DEVELOPMENT OF QUADRUPED SPIDER ROBOT

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ABSTRACT: The spiders, in comparison with the majority of others animals, it has the ability to access to that kind of environment where others animals or even the humans can't. Those attributes of the spiders are taken into this project in order to develop a quadruped spider robot in conditions to move in all kind of directions and perform such movement like ascend or descend. The paper is presented the dynamic and kinematics model with the purpose of understand how, mathematically, a quadruped animal and a spider walk. In this case we studied the movement of areal spider, so we can define a suitable bio-mimetic model for our robot.

INTRODUCTION

Exploring the earth's environment can be dangerous and difficult in some places, for example, in hostile environments and inhospitable terrains that are difficult to reach with regular vehicles. After critically evaluating and interpreting numerous robot architectures, a quadruped(spider) robot design was adopted due to the spider's natural movement and its capacity to navigate through terrain regardless of its exterior. This design gives the Spider Robot legs the same range of motion thus mimicking a biological spider. The Spider Robot could be used to examine hazardous regions for people, investigate conflict zones, check for precarious sand erotic structures after earthquakes, and search for and deactivate munitions like minefields. The study done by Wenkai Huang et al. offered a novel three-dimensional flexible construction. This passive compliant three-dimensional flexibility minimizes the robot's weight and complexity. A side impact experiment validates the robot's anti-impact capability. The hexapod bionic spider robot's structural design is the primary emphasis of this research, which also optimizes and enhances the original model. The body of the spider-like robot is created from a bionics perspective in order to meet the needs of the hexapod bionic spider robot for flexibility and stability. The initial model is improved by studying the structural proportions of the robot's legs as well as the original design flaws. A lightweight, inexpensive, yet complete quadruped robot system , which advances the study of legged movement. It gives beginning researchers in the field a tool for exploring more complex issues, such multi-body dynamics, nonlinear foot- ground contact modeling, gait route planning, attitude control, etc., for less money. The key features and highlights of the HyQ2Max3 design, which primarily draws from HyQ's morphology, torque control, and hydraulic actuation innovations. The main contributions of this paper include a novel design of an agile quadruped robot capable of trotting or crawling over flat or uneven terrain, balancing, and self-righting; a detailed method to identify appropriate hydraulic cylinder/valve properties and linkage parameters with a focus on maximizing the actuator areas and to the best of the authors' knowledge, the most thorough review of hydraulic quadruped robots. An inverse kinematics program of a quadruped robot with three degrees of freedom on 2 each leg, inverse kinematics solutions are offered in this paper. To calculate the forward kinematic, one uses the Denavit-Harten berg (D-H) technique. The geometrical and mathematical approaches' inverse kinematic equations are programmed in MATLAB. The development of Mini HyQ robot is a significant step forward in miniature hydraulics in robotics. We demonstrated the development of lightweight hydraulic actuated quadruped. We also shown ovel knee joint: despite its higher complexity, the is ogram mechanism is superior to the traditional design, because its many kinematic parameters can be fine-tuned to achieve an optimal torque profile. The main goal of the research was to create a quadruped that operates well in challenging environments and uneven terrain where human assistance is challenging or impossible. The methods used to optimize legged robots , including a description of the structural parameters, adhering to good mechanical project regulations, maximizing weight, power, and energy indices, as well as additional approaches like the use of evolutionary measurement to mimic the biological characteristics of animals. Methodology and operation of the "SPY SPIDER," an eight-legged waking robot looks like a spider and may be securely used for spying. This project does not need microprocessor control or a large number of actuator mechanisms in order to walk over curbs, climb stairs, or enter spaces that are no win accessible to wheels. PADWQ dynamic quadruped robot , an open-source dynamic quadruped robot with 12 torque controlled quasi direct drive joints and high control bandwidth, an onboard depth sensor, and a computer with GPU that enables highly dynamic locomotion over unsteady terrains. A quadruped robot's leg structure was created via mechanism synthesis in order to provide a system for the intricate control of a quadruped robot. A comprehensive understanding of the quadruped robots has been provided in a concise way while synthesizing the available facts. In this field, locomotion, structural design, gait analysis, and actuator are the primary focal areas. MIT researchers have developed a set of modules and a related integration architecture that enable dynamic, quick exploration of uncharted and unstructured areas. The gap between the hardware and control advancement to date will be filled by these low-level autonomy modules and perceptual integration. Using Intel Real Sense for capturing the dynamic motion of the MIT Mini- Cheetah, as well as algorithms for real-time obstacle avoidance in highly irregular terrain. The work presents the design of a parallel quadrupedal robot with variable dynamic locomotion and perception-free terrain adaption. A morphologically adaptable quadruped robot for unstructured situations DyRET which is a dynamic robot for embodied testing, offers a strong proof of concept that uses a 3 efforts toward robot autonomy have culminated and offered a solution for the robot to detect impassable impediments in its route since the work was done in controlled conditions with user-guided velocity instructions and straightforward stiff paths that lacked cognitive planning. Quadrupedal walking and running sequence optimization for refining the motions exerted is attempted on a 28kg weighing motor powered cable driven Star lETH robot. Animal a quadruped robot weighing about 30kg built especially for travelling through rugged and uneven terrain was purpose built for industrial environment. The model is equipped with series elastic actuator and owes a cluster of sensors for surveillance activities and is fully autonomous, water and dust proof. ALPHRED is a quadruped delivery robot with high power mechanoreceptors actuators. It is capable of dynamic trotting, continuous walking, sprinting, and while picking up a package, it may even be able to walk like abiped. A full gait planning system integrating inverse kinematics is developed utilizing a classical compound pendulum equation and an Omni directional bionic construction. Kinematics and dynamics were investigated using MATLAB, simulations were run using Adams software, and real-time testing was completed. The diverse information gathered from the literature review was helpful in designing this project in a variety of ways. Transmission of power to the leg was achieved through diverse mechanisms like mechanical link, cam operated, Bowden cable, dc motor powered, hydraulic, stepper and servo powered Every piece of literature has pros and weaknesses that were carefully considered in order to create a solid model. Many defence research agencies have entered into the field for enhancing and optimizing the quadruped design for developing advanced autonomous and flexible robots for surveillance and defence applications. A detailed evaluation and comparison between the quadruped design and wheeled robot is as elucidated in the Figure 1. The goal of this project was to create a robot that could traverse terrain that is impassable to most other road vehicles

