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The Development of Elementary Robot Arm Using Educational Simulation Tool

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Abstract: Robotic system has become one of the vital techniques in various fields, from technical to non-technical. A robotic system can help to speed up the process of operation with minimal workforce involvement. As such, it is beneficial in reducing operational and maintenance costs that include labour and are time-consuming. The work is developed with the vision to the ensemble with the chemical dangerous substances industries capable of reducing the exposure of the manpower to the chemical danger. The initiative is to prevent accidents that can be harmful or poisonous when in contact with any human parts. The simulation was done using an education-based simulation tool, Arduino Uno, and the analysis shows that the performance of the robot arm achieved the minimum educational requirement.

Keywords: Robot arm, Arduino, flex sensor, MPU6050, degree of freedom, robotic

1.0 INTRODUCTION

Advanced robotics technology is one of the leading growing technologies in worldwide industries. It is ready to evolve into much more efficient industrial operations. Compared with a standard robot, advanced robots are built with greater perception, mobility, adaptability, and integrality. There are various types of robotic parts that have been invented to ease and speed up a process. One of the most common robots that are being used today is the robot arms.

Industrial robots have six main types that can be found in industries nowadays. They are polar, cartesian, cylindrical, delta, SCARA, and vertically articulated.

Table 1 Types of industrial robots

Types	Description
Articulated	Also called as a joint mechanical arm or joint robotic arm [1].Requires a larger relative space and an absolute workspace than other robot under the same condition of the similar size [2].
Cartesian	The Cartesian is based on a simplified control application system that can be demonstrated by the strong position and the load control that was not limited to only a single axis or a zero commanded loads [3].
Cylindrical	Have a minimum of one rotary joint at the bottom of the robot to perform a rotational movement.
Polar	Combined both linear joint and two rotary joints with an arm attached to a robotic base and a twisting joint.
SCARA	Stands for Selective Compliance Articulated Robot Arm. Consists of two arms that is joined at the base and the intersection of arms one and two [6]. The SCARA robot's arm was inflexible in the Z-axis and pliable in the X and Y-axes, which allowed it to adapt to holes in the XY-axes [7].
Delta	A kind of parallel robot consisting of three arms linked to the universal joints at the base of the robot itself. The use of parallelograms in the arms to maintain the orientation of the end effector, by contrast

	to Stewarts platform that can change the orientation of its end-effector [8].

2.0 OBJECTIVES

The work is developed to meet the minimum requirement of chemical substance industries which would require strict safety protocol. The safety precaution is one of the industry playmakers' main concerns. Thus, the elementary robot arm has a potential to alleviate the company loads. Note that the robot arm is developed in small scale. Though, it is believed that is has great potential to contribute to the industries and society.

The objectives of the paper are specified into 3 parts.

i. To develop a 4 degree of freedom (DOF) robotic arm.
ii. To develop a low voltage operated robot arm.
iii. To construct a small-scale robot arm.

4 DOF robotic arm is common in robotic design with 3 basic cartesian axes, X, Y and Z. The position control takes this axes into account plus its individual angle. This robot arm focused on the forward and reversed, up and down and left and right movement. In general, DOF can be expressed from Equation (1) .

$$DOF = m(N - 1 - J) + \sum_{i=1}^{J} f_i \qquad (1)$$

Where N is the number of bodies including ground, J is the number of joints, m the rigid body and f_i is the joint constraints.

3.0 METHODOLOGY

The elementary robot arm is developed using 2 types of sensors. It is programmed using Arduino Uno as the base of the robot arm. The method of the process is depicted in flowchart as shown in Figure 1. The components applied in this paper is tabulated in Table 2.

Figure 1 shows the flowchart of the robot arm development. The motion of the robot arm is controlled by MPU5050 and the flex sensor. The system will function when it is turned on. There are 4 servo motors applied in the system where 3 servo motors are controlled by MPU6050 and 1 which is named servo 4 is controlled by the flex sensor. The list and functions of the components are detailed up in Table 2.

