Hand Gesture controlled Robotic Arm using Fuzzy logic

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***Abstract*—Nowadays, robots are a rapidly developing field. A robot is a mechanical device that can perform physical tasks, using human supervision and control. Several robots have been built to do dangerous work that is impossible done by humans directly. One type of them that is very popular is the robot arm. In this paper, it is proposed controlling robot arms based on finger and hand movements. This research is aimed at describing simple robot arms that must be controlled by human fingers and human hand movements. We have designed a robot arm with a Fuzzy logic method consisting of flexible sensors on the fingers, and human hand movements to control the robot arm's movement system. The movement of the robot arm is controlled by using a flexible sensor, the Arduino microcontroller, which is connected to several servo motors. The control angle of the robot arm, controlled using human hand movements and gyroscopes. All input and output processes on sensors, hand movements, and microcontrollers used are processed by fuzzy logic. From the experimental result, it was found that Fuzzy Logic was successfully implemented on the robot arm to control objects using Flex sensor, and hand gestures.**

Keywords - Arduino, Fuzzy Logic, Flexible Sensor, Hand Gesture, Robotics

I. Introduction

In the world of risky professions, mishaps like fractures or other bodily injuries are unfortunately all too common. But fear not! Thanks to cutting-edge technological breakthroughs, we now have artificial body parts that can lend a hand—literally. Enter the realm of prosthetics, where the star of the show is none other than the illustrious robot arm.

Imagine a mechanical marvel that mimics the dexterity of human hands, capable of tasks ranging from welding to intricate insertions. These robotic wonders are not just handy; they're indispensable to the manufacturing industry, venturing into perilous zones and reaching heights humans wouldn't dare.

Now, picture this: our quest is to craft a robotic arm that's more than just a metal limb—it's a powerhouse of productivity. How do we achieve this feat, you ask? With the magic of Arduino microcontrollers and the finesse of flex sensors, of course! Flex sensors, those nifty gadgets that measure physical movements, play a pivotal role in our grand design.

But wait, there's more! Join us on a journey through the nuances of human finger and hand movements as we delve into the intricate dance between man and machine. Welcome to a world where robotics meets creativity, and where every gesture brings us one step closer to our robotic masterpiece.

II. Literature Review

Sihombing et.al in 2020 discussed about How to control robotic arm with hand gestures using fuzzy logic [1]. The next discussion by Abidhusain et.al. described how to control the robot arm using sensors and microcontrollers [2]. In [3]. Rashmi A. et.al. have also outlined how to control the robot arm using Arduino microcontroller and sensors. Mounika Bhusa, et.al. describe the control of a robot arm using sensors on human fingers in [4]. Chandrasekhar P. Shinde describes the design of a myoelectric arm. Ranjan Singh, et. al [5] have developed a controller using gloves to help people with physical disabilities. In [6], L. Shrimanth Sudheer.et.al. developed the robotic arm using a microcontroller and sensors used for fluid control systems. Conway et. al. [7] used the gesture speed recognition to perceive assertiveness and anger between coworkers.Cook et. al. [8] demonstrated gesture based learning for children in multiple domains , including mathematics and science.

III. The Methodology

There are many ways and methods to control robot arms that have different shapes and sizes depending on the type of work required. This section describes the robotic arm controlling based on fingers and hand gestures. We use the fuzzy logic method to process the input values of several flex sensors, Arduino microcontroller, and hand gestures. The output of the fuzzy logic process is used to decide the robotic arm movement. We use also the gyroscope model to determine the slope of the movement of fingers and human hands followed by the movement of a robotic arm. The brief description as follows:

A. Robot Arm Model

Robot arms are a type of mechanical arm, usually programmable, with functions similar to human arms. The arm may be the total number of mechanisms or may be part of a more complex robot.

