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HUMANOID LOCOMOTION MANIPULATED USING DYNAMIC FINGER GESTURES

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Abstract-The fundamental technologies for Human-Computer Interaction are Hand motion tracking and Gesture Identification. The same technology has been adapted for Human-Robot Interaction. This paper discusses a natural methodology for Human-Robot Interaction. In the proposed system, the accelerometers at the fingers, tracks specific gestures. These gestures are identified by the controller, which in turn controls the actuators that results in Humanoid walking. The Humanoid under consideration has 8 Degrees of Freedom.

Keywords- *Human-Computer Interaction; Human-Robot Interaction (HRI); Degrees Of Freedom (DOF); Humanoid; Hand Motion Tracking; Gestures; Accelerometer;*

I. INTRODUCTION

According to Webster dictionary, a Gesture is defined as, “a movement usually of the body or limbs that expresses or emphasis an idea.” Earlier, conventional input devices like Keyboard and Mouse were used for Human-Computer Interaction. These type of interaction lacks naturality. Thus interaction using gestures became a subject of study. The same interaction method can be utilized for Human-Robot Interaction (HRI). HRI is the study of interaction dynamics between Humans and Robots. Many researches are under way to develop an efficient system for Human-Robot Interaction using Gesture Identification. This type of interaction schemes are difficult to design for robots due to complex processes involved in it. Difficulty to recognize gestures and to interpret their meaning , complex backgrounds, person-independent recognition, processing speed, computational costs etc are the challenging factors involved in the design of such a system[1]. There had been several research works on telemanupulation of Robotic arm using finger gestures [4]. This paper emphasis on developing a simple system for HRI using finger gesture Identification to make a Humanoid Robot walk successfully.

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II. OVERVIEW ON GESTURES AND GESTURE RECOGNITION

A. Gestures

Gestures are broadly classified into two

1) Static Gestures

Static Gestures are also known as Postures. If the finger position does not change for an amount of time, known as the gesturing period, then those gestures are known as static finger gestures or finger postures. Static gestures, deals with information on bend, turn or fold parameters of the fingers[1].

2) Dynamic Gestures

Dynamic Gestures could be simply called Gestures. In Dynamic finger gestures, the position of the finger is temporary and it changes, with respect to time. It could be interpreted as a sequence of static gestures[1].

B. Gesture Recognition

There are different methods for Gesture Recognition. The most widely used are-

1) Sensor Based Systems

In this type of system, finger joint angles and spatial positions which reflects finger Gestures are measured using different sensors. Parameters like acceleration from accelerometer, angular velocity from gyroscopes etc are used to detect and determine the motion of a particular human limb. Advantages of sensor based systems are that, they are independent of surroundings, not affected by environment and are always attached to the user. Thus these types of systems are said to be reliable ones. Constraints in execution of natural gestures is major limitation factor of such a system[1,2,3].

2) Vision Based Systems

Vision Based systems, makes use of images captured by a video camera for gesture recognition. Advantage of such a system is that, they produce extremely excellent results in indoor conditions. But in such a system, the user has to stay in restricted camera field. Variations in light levels and various environmental interferences, makes the system more complex[1,2,3].

The present paper deals with recognition of Dynamic figure gestures using Sensor based systems.

III. PROPOSED SYSTEM

The block diagram of the proposed system is shown in Figure 1. The whole system is classified into two parts- Human End and Robot End. The gestures are picked up using 2 accelerometers attached on to the fingers. Accelerometer converts, finger movements into various voltage levels. These voltages are fed to the Analog to Digital Converter of the microcontroller within the Monitoring circuitry. The microcontroller is programmed in

