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Surveillance and Controlling of Firebird-V Based Hexapod using Raspberry Pi

Mahesh Pawaskar[1], Ankit Khandeparkar[2],Adesh C Hardas[3],Sonia Aneesh[4]
Department of Electronics & Telecommunication Engineering, A. P. Shah Institute of technology,
Thane, India
[1]mahesh.pawaskar@gmail.com, [2]anky199714@gmail.com, [3]achardas@apsit.edu.in, [4]saneesh@apsit.edu.in

***Abstract*— Hexapod legged robot's mission require high level of stability and precision, particularly in irregular areas. This paper aims to implement functionality in Firebird-V Hexapod which can enable it to move fast, smooth and stable. Firebird-V Hexapod consists of six legs built on a Firebird-V bot, each leg has 3 servo motors. So, in combination, the bot has 18 degrees of freedom. Mechanical structure and leg configuration, motion conditions, and walking gait needs to be taken into account to implement proposed work. Camera is mounted on robot for surveillance purpose and interfaced with Raspberry Pi, which enables live video streaming feature. ATmega2560 controller is part of Firebird-V which is interfaced with Raspberry Pi. For Controlling, commands are transmitted from Raspberry Pi to ATmega2560. The monitoring and controlling of robotic movements through WiFi is done by using a web browser and joystick as well.**

Keywords— Firebird-V, Hexapod robot, Raspberry Pi, Web server, ATmega2560

I. INTRODUCTION

Some industries are using human controlled Arm of robot to do machinery activities like positioning, placing, grabbing etc. For example, in packing section of industry various arms need to be move very precisely with specific speed. Kinematics plays vital role for the same. In some of the cases arms are used to move dangerous chemicals material. In that case, accuracy and safety is important. Monitoring and controlling robot or arm will be useful for above applications. Controlling can be done by PC based technology whereas monitoring can be done with the help of real time live video streaming [1][2]. Raspberry Pi is recommended to monitor and control robot's arm via website [3].

Chassis is one of the important part of robot. Legged based chassis, wheel based chassis or tracked based chassis are different types of chassis. Legged chassis are quite slow but extremely robust in rough terrain. This type of chassis are capable to cross large obstacles or holes. Normally legged chassis are preferred for space mission. Hexapod walking vehicles can also be used in a wide variety of tasks such as forests harvesting, in aid to humans in the transport of cargo, as service robots and entertainment. [4].

F. Tedeschi et al. gives an overview of the state of the art on hexapod walking robots by referring both to the early design solutions and the most recent achievements. Careful attention is given to the main design issues and constraints that influence the technical feasibility and operation performance [4].

Zak, et al. deals with design, construction and control of a hexapod (i.e. six-legged) walking robot, basic characteristics of legged robots, a few existing robots and their pros and cons. A Hexapod robot was designed, constructed and tested during this project. Robot can walk using tripod, wave and ripple gaits and it was equipped with ultrasonic sonars, force sensitive resistors, encoders and LCD display. Ground sensors on legs allow ground detection, so the robot can walk in rugged terrain [6].

According to Priandana et al. in multi-legged robots, leg coordination plays a vital role in defining the robots movement. Generally, multi-legged robots move according to the pre-planned gait. The tripod-gait movements defined by simple geometrical and inverse kinematics approach are proposed for the controller of a hexapod robot [7].

Hasnaa, et al. proposed hexapod robots are mechanical vehicles that use six legs to walk. This category is very interesting for several reasons. In this paper there is the presentation of the structure of the legged robot with an efficient setting of the coordinate frames, they have proposed a particular approach to model a tripod gait for the hexapod robot [5].

The Fire Bird V robot is the 5th in the Fire Bird series of robots. First two versions of the robots were designed for Embedded Real-Time systems Lab, Department of Computer Science and Engineering, IIT Bombay, India. Firebird-V ATMEGA-2560 provide excellence environment for experimentation, algorithm development and testing. Theses platforms were made commercially available from the version 3 onwards [9].

Many Hexapod robots are biologically inspired by Hexapod insect locomotion. Like a spider, Hexapod contains six legs and for proper stable movement the coordination between the legs must be properly maintained. In general as the number of legs increases the stability of the robot increases. Commonly as Tripod Gait is more statically stable, even on more than three legs, this concludes that the hexapod robot provides a good amount of flexibility in how it can move in an omnidirectional manner. If a leg gets disabled, the robot may still be able to perform Bipod Gait also known as two-legged Bipod Gait which is faster than Tripod Gait but on even terrain. Atmel Studio 7 is used to implement the proposed system using Firebird-V.

Code composer, Python, Arduino, php tools are used to implement proposed system.

II. PROPOSED METHOD

In proposed system, wireless communication is established between Firebird-V based hexapod robot and user using Raspberry Pi through WiFi. This robot activities are controlled by the webpage through Raspberry pi board.

