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Yantramanav: A 8 DOF Bipedal Walking Robot - A Developmental Design

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Abstract—**This paper proposes a study on developmentdesign of bipedal walking robot. A bipedal walking robot isa type of humanoid robot which mimics the walking of human beings and can be programmed to perform specifictasks as required. In this paper we present the building of arobot that provides physical locomotion such as walking, climbing stairs, etc. along with providing live video feedback to the user. Our bipedal robot is constructed by 8motors and it has one DOF (degree of freedom) in each joint. This paper also describes how the bipedal robot is built, how the movement steps are obtained and how fall detection mechanism is implemented. To maintain the real time balanced locomotion and to measure the stability performance of the robot, an accelerometer and gyroscope sensor and foot pressure sensors are used. The movementof the robot can be controlled by using a remote controller.This bipedal robot can assist humans to carry out surveil- lance in hazardous environments like mines, fire, natural disaster etc. This greatly helps the rescue process during disasters and accidents.**

Keywords — **Bipedalism, bipedal robot, humanoid robot, bipedal walking, wheel robot, single support phase, double support phase, swing phase, stance phase.**

I. Introduction

Present world is growing with different robot. Robothave become important part of human life. Now a day's robot is being used in industrial area, human assistant purpose,fun game and other application. There are many types of robot such as hexapod [1], quadrupeds [2], wheeled robot[3], etc. In this today's world many bipedal robot projects are increasing day by day for the purpose of making human life more productive and easier [4]. Bipedalism is defined as a method of movement by which organisms moves in different surroundings on their two feet like running, hopping, and walking [5]. Much research on mechanical design and understanding the human balance has been done to make bipedal robots. The number of research and development projects aimed at building bipedal and humanoid robots has been increasing at a rapid rate. The goal of this paper is to design the 8 DOF (degree of freedom) bipedal robot. The terms bipedal robot and humanoid robot both are different term. As the name implies, the term bipedal robot refers to a robot that walk on two legs, whereas the definition of the term humanoid robot is vast. In general, a humanoid robot is defined as a robot with some human-like features (not necessarily the ability to walk on two legs). For example, some humanoid robots consist only of an upper body or a head. In this paper we refer to the development design of 8 DOF (degree of freedom) bipedal walking robot. After all the research we did, it became crystal clear that this project is one of a kind because in our country none have been successful in making a fully functional biped robot. We have seen the wheeled robot that are currently being used in restaurant, but they are wheeled robots not bipedal robots and has limitations. The main objective behind the construction of our bipedal robot came from the drawbacks ofwheeled robot i.e. being unable to walk in difficult places wherethe wheeled robots don't have access to.

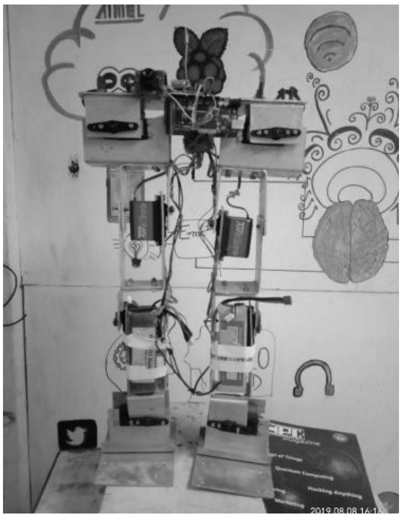

Fig. 1. Yantramanav

II. Design

The balance control approach of a bipedal robot is presented in this paper. The robot consists of three subsystems: knee joint, ankle joint, hip joint of left leg and right leg. The structure of robot is shown in figure 2.

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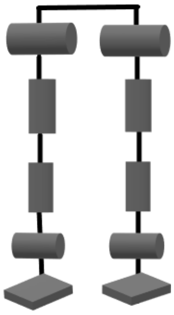


Fig. 2. 8 DOF Structure of Bipedal

A. *Anatomy*

In Yantramanav there is a total of eight degree of freedom where two dof is seen in each hip and similarly single dof in knee and ankle each. It is the minimum requirement for a bipedal robot for fairly smooth motion. In our deign we have used a 3mm aluminum sheet as materials for external design asit is light weight and Arduino Mega, a micro-controller, for overall control of the robot. Li-po battery is used in order to provide power supply to all the hardware, servo motor used at joints and overall motion of the robot and finally servo motor controller for controlling the servo motors. We have used different sensors such as foot sensor, gyroscope and accelerometer sensor for the stability of the robot. We have used camera for the live video surveillance from a remote location [6].

