LAMPPOST CLIMBING ROBOT UTILIZING ARDUINO DEVELOPMENT BOARD

Poe Zarli Maung[1], Mar Mar Swe[2], Hla Htay Win[3], Khin Mar Win[4]

Abstract

Design and construction of a model of Lamppost Climbing Robot is implemented by using the locally avaivable components. The system design consists of two stepper motors, two ULN 2003 ICs, limited switches, 4-key remote transmitter and receiver and Arduino Nano development board. The Arduino Nano board utilizes ATMega328 microcontroller. A program sketch was created with Arduino IDE software to operate the system. The robot consists of two parts – motor unit and controller unit. The circuits and motors are mounted on each unit. The system is very useful and can be applied to send tools or objects in dangerous places, instead of human.

Keywords: ARDUINO NANO, Remote Control, Stepper Morts, Ball Barings and Springs

Introduction

The term robot comes from a Czech word, robota, meaning "forced labor". A robot is a machine designed to execute one or more tasks automatically with speed and precision. People have been interested in building machines to do work for them for a long time. But it takes time and money to build such a machine. Leonardo da Vinci designed a man-shaped machine to look like a knight in 1464. But it was controlled with ropes and wheels. The most successful robot design was build in 20th century and they did not look like people. They were designed to use. George Devol made the first of these, the Unimate, in 1954, with one arm and one hand. They are used to lifting, transporting and stacking pieces of metal that were too hot or heavy for people. The engineers could program the machine to operate.

A robot is an integration of mechanics, electronics and software. There are many different reasons for using a robot but the major reason for most applications is to eliminate a human operator. The most obvious reason is to save labor and reduce cost in production sites. The other reason is safety concern, a robot can handle dangerous materials, such as radioactive

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materials, thermal radiation devices, defusing a bomb, climbing high towers or poles, sending underground caves and investigating a toxic area, which are not suitable to a human being. Therefore, various kinds of robots are invented for various fields; production sites, military use, scientific experimental use and even for personal helper.

In this thesis, a climbing robot is designed and constructed. Different mechanical hardware are constructed and tested repeatedly, until an operating prototype is achieved. The climbing robot design consists of an Arduino Nano development board, two stepper motors, two stepper motor driver ICs, a 4-key remote transmitter and receiver module, and two lithium ion batteries. The primary purpose of the device is to carry accessories vertically around a lamppost. It is hard working for electric power service workers to climb a lamppost personally. If they are on the top, and some accessories are currently required, the climbing robot is a solution for them. That's why the climbing robot is researched and developed in this thesis report.

In the prototype model, only a few light weight accessories are able to transport vertically. Design and development is infinity, it can be upgraded with powerful motor and can be integrated with sensors to be autonomous, such as changing the bulb of a lamppost automatically instead of human worker.

Construction of the Circuit

The components are soldered on the printed circuit board as design of the drawings on the printed circuit. There is only one circuit to make soldering components. Components and jumpers were inserted and soldered in the following procedure;

1. The wire jumper connections
2. Resistors
3. Switch and LEDs
4. IC socket, and male connector pins
5. Female socket for 4-key remote receiver
6. The green terminal

The resistors, and jumpers, are inserted in their positions and soldered carefully. It is shown in Figure 1. The soldering side was illustrated in Figure 2.

Instead of soldering the Arduino Nano directly on the board, female connector pins are inserted from the component side. Then the pins are soldered carefully from the soldering side. There are two groups of five male connecter pins on the upper side of the circuit. The pins are differentiated with color; the blue is for the stepper motor signal pins and the red for common power pin of the stepper motor. On each group, two stepper motor wire terminal can be fitted on each position. There are two 16-pin IC bases required to solder in their position. But in the moment, only one of the 16-pin dual inline package is available, therefore, two 8-pin dual inline sockets are inserted on the right side of the socket position as shown in Figure 3. There are two blue LEDs on each side of the circuit to indicate the climbing robot operating function. The two 560 Ω resistors are used to limit the current for LEDs. There is a green terminal on the far right of the circuit. It is used to connect with a dc power source. Between the Arduino Nano and the power input, a double pole double throw toggle switch is inserted and soldered for power switching. The last part on the circuit is 4-key remote receiver module and it is also not directly soldered on the circuit. Instead, a 7-pin female header is inserted and soldered on the lower edge of the circuit.

