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Ladder Climbing Robot

Anu Wilson, Haripriya R. P., Rijul Reji P., Sukesh S. Menon

***Abstract* – In this paper, we describe a new design of a robotic system having two arms that is suitable of motion in uneven surfaces as well as climbing ladders. Ladder climbing is an essential mode of locomotion for navigating industrial environments and conducting maintenance tasks in buildings, trees and other man-made structures. The motion of robot is mapped by hand movements. An arduino board is used to control the whole operation. It collects data from the controller and sends it to the robot (wireless communication). The final product is an autonomous robot that is able to climb the ladder successfully.**

***Keywords* – Hybrid Design, Flex Sensors, Zigbee Transceiver, Servo Motor.**

I. INTRODUCTION

Robotics is the branch of technology that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behavior, and/or cognition. Many of today's robots are inspired by nature contributing to the field of bio-inspired robotics. Many robots do jobs that are hazardous to people such as diffusing bombs, exploring mines and shipwrecks.

Ladders are present in our man-made environments. They are designed to help humans to bridge vertical distances easily. However, this man-made structure poses a serious challenge to vehicles and robots Thus, in order for robots to operate efficiently and effectively in urban environments; this challenge has to be addressed.

Autonomous ladder climbing robot has been the subject of ongoing research in the last few years. Most of the robots use only leg-like mechanism [1, 2], while some of them use track mechanism [3]. The main disadvantage of these mechanisms is that we cannot control the speed, inclination, and even if errors occur we cannot correct it at that instant.

As a result, a hybrid design is proposed here. The robot can move fast on flat surfaces and limb like mechanism is used to climb up and down ladders. It can climb ladders that are higher than the robot.

II. CONTROLLER PART

The controller part consists of a hand gloves which extends up to the shoulder and having three flex sensors attached to it, one each on the finger, elbow and the shoulder. The flex sensors produce resistance changes in proportion to variations in bending of these parts. These variations are transmitted using zigbee transmitter module from arduino microcontroller. A zigbee receiver module is also included which receives data from arduino controller and employs the servomotors for movement of robotic part.

The onboard controller will be main controller to process the information coming from the flex sensors. It makes use of the information to convert it into binary data for transmission to the robotic part.

The flex sensors are used to determine the tilt angle of the user's hand.

Fig.1. Flex sensor arrangements in controller part

III. ROBOTIC PART

At the robotic section, the main parts include six high power servo motors, a heavy base with four wheels, an arduino board and a receiver. The motion of the whole system will be based on the movement of the hands. Based on the output from the controller part, the arduino board moves the servo motors. There is no separate control for the wheels on the base. A heavy base is used to adjust the centre of gravity to maintain the stability of the system. In accordance with the rotation of the servo motor, the robot is able to move either horizontally or vertically. Vertical motion of the robot is brought about with the help of two robotic arms which are fixed at the base. Vertical motion of the robot requires the use of a specially designed ladder whose dimensions are in according with the dimension of the robotic arm. Robotic arm, completely programmable and controllable through an arduino board is used.

Arduino software allows easy to use interface for movements and programming sequences. Once the sequence is programmed a program for Rhino Robot Controller Board or Arduino can be generated directly from software so that the arm can be controlled independently. It can also be controlled through Rhino Robot Control Board, Arduino or any other microcontroller capable of driving six RC Servos to control the robotic arm directly. With optional Bluetooth module mounted on servo controller pcb – the arm can be controlled wirelessly over blue-tooth from PC. Apart from arm extra servos can also be connected to the controller.

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Each arm consists of three links and is used primarily for climbing up and down the ladder. When the robot is not climbing the arms can be used as gripper to clear or remove unwanted obstacles in front of the robot or for transportation of items. It has one servomotor attached to each link.

