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Design of an Advanced Wireless Controlled Stair Climbing Robot

Ms.Shilpa Kanchi
M-Tech Student
Department of Mechanical Engineering
Mahatma Gandhi Institute of Technology, Rajendranagar,
Gandipet, Hyderabad, T.S, India.

Mr.K.V.K.Viswanadham
Assistant Professor
Department of Mechanical Engineering,
Mahatma Gandhi Institute of Technology, Rajendranagar,
Gandipet, Hyderabad, T.S, India.

Mr. Dr.K.Sudhakar Reddy
Professor & Head of the Department
Mechanical Engineering,
Mahatma Gandhi Institute of Technology, Rajendranagar,
Gandipet, Hyderabad, T.S, India.

Abstract: ***The advent of new high-speed technology and the growing computer Capacity provided realistic opportunity for new robot controls and realization of new methods of control theory. This technical improvement together with the need for high performance robots created faster, more accurate and more intelligent robots using new robots control devices, new drivers and advanced control algorithms. This project describes a new economical solution of robot control systems. The main objective of this present work is to build a robot machine which is capable of climbing stairs using PC based zigbee wireless communication network. The structure of the robot is based on the Tri-wheel configuration which refers to a system of three wheels sandwiched between two Y-frames. This mechanism supports for two kinds of motion of the wheels of the tri-wheel system – first, about the axis through the centre of each of the wheels and second, the rotator motion about the axis of the tri-wheel Spur gear mechanism itself. This flexibility empowers for the transporter to climb steps easily. The presented robot control system can be used for different security, military based war robotic applications for climbing stairs. The presented robot control system can be used for different sophisticated robotic applications.***

Key Words: *Tri-wheel Spur gear mechanism robot, Zigbee transceivers, DC motors.*

INTRODUCTION

Today, due to technological advances of robotic applications in human life, it is necessary to overcome natural and virtual obstacles such as stairs which are the most known obstacles to the motion of such robots. Several researches have been conducted toward the design of stair climbing and obstacle traversing robots during the past decade. A number of robots have robots have been built for climbing stairs and traversing obstacles, such as quadruped and hexapod robots. Although these robots can climb stairs and traverse obstacles, they do not have smooth motion on flat surfaces, which is due to the motion of their legs. Buehler built a hexapod robot (RHex) that could ascend and descend stairs dynamically. There is an enormous variety of walking robots in the world today. Most of them have six legs to maintain good static stability, many have 8 legs for greater speed and higher load capacity and there are some that implement clever balancing algorithms which allow them to walk on two legs to move over sloping ground and to climb up and down stairs, like humans do (eg. Such as Honda's Asimo robots). Rough-terrain robot navigation has received a significant amount of attention recently, most prominently showcased to the broader public by the success of current Mars rover missions.

In the future, increased autonomous capabilities will be required to accomplish ambitious planetary missions as well as a whole variety of Earth-bound tasks. This demand has led to the development of numerous approaches to solving the rough-terrain robot motion planning task. The common factor with all such research lies in the underlying characteristics of the rough terrain itself by the very nature of the task, binary obstacle definitions cannot be exclusively applied to rough-terrain motion planning. Each configuration of the robot operating on the terrain has a characteristic difficulty associated with its attainment. Depending on the properties of the problem being studied, different aspects of the robot/terrain interaction assume high relevance. These factors are consequently included in the terrain abstraction while other aspects are typically chosen to be omitted.

Nevertheless, independently of the terrain model used, there remains the specific difficulty associated with reaching a particular configuration. Further, in near future, robots will take the place of human labor in many areas. They will

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perform various hazardous duties like fire fighting, rescuing people, de mining, suppressing terrorist outrage, and scouting enemy territory. To make use of robots in these various circumstances, robots should have the ability of passing through rough terrain such as steps.

Military robots are autonomous robots or remote-controlled devices designed for military applications. Such systems are currently being researched by a number of militaries. Robot builders may be of any age and come from any walk of life. There are three types of moving mechanisms for this kind of robots in general: wheel type, track type and walking type mechanism. Robots with wheel mechanism are inferior to robots with track when they are to move on rough terrain. Walking robots have complex structures so that they are usually difficult to control and slower in speed.

