic objects in its vicinity. It has a special sensor system that uses electromagnetic principles to identify and locate metal targets. This allows the robot to provide valuable information about the presence and approximate location of metal objects. This metal detection capability opens up various applications for the robot, including search and rescue operations, archaeological explorations, and industrial inspections.

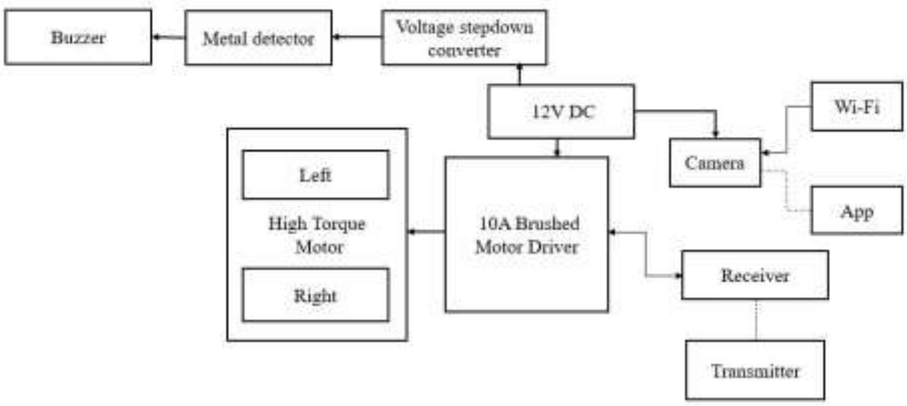

Figure 1. Proposed block diagram.

Additionally, the robot is equipped with a live streaming feature, enabling it to transmit real-time video to a remote location. This feature allows users to remotely monitor the robot's surroundings and activities, providing better situational awareness and assisting in decision-making. The live streaming capability is made possible through the integration of wireless communication technologies, ensuring smooth transmission of video data over a network connection. To power the high-torque motors used for the robot's movement, a 10A brushed motor driver is employed. This motor driver not only supplies the necessary power but also controls the motors with precision. It ensures the robot moves accurately and can easily maneuver through different terrains. The 10A brushed motor driver also includes protection features that safeguard the motors from any potential damage caused by overcurrent or voltage issues.

Step 1: Chassis and Mechanical Design: Design and fabricate a robust chassis capable of accommodating the necessary components and providing structural integrity. Select and install ruggedized wheels suitable for all-terrain traversal, ensuring optimal traction and durability.

Step 2: Motor System Integration: Choose high-torque motors capable of providing sufficient power for the robot's locomotion across different terrains. Mount the motors securely onto the chassis, ensuring proper alignment and connection with the wheels. Connect the high-torque motors to the 10A brushed motor driver to enable precise control and power management.

Step 3: Metal Detection System: Select an appropriate metal detection sensor system based on the desired range, sensitivity, and detection principles (e.g., electromagnetic induction). Integrate the metal detection sensor system onto the chassis, positioning it in a suitable location for optimal coverage and proximity to the ground.

Step 4: Establish the necessary electrical connections between the metal detection sensor system and the robot's main control system.

Step 5: Live Streaming Functionality: Choose a suitable camera module capable of capturing high-quality video in real-time. Integrate the camera module onto the robot, ensuring proper alignment and stability. Establish a wireless communication module (such as Wi-Fi or cellular) to enable video streaming capabilities. Develop the necessary software and protocols to encode, transmit, and receive the video stream in real-time.

Step 6: Control System Development: Design and implement a control system architecture for the robot, incorporating motor control, metal detection, and live streaming functionalities. Develop the necessary algorithms and software modules to control the motor system, enabling smooth movement, obstacle avoidance, and maneuverability. Implement signal processing algorithms to interpret and analyze data from the metal detection sensor system, providing accurate information about detected metallic objects. Integrate the live streaming functionality into the control system, ensuring seamless transmission of video data to the remote monitoring location.

Step 7: Power and Electrical Systems: Select appropriate power sources, such as batteries, capable of providing sufficient voltage and current for the robot's operation. Design and implement a power management system to regulate and distribute power to the various components, ensuring efficient operation and protection against overcurrent or voltage abnormalities. Establish proper electrical connections and wiring to connect the power sources, motors, motor driver, metal detection system, camera module, and communication modules.

Step 8: Testing and Validation: Conduct extensive testing of the robot's locomotion capabilities across various terrains, verifying its ability to overcome obstacles, handle inclines, and maintain stability. Test the metal detection system's performance by evaluating its ability to detect and locate metallic objects accurately. Validate the live streaming functionality by monitoring the video stream quality, latency, and reliability under different network conditions.

Step 9: Refine and optimize the control system algorithms and parameters based on the test results to ensure efficient and reliable operation.

3.1 Methodology

The all-terrain robot consists of several key technical components that enable its functionality:

Chassis and Wheels: The robot is built with a sturdy chassis that provides structural integrity and support for the other components. It is designed to withstand the challenges of various terrains. Ruggedized wheels are attached to the chassis, ensuring optimal traction and durability during locomotion.

High-Torque Motor System: The robot is equipped with high-torque motors that deliver significant rotational force. These motors provide the necessary power to propel the robot across different surfaces, including rough terrain and steep inclines. They are carefully mounted and connected to the wheels, ensuring a reliable and efficient transfer of torque.

Metal Detection Sensor System: The robot features a dedicated sensor system designed to detect metallic objects in its surroundings. This sensor system operates based on electromagnetic principles, enabling it to identify and locate metal targets. It provides valuable information about the presence and approximate location of metallic objects, enhancing the versatility and functionality of the robot.

Live Streaming Functionality: The robot is equipped with a camera module that captures high-quality video in real-time. This module is integrated into the robot, allowing it to stream live video to a remote location. Wireless communication technologies, such as Wi-Fi or cellular connectivity, are incorporated to facilitate seamless transmission of the video data over a network connection.

10A Brushed Motor Driver: To control the high-torque motors effectively, a 10A brushed motor driver is utilized. This motor driver serves as an intermediary between the robot's control system and the motors. It provides the necessary power and control signals to the motors, enabling precise movement and maneuverability. The motor driver also incorporates protection features to prevent damage to the motors from overcurrent or voltage abnormalities.

3.2 Hardware modules

- Arduino UNO controller
- 10-CH transmitter & receiver
- High torque motor
- 10A Motor Driver
- Wifi Camera
- Power supply
- Robot body chassis
- CNC laser cutting
- CNC metal bending
- 3D printed brackets, clamps and sloid parts

3.3 Software modules

1. Catia V5
    - Mechanical design

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- Parts design
- Sketcher
- Assembly design
- Drafting
- Generative sheet metal design

2. Arduino IDE

4. RESULTS

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5. CONLUSION

In conclusion, the all-terrain robot with metal detection and live streaming capabilities offers a versatile and powerful solution for various applications. With its robust chassis, ruggedized wheels, and high-torque motor system, the robot can traverse challenging terrains and overcome obstacles with ease. The 10A brushed motor driver ensures precise control and manoeuvrability of the robot's movements while providing protection against overcurrent and voltage abnormalities. The dedicated metal detection sensor system enhances the robot's capabilities by allowing it to detect metallic objects within its surroundings. This feature opens up possibilities for applications such as search and rescue operations, archaeological explorations, and industrial inspections, where the detection and localization of metal objects are crucial. The integration of a live streaming feature enables real-time video transmission to a remote location, providing users with the ability to monitor the robot's activities and surroundings remotely. This enhances situational awareness and facilitates decision-making in various scenarios, making the robot an effective tool for surveillance and monitoring applications.

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