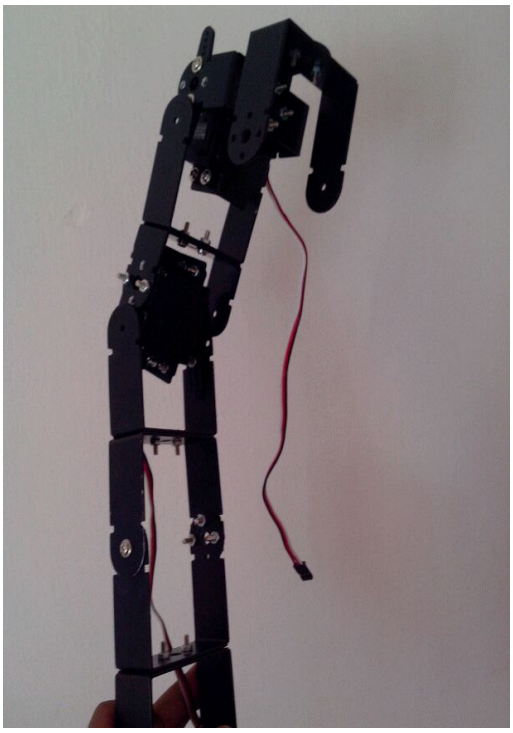


Fig.2. Robotic arm

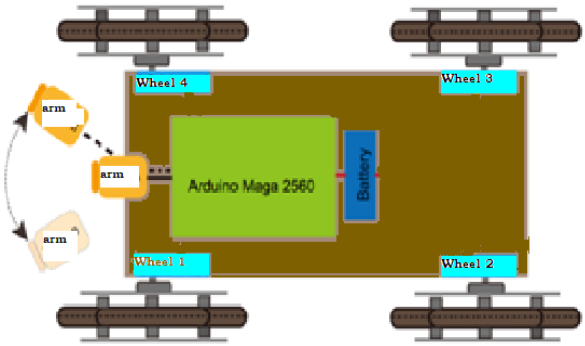


Fig.3. Model of robotic part

The servo motor used is a high torque metal gear servo with dual ball bearings. It has the ability to provide torques in the range 15.5Kg/cm to 17kg/cm. This servo motor is ideal for making hexapod, walking insects, and heavy duty sensor / camera pod. Servo motors are used in radio control models. Small size and low cost. Servomotor has built-in motor, gearbox, position feedback mechanism and motor controller. The servo motor can be controlled to move any position just by using simple pulse controlling. This motor has three wire interfaces for control and power supply.

A zigbee receiver module is used to receive the digital data that is transmitted by the zigbee transmitter module at the controller part. It's output is then given to an arduino board.

Table 1: Specifications of the Robot

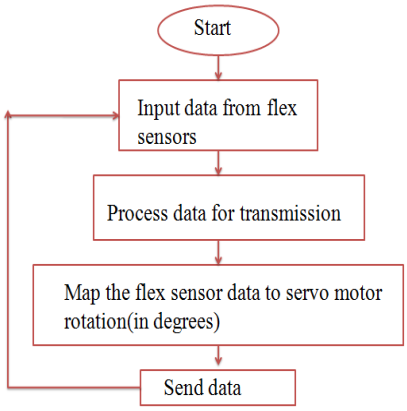
One Arm Mass	500 gms
Body Dimension	17cm x 15cm
Body Height	33.5 cm
Arm Length	31 cm
Whole Vehicle Mass (without battery)	1.1 kg
Maximum Motor Torque	17 kg/cm at 6V
Ladder Height (for one step)	14 cm
Ladder Width (for one step)	18 cm

IV. Software Implementation

The onboard programming for arduino controller is carried out using C language. The user makes decisions on all the maneuvers.

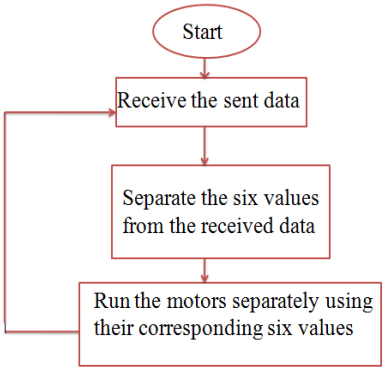
Algorithm/Flowchart:

A. Transmitter Part:



Flex sensor data is analog output voltage variations. Processing data for transmission include conversion of analog data to digital data. This data is transmitted serially from zigbee transceiver which acts as transmitter. Before concatenation of data, the digital values are mapped to angular variations. The angular values are transmitted serially.

B. Receiver Part



The receiver part receives serially transmitted data and separates it to drive each of the six servomotors being used. Then it waits for next set of data and continues the process.

