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# An IOT Based Quadruped Spider Robot

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**ABSTRACT**:This project investigates the design and construction of a quadruped spider robot with multiple functions. A quadruped robot, also known as a multi-legged robot, is one that walks or moves on four legs. There are numerous options for leg placement, leg designs, and gait patterns in quadruped robots. This project's goal is to build a four-legged robot that looks like a biological spider. It walks in a spider-like fashion thanks to several servo motors. The robot moves using a Bluetooth application that sends corresponding signals to move. It also has sensors that detect the status of the environment in real-time, such as forests, buildings, and large factories.

**KEYWORDS:**Quadruped Robot, Spider Robot, Bluetooth.

## I.INTRODUCTION

At the moment, mobile robots are gaining popularity. They are classified into three types based on how they move [1]: legged robots, wheeled robots, and tracked robots. The main advantage of legged robots is that their legs can walk on uneven terrain while remaining balanced. Legged robots have the potential to work in unstructured, harsh, and potentially hazardous environments [2].They do, however, have the disadvantage of a low utilisation of energy efficiency. As a result, the concrete choice of robotic type is determined by the tasks and environmental constraints.
Quadruped robots are currently being studied extensively. In general, quadruped robots are classified into three types based on actuation: hydraulic actuators, pneumatic actuators, and electrical actuators. Electric actuators have high control precision, but they cannot withstand heavy loads. Because of their nonlinear characteristics, pneumatic actuators are difficult to control. Because of their high power, hydraulic actuators are widely used. However, the vibration is a little stronger. Therefore, electric actuators such as servo motors are generally used in creation of small quadruped robot.
The robot locomotion system is a critical component of mobile design, and it is determined not only by working environment but also by technical aspects like manoeuvrability, controllability, terrain condition, efficiency, and stability. Each system has its own set of benefits and drawbacks [3], [4]. Table 1 shows a detailed comparison of the technical criteria of the legged robot versus the wheel robot.

| Parameter | Legged Robot | Wheeled Robot |
|---|---|---|
| Manoeuvrability | Good | Poor |
| Navigability | Good | Poor |
| Controllability | Poor | Great |
| Efficiency | Great | Poor |
| Cost effective | Yes | No |
| Navigation over obstacles | Yes | No |

Table. 1. Comparison between legged robot and wheeled robot

The benefits of legged locomotion vary depending on posture, number of legs, and leg functionality. Though wheeled and tracked robots can operate in flat terrain, the majority of them cannot operate in cluttered terrain, complex, or hazardous environments. The legged robot, like an animal, has the ability to roam almost all of the earth's surfaces in various terrains [1].The quadruped robots are the best choice among all legged robots related to mobility and stability of locomotion. The four legs of the robot are easily controlled, designed, and maintained as compared to two or six legs.The goal here was to create a robot that individuals could use to accomplish their goals while remaining easy to control. First and foremost, robot design A spider robot, inspired by a biological spider that can navigate different terrains, is ideal for the intended application. It was critical to devise a simplified plan for the robot so that it could freely move around and perform the required developments. The plan required a dependable leg plan that could move

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in any direction. Because safety is a priority in this design, a large portion of the robot outline is smooth and free of sharp edges.Furthermore, the electrical components, such as servos and the microcontroller, are reusable, reducing the environmental impact of this robot. Second, the software section provides the spider's rationale. It is exceptional to provide the client with an immediate move with no delay. A basic control framework is expected to make guiding and controlling the robot simple for the client.

