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Quadruped Robot Used for Search and Rescue Operations

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ABSTRACT :-

This research paper provides an in-depth overview of quadruped robots, focusing on their design, control, and applications. The popularity of quadruped robots has grown rapidly in recent years due to their ability to navigate difficult environments and perform tasks that are impossible or challenging for wheeled or bipedal robots.

The paper examines various types of quadruped robots, including those with hydraulic, pneumatic, and electric actuators. It also explores the design considerations for each type of actuator, such as weight, power consumption, and torque capabilities. Furthermore, the paper discusses different control strategies, including model-based, learning-based, and hybrid approaches, and the challenges associated with each method. The article also delves into the applications of quadruped robots, including search and rescue, exploration, agriculture, and military operations. It highlights the unique advantages of quadruped robots in each application and the challenges that come with implementing them. Overall, the paper provides a comprehensive overview of the state-of-the-art in quadruped robot development, showcasing significant advancements and potential future directions for this field.

As part of this research project, the robot was built using open-source software and hardware such as Arduino Uno, Bluetooth Module HC-06, Arduino sensor shield, and servo-motors. The primary objective of the project was to create an autonomous walking robot to avoid human risks in dangerous areas. The paper outlines the benefits of using such a robot and the hardware and software used to build it.

Overall, this research paper provides a detailed analysis of quadruped robots, their design, control, and applications. It covers different types of quadruped robots, including their actuators and the design considerations, as well as various control strategies and challenges. The article also explores the different applications of quadruped robots, highlighting their unique advantages in various fields. Finally, the paper outlines the hardware and software used to build an autonomous walking robot to avoid human risks in dangerous areas.

I. INTRODUCTION

1. Introduction

Search and rescue missions can often involve perilous environments that are inaccessible or dangerous for human responders. As a result, there has been a growing interest in utilizing robots for search and rescue operations, especially in situations where human rescuers are at risk. One promising technology in this field is quadruped robots, which have four legs like animals, allowing them to navigate through rough terrain and overcome obstacles, making them an ideal option for search and rescue missions in challenging environments like natural disasters, collapsed buildings, or hazardous material incidents.

The objective of this research project is to create a quadruped robot specifically designed for search and rescue missions. The robot will be outfitted with various sensors to aid in navigating through complex environments and locating survivors. It will also have the capability to perform tasks like lifting and moving debris, providing medical aid, and communicating with human responders.

This research project has the potential to make a significant impact in the field of search and rescue operations by developing a robot that can effectively assist human responders in dangerous environments. By capitalizing on the distinctive capabilities of quadruped robots, the speed and efficiency of search and rescue missions can be improved, leading to more successful outcomes and ultimately saving more lives.

Top of Form

2.Objective

The aim of the project is to develop a quadruped walking robot that can perform tasks in dangerous areas, reducing the risk to human life. Quadruped robots are known for their excellent mobility in rough terrain, and this project aims to present an innovative, modular, and cost-effective design for locomotion, search, research, and obstacle avoidance purposes.

3.Problem Definition

In recent times, there has been a rise in criminal activities worldwide, creating a need for reliable surveillance technology. The areas with such activities rely on fixed surveillance technology that can be easily tampered with. The current surveillance methods in dangerous areas are mainly carried out by border security forces, using technologies such as UAVs and tracked-wheeled robots. However, these technologies have limitations and cannot perform tasks effectively. A quadruped walking robot can provide a solution to this issue by reducing the risk to human life and making it ideal for surveillance and rescue operations.

II. LITERATURE SURVEY

1.“Design of four pedal quadruped robot” by M. Nandhini; V. Krithika; K. Chittal

A quadruped is a type of locomotion where an animal or machine moves on four legs. This term, which means "four feet," is commonly used to describe animals such as mammals and reptiles that move in this way. This project focuses on the design and programming of a quadruped robot, which mimics the movement of animals with four legs. The robot is designed to walk and run, depending on the motor speed, and its walking gaits are manually developed using C-language and compiled in the Arduino IDE. The project aims to provide a detailed insight into the technical and programming aspects of creating a walking robot that resembles a four-legged animal.

2.“Design and conception of Arduino based quadruped robot”by S.RajeshBabu,K.SenthilKumar,G.Sabari Narayanan R.Raja K.Anbazhagan H.Yasar Sathab

Mobile robots have the ability to move around freely and are not restricted to a fixed location. They can operate autonomously, without any need for regulation. The use of mobile robots has gained importance in various fields, such as warehouses, hospitals, industries, military, and security purposes. There are mainly three types of mobile robots: legged, wheeled, and tracks follower. Legged robots use mechanical limbs for motion, which makes their movement more complex than wheeled robots. They are particularly well-suited for traversing rough terrain.

