Design and Fabrication of Mobile Phone Controlled Four Legged Walking Robot

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ABSTRACT

In recent years, practical mobile robots have been successfully used in controlled environments such as factories, offices, and hospitals, as well as outdoors on prepared surfaces and terrain with minor irregularities. The most common type of robot has rigid body and is driven on wheels or tracks. However, for the operation of mobile robots in extremely rough, uneven terrain has been impossible or unreliable at best. So instead of wheeled robot, it has looked to the animal world for inspiration, attempting to develop walking robot to imitate the body structure and method of locomotion of mammals, human beings, and other arthropods. However, reliable mobility on extremely uneven terrain such as step climbing, gap crossing, gradients, side slopes remains an elusive goal for manmade devices. Most legged robots have been based on the concept of a single rigid body having articulated legs. Such a robot become attractive for any required application traversal of terrain that is difficult for wheeled and tracked robots, and is expensive or dangerous for humans.The present project work describes design of four legged robot which uses legs for its movement instead of wheels. This robot is capable of receiving few sets of command instructions in the form of DTMF tones and performs the necessary tasks. This robot is controlled by mobile and is capable of walking front & back and other specified direction with the help of the legs. The robot also senses the movement of living beings, leakage of gas and gives the siren and sends the message so that robot can be used as a security device in many applications.

KEYWORDS: *Animal world, Control system, DTMF, Legged robot, Sensor, Uneven terrain, Wheeled robot.*

I. INTRODUCTION

Traditionally, most mobile robots have been equipped with wheels because the wheel is easy to control and direct and provides a stable base on which a robot can easy to build. One of the major drawbacks of the wheeled robot is that, it requires a relatively flat surface on which it can operate. On rocky or hilly terrain, which might be found in many applications as forestry, waste cleanup and planetary exploration, it is quiet difficult to operate with the use of wheels. A second approach to this problem would be to use tracked wheel robots. For many applications this is acceptable, especially in very controlled environments. However, in other instances the environment cannot be controlled or predicted and a robot must be able to adapt to its surroundings. Such a surrounding can be, places where robots would have to step over the obstacles such as a surfaces where pipes are running and where they have to move on the discontinuous terrain like steps. The research into legged robotics promises to overcome these difficulties. The complexity of control required for a legged robot to navigate autonomously over unfamiliar terrain has made them difficult to build. The use of legged robot is interesting for various applications, including cargo transport, entertainment, education, land mine removal, forestry and space exploration.

Their versatility allows the legged robot to access challenging terrains with high safety like paddy fields, sandy soils, and rough surfaces which are difficult for wheeled robot to cross. Similarly many manmade “terrains” are also difficult for robot because of narrow doorways, sharp turn, floor irregularities, ramps, steps, ladders, etc. So, in general, legged robot become attractive for any required application traversal of terrain that is too difficult for wheeled and tracked robots, and is too expensive or dangerous for humans. So this project work provides a legged robot which eliminates the limitations of wheeled robot that cannot operate on uneven terrain.

One can also think of detecting the human being by using the wireless remote controlled robot, which has the sensors that detects the presence of the human being and indicates the user. Also in hazardous situations the robot can be designed to detect the gas leakage using gas sensor. Using wireless robot, the unit can be easily mobilized and can be controlled by the micro controller, which is programmed to control the input and output modules interfaced to it. The controller makes use of a PIR and gas sensor to sense the human beings and any gas leakage respectively and give an alert indication through the buzzer. It also makes use of a mobile phone, which is used to control the robot.

The unit can have micro controller based motherboard which is present with the robot itself. It is interfaced with some servomotors for moving the robot, a PIR sensor for living organism presence detection, and a gas sensor to detect the leakage of gas, GSM module for sending the message and a DTMF decoder for receiving the instructions from the mobile phone utilizing eight servomotors. The motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary permanent magnets, and rotating electrical magnets. The driver used for motors is L293D**.** The device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads and switching power transistors. This project makes use of a micro controller, which is programmed, with the help of embedded C instructions. This microcontroller is capable of communicating with input and output modules. The controller is interfaced with DC motors, which are fixed to the robot to control the direction of the robot.