In that sense, the track mechanism has advantages in high speed driving and mobility under severe conditions. In spite of these merits, it consumes more energy than the others. Therefore it is needed to design a robot to overcome this drawback. Some recent researches are to develop a novel track mechanism with flexible configurations adaptive to various ground conditions.

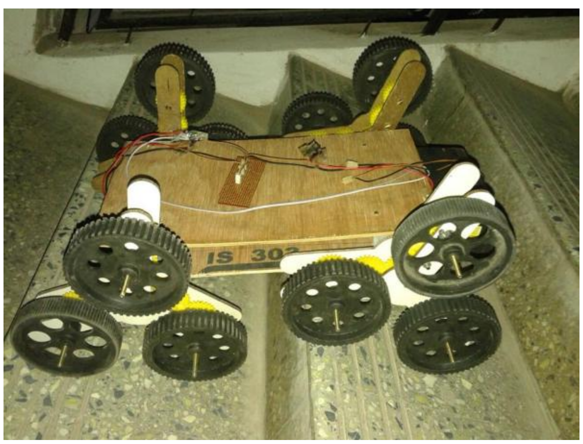

Fig-1: Model of All terrain stairs climbing robot

RELATED WORK

The objective of the proposed system is to design an all terrain stairs climbing robot with Zigbee modules for establishing wireless communication between PC and Robot which is capable of climbing the stairs. The DC motors is attached to the robot for the movement of the robot and PIC microcontroller which performs the controlling operations of Robot in climbing the stairs. Four main principles - rolling, walking, crawling and jumping - have been identified for full or partial solid state contact. However, additional locomotion principles without solid state contact could be of interest in special environment. Most of the mobile robots for planetary exploration will move most of their time on early flat surfaces, where rolling motion has its highest efficiency and performance. However, some primitive climbing abilities are required in many cases. Therefore hybrid approaches, where for example rolling motion is combined with stepping, are of high interest.

Deriving the Star-Wheel parameters depends on the position of Star-Wheel on stairs where it depends on two parameters, the distance between the edge of wheel on lower stair and the face of next stair (L1), and the distance between the edge of wheel on topper stair and the face of next stair (L2). By comparing these parameters, three states may occur L1<L2. After each stair climbing, L2 becomes greater and after several climbing it will be equal or greater than b (L2>=b). In the design of Star-Wheel, five parameters are important which are the height of stairs (a), width of stairs (b), radius of regular wheels (r), radius of Star-Wheel, the distance between the center of Star-Wheel and the center of its wheels (R) and the thickness of holders that fix wheels on its place on Star-Wheels (2t). For the calculation of radius of Star-Wheels (R) with respect to the stair size (a, b), this equation is used: 3( ) $a2$ $b2$ R +=(1), where a and b are the height and width of stairs. The minimum value of the radius of regular wheels (rmin) to prevent the collision of the holders to the stairs where R is the radius of Star-Wheels and t is the half of the thickness of holders.

The **tri-star** is a novel wheel design originally by Robert and John Forsyth, assignors to Lockheed in 1967 in which three wheels are arranged in an upright triangle with two on the ground and one above them. If either of the wheels in contact with the ground gets stuck, the whole system rotates over the obstruction.

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Fig-2: Tri Star wheel model of stairs climbing robot

Advantages of Tristar Wheel

- The control system is simple and the robot is controlled remotely.
- Mechanism is simple comparing to other available designs and it is easy to assemble and disassemble when necessary.
- Use of Castermid as the material for gears makes them light and no lubrication is required during movement.
- Using the worm gearbox makes robot's travel safe. If by any chance voltage is cut off or batteries ran out of charge the robot will stay in its position.
- The cost is reasonable compare to other available designs.
- The net weight of the robot compare to its size is reasonable.
- The possibility of malfunction is almost zero, since there is no complex assembly or mechanism.

Tri Star Wheel Works Based On Spur Gear Mechanism

Spur gears or straight-cut gears are the simplest type of gear. It consists of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form of the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shafts.

