PID Control for a Manipulator Robot Using Internet Networking and Matlab-based

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Abstract. This paper presents the design to the implementation of the proportional, integral and derivative (PID) remote control system of robot manipulator using Matlab-based Internet network. These studies seek the solution of distance operations, time constraints, and monitoring the operation response of robot manipulator motion as robot that possible to carry dangerous objects which is should be monitored remotely during the operation. PID control system that is controlled remotely by the client and server systems. The monitoring process of robot manipulator is Matlab-based. Testing is done by doing observation to the speed response of the DC motor as the robot’s axis driver on open loop system condition, and then doing observation using PID control system. The test of axis robot driver has also been carried out with a variety of no-load and load conditions. The test results showed the motor driver of robot will work optimally when using PID control system. The data acquisition and the stability of data communication between the client and server are affected by the condition of the existing data transfer on the network and also the distance from the server to the plant.

1. Introduction

Robot manipulator as load-carrier (payload) has several advantages over conveyor, robot manipulator can carry the load with location that move, thin material, lighter, more efficient in power consumption, only requires small actuator, easier to operate, and cheaper in the manufacturing process [1]

The phenomenon of proportional control system, integral and derivative (PID) which is often to used in industrial and community is the control system between the operator and the plant is at the same location, this system has the advantage to monitoring the response of all robot motion. It certainly has not meet the market willingness that wants a remote control system which is not limited to space and time and still be able to monitoring the response of all robot motion. This study tries to bridge the gap between the features expected in today’s society with the condition of the control system which is still relatively a conventional PID that must be monitored by operator at the plant. This study will build prototype between clients and servers using the internet network to operate a matlab-based PID remote control system. This study is expected to monitor the performance of matlab-based robot from client computer located far away from the server computer located on the robot.

The use of robot manipulators is more profitable than the conveyor system in the process of material moving that changing the target location. This is because the robot manipulator requires only thin material, lighter, more efficient in power consumption, small actuator, easier to operate, and less
expensive in the manufacturing process [1]. This type of robot manipulators used in many applications such as luggage transportation process, micro surgery, maintenance of nuclear equipment and is particularly suitable for space [2]. The most challenging problem is the process control system on the arm-robot, specifically on remote control system considering the robot manipulator is often used in danger area.

Robot manipulator is chosen in practical application, because this robot provides many flexibility. So the process of controlling and maintaining the position accuracy of the arm becomes very challenging. It is very important to track the natural flexibility of materials that are thin with mathematical model [3]. In performing mathematical calculations on motion characteristics of robot manipulator’s arm, Wang and Mills [4] have used finite element methods to elaborate the dynamic models and vibration controls on one-link robot manipulator. In mathematical calculation the flexibility of one-link manipulator robot has also been done using particle swarm optimization method [5]. While the elaboration of the flexibility and the characteristics of the two-link arm robot have been performed using the method of presupposition mode [6]. While Tian et al. [7] has also performed a mathematical calculation using the absolute point coordinate method to determine the flexibility of the arm on the robot manipulator. As anticipation of excess flexibility, it developed a control process on robot manipulator using the robust control system [8].

In controlling the arm of robot manipulator, it requires a control system and sensors that will make it able to communicate with the surrounding environment. The position sensor is used in order to provide accurate movement of the arm-robot to a certain degree of freedom.

The control system used is the control system of Proportional Integral Derivative (PID) is a type of closed loop control system. This control system is a combination of three control systems which are proportional, integral and derivative control system. Signals included in this system are set point values (the desired output values). The proportional control system is essentially an amplifier with certain gain constants. By using this control system only, the response of the controlled system is less satisfactory because of the offset, ie the distance (difference) between the output value that occurs with the desired output value. Therefore, we used the combination of three control systems above that called Proportional Integral Derivative (PID) control system. The combination of this control system has the characteristics of its constituent control system, so the output response of the system will be fast, no offset, and not oscillate [9].

PID control system is a controller to determine the precision of an instrumentation system with the characteristics of feedback on the system. PID control system consists of three ways of setting by controlling P (Proportional), D (Derivative) and I (Integral), with each has advantages and disadvantages. In the implementation, each control system can work alone or combination of them. In the design of PID control system what needs to be done is set the parameters P, I or D in order to get the response of output signal to certain input as desired.