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Camera in attached at top position of the Hexapod and it is interfaced with Raspberry Pi whereas joystick is interfaced with Arduino Nano. Information of position of joystick is feed to the Raspberry Pi sever via wifi, to move position of camera. The RPi which is mounted on the Hexapod acts as a Server, and the operating side acts as a Client. User has to enter local ip address of RPi into web browser like google crome from client side. On the Client side there is a web page which has buttons, and live video feed from the camera. Buttons are used to control the movement of the Hexapod. The web page can be accessed from any device like Laptop, Tablet, Computer etc.

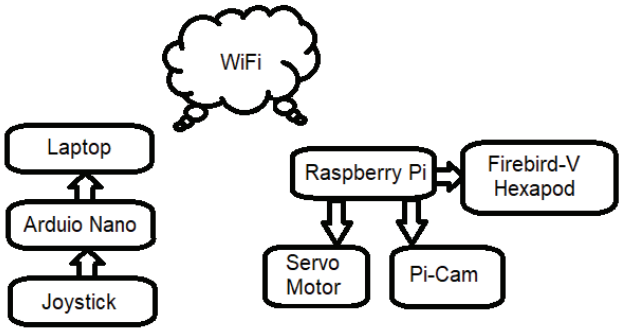

Fig. 1. Block diagram of proposed system

Clients fetch web contents from web server through wireless network. Hypertext Transfer Protocol (HTTP) is used to do communication between server and client.

Steps to Operate

- Switch on Hexapod and Raspberry pi.
- Run the Client and Server code for Joystick access.
- Open wifi of laptop or similar device and connect to the server.
- Type the local host IP address.
- Camera will be live and buttons to operate the Hexapod.

The Firebird-V Hexapod has an ATMEGA-2560 chip on board, it has 3 hardware serial ports for serial communication. The Client connects to the Rpi on wireless interface by using SSH (Secure Shell) Protocol, this protocol uses port 22 for its communication. On the Client side there is a web page which has buttons, and live video feed from the camera. Buttons are used to control the movement of the Hexapod. Once user pressed the button on web pages, a unique ASCII code is generated by using python in Raspberry Pi and it is transmitted to the Firebird-V to call corresponding subroutine to be executed by ATMEGA-2560. The web page can be accessed from any device Laptop, Tablet, Computer etc. An Arduino Nano is connected to the Laptop which is interfaced with a Joystick. The joystick provides the smooth working of PAN/TILT for the camera. The communication of the PAN/TILT is done by Python Sockets which gives almost less than 10ms of delay while operating.

The whole things are connected to the same network, same can happen if connected to a different network. Requirement for this will be to use port forwarding.

III. Design and Implementation

Following hardware modules are playing very important role in the proposed work

1. Raspberry Pi
2. Firebird-V based hexapod
3. Arduino Nano
4. Pi Camera
5. Servo Motors

The Firebird-V Hexapod has 6 legs built on Firebird-V bot, each leg containing 3 servo motors. So, in total, the bot has 18 degrees of freedom.

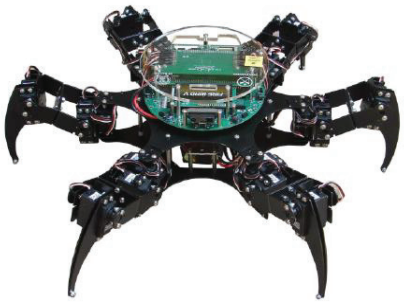

Fig. 2. Standing position of Firebird-V Hexapod

Gait can be generally visualized as a walking style of a mammal. Usually, insects or animals have various types of Gaits, for acquiring maximum efficiency the type of Gait is changed according to the condition of the terrain and the speed required. Every insect or animal does not have the same Gait, they may vary from one another. Considering a quadruped for selecting a Gait to consume less energy walk is preferred, to increase the speed gallop Gait can be used which will result in more energy consumption.

Major 3 tasks are handled

A. Motion:

There are 12 different directions of motion (6 corresponding to its 6 legs and the other 6 for movement in direction between two legs). Gaits implemented for motion: Tripod, Tripod continuous, Quadruped, Wave hello, Wave and Ripple.

1) Tripod Gait: If the legs of hexapod are numbered from 1 to 6, then legs 1, 3 and 5 form one tripod and legs 2, 4 and 6 form the other. During walking, the hexapod uses its 2 tripods from one foot to the other. Stable state is reached after one complete cycle.

2) Tripod Continuous Gait: This is like tripod gait given that it never reaches stable state while in motion i.e. when one tripod is moving forward, the other is preparing for it.

3) Quadruped: Hexapod stands on four legs instead of six. The remaining two legs are left in the air, they can be used to pick and place if needed.

4) Wave hello: Leg 1 of the hexapod makes a movement to wave hello.

5) Wave Gait: In the Wave Gait, all legs are moved forward in succession. This is then repeated on the other side.