3.“Design and development of a structurally stable quadruped robot surveillance”by Nakul Yadav, Tejasvi Raina, Naman Gupta and Nikhil Vivek Shrivas

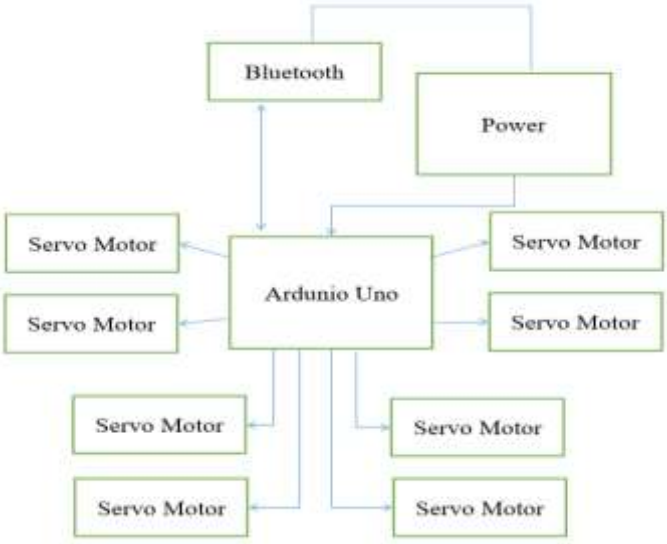
Quadrupedal creatures possess the unique ability to access environments that are otherwise inaccessible to humans and other organisms. Leveraging such attributes, this project aims to develop a quadrupedal robot capable of diverse motions, including traversing various terrains in all directions, as well as ascending and descending over obstacles. Given that the actuation system is the primary contributor to a mobile robot's weight, the challenge lies in using an appropriate number of actuators to minimize the robot's weight. This project's mechanism emulates the locomotive motion of typical quadrupeds, using a reduced number of actuators to decrease both the weight and cost of the robot.

4. “Mobile structural health monitoring using quadruped robots” by kaySmarsly, Kosmas Dragos, Marc Wenner

presents a MATLAB Simulink model of a quadruped robot, along with its remote control and monitoring user interface. The interface has been developed using Internet of Things principles on a Node-Red Flow and FRED-Cloud Server. The rapid development of robotics and automation has been a major driver of Industry 4.0, replacing manual supervision and operation in industrial and manufacturing processes worldwide. By integrating advanced robots with computer-based software for automation, tasks have become easier to manage in short periods, and efficiency has increased significantly. Quadruped robots are highly stable and mobile, making them valuable assets on different terrains with minimal subtle changes.

III. PROPOSED METHODOLOGY

1. System Block Diagram



i. Block Diagram

Components:-

a. Arduino Uno microcontroller

The Arduino Uno is a microcontroller board that runs on the ATmega328P (datasheet). This board has 14 pins for digital input/output (6 of which can be utilized as PWM outputs), 6 inputs for analog signals, a 16 MHz quartz crystal, a USB port, a power jack, an ICSP header, and a reset button.

b. Arduino Sensor Shield V5.0

The Arduino Sensor Shield is a board designed to work with Arduino Boards and features a standard header layout. It allows for the connection of sensors, servos, and LCD screens to the Arduino board without the need for soldering. The board is connected to the Arduino Board using jumper wires. The latest version of the sensor shield, V5, includes an external power connector to prevent overloading the Arduino board when working with a large number of actuators and sensors.

c. Sensors and modules

The HC-06 is a Bluetooth module that facilitates wireless data communication over short distances between two microcontrollers or systems. It operates on the Bluetooth 2.0 communication protocol and can only serve as a slave device. This option is the most economical way of wireless data transmission and is more adaptable than alternative approaches.

d. **Power supply**

i. 10000 mAh power bank for Arduino

A Power Bank is a device that enables you to recharge your electronic devices while you're away from a power source. They come in various sizes, from small and easy-to-carry devices to larger ones that can hold more power.

