Design and Build of a Microcontroller Robot Arm with Smartphone Control Based on the Internet of Things

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ABSTRACT

This research discusses the design and implementation of a robot arm that is controlled via smartphone using the Internet of Things (IoT) concept. This robotic arm is controlled using a microcontroller connected to the internet. The aim of this research is to develop a system that allows users to easily control the movement of the robot arm via a specially designed smartphone application. At the design stage, the microcontroller is programmed to control the motors that drive the robotic arm joints. Communication between the smartphone and the robot arm is implemented via a network communication protocol, so the user can give commands via an intuitive application interface. The use of IoT technology allows this robot arm to be controlled remotely via the internet, opening opportunities for use in various contexts, such as use in production, education or even entertainment environments. Test results show that the robotic arm can automatically carry out repetitive tasks with a high level of accuracy. This advantage can increase productivity in the production process and reduce the potential for human error. In addition, robots can operate in environments that are potentially dangerous to humans, such as toxic, radioactive or extreme temperature conditions.

Kata Kunci: Lengan robot, Smartphone, Internet of Things (IoT), Mikrokontroller,
(hot or cold) areas. This capability effectively reduces the risk of human exposure to these potential hazards.

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1. INTRODUCTION

The very rapid development of technology in the current era of globalization has provided many benefits and advantages in progress in various social and industrial aspects. The use of technology by humans to help complete work is something that is mandatory in life. This technological development must also be followed by developments in Human Resources (HR). Humans as technology users must be able to take advantage of existing technology, as well as subsequent technological developments that will come. Human adaptation to new technology that has developed must be done through education. This is done so that future generations are not left behind in terms of new technology. That way, technology and education are able to develop together along with the new generation as the successor to the old generation. Some of these adaptation methods can be realized in the form of training or education.

With advances in technology, opportunities that arise in the field of education also play an important role in the development of science. Apart from the old methodology, the education system has now started using the latest Robotics technology. Japan and South Korea are among the countries that are aggressively trying to replace teachers with robots. Robot Arm is a Manipulator technology that is used to assist human work in carrying out work related to goods, this technology is able to replace limited human labor in order to reduce the risk of accidents when working in carrying out lifting and also moving goods [1]. In other research results, it is stated that the arm robot is a robot that has 4 freedoms that uses a servo motor as a driver. The first servo motor functions to move the gripper, the second servo moves the elbow arm, the third servo motor to move the shoulder and the fourth servo motor functions to rotate the base [2]. Other studies also say that they have created a robotic arm control system that can control a robotic arm by simply moving their hands and pressing buttons [3].

The robot arm system is a series arrangement of several parts that are similar to parts of a human arm. Many designs have been put forward at this time. The number of parts of this robot is usually 3 to 7 DoF (Degree of Freedom) or more than that in the future if needed for certain applications. The robot arm control system can be in the form of continuous calculated data or constant programmed values. Dynamic systems usually use a computer algorithm to perform kinematic calculations [4].
This is a combination of work between humans and robots. Several cases of the combination of Humans and Robots are solutions for special problems that cannot be done using robots alone [5]. In other design results, the robot mechanical system is designed in the articulated joint type and is a goods moving robot, which consists of an arm and a simple clamp (gripper) and has five degrees of freedom. This robot is designed to use a DC motor as a driving force with a transmission system in the form of linear gears (spur-gear) and worm gears (worm-gear).

2. METHOD

The system that will be examined at this time is an Internet of Things-based microcontroller robotic arm design. This robot arm requires a robot kit or robot frame made of acrylic material as a prototype in designing the robot arm circuit, and requires a smartphone that will be connected to the websocket as the controller of the robotic arm. The process of controlling this robotic arm will be carried out using the Internet of things, where the websocket is the media in its control. The websocket will send data to the microcontroller, then the microcontroller will give commands to the servo motor which will move the robot arm.

Software design begins with creating a flowchart to make it easier to plan and create programs on the microcontroller. Creating a flowchart aims to make it easier to understand the working process of the tool. The program flowchart of this study includes the control system for the running of the tool, which can be seen in the picture.

![Flowchart Image]

Figure 1. Flowchart
2.1 Hardware Design

Design of hardware in the design of an internet of things based microcontroller robot arm using an ESP32 microcontroller as a data processor and several other components such as servo motors, jumper cables, which are placed in a series of robotic arm kits made of acrylic material and designed in such a way such as the Gripper robot tools so that they can move according to the specified point or axis.

