

# Design and Control of a Four-Legged Spider Robot Using Servo Motors with AI Voice Assistance and Embedded Coding for Earthquake Human Rescue and Landmine Detection

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## Abstract

Abstract-in the realm of robotics, the design, development, and motion planning of a mobile robot are now being explored as research fields. Mobile robots can be used in space exploration, military applications, and industrial applications. As a result, designing and developing a mobile robot is an important aspect of the aforementioned applications. In this paper, a quadruped robot (spider), which is a four-legged robot that outperforms wheeled and tracked robots by being able to explore in all terrains, like human and animal is developed. This research work focuses on different quadruped robot design, development, and control methodologies. The robot is controlled by two methods: Bluetooth and web control, along with live video streaming, motion detection, and location tracking features.

*Index Terms— Bluetooth, Quadruped robot, Web control, Live video streaming, Motion detection, and Location tracking.*

## 1. INTRODUCTION

The current robotic systems have a few drawbacks, such as their large size, surface constraints, rotational restrictions, and movement flexibility. A good robotic system is required to address all of these challenges in an efficient manner. Wherever they are deployed, mobile robots are ready to put their expertise to work and complete tasks efficiently. In mobile robots quality will be attained by the use of a mechanism. Mobile robots containing these mechanics are classified as three-legged robots or wheeled robots respectively, based on the two major classes of three-legged mechanisms and wheeled mechanisms. Four-legged robots, which are well known to be superior to wheeled robots, are the primary focus of the present work. A quadruped robot is a four-legged walking robot that is a bionic duplicate of a spider (Arachnid species) that uses its legs for locomotion and can accomplish activities with or without human interaction. A four-legged mechanism is necessary for the locomotion of four-legged robots. Due to the ease with which quadruped robots can be biped, quadruped constructions were chosen over other three-legged architectures for the present work. A quadruped golem is made up of a portion frame, a management system, and a converter. As a

locomotion component, it has four legs. The movement of the legs with respect to the component frame must be controlled for quadruped golem locomotion. A quadruped golem leg is a mechanism. The most significant advantage of legged robots as compared to wheeled robots is their capability to arrive at the locations easily. It will be feasible to improve the performance of mobile robots by mimicking the bodies of legged creatures. Some biological notions are incorporated into the designs to provide a stable system and fast walking. The most compelling reason for exploring legged robots is to provide access to regions that are dirty and dangerous, as well as to provide access to jobs that are extremely tough. Legged robots are frequently employed for earthquake rescue and in harmful areas like inside the reactor. This shows that biologically based self-legged robots are having a good amount of strength. The main objective of the present work is to develop an innovative, dynamic four legged robot whose body resembles a spider and to integrate Esp32 camera into the robot. The robot is controlled using Bluetooth - Android Application from a distance to perform appropriate commands.

A mobile robot needs a particular type of locomotion mechanism to move through its environment. There are several mechanisms for the same such as four, and six legged locomotion and certain configurations of wheeled locomotion as well. The focus here is about legged type of robots. A legged robot is well suited for the rough terrains because it is easy to climb steps, to cross the obstacles and to walk on irregular grounds. In this scenario, the use of wheeled robot would not be beneficial. To design a mobile type legged robot, each leg must have at least two degrees of freedom. For each degree of freedom one joint is desired, that is powered by one servo motor. Due to this a four legged robot requires at least eight servos. Since, legged robot needs more number of servo motors, it consumes more power compared to that of wheeled robot. While many of them choose wheeled over legged, there is always scope for exploring about legged robots which is suitable for multiple applications.

Few applications of the legged robot can be traversing a construction site and survey terrain, snapping images using high definition cameras, and build out 3D maps, providing operators a way to assess progress with both ease and precision.

