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Robot Arm Teleoperative System Design with Flex Sensor

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Abstract

With the technology currently available, the hands of the most advanced humanoid robots used in prosthetics or robotics can be very expensive, making them inaccessible to disabled and robotics enthusiasts. Using 3D printing technology, these robotic hands can be mass produced and have the basic functions of a sophisticated and inexpensive expensive hand. The hand robot is controlled using sensor gloves that can read the finger movements and the compressive power of the user's fingers. The flex sensor is a sensor that has a function to detect curvature. The reason I use the flex sensor is because of a need to get motion values for the curvature of the fingers. This research consists of selecting a 3D printed hand model, assembling the mechanical and electronic components of the robot arm, making software, testing the robot arm and integrating it with sensors and implementing tele-operations. The robot hand is able to hold 358 grams of load, with an efficiency of only 5.98% compared to the torque output of the actuator. The maximum error for sensor reading is 5.61% and integration is 11.73%.

Keyword: Flex Sensor, Robot Hand, Teleoperative

1. Introduction

In the industrial world, many have taken advantage of technological advances with robotic systems as the main media in the production process. This is because the robotic system has less risk than humans. The main applications for humanoid robot hands are in the fields of robotics and prostheses. With the technology available today. Mimicking the function and behavior of complex biological systems using rigid mechanical components can be a challenging task, and human hands are no exception. Consists of 29 bones, 34 muscles, and 123 ligaments[1].The most advanced robotic hands can cost a fortune, making them unattainable for both disabled people and robot hobbyists. In addition, many of the features provided by this expensive technology were developed for research purposes in an attempt to replicate the human hand, but are redundant for most users who only want to perform a fraction of normal human functions without paying a fortune. This creates a financial burden for many users, especially children with disabilities whose prosthetics have to adjust to growing hands. We can design a robotic hand that follows the movement of the human hand and performs tasks for that we need to install a number of sensors on the fingers and palms, this sensor will detect finger movements and the signal output will be sent to the robotic hand via the robotic hand via wireless communication and receive the signal.

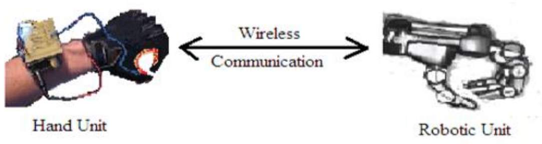

Figure 1. Wireless hand robot

There are several robotic technologies that are widely used in this modern era such as finger robots. The finger robot is one type of robot that is widely used in several industries. The finger robot mimics the characteristics of a real human hand. All joints can move in accordance with the motion of the rotation. Although these movements are not completely the same as the movements of the human hand. This is because the joints in the robot only have a limited degree of movement and freedom (Adriansyah, 2014)[2].

In this study, the developer will build a robot finger prototype that has the same capabilities as human fingers. The finger of this robot has 5 motors that can move each of the robot's fingers. As well as 5 flex sensors that will provide input values to the program. Thus the movement of the robot's fingers will produce a movement that is the same as the command for moving the fingers of a human hand. At the input value the developer uses a flex sensor. The flex sensor is a sensor that has a function to detect a curvature in principle. The system works the same as the pot, which provides a value when there is movement of the sensor. Developers chose the flex sensor because of a need to obtain motion values for the curvature of the fingers. The flex sensor itself has a thin, curved texture. Therefore the flex sensor can be embedded in the human finger and is able to follow the curvature of the finger.

From the results of research that has been done, several existing studies have many complexities in their design. The research above uses a large number of components. Here the author wants to be able to design a control system that is quite simple and easy to understand with several components such as a microcontroller using an Arduino Nano, a servo motor (5 pieces), a flex sensor (5 pieces).

2. Methods

Tool components to be used are as follows:

1. Arduino Nano

Arduino Nano is a microcontroller development board that is small, complete and supports breadboard use. Arduino Nano was created on the basis of the ATmega328 microcontroller (for Arduino Nano version 3.x) or ATmega 168 (for Arduino version 2.x). The Arduino Nano has more or less the same functionality as the Arduino Duemilanove, but in a different package. The Arduino Nano does not include a Barrel Jack type DC plug, and is connected to a computer using a USB Mini-B port [3].