The control system between client and server in this study will use wireless network or Wi-Fi. It is expected that the client computer can operate matlab software on the server computer, in addition the client computer also has available matlab software. The use of internet connection through the TeamViewer software will be discussed in this study. By using the remote control, the client can access the server computer remotely using the internet network, this can be used to control the server, or do any task from local PC at home.
2. Methodology

This study uses the Research and Development study approach. In the implementation, there are three stages to do, they are (1) the product development of robot manipulator with matlab-based PID control system (2) development of PID control system with wireless remote TCP/IP network. (3) The third stage is the system testing and the results comparison between local computer control system with remote control systems (client-server). In the product development stage, the process is to develop the hardware and software of robot manipulator with any variety of supporting components.

The study of PID remote control system is an interesting issues, because the development of matlab-based PID control system with implementation to robot manipulator today is only based on local PC and not controlled remotely yet. While the remote control system was generally using a remote device which any user can’t observe the robot movement by real time because of the distance. This study will develop PID remote control system using matlab as input-output access software and wireless with TCP/IP. This study is important to the community, especially in the field of control to begin the utilization of remote control system based on the real time monitoring.

The design of the speed control system hardware consists of the microcontroller AVR ATMega16 and minimum system as the system controller, H-bridge as actuator, DC motors as axis robot actuator, and encoder (optocoupler) as feedback. The minimum system is a module, so the microcontroller can functioned well.

In designing the minimum system module, we must recognize the specifications at every pin of microcontroller. The microcontroller’s specifications can be seen on its datasheet. In designing the speed control system, the minimum system arranged to support other modules such as the H-Bridge and DC motor, serial communication, and In-System Programming (ISP) using the USB port on PC.

![Figure 1. Schematic of Remote Control System](image)

3. Result and Discussion

Determining the value of the PID parameters with Ziegler-Nichols tuning method. The parameters are presented in Table 1.

| Table 1. Parameters P, PI and PID |
|----------------------------------|
| controller | $K_c$ | $\tau_i$ | $K_i$ | $\tau_d$ | $K_d$ |
| PID         | 1.11  | 0.16     | 7.50  | 0.033    | 0.040  |
Open Loop. In testing of the open-loop system, the maximum pwm value was given to plant in order to determine the response speed of the dc motor as the axis robot driver. In the open-loop system, dc motor speed feedback is not used to locate the error of the output value to the value of feedback. In this test, maximum voltage was given to the plant in order to determine the output value of system, so we can observe the response from the generated graph. System testing with controllers and without controller can be seen in Figure 2 below.

![Figure 2](image2.png)

**Figure 2.** The motor response with controller and without controller

PID controller, In PID controller test is combination of P, I and D constant. With kp value= 1.27, ki value= 6.50 and kd value = 0.020. Testing is done by changing the load from no load, the load 1 to load 3. In the first test can be seen that the condition of the plant is not stable until 600. So many ripple occurs from the first data to 500. The response can be seen in Figure 3, 4, and 5.

In Figure 3, the condition of motor when the arm-robot without any load can functioned well as targeted. After the data 200 the load was given to robot so we can see the response change from the arm-robot that showed by encoder sensor. However, the change only makes the response go down in a few moments then return to the steady state conditions.

![Figure 3](image3.png)

**Figure 3.** The motor response with PID controller no load to the first load changes.
System testing. The testing of DC motor control is done wirelessly using 2 units of laptops to test the reliability of data communication when making deliveries between the microcontroller, server and client. The testing distance without any obstruction is 7 meters and 15 meters. The data obtained can be seen in Table 2 and 3 below.

### Table 2. Amount of data 7 meters

| Amount of data | Trial 1 | Trial 2 |
|----------------|--------|--------|
| 10 Mbps        |        |        |
| 5 bar signals  |        |        |
| Open Loop      | 600    | 600    |
|                | 600    | 600    |
| PID            | 600    | 600    |
|                | 600    | 600    |

### Table 3. Amount of data 15 meters

| Amount of data | Trial 1 | Trial 1 |
|----------------|--------|--------|
| 10 Mbps        |        |        |
| 5 bar signals  |        |        |
| Open Loop      | 600    | 600    |
|                | 600    | 600    |
| PID            | 600    | 600    |
|                | 600    | 550    |

### 4. Conclusion

PID controller is more appropriate to be applied to DC motor of axis robot driver manipulator plant. The stability of data communication between the client and server are affected by the condition of the existing data transfer on the network and also the distance from the server to the plant. The overflow of data transmission occurs when data sent from the server is delayed due to delivery delays in network. Delayed data in transmissions will be sent simultaneously in a single data delivery package.

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