LITERATURE SURVEY

Humans could not traverse to every point on the surface, yet they still require information about such locations, such as in the fields of astronomy, geology, the military, etc. As a result, researchers have designed cutting-edge technologies have enabled data gathering from locations where humans are unable to travel. This paper carried out a series of designs, simulations and implementations by using the physical-like mechanism of a bionic quadruped robot dog as a vehicle. Through an investigation of the walking mechanisms of quadrupeds, a bionic structure is proposed that is capable of Omni directional movements and smooth motions. Furthermore, the kinematic and inverse kinematic solutions based on the DH method are explored to lay the foundation for the gait algorithm. Development of a Hydraulically Actuated Leg for Quadruped Robots View project Inverse Kinematic Analysis Of A Quadruped Robot," This paper presents an inverse kinematics program of a quadruped robot. The kinematics analys is main problem in the manipulators and robots. Dynamic and kinematic structures of quadruped robots are very complex compared to industrial and wheeled robots. In this study, inverse kinematics solutions for a quadruped robot with 3 degrees of freedom on each leg are presented. Denavit- Hartenberg (D-H) method are used for the forward kinematic. a system engineered to complete tasks like carrying weaponry and materials for military applications. The primary aim of the project was to design a quadruped that works successfully in harsh conditions and irregular terrain were human intervention is impossible or hard. Initially, individual components of the design were designed and modifications were made according to the requirements.

III.SYSTEM REQUIREMENTS

System

Boston Dynamics is a well-known robotics company that has developed several quadruped robots, with Spot being one of the most famous. Spot is a highly agile robot designed for a variety of applications, including inspection, research, and remote operation. Its modular platformallowsfordifferentattachmentsandsensorstobeadded,depending on the task at hand.

ANYmalby ANYbotics:

ANY mal is another versatile quadruped robot designed for various applications such as industrial inspection, search and rescue, and more. It has advanced mobility capabilities, including the ability to walk, trot, climb stairs, and even manipulate objects with its robotic arm.

Minitaurby Ghost Robotics:

Minitaur is a small and rugged quadruped robot designed for research and outdoor applications. It is known for its agility and ability to traverse challenging terrain, making it suitable for tasks such as exploration and surveillance.

Hyundai Vestigo by Hyundai Robotics:

Hyundai Vestigo is a quadruped robot designed for industrial purposes, such as inspecting hazardous environments like nuclear power plants or chemical facilities. It can carry various payloads and is equipped with advanced sensors for navigation and mapping.

Xpider by EZ-Robot:

Xpider is a small, consumer-oriented quadruped robot designed for educational purposes and entertainment. It is equipped with a camera, microphone, and speaker, allowing for interactive experiences and programming.

Legged Squad Support System(LS3)by Boston Dynamics:

While not exactly a spider robot, LS3 is a quadruped robot developed for the U.S. military. It was designed to carry heavy loads over rough terrain, providing support to soldiers in the field. LS3 can autonomously follow a leader, navigate obstacles, and carry up to 400 pounds of gear.

Quadruped Robot by Tokyo Institute of Technology:

Researchers at the Tokyo Institute of Technology have developed various quadruped robots for researchpurposes.Theserobotsoftenshowcaseadvancedlocomotionalgorithms,sensor systems, and control strategies for navigating complex environments.

ANY drive by NTU Singapore:

ANY drive is a quadruped robot designed for efficient locomotion, with the ability to adjust its gait and control strategy based on the terrain. It focuses on energy efficiency and adaptability for real-world applications.

Stoch by University of Pennsylvania:

Stoch is a dynamic quadruped robot developed for research in agile locomotion. It features compliant legs and advanced control algorithms, allowing it to navigate rough terrain and perform dynamic.