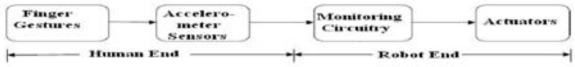

Figure 1. Block Diagram

such a way that, each voltage level is assigned to a particular actuator movement, which results in Humanoid walking. The Human End is composed of Finger Gestures and picking up of these Gestures using Accelerometer sensors. The accelerometers are attached on to middle finger and index finger. Human walking like Gesture is mimicked using these two fingers as shown in figure 2. Consider that, accelerometers are connected on to middle finger and index finger of right hand. The main aim is to make the robot walk in such a way that, when middle finger is moved forward, by keeping index finger positioned at a point, the robot lifts its left leg and moves it forward. Now when, index finger is moved forward by keeping middle finger idle, the robot lifts the right leg and moves it forward. The Humanoid robot under consideration is specially designed for this particular application. It is an 8 DOF humanoid robot with PIC 16F877A microcontroller as its heart. The upper body has two arms with shoulder and elbow (2 DOFs each). The lower body has 2 legs with hip and ankle (2 DOFs each). Design Model and configurations of links and joints of the proposed robot is shown in Figure 3.The elbows and the ankles are of roll orientation. The shoulders exhibits pitch orientation and hips are of Yaw orientation.

IV. STAGES OF GESTURING AND BIPED LOGIC GAIT PHASES

Consider that there are three stages while imitating walking like gesture using fingers. Biped logic gait phases are broadly classified into seven, including the initial phase. Each stages of gesturing is assigned to attain certain biped gait phases for successful walking. Stability is the major problem that arises during robot walking. For a Humanoid robot to walk, it stands on single leg and swings the other leg forward. To provide stability when only one leg is on ground, a 'Dead Weight' is utilized. By this, the weight of the upper body of the robot is moved, so as to bring the centre of gravity on the axis of footing leg[5]. Various gesturing stages and biped logic phases assigned are explained as follows.

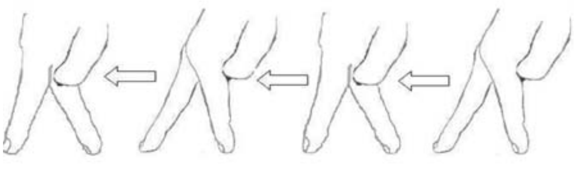

Figure 2. Finger Gestures Under Consideration

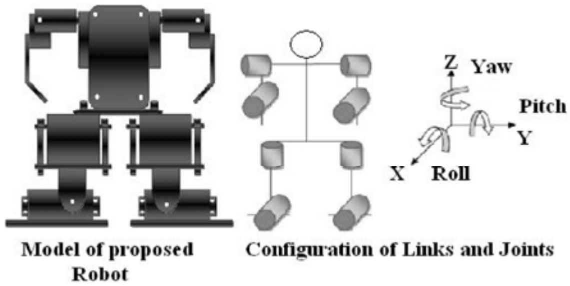

Figure 3. Design Model and Configuration of Links and Joints

- Stage 1- Both Middle finger and Index finger are aligned in same line. Now the robot should execute phase 1 of Biped logic gait. In phase 1, the dead weight will be shared among the two legs. Dead Weight is denoted by W_M. This is the neutral condition, in which Centre of Gravity is maintained between the two legs. This is shown in Figure 4.
- Stage 2- Stage 2 is illustrated in Figure 5. The middle finger is moved forward, while keeping index finger positioned at a point. This executes phase 2, phase 3 and phase 4 of biped gait phases. During phase 2, the robot leans from left to right. The dead weight is moved towards right leg, by the roll orientation at the right leg. The centre of gravity is now concentrated on right foot region. Once the left leg is lifted, it is made to swing in air at an angle Θ_R, keeping right feet under the upper body using the yaw orientation of the hip. This is the phase 3 of biped gait logic. In phase 4, as left feet reaches the highest point of trajectory, the feet is lowered back to the ground. The centre of gravity is now again between the two legs.
- Stage 3- The Index finger is moved forward, while keeping the middle finger positioned at a point. Phase 5, Phase 6 and Phase 7 are executed now. During Phase 5, the robot leans from right to left. Dead weight moves towards left leg. Centre of Gravity is concentrated on to left foot region. In phase 6, right leg is made to swing in air at an angle Θ_L, keeping left feet under the upper body. As right feet reaches the highest point of trajectory, the feet is lowered back to ground. This is phase 7 . Stage 3 is illustrated in Figure 6 [5,6,7].

