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Four Legged Walking Robot for Surveillance

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Abstract - *In the current century, there has been an increase in crimes and malicious activities around the world creating a need for a reliable surveillance technology. The areas with such activities rely on fixed surveillance technology which can be easily tampered with. A four legged walking robot is capable of accessing such places and it can also conquer rough terrain, dodge obstacles making it perfect for surveillance and monitoring. Aim behind the project is constructing a robot to carry out task using robotic arm and carry out monitoring in remote areas. The robot is constructed using open source software and hardware like Arduino Mega, ESP32, servo-motors etc. The motto behind the project is avoiding human risk which is involved in dangerous areas by use of an autonomous walking robot.*

Key Words: **Four legged walking robot, Arduino Mega, Sensors, Robotic arm, Obstacle avoiding robot, Surveillance robot.**

1. INTRODUCTION

Surveillance in dangerous areas is still mostly carried out by border security forces. There are some technologies being used in such areas like UAVs and tracked- wheeled Robots which are not reliable and cannot perform tasks. A Four Legged Walking Robot can solve this issue and can reduce risk on human life.

These are many Mechanism and devices developed to ease the human effort like cars, drones etc. But in comparison with the Mechanism of a living organisms this technology fall short. These technologies like wheeled robots and tracked robots cannot operate with continuous ground contact but a four legged walking Robot adapts to the terrain with losing balance [6]. The legged Mechanism balances the forces on the body if path is rough or slipper or filled with obstacles. Currently used surveillance and monitoring technologies are mostly unmanned vehicles like spy cars, drones, unmanned tanks etc. These technologies do not support task performance along with Surveillance. But rise of new computing software and hardware along with sensor has paved way for the growth of smart autonomous technologies like four legged walking robot.

2. EXISTING LITERATURE

2.1 Walking Robot

4 legged walking robots are based on support polygons, proper foothold choice, recuperation strategies to name a few. Also many crucial elements for walking robot are known but a strong research is still going on. There was this study in 2009, where researchers in California conducted a report that included simulation and real-world dog robot walking on rugged terrain was tested [3]. The same architecture of robot was suggested by in Israel in 2013. In order to achieve the results of robust and compliant locomotion over rugged, unperceived, and moving terrain a controller was introduced which helps the proposed robot can walk on rough terrain while carrying additional payload [7]. The same research paper which was presented by our country a thesis on the locomotion of quadruped robots was conducted in Vietnam in 2014. The conditions are rare where the robot proves a robust stability on inclined surface [9]. The current quadruped has evolved now to 8 degrees of freedom powered by servomotors and walks on flat terrain using symmetrical gaits such as trot and speed.

2.2 Use of open source software and hardware like Arduino and Sensors

Arduino is an open source computing framework or an open source microcontroller that can be used to program, erased and reprogrammed to build electronic devices that is based on basic microcontroller boards [19]. The benefit of using Arduino is that open sources offer free or nearly free, more accurate and inexpensive technologies [18]. The software configuration as a whole can be written in key functions-

1) Setup ( ): This feature is used to initialize configurations and is called at least once during program execution.
2) Loop ( ): This function is performed iteratively before the main board is turned off [21].

They can be linked to sensors such as a passive infrared motion sensor, a photodiode (LDR), a temperature controller (LM35), a sound sensor (SparkFun Electret Microphone Breakout), an ultrasonic sensor (HCSR04), or a smoke sensor (MQ-2). Both the sensors are directly attached to the main controller, an ATmega328-based 16 MHz micro-controller (Arduino UNO) [17]. For improved visibility a camera is mounted on robot. Various sensors do

different kind of things such as when an individual or object approaches a monitoring environment, the PIR sensor detects it, and the smoke sensor detects the blast, a metal detector to find the bomb so we know that every bomb contains some concentration or proportion of metal elements. This Multisensory device improves intelligence monitoring and also enhances to the next level [20].

2.3 Use of sensors to avoid obstacles

The most important necessitates a robot should have is the identification and avoiding of obstacles when leading the robot to its destination. This is because Collisions with objects or anomalies in the floor or a collision with one leg with any height can cause the robot to lose its balance and may lead to severe damage to human life as well as robot. The goal here is to know the known and the unknown the abnormalities in robots direction. As a result, an analysis involving a four-legged robot with obstacle-avoidance capability was carried out for the end conclusion of need of identification and avoidance strategies in Brazil 2016. The most important thing for overcoming obstacles is the only input touch sensors mounted on the robots feet. For a generalized solution to the problem of obstacle overcoming, the approach used to solve the problem was to segment a complex movement task into a group of basic movements performed in a simple pattern rather than developing a complex model. The concept was applied in the project built in India by using a cell phone as a network bridge. This concept gave birth to self driving cars in terms of hardware, applications, and contact environments with real-time obstacle detection and avoidance [10].

