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Electric Pole Climbing Robot with R.F Remote control for a electric lineman assist applications

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ABSTRACT

The basis of this project is to create an electric pole climbing robot which can be used to reduce the risk of an electrician to connect the distribution lines for supplying purposes. Pole climbing robot, nowadays, is a very common and interesting idea, which mainly works by connecting the distribution lines according to the directions given to it. In this modern era robots are being developed for various purposes to accomplish many tasks which seem to be too complex and life endangering for humans. Benefits of using robots have been immense in terms of risk-free, speed and efficiency of doing required tasks compared to that of humans. The main objective of this work is to to save human lives as numbers of people are died from electrical injuries almost every year in Bangladesh. Considering on that issue, a pole climbing robot has been designed, built and simulated. However, further modifications of this work might be able to perform the wiring and repairing tasks instead of an electrician. The developed robot works on the principle of linear motor, which is partially autonomous. With the installation of this project, risk of human injuries and death can be minimized while working in the distribution lines.

Keywords: climbing robot, electric lineman, R.F remote, linear motor.

1. INTRODUCTION

For many years working labors have been losing their lives or sustaining injuries performing risky jobs. Deaths and injuries from monotonous jobs in dangerous environments have been very common in developing countries. One of the countries is Bangladesh where electrical injuries constitute about one third of the total burn injuries in the country. Electrical injuries caused 42% of the deaths [9]. The main causes for the numerous numbers of such accidents are due to lack of safety precautions, lack of proper training to the workers and dangerous working environments. These are few of those many problems prevailing in our country that needs to be eradicated if the human deaths are to be reduced. During the last decade, different types of poles climbing robots were developed for numerous purposes. So it is an outstanding idea to develop a pole climbing robot for a unique application which has a great necessity for developing countries like Bangladesh as well as other power growing countries. Hence building up a pole climbing robot that can imitate the actions of an electrician and does his work can save his life. The robot can be made to perform the monotonous dangerous task by climbing mechanism and hooking mechanism. It saves time taken for connecting distribution lines, efficiency of performing the task can also be increased, risk of human lives can be reduced.

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Fig.1: Electrician at Work

Fig: 2: Accident While Working

The pictures above are of the accident that took place on the 1st of January 2015 in Bhavanipur near Bogra [18]. The body hanging on the wire is not of someone working but the dead body of the worker. Due to the negligence of the electricity board, the worker had to lose his life. He was working on the repair of the wire, knowing that the electricity would not be back before a few more hours. But then the electricity came back all of a sudden and the electric shock took away his life.

2. Literature Review

Investigations over a pole climbing robot have been going on for the last20 years due to inspections, cleaning and maintenance of high rises , nuclear experiment, pipes and so on [1], [2]. Brushless motors have widely been used so far to construct a pole climber. Actuators are nowadays used to increase the efficiency minimizing the power losses.

Brushless DC electric motor also known as electronically commutated motors are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. DC motors are being used since the very beginning of the idea of a pole climbing robot. These motors provide energy for both climbing and griping purposes. For gripping purpose DOF, more specifically 4DOF or 6DOF structure is used which means more power loss to the corresponding motor [3]. Usually three DC Brushless motors are used to fulfill this task. Two motors to grip and the other one is used to climb the pole. The motor that grips the pole actually enables the DOF structure to move and hold on to the pole and vice versa. Other one pushes the upper hands upward as well as pulls the lower hands. Three motors and two

DOFs make the structure a little bit complex. Although it is the most common process, it causes a huge loss which is to concern. Again usage of brushless motors means high maintenance. It also causes noise pollution and may cause EMI. Electric controller is required to keep the motor running. It offers double the price of the motor [3]. Brushless motors have a lower speed range since friction increases at high speeds at the rotor. These DC motors are simple to control but efficiency is not good enough. That is why some modifications were required.