It has not extra power regulator circuits in pcb design, since the Arduino Nano consists of 5 V and 3.3 V on board regulators.

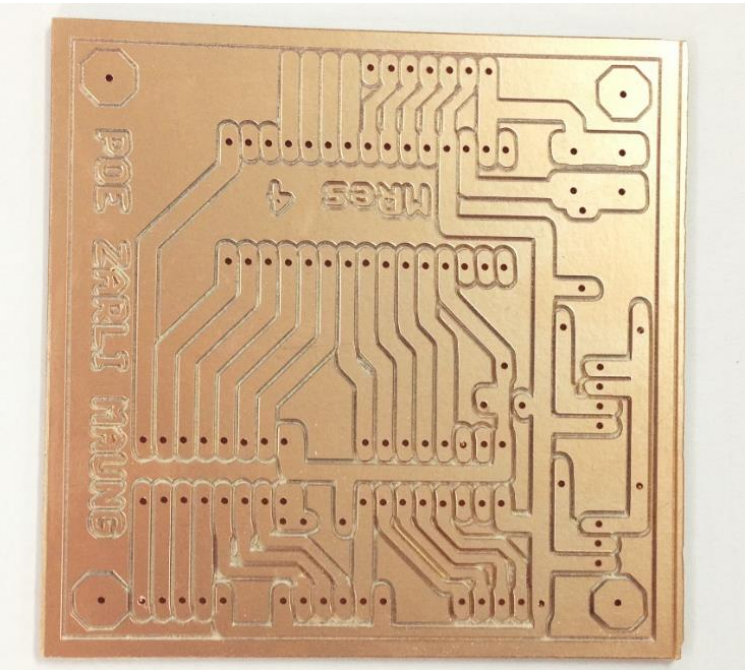

Figure 1: The Result Photo of Printed Circuit Board

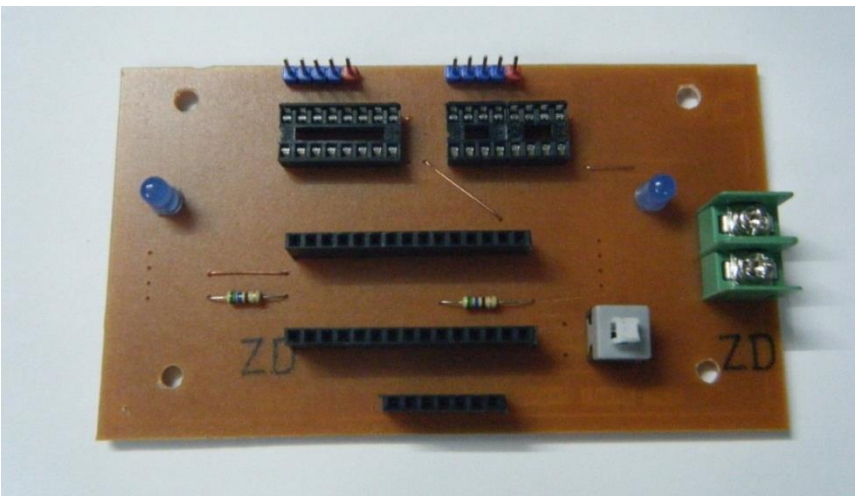

Figure 2: The Components Side of Circuit Board after Soldering

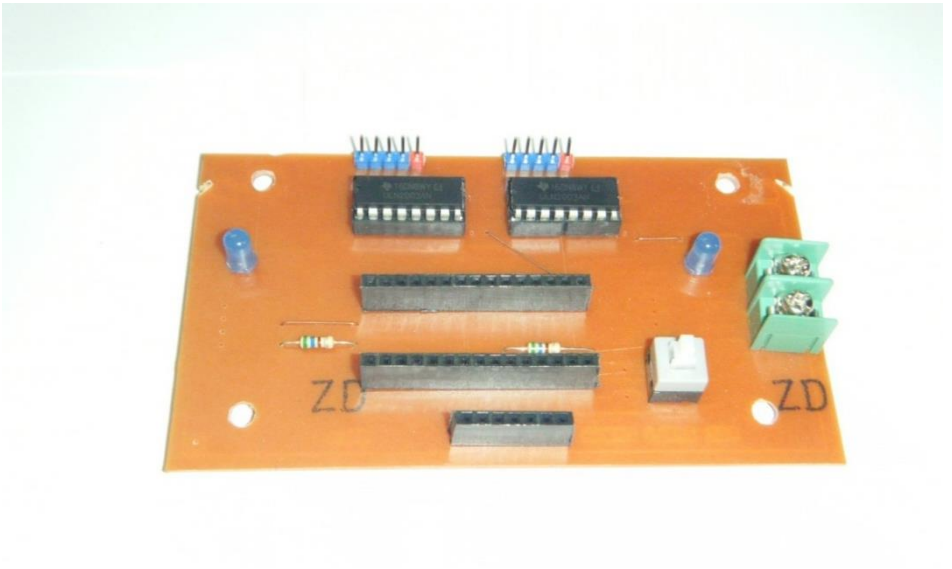

Figure 3: Control Circuit Board Preparation for Control Unit Assembly

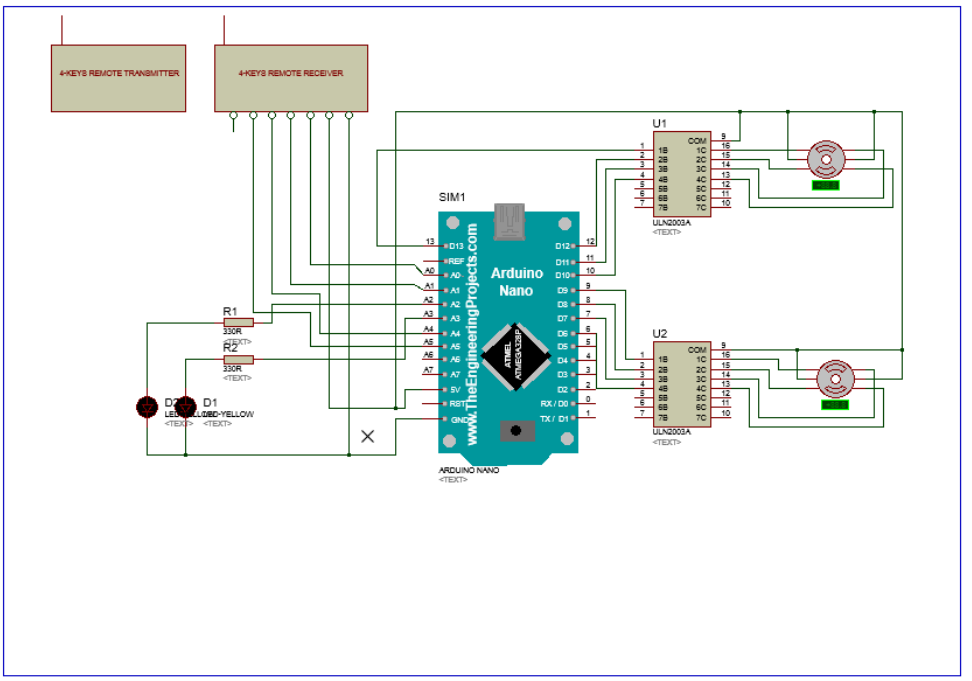

Figure 4: Complete Circuit Diagram of Lamppost Climbing Robot on Proteus Stimulation Software

Assembly of the whole Circuit

The circuit after soldering was tested for soldering shorts between the IC pins and isolated track lines on the board. Some of the soldering shorts are removed by using soldering gun and solder sucker. The circuit design in isolation routine, it was perfectly designed and drawn. Therefore, no more extra wires are connected on the back of the circuit board.

For the hardware assembly of climbing robot, there are a total of four cutting pcb boards. Each pair are attached together and become two units; controller side and motor side. The controller side consists of circuit board and battery unit. The motor side consists of two unipolar stepper motors.

The assembly of controller side was attaching control circuit and battery holder board with 4 mm bolts on each corner. Between the two boards, some spacers and baring wheels are added as shown in the Figure 5. Before inserting the battery and components on the circuit, two battery wires are inserted and screwed on the green terminal as shown in Figure 6. Then the Arduino Nano and remote receiver are inserted in their positions as shown in Figure 7.