## II.LITERATURE SURVEY

The idea here was to have a robot that can be used by individuals to reach their desired goals and to make it easy for them to control. First of all, robot design Inspired by a biological spider, which can navigate through different terrains. People have long studied animal walk patterns, and the development of quadruped robots is no exception.Chebyshev developed the firstwalking mechanism in 1870, which primarily converts rotational motion totranslation motion with constant velocity based on the four-bar mechanism.The Chebyshev's mechanism looks like the Greek letter Lambda; therefore, thelinkage is also named a lambda mechanism. This device could walk dynamically onflat terrain only and does not have an independent leg motion. In the 1980s, Marc Raibert of MIT and Shimoyama of Tokyo University conducted a kinematics study on quadruped robots, which is considered as the first comprehensive study of a mammal quadruped robot [5]. The performance of quadruped robot became betterafter 2000. Tekken IV is constructed by Kimura, which uses a Central Pattern Generator to control the motion of its legs and fulfill a number of gaits.Other robots MRWALLSPECT III, able to climb slopes and avoid tumbling and slipping, and AiDIN I and III, able to trot and climb slopes while carrying a maximum mass of 3 kg. Vanderbilt University's pneumatically actuated quadruped robot, VU quadruped, and Toyota Technological Institute's RoboCat-1, verifies the locomotion control algorithm and fulfills real-time trot-running cycles.Boston Dynamics developed the latest dog-like untethered quadruped robot namedSpot. The robot has Omni-directional walking and trotting gaits.And in the future, the technology may allow us to manufacture the quadruped robotwhich can climb on walls vertically, it may have an optical camouflage to blend inwith the environment, can be connected to our own body and can act as another bodypart.All of these upgrades on quadruped robot are important in creating an entity withmuch complex traversal abilityand they have driven the design and execution ofhighly refined systems, with robotics gaining more and more popularity in majoritycommercial fields, such as entertainment, transport, and medicine.

The author of the article, A review on spider robotic system [6] reviewed some earlier case studies on spider robot, highlighting main features and operation. Authors also discussed the challenges and limitations of spider robots including control, limited power supply and adaptability in different terrains. Another study also provides insight into future directions for spider robot system such as developing a more efficient locomotion mechanism and improving the sensory system[4].

Research paper by MLRIT Hyderabad [7] gives information about construction, programming and working of Arduino based Quadruped Robot, they describe hardware components and software design of the robot which involves the programming of the robot. Another paper [8] discusses the use of small quadruped robot in exploration and search & rescue. It also discusses hardware and software components such as servo motors, microcontroller, etc. Overall, the above-mentioned papersare a comprehensive guide for building a quadruped robot with a microcontroller such as the Arduino, making it a valuable resource for robotics hobbyists and students.

## III.PROPOSED METHODOLOGY

The proposed methodology for building a Quadruped Robot involves many steps that need to be followed in a logical sequence. These include hardware and software design of the robot. The first step is the planning process where the project is carefully considered and designed. During this phase, the size and type of spider robot is determined, as well as the number of sensors that are going to be used, the number and type of actuators, and the size of the robot is determined. The second step is the material and component selection that are needed to build the robot. Components include the microcontroller like Arduino board, servo motors, sensors and power supply. Component selection is an important step because the cost of the robot depends mainly on the electronic parts used. Once the components are gathered, the building process can begin. The spider robot is built by assembling the components together and wiring them to a microcontroller like for example Arduino family of microcontrollers. The servo motors used in the robot serve as the actuator in the robot's leg that brings about the locomotion of the robot. Servo motors shall be calibrated properly in order for the robot to move without any stagger. Sensors that will detect the environment shall also be tested and connected to the microcontroller board. Bluetooth sensor will take signal from the user and tell the microcontroller about what direction to move in. The programming phase begins once the physical construction is complete. The microcontroller can be programmed in Embedded C to perform the computational work of the robot, this may include sending the proper signal to servo motors, detecting surrounding data, giving power to the servo motors,

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etc. The Bluetooth application on user's phone can be created using Java or Kotlin language. After programming of the robot and the phone application is done, tests should be performed to calibrate the servo motors and other components to check if everything is working as intended or not. There could be a necessity to disassemble and reassemble the robot to fix the angle of a servo motor. These tests are necessary to ensure the optimal performance of the quadruped robot on the field. Overall, building an Arduino-based quadruped spider robot necessitates meticulous planning, attention to detail, and technical skills in both hardware construction and software programming. Anyone, however, can successfully build and operate a functional quadruped spider robot using an Arduino board with the right approach and resources.

