Four Leg Spider Robot Using Arduino

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Abstract— In Nowadays, due to increasing advancement in technologies, bio- inspired robots are widely used and developed due to easy availability of electronic components and open source software at inexpensive cost. These robots are extremely useful for performing task in dynamic environment where normally performing task is very difficult, due to its flexibility and smooth interaction with environment. This project is also about a bio-inspired robot which is actually a four leg spider robot using Arduino nano. In this project, Arduino nano is the main component. Bluetooth module is used for controlling it with using remote control or android app. Micro servomotors are used for its movement acting as actuators. There are basically two programming codes used one for initializing servomotors positions and other for controlling its movement. 3D printed parts are used and assembled for its body. These robots are widely used for explorations and surveys in critical areas, space applications, medical fields and carrying loads.

Keywords: Spider Robot, Arduino

I. INTRODUCTION

Biological inspiration in robotics produced complex structures with sensory-motor coordination, in which learning is important for adaptation. In addition, rehabilitation robotics has produced new ideas and original human helping devices in the growing field of biomedical robotics.

Nowadays along with many advancements made in robotics, bio inspired robots are also made for flexible use in extreme environments. It comes in wide use due to its robust nature and suitability in unstructured and dynamic changing environment. These robots are becoming extremely important due to increasing complexities in technological demands. Bio inspired robots mimic both physical appearance and natural dynamics of biological movements resulting in robust and sharp robots. These robots are important for environments where dynamics, sensory processes and interactions with the surrounding environment are important.

The science and technology of rehabilitation robotics will progress through the collaboration among robotic researchers, medical doctors, and patients.

Fig. 1:

II. COMPONENTS REQUIREMENT

A. Arduino Nano:

Arduino Nano is a small, compatible, flexible and breadboard friendly Microcontroller board, developed by Arduino.cc in Italy, based on Atmega328p (Arduino Nano V3.x) / Atmega168 (Arduino Nano V3.x).It is similar to Arduino UNO due to same microcontroller, but quite in small size. It has an operating voltage of 5V and input voltage can vary from 7 to 12V.Arduino Nano Pinout has 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. Each of these Digital & Analog Pins are designated with multiple functions but their main function is to be set as input or output. They act as input pins when they are interfaced with sensors, but with driving load then they act as output.

Fig. 2:

B. Bluetooth module HHC05:

HM-05 is a Bluetooth module designed for establishing short range wireless data communication between two microcontrollers or systems. The module works on Bluetooth 2.0 communication protocol and it can only act as a slave device. This is cheap and flexible method for wireless data transmission and it even can transmit files at speed up to 2.1Mb/s.HC-06 using frequency hopping spread spectrum technique (FHSS) to prevent interference with other devices and ensure full duplex transmission. This device works within frequency range from 2.402 GHz to 2.480GHz.

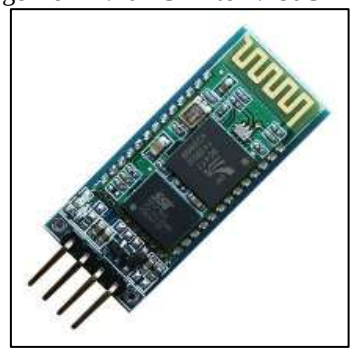

Fig. 3:

C. Printed Circuit Board/ Zero PCB:-

Printed circuit board is a flat, stiff and insulating material that has thin conducting structures sticking to one side. These conducting structures create geometric patterns of shapes

such as rectangles, circles and squares. Long and thin rectangles function as interconnections in place of wires and various shapes are used as connection points for components.

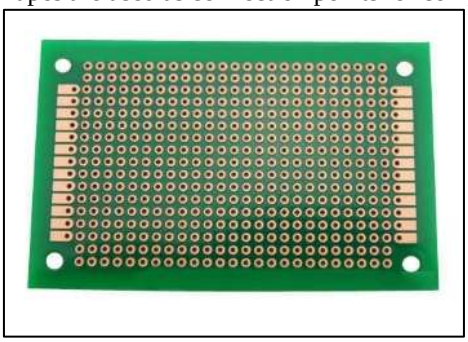

Fig. 4:

D. Jumper Wires:

Jumper wires are used for making connections between components on breadboard and Arduino pins.

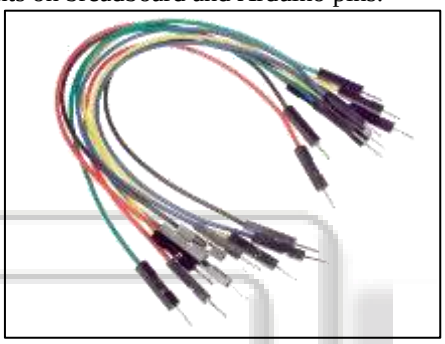

Fig. 5:

E. Breadboard:

A breadboard is used to make up temporary circuits for testing before implementing the circuit into pcb board. No soldering is required so easily connections are made and components can be replaced. Parts don't get damaged and can be used again.