The main construction consists of the component of an Arduino nano microcontroller, sensors, servo motor and power

supply. The assembling model of Robot arm is shown in Fig.1. Parts of this robot are composed of shoulders, upper arm, lower arm, wrist, and gripper.

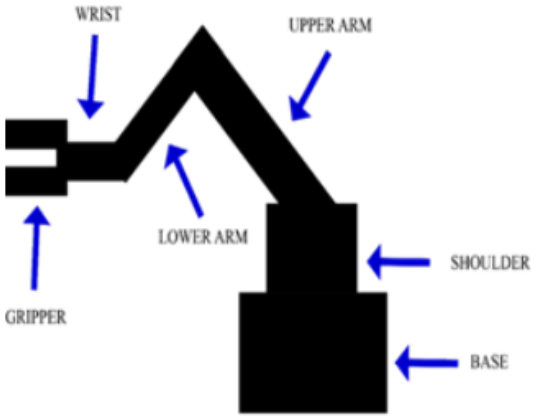

Fig. 1. Robot Arm model

This robot arm will be controlled using fingers and hand movements which are connected with Gyroscope and flex sensor. The architectural description of the main construction is shown in Fig.2.

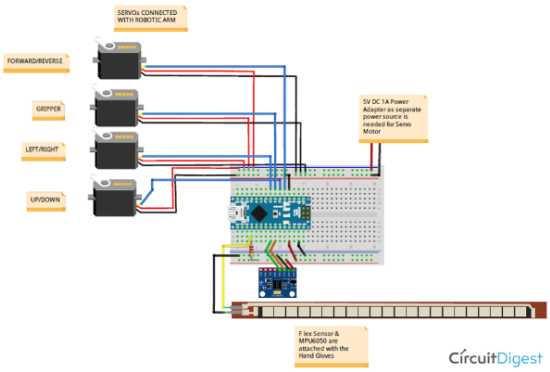

Fig. 2. The Architecture Design

A brief description of the main construction architecture is as follows:

1) The flex sensor on the human hand detects the curvature of the user's finger.
2) The MPU-6050 sensor in the human hand detects the tilt of the robot hand controller.
3) Flex sensor detects gripper
4) Data from the flex sensor and MPU-6050 sensor will enter to the Arduino Nano and be processed with fuzzy logic.
5) Results of data received from Flex sensor and MPU-6050 are processed by Arduino Nano on the robot.
6) MPU-6050 and Flex sensor sends a signal based on Arduino Nano data to drive the servo motor on the robot. endenumerate

The main construction of robot arm is shown in Fig.3.

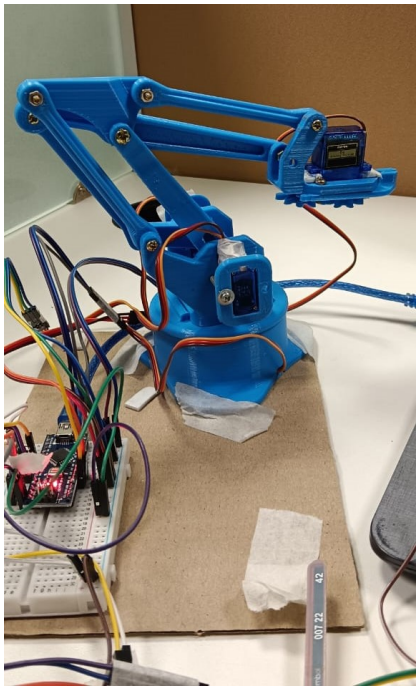

Fig. 3. Main Contraction of Robot Arm.

B. MPU-6050 Sensor

The MPU 6050 is a sensor based on MEMS (microelectro- mechanical systems) technology. The gyroscope is embedded inside a single chip. This chip uses I2C (inter-integrated circuit) protocol for communication.

The MPU-6050 sensor is placed in the glove position area to control the angle of the direction of robot movements. The MPU-6050 sensor functions as a sensor to control the robot's shoulder and upper arm, as shown in Fig. 4.