## BACKGROUND

From a design and operation standpoint, legged movement is highly difficult, since it necessitates a good amount of information in mechanics, sensing, control and programming. Earlier research has focused on multiple-legged locomotion, with the objective of developing appropriate design methods and intelligible solutions in accurate locomotion tasks as well as developing locomotion architectures for various types of robots. The creation of a spider robot that is adaptive and intelligent is demonstrated in [1]. The four-legged spider robot can monitor the environment wirelessly with the help of sensors. A new National Instrument controller with lab view for auto-station adaptation is used. This robot includes a temperature sensor, an ultrasonic sensor, and a smoke detector. In [2], a spider robotic system has three subsystems, which comprises the spider robot's body construction, sensor, and control algorithm is developed. Since aluminum can tolerate pressure stress and tensile on its outside, the spider robot's configuration is built of aluminum. Each of the spider robot's distinct legs has three degrees of freedom due to the use of a servo bracket attached to the joint of the legs. A system is developed wherein if any undefined human life or unrecognized face is taken on the camera, the user is notified by receiving an email on his machine [3]. In addition, if the robot recognizes the user's face, it retrieves the person's name from the database, where the user has specified a unique identity name for the face recognition. According to the number of individuals in the family, the user can add as many identities to the database as they want. If a non-family member comes across the robot, the identification is unrecognized, and the robot immediately buzzes with a loud alert, as well as sending a notification to the user if the person is elsewhere.

A spider-like robot is created in [4] that can walk, spin, and is equipped with sonars, a temperature sensor, a triple-axis accelerometer-gyro, and liquid crystal display. The robot can be controlled from a base station or a remote location that provides all available sensor data to the computer, which is shown in the user interface program. A software is also developed in the robot's micro controller unit, which is capable of controlling the servo motors and sensors. A reconnaissance robot is developed in [5] that is designed to enter extremely dangerous zones without its surroundings being aware of its presence and transmit data about its surroundings to a remote server (which may also be controlling it) for feature feed. A camcorder is used by the robot to record its surroundings. Using the human eye as an example, a sensor is constantly sending signals to the cerebrum about what it perceives. As a result, the mind makes a specific movement in the same way that our limbs do (actuators). Similarly, the robot's camcorder has the same capabilities as an eye. An autonomous robotic platform with a camera for remote surveillance through the internet and a web page is developed in [6]. The system is intended to be

used for surveillance as well as reconnaissance. The robot's present location is determined by GPS tracking using Google Maps, and the robot takes images of the surrounding region on a regular basis and uploads them to a website. The robot's GPS module continuously updates the location GPS coordinates, and the robot's real-time location, together with visual data, may be viewed on the web page. In [7], computerized support based on a GPS framework is designed to be much more conservative and accommodating to a variety of businesses. This system is cost-effective, supportive for a variety of enterprises.

A study on robot control via a web browser is described in [8]. The purpose of this work is to show how Internet connectivity can be used to boost machine productivity. When an issue that a computer is experiencing is beyond its cognitive capabilities, local intelligent systems call human experts for help. A system with limited autonomy will be built, but with the use of periodic Internet-based human supervision and movement on land, it will prove to be substantially more productive. The video surveillance robot is developed in [9], controlled by Raspberry-Pi and web application. The surveillance robot is focused at better monitoring of vision and motion. Based on flexible & whole scalability, the surveillance robot is developed to be expandable and permit for upcoming control upgrades, thus upgrading the user accessibility.

Spider-like robots are used to automate cleaning (glasses) operation in [10]. Hexapod robot contains eighteen double shaft NEMA-17 motors that are synchronized and are controlled by using Arduino. To move forward, the tripod gait mechanism is used and pressurized steam is applied to provide the suction essential to hold on to the wall. A design of a hexapod bionic robot using physiological structure characteristics of 6 legged insects is developed in [11]. According to the flexibility and stability requirements of the hexapod bionic spider robot, the body of the spider-like robot is designed from the perspective of bionics. The static analysis of the hip and knee joints of the robot was carried out to verify the rationality of the hexapod bionic spider robot mechanism.