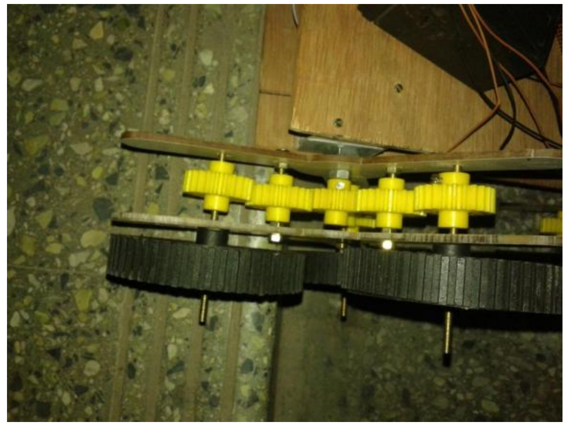

Fig-3: Spur gear mechanism of stairs climbing robot

The Spur Gear Design Mechanical engineers working in transmission field would often have to decide upon kind of gears for usage. A designed gear criteria conforming to AGMA standards should have the following:
1. Enough mechanical strength to withstand force transmitted
2. Enough surface resistance to overcome pitting failure
3. Enough dynamic resistance to carry fluctuating loads

The designing Features:

1. Required monitoring of amount of power to be transmitted, pinion, speed, gear ratio, life of gear drive and other working conditions.
2. Based on the transmitting power and gear ratio, select a suitable material. Usually the pinion is subjected to more loading cycles then gear and hence the material selected for pinion should be strong than gear material.
3. Note the design surface compressive stress and bending stress for the selected material from design data book (or) find them by using the formula.

Determine Design Horsepower using formula:
DHP = HP x SF
Where: DHP = Design Horsepower
HP = Actual Horsepower
SF = Service Factor (from page G-84)
Determine Pitch Diameters using the formulas:
PD1 = CD x 2/Ratio + 1
PD2 = PD1 x Ratio
Where: PD1 = Pitch Diameter of Pinion (small gear)
PD2 = Pitch Diameter of Gear (large gear)

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CD = Center Distance
Check the Center Distance:
CD = PD1 + PD2/2

Select Pitch from Horsepower tables on pages G-25 — G-27.
Check selected pitch for necessary Pitch Diameters.
Check Horsepower capacity of Large Gear.
Check maximum bore capacity of selected Gears.

HARDWARE DESIGN OF PROPOSED SYSTEM

In this paper we presented a PC based wireless stair climbing robot which is capable of climbing all terrains stairs in its path and which is wirelessly controlled through PC using Zigbee technology. The controlling device of the whole system is a MICROCONTROLLER to which Zigbee module; DC motors of robot are interfaced through a motor driver. Whenever the appropriate keys are pressed in the keyboard of computer, the data related to those keys will be transmitted over Zigbee module using RS232 cable. This data will be received by Zigbee module at robot and this data is fed as input to the controller. The controlling device of the whole system is a Microcontroller. Whenever the user presses any key from keyboard of the PC, the data related to that key is sent through Zigbee module interfaced to PC. Whenever the appropriate keys are pressed in the keyboard of computer, the data related to those keys will be transmitted over Zigbee module. This data will be received by Zigbee module at robot and this data is fed as input to the controller. The Microcontroller checks the data with the program embedded in it and performs appropriate actions on the DC motors of the stair climbing robot. This data will be received by the Zigbee module in the robot system and feds this to Microcontroller which judges the relevant task to the information received and acts accordingly. The Microcontrollers used in the project are programmed using Embedded C language.

The proposed working model of the robot system consists of two sections mentioned below-

a. PC or Transmitter or Remote section-

In the remote section of the robot at transmitter side we use PC for all the basic control operations of the robot. When the user presses the relevant key from keyboard of the PC then the zigbee module should be connected to the PC transmits the relevant command to the receiver unit wirelessly. The remote controlling section consists of PC, zigbee transceiver module and a battery for the module to enable. User needs to follow the steps to connect hyper terminal of the PC.

START—All Programs—Accessories—Communications—Hyper Terminal—now the user should can enter a suitable name for his/her hyper terminal (Ex-abc)—now needs to select com port (generally COM1) —one dialogue box gets opened—need to enable the restore setting button to select the properties of select communication—hyper terminal window gets connected.