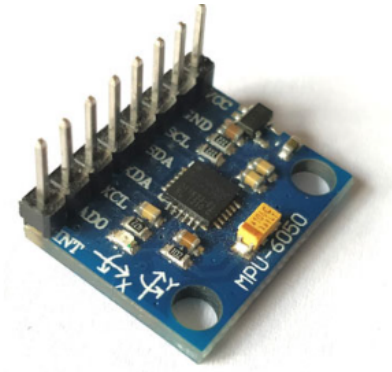

Fig. 4. MPU- 6050 Sensor

C. Sensor and Servo Motor

The robot uses a flexible sensor and as many as 4 servo motors to drive the robot. The servo motor used consisted of 4 SG90 servo motors.

The flex sensor is placed on an index finger of the glove. The Flex sensor's function is to control the gripper. as shown in Fig.5

Fig. 5. Flex sensor

D. The Implementation of Fuzzy Logic

The implementation of fuzzy logic in this research lies in the robot hand controller and the robot arm.

1) The Implementation of Fuzzy Logic in the Robot Hand Controller: The implementation of Fuzzy logic in the robot hand controller (glove) can be explained in the following description. We used the fuzzy logic in the processing of the Flex sensor and MPU-6050 on fingers and hand gestures to control the robot arm. As an input, the value of Fuzzy logic is obtained from the MPU-6050 sensor which is based on the degree of slope of the x-axis and the y-axis. The boundary values are reach1_gyroX, reach2_gyroX, reach1_gyroY, and reach2_gyroY. The robot arm will move according to the value of the slope of the user's hand movements. The controlling process of the MPU-6050 sensor value by Fuzzy logic is described as follows:

The MPU-6050 sensor is used as a controller of the robot arm, which is processed by Fuzzy logic with the following conditions:

a) If the angle value is x -5 (range1_gyroX), its mean sends a command to move the shoulder to the right.
b) If the angle value is x 25 (range2_gyroX), its mean sends a command to move the shoulder to the left.
c) If the angle value x¿ -5 and ¡25, there will be no related command to move the shoulder (fixed position).
d) If the angle value is ≥25 (range1_gyroY), its mean sends a command to move the upper arm up.
e) If the angle value is y ≤-40 (reach2_gyroY), its mean sends a command to move the upper arm down.
f) If the angle value of y >-40 and y <25, it means no related command to move the upper arm (fixed position).

2) Fuzzy Logic in the Flex Sensor of Index Finger: Flex sensors get a value based on the curve of the index finger. The value limit is made so that the robot arm moves according to the curve of the finger. The flex sensor on the index finger, with the following conditions:

a) If the value of $flex1$ <160 (range1_flex1), its mean sends a command to move the lower arm up.
b) If the value of $flex1$ >160 and <200 (range2_flex1), its mean sends a command to move the lower arm down
c) If the value is $flex1$ >200, it means no related command to move the lower arm (fixed position).

Flex sensors get a value based on the curve of the index finger. The value limit is made so that the robot arm moves according to the curve of the finger. The flex sensor on the index finger, with the following conditions:

a) If the flex sensor data is greater than 750 the servo motor angle of the gripper is 0 degree
b) If the flex sensor data is less than 750 the servo motor angle of the gripper is 180 degree

All of the commands based on sensor values processed by fuzzy logic will be sent to the robot arm via sensors. Fuzzy logic provides an effective estimate of averages that describe the behavior of several complex systems. Fuzzy logic can be the modeling of human reasoning and decision making, which is important for us to make rational decisions. The fuzzy logic control method was used to minimize the position error rate and shorten the response time required for the robotic arm.

E. TESTING AND RESULT

1) Movement down and up: The following are the results of servo motor testing. Fig.6. shows the servo movement in the lower arm. This movement starts from the value given to the flex $sensor$ <160 so that the lower arm of the robot will move down to its lowest position.