TABLE I

RANGE OF MOTION FOR LEFT LEG

Joint	Range in degree
M1	70+φ
M2	85+φ
M3	75+φ
M4	90+φ

φ=angle in degree.

TABLE II

RANGE OF MOTION FOR RIGHT LEG

Joint	Range in degree
M1	60+φ
M2	40+φ
M3	20+φ
M4	90+φ

B. *Actuator*

We have used servo motor as actuator which have the range from 0 degree to 180 degree. Servo motor used in our robot is S8218. This have three pins (VCC, ground and signal). It is used for dynamic motion of robot which consist of stance phase and swing phase.

SPECIFICATION OF SERVO MOTOR

Modulation	Digital
Torque	7.2V: 40.00kg-cm
Speed	7.2V:0.18sec/60 deg
Weight	164.0g
Dimension	Length: 2.34 in Width=1.14 in Height=2.17 in
Gear type	Metal

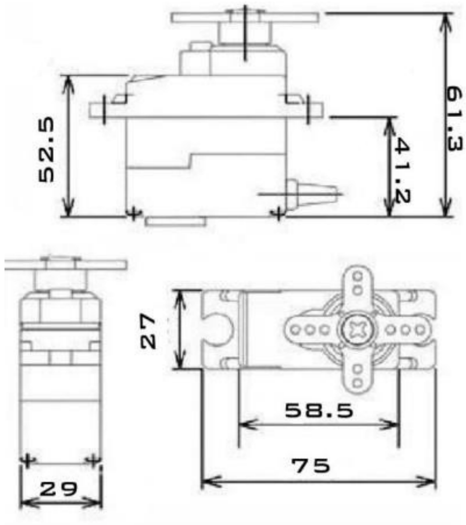


Fig. 3. Schematic Diagram of servo motor

C. Force and Pressure Sensor

To measure the force exerted on foot of leg we used force pressure sensor. To make the robot stable, we need value of pressure exerted on both leg when they are in double support phase and single support phase. When the robot is in double support phase the robot is more stable than in single support phase. Force sensor are installed on each sole of the foot, to measure the pressure of four corners of each sole. During the single support phase, the position is calculated by equation (1)[7].

$$CoP = \frac{\sum_{i=1}^{n} F_i \cdot j_i}{\sum_{i=1}^{n} F_i} \quad (1)$$

where F_i is the pressure value measured from the i^{th} sensor and J_i is the vector from CoP to the i^{th} sensor. The CoP positioncan be also calculated from 1 by changing the value of n.

III. **Control mechanism in different phase**

Bipedal walking robot is not easy to control like human walking in different terrain. The dynamic motion of bipedal robot is difficult. For the walking of bipedal robot, we have to think of orientation, position, torque exerted in each joint, inertial force and force exerted in foot when it is in different phase. To control the locomotion of robot we can divide walking in two phases: swing phase and stance phase.