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Fig:3 D-Climber

A number of experiments have been performed to increase the efficiency of pole climbing robot. For industrial purposes nowadays, AC motors are used in the climbing robot. For instance, the most important application is performing periodical inspections by NDT probes in order to detect the progression of material degradation and welding defects [4]. Dangerous and difficult jobs for human are easily performed by these robots. Industrial pipe containing chemicals where a human cannot go, a climber robot can easily get inside climbing the pipe to investigate. This robot is very safe, cheaper and faster process to do than using human workers that is why the demand of this pole climbing robot is increasing day by day to the industries. In the 3D-Climber project this group aimed to build an industrial PCR with good maneuverability skills. After a survey on the already developed PCRs, they focused on the current available technologies, the following objectives were chosen for the 3D-Climber. The robot should be able to climb from the designed structure, scan the whole surface of the structure, autonomously navigate across the structure, modularity and simplicity should be considered in the design of the robot etc. The Plan of the 3D-Climber project was to develop an industrial PCR able to climb over 3Dcomplex human-made structures including T-junctions and perform test and maintenance tasks in those structures and also be able to semi-autonomously climb over 3D structures and perform in target tasks assisted by a remote operator [3].

Greater degrees of freedom (DOFs) are required for serial multi-legged robots for climbing purposes. This project aimed to build a simple robot using less no of DOFs in order to increase the efficiency. Actuators were used to climb and grip the pole for autonomous climbing according to the developed controlling codes. With the progress of technology autonomous controlling is the most popular process that every industry prefers for. Actuator played here the vital rule to fulfill the demand of autonomous climbing of a pole climbing robot since it is easy to control with the microcontroller or arduino codes [5].

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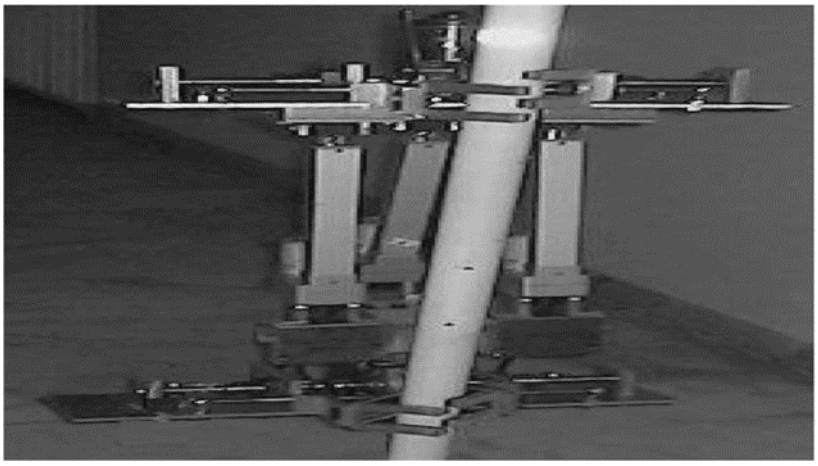

Fig 4: Hybrid-Pole Climbing Robot

Other projects: Different types of climbing robots have been developed for climbing over a flat or curved surface for about last two decades. A short note on various projects of climbing robot is given here. Climbing robots nowadays are getting popular for climbing wall, smooth surface suction cups and so on. For climbing inside pipes, pole climbing robots have received an increasing attention due to their applications in pipe inspection [3], [10]. However, different types of pole climbing robots have been designed and developed. For example, a continuous motion PCR is developed in University of Tehran for cleaning the poles, "ROMA" is a pole climbing robot with a 6-DOF serial climbing mechanism, "Trepa" robot is a pole climbing robot with a 6-DOF parallel climbing mechanism, The biologically inspired pole climbing robot "RISE" can climb from straight structures with soft and non metallic materials. A six-DOF parallel robot with pneumatic actuators has been modeled and simulated by Saltaren et al. The modeled robot has a large load capacity which is an important issue for industrial pole climbing robots [5], [7]. This robot was built for autonomous climbing along tubular structures. Application of actuators instead of motors, to make a pole climbing robot, minimizes the power loss to the project.

3. METHODOLOGY

3.1 WORKING:

Climbing robots are useful when a task requires the use of far-reaching tools or is risky if carried out by humans. These robots can be equipped with video cameras, microphones, other sensors, and robotic manipulators to perform certain tasks. Here in this project a new type of pole-climbing Robot mechanism is proposed, the configuration and characteristics of the mechanism are introduced. The Robot mechanism action of hold pole, put pole, main move, and process of climbing pole, fixed the pole, and across barriers are analyzed.

The principal theory which is used in the pole climbing robot is elaborated the control system of pole climbing robot is designed. Analysis shows that the mechanism has the characteristics of compact body, easy control, good move characteristics, and is a promising application of pole climbing robot structure. Our prototype of pole climbing robot has the capability to climb over the poles and perform the desired task smoothly. we need to design a wireless circuit which helps robot climb on the pole, can be controlled using wireless technology like RF Technology.

