p-ISSN 2715-2871
e-ISSN 2714-5247

Design And Develop Robotic Arm For People With Disable Hands Using EMG And Gyroscope Sensor Control

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Abstract*— Robotics technology is currently developing rapidly, including in the medical field. In this world there are many people with hand disabilities or patients who have amputations on their wrists, so they experience difficulties in carrying out their daily activities using their hands, such as to grasp objects. Then the thought arose to conduct research, with the aim of creating a Robotic Arm that could recognize 2 movements, namely the opening and clenching of the fingers like a hand in general. The Electromyogram sensor is used as a Robotic Arm control system, while the Gyroscope with Arduino as the control center. Based on the overall test results, the Robotic Arm can be moved with muscle contractions and user gestures to open and clench finger movements.

Keywords*— Robotic Arm, Amputation, Electromyogram, Gyroscope (key words)

I. Introduction

The Industrial Revolution 4.0 has brought significant technological advancements, particularly in electronics, which have streamlined many tasks, making them faster, more effective, and efficient. Automation systems, for instance, have greatly benefited from these advancements. Robots, with their numerous advantages, have become invaluable in various fields, including the medical sector. One critical application is in assisting with complex medical procedures and patient rehabilitation.

Amputation is a medical procedure involving the removal of part or all of a limb or extremity. This drastic step is typically considered a last resort when other treatment methods have failed, or when the affected limb poses a significant threat to the patient's life, such as through severe infection or complications. The goal of amputation is to improve the patient's quality of life and prevent further health issues.

In the realm of medical robotics, electromyogram (EMG) sensors have been instrumental in developing prosthetic limbs. These sensors detect electrical activity produced by muscles, allowing for the control of robotic limbs. However, one challenge with EMG sensors is that they require continuous muscle contractions to maintain a grip on objects, which can be strenuous and inefficient for the user.

To address this issue, researchers are exploring the integration of additional technologies to enhance the functionality of robotic arms. One promising approach is combining EMG sensors with gyroscope signals. This combination allows for more intuitive and efficient control of the prosthetic limb through natural hand gestures, reducing the need for constant muscle contraction and providing a more seamless user experience.

In summary, the advancements in robotics and sensor technology hold great promise for improving the quality of life for individuals requiring prosthetic limbs. By leveraging EMG sensors and gyroscopes, researchers aim to develop robotic arms that respond more naturally to the user's intentions, ultimately making these devices more practical and comfortable for everyday use.

II. Methods

Quantitative analysis methods are used to complete this robotic arm, namely by analyzing how the tool works and analyzing the results of observations when testing is carried out on the tool. This Robotic Arm design uses the Arduino Uno microcontroller as the control center and a gyroscope which is used to detect the movement of the earth's gravitational acceleration. In addition, this tool also has several sensors, namely the Electromyogram (EMG) sensor which is used to detect electrical signals in muscle movements.

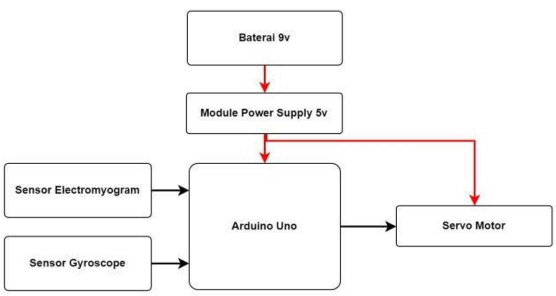

Figure 1. Block Diagram

In Figure 1, the block diagram of the robotic arm control system circuit. The explanation of the system block diagram above is as follows:

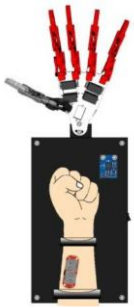

Figure 2. Robotic Arm Design

From figure 2. The designed Robotic Arm consists of several parts, namely the Electromyogram sensor, Gyroscope sensor (ADXL335), Arduino Uno microcontroller, and Servo motor. The Electromyogram sensor is used to read the user's muscle contraction data, while the Gyroscope sensor is used to read the user's arm gesture data, both sensors are processed via the analog pin on the Arduino Uno microcontroller. The Arduino then receives data from the sensor, converts it into ADC (Analog to Digital Converter) values which are then displayed on the serial monitor and stored in the Arduino database in the Arduino IDE application