II. HISTORY

Legged locomotion systems that have evolved in nature, show very good performances in terms of stability, payload capabilities, dynamic behavior. Thus, usually they are considered a very important source of inspiration for designing legged robotic systems mainly for aspects ranging from the mechatronic design to the path planning and gait generation. Several researchers have stressed these topics by using a multidisciplinary approach. For example, several studies have been addressed to the transmission system of vertebrate legged animals from a kinematic point of view. In fact, bones and articulations can be easily modeled as links and joints of a kinematic architecture. Those have been and still are an inspiration both for design and operation of walking legged systems. In different places of the world, there are many scientists worked on the different walking robot. E.g. RIMHO II,
SCOUT II, TITAN VIII, AIBO robot.

III. METHODOLOGY

3.1 ARCHITECTURE OF THE PROJECT

Fig 3.1 explains the Architecture of the four legged robot

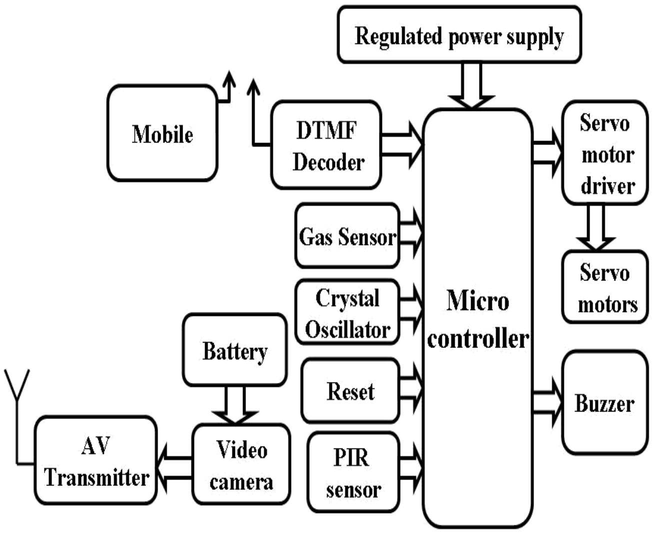

Fig. 3.1: block diagram of mobile phone controlled four legged walking robot.

3.1.1. Power supply: It consists of wireless communication; which requires 0 to 30 volt DC supply for the operation of the system.

3.1.2. Micro controller (16F877A): Microprocessors and microcontrollers are widely used in embedded system products. It is a programmable device. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip. The microcontroller used in this work is PIC16F877A

3.1.3. PIR sensor: Pyroelectric infrared (PIR) sensor is used for living organism detection. It provides an optimized circuit that will detect motion up to 6 meters away and can be used in burglar alarms and access control systems.

3.1.4. Gas Sensor: A MQ-6 gas sensor is used for combustible gas detection which with lower conductivity in cleans air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising.

3.1.5. DTMF Decoder: DTMF is the most common telecommunications signaling method used. DTMF stands for Dual Tone Multiple Frequency; is used to send information through phone lines to and from one local exchange. Most often, an MT 8870 or compatible circuit would be used as a DTMF decoder.

3.1.6. Servo motors and motor drives: There are eight servo motors used in this robot for the motion of the legs. For each leg two motors are required, one for knee and one for motion. Servo motor drives are used for the driving the motors.

3.2 Kinematic analysis:

The kinematic analysis of a four legged robot consisting of a fixed base and moving platform manipulated by four serial chain legs with six DOF per leg undergoing motion in space is presented. The serial chain legs in each configuration are kinematically identical to each other and are independently performed for each leg. Figure 3.2 shows the schematic of the four legged robot consisting of a fixed base and a moving platform. The rigid platform forms a plane in space and the orientation of every point of the platform is the same as that of the platform itself. The base of each of the four legs could be at some arbitrary distance from each other. The position and orientation of each leg relative to the base frame is then calculated.

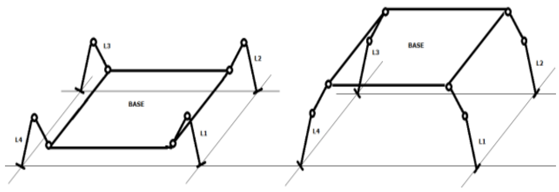

Fig. 3.2: Schematic of the four legged robot.