The spider type legged robot is developed in [12] with the control mechanism and accomplishes several walking actions. The efficiency of the robot is measured based on the performance on rough terrain through six legs. The review has been done on several design and development methods for the four-legged robot [13]. In [14], the four legged walking robot is developed that can replace the present surveillance technologies. In [15], a four legged robot is designed that has a real time web control system used to detect the real time status of the environment.

From the above papers, it can be seen that the present robotic system is having few limitations like heavy weight, surface limitation, restrictions in rotation and less flexibility while moving. Hence there is a need for a proper robotic system that overcomes all these issues in an efficient way which can be obtained by the proposed robot. Presently, the developed robot is a novel, flexible and reasonable design of a four-legged for ecological study purposes. The aim of the

proposed robot is to build a low-cost legged platform that allows experimentation of walking chassis and monitoring ecological conditions. The robot should be driven from a distant location. The prime benefit is in transverse capability and expertise. Legged robots have a distinctive ability to separate their body from territory irregularities, evade undesirable footholds, regulate their stability, and attain energy efficiency. The design of a four-legged robot is useful for space exploration and rescue tasks of monitoring environmental conditions.

## I. SYSTEM DESIGN

### A. Body of the Bot

This robot has four legs, each with three degrees of freedom, for a total of twelve degrees of freedom; this is the bare minimum for forming a spider-like shape and performing acceptable movements.



Fig 1: Block diagram of the spyder bot.

This decision necessitates the employment of a controller with functions to control the locations and speeds of twelve independent servomotors. Shapes are given a lot of thought so that difficult solders and bonding can be avoided, making it possible to assemble it with merely double stick tape. The spider's chassis is made up of a base on which the servo motors and legs are mounted. As a result, the resulting shape is strikingly similar to that of a spider.

Fig. 1 describes the block diagram of the spyder robot which includes predefined, Bluetooth and Web control mechanism to control the bot, with live Surveillance, motion detection by using GPS live tracking feature. Arduino Uno is used for movement of the legs. Arduino breakout board is used for connecting 12 servo motors to arduino UNO.

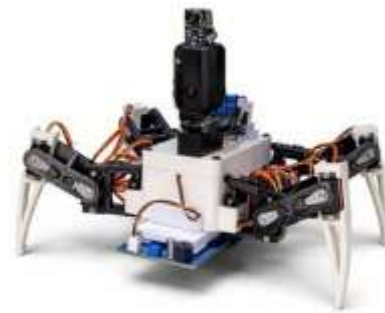


Fig 2: Design the body of the bot.

The body of the bot consists of 4 legs and each leg has 3 servo motors (S1 to S12). Raspberry pi camera module is used for live surveillance with motion detection feature. HC-05 bluetooth module is used for bluetooth connectivity. GPS sensor is used for GPS location tracking of the robot. The HC-05 Bluetooth module that has been used operates in Master-Slave mode that means it will neither send nor receive data from external sources. Thereby improved security can be obtained and consumes less power.

Because of the vetronite's flexibility, an additional element is devised to be installed under the robot to strengthen it and eliminate dips. Fig. 2 shows the design of the proposed bot.

### WORKING PRINCIPLE AND METHODOLOGY

The whole robotic system has been designed very carefully by following the procedure sequentially as shown in Fig. 3.

Commands	Leg 1	Leg 2	Leg 3	Leg 4	Commands	S2	S1	S3
STAND	1	2	3	4	STAND	2	1	3
FORWARD	3	2	1	4	FORWARD	3	2	1
BACKWARD	2	3	4	1	BACKWARD	3	2	1
LEFT	3	2	4	1	LEFT	3	1	2
RIGHT	4	1	3	2	RIGHT	3	1	2

Similar for all Four Legs



Fig 3: Sequence of legs and servo motors movement.

