Study and Development of Android ControlledWireless Pole Climbing Robot

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Abstract— **In this research study, we suggest a wireless pole-climbing robot with an embedded system for several applications. Electrical professionals who must climb poles to do maintenance work on electricity transmission lines, climb trees, etc. in underdeveloped countries like India, Bangladesh, Sri Lanka, etc. may find this to be a great help. First, we couple a smartphone with a Bluetooth module that is attached to an embedded system within a robot. Then, we may direct the Android app to go up, move down, or stop moving by utilizing its graphical user interface. These orders are sent by the Bluetooth module to the embedded system board's Arduino, which then operates the motor driver in accordance with the instructions given by the Arduino's code. In this paper, we provide a detailed explanation of the operation of wireless motor control, the creation of an app using MIT AppInventor, and a model of a pole-climbing robot.**

***Index Terms*— android app, arduino uno, bluetooth module, motor driver, pole climbing.**

I. Introduction

For many years, scientists have been developing robots that can climb poles using different systems and techniques. Robots that can climb poles are often used to repair electricity transmission lines, lampposts, climb trees for harvesting, maintain bridges, and more. Most of these robots are semi-automated and include characteristics like hauling big loads, reducing power usage, transporting large loads, having many degrees of freedom, etc. Robots that can only climb poles mechanically are also available. Some robots are even made to transport humans. They typically consist of a climbing framework with wheels, actuators, and motors. The day's quotation is "All wired systems turning wireless." Wireless alternatives are sought for everything from keyboards and mice to watches, phones, and even power distribution. This is a result of the development of low-cost wireless interfaces and the availability to developers, researchers, academics, students, etc. of vast amounts of open source hardware, software, and materials. Due to the enormous benefits of wireless technology and safety, everything that was formerly wired is now moving toward wireless. In this essay, we go through the straightforward architecture of the pole-climbing robot, the wireless control system, or bluetooth interface, and an Android app to operate the robot. Additionally, we discuss the testing strategy, the Android user interface, and the implementation.

Motivation

It is always perilous for anyone to climb poles to mend problems with electricity transmission lines, bridges, trees, or light posts, among other things. Even a fleeting act of negligence may cause someone to fall from a height of several meters, leaving them severely disabled and sometimes even dead. In impoverished and underdeveloped countries, this situation is particularly problematic since it might leave the whole family orphaned if the accident victim is also the sole breadwinner. The employees may also utilize sophisticated elevators, which are not often seen in undeveloped or impoverished countries, as an alternative. In these nations, city roadways do not have many lanes, and when repair work is being done, it is quite noisy, especially on highways, which inconveniences the general public. The user must get extensive training in order to operate the presently available pole climbing robots and perform the desired repair operation. The control system for the pole-climbing robots that we suggest in this research is based on a cell phone and is straightforward and easy to use. It also takes very little training for the employees to utilize.

Related Works

Even in the early 2000s, research on pole-climbing robots began. The authors of the work [1] address the design and development of a modular "grasp-push-grasp" arrangement-based pole-climbing robot for agricultural applications. It is a wired system with a PLC as the controlling element. In article [2], the kinematics model of a pole-climbing robot is deduced. They arrive at a driftless nonlinear control system with affine inputs that is underactuated and controls the robot's mobility.

The creation of a legged robot for climbing a regular cylindrical structure, such a telephone pole, is shown in Paper [3]. The linkage design for the legs, non-backdrivability, and energy dense power transmission, according to the authors, are only a few of its numerous new characteristics. They claim that it has a wireless 802.11 connectivity and is totally independent. In the work [4], three types of pole-climbing robots are covered in depth. The first model is a complicated powered robot with actuators. The second one has a basic framework and just one electrically propelled wheel, and its design was influenced by human anatomy. The active track is used in the third one in lieu of the active wheel, which is a version of the second. Every model has a wired control system. [5] describes an extremely sophisticated wired pole climbing robot featuring a climbing mechanism, cross-arm manipulation system, and the

building of distribution lines using a bolting mechanism. Climbot, a bipedal climbing robot inspired by nature, is seen in [6]. The climbing of animals and worms served as inspiration for the model. This form of wired control allows for the removal of a street light from a lamp pole.

II. Design And Implementation

The block diagram of the propose design and interface is shown in the Figure 1.