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6) Ripple Gait: On each side a local wave comprising non-overlapping lift phases is being performed, and that the 2 opposite side waves are exactly 180 degrees out of phase with one another. For instance, if 1st, 2nd, 3rd leg forms a wave, a wave 180 degrees out of phase is there on the 4th, 5th and 6th legs.

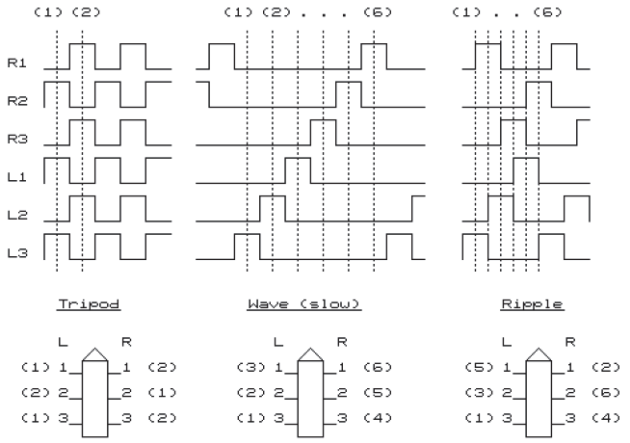

Fig. 3. Phase diagram of Hexapod legs motion [6]

B. *Turning:*

Hexapod can turn either clockwise or anticlockwise. Gaits implemented for turning; Tripod turn, Tripod turn continuous.

C. *Wireless Communication:*

Motion of the bot can be controlled by a button on a website for wireless communication. Joystick is interfaced to control the PAN/TILT of the camera servo.

IV. RESULT AND DISCUSSION

A. *TRIPOD GAIT*

As the most stable gait is the Tripod Gait, it is important to implement this to check if the hexapod is physically stable and is capable of standing on three legs. So the hexapod will be standing on three legs and there will be nine servo motors that will be handling the load. The most common approach for this gait is to look for even leg pairs and odd leg pairs, so at a time all the even legs will be on the ground balancing the hexapod and other times the odd legs will be on the ground and vice versa. This was successfully implemented on the Firebird-V so as to work on more gaits.

Fig. 4. Tripod Gait

B. *QUADRUPED*

This makes the hexapod stand on four legs, while the remaining two are free. Making this possible further creates instability with the hexapod, making the hexapod move forward on four legs is a very difficult task. Here the Tripod gait may or may not work as the weight of the hexapod and the servo motor which are used should be carefully designed and taken into consideration. The remaining two legs can be used to make pick and place activities if needed.

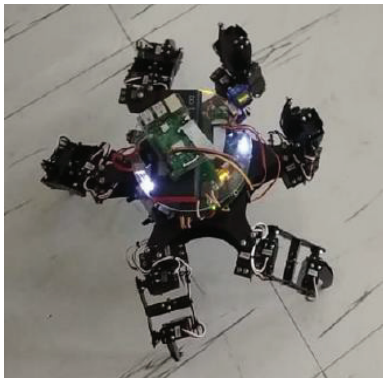

Fig. 5. Quadruped

C. *Servo PAN/TILT*

When a normal camera is mounted on the hexapod, the field of view (FOV) of the hexapod is very important. The FOV will be the direction at which it is looking at. For instance the user wants to look to the left at an elevated angle; this is only possible when there are servo motors to make the movement of the camera. The Pi camera mounted on the hexapod is attached to a servo which is placed on top of a servo. Servo 1 to make PAN motion and servo 2 to make the TILT.

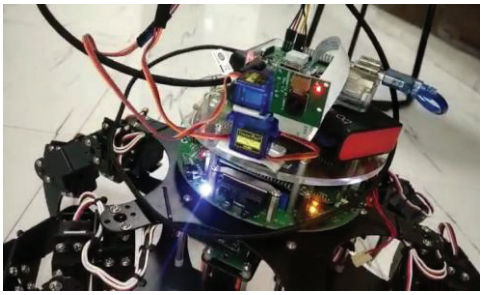

Fig. 6. PAN/TILT camera mount

The transmission is completely wireless and done with the help of Python Sockets and the GPIO pin on the Raspberry Pi.

V. CONCLUSION

Firebird-V ATMEGA-2560 based hexapod provide excellence environment for experimentation, algorithm development and testing in robotics. Monitoring and controlling the Firebird-V hexapod robot via wifi network using Raspberry Pi through webpage is done successfully. No any interrupts are occurred during transaction of commands from the user to the robot and the response from the robot to user. The robot can be easily controlled through using the personal computer or a smart phone. Six different

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giants for Hexapod are implemented and controlled remotely. Live video streaming is appeared on web page with very small amount of delay. Port forwarding can be used to connect entire network to the internet, so that hexapod can be controlled from anywhere.

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