In this project we are using a new gripping mechanism for climbing the pole for that we are using two power supplies one lead acid battery and another from ac power. The H-bridge is used to control the

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direction of the motors used for climbing purpose. Two switching arrays are used for controlling the robot The RF modules uses Transmitter, Receiver, RF Encoder and RF Decoder. The two switches are interfaced to the RF transmitter through RF Encoder. The encoder continuously reads the status of the switches, passes the data to the RF transmitter and the transmitter transmits the data.

Main features present in this project:

1. It performs the task smoothly.
2. Easy control, good move characteristics.
3. Capability to climb over the poles.

Major blocks present in this system:

1. Micro controller
2. Regulated power supply
3. RF Decoder
4. RF Transmitter
5. Crystal oscillator
6. Reset
7. H-Bridge
8. DC Motors

Software's used in this project:

1. PIC-C compiler for Embedded C programming.
2. PIC kit 2 programmer for dumping code into Micro controller.
3. Express SCH for Circuit design.
4. Proteus for hardware simulation.

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Regulated power supply:

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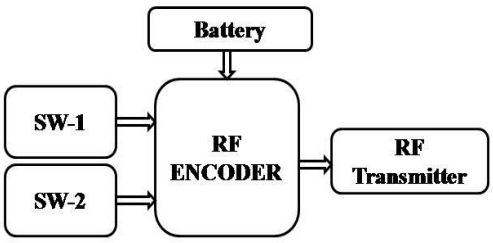
Transmitter:



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4. RESULTS

Fig.5: Full Mechanical Structure

4.1 A Gripper

The robot's gripper consists of two U-shaped bodies. These bodies are made of steel over aluminum since steel makes the robot more adaptable to the weight of the robot that it has to carry. Steel allows the gripper to withstand the pressure it experiences when it is holding onto the pole. Grippers have rubber placed on them which adds friction between the pole and the gripper to ensure proper gripping of the pole. Rubbers also reduce the risk of current flowing through the robot since it is an insulator. Each of the gripper has one sensor which is attached to the rubber. Force Sensitive Resistors (FSR) are attached to each pair of (Upper and Lower) gripper in order to measure force on different locations of the gripper, which not only provides information about the amount of force exerted by grippers, but also provide information on how grippers are connected to the structure. We use FSR to measure the pressure from the gripper to the pole. While actuator works, the FSR placed on the gripper gives pressure as the feedback output to the Arduino. When the gripper will properly grip the pole that is when sensor would sense maximum pressure only then would the arduino signal the actuator to stop working. According to that output Arduino maintains the gripper control. Gripping and releasing the pole is hence determined by the actuator. Of the two grippers, one gripper is fixed and the other one moves along with the actuator. Only one actuator would work at a time for smoother gripping.

4.2 B FSR

Force sensing resistor (FSR) is basically a polymer thick film device [12]. It is a device whose resistance varies when a pressure is applied to it. It shows a relation between the increase in the force applied to its sensing area and the decrease in resistance. The FSRs used in this project are of a length of 1.75" and width of 0.28" having a sensing diameter of 0.16" each [13]. These sensors determine the pressure applied to the pole by the grippers to ensure proper gripping. Sometimes proper gripping may occur before an actuators contracts fully and it may cause power losses. Again, excessive pressure on the pole by the grippers may break the robot's arm. FSRs are used here for the safety of the arms and also to minimize the power losses.

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4.3 C Arms for Climbing

The pole climber has been given four arms (Upper and Lower) in place of wheels for climbing to avoid slipping and toppling over. The robot's arms too are made of steel so that they can carry the weight of the body without breaking. Two arms are crossed connected by an actuator. Of the two arms one arm remains fixed while the other arm's closing or opening is determined by the actuator. They are cross connected to maintain a balanced pressure on the actuator. The steel grippers are welded onto the arms.

4.4 D Climbing Procedure

A visual explanation is given by the pictures below.