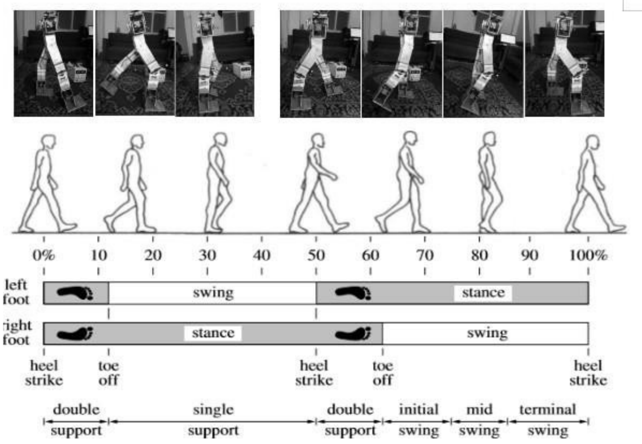


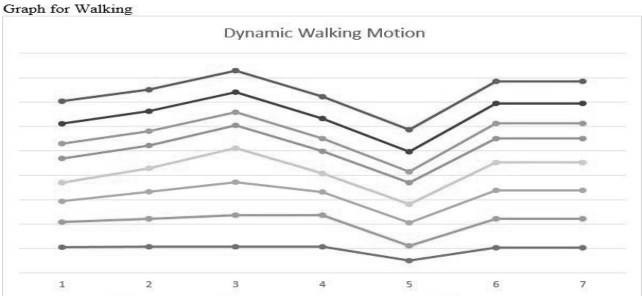
Fig. 4. Walking of Yantramanav is Compared with the Diagram of Typical Human Gait Cycle [8].

IV. A. Analysis

Actuator Angle for Dynamic Walking

Left Knee		Right knee		Hip		Ankle	
m6	m7	m2	m3	m4	m5	m1	m8
106	103	85	76	99	61	82	92
108	114	111	96	93	59	82	88
108	129	135	140	93	54	82	88
108	129	95	76	91	52	82	90
51	60	95	76	88	45	82	90
104	118	117	114	98	62	82	90
104	118	117	114	98	62	82	90

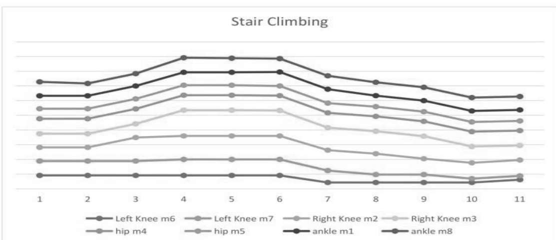
Graph for Walking



Actuator Angle for Stairs Climbing

Left Knee		Right Knee		hip		ankle	
m6	m7	m2	m3	m4	m5	m1	m8
90	98	93	93	102	68	88	95
90	98	93	93	102	68	88	84
90	98	160	93	102	68	88	84
90	109	160	175	102	68	88	99
90	109	160	175	102	68	88	96
90	109	160	173	101	66	95	91
42	81	139	153	101	66	95	91
42	54	142	153	101	66	75	91
42	54	108	153	101	66	75	91
42	26	108	111	101	66	75	91
61	26	108	99	101	66	75	91

Graph for Stairs Climbing



V. METHODOLOGY

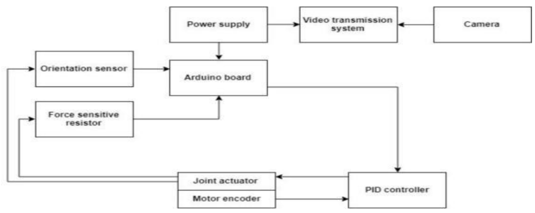


Fig. 5. Block Diagram of Yantramanav

This above diagram explains about how our robot work. First, we have to sense the motion and position of robot using orientation sensor and also sensing the force on the footusing force sensor to have information about the stance and swing cycle. After that Arduino read the sensed value and manipulated it. Arduino send manipulate data to PC through Bluetooth module (wireless communication). Now PID tuningis done in data in MATLAB to stabilize the robot movement. With the help of tuned value, joint actuator moves. While moving the joint actuator, if the robot is unstable then again, wehave to go for PID tuning to stabilize it otherwise we go forward to complete our work (walking, sitting). If our work doesn't complete, we repeat all above process again and again. If workcompleted, then we stop our process.

VI. CONCLUSION

In this paper, a design development of eight degree of freedom bipedal robot is manifested. While designing the bipedal robot, we hardly faced any problem but when we realized the actual robot, we faced numerous problem such as difficulty in stabilization, precision etc. To eradicate the problem, we studied human gait cycle and optimized the motion according to our requirement that finally helped us to achieve the motion we wanted. Methodology we used for dynamic walking of our bipedal robot is mention in above section.

VII. REFERENCES

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