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Wireless hand motion controlled robotic arm using flex sensors

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ABSTRACT

In today's world, in almost all industries, much of the work is performed by robots or robotic arms with varying degrees of freedom (DOF) as necessary. The aim of this study is to adjust the perception of remote controls for manually controlled robotic-arm operation. This paper offers a way of thinking and a way to eradicate the keys, joysticks and replace them with some of the more intuitive strategy that is to operate the full robotic arm by hand movements operators. The robotic arm is constructed in such a way that it consists of two movable fingers and other movement, which is, a spreading elbow and the up down movement. The robotic arm is designed to mimic the motions of human hands using a hand glove. The hand glove consists of 3 flex sensors for controlling the motions of the finger, the elbow, and other movements. Servo motors are the actuators used by the robotic arm. The proposed electronics device recognizes a basic hand gesture that will be made in real lifetime and will relay valued signals wirelessly through the RF module.

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1. INTRODUCTION

The robotic arm is ideal for use in both factories and homes [1]-[6]. The Robotic Arm worked and controlled wireless with the aid of hand movements that relay signals to the robot via a hand-held auto system instead of manually controlling this through a classic joystick controller [7]-[10]. During this time, the robotic application was commonly used in some industries. The purposeof creating a robotic arm is to replicate the function of human hands and can be implemented in many ways in our modern world [11]-[17]. To do this, some servo motors, flex sensor and wireless modules were used. The definition of this robot arm is a 5 degree of freedom (5DOF) since the joint is on the shoulder, the base is also available, the wrist, an elbow, and the slider are available. This project use resistance value from the bend of the flex sensor to ensure the movement of the robotic arm to move accordingly [13], [18]. The NRF24L01 module on this project is used to communicate and transmit data rate up to 2 Mbps using an ultra-low power application. It can also be called a transceiver as the module can be used to send and receive data. With a high-power source, NRF20L01 can transfer data up to 100 m in open space. A current level of industry technologies can also be improved with the use of the 5DOF and flex sensor, which shifts our point of view in the history of the industry.

Robotic technology also offers human-like dexterity in a wide variety of environments [18]. This may involve welding and fixing pipes on the ocean floor or swept up radioactive and other toxic waste. Robots can perform a lot of this work more effectively than humans, because they are so fast and accurate [18], [19]. Worker accidents, including repeated stress injuries and more severe mishaps that may cause serious damage, have also been dramatically decreased [20], [23]. In comparison, robots turn out to be a more consistent commodity at a considerably lower cost than humans would [21], [23]. For people, there are no sick days, strikes, job slowdowns or any issues that can occur [16], [17]. Robots will, perform with a minimum of human oversight around the clock [23]. Generally, there are two ways of running this initiative, the wireless system, and the wired system. All have strengths and weaknesses as the wired is less complex, cheaper and uses less batteries [14], [15]. On the other side, the wireless link can be controlled from a wide distance. In this article, the least possible hand motion wireless device based on real time, and the process step by step was proposed. The first step is checking the flex sensor serial monitor. The flex sensors was choose as the hand function for this method. Flex sensors are perfect testing of the hands, and it is invariant of size, rotation, and motion. The next move is to monitor the position and direction of the hand in order to avoid errors in the segmentation process. In the last step, the approximate hand state was used to extract several serial monitor hand features to hold a deterministic gesture mechanism.

Arduino has a free software which is popular to be used in project [21], [24]-[26]. Arduino Uno is the most perfect choice for a beginner other than others Arduino Family. For this project, servo motors are necessary to the robotic field. The servo motor is used in robotics to trigger gestures, giving the arm a specific angle. This motor is powered by a pulse width modulator signal. The uses of servo motors involve predominantly in computers, robots, toys, and plenty more. As the servo motor being connected to the Arduino UNO at 5 V pin, the other wires are connected to the analog digital pin and ground pin. Servo motors change the PWM signal that being transferred from the analog input to the electronic circuit inside the servo motor. The power given which is 5 V helps to move the DC gear based on the PWM signal accepted. Other than that, the NRF24L01 also was used as it is a wireless transceiver module, meaning that each module can both transmit and receive data. They run at a frequency of 2.4 GHz, which comes within the ISM band. As for Flex sensor has been used for this project, it plays an important role in this robotics project. This is because the sensors are used to determine the actual state of the device. Since robotic applications need a sensor with a high degree of repeatability, precision, and reliability. Flex sensors perform the function with a high degree of precision. Figure 1 shows the system of servo motor while Figure 2 shows the PWM servos control [15]-[17], [27].