Fig 6 Step-1: Upper arms released

Fig 7 Step-2: Middle Actuator Released

Fig 8 Step-3: Upper Arms Gripped

fig 9 Step-4: Lower Arms Released

The design has advantages of both climbing and gripping modules. Instead of using motors for the working mechanism, we have used three actuators. Actuators made the robot light, minimized cost and reduced power consumption. Only one actuator would work at a time for smoother climbing and

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gripping. One actuator has been used in the main body of the robot that expands and contracts to make the robot climb while the other two actuators are connected with the upper and lower arms to determine gripping. For both of the upper and lower arms as they grip the pole fully, the FSR sensors in the gripper send signals to arduino that maximum pressure has been attained. Arduino then signals the corresponding actuator to stop to prevent energy loss. Here, climbing mechanism follow some sequences which starts with gripping the pole by both of the upper and lower arms fully as soon as the robot is powered on. As the user commands the arduino via Bluetooth to start climbing procedure, upper arms release the pole and the main body's actuator pushes them upward. Then the body's actuator stops and the upper arms start to grip the pole again. As soon as it grips fully, the actuator of the lower arms then sets to motion and expands to release the pole. The body's actuator then contracts to pull the lower arm up. The body's actuator stops contracting and the lower arms grip the pole fully then. The robot continues to climb the pole following this process until it reaches at the desired height which is determined by an IR sensor. A black mark was drawn before at the desired point on the pole and as soon as the sensor finds it, the robot stops climbing making sure that both of the upper and lower pair of arms grip the pole properly. Similarly, while getting down to the ground, the robot follows the process just in the reverse way.

4.5 E External Hand & Hooking

The external hand that is to be used for hooking the distribution line is a steel rod that has been cut in between to give it a U-shape considering a plug in-out wiring system to the distribution lines. For example, like a connector will be at the end of the wire to plug it in a desired port on the electric pole. The robot will carry the wire and plug it in to the desired port according to the instructions given by the user. The hooking will be determined by the movements of the hand. The hand's horizontal and vertical movements would be controlled by a Bluetooth. We have used a servo motor for the angular motion of the hand. The robot

moves its arms by the turning of a servo motor which is turned by using mobile through Bluetooth connection.

Fig 10 : External Hand

4.7 Block Diagram & the control Circuit

Block Diagram actually shows how the control circuit has been implemented for EPDRO to serve its purpose. Bluetooth controller is used to give the robot instructions when to start climbing or when to break. As soon as the controller gives a signal to the Bluetooth shield, connected to the Arduino, gives

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signal to the arduino for running the climbing program. Actuators work according to the arduino command where actuators give a measurement of pressure as a feedback to the arduino. Depending on that feedback arduino continues working. Actuators are actually connected through relays. Relays give signals to the actuator when to extend or contract. An IR sensor is connected to the robot. This sensor detects the black mark drawn before on the pole by the user in order to determine at what distance the robot needs to stop climbing.

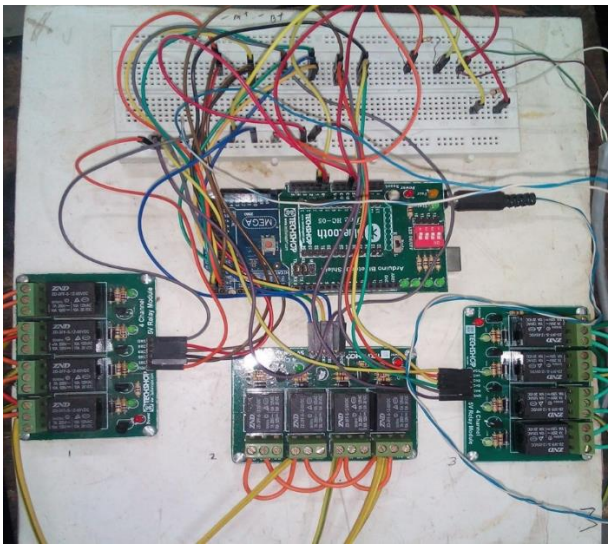

Fig 11: The H-bridge connected whole control circuit

4.8 Resistance versus Pressure

Since Force Sensitive Resistor responds to the pressure applied to it, a resistance versus force graph can be built by applying variable forces on it. This graph from the data sheet of FSR, made by the producing company, is given below [14].