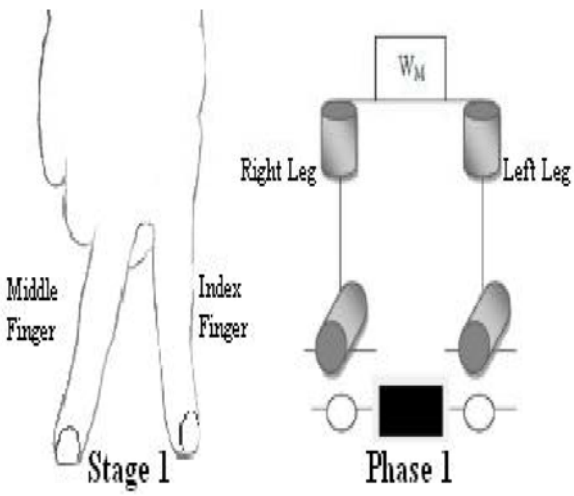

Figure 4. Stage 1

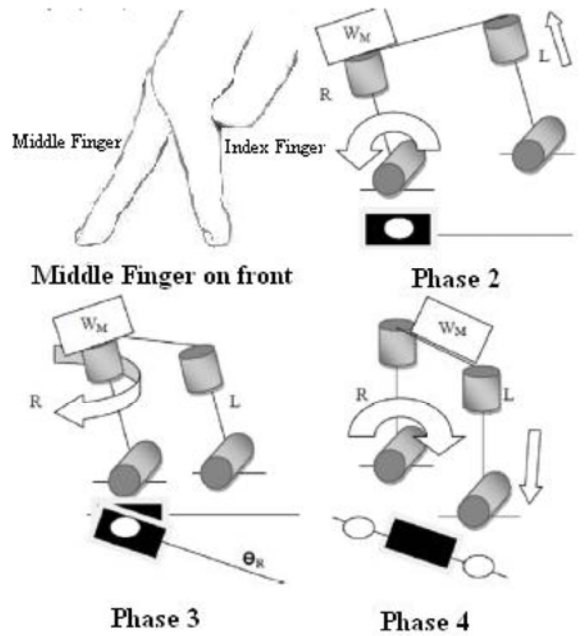

Figure 5. Stage 2

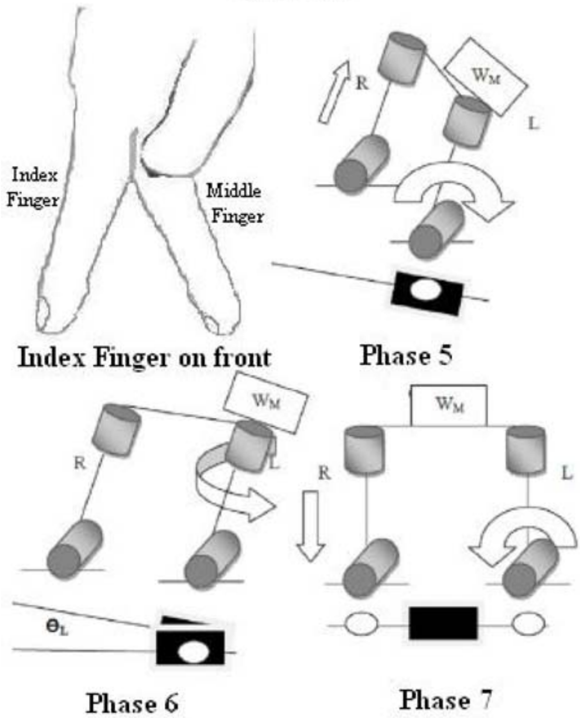

Figure 6. Stage 3

V. ELECTRICAL DESIGN

A. Monitoring Circuitry

Monitoring Circuitry is within the main control board of the Robot. There are two PIC 18F452 microcontrollers which acts as, processing elements in the main control board. The circuit is designed in such a way that only one microcontroller will be active at a particular time. With the help of controller selection switch, microcontroller to be used could be selected. A servo extension board is provided, due to space limitations in the main control board. This board provides power and signals for the servomotors. The servo extension board is connected to main control board via FRC. Main Control Board and Servo extension is shown in Figure 7.

B. Accelerometer

An Accelerometer is an electromechanical device that will measure, acceleration forces. Different types of Accelerometers are available. The module used in this project is based on Freescale's MMA7361L and is shown in Figure 8. It is a simple, 3 Axis accelerometer which provides analog output at each axis. The module operates at a voltage range of 5 v and is highly sensitive. Accelerometer is connected to analog pins of any one of the microcontroller in the main control board, after selecting the required controller.