## IV.DESIGN ANALYSIS

Animal motor behaviours have an extensive list of characteristics.Consciousness, vestibular reflexes, and regulatory requirements are just a few of the essential traits required for adaptable and flexible locomotor behaviours. Manoeuvring self- organisation reflects the ability to produce spontaneous, self-organized locomotion. Vestibular reflexes and compliance might enhance the functioning of self-organized mobility in the face of unforeseen events such as gradients in the ground plane and external disruption. Understanding the biological underpinnings of these characteristics thus aids in illuminating the fundamental mechanisms underlying the evolution of adaptive locomotion and the subsequent creation of sophisticated artificial robot manipulators.For robots with four legs, the most common configuration is two parallel rows of two legs (2+2) or at a 120-degree angle, evenly spaced from the centre. To stay upright, a walking robot must be dynamically stable and moving. Because of its centre of mass, the robot couldcollapse if it stopped walking. A statically stable robot will not topple over even if its gait is interrupted at any time. A quadruped is statically stable if every single one of its legs perpetually remain in contact with the ground and its centre of mass is positioned within its feet.

A quadruped spider robot's design comprises an intricate combination of mechanical, electrical, and software components that must function in unison to achieve optimal performance. A thorough design analysis is essential for guaranteeing that the robot can navigate different terrains and perform jobs consistently and effectively.The legs must be built to sustain the weight of the robot while also providing adequate grip on various surfaces. The joints must be carefully designed to allow for a large range of motion while remaining stable and durable. The leg and joint sizes and shapes must also be optimised to reduce weight and power consumption while enhancing performance.The power source must be considered based on the power requirements of the robot and its surroundings during operation. Motors and sensors, for example, must be chosen for their dependability, longevity, and interoperability with the rest of the system. The electrical system must also be built to reduce power consumption and heat generation, both of which could have an impact on the robot's performance and lifespan.The software component must also include sensory and perceptive algorithms that allow the robot to recognise and react to obstacles and environmental changes. The control system must also be built to maximise energy efficiency while eliminating errors and delays in component communication.Overall, quadruped spider robot design analysis is a complicated and multi-disciplinary process that necessitates thorough evaluation of mechanical, electrical, and software components. Quadruped spider robots have the potential to revolutionise a variety of fields, notably search and rescue, surveillance, and exploration in tough and hazardous situations, with proper design analysis.

## V. RESULT AND DISCUSSION

There has been a steadfast development in the field of quadruped robot.One significant reason is their ability to do jobs in complex and hazardous situations that conventional wheeled or tracked robots find difficult to navigate. They are also capable of doing activities that necessitate a great degree of mobility and adaptability.Quadruped robots can cross uneven terrain, climb stairs, and manoeuvre through tight gaps, making them excellent for search and rescue, surveillance, and exploration in disaster zones, mines, and other dangerous regions. Quadruped robots emulate the mobility and behaviour of real spiders, allowing them to cross complicated terrains and execute jobs that typical wheeled or tracked robots find challenging.Several experimental studies have been carried out to assess the performance of quadruped spider robots in various settings. The study's findings revealed that the robot was capable of generating a steady and adaptive gait that allowed it to easily cross diverse types of terrain [3]. The robot could also keep a steady pace and direction while changing its gait to variations in the terrain.Another investigation looked on the stability and agility of a quadruped spider robot in dynamic environments[2]. The robot was outfitted with a unique control system that enabled it to react fast to environmental disturbances and retain stability despite traversing uneven and uncertain terrain.The results demonstrated that the robot could easily take on complex manoeuvres such as climbing stairs and crossing tiny gaps.Apart from movement, quadruped spider robots have been researched for sensing

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and manipulation abilities. In one study, researchers investigated the deployment of a tactile sensor array on the legs of a quadruped spider robot to identify and avoid obstructions in its path [5]. The results demonstrated that the robot was capable of navigating a congested area while avoiding obstacles. Not only it can detect obstacles in front, the robot was able to gather and monitor environmental data. Because of IoT, the robot can assess environmental data and notify the user accordingly. They can, for example, be used for detecting forest fires by outfitting them with a heat and smoke sensor; they can also be dispatched into radioactive zones to measure radiation levels.