Table 2 Components and functions

Component	Functions
MPU6050	To control the movements of back and forth, up and down, left and right.
Flex sensor	Connected to the servo motor that acts as the gripper of the robotic arm
Servo motors	To control the movements of the handling parts of the robot arm
Arduino UNO	To interpret the coding and sends a signal to the servo motors
LM2956	To step down the voltage that enters the motor to avoid overload

4.0 FINDINGS AND OBSERVATIONS

4.1 Development of 4 DOF robot arm

Figure 2 shows the prototype of robot arm. The development processes are shown in Figure 2(a), (b), (c) and (d).

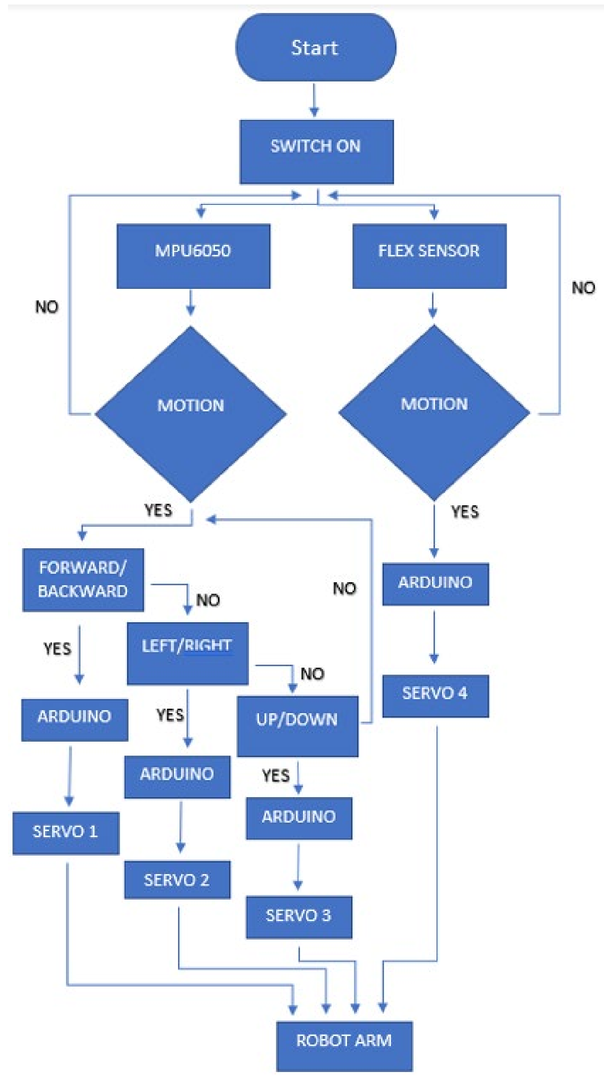

Figure 1 Flowchart of robot arm development

The prototype in Figure 2(a) shows the position of the components on the robot arm. The white cup below the robot

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arm is used to elevate the robot arm to prevent the collision with the ground, which might have cause damage to the robot arm itself.

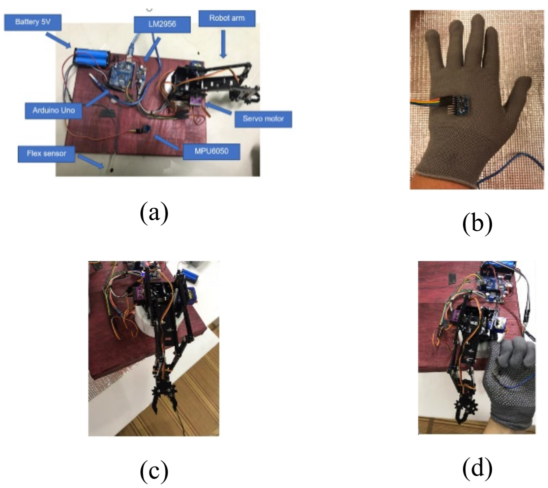

Figure 2 Robot arm prototype development

Table 3 X Axis forward/reverse (F/R) and up/down (U/D) results

	Angle				Range	Position
Servo 1	0	60	0	90	0<X<=60	F/R
Servo 2	360	250	0	190	300<X<360	U/D