2. Flex Sensor

A flexible sensor is also known as a curve sensor. It's also capable of feeling every kind of minute bend in its structure. This sensor is designed with a thin plastic strip with small carbon particles coated on one surface. This carbon layer is divided into smaller parts and connected together by a conductive layer. [4]

3. Servo Motor

Servo is an electric motor that has a closed feedback control system, where the position of the motor will be informed back to the control circuit in the servo and will move the output shaft to the desired position (Jameco Electronics) [5].

4. Teleoperation

Based on the control process, the robot is divided into two, namely an automatic robot (Automatic Robot) and a Teleoperative Robot (Teleoperated Robot). Automatic robots can move by themselves based on commands that have been written in the control program. This type of robot can find out the environmental conditions around it because it is equipped with sensors. Sensors for automatic robots function as input components that can provide data about their environment to the processor which functions as an automatic robot brain. Meanwhile, a Teleoperated Robot is a robot that moves based on commands sent manually, either wirelessly / wirelessly (remote control) or with a cable (joystick)[6].

In this study, the developer will build a robot finger prototype that has the same capabilities as human fingers. The finger of this robot has 5 motors that can move each of the robot's fingers. As well as 5 flex sensors that will provide input values to the program. Thus the movement of the robot's fingers will produce a movement that is the same as the command for moving the fingers of a human hand. At the input value the developer uses a flex sensor. The flex sensor is a sensor that has a function to detect a curvature in principle. The system works the same as the pot, which provides a value when there is movement of the sensor. Developers chose the flex sensor because of a need to obtain motion values for the curvature of the fingers. The flex sensor itself has a thin, curved texture. Therefore the flex sensor can be embedded in the human finger and is able to follow the curvature of the finger.

3. Design And Implementation

3.1 System Overview

An overview of the system can be seen in the following block diagram:

Figure 2. Overview of the system

Figure 2 is a block diagram of the system created, where the value of the angular resistance will be detected by the flex sensor and will be processed by Arduino Uno. This processing is obtained from the resistance value that was previously converted to digital data. The data will be divided into 4 conditions, namely the conditions when it is at 0, 30, 60, and 90 degrees on the servo. The servo will move according to the previously processed value. The processed value will output the robot arm. This change in the movement of the robotic arm will produce movements like that of the human arm. Movement is limited by several kinds of movement combinations.

3.2 System Electronics Circuits

By modifying the output, by adding a wireless module as a data transmission channel. The Bluetooth module transmits data via serial connection protocol (RX, TX). The circuit schematics of Bluetooth are shown in Figure 3.

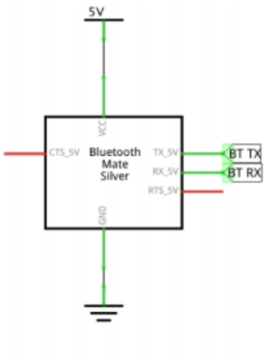

Figure 3. Bluetooth Module Circuit Schematics

The wireless module can use the pins available on the Arduino. To use the SPP-C Bluetooth module, the robot hand using the Arduino Mega 2650 microcontroller is connected to the Bluetooth module via pins D18 (Tx), D19 (Rx) with a 5V voltage source. With this information, a series of robotic hands is added as in Figure 4.

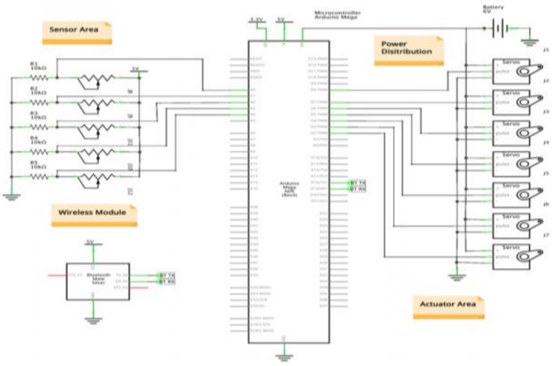

Figure 4. Schematic of robot arm electronics circuit with Bluetooth module

As for the sensor gloves, the Arduino Micro microcontroller is connected to the Bluetooth module via pins D1 (Tx) and D0 (Rx) with the same voltage source, namely 5V. With this information the circuit becomes as follows:

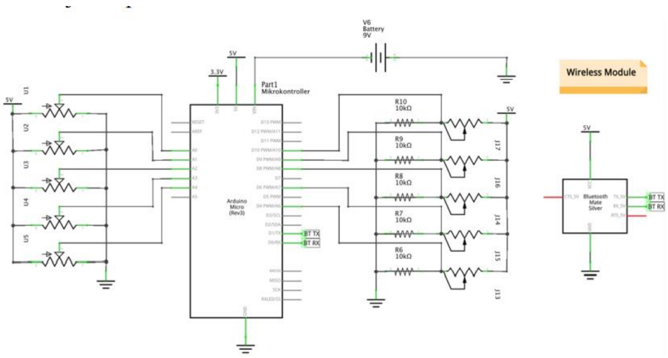

Figure 5. Schematic of sensor glove electronics with Bluetooth module.