## VI. WORKING

When a statically stable robot's gait is ever stopped, it will not topple over. A quadruped is statically stable if three of its legs are continually in contact with the ground. The maximum torque required at a specific joint, that is when one of the robot's legs shifts up while the other three support the robot, is all that is required to choose the motor torque.The quadruped robot's walking pattern for preserving dynamic stability during manoeuvring, with the beginning posture being two legs extended out on a side while the other two legs are pushed inside, will be elaborated in Figure 1.While on the other hand Figure 2 depicts the waking pattern by picturing a movement diagram utilising joint coordinates along the X and Y axes over the top view of the model.The electrical system of the robot is in charge of powering and operating the various components of the robot. The motors that control the legs are included.The software component is designed to generate adaptable and stable gaits that enable efficient mobility on a variety of terrains.Therobot manoeuvres around thecoordinates by receiving corresponding signals over Bluetooth and captures the video by using an ESP-32 Wi-Fi Camera module. ESP-32 camera module allows streaming of the camera in real time thanks to its Wi-Fi connectivity. Robot streams the camera feed to a local host that has been programmed in ESP-32.A memory card is attached to the ESP32 CAM modulehas a built-in micro-SD card slot by which the camera feed is recorded. To complete the gait planning in thisquadruped robot, the foot-end trajectory and inverse kinematic solutions are combined. This quadruped robot has a traditional compound pendulum equation. During the diagonal trot gait trial and self-balancing test, the quadruped robot can control the roll and pitch angles of its torso. The prototype, on the other hand, attempts to create a scalable, versatile, quick, accurate, fairly priced, and logic-based legged robot. The prototype is statically stable, which means it will not fall over if its gait is ever stopped. The basic operation of the quadruped spider robot is shown in the Figure 3.