Table 4 Y Axis Left/Right (L/R) results

	Angle				Position
Servo 4	0	60	90	180	L
Servo 2	360	300	90	0	R

Figure 2(b) shows where the MPU6050 is attached to the glove. The movement of the robot arm depends on which angle the MPU6050 is tilt. If the device is tilted on -90 degree the robot arm will turn to the left and if the device is tilted 90 degrees, the robot arm will turn right. Moving hand upward will cause the robot arm to move forward and by moving hand downwards, the robot arm will move backwards and slightly down.

Figure 2(c) shows when the robot arm is being turned on and is on a default state. Figure 2(d) shows the placement of the flex sensor. From the observation, when is flex sensor is being bent, the gripper begins to clamp shut and when the sensor is at default state, the gripper will be opened. More tests were also made for left and right tilted position and picking up object.

Observation also shows that the gripper is closed when the flex sensor is being bent. The MPU6050 sensor is tilted to the right and the robot arm will also move with the same direction to the sensor.

Table 3 and Table 4 show the position of the servo motors. 3 servos were assigned for the position control, servo 1, servo 2 and servo 4. Servo 3 was designated to the flex sensor as shown in Figure 1.

4.2 Development of low voltage operated robot arm

The robot arm is developed using Arduino simulation software. It is an educational level based simulation tool. It operates with low voltage supplies, 5V. It is functioned as programmed and show significant results where the command for both sensors, MPU6050 and flex sensor worked well.

Table 5 showed the output voltage measurement from the servo motor. 4 servo motors were positioned in the circuit construction. As mentioned earlier, the supply voltage is 5V and results showed significant results where the servo motors operated within 5V range.

Table 5 Servo motor voltage measurement

Movement	Measured voltage (V)
Servo motor 1	3.8
Servo motor 2	3.9
Servo motor 3	4.1
Servo motor 4	4.0

4.3 The construction of small-scale robot arm

The robot arm is developed in small scale approach suitable with the educational basis level with limited access of technical tools. This suggested that it is feasible for low level teaching and learning purposes. It can be improved for a more complex development for commercial or industrial drives.

5.0 DISCUSSIONS

The results show the efficiency of the MPU6050 and other the components in the robot arm. Arduino Uno is the main processor of the robot arm and the sensors, the MPU6050, and flex sensor controlled the motor efficiently to verify the robot arm functioned as it was programmed.

The robot arm moved as instructed in the program where it is able follow the instructions to move in lateral and vertical motion on the subjected plane. It is also successfully picked and placed an object on the designated position.

As such, the systems worked properly based on the expected outcome. This is based on how each component which is the MPU6050 sensor, Arduino Uno, flex sensor, LM2596, and motors work as it functions although there are some several improvement and upgrade that needs to be done to make it function even better.

6.0 CONCLUSION

As the conclusion, the prototype that was developed in this work achieved the objectives. Based on the results, the robot arm successfully follow the command that was programmed to pick and place the object from point A to point B. The movement achieved the 4 DOF movement objective and the system is programmed and test using low power, 5V voltage supply and the presented outcome is the small scale robot arm system.

The robot arm is developed using minimal technical tools appropriate with the targeted educational level. However, the application has larger potential beyond education level. For example it can benefit the chemical substance industries in many ways.

Furthermore, to acquire a better performance for the future enhancement for this work, some modification and upgrading needs to be added to the robot arm. Two recommendations are suggested to upgrade this work. First, by adding more features to the robot arm such as adding a wireless connection that can control the arm from a moderate distance. With this feature, user will not have to handle the messiness of the wire and is easier to control without any interruptions. Using a Bluetooth or RF is some of the option to make it go wireless. Second, to add a camera to the above of the gripper on the robot arm. With the camera attached to the robot arm, it will make it easier to control the arm because the user will be able to watch what is in front of the robot arm. Using the robot arm from long or far distance will not be a problem since the user can watch it on the monitor.

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