AUTONOMOUS BIPEDAL PROTOTYPE FOR VISUAL SURFACE INSPECTION

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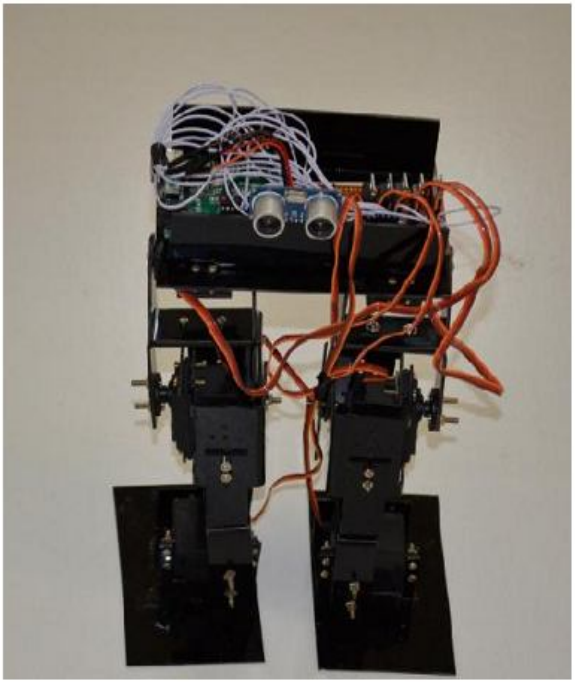
Abstract— During last few decades automation took a rapid development and proved to be an ebullient platform for innovation. In this paper we are projecting an idea on automation in the biped robot SIBR, which is different from conventional bots like wheeled type, stem type. Ultrasonic sensor is employed for decent ranging which provides the gist of autonomousness in the bot and a wireless camera is added on the bot to empower it with machine vision. This proposed paper may be a stepping stone for the future research in automation as well as bipedalism.

Keywords—Ultrasonic, Bipedal robot, Obstacle avoidance, Machine vision

I. INTRODUCTION

In this technological era automation is a heart of advancement. Robotics is the best gateway or platform to test the power of automation. New technologies and many more new issues have greatly influenced the robotics field and paved a way for integrating the word automation in to the world of robotics. From the inception of robotics the study and implementation in the field of humanoids or bipedal prototypes was sophisticated dream to lot of robot engineers and scientists and making the humanoids more human is their target. Many works are going on in this particular area like building a humanoid robot for obstacle avoidance using sensors[2] and not only this there are also works going on for compiling an effective way of obstacle avoidance using sensor technology[1].

So when these acts are going on at one end the evolution of camera technology created yet another revolution in the field robotics and it introduced a new word to the world, called Machine Vision which played a key role in solving certain complicated real time issues and is under research still in order to solve more complex problems in the future, one such work is building a humanoid robot for path planning and obstacle avoidance using stereo vision [3]. So here in this paper we are going to introduce SIBR (Surface Inspecting Bipedal Robot) which embeds the idea of obstacle avoidance as well has the power of machine vision. SIBR was built on the basic idea to test automation in bipedal robots as it is terrain flexible and the alternate focus is on visual surface inspection using a wireless camera which supports the machine vision system of the bot. Arduino platform is used as the brain and servo motors are used as actuating systems. SIBR is employed with an ultrasonic sensor assisting it in effective obstacle avoiding function.



This SIBR is nominal but an effective prototype to test automation in bipedal robotics and equipping it with a wireless camera adds on the power of vision which in turn assists for the purpose of surface inspection and more. The sole purpose of developing this bot is to amalgamate all the three complicated yet interesting and under research domains like Autonomousness, Bipedalism and Machine Vision in to a single project in a cost effective and laymen way for performing a particular task. So this could help as the starting step in developing such combinational projects in robotics for various other applications.
The Hardware Focus of SIBR As mentioned in the introduction the bot is controlled using Arduino Uno platform which consists of ATMEGA8 microcontroller. SIBR consists of six servo motors as actuators that are connected to the PWM pins on the Arduino board in order to drive them. Two thirteen

kilograms (13kg) torque servo motors are used at the hip part of the bot in order to effectively maintain the balance while the bot is on move. The other four six kilograms (6kg) torque servo motors are used at the knee and foot parts respectively. Along with the arduino board one more Voltage Regulator board having 5*7805Voltage regulators are employed in order to get the required 5V potential as output. The SIBR's body is designed using Acrylic sheet material which is cost effective, water durable and light weight and which is perfectly suitable for such applications. The Ultrasonic sensor and the wireless camera are the other external core devices embedded in to the SIBR's body in order to complete the task for which it is designed for.