4. Testing And Analysis

4.1 Testing robotic hands

Grip Force is the force exerted by the finger on the object being grasped, so that the force of gravity does not fall, it is necessary to know the minimum force. Mia's article [7] modeled a hand raising a glass filled with soft drinks assuming the arm acceleration is zero, the acceleration will add weight to the glass if the arm moves quickly [8].]At first, the robot hand is in the position of the fingers slightly open, and the object is placed between the palms, the hand is already in a parallel position with the object so that it is enough to activate the actuator, the object is immediately grasped perfectly. The test is shown in Figure 6. The independent variables of the test are the object's weight and angle. Then look for the relationship between the angle and the force obtained on the graph and the performance of the robot's hand to grasp an object with a certain mass. First is the angle test, the servo will be given an angle signal, namely 90, 120, and 180 and then the force experienced on each finger is measured. Then the test continued with an increased load, with the initial 200 grams then adding it until the object fell from the hand.

Figure 6. Robot Hand grasping objects

The following is a graph of the resulting measurement results, is a table for measuring the force at each fingertip with angle variations.

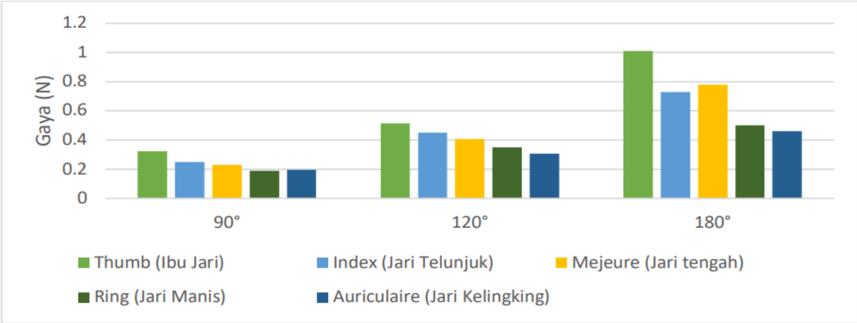

Figure 7. The results of the force measurement on the addition of the angle of the robot arm actuator.

Then proceed with the test of holding objects, the load is a plastic bottle filled with water, then the overall weight is measured by digital scales. The test produces the values in the table as follows, then adaptive testing is carried out, namely the load will be added successively from 200 grams then followed by testing the additional load every ± 1 gram per second, until the hand is unable to withstand the load (overpayload) and the object falls. During the addition of the load, the robot's hand will be measured the force it experiences. Then the measurement results are plotted on the graph. The resulting graph is as follows.

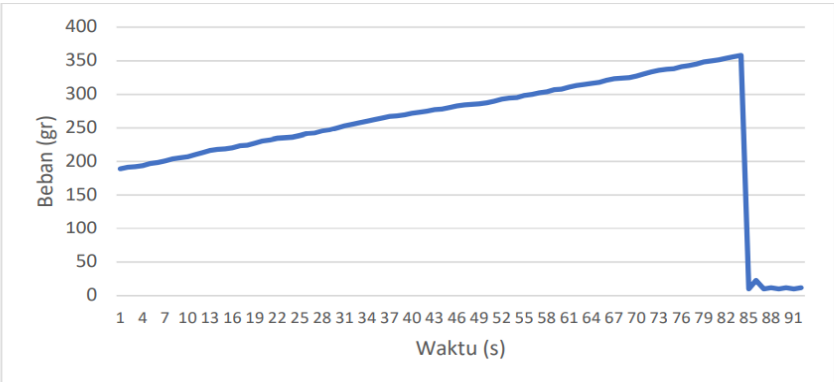

Figure 8. Payload test on the robot's hand

4.2 Testing and Analysis with the Teleoperative method

In this test, the same as what was done in the previous experiment, the wireless module was used in data transmission and tested in a separate room 3 meters away. The examiner looks at a laptop connected to a camera to monitor the movement of the robot's hand when grasping objects. The test is shown in Figure 9. Because it is facing, it is necessary to mirror it so that the orientation seen is the same as us if it is on the side like the previous test.