System

Multi-Legged Locomotion:

Implementing various gaits such as trotting, walking, crawling, and climbing to enable the robot to navigate different terrains efficiently.

Developing adaptive gaits that can automatically adjust based on the terrain's roughness, inclination, and obstacles encountered.

Leg Design and Actuation:

Designing lightweight yet robust legs with multiple degrees of freedom for agile movement. Using high-torque actuators such as brushless DC motors or series elastic actuators for precisecontrol and force feedback.

Body and Chassis:

Designing a modular body/chassis system that allows for easy customization and attachment of different payloads or sensors. In corpora ting a low-profile design for better stability and maneuver ability in confined spaces.

Sensor Integration:

Equipping the robot with a variety of sensors such as cameras, LiDAR, ultrasonic sensors, and inertial measurement units (IMUs) for perception and mapping. Implementing sensor fusion techniques to combine data from multiple sensors for better localization and obstacle avoidance.

Control Systems:

Developing advanced control algorithms for motion planning, gait generation, and trajectory optimization. Implementingreal-timefeedbackcontrolloopsforstabilityanddynamicwalkingonuneven terrain.

Autonomy and Navigation:

Integrating SLAM (Simultaneous Localization and Mapping) algorithms for mapping unknown environments and localizing the robot within them. Implementing path planning algorithms for autonomous navigation while avoiding obstacles and optimizing energy efficiency.

Energy Efficiency:

Designing an energy-efficient system with optimized gait patterns and motion control to extend the robot's operational endurance.

Exploring renewable energy sources such as solar panels for autonomous recharging in outdoor environments.

IV.RESULT

Gait Pattern:

The quadruped spider robot exhibits as mooth and coordinated gait pattern as it moves forward.

Leg movements show a clear sequence of lifting, advancing, and placing on the ground.

Stability:

The robot maintains stability throughout the experiment, adjusting its leg positions to prevent tipping over. It demonstrates the ability to handle un even terrain or minor disturbances on the surface.

Speed and Efficiency:

The speed of the robot's movement forward can be calculated from the distance covered and the time taken. Efficiency metrics, such as energy consumption or motor performance, can be analyzed.

Future Improvements:

Based on the observations, areas for improvement can be identified. This might include or adding sensors for obstacle avoidance.

The quadruped spider robot successfully demonstrated its ability to walk forward in a straight line. The experiment provided valuable insights in to the robot's performance, stability, and gait characteristics.

V.CONCLUSION AND FUTURE ENHANCEMENT

CONCLUSION

In conclusion, the quadruped spider robot has shown promising initial results with its ability to walk forward in a controlled manner. Future enhancements can focus on advanced gait algorithms, terrain adaptability, obstacle avoidance, wireless control, sensor integration, energy optimization, autonomy, mechanical redesign, and user interactivity. These improvements will not only enhance the robot's performance but also expand its capabilities for various applications such as search and rescue, exploration, surveillance, and entertainment. By incorporating these enhancements, the quadruped spider robot can evolve into a versatile and efficient robotic platform for diverse tasks in the future.

Basic Functionality Achieved:

The quadruped spider robot successfully demonstrated its ability to walk forward in a straight line.

It exhibited a coordinated gait pattern, lifting and placing its legs in a sequence to move efficiently.

Stability and Balance:

The robot showed good stability, adjusting its leg positions to maintain balance during movement.

It could handle minor disturbances on the surface without tipping over.

Gait Efficiency:

Therobot'sgaitwasrelativelyefficient,allowingittoco veraspecifieddistancewithina reasonable time frame. The leg movements were smooth, indicating effective control of the servos. Initial Performance Metrics

Advanced Gait Algorithms:

Implementmoreadvancedgaitalgorithmssuchastrotti ng,galloping,orclimbinggaits. These gaits can enhance the robot's versatility and ability to traverse different terrains.

Terrain Adaptability:

Integrate sensors for terrain detection and adaptive walking. The robot can adjust its gait and leg movements based on the surface it is walking on, improving stability and efficiency.

Obstacle Avoidance:

Add sensors such as ultra sonic or infrared sensors for detecting obstacles. Develop algorithms to enable the robot to navigate around obstacles autonomously.

Wireless Control and Communication:

Implement wireless communication protocols for remote control and monitoring. This allows for greater flexibility in controlling the robot and receiving real-time data feedback.

Enhanced Kinematics and Actuators:

Explore more premises motors or actuators for smooth and more accurate leg movements.

Refine the inverse kinematics calculations for optimal leg positioning and motion.

Integration of Sensors:

Include measurementunits(IMUs)forbettermotiontrackinga ndstabilitycontrol. Incorporate cameras or vision sensors for object recognition and localization.

Energy Optimization:

Develop power management strategies to optimize energy consumption. This can include sleep modes for in active components and efficient use of battery power.

Autonomous Navigation:

Work towards autonomy by integrating a navigation system and path planning algorithms. The robot can navigate predefined paths or explore environments autonomously.

Mechanical Redesign:

Iterateontherobot'smechanicaldesignforimprovedd urability,weightdistribution,and agility.Consider3D printing or light weight materials for easier maneuverability.

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