Fully Automous and Controlled Quadraped Having Detection and Tracking

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***Abstract*— In this paper, authors have explained the development of Quadraped Robot having both autonomous and manual capabilities. Our development also emphasizes on having inbuilt detection and tracking of an object. Quadraped is a 4 legged robot almost resembling a spider. The complete assembly is made into 2 parts viz a Transmitter assembly comprising of a transmitter RF module (wireless communication), processor (brain of the remote controller) and receiver part which comprises of servo motors (locomotion of the quadraped), receiver RF module (wireless communication), webcam (object detection and tracking) and processors (controlling whole quadraped).The entire chassis is made from non-flexible acrylic sheets on which servo motors and processor are mounted. Legged robots are of much greater use as they can perform manipulative tasks which the wheeled ones cannot.**

***Index Terms*— Robotics, Gyroscope, Accelerometer, Servo motor, Visual Studio, OpenCV, Arduino, APC 220.**

I. INTRODUCTION

Robotics is a branch of technology that deals with the design, construction, operation and application of robots. Robotics is a rapid growing field, as technological advances continues, research, design and building new robots serve various practical purposes-domestically, commercially or militarily. These days many types of robots are being developed from manual to semi-autonomous robots having capability of Artificial intelligence i.e. capable of making its own decisions. **The authors have developed a robotic quadruped having both manual and autonomous capabilities, from their own learning and resources, which is controlled via wireless remote controller.** The robot can even work autonomously without any requirement of remote controller. The robot can move in forward, backward, left or right direction, It also consist of various special functions like object detection, kicking, taking a round and waving etc. Also the quadruped has the capability of detecting and tracking a particular object around its environment. Unlike traditional quadruped robot, we have introduced the *Object Tracking* as well as *locomotion recording and playback*.

II. METHODOLOGY

A. REMOTE CONTROLLER

Remote controller comprises of a complex circuit which is used to control the Quadruped. It transmits the signals to Quadruped (Receiver) via a set of inputs. It consists of Arduino Micro which is programmed in such a way so as to receive the input from the both the analog & digital buttons and transfers the data through APC-20 Module (Trans-receiver) to the receiver quadruped.

The remote controller consists of 12 digital input buttons and 2 analog sticks having separate individual functionality. The buttons sends the data to the Arduino Micro (microcontroller) in the form of bits either 0 or 1; microcontroller recognizes the bits produced by the particular button. The two analog sticks provide data to the microcontroller in the form of inputs ranging from 0 to 1023. The microcontroller processes the twelve digital and two analog signals and sends it to APC-220 (Trans-receiver). The processed values are then transmitted from the Module (Trans-receiver) to the quadruped. The module takes the feedback from the quadruped and sends the new processed signals to it. Further the controller is provided with the select button which has the capability of deciding whether the quadruped would be controlled manually or autonomously.

B. QUADRUPED

It is the main instrument where actual implementation of the program from the remote controller takes place. The quadruped might be controlled manually from the remote controller or it can work autonomously by just pressing the select button from the remote controller. It consists of total of 14 nos. of Servos, out of which twelve servo motors are being used for the locomotion of the quadruped. Quadruped stands on 4 legs; each leg of the quadruped contains three servo motors which provide 3 DOF's (Degree of Freedom) to the system. Remaining two servos are connected with the camera, which is being used for its movements in the X and Y plane. The movement of the robot is done with the help of GAIT walking. The APC-220 (trans-receiver) module receives the data from the remote controller and sends it to micro controller Arduino Mega 2560. From the micro controller the data is sent to the servo motors which control the locomotion of the quadruped. The quadruped moves accordingly in forward, backward, left and right as well as performs special functions as provided by the remote controller. The entire chassis is made of Acrylic sheet to provide better stability and less weight. Both circuitry and servo motors are attached with the base made of acrylic sheet, legs are also made from laser cut acrylic sheets. Various sensors such as accelerometer and gyroscope are embedded within the robot in order to get proper readings of the robot tilt in all the directions.

As mentioned the robot is equipped with a camera which is able to detect and track a particular object, this is achieved by using software called OPENCV library and Visual Studio C++. The camera takes the images of the object which relays the data to the software for processing. After processing part is done, the data is sent via serial communication to the

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microcontroller for the movement of the Servo motors in X and Y plane. Also when the object is captured by the camera the quadruped follows the object accordingly.

C. CONSTRUCTIONAL DETAILS

The quadruped is developed consists of following parts:

• *Transmitting End (Remote controller):*
1. APC-220 Module transmitter
2. Arduino Micro
3. Analog sticks
4. Input buttons

• *Receiving End (Quadruped)*:
1. APC-220 Module
2. Arduino Mega-2560
3. 14 nos. Servo Motors
4. Gyroscope
5. Accelerometer
6. Camera
7. Chassis

The construction is explained in various steps as follows:

Step 1- Boards:
Two microcontroller boards were taken up as per the requirement for the project.

1. *Arduino Micro*:
It is board based on the ATmega32u4. It has 20 digital input/output pins (of which can be used as PWM outputs and 12 as analog inputs), a 16 MHz crystal oscillator. Operating voltage of the micro controller is 5V. It has 32 KB. It also has 2.5 KB of SRAM and 1 KB of EEPROM.