Another part to assemble is the motor unit. The motor unit consists of two motor holder plates and a unipolar stepper motor is attached on each plate. The rotor pole of stepper motor is 3 mm and two (50 mm diameter) wheels are attached on each side. The wheels consist of high efficiency rubber tires, with slipping protect on each wheel. The wheel is extruded about 5mm from the motor holder board. Similarly, four baring wheels are inserted in parallel with two stepper motor wheels. But the baring wheels are used only to support smooth climb up/down function. Therefore, the corner of the motor holder board will not jam on the way climbing up or down. There are four pulling springs on each corner of the motor unit. The purpose of the springs is to pull each unit facing against the lamppost. The force of the springs must be balance with the stepper motor. If the springs is stronger than the stepper motor torque, the movement of climbing robot will not achieve. Therefore, it is important. If the stress of springs is very weak, the two facing unit cannot hold the position and will fall back.

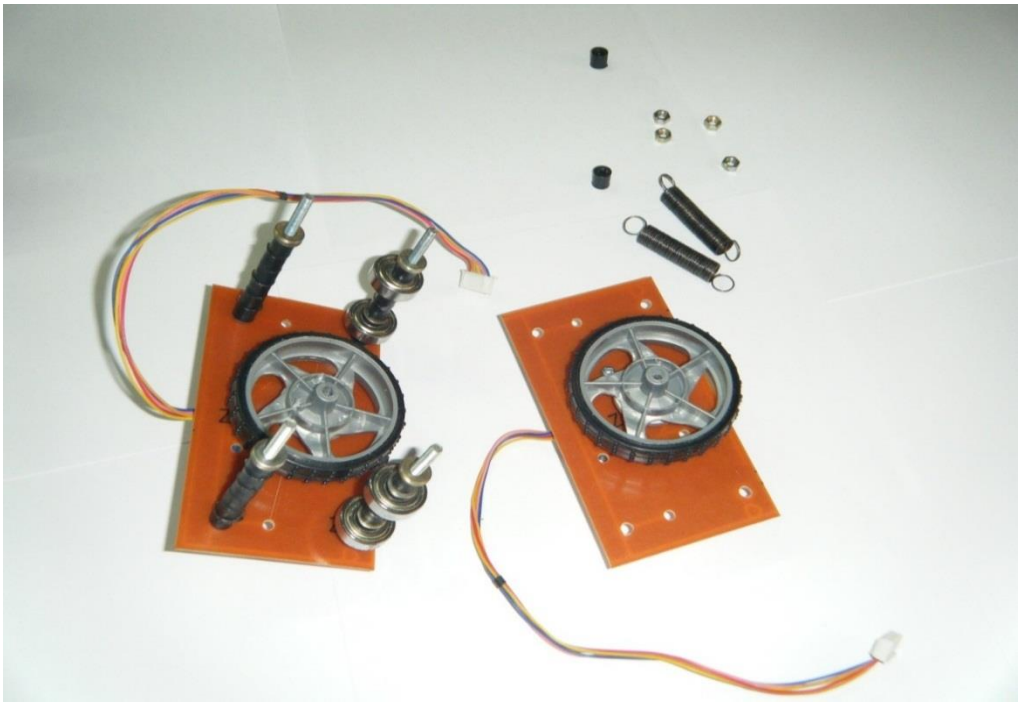

Figure 5: The 50mm Wheels are Attached on Each Stepper Motor

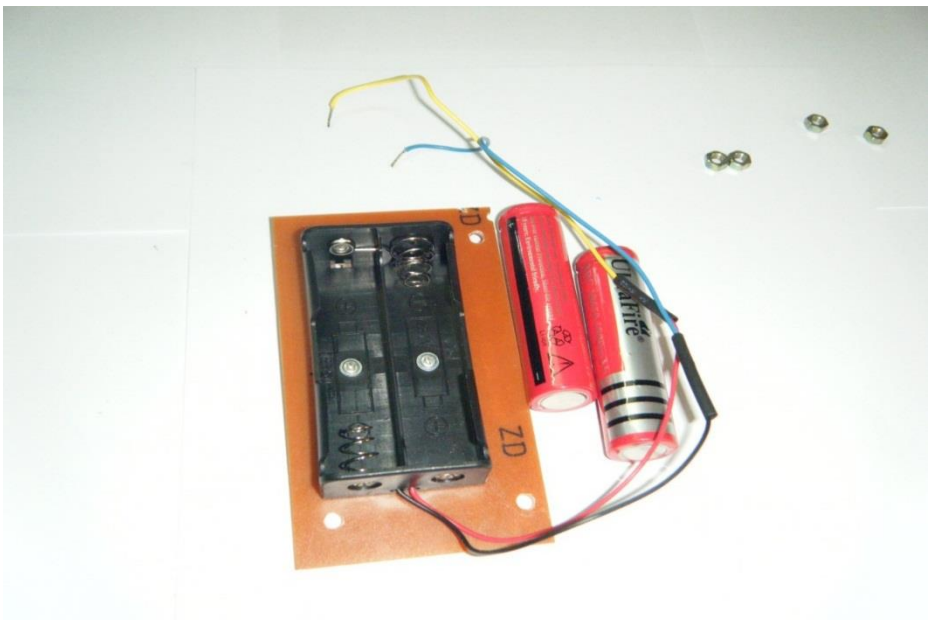

Figure 6: Battery Unit Plate Preparation for Control Unit Assembly

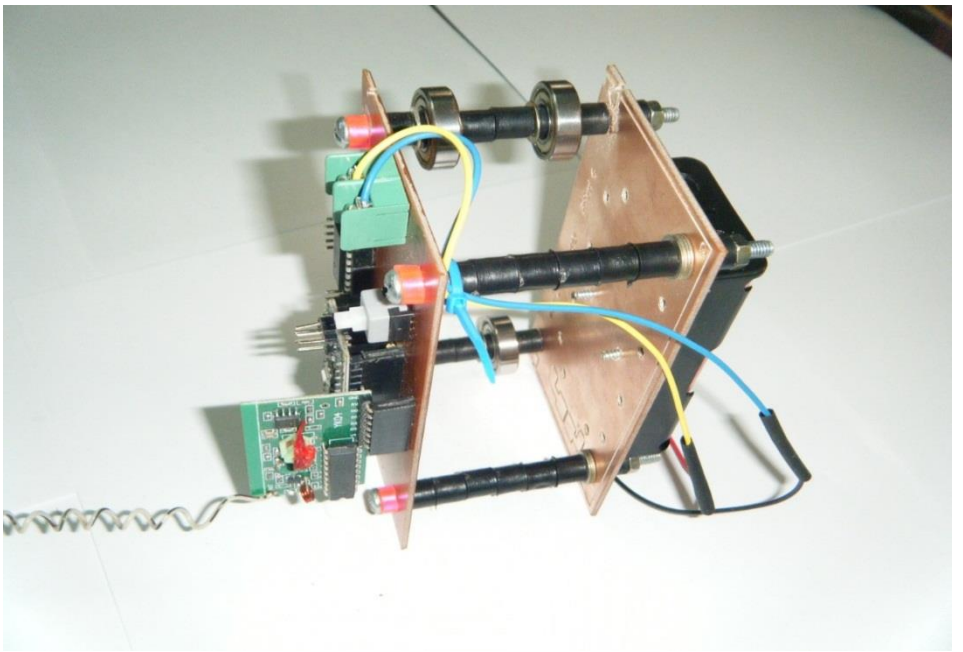

Figure 7: Complete Photo of Control Unit

Flowchart

The initial step to create the program sketch is drawing an outline flow diagram and it is usually known as flowchart diagram. The flowchart illustrate, programming flow with blocks and labels. In regular statements, it is illustrated with rectangular shape text boxes. In decision making process, it is illustrated with diamond shape text boxes. The flowchart of the lamppost climbing robot operating system is illustrated in Figure 8.