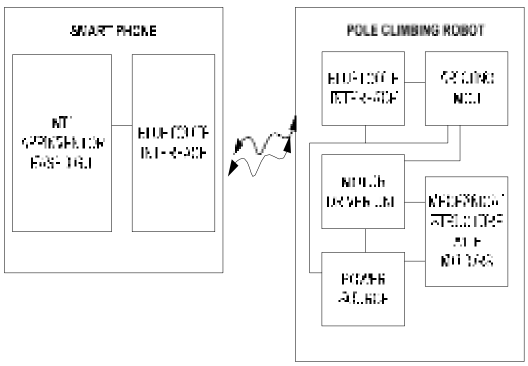

Figure 1. Block diagram of the system.

The user can use the GUI developed using the MIT appinventor to control the motion of the climbing robot very easily. The developed app allows the user smart phone blue tooth (BT) to pair with the blue tooth interface installed in the pole climbing robot. Once the smart phone BT interface recognizes the robot BT interface, the control is very easy with the up and down icons. The pole climbing robot is a 8 wheeled structure with four wheels on the top and four wheels at the bottom, placed diagonally opposite to each other. Figure 2 shows the pole climbing robot model.

Figure 2. Pole climbing Robot Model

The motors are controlled by the motor driver unit with an Arduino based MCU. The motors attached to the legs arecoordinated in a simple manner in which all the motors move either up or down depending on the whether the robot should climb up or down. In the course of controlling the robots, the various motor driving mechanism of the motion of the robot ispresented here. In the first scenario, relay based motor driving mechanism was implemented and tested. This implementation is the cheapest but with a trade off. The speed of the motor cannot be controlled. This should not be a problem as pole climbing robots are not race robots. This setup used the HC-05BT module along with the relays. The setup is shown in the Figure 3. The relays can control the direction of the movement of the motors to which the wheels are attached for climbing upor down, but at a constant, non-varying speed.

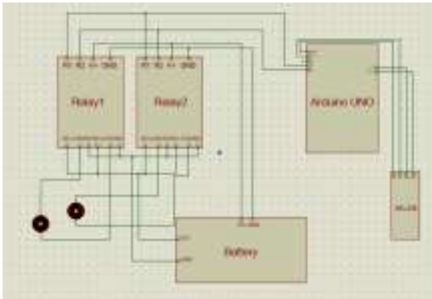

Figure 3. Circuit diagram of controlling motor with 2 relay boards.

Motor drivers are a bit expensive as compared to the relaysbut the controlling and connections are easy. The extra feature for the motor driver which is not in the relay is to control the speed of the motor by changing the PWM (Pulse Width Modulation). The PWM signal can be controlled via Arduino MCU. The direction of the motors can also be controlled usingthe Arduino MCU with the direction control signals of the motor driver board. The setup is shown in Figure 4.

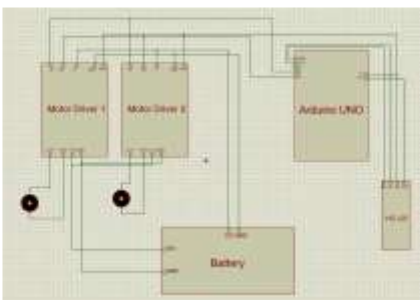

Figure 4. Circuit diagram of controlling motor with 2 motor drivers.

The number of motors cannot be driven by a single motor driver. Due to the load it must drive, we see that it is heating up fast. High torque 12 V DC motors with a maximum load current of 7.5 A are used to drive each set of wheels. At 10 RPM, they produce a torque of around 120 KgCm. The Hercules 6V - 36V, 16A Motor Driver is the motor driver we utilized for this project.

Instead of utilizing the serial monitor on a smartphone to control the motors using the Arduino MCU, we are using the BT interface, which is managed by an Android application created with MIT App Inventor (Open Source Software). Figure 5 depicts the circuit for the Bluetooth module with the Arduino MCU.The UART serial converter module is used with the BT transceiver module HC-05. It may be powered by the Arduino MCU at 5V and 50 mA. This module may be set to operate at baud rates between 1.2 Kbps and 115 Kbps. Its range is around 10 meters. The Bluetooth module will begin flashing consistently as soon as the Arduino board is powered up, signaling that it is ready to connect with a device. After setup, the BT module may be connected to the smartphone running our software. It will flash twice for a second after pairing.

The MIT appinventor's android mobile phone app is used to steer the pole-climbing robot. A free online tool for developing Android apps is called MIT AppInventor. Because the program is so easy to use, creating the app's basic UI is fairly simple.

Figure 5. Circuit diagram of connecting bluetooth module with arduino.

Figure 6. Components tab showing elements present in app.

The components tab shows the elements present in app as shown in Figure 6.All the visible components can be added to app from the user interface tab which is present on left hand side. Here we kept the background image and place where different buttons required are placed.