For making the body of the robot STL (Standard Tessellation Language), files are used for 3-D printing each part of the spyder body. After getting it 3-D printed all the parts were assembled. The servo motors are placed at the joints for movements of the legs by proper orientation of the servo motors. The connection of the Arduino uno to the breakout board is made. First, the spider bot is tested via programming and observed how it responds for each command. The errors are observed and made the necessary adjustments in the body of the robot. Henceforth, the robot started working successfully with the predefined commands. The controlling

part of the spider is developed wirelessly through a bluetooth android application and it could perform various motions such as forward, backward, left and right.

The installation of the required software tools (Putty, VNC Viewer, etc.) is made. The camera module is integrated with the microcontroller. Further motion detection is enabled with live camera surveillance. This camera captures the scenes and transfers them to a server where the user can monitor what is going around the bot and also controlled it using Pi-Cam-Web-Interface. Neo 6M GPS module is interfaced with Raspberry Pi and Thingspeak Google Cloud API is used to create a live location tracking system. The location of the bot in terms of longitude and latitude is obtained and can be identified the location on a live map. Then, for web control, serial communication is established between the Arduino and the Raspberry Pi. Finally, there's an spyder bot with live surveillance, GPS tracking, web control, and motion detection.

### III. IMPLEMENTATION

The Arduino UNO has been programmed so that the user doesn't need to give the bot any commands. Based on the specified commands with the appropriate time delay, it will operate independently. These include the motions of standing, sitting, moving forward or backward, dancing, waving your hands, and shaking your hands. This served as a test case to determine whether or not our robot can execute all required commands and motions. The proposed bot can be applied for live surveillance, motion detection, Bluetooth control, web control and GPS Tracking.



Fig 4: Arduino Bluetooth control

#### Bluetooth Control

The commands will be delivered by the user using an Android-based Bluetooth application. The HC05 Bluetooth Module is used to achieve Bluetooth connectivity between the bot and the android phone. The types of motions included here are Stand, Sit, Forward, Backward, Dancing, Hand wave, and Hand Shake. The methods used for the implementation of Bluetooth control for robot is shown in Fig. 5.

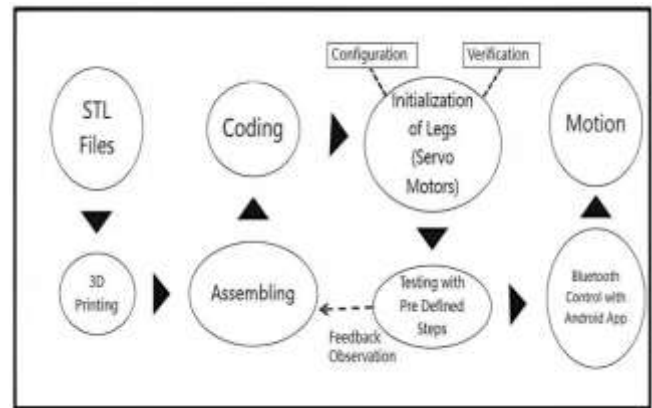


Fig 5: Methods used for the implementation of Bluetooth control.



Fig 6: Android Bluetooth application user interface.

### Result

The movement accuracy of the spider robot was evaluated through a series of controlled tests designed to measure the precision of both linear displacement and angular rotation. The linear displacement accuracy was assessed by commanding the robot to walk forward for a fixed number of step cycles along a measured straight-line path and comparing the actual distance traveled with the theoretical distance calculated from the step length and cycle count. The theoretical step length, based on the servo arm geometry and the commanded coxa servo angular displacement, was calculated to be approximately fifteen millimeters per step. The measured average step length over fifty trials was found to be thirteen point five millimeters, yielding a step length accuracy of ninety perce