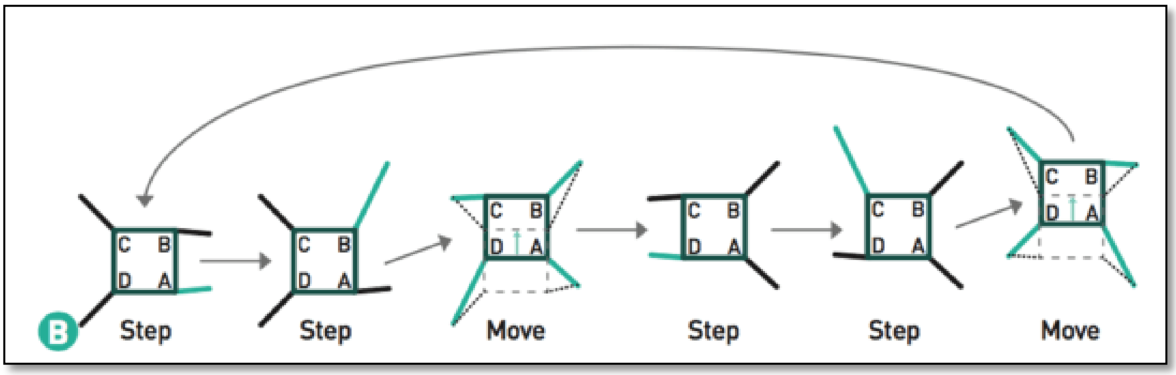


Fig. 1 Movement diagram with joint coordinates for spider robot

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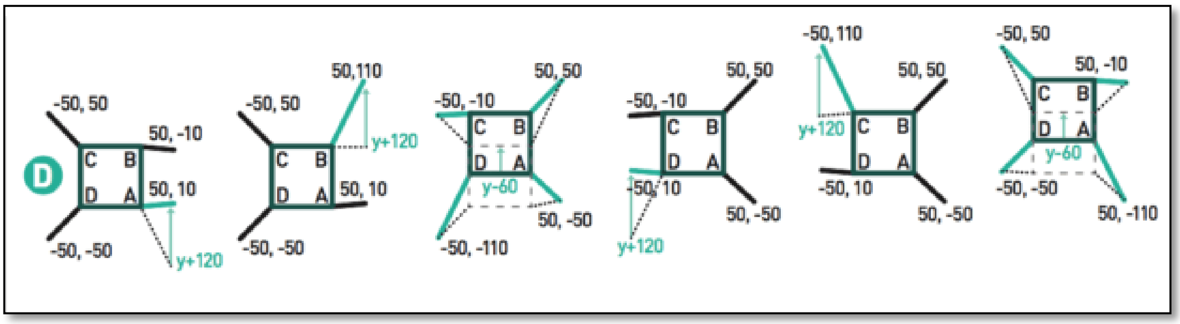


Fig. 2Movement diagram with joint coordinates for spider robot

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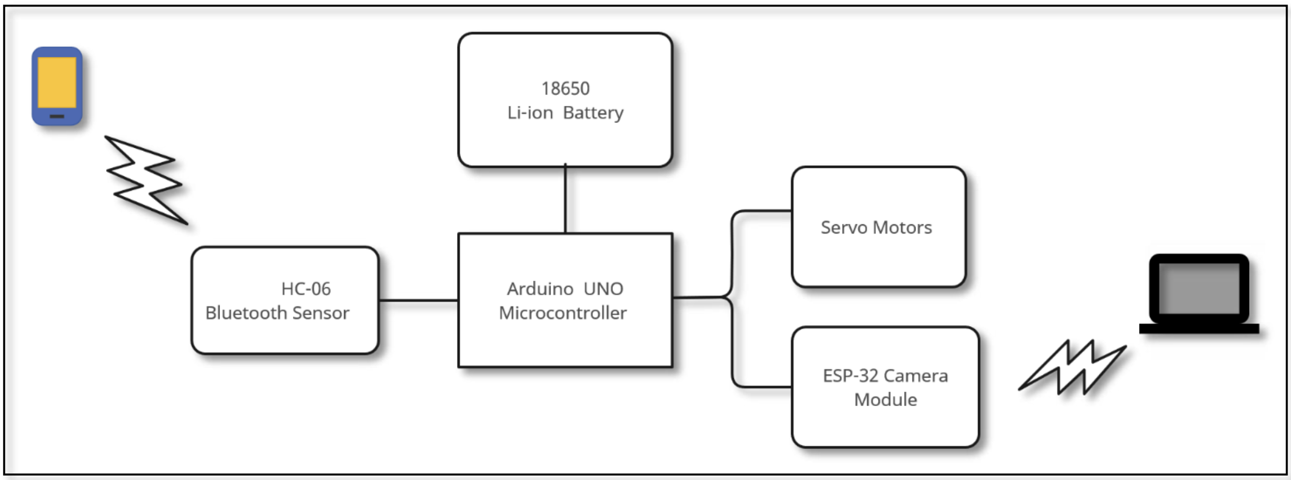



