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AI Based Spider Robot for Military Operations

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Abstract: Robotics is the division of engineering which deals with the manufacturing, production and application of robots. There are many types of robots like Ariel, ground, wheeled, industrial, mobile robots etc. Spider robot is a type of ground robot capable of walking. Current status of this project is that our robot can freely move along all axes . Till now our spider can be controlled by a wireless control remote. The robot can be used for both indoor and outdoor purposes. The project's main hardware includes ESP 32, IP camera and servo motors. This robot ideal case is to work according to our instructions like rotating in all direction for video surveillance etc. The robot can be regarded as a basic prototype for a robot which works according to our instructions or can make its own decisions, based on the sensors output, and then executes those decisions using servo motors to change the position or to move in a require pattern

Keywords: Spider Bot, ESP32 Controller, Face Recognition Application, Proximity Sensor, Intruder Detection.

I. INTRODUCTION

Robots are one of the intelligible creations in the human history that has revolutionized the world and has created a numerous opportunities and wide range of research possibilities in the field of automation. Robots are now used to replace human tasks which are highly dangerous and can be used to operate in places where the humans can hardly reach. there are many types of robots that replace humans like robots used in assembly line for repetive task and on such robot this multilegged robot which is used for moving on irregular surfaces and can be used for various purposes depending on scenarios and number of legs. The first spidebot robots that have been ever made are in such a way that they have pre-determined motion as a results of which they don't adapt for different type of surfaces .in 1950 robots which are made were operated manually. the first successful spidebot robot was constructed by university of Rome in 1972.

A rapid development in the control system has been made in the last two decades. different types of sensory equipment's are added to functions of spidebot. At the present scenario most of the robots are using their artificial intelligence systems for operation purposes for example Robot-3 had a total of 24 Doffs. Its architecture was based on structure of cockroach trying to imitate their behavior . Hamlet was a spidebot robot constructed at university of canterbury, New Zealand it consists of three revolute joints with identical legs the main purpose of this robot was to study force and position control on irregular surfaces ..

II. LITERATURE REVIEW

In [1] paper**,** A spider robot, often referred to as a spider-like robot or hexapod robot, is a type of robotic system designed to mimic the movements and characteristics of a spider. These robots typically feature multiple legs arranged in a manner similar to those of a spider, and they can vary in size and complexity. Spider robots are often used in various applications, from research and exploration to industrial tasks and entertainment. The design of spider robots is inspired by the natural locomotion of arachnids, allowing them to navigate through challenging terrain and perform tasks that traditional wheeled or tracked robots may find difficult. These robots are equipped with sensors, actuators, and sometimes cameras to interact with their environment and carry out specific functions. Depending on their purpose, spider robots can be autonomous or remotely controlled.

In [2] paper, Our paper presents a four-legged spider-inspired robot equipped with various algorithms for versatile locomotion and interactive functionalities, including dancing and greetings. Quadra Spider's movement capabilities extend beyond basic walking to include agile navigation through challenging terrains, such as rough and uneven surfaces. We demonstrate the robot's exceptional agility and stability through extensive testing, ensuring that it can traverse a

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diverse array of environments with efficiency and reliability. Beyond basic locomotion, the robot exhibits additional capabilities such as shaking, forward/backward movement, and lateral navigation. Energy efficiency is a critical consideration in robotic systems. To address this, we conduct comprehensive power consumption tests and incorporate power chargeable silicon batteries into Quadra Spider's design. This feature ensures prolonged operation and minimizes the need for frequent recharging, making the robot practical for extended use in various contexts.