Figure 7. Bluetooth component is added to non visible components of app

The Bluetooth component is added to the nonvisible components of the app as shown in Figure 7. It can be added tothe from the connectivity tab. Many other features can beadded from tabs presented on left side. When all required components are added then the blocks should be edited to makethe app functioning as per Figure 8.

Figure 8.Blocks connection for bluetooth connection.

Figure 9.Blocks connection for data transmission.

We must initialize each component first. Select the component on the blocks tab to initialize. Click on the screen1 component, choose the "when screen1 initialize do" block, and then connect the other blocks to initialize screen1. To initially deactivate all button blocks, attach them all. Figure 9 illustrates how data transfers and the buttons are programmed to operate when Bluetooth is connected.

The Bluetooth blocks should then be configured. The scanning list picker must first be initialized. The Bluetooth client block is maintained here to allow the scanning components when this list picker is activated. Then a list of the mobile's bluetooth-paired gadgets will appear on the screen. The display text will be set to "CONNECTED" after the appropriate Bluetooth device has been chosen. All of these tasks will be completed when the picking block has been scanned. The buttons blocks will be used to set all of the buttons to active when the mobile device is connected to the appropriate Bluetooth device. Logic blocks may be used to set them as active or inactive.

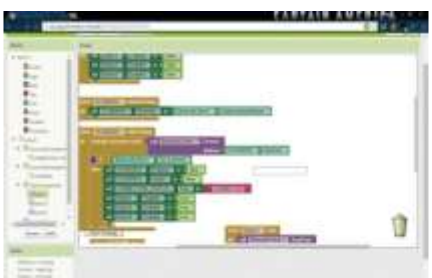

Figure 10. Configuration of bluetooth when device is connected.

After setting all buttons to active state then another block which has the condition when button clicks should be added. When button is pressed it should call Bluetooth client to send data to the Bluetooth device according to the logic provided inFigure 10. Since our Arduino code is written in such way that it will receive character so in block the text block is assigned to send the desired character. This block arrangement is shown inFigure 11.

Figure 11. Block connection showing the data to be transmitted for differentbuttons.

When all the blocks are assigned correctly then the app is ready to use. The app can be downloaded by using QR code method or can be downloaded directly to PC.

III. Experiments And Results

As we increased the number of motors in connection with the relays directly it worked well. But as we connected to the pole climbing robot it is difficult for the relays to supply the current or voltage to the motors. We noticed that 2 relays are not enough to manage multiple motors, and then we connectedanother set of dual relay board. Some problems are faced with the single relay board. The working is quite nice with the 2 dual relay boards. As relays are required in more numbers to move the motors more smoothly and conveniently so we tried to use two motor drivers for eight wheel pole climber. Then to make it more economical we tried to replace the two motor drivers with single motor driver. Even after using a single motor driver the robot worked properly. Hence we replaced one motor driver instead of two motor drivers. The result was satisfactory.

Figure 12. Pole Climbing Robot in Action

The pole climbing robots we used for testing is shown in figure 12. The smart phone with the mobile app is given to 7 users and was asked to control the robot motion up and down the pole. The results are tabulated in Table 1 and 2. Each of them was asked to repeat the motions 10 times. Table 1 shows the success and failure counts out of 10 times the users made the robot to climb up. In Table 2 we see the success and failurecounts when the users made the robot to climb down 10 times.

Table I. Success and Failure Counts - Robot Climbing up

Users	Success Count	Failure Count
1	8	2
2	10	0
3	6	4
4	9	1
5	8	2
6	8	2
7	10	0

Table II. Success and Failure Counts - Robot Climbing Down

Users	Success Count	Failure Count
1	10	0
2	9	1
3	7	3
4	10	0
5	10	0

6	9	1
7	10	0

CONCLUSION

Finally we made the pole climbing robot work with our circuit which is controlled by android application which uses Bluetooth technology. We are able to use only one motordriver which helps in reducing the circuit size and cost. This works well for normal pole heights.

FUTURE WORKS

We are working to extend the wireless data transmission range between a phone and a Bluetooth receiver in the future. If necessary, we will utilize a Bluetooth transmitter and receiver since they have a wider operating range. We can use this circuit to power robots that can scale walls and climb hills since it is reliable. This may be used in rescue missions, for which the components need to be improved so they can withstand environmental changes. By maintaining speed control and using pulse width modulation, we can also enhance the user interfaces of the Android applications. Therefore, we may move the robot faster while travelling up and slower while moving it faster when moving down since the robot moves down faster due to its weight.

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