Fig. 6:

F. Soldering equipment:

Soldering iron is a hand tool used for soldering. It provides heat to melt solder to flow into the joint between two work pieces and join them. It is composed of a heated metal tip and an insulated handle. Heating is achieved electrically by passing an electric current through a resistive heating element. Cordless irons are heated by combustion of gas stored in a small tank, using a catalytic heater instead of flame, varying with the amount of light to which it is exposed the output voltage varies with the luminous intensity. This module sends digital and analog signals. The potentiometer is used to adjust the sensitivity of the digital signal. The output of the digital signal is high when light intensity attains value set by the potentiometer and vice versa. The analog terminal outputs rise with the luminous intensity.

Fig. 7:

G. Micro servomotor:

Servomotor is a rotary actuator or linear actuator used for precise control of angular position, linear position, velocity and acceleration. It contains a suitable motor coupled to a sensor for position feedback. It forms a closed loop system where its position is sensed by potentiometer from which analog signal is send to control unit where desired position information is given to suitable motor causing motion related to reference position.

Fig. 8:

H. Lithium ion battery:

Lithium ion battery is a rechargeable battery type. During discharging, lithium ions flow from negative electrode to positive electrode and back during charging.

Lithium-ion batteries consists of LiCoO2 and graphite which are used widely as power sources for mobile phones, laptop computers and other electronic devices. Graphite and LiCoO2 are known as lithium insertion materials.

Fig. 9:

III. SOFTWARE REQUIRED

A. Arduino IDE:

Arduino IDE is a software used for writing C and C++ programs to the Arduino compatible board but also suitable for 3rd party core and other vendor's development. The

Arduino IDE contains a software library for wiring projects. This allows multiple inputs and output procedures. It is suitable for many other boards for programming and compiling. The programs which are written in the Arduino IDE is known as sketch.

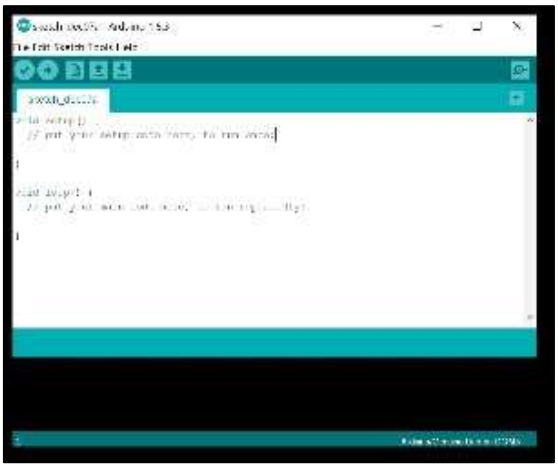

Fig. 10:

B. Android app:

Android app allows to connect robot through Bluetooth and make forward and backward movements and left right turnings, it allows to control the robot ligt in real time.

C. 3D printing:

3D printing is used in many manufacturing process which in addition builds or forms 3D parts in layers from CAD data. The technology is useful because it allows direct manufacturing, meaning a design formed directly from you to physical product through a computer and a printer.

IV. WORKING OF THE SYSTEM

When the robot walks, it has to keep its balance. There are two general strategies for doing that, and according to them, we divide the gaits into statically stable and dynamically stable.

For statically stable gaits it doesn't matter how fast they are performed, or whether the robot is stopped in a middle of a step – it is stable at any moment, at all times.

Dynamically stable gaits are much harder, as they have to be performed at a particular speed and cannot be interrupted at an arbitrary point.

A. Centre of gravity:

Center of gravity (CG) is main factor while walking. Center of gravity remains center of the body to stand balance if Center of Gravity moves out of center on certain limits then balance will be affected and leads to falling down. So let us see about maintaining CG while walking. If every leg is in 45 degree then the CG will be perfectly main in center, But if we moved any leg the cg will shift to that side so it lead to falling on that side. So to avoid this the either end legs are maintained at an angle greater than 45 degree based on the bot size, so the three legs will form a triangle, were the CG will be inside it and the fourth leg will be free to move and CG will remain inside a triangle.