The robot kinematic diagram is given in Figure 3.3

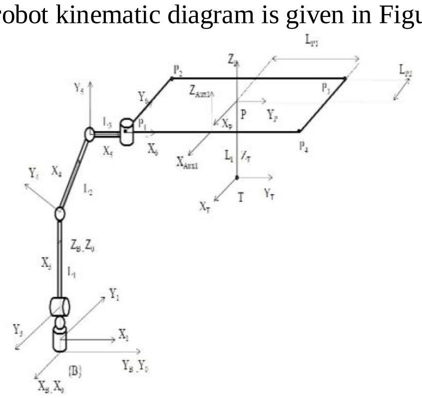

Fig. 3.3: Kinematic diagram.

The computation of joint angles θ1, θ2, θ3, completes the solution. Since these axes intersect and affect only the orientation of the manipulator, they can be computed based on the rotation portion as given below,

Eq. 20

$\theta_1 = Atan2(-{}^0_3R_{13}, {}^0_3R_{23})$ Eq. 21

$\theta_2 = Atan2({}^0_3R_{33}, {}^0_3R_{23}/C_1)$ Eq. 24

$\theta_3 = Atan2(-{}^0_3R_{32}, {}^0_3R_{31})$

3.3 Force and torque analysis:

Eq. 23

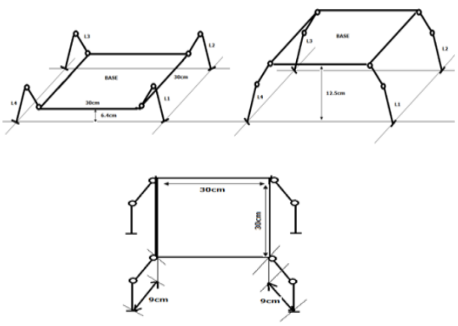

Fig. 3.4: Details of four leg mechanism.

III. SELECTION OF SERVO MOTORS

Weight of robot= 6 kg
Distance from servo output on foot (radius) = 9 cm = 0.09 m
Servo Torque = 0.6864 N-m
Weight=torque / radius= 7/9 = 0.78 ×9.8
= 7.644 kg-f
Torque= radius × weight
Torque= 0.09 × 7.644
Torque = 0.688 N-m
But that's only for whole body since there's at least 2 legs on the ground at a time so 0.688/2= *0.344 Nm* which means that standing still, the robot should be able to easily support the weight. So *static*= 0.688N-m, then no need to Figure out dynamic. But for that it needs to get the acceleration of the robot so depending how fast the robot to accelerate, my motors may require more torque.
In moving condition the robot covered the 30 cm distance in 4 sec. so, distance covered in 1sec = 7.5 cm, therefore the acceleration of robot is 7.5 cm/s^2 i.e. 0.075 m/s^2
Force= mass × acceleration
Force= 6 kg × 0.075 m/s^2
Force= 0.45 N
Dynamic torque = force × radius
= 0.45 × 0.1
= 0.045 N-m
Then:
Torque = static + dynamic
Torque = 0.688 + 0.046
Torque = 0.752N-m
Then:
torque = 0.752/2
torque = 0.376 N-m (for each leg)

IV. ADVANTAGES

- They are capable of omnidirectional motion without the need for turn-in-place.
- They can access a wide variety of terrains. Boulder fields, steep slopes and loose, sandy areas can all be traversed by walking, in addition to any location accessible to wheeled robots.
- A legged system is well adaptive to uneven terrains, namely the legs can be arranged according to the level changes.
- The legged robots can be used to reach in both structured and unstructured environments
- Legged robots can negotiate irregular terrain while keeping their body always levelled. This is important when carrying on board sensors and pieces of equipment that need to be levelled.

V. CONCLUSION

It is designed such that the robot can be operated using mobile phone in any part of the world. It is designed with PIR sensor, Gas sensor and a video camera mounted on it so it can be used,

- To detect persons in restricted areas.
- To detect the human beings and detect the gas leakage in the hazardous condition of mine (i.e. Coal mine, gold mine, etc.).
- In industries to detect the several gas leakages and human detection to avoid the human casualties in any accidental condition where a man cannot be reached.
- In forest to detect living animals without any person going to the forest and search for the living animals.
- At home as safety device to detect the gas leakage.
- In the army as spy robot.

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