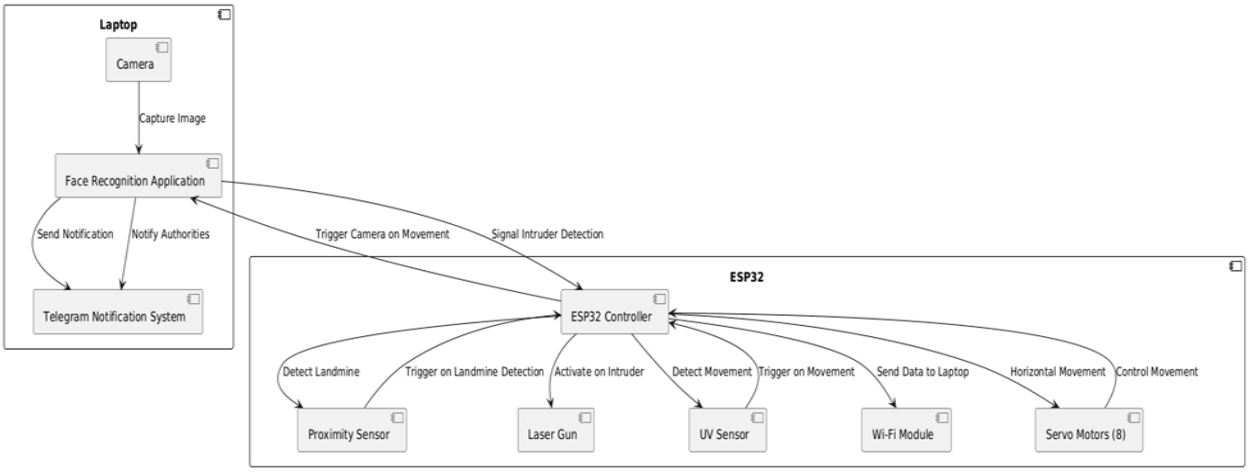
In [3] paper, Autonomous companion robots have shown to be particularly beneficial for gathering information in areas where people are restricted. In many cases, mobile platforms are required to move in areas where wheeled vehicles are unable to travel due to difficult landscape conditions. Explore and salvage tasks, and also conveying freights, provide examples of such situations. Walking robots, unlike wheeled robots, are characterized by their extreme portability in hostile environments. The main goal of this article is to demonstrate a creative, flexible, and practical strategy for a four-footed robot for ecological research.

In [4] paper, Legged robots are much more effective and useful in uneven terrains than wheeled robots because they can easily climb rocks and rough surfaces. Because their mechanized legs are designed for these surfaces, legged robots such as Quadruped robots can easily climb terrains such as rocks, sludge, incline and decline surfaces. Quad Bots can be built in a variety of shapes and sizes. The first quad robot was designed in the appearance of a dog. The spider-shaped quadruped robot shown below was created. This is a basic quadruped robot prototype. These robots can also be controlled via Wi-Fi or Bluetooth, and AI can be used to automate them. This concept depicts the use of various creeping walks to achieve coordinated robot innovation. The purpose of the research work is to create a dependable framework for integrating reliable and secure walking on smooth or off-road terrain environment in real time and transmitting it to the ground station via a receiving set.

In [5] paper, As the Korean demilitarized zone (DMZ) has unique geological features and terrains, conventional wheel-based unmanned ground vehicles (UGVs) are hard to perform the landmine removal tasks. Compared to other types of robot platforms, multi-legged robots, which climb the inclined way and overcome the complex obstacles with lower contact area on the ground, have several advantages to perform landmine detection tasks in DMZ effectively. Thus, to exploit such benefits, in this paper, we propose the design schemes and gait methods of multi-legged spider robots. Especially, this paper presents the design and motion control of multi-legged spider robots with four and six legs. In detail, we implemented the design and motion control of multi-legged spider robots suitable for landmine detection in the DMZ by applying the gait algorithms on Arduino and Dynamixel servomotors. Our proposed algorithm and system design demonstrate that the proposed system design architecture enables operational flexibilities while walking in harsh conditions.