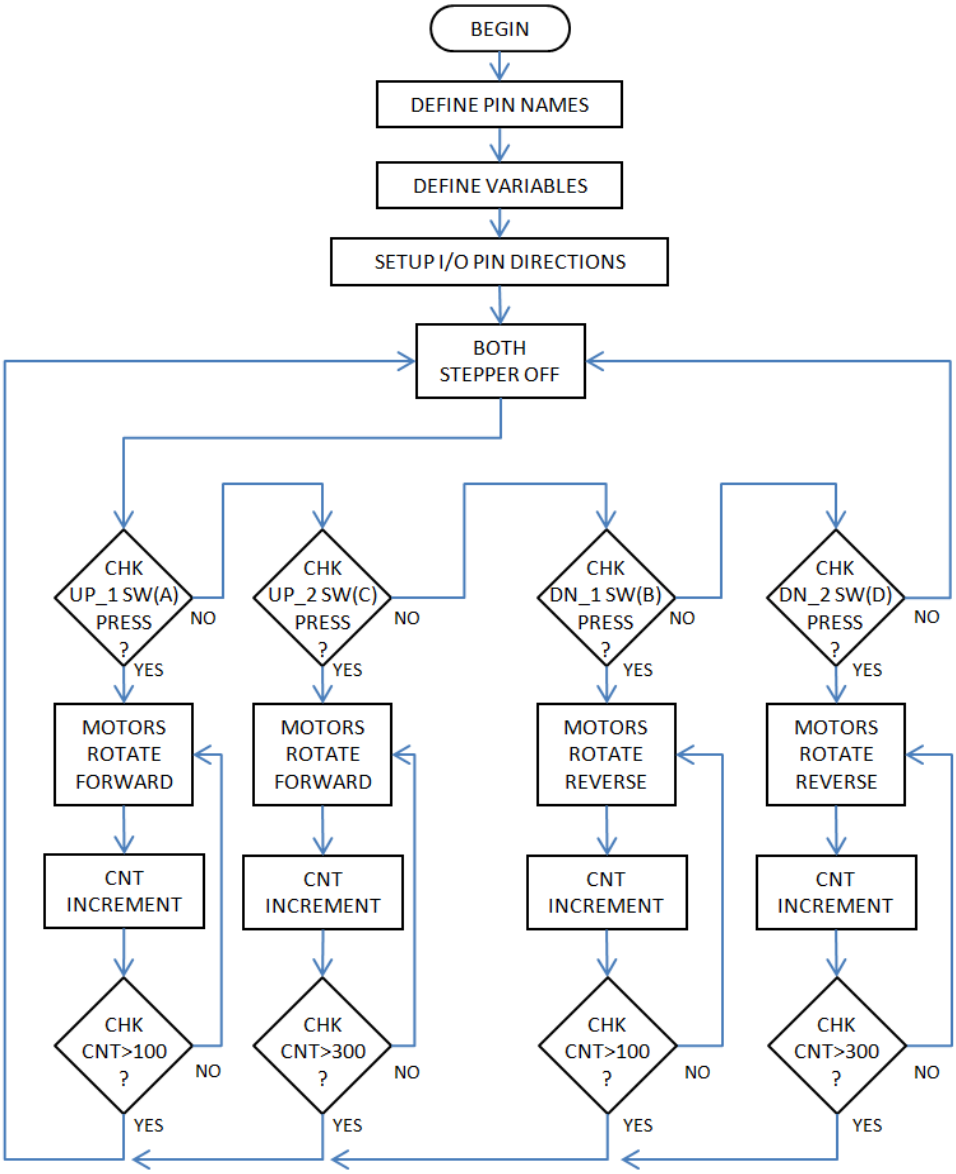

Figure 8: Flowchart Diagram of Lamppost Climbing Robot Control System

Result and Discussion

Research field in flying and climbing robots have been very popular and attractive for many decades, since there are numerous applications that cannot be performed directly by human operators because of difficulties in accessing the operating positions in a proper and safe manner. Some flying devices can move vertically around the wall or a tree, but it is not safe to close with the wall or tree since they are bulky and the propellers can be crush into the wall or tree. But for a climbing robot, it is safe and easy to go over the wall or tree without crushing. But the height and load is limited.