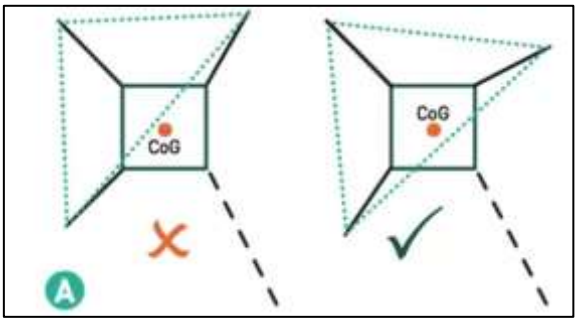

Fig. 11:

B. Creep gait algorithm:

Creep Gait : This gait is the easiest walking gait to use. The robot keeps 3 feet on the ground and keeps its center of gravity (COG) inside the triangle formed by those 3 feet. If COG goes outside the triangle for too long it will fall over. In case of quadrupeds such as animals ; they use movements of the head and tail to move the COG back and forth to keep it within Stability Triangle.

1) (From left side)This is the starting position, with two legs extended out on one side, and the other two legs pulled inward.
2) The top-right leg lifts up and reaches out, far ahead of the robot.
3) All the legs shift backward, moving the body forward.
4) The back-left leg lifts and steps forward alongside the body. This position is the mirror image of the starting position.
5) The top-left leg lifts and reaches out, far ahead of the robot.
6) Again, all the legs shift backward, moving the body forward.
7) The back-right leg lifts and steps back into the body, bringing us back to the starting position.
8) At all times, the triangle formed by the legs on the ground contains the CoG. This is the essence of the creep gait. In this pattern, we can see it is essentially two sets of mirrored movements. Step, step and shift, followed by another step, step and shift on the other side.

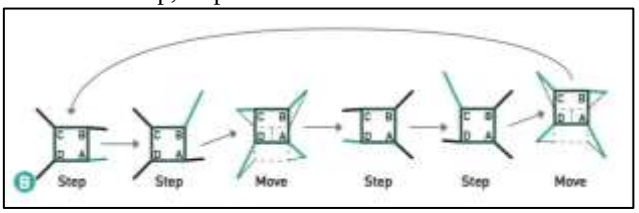

Fig. 12:

C. Circuit Diagram:

12 micro servomotors for 3 DOF or 8 micro servomotors for 2 DOF can be used. Each micro servomotor has 3 wires, power(red wire), GND(black wire) and command pulse(yellow wire). Command pulse of each wire can be connected to digital pins. For bluetooth module, its RXD pin is connected to TXD pin of arduino and its TXD pin is connected to RXD pin of arduino. Its GND pin is connected to GND pin of arduino and its VCC pin is connected to 5V pin of arduino. Power supply used has two wires power(red wire) and ground(black wire). Then, two programs are used. One for initializing positions of micro servomotors and other

for working of spider robot. The spider robot can be controlled by either android app or remote control using wireless RF module. Servo controller can be used for operating servomotors more efficiently. Compared to the mentioned schematic diagram Arduino Nano instead of Arduino Uno.

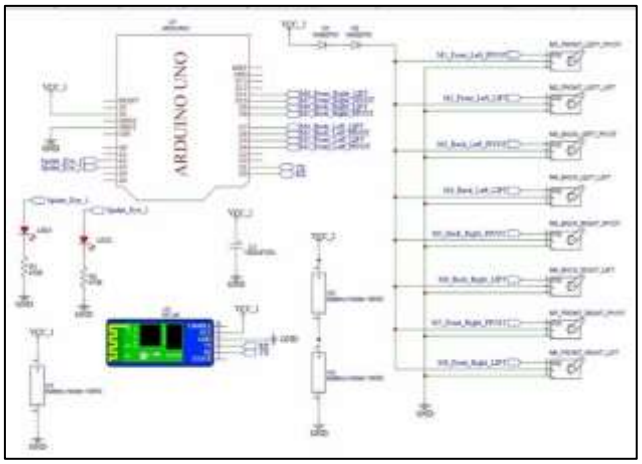

Fig. 13:

D. Micro servomotor as main actuator

Servomotor is a rotary or linear actuator that precisely controls angular position, linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor used for position feedback. It requires a sophisticated controller, a dedicated module designed for use with servomotors. Servomotors are not a specific class of motor but the term servomotor is used to refer to a motor suitable for use in a closed-loop control system. Generally the control signal is a square wave pulse train. The positive pulse width determines the servo position.

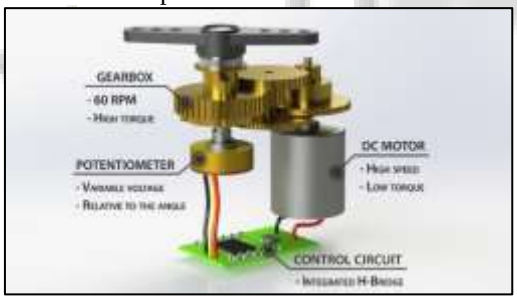

Fig. 14:

E. Leg structure

The leg structure of the four leg spider robot is designed in series. Each leg consists of three segments (coxa, femur and tibia) and three joints (base joint, hip joint and knee joint)

Each joint require a micro servomotor so in total it needs 12 micro servomotors based on 3 DOF

Coxa and tibia are joined through femur, by which two joints with two micro servomotors respectively get joined.