2.2 Software Design

Software design (software) using the Arduino IDE. The first program is a program to create a web that will be used on smartphones as controllers of robotic arms using the Arduino IDE application with HTML language. The next program is the Arduino IDE programming which is used to adjust the microcontroller output.

2.3 Circuit Block Diagram

The design of the block diagram circuit is the design of electronic components in such a way that they have the desired function. In general, the tool design planning is as follows:

![Figure 2. Circuit Block Diagram](image)

The block diagram in Figure 3.2 shows that the first process is connecting a smartphone to the internet via a wifi network to connect to a websocket, then the robotic arm will be controlled using a smartphone which was previously given a program code via the Arduino IDE application. Furthermore, the processed data will be sent to the microcontroller via jumper cables so that it can move the servo motor as a device that will move the robotic arm. Servo motor is a motor with a closed feedback system where the position of the motor will be informed back to the control circuit in the servo motor [7].

2.4 Running System Analysis

This section discusses the working principles built to implement the tool system, namely the discussion is focused on the design of the tool which is carried out with reference to the sources associated with the tool. In general, the tool design planning is as follows:
2.5 Electronic Circuit Scheme

Electronic circuit schematic using ESP32 as a microcontroller that receives input data from a smartphone via websocket. The ESP32 design functions as a robot arm driver. Serial communication between the computer and the ESP32 is connected via USB. The ESP32 output will be connected to 4 servo motors on the robot arm. The following is an illustration of the electronic circuit schematic of the microcontroller robot arm:

![Electronics Circuit Schematics](image)

Figure 4. Electronic Circuit Schematics

The pins used to connect the ESP32 to the robot arm include 0,1,2,3. The servo motor connected to the pin can rotate 180°. Pin 0 is connected to the joint base which changes the position of the entire robot. Pin 2 connects to the shoulder joint. Pin 1 is connected to the elbow joint. Pin 3 connects to the wrist joint.

2.6 System to be Tested

The following is a websocket design that will be tested as a microcontroller robot arm controller and can be seen in Figure 5.
3. RESULTS AND DISCUSSION

To activate the mg90s Servo Motor using the Arduino IDE with the following steps:

1. Open the Arduino IDE software with an unfilled program like this:

   ![Initial appearance of the Arduino IDE software](image)

   Figure 6. Initial appearance of the Arduino IDE software

2. Then enter the program code below:

   ![Display of the Servo Motor Program Code](image)

   Figure 7. Display of the Servo Motor Program Code
3. Then select Sketch on the Arduino IDE Menu Bar and click Verify/Compile to test the success of the program as shown in the image below:

![Figure 8. Program appearance after successful compilation](image)

4. After the program code is successful, then assemble the hardware as in Figure 9:

![Figure 9. Servo Motor Connected to the Microcontroller](image)

5. After the program code and design have been completed, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE then clicking upload with a note that the Boart and port settings on the Arduino IDE Bar menu are complete.

6. Next, wait a few moments until the upload process is complete, then the program that has been uploaded will be automatically saved on the microcontroller.

3.1 **Web Socket Experiment.**

The next thing to be done is web socket testing. Open the Arduino IDE software with an unfilled program like this:
Figure 10. Initial Display of the Arduino IDE Software

Enter the program code below:

Figure 11. WebSocket Program Code Display

Then select Sketch on the Arduino IDE Menu Bar and click Verify/Compile to test the success of the program as shown below:

Figure 12. Program appearance after successful compilation

After the program code has finished compiling, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE then clicking upload with a note that the Boart and port settings on the Arduino IDE Bar menu are complete. Then wait a few moments until the upload process is complete, the program that has been uploaded will be automatically stored in the microcontroller.

3.2 Overall Test Implementation and Design Using Four Servo Motors and Connected to a Web Socket

Implementation of this test is carried out to determine the performance of the components that will be used in this thesis with the output in the form of a servo motor that will control the
robot arm according to the desired command via a smartphone connected to the internet and then connected to a websocket as a microcontroller robot arm controller. This test is carried out by trying to move an item from one point to another using a robotic arm as a means of moving it which will be controlled via a smartphone via a websocket. After all the circuits that have been designed in "Design and Build a Microcontroller Robotic Arm with Internet of Things-Based Smartphone Control", then all the circuits that have been completed are combined to form a robotic arm in such a way.

4. CONCLUSION

Robotic arms can be used to automate tasks that are repetitive and require high accuracy. This can improve production efficiency and reduce human errors. Robots can be used in dangerous environments such as toxic, radioactive environments, or places that are too hot or cold for humans. This can reduce the risk of human exposure to these hazards.

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