In this research work, a lamppost climbing robot is designed and constructed. It is intended to save the lives of electricians who often climb the lampposts and risk their lives on duty. Instead of checking or repairing personally at the top of a lamp post, a climbing robot can be used safely. The design of the lamppost climbing robot consists of three stepper motors, limit switches, control switches, stepper motor driver circuits and an Arduino development board, utilizing ATMega328. The ATMega328 is an 8-bit microcontroller and it was chosen for numerous pins numbers, 32 kbyte of program memory and easy to develop a prototype developing experiments, which is well suit to the lamppost climbing robot.

The system design consists of two different experimental fields; hardware construction and software creating. The hardware consists of mechanical moving parts and they are used to climb the lamppost. But the hardware mechanisms cannot operate without a microcontroller. The microcontroller is loaded with a program sketch created with Arduino IDE software.

The system design construction can be used in many different practical applications other than climbing lamppost. The system can be used in, inspecting, cleaning, changing bulbs and connecting and cutting the wires over the top of lamppost. The prototype of climbing robots is intended to replacing human operators in the accomplishment of essential safety critical tasks in hazardous environments such as firefighting scenes, petrochemical plants, and nuclear reactors or even in emergency rescue teams.

Conclusion

The lamppost climbing robot control system is designed and constructed. It is constructed on a self-designed printed circuit board. The printed circuit was made by using CNC pcb isolation routing method. Circuit construction and error corrections were made before connecting the Arduino Nano and remote receiver circuit. The microcontroller was loaded with a program code, which is created and tested with Proteus virtual simulator software. After completing the debugging the program is compiled and uploaded into the memory ROM of ATMega328. Then the coding was tested with the constructed prototype circuit board. The results were illustrated with photos in circuit operation title. In the results and observations on actually climbing on a lamppost, there are some difficulties and problems. The speeds of climbing up and down are not equal for both without load and with loads. The climbing down operation is smooth and faster than climbing up operation. Some changes were made for the spring's tensions. Adding springs tension make more difficult to move along the lamppost. Reducing the spring's tension cannot hold the position. For a better and really applicable lamppost climbing robot design, many more developments are required to research. Anyway it is very first prototype of climbing robot and further enhancements and developments may achieve a great help to those electrical powering repair men and telecommunication workers.

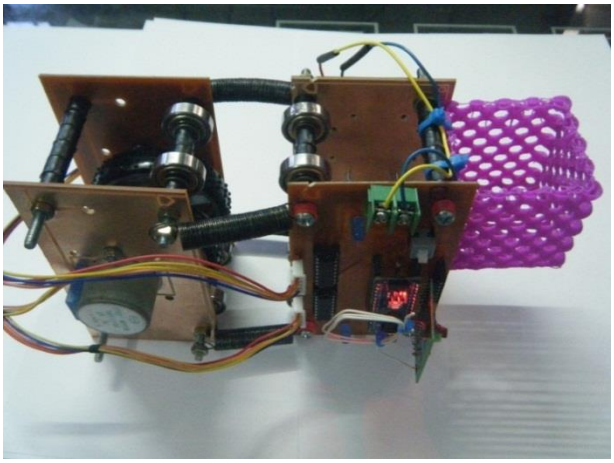

Figure 8: The Climbing Robot Itself Ready to Test

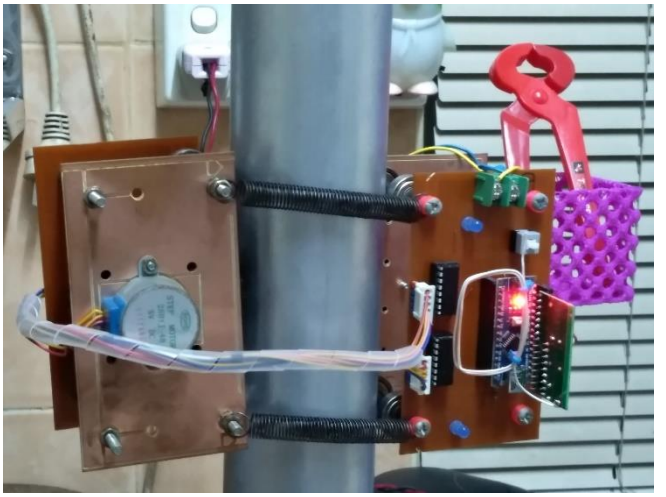

Figure 9 : The Controller Circuit Side of Climbing Robot Attached on the Lamppost

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