Fig. 3The basic operation of Quadruped robot

## VII.CONCLUSION

A quadruped robot is the best option to the current robot or human intervention system for data collecting from places where people and conventional autos cannot travel.These robots are capable of navigating hard and hazardous settings, completing previously thought-impossible jobs, and opening up new avenues for exploration and discovery. Because of their distinctive design and adaptability, they are well-suited for a wide range of uses, including search and rescue operations, military, and industrial applications.This device would revolutionise the way people search for their loved ones following a natural disaster with complex terrain and a frigid environment, such as an earthquake, volcanic eruption, or snowstorm.Quadruped devices can be deployed in conflict zones and used to perform reconnaissance duties in an energy-efficient manner.Robust construction and dynamic stability allow for quick manoeuvring in difficult and rugged terrain. The proposed arrangement could be improved by integrating a wireless controller and a group of sensors equipped with cameras to collect data in places where humans appear to be unable to.However, quadruped spider robot design and development are still in their initial phases, and more research and development is required to improve their performance, efficiency, and reliability.We employed an ESP-32 Cam hardware to achieve applications like as rescue missions and navigation.However, if the prototype is to be used for defence and security applications, it is recommended to utilise a nitrogen-filled camera with an IR-cut sensor, which works by filtering unwanted IR light and preventing it from affecting the colours of daylight photos, making them appear much more realistic. And instead of Bluetooth to communicate with the robot, Wi-Max standard is advised to use as it provides faster and secure communication than Bluetooth.

## VIII.FUTURE SCOPE

With upcoming developments in materials science, electrical engineering, and artificial intelligence, quadruped spider robots have the potential to revolutionise different professions and businesses while also making important contributions to society. As a result, it is critical to continue to invest in research and development in this field in order to realise the full potential of these incredible robots.The future potential of quadruped spider robots is considerable, with enormous potential for a wide range of applications. The development of improved control systems that allow these robots to do more complex jobs with greater efficiency and precision constitutes one of the most promising fields of research. Advances in artificial intelligence and machine learning are predicted to dramatically increase robots' ability to navigate difficult settings, recognise and react to environmental changes, and adapt their gait and motion to diverse terrains.Aside from enhanced control systems, there is tremendous potential for the employment of upgraded sensors and perception systems that allow robots to detect and respond to a wide range of inputs. Sensors for temperature, humidity, and other environmental conditions are included, as with cameras, lidar, and other imaging systems that allow the robots to navigate and map their surroundings.These robots can be used to detect and respond to natural disasters like as earthquakes and hurricanes, assisting in rescue and recovery activities. Quadruped robots can be used in agriculture to monitor and maintain crops, lowering labour costs and increasing yields, can be used in mining to investigate and harvest minerals from remote and dangerous regions, improving efficiency and safety.

## REFERENCES

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 5, May 2023||

|DOI:10.15662/IJAREEIE.2022.1205010 |

[1] Wikipedia, Mobile Robot, [Online], Available: https://en.wikipedia.org/wiki/Mobile_robot

[2] Biswal, Priyaranjan & Mohanty, Prases. (2020). Development of quadruped walking robots: A review. Ain Shams Engineering Journal. 12. 10.1016/j.asej.2020.11.005.

[3] Zhong, Yuhai, et al. "Analysis and research of quadruped robot's legs: A comprehensive review." *International Journal of Advanced Robotic Systems* 16.3 (2019): 1729881419844148.