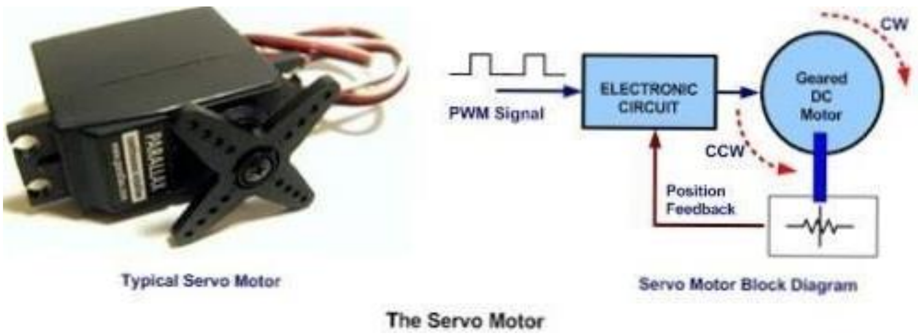

Figure 1. System of servo motor

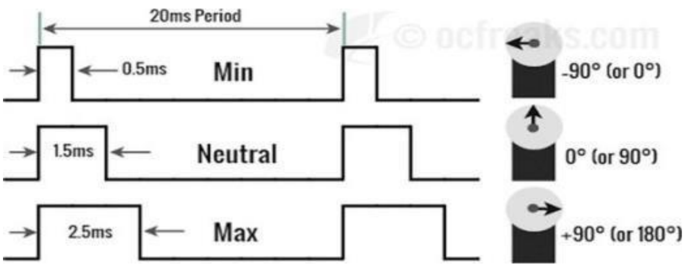

Figure 2. PWM servo control

There are heavy requirements to produce artificial arms in certain inhuman conditions where human encounters face obstacles or are impractical. With the creation of a wireless hand motion controlled robotic arm as a remedy. With this the project will be able to resolve those inhuman conditions that are operated and controlled wireless communication with the aid of hand movements. In order to make the future of humanity better, it is proposed that the robotic arm be used today, as it is typically used in a huge factory, facility, and big corporation that manufacturers the product. It is not largely exposed to our daily day-to-day existence or in a small warehouse, people generally assume that the application of technology is always too difficult to comprehend and to fill in depth. The robotic arm that is normally used in manufacturing can be applied to human activity on a regular basis.

This project may contribute in several ways to Malaysian society or government. In many uses, useful for military, home business which include in hot oil, camera surveillance and so forth, the function of Wireless Hand Motion Controlled Robotic Gripper Arm is suitable. It is also used for many uses in industries such as thermal spray et cetera. It is designed to follow and move the movement of transmitter hand. For the future, this project can be use within the development scope such as for the construction, Flex sensor for the infrastructural designs where it can control heavy machine. From this project, we can see that the proposed system is applicable even in rough conditions such as hazardous environment where a camera can be attached to the robot and can be monitored by the person who is controlling it from his station. This system can also be employed in medical field where miniature robots are created that can help doctors for efficient surgery operations for more efficient response with much accuracy. For more detect gesture and advanced features such as finger counts that provide different functional commands can be used in this project.

2. METHOD

There are two parts to do during the project, both software and hardware. For the hardware setup, there are two things that need to build, for both main components are microcontroller and electronic component such as wireless module NRF20L01, three types of jumper wire, resistor, capacitor, and servo motor. The wireless module NRF20L01 was used to communicate and transmit data rate up to 2 Mbps using an ultra-low power application. It can also be called a transceiver as the module can be used to send and receive data. The Arduino Uno controller is used to process the input data and making other component to outcome with the output.

There are a lot of troubleshooting and fault during the process if doing it without any precautious. Thus, some numbers of jumpers are needed for the connection from component to Arduino. The values of resistors are same but the value of resistance from the flex sensor is different because it is what makes it move. The Figure 3 shows the process of the project.

Figure 3. System diagram of project

Figure 4 shows the actual prototype of flex sensors at transmitter. It requires a circuit with the goal for it to be viable with Arduino. Flex sensors can be defined as variable resistors which the utilization of 10K resistor is needed. It is to sending information starting with one NRF24L01 then onto the next NRF24L01 utilizing a specially appointed, device to device organization. Figure 5 shows the actual design of receiver prototype for this project. Now, the servos should as of now be putted into the lower arm. Interface it to the supply and Arduino, a little breadboard is utilized. The connection for negative on the breadboard to the Arduino's GND. All the GNDs in a circuit require to be connected for it to be work. It is to sending information starting with one NRF24L01 then onto the next over NRF24L01 utilizing an impromptu, device-device organization.