2.4 Task performing using robotic arm

A robotic arm has links of kinematic chain mechanism which is same as that of mechanical arm which can be programmed to perform similar functions to a human arm. The arm is the sum of total of the manipulators connections. Depending on the program any designed task to perform any desired activity in dangers of treating suspicious objects in their current world and workplace such as welding, grasping turning etc. would make it possible for humans to avoid dangers [14]. The project in Tamil Nadu intends to make it easier for humans to avoid dangers of treating suspicious items in their current atmosphere and workplace by making complex and complicate duties faster and accurately with this design. The key benefit of this robot is its gentle grabbing motion; this technology is designed to prevent applying extra pressure to the suspicious target for safety purposes and to avoid the dangers of treating suspicious objects in their current world and workplace [16].

2.5 Surveillance Robots

In simple terms, a computer artificial entity is referred to as a robot where it takes place on a vehicle outfitted with a web camera that captures and transmits video to a TV or PC. This prototype was developed in India in 2013 known as spy robot [11]. The microcontroller plays an important role in controlling moment of the robot as well as the wireless night vision camera that can relay image of the in order to avoid any injury or harm to human life [12]. As cases of terrorism and hostage situation are on a rise and any other extreme situations cannot be managed by humans alone. Many protection and surveillance tasks can be performed more efficiently by robots than by humans. The robot SPI PGM software was backed by Keil micro-vision software for successfully writing of c codes for the robot and to pass hex files to the microcontroller. A UART protocol was set up so that Arduino can communicate with Bluetooth module. The commands were received successfully and its movement was regulated as well as its performance, quality and repeatability are unparallel.

3. METHODOLOGY

The Methodology of the project included the following steps-

Step 01: Finding the issue in the Surveillance system

Step 02: Reviewing the existing literature

Step 03: Defining problem statement

Step 04: Selection of sensor, motor controller etc.

Step 05: Design of the body

Step 06: Design of robotic arm and effectors

Step 07: Design Calculation

Step 08: Design Assembly

Step 09: Writing source code for robot ad controller

Step 10: Checking for optimality and if YES the moving ahead, if NO the going for redesign from step 5.

Step 11: Fabrication of the robot

Step 12: Solving the issues encountered

3.1 Components Required

3.1.1 Servo Motor:

Fig -1: Servo Motor

Servo motors are important component of the robot. They used to produce the movement of the legs and are present at the joints. Servo MG996R shown in figure 1 has 12 kg/cm. Of torque and can withstand 5-7 volts of current.

3.1.2 Arduino Mega:

Fig -2: Arduino Mega

Arduino Mega shown in figure 2 is the brain of the robot which stores and executes the Programming which is programmed by the user. It has 54 I/O ports for programming and 256 kb of processing power. It can withstand 12 V current.

3.1.3 ESP32 dev board:

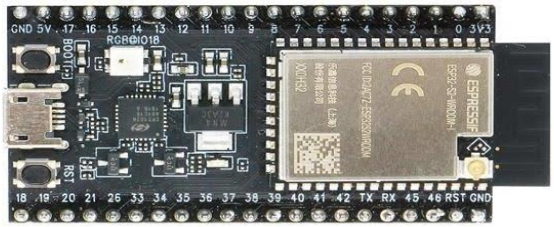

Fig -3: ESP32

ESP32 shown in figure 3 is a microcontroller base cup used to control the robotic arm. It has 2.4Hz Wi-Fi communication as well as Bluetooth communication. It can be controlled from anywhere using Ethernet connection. It can withstand 12 V current.

3.1.4 Bluetooth Module HC05:

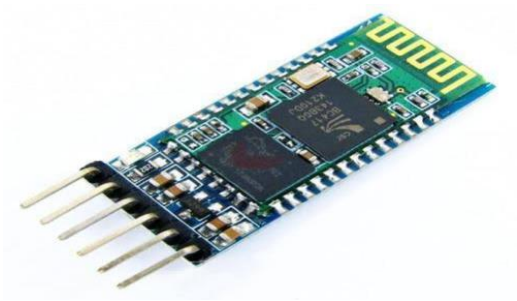

Fig -4: Bluetooth Module

HC05 shown in figure 4 is used as a communication device between Arduino Mega and Android controller.

3.1.5 Temperature Sensor:

Fig -5: Temperature Sensor

DHT11 shown in figure 5 is used to measure the temperature of the surrounding within a distance of 08-1 meters. It has o 8bit microprocessor which records and relays the temperature. It can withstand 5 V of current.

3.1.6 Obstacle Sensor:

Fig -6: Obstacle Sensor

Obstacle sensor shown in figure 6 is used to dodge the obstacles in the path of the robot. It makes use of ultrasonic waves to measure the distance from an obstacle.