e. Connectors and cables

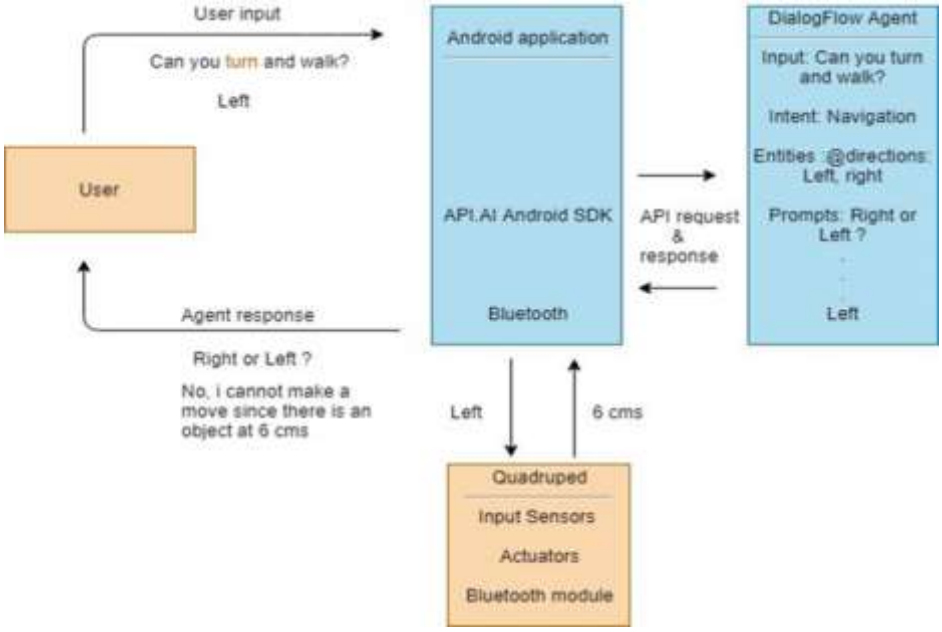
i. Jumper wires

A jump wire, also referred to as a jumper, DuPont wire, or jumper wire, is an electrical cable or a group of wires that has a connector or a pin at each end (sometimes without them, just "tinned"). This wire is typically used to connect the components of a breadboard or other prototype or test circuit internally or with other equipment or components, without the need for soldering. It offers a convenient and easy way to interconnect the components of a circuit during testing and experimentation.

ii. USB Cable

The Universal Serial Bus (USB) was created during the 1990s to simplify the connections between computers and peripheral devices. Its popularity has grown due to its compatibility with various platforms and operating systems, its low implementation cost, and its user-friendliness. USB has become the preferred interface for most home and office peripherals such as printers, cameras, modems, and portable storage devices.

IV. FLOW CHART



V. SIMULATION

A 10000mAh power bank was used to supply power to the Vcc of an Arduino Uno board via USB cables. The code was written in the C programming language and uploaded to the Arduino board. The robot can be controlled by a Bluetooth module (HC-06), which sends commands to the Arduino Uno. The commands received by the Arduino board are then used to control the servo motor accordingly.

i. Source Code (C Programming)

VI. CONCLUSION

The report aims to provide a comprehensive overview of the advancements made in the field of quadruped robots, with a particular focus on their locomotion, structural design, gait analysis, and actuator. Despite significant progress made over the years, quadruped robots still lag behind their biological counterparts in terms of capabilities.

The report summarizes the state-of-the-art technologies, their performances, and potential applications of quadruped robots. These machines are designed to operate in practical scenarios where four-legged locomotion is essential, such as mine inspection, exploration, rescue operations, or navigating unconstrained environments. The report emphasizes that the success of quadruped robots is primarily dependent on advanced technology and quality design, enabling them to perform their intended tasks.

1. The following points are summarized:

a) High precision joint actuators and controllers play a crucial role in increasing the robustness of mobile robots. Joint actuators need to have a high torque output to weight ratio, which is essential to account for the complexity, cost, and weight of the robots. Actuation types such as hydraulic and pneumatic systems are preferred due to their high output power to weight ratio, fast response, and ease of implementation.

b) Quadruped robots can incorporate artificial intelligence (AI) due to their mobility and stability of locomotion, similar to how quadruped mammals adjust their leg movement patterns based on speed. This feature can be utilized to create more efficient and adaptable quadruped robots.

c) The current limitations of mobile robot systems are often related to their visual perception systems. Incorporating features such as recognition, memorization, and learning from the environment can significantly enhance the autonomy of mobile robots, making them more capable of handling unstructured environments.

2. Advantages

a) Quadruped robots are designed primarily to traverse uneven terrain more effectively than wheeled robots due to their four-legged design.

b) The small and compact size is a notable advantage of this robot.

c) Quadruped robots are a cost-effective option as they can be powered by a microcontroller and require minimal battery power, making them relatively affordable and easy to build.

3. Applications

a) The aim of the project is to reduce the risk of human involvement in hazardous areas by utilizing quadruped walking robots, which are highly mobile in rugged terrain.

b) The primary objective is to introduce a novel, low-cost, and modular design of a four-legged robot for exploration and research purposes in locomotion.

c) System for Avoiding Obstacles.

VII. FUTURE SCOPE

a) In the future, the plan is to develop a more advanced robot that is equipped with a 3D scanning sensor and a more powerful processor. The aim is to enable the robot to process information from the scanning sensor and control the robot's actuators more effectively.

b) The future design will be based on a Raspberry Pi flight controller and a live onboard camera. The robot has a high weight-carrying capacity, which will allow the addition of more sensors like inertial measurement units, laser scanners, and other sensors in the future.

c) The ultimate goal is to enable the robot to navigate autonomously through rough terrain. The future work will also focus on dynamic locomotion to enable the robot to run and avoid dynamic obstacles.

VIII. REFERENCES

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