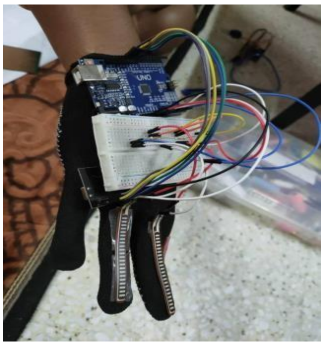

Figure 4. Transmitter prototype

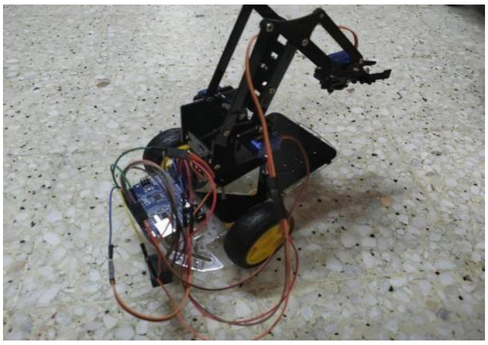

Figure 5. Receiver prototype

Figure 6 shows the transmitter schematic diagram which there are three resistors which are all 10K and a Wireless Module NRF24L01. There are also three flex sensors that powered by 9V battery. The schematic is being made by using Fritzing software since the proteus 8 professional software does not have complete library for the design. The primary GND (ground) wire associated with all individual GND wires from the sensors gets associated with the GND of the Arduino. The +5 V from the Arduino goes to the positive voltage wire.

Figure 7 shows the receiver schematic diagram where there is battery which are 9 V connected to Arduino Uno. There is also NRF24L01 as a receiver and four servo motors attached to it. The connection for negative on the breadboard to the Arduino's GND. All the GNDs in a circuit require to be connected for it to be work.

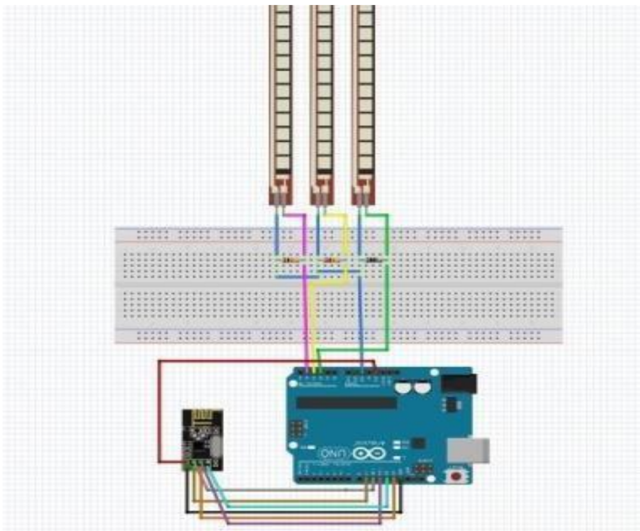

Figure 6. Schematic diagram for transmitter

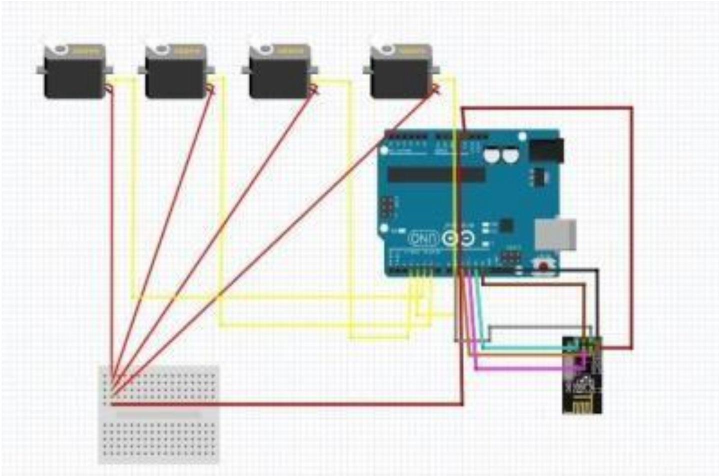

Figure 7. Schematic diagram for receiver

3. RESULTS AND DISCUSSION

The project in the end successful to move and has been tested repeatedly to ensure that the prototype is moving accordingly, and to test the distance of the transmitter to receiver. Figure 8 shows that when the middle finger that has flex sensor on it bends, the prototype wirelessly will turn to the right. In Figure 9, it shows that when the ring finger is bending, it will go toward left and Figure 10 shows when both flex sensor is bend together, it will open the clow. This is happening because of the resistance that has been recorded inside the Arduino is capturing its data when setting it up. The main key of this project to be functional other than coding is the NRF24L01 itself. This is because the project can only be move if the NRF20L01 is functioning properly and due to the close space, the farthest range of it can transmit the data is around 2 meters from the location.