3.1.7 Night vision A/V camera unit with radio receiver:

Fig -7: Night vision camera unit with radio receiver

SafeXpresS Model 4534534 Night vision camera helps in monitoring task and also when robotic arm is performing task. The camera is mounted on the gripper of the robotic arm and is connected to the power source. The receiver end is connected to the display unit and Audio/Visual

communication is established between camera and user end. This camera has a 15m transmission range, up to 25m in line of sight and up to 10m through walls.

3.1.8 Body:

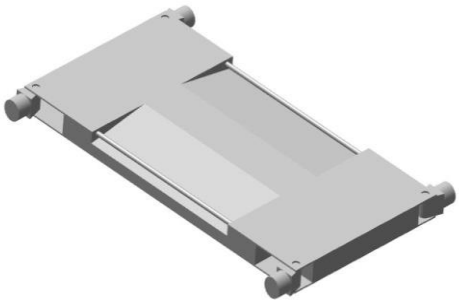

Fig -8: Body

Body of the robot is the part which houses the joints for the legs, steering mechanism, Arduino Mega and ESP32. Body is constructed in such a way that a load carrying apparatus can be mounted on it. The robotic arm is connected above the body.

3.1.9 Legs:

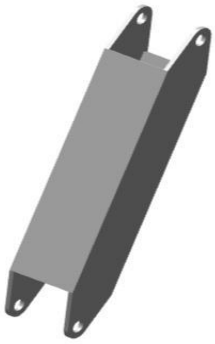

Fig -9: Leg part

The robot has four legs each made up two parts joined in the middle using a rotating joint. One end of the upper leg part connects to the body and the other end is connected to the lower leg part via a servo motor. Lower leg part is connected to the foot by simple rotating joint. Legs of the robot support the weight of the robot and they are flexible for any movement.

3.1.10 Foot:

Foot of the robot support the robot when the robot is on its two legs during walking. The reason for a wide foot is to increase the ground contact during the walk without losing the stability. The foot is not connected to servo motor and is free to move which helps it to adapt to any terrain.

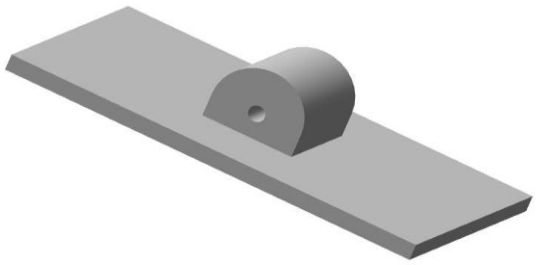

Fig -10: Foot

3.1.11 Pin:

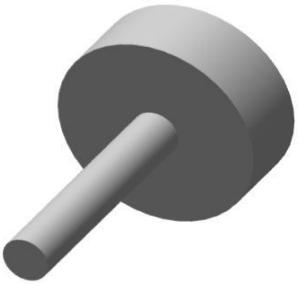

Fig -11: Pin

Pin is the part which connects the leg part and the motor together. It is connected to the legs though bearing at the contact points.

3.1.12 Steering Rod:

Fig -12: Steering Rod

Steering rod connect the two diagonal legs together. The steering rod is connected to a servo motor at the center of the body. It is connected to the legs via four screws each.

3.1.13 Robotic Arm:

Robotic arm is the main task performing component of the robot. It has six degrees of freedom and a two jaw gripper attached to it. The camera unit is mounted on the gripper. Two-jaw gripper helps to pick and lift objects as well perform task. Motion of the arm is controlled by three

servo motors and gripper is controlled by a single servo motor via gear mechanism.

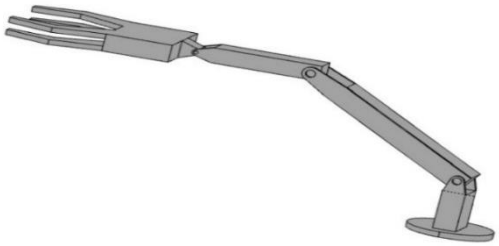

Fig -13: Robotic Arm

3.2 Programming used in the robot

3.2.1 Programming of the robot

Walking Mechanism programming is done in Arduino IDE software using micro c language. In the figure below shows the walking cycle for forward movement. The servo motor moves as discussed in the walking mechanism.