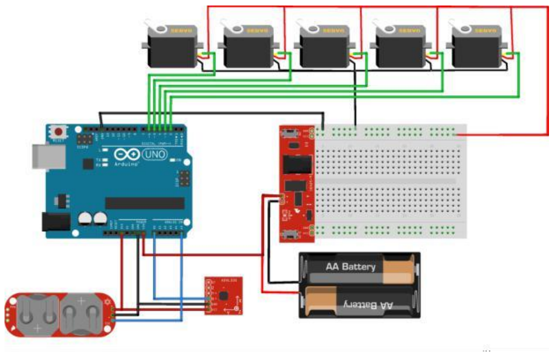

Figure 3. Wiring Diagram

III. Results and Discussion

After completing the design phase and material selection for the robotic arm, the next step involves translating the conceptual design into a tangible prototype. This stage focuses on constructing the robotic arm based on the previously developed designs, ensuring that all components fit together seamlessly and function as intended. This includes assembling the mechanical parts, integrating the EMG sensors and gyroscope, and programming the control system. The objective is to create a fully functional prototype that can be tested and refined, ultimately leading to a robotic arm that effectively mimics natural hand movements and provides reliable assistance to users.

Figure 4. Tool Design Product

In Figure 4, the design product show the shape of the Robotic Arm which consists of several parts, namely Servo motor, Electromyogram sensor, and Gyroscope sensor.

Table 1. EMG sensor test data

Testing Number	Voltage	EMG Value (0-1023)
1	0.92	207
2	0,97	211
3	1.04	212
4	1.07	215
5	1,12	220

In Table 1, there is a display of data obtained from the results of testing electromyogram sensors placed at the same point on 5 volunteers. The average test when the arm muscles contract is an EMG value of 213.2. From the results of this data, it can be concluded that the greater the force of contraction in a person, the greater the voltage and sensor value produced.

Table 2. Gyroscope sensor test data

No	Degree Angle	Voltage	Sensor Value (0-420)
1	0°	1.51 V	282
2	30°	1.44 V	301
3	60°	1.34 V	316

4	90°	1.28 V	350
5	120°	1.34 V	378
6	150°	1.42 V	401
7	180°	1.58 V	419

See Table 2, from the data produced in the experiment above, it can be concluded that the greater the angle of inclination of the sensor, the greater the ADC value produced, and the greater the inclination of the sensor both to the right and to the left with a point parallel to 90°, then the voltage released the greater it is.

Table 3. Robotic Arm grip strength test data

No	Heavy Load	Robotic Arm Finger Status
1	50 g	Holding/grip
2	100 g	Holding;/grip
3	180 g	Holding/grip
4	280 g	Holding/grip
5	320 g	Not holding/ open
6	400 g	Not holding/ open

From the test data results in table 3, the robotic arm's fingers are unable to grip when the weight is above 280 g. it can be concluded that the grip strength of the robotic arm is a maximum of 280 g.

IV. Discussion

After carrying out several tests, the author obtained data including: the system can read EMG when there is a muscle contraction, and the system can also read the earth's gravitational acceleration in the form of a voltage signal which is converted into an analog to digital converter value.

The Robotic Arm Prototype works based on a servo motor. If the electromyogram sensor reads muscle contraction with a set value, the servo motor will move and the robotic arm's fingers will change position to grip. If the electromyogram sensor cannot read contractions or errors, to activate the servo motor you can use the gyroscope sensor by rotating it 90° to the right from the vertical position to move the robotic arm's fingers into a grasping position. To move the robotic arm's fingers into an open position, this is done by turning the hand 30° to the left.

V. Conclusion

The conclusions drawn from this research highlight two key achievements: the author successfully created a robotic arm capable of grasping objects and effectively assembled and built a device controlled using Electromyogram (EMG) and Gyroscope sensors. These advancements demonstrate the potential of integrating multiple sensor technologies to enhance the functionality of prosthetic devices.

Based on these conclusions, the researcher offers suggestions for future improvements that could serve as references for other researchers. One recommendation is to use a battery with a larger capacity to allow for extended and uninterrupted use of the robotic arm. This enhancement would make the device more practical for daily use and increase its reliability for users.

Additionally, the researcher suggests further development by adding movement commands for each finger. This refinement would significantly enhance the robotic arm's dexterity and precision, enabling more complex and natural hand movements. Such improvements could lead to more advanced and user-friendly prosthetic devices, ultimately benefiting individuals who rely on these technologies for improved quality of life

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