VI. FIRMWARE DEVELOPMENT

A 3 axis Accelerometer has 3 outputs, i.e. X, Y and Z. For each gesturing stages, a range of voltages are assigned. So during a legitimate gesturing, a particular voltage range will be fed into the analog input pins of the microcontroller, from accelerometer. The microcontroller is programmed in such a way that, the voltage ranges fed are compared with

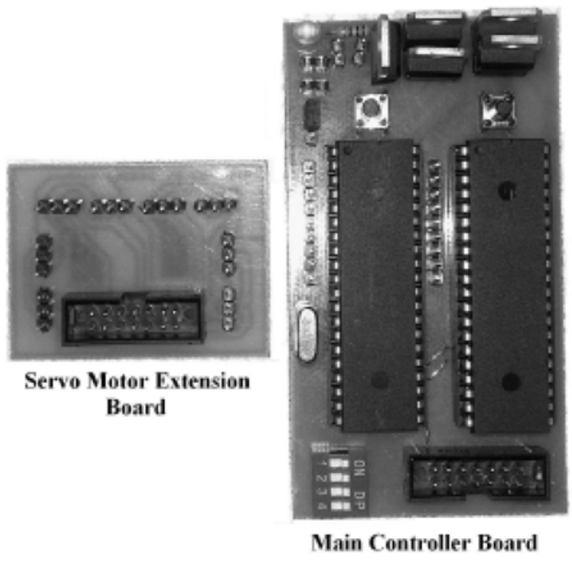

Figure 7. Main Control Board and Servo Extension

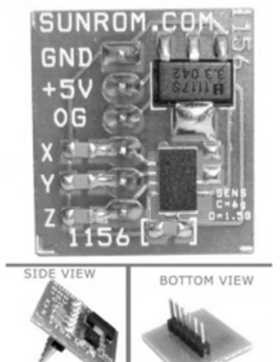

Figure 8. Accelerometer module used

a set of predetermined, voltage ranges within the controller. Each predetermined voltage ranges are assigned with programs to generate PWM signals for servo motors, to achieve various walking phases associated with each gesturing stages. It should be noted that, same voltage levels shouldn't come consecutively. This leads to execution of same phases one after the other causing the robot to fall. The flow chart of firmware logic with respect to each stages and phases, illustrated in Figure 4, Figure 5 and Figure 6 is shown in Figure 8.

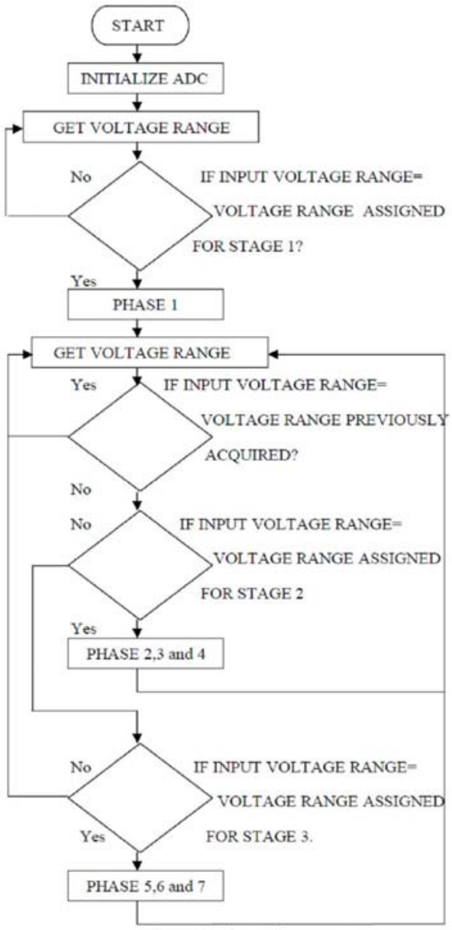

Figure 8. Flow Chart

VII. CONCLUSION

This paper presents ,the design of a low cost and natural way of Human Robot Interaction, to make a Humanoid robot walk successfully. The system is simple and easily understandable. The calibration of accelerometers to acquire correct voltage ranges for each stages of gesturing is the complex action involved in the design phase. Only Robot locomotion is discussed in this paper. Same methodology can be used to make the robot to do an application like pick and place. More useful and advance applications can be incorporated by future research in this area.

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