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V. Method of Climbing the Ladder

Before the robot starts to climb, it will have to be positioned in front of the ladder and ground with its two arms folded. This is designated as the initial mode or position. According to the motion of the user's hand, the robotic arms will move. The user will provide adequate hand movements so that the robot will keep one of its arms on the first rung of the ladder. He then makes the robot place its other hand on the rung. After placing both the hands on the first rung, first arm is detached and then placed on the second rung. Then the next arm is placed in the same manner. This process continues till robot reaches top of the ladder.

Basic working principle includes working of both controller and robotic part. In the controller part flex sensors bend according to movement of user's arm. Resistance variations are produced which give rise to corresponding voltage variations (0-5V). These voltage variations are analog in nature. These analog values are mapped to corresponding digital values from (0-1023).This is due to the fact that AT Mega is an 8-bit processor. Analog to digital conversion is done by an inbuilt ADC in Arduino controller. These values are converted or mapped to corresponding angle variations and transmitted using zigbee transceiver. Power supply is given by USB connection from PC. In robotic part the zigbee transceiver acts as receiver which receives the angular values and produces corresponding rotations in servomotors. Power supply is given by a battery source. On rotation of servomotors the robotic arm bends at different degrees initiating ladder climbing motion.

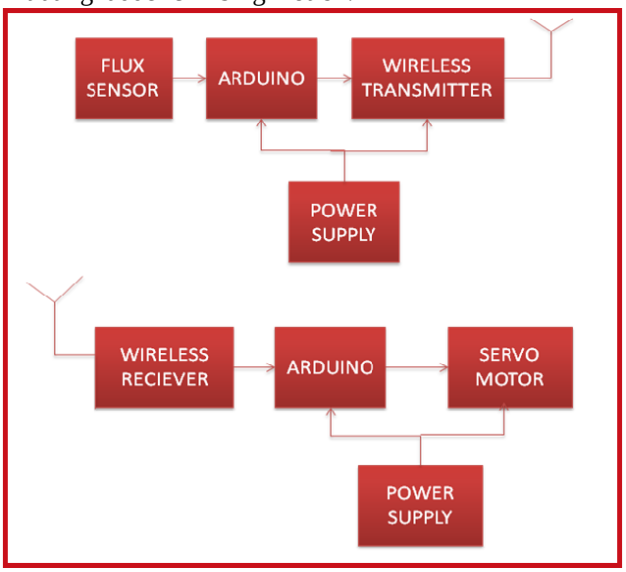

Fig.4. Block diagram of setup

VI. Applications

1. In the field of rescue operations.
2. Spying works for security issues.
3. Monitoring purposes using fixed surveillance cameras.
4. Cleaning walls of sky scrapers without risk of accidents
5. In nuclear power plants.
6. In applications like automated or tele - remote controlled (semi-automated) construction.
7. In firefighting robots that can climb over rough terrain along with carriage of water hoses.
8. Increased portability due to light weight design.
9. Capable of sustained motion for extended periods of operation.

VII. Conclusion

Here a robotic system having three arms which is capable of motion in uneven surfaces as well as climbing ladders is discussed.. This machine has two parts: the controller part and the robotic part. We make use of arduino board to control the whole operation. The motion of the robot is mapped by hand movements. It has the ability to reduce human work to a great extent. It is designed to move in both vertical as well as horizontal directions. It uses a zigbee transmitter module and receiver module for transmission from basic controller part and reception by robotic part for perfect mapping. It is compatible with any model of ladder. The operation is completely user controlled and hence error rate is minimum. The heavy battery drainage and inability to carry heavy loads are the major drawbacks. Power saving must be taken to consideration in next stages.

As the number of sensors increase the mapping of motion of arms become easier. More number of sensors can be introduced. High power servomotors can be used to increase the load carrying capacity.

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AUTHOR'S PROFILE

Anu Wilson
is currently pursuing Bachelor of Technology (ECE) from Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India.
Email: anuwilson117@gmail.com

Haripriya R. P.
is currently pursuing Bachelor of Technology (ECE) from Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India.
Email: haripriyaradhakrishnan9 @gmail.com

Rijul Reji P.
is currently pursuing Bachelor of Technology (ECE) from Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India.
Email: rijulrejip@gmail.com

Sukesh S. Menon
is currently pursuing Bachelor of Technology (ECE) from Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India.
Email: sukeshsmenon@gmail.com