II. THE SOFTWARE FOCUS OF SIBR

The Arduino 1.0.1 software is used to program the bot i.e. to command the bot to perform the required operations in a synchronous manner.

Fig: Arduino 1.0.1

Code Snippet:
Include <Servo.h>
Initializing variables
{-------
}
Interfacing variables to the controller
{--------
}
Loop () function to execute the robots operations in real time
{---------
During No Object
{--------
}
During Object encounter
{---------
}
}
The above is the skeleton code snippet of SIBR which is responsible for SIBR acting autonomously i.e. avoiding obstacles in real time environment.

Focus on SIBR's Operation

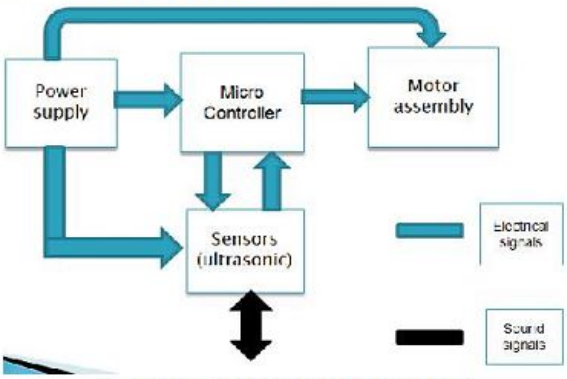


Fig: SIBR's CONTROL SIGNAL FLOW

Servo Operation: Both the type servos i.e. of 6kg and of 13kg used in the bot have an On-time value of pulse generation varying from 1 to 2 milliseconds. So to calculate the off- time we use the formula:

20-Ontime=off time

Every one degree movement of servo (either upwards or downwards) has been programmed to take 50µs, so each motor is descended to a speed of 20° /sec for stability control.

Ultrasonic Functionality

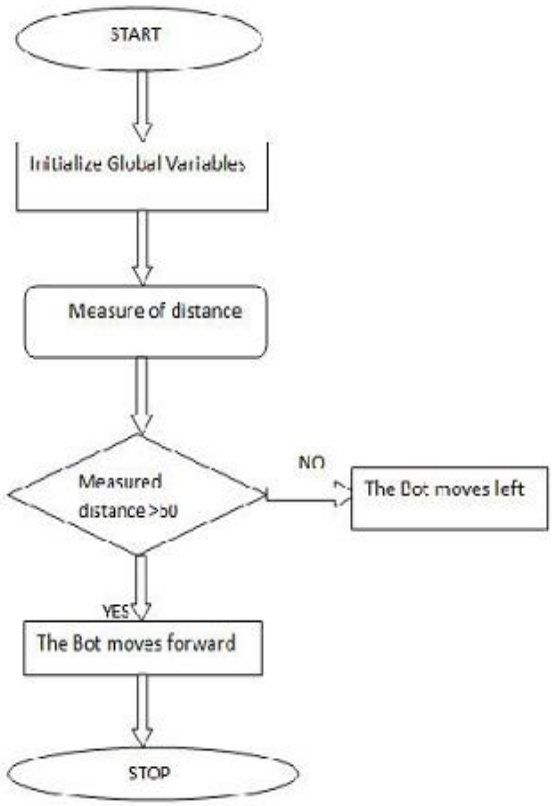


Fig: Obstacle Avoidance Scenario Using Ultrasonic Sensor

The Ultrasonic sensor which is employed in the SIBR has four pins namely Vcc pin, Trigger pin, Echo pin and Ground pin.