2. Arduino Mega:
It contains Atmega AVR 2560 R3 micro controller. It has 54 digital Output/Input pins (of which 15 pins can be as PWM output), 16 analog inputs, 4 UART (hardware serial port), a 16 MHz crystal oscillator. Operating voltage of the micro controller is 5V.

Step 2- Camera:
To communicate with the environment, the quadruped is provided with a camera. The camera is connected to the Servo Motors in such a way that the servo motors provide the movement of the camera in X and Y plane. The images are taken as input from the environment and sent to the Visual Studio C++ and OPENCV library software for processing.

Fig 1: Circuit of Remote Controller

Step 3- Sensors:
In order to have proper mechanism and response from the robot, proper readings had to be taken for it. In this, we have used 2 sensors:

1. ADXL335:
It is 3- axis accelerometer sensors, which can measure the forces applied on to the sensor in all the 3 directions X, Y and Z axis. Further the raw data from the sensors are converted into acceleration by using some complicated equations. The advantage of the accelerometer is that the values do not change unless there is a change in position. But the problem with the accelerometer was that it contained high level of noise which makes the values inaccurate. So, to make these values accurate Gyroscope sensor was used.

2. L3G4200D:
It is a 3- axis Gyroscope sensor which can measure the degree of rotation in the entire 3 axis in form of alpha, beta and gamma. The values provided by the Gyroscope are very accurate but values do not remain static and tend to drift to the position Zero. To make the readings accurate as well as static both the values from the Accelerometer and Gyroscope were combined by using Complimentary filters.

Step 4- Communication
To get the most out of the system, it was better to transfer the data wirelessly. This was done with the help of RF module communication between the Robotic Arm and glove. The APC-220 Module was used in the process, which is highly integrated semi-duplex low power transceiver module with high speed MCU and capability RF IC. It has high sensitivity and strong interference circumstance as well.

Characteristics:
• 1000 meter of communication distance (2400bps)
• Output power is 20 milli-watts.
• Frequency is from 418 MHZ to 455MHZ
• More than 100 channels
• UART/TTL interface
• Exceeds 256 bytes of data transfer

Step 5- Locomotion Recording:
This is the most important and vital aspect for the quadruped. In order to provide maximum stability and determining the angles for the movements of the quadruped, inverse kinematics is used generally.
However, we came up with a new way to achieve the above. Instead we derive the angles directly from the servo motors which are then put into quadruped.

Step 6- Quadruped Mechanism:
The quadruped consists of 4 legs that are at right angles to each other and are connected to common base. Each leg comprises of three servo motors where each servo motor is connected to another with a bracket. A total of 12 nos. joints are present in the quadruped where each joint provide a single DOF (Degree of Freedom) to the robot.

D. FUNCTIONING OF QUADRUPED:

The quadruped developed by us performs the following functions:

MAIN FUNCTION:

• Object detection, following and kicking:

A small object is placed near the quadruped at a distance within the range of the camera. At this point operator can either select manual control or autonomous control. The movement of the robot is achieved by using GAIT walking.

Fig 2- Complete Assembly of Quadruped

Manual Control:

The operator uses remote control analog joysticks to send the data to the Quadruped for the movement of the camera in X and Y plane and as well as controlling the locomotion of the quadruped in forward, backward, right and left. Once the object is detected by the operator then quadruped can be moved towards the object. After coming close; the robot can now kick the object by providing the kick signal from the remote controller.

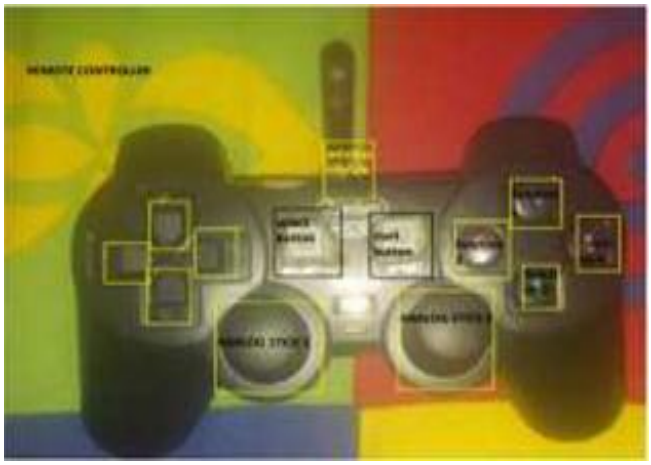

Fig 3- Complete Assembly of remote controller

Autonomous Functionality:

The operator selects the button for the autonomous control. After selecting; the quadruped now works independently on its own. The quadruped first searches the object using camera which is mounted on servo motors as discussed. The servo motors moves in X and Y plane continuously in horizontal and vertical direction. Once the object is detected the quadruped automatically moves towards the object until it comes to a particular distance. After coming close; the robot moves its front leg and kicks the ball autonomously.

OTHER BASIC FUNCTION:

- Forward Movement
- Backward Movement
- Right Movement
- Left Movement
- Up/ Down Standing
- Waving
- Twisting

III. APPLICATIONS

Such types of robots can be put to use in various types of application as follows.

1. Used to test biological theories about insects locomotion, motor control, and neurology.
2. Manufacturing Automation.
3. Machine Tools.
4. Spy robots.
5. Medical Robots.
6. Artificial Intelligence.
7. Manipulative tasks which the wheeled ones cannot.
8. Advance robotic toys for learning purpose.

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