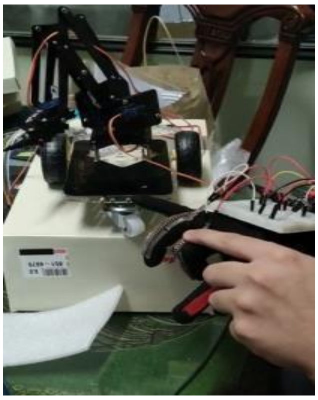

Figure 8. Moving to the right

Figure 9. Moving to the left

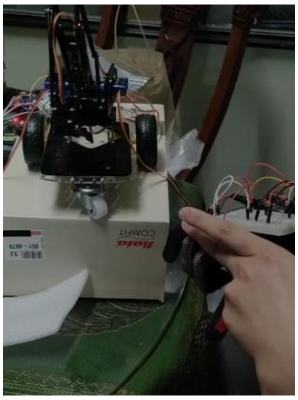

Figure 10. Claw open

There are only 3 flex sensors connected to the Arduino. The flex sensor first needs to be declared inside the Arduino software system. This is because flex sensors have certain values that need to be transferred into a shape of data. In the void setup, "Serial.begin" instructs the Arduino software to open the serial monitor. This function sets the data rate as "bit(baud)" in the transmission. To communicate with serial monitor, ensure the serial baud is set at the right value.

Figure 11 illustrates the receiver most important part that needed to be done first to ensure the project can be running smoothly. There are 4 servos that connected which is one at the base and the claw, while the other two is at the shoulder. It needs to be extra careful during attaching all the items to the robotic hand because it is fragile and can be broken easily with a little pressure during attaching the arm using a screw. Some servos cannot be forced to spin using a hand to many times or it will be getting hard to turn and eventually damage the servos.

The Flex sensor is placed and soldered appropriately on the handle of the transmitter in Figure 12 for the transmitter. To build the right servo-motor resistance, the index finger must curve about 90°. Both sensors must bend a robotic arm over 90 degrees to move the whole limb. The flex sensor only releases the claw in its initial position. The reverse switching operation damages the flex sensor. Extra care is required when soldering as the current leak quickly happens when the flex sensor and jumper cable are soldered. The flex sensor has been placed onto the glove by using glue, and the bending can be achieved successfully.

For the soldering things, only basic equipment is needed such as the soldering holder, wet sponge, coil, coil cutter, and the solder itself. For the protection part, wear a glove while the components are soldered. The soldering equipment is shown in Figure 13.

As the result, the students are able to lift an item weight less then 1kg as Figure 14 shows below. This robot arm which may have the capability to move like a human hand like hold, grasp, and put an object or material without damaging the object also has some disadvantages. Despite having such advantages using this technology, it also has a limitation where the robotic hand action is controlled by a human through sensor gloves since the intelligence of the robotic hand is limited. If the hand that used the glove moves up, the robotic also moves upwards. The same goes when the user moves their hand down, left, or right. A complex movement may be done as the robotic arm performs the different movements. As an example, when the user moves a certain part of their fingers, the robotic arm moves as it has been programmed. The strength of the robotic claw may lift from 0.01 kilogram to 1.5 kilograms, approximately. It may also provide faster reflex followed by the user and it also can do a handshake.

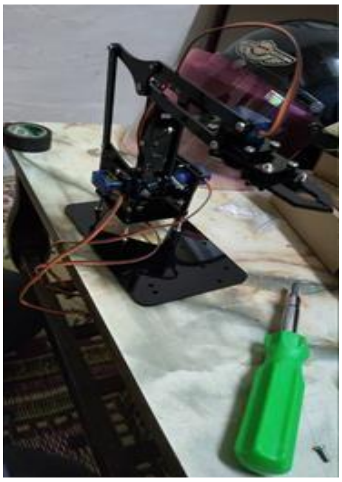

Figure 11. Top parts of the project

Figure 12. Transmitter parts

Figure 13. Soldering parts

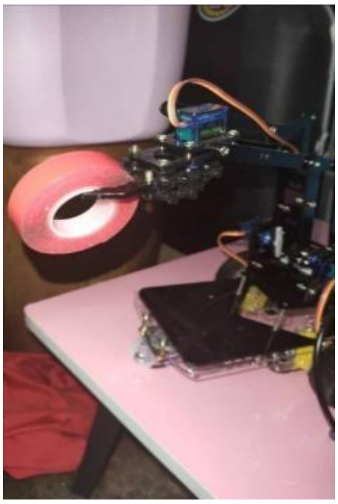

Figure 14. Lifted item

4. CONCLUSION

In conclusion, the paper presents a Wireless Hand Motion Robotic Arm Using Flex Sensor with five degrees of freedom (5DOF). The robotic arms were made from resources and materials that were readily available to ensure low cost and minimization for the cost of production. The functionality as well as usability of the robotic arm was tested after the model of robotic arms was constructed. The robotic arm can be controlled by using NRF24L021 connectivity and a camera for visual feedback. Further improvement can be made in the future to the prototype base on specific requirements.

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