Fig: Ultrasonic Sensor

Ultrasonic Specifications and Calculations:
The Ultrasonic sensor employed in SIBR is RKI- 540 model and has a range of 2cm to 400cm.
Speed of Sound= 343m/sec=.0343cm/µsec
Now time interval between the transmitted wave and the received wave is calculated in µsec.
Now the distance is obtained using the formula:

Distance=Time calculated X 0.343cm/ µsec

SIBER's Forward Motion Sequence:

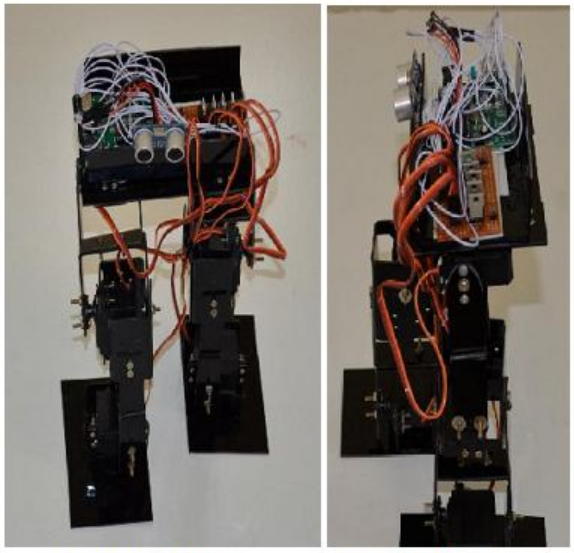


Fig: Front View Fig: Side View

SIBR's Forward Motion Sequence Algorithm
Loop
{
 Left Motor will tilt the SIBR to the left with the assistance of Right Foot Servo as a support.
 Now, the Right Knee Motor comes in front by synchronous action of Right Knee and Hip Servo
 Now, the Left Foot Motor goes back to opposite position of Right Foot Motor with its support.
 Now, the Left Knee comes forward with the support of Left Hip Servo
 Finally, all the motors come to the equilibrium position.
}
SIBR's Obstacle Avoiding Algorithm:
Loop (while encountering an obstacle)
{
 Left Motor will tilt the SIBR to the left with the assistance of Right Foot Servo as a support.
 Now, the Right Knee Motor comes in front by synchronous action of Right Knee and Hip Servo
 Right Knee Motor comes back to the equilibrium position with a light tilt.
} (Until the obstacle is out of sensor's range)
The above sequence makes the SIBR turn left in order to avoid obstacle.

III. SURFACE INSPECTION PHASE OF THE SIBR

Surface Inspection or in more laymen language terrain inspection is an essential step to be taken in lot of real time scenarios in order to investigate and take an effective decision. SIBR uses a wireless spy camera which has very low power consumption and can also transmit audio recordings through an inbuilt transmitter; this can be received at the user's end using a wireless receiver. Such plans can be used in terrain patrolling, inspection and many other diverse fields. SIBER's camera uses Radio Frequency (RF) which is of 2.4 MHz frequency which is WIFI friendly, like other general purpose frequencies don't interfere with this particular SIBR's frequency [6]. As this wireless spy camera is very small in size and weightless this is apt for this type of bipedal prototypes to visually inspect terrains and surfaces and transmit the live recordings, this will be one of the useful assays done by the robots all time.

Fig: SIBR's Wireless Camera and Receiver

CONCLUSION THE RESULT

This is a live snap shot of SIBR encountering the wall and avoiding it due to the functionality of ultrasonic sensors.

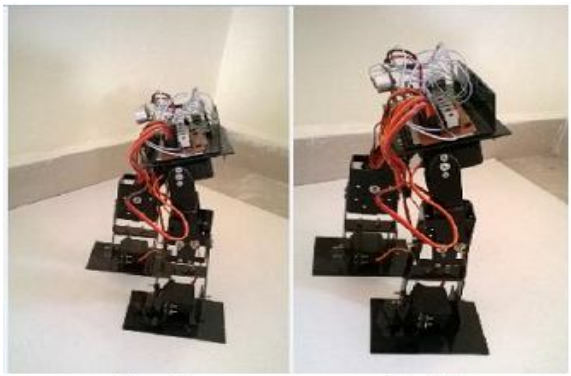


Fig: (a) Fig: (b)

(a) SIBR encountering the wall (Obstacle)
(b) SIBR avoiding the wall (Obstacle)

So the bot discussed in this paper had successful working algorithms for walking in a balanced manner and in parallel avoiding obstacles. And the add on wireless camera provided a technical edge in visually inspecting terrains and surfaces.

This particular working model assayed in this paper proved to be a conventional one of such type, so further advancements in this prototype could ignite a revolution in the field of robotics.

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