In [6] paper, This project is a demonstration of a legged robot called "WICORS" which has four legs for movement. Legged robots have also been very useful in the military in performing the remote operations from a distant place. Legged robots are the robots that imitate the walking patterns of various animals. It is used for the data retrieval for the specific applications in different areas. This project is made for the purpose to collect data in the regions where it is dangerous for humans to enter such as the mining areas containing the toxic gases. It also serves the purpose of collecting the information about the injured and casualties in the disaster affected regions. The sole purpose of this project is to increase the real-time data transmission wirelessly by reducing the live interaction by humans with the surrounding environment.

III. METHODOLOGY



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This block diagram illustrates a comprehensive automated surveillance and security system consisting of a Laptop and an ESP32 Controller, interconnected with various hardware components. The Laptop hosts a Camera that captures images upon receiving a trigger signal. These images are processed by a Face Recognition Application, which can send notifications and alerts to authorities via a Telegram Notification System. The Face Recognition Application also triggers the camera upon movement and signals intruder detection.

Working Principle:

The methodology represented in this diagram can be described as follows:

- System Components Overview-The system integrates hardware and software components for security purposes. The two main components are-Laptop: Handles image capture, face recognition, notifications, and communication. ESP 32: Acts as a central controller for sensors, actuators, and communication modules.
- Detection and Response Flow-The system operates based on movement detection or landmine detection. It can identify intruders and respond accordingly. Proximity Sensor-Detects landmines., Sends a trigger signal to the ESP32.Servo Motors-Controls horizontal movement. Laser Gun-Activates upon intruder detection for a response mechanism.
- Laptop Functionalities-The laptop plays a critical role in-Capturing Images, Face Recognition Application-Analyses the captured image to identify an intruder, sends notifications or alerts based on the results. Notification System-Utilizes a Telegram Notification System to:
- Workflow Summary-Detection Phase-Sensors (Proximity, UV) detect movement or landmines and trigger the ESP32.The ESP32 activates actuators (e.g., servo motors, laser gun) based on the sensor triggers. Communication Phase-The ESP32 sends data to the Laptop via the Wi-Fi Module.
- Intruder Detection through motion and landmine sensors, Image-based Recognition for confirming intrusions, Automated Notification to authorities for rapid response.

IV. HARDWARE AND SOFTWARE DESCRIPTIONS

Arduino ESP 32:

ESP 32/Genuine Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again. "Uno" means one in Italian and was chosen to mark the release of ESP 32 Software (IDE) 1.0. The Uno board and version 1.0 of ESP 32 Software (IDE) were the reference versions of ESP 32, now evolved to newer releases. The Uno board is the first in a series of USB ESP 32 boards, and the reference model for the ESP 32 platform; for an extensive list of current, past or outdated boards see the

ESP 32 index of boards.

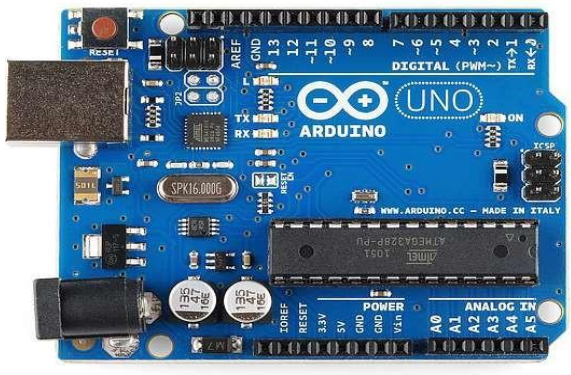

Figure: Arduino ESP 32

SERVO MOTOR

The motor is paired with some type of position encoder to provide position feedback (and potentially also speed feedback in more sophisticated designs). The controller compares the measured position with the desired position to generate an error signal, which when fed back causes the motor to rotate in the direction needed to bring the shaft to the desired position

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ESP 32 CAMERA

The ESP32 CAM module is an ESP32-based low-cost full-featured microcontroller with an integrated small-size OV2640 camera module & microSD card socket. This module integrates Bluetooth, WiFi, and BLE Beacon with two 32-bit high-performance LX6 CPUs. The frequency adjustment range of this module ranges from 80MHz to 240MHz. It adopts a stage pipeline architecture, a Hall sensor, an on-chip sensor, a temperature sensor, etc.