To move the robot, arm up, starting from the value of the flex sensor given is¿ 160 and ¡200, its mean the arm will move up to its maximum position as shown in Fig.7

2) Movement rigt and left: The robot arm will move to the right if the angle given x axis is ≤-5 value by the MPU6050 sensor. The robot arm will move on to the left if the angle given x-axis is ≥25 value by the MPU6050 sensor. The robot arm can move on to the left until the maximum position as shown in Fig.8

3) Close and open gripper: The gripper can to close, if index finger up where flex sensor is present. The gripper is open if the index finger down where flex sensor is present. Fig. 9 shows when the gripper is open

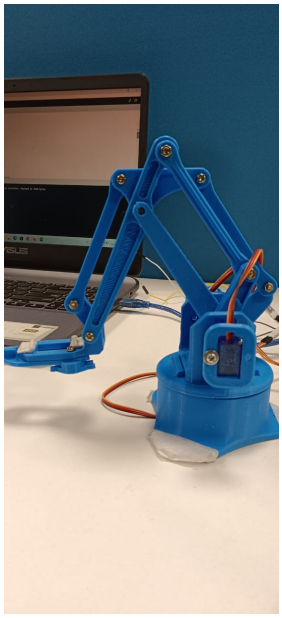

Fig. 6. Robot Arm moves down

Fig. 7. Robot Arm moves up

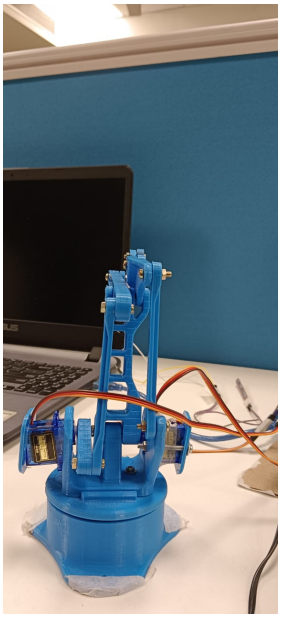

Fig. 8. Robot Arm moves right and left

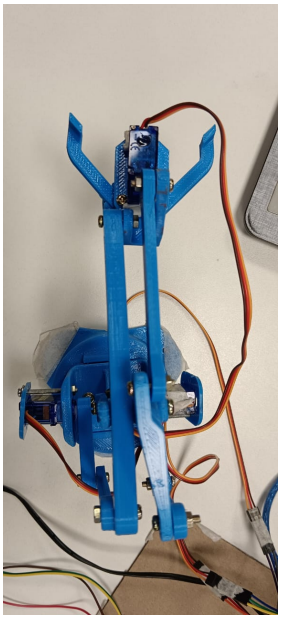

Fig. 9. The gripper is open

IV. CONCLUSION

This research shows the robotic arm controlling based on fingers, hand gestures, and the fuzzy logic methodology as a reference has successfully. The robot arms can be controlled by using sensors, Arduino, and hand gestures. We used a flex sensor placed on the finger glove and hand gesture as the input to control the robot arm. We also used the MPU-6050 sensor is placed in the glove position area to control the angle of the direction of robot movements. The MPU-6050 sensor functions as a sensor to control the robot's shoulder and upper arm. The MPU-6050 sensor obtains the x angle and the angle of the hand movement. We used fuzzy logic as a reference to process the input of the Flex sensor, MPU-6050 sensor and hand gesture of the glove to control the robot. The robotic arm was made of low-cost materials that were readily available. The model of the robotic arm was constructed and the functionality was tested.

We have described the combined hardware and software

scheme of the robot arm controller with several servomotors and microcontrollers. The robotic arm is expected can be used by the community to replace certain jobs that are considered dangerous if done directly by human hands. Our project can work successfully at the demonstration. This program can be modified flexibly to match the drive controls needed from a servo motor. Controlling the robot arm is done wirelessly, so it can be used more efficiently.

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