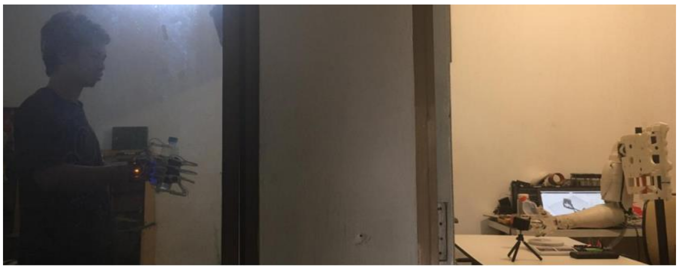

Figure 9. Testing integration with teleoperation.

4.3 Testing Integration with Teleoperations

Teleoperative testing using a Bluetooth module as discussed in the previous chapter, using direct connection or also known as peer-to-peer pairing. The test was carried out 2 times, the first was the direct Bluetooth test (without obstructions) with a distance of 5 meters, then the test with a wall barrier with a relatively equal distance was carried out in a separate room. This test aims to determine the performance of the Bluetooth module and overall wireless communication capabilities. From the first test, the following results were obtained

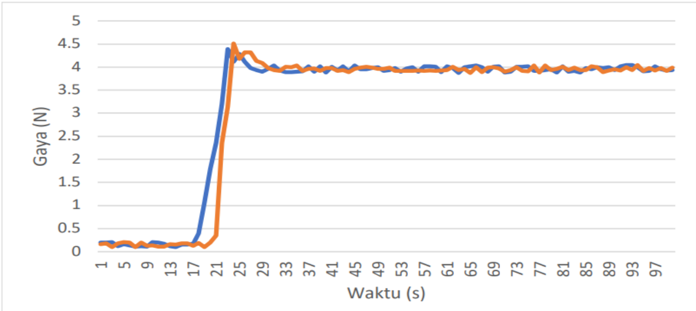

Figure 10. Results of teleoperative testing without obstructions

Whereas in the teleoperative test with a separate room, it produces a graph like the following:

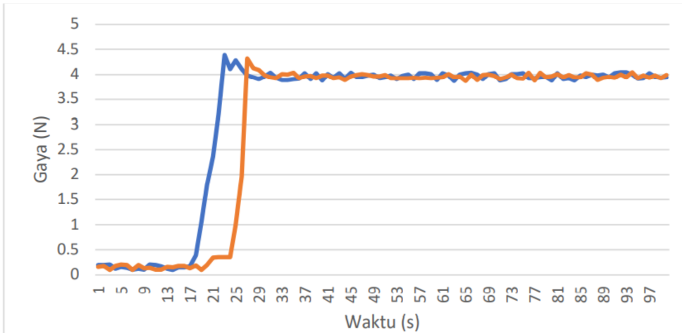

Figure 11. Teleoperative test results in different rooms

This test aims to test the ability of the robot's hand and sensors to perform tele-operations or indirect operations. With a wireless module this is possible. Testing is done using a wireless module, namely Bluetooth, objects with a load of 200 grams can be lifted and the sensor experiences a force transition from 0.1 N to 4.8 N in a fairly short time, namely ± 2 seconds. Like the previous test, there was an overshoot of 11.98% and 10.2% in the robot's hand. Compared to wired mode, the delay is greater, which is ± 3 seconds. In different room tests, there was a delay which increased by ± 1 second due to a barrier in the form of a wall.

5. Conclusion

From the results of this test, the following conclusions are obtained:

- The robot hand is capable of holding 358 grams of load, with an efficiency of only 5.98% compared to the torque output of the actuator. The maximum error for sensor reading is 5.61% and integration is 11.73%. The system delay is <1 second for wired connection, 1-2 seconds for Bluetooth mode, and 2-3 seconds for Bluetooth mode with obstructions.

- The robot hand can be used as a manipulator that requires grasping power like humans who use 5 fingers. With this capability, it can be developed for operations and manipulation in various applications such as prosthetics for people with disabilities, handling of hazardous substances, disaster management, space or underwater survey robots as well as assisting human daily needs such as humanoid robots.

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