Proximity sensor

These devices can sense the presence of nearby objects without physical contact. There are several types of proximity sensors, including capacitive, inductive, magnetic, optical, and ultrasonic.

SOFTWARE REQUIREMENTS

Open-CV (Open-Source Computer Vision Library) is an open-source computer vision and machine learning software library. It provides a wide range of tools and functions for image and video processing, including various algorithms for object detection, feature extraction, image filtering, and more. Open-CV is written in C++ and has bindings for Python and other programming languages, making it accessible for developers working on different platforms.

Embedded C is one of the most popular and most commonly used Programming Languages in the development of Embedded Systems. Embedded C is a specialized version of the C programming language designed for developing software for embedded systems, which are compact computing devices integrated into hardware.

V. RESULT

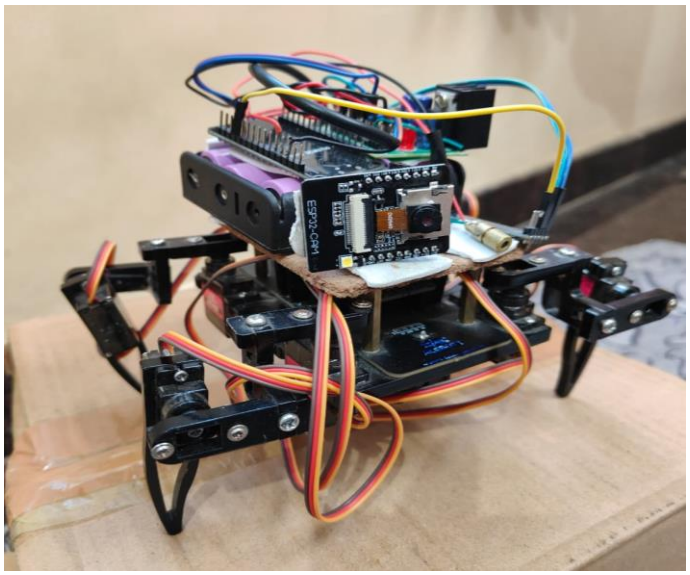

Figure: Complete Model

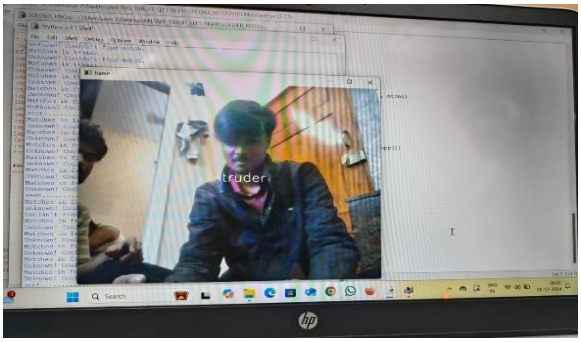

Figure: Enemy Detection

Figure:Message Received on Telegram

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Figure: Missile or Tanker Detection

Figure: Metal Detected on Robot

VI. CONCLUSION

The Project outlines an integrated security and detection system that combines hardware and software components to detect intrusions, identify threats, and provide timely notifications. The system utilizes an ESP32 controller as the central unit to manage multiple sensors (proximity and UV), servo motors, and a laser gun, allowing for movement detection, landmine identification, and intruder activation. The ESP32 communicates wirelessly with a laptop via its built-in Wi-Fi module to send data and trigger a camera for image capture. On the software side, the face recognition application processes the captured images to identify intruders, while a Telegram notification system sends real-time alerts to authorities or users. This integration ensures immediate responses to detected threats and provides a reliable surveillance mechanism. However, the system has some limitations, including hardware constraints**,** sensor inaccuracies**,** and dependence on stable Wi-Fi connectivity. False triggers due to environmental factors or face recognition errors under poor conditions may also reduce its effectiveness. Furthermore, reliance on the ESP32 as a single point of control poses a potential risk of system failure.

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