Fig 7: Four-Legged Spider Robot Prototype

## CONCLUSION

The proposed robot will be helpful in locomotion in rough surfaces where ordinary motors cannot be operated. Through this the user can eradicate the demand for access at such places by providing continuous information. This structure of the bot adapts to the situation and obstacles due to its legs. The user of this developed spider robot will achieve solutions to problems by eliminating the need of humans to reach places and often provide information that would not otherwise be available for humanity. Unlike the regular dual leg robots, this developed robot works without interfacing and it can simply adapt to the novel situation owing to its legs of locomotion. Here, a wireless spider robot that helps in better adaptation and overcome the drawbacks of existing robots has been designed. The bot can be controlled using Bluetooth. The system requires high power and can be overcome by using compact Lithium Ion batteries. The application of our bot is restricted for a short distance where the wifi range is available.

## REFERENCES

- [1] Rozita Teymourzadeh. "Adaptive Intelligent Spider Robot", UCSI University, Malaysia, 2018.
- [2] Mehmet Çavaş and Muhammad Baballe Ahmad. "A Review on Spider Robotic System", International Journal of New Computer Architectures and their Applications, vol. 9, no. 1, 2019.
- [3] Dr. Shanthi Mahesh, Neha Dixit, Preethi P, Shree Lakshmi Deshmukh. "Surveillance robot using raspberry pi for home security purposes", International Journal of Creative Research Thoughts, vol 8, no. 6, 2020.
- [4] Ritesh G. Waghe, Deepak Bhoyar, and Sagar Ghormade. "A Real Time Design and Implementation of Walking Quadruped Robot for Environmental Monitoring", 2018, International Research Journal of Engineering and Technology, vol 5, no. 5, 2018.
- [5] V. U. Rani, J. Sridevi and P. M. Sai, "Web Controlled Raspberry Pi Robot Electric Transportation, Hyderabad, India, 2021, pp. 1-5 DOI: 10.1109/SeFet48154.2021.9375666.
- [6] Bagathi Santosh Kumar and Gouri Shankar Sharma, "Surveillance Robot For Military Applications Using GPRS And Raspberry Pi With GPS Tracking", International Journal for Science and Advance Research in Technology, vol 3, no. 12, 2017.
- [7] N.Manikandan, et.al., "GPS Based Autonomous Robot Navigation in Robotics Along With Directionality", IOSR Journal of Electronics and Communication Engineering, vol 16, no. 3, 2021.
- [8] Pragya Jain et.al., "Web Browser Controlled Robot with Night Vision Camera", International Journal of Engineering Research & Technology, 2017.
- [9] Hiral Gachake, "Robust Pi Surveillance Robot", International Journal for Research in Applied Science and Engineering Technology, 2022.
- [10] Aashika Perunkolam, V. Berlin Hency, "Spider Robot for Façade Cleaning, International Journal of Recent Technology and Engineering (IJRTE), 2020.
- [11] Chao Sun, Minghai Yuan, "Design and Simulation Analysis of Hexapod Bionic Spider Robot", CISAT IOP Conf. Series: Journal of Physics, 2019.
- [12] Tolga Karakurt, Akif Durdu, N. Yilmaz, "Design of Six Legged Spider Robot and Evolving Walking Algorithms", International Journal of Machine Learning and Computing, 2015.
- [13] Priyaranjan Biswal, Prases K. Mohanty, "Development of quadruped walking robots: A review", Ain Shams Engineering Journal, vol 12, no 2, 2021, pp. 2017-2031 <https://doi.org/10.1016/j.asej.2020.11.005>.
- [14] Manish Dhakolia, Pranay Chalke, Shubham Baniya, Atharv Desai, "Four Legged Walking Robot for Surveillance", International Research Journal of Engineering and Technology (IRJET), vol. 08, no. 05, May 2021, pp. 1457-1463.
- [15] Mahesh Jadhav, Prasad Kubal, Sarthak Ghanekar, Rahul Dawa, "IOT based quadrupedal spider robot for surveillance" International Journal of Creative Research Thoughts, vol. 10, no. 4, 2022.