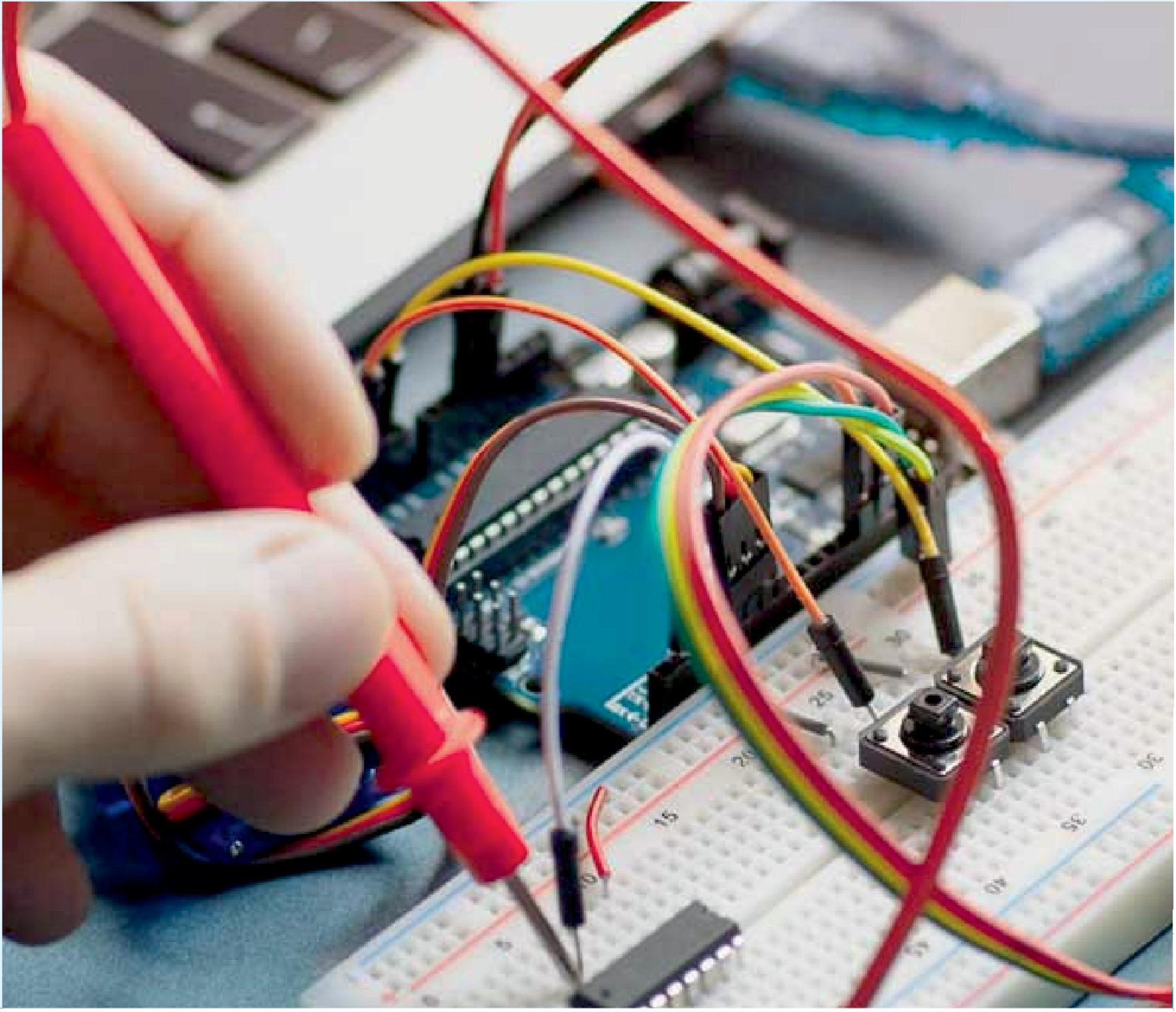
[4] Rubio, Francisco, Francisco Valero, and Carlos Llopis-Albert. "A review of mobile robots: Concepts, methods, theoretical framework, and applications." International Journal of Advanced Robotic Systems 16.2 (2019): 1729881419839596.

[5] M.H. Raibert, Legged robots that balance: MIT press, 1986.

[6] Cavas, Mehmet &Baballe, Muhammad. (2019). A REVIEW ON SPIDER ROBOTIC SYSTEM. International Journal of New Computer Architectures and their Applications. 9. 19-24. 10.17781/P002604.

**[7]** Mr.V.Arun, Mr.S.V.S.Prasad, G.Sridhar Reddy, L.Ruthwik Reddy, M.Venkatesh, M.Sai Pavan Kumar (2016). IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 3, Ver. III

[8] R. Teymourzadeh, Rahim Nakhli Mahal, Ng Keng Shen and Kok Wai Chan, "Adaptive intelligent spider robot," *2013 IEEE Conference on Systems, Process & Control (ICSPC)*, Kuala Lumpur, Malaysia, 2013, pp. 310-315, doi: 10.1109/SPC.2013.6735153.





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