Tibia has one micro servomotor, coxa has one micro servomotor attached to the micro servomotor at the body.

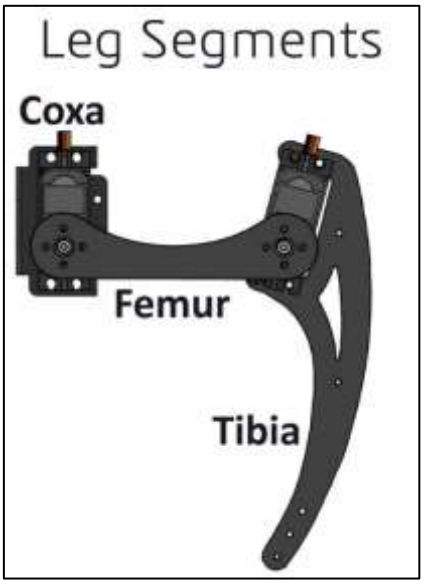

Fig. 15:

F. Assembling robot:-

The procedure for assembling robot is easy so by following steps firstly each leg is prepared where two servo motors are required for the joints and the Coxa, Femur and Tibia printed parts are assembled accordingly with this small attach part.

Starting with the first servo, it is placed in its socket and is hold with screws, after that servos axe is turned to 180° without placing the screw for the attaches and moved to the next part which is the Femur connecting it to the tibia using the first servo joint axe and the attach piece. In last step leg is completed by placing the second joint by holding the second servo holding the third part of the leg which is the Coxa piece. Same thing is repeated for all legs and all four legs are completed. After that taking the upper chassis it is placed and rest of servos are placed in the sockets and then each leg is connected to the appropriate servo.

Fig. 16:

G. Code and test validation:-

After assembling robot its joint angles are set by uploading the setup code allowing each servo in the right position by attaching the servos in 90 degrees and connecting the 7V or 9V lithium ion rechargeable battery to run the robot.

The main program is uploaded to control the robot using the android app.

The robot follows all the instructions sent from the smartphone.

H. Android App:

Android app allows to connect the robot through Bluetooth and make forward and backward movements and left right turnings, in real time.

V. RESULT

In this project, the spider robot is assembled along with corresponding electrical circuit. In the electrical circuit , Arduino and Bluetooth module are used, along with micro servomotors which are supplied by separate two lithium ion batteries. Robot is connected through mobile app by Bluetooth module, as shown in the figure below.

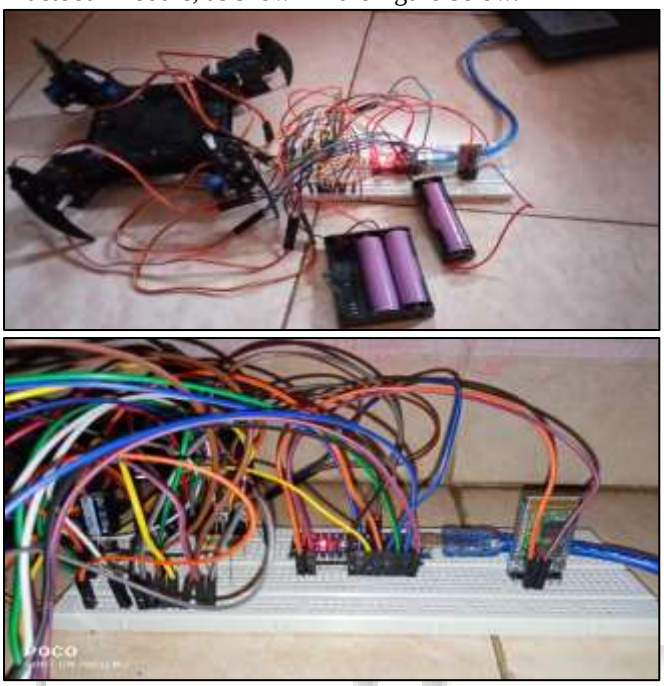

Fig. 17

VI. CONCLUSIONS

4 leg spider Robot can be made using Arduino Nano and can be controlled via bluetooth module by Android app or remote control with specific designed printed circuit board and programming code. With its great flexibility, cheap cost and simplicity it can be used widely in analysis and survey in dynamic environments where it is not possible for humans. With its walking ability it can easily walk in rough terrains where it is not possible for wheeled vehicles. It can be also used for medical fields, military purposes and carrying loads.

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