Connect a zigbee module at the com port of PC using DB-9 Serial RS-232cable.

b. Robot or Receiver section:

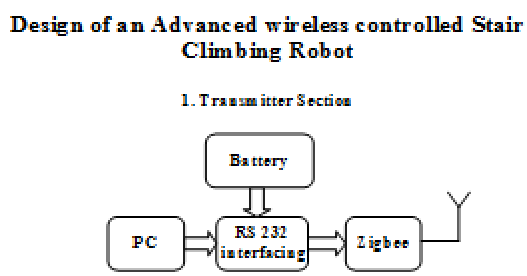

Fig-4: Transmitter section of Stair climbing Robot

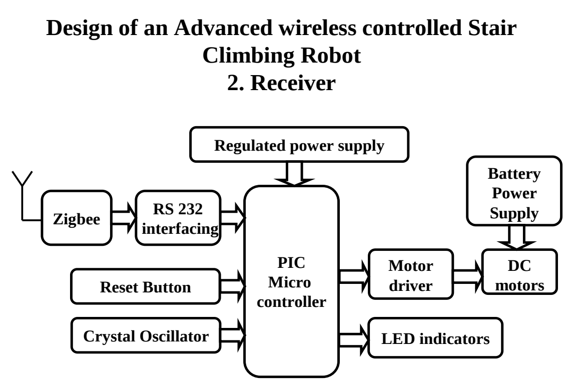

Fig-5: Receiver section of Stair climbing Robot

In the receiver section along with PIC microcontroller mother board RPS segment, zigbee module, 4 DC motor drivers along

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with 4 relay board for motor driver, are interfaced. If the user sends 'f' via serial communication i.e. zigbee module the climbing robot will move forward. Zigbee module is connected at pin no B0 & B1 of the microcontroller. Microcontroller will receive signal and rotate the DC motors in forward direction. In the similar manner the appropriate keys given from PC the combat robot performs the relevant operations like making robot movement forward, backward, left, right directions. We are using Relays as a DC motor driver. This data will be received by the Zigbee module in the robot system and feds this as input to Microcontroller which judges the relevant task to the information received and acts accordingly. And for each and every DC motor one enable pin of the IC should be connected to the microcontroller. Here we are using 2 DC motors connected to 4-relay board. Wheels are connected to the DC motors. The unique feature of the design is that the wheels can rotate independent of the motion of the entire tri wheel system as such. The design also has provision for rotation of the entire tri-wheel system. The rear wheels are ordinary circular wheels with diameter of 10 cm. Their main function is to provide support to the tri wheel and also an up thrust to the entire vehicle during ascent over the stairs.

CONCLUSION

An existing All terrain climbing robot system "Advanced wireless controlled Stair Climbing Robot" was designed such that the robot can be operated using PC which is capable of climbing stairs based on Tri-wheel configuration patented. The controlling device of the whole system is a Microcontroller. Whenever the user presses a button in the PC, the data related to that button is sent through Zigbee module interfaced to PC. Whenever the appropriate keys are pressed in the keyboard of computer, the data related to those keys will be transmitted over Zigbee module. This data will be received by Zigbee module at robot arm and this data is fed as input to the controller. The Microcontroller checks the data with the program embedded in it and performs appropriate actions on the robot.

The robot can also be extended by connecting wireless camera to the robot, then we can view the outer world from our personal computer only by using GPRS and GPS. We can use this robot at so many fields and we can use to handle so many situations.

By connecting bomb detector to the robot, we can send it to anywhere i.e (battle field, forests, coal mines, to anyplace) by using our personal computer and we can able to detect the bomb at field, here sensor detects the bomb and gives information to micro controller and it gives the information to transceiver and it sends the information to the personal computer. It can also be extended by connecting temperature, gas, smoke sensors to the robot we can get the temperature, leakage of any gases, smoke of dangerous zones as it can climb all terrains, hilly and rocky regions also in personal computer itself instead of sending human to there and facing problems at field we can send robot to there and sensor will detect the environmental condition and it gives information to the micro controller and micro controller gives the information to the transceiver from that we can get the data at pc side.

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