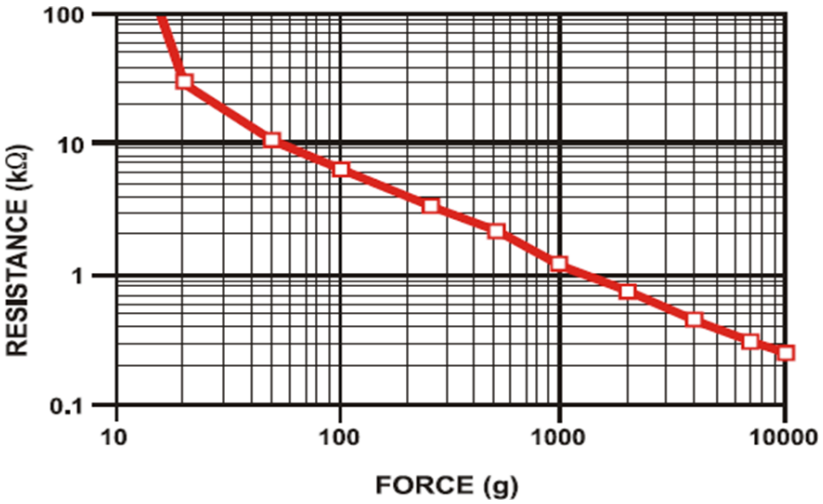

Fig 11: Resistance versus Force (Pressure)

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4.9 Voltage versus Pressure

FSR gives a voltage signal as output of the applied force on it. It is basically an analog output which is converted in digital by arduino. Using LCD display this values can be gathered to have a graph between voltage output and the applied force. From the data sheet of FSR this graph is given below [14].

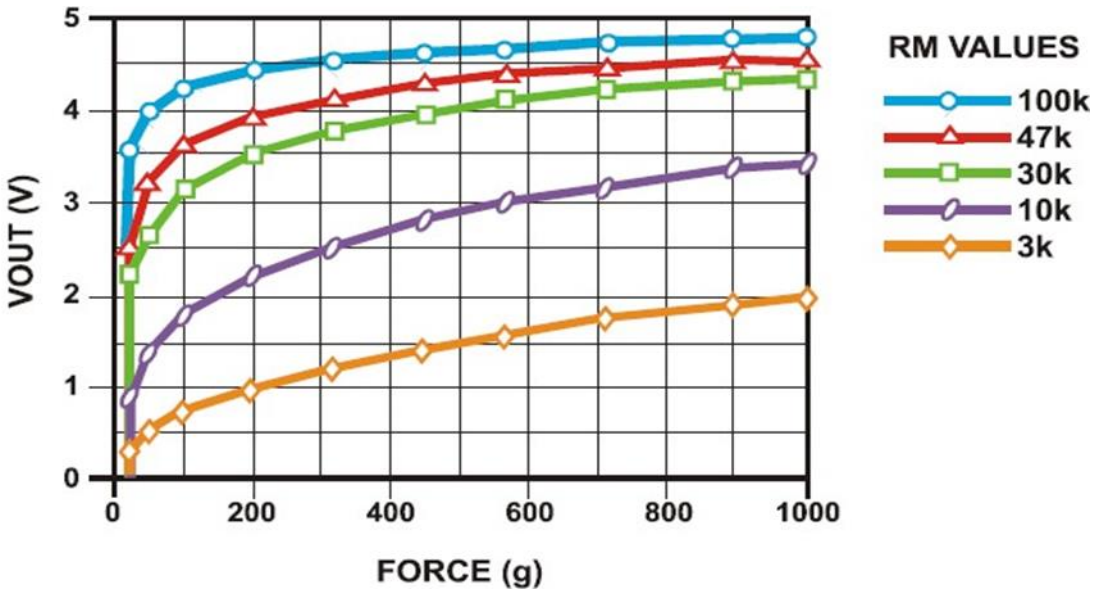

Fig 12: Output voltage versus Force (Pressure)

5. CONCLUSION

The technology in the field of robotics has advanced remarkably in the recent years. In this modern era robots are being developed for various purposes to accomplish many tasks which are dangerous, complex and monotonous for humans. This paper comprises of all the steps and procedures that have been undertaken to build the pole climbing robot that would climb a pole get the necessary wiring done and then climb down. The robot has been designed and programmed to climb up the pole by sensing pressure and get down in a similar manner. This robot promises to be beneficial to the electric industry where the importance of such type of robot as explained in this paper is immense. This robot is very helpful to the society in terms of reducing the number and risk of accidents that usually happen to electricians while connecting wires.

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