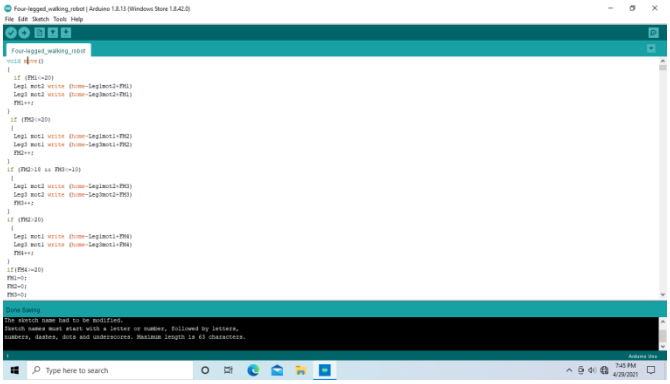

Fig -14: Arduino IDE programming

3.2.2 Programming of the Android Application:

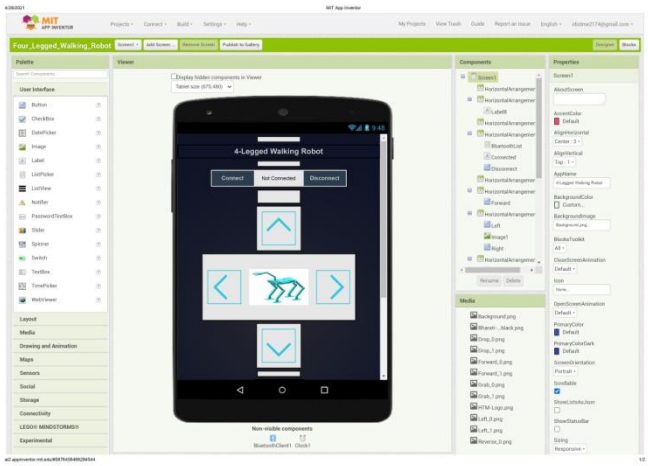

Fig -15: Application for the movement

Android application was created using MIT App Inventor 2 software. It is simple open source software for creating apps. The app connects to robot via Bluetooth on push of a button. It controls the robot by sending a number corresponding to the button pressed by the operator and the number received by Arduino Mega is processed to execute a particular command like walk or turn.

3.3 Construction of the robot

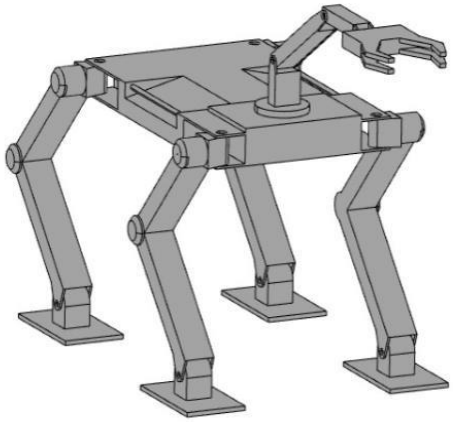

Fig -16: CREO Model of the robot

The complete design of the robot made on PTC CREO Parametric software is shown in figure 7.The body of the robot is made up of Aluminum. It has four legs and every leg is made up of two servo-motors and one free joint. Servo motors are joined at the joints using pins. The electronic, microcontroller and communications are all placed in the body. Robotic arm is present above the body and can work independently as it is connected to ESP 32. Balance is maintained by flat foot mechanism, which rotates freely to adjust to any surface. Camera and temperature sensor are placed above the gripper of the arm along with the obstacle sensor.

3.4 Working of the robot

The walking robot can be easily operated with Mobile Application. Working of the robot is as follows-

- When an operator commands the robot to perform a specific task via an android app.
- The command then travels to the Arduino Mega via Bluetooth module in the form of a bit number.
- Arduino Mega receives this bit number and executes the command programmed for that number like walk, turn etc.
- Execution of the command results in movement of the servo motors in a specific pattern to perform a move.
- Sensors can sense the surrounding temperature and any obstacles.
- This data is sent to the user via Bluetooth module.

- The app then displays the surrounding condition to the user.
- In the mean time the Camera display is continuously providing the audio-visual to the operator.

4. SPECIFICATIONS AND DIMENSIONS

4.1 The specifications of the robot

1. Its robotic arm has 6 degrees of freedom
2. It has a Two-jaw gripper
3. Equipped with Night vision camera
4. Can sense temperature, humidity and Obstacles
5. It is controlled by android app made on MIT inventor 2 software
6. It has three rotating joints in a leg
7. Servo motors are meta gear and durable
8. It uses a 12 V Li-Po rechargeable battery

4.2 Dimensions of the robot

The robot is constructed using so that is can access any entrance and performance any task. Hence the following dimensions were chosen for the robot.

Table -1: Robot Dimensions in cm

Parameters	Body dimensions	Parameters	Robotic arm dimensions
Length	60cm	Length	28cm
Breadth	40cm	Breadth	6cm
Height	44cm	Claw length	8cm
-	-	Claw mouth length	6cm

5. CONCLUSION

From the study and literature review, it can be concluded that the four legged walking robot can prove to be effective surveillance technology with large number of applications. It can be concluded that the robot can be easily constructed using open source software and hardware and considerably low price. It can also be concluded that the four legged walking robot can replace the current surveillance technologies as a better replacement and more reliable device.

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