

Teleoperation Representative Robot Telkom University

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Abstract:Robotics technology has penetrated various sectors, including entertainment, education, healthcare, and the food and beverages (F&B) industry. In the face of tasks that require precision and to minimize human error, the development of robots with unique capabilities is becoming increasingly important in modern society. One example of applying this robotics technology occurs in the food service profession, where customer service accuracy is critical. As a solution, the concept of Representative Robot (REBOT) servers that can be controlled remotely is an exciting research focus. REBOT is designed for production cost efficiency and order service time. The interactive capabilities of REBOT, both audio and visual, are an added advantage in meeting customer service needs. The test results show that the manual control system successfully moves the REBOT remotely according to the directions. The delay measurement of the manual control system offers an average of 68.875 MS based on delay data taken from 20 samples. This shows the ability of REBOT to provide an efficient and accurate solution in order service with the potential for further development.

Keywords: *Teleoperation, Robotic, Control, Technology.*

1. Introduction

Based on research conducted by the McKinsey Global Institute, it is estimated that nearly 50% of human tasks in various jobs can be replaced by technology, especially by robots.[1]. A robot is a set of mechanical devices that can perform physical tasks, either with human supervision and control or using a predefined program.[2]. Thus, it is necessary to develop robots that can replace roles previously carried out by humans.

Systems that allow users to control robots have been developed to facilitate the completion of complex tasks in remote environments. Mobile robots can be considered as a particular example of these systems, which can be operated remotely to carry out specific tasks. [3]. One role that can be used as an example is the ability of robots to represent human tasks, especially in the context of the food and beverage (F&B) industry, where customer service is a key element.

In the context of robots, the ability to be remotely controlled is of significant value as it allows practical access and operation without the need for intensive physical customization. The ability to remotely control robots is also considered a crucial asset, as it allows for more flexible human intervention in such activities.[4]. With remote control, robots can be used more freely, especially in the context of human representation.

Remote control robot can be an alternative as something that can represent humans. So far, human representation has been widely used in the form of social media, which only allows humans to interact visually without any physical interaction. Ideally, the knowledge representation of a robot combines various forms of knowledge with reasoning capabilities so that it can design an optimal action plan to carry out its task. [5]. With this manual control system, the reasoning of the user, namely the human, can be combined with the robot so that it can produce an optimal representation, especially in terms of interaction.

Interaction between humans and robots can be interpreted as the need to create a communication channel between the two. The form of communication between humans and robots can vary, depending on whether or

not humans and robots are close to each other.[6], [7]. The use of manual control in robots can fulfill human interaction regardless of distance.

The robot created this time is an evolution of the previous robot known as DOPER. The main functionality of DOPER is to replace the role of doctors in monitoring and treating COVID-19 patients during the pandemic.[8]. This robot has human-like capabilities like DOPER but with a wider range of control, designed to act as a human representative in interactions between parties in various locations and at any time.

2. Theory Review

A. Teleoperation

Teleoperation, where a user manually controls a robot, reflects a model that is well-known and in demand in the robotics domain. Teleoperation itself is a system or process where a user, usually a human, remotely controls a device or system. In the context of robotics, teleoperation involves manual control of a robot, where the user can direct the robot's movements and actions, from a different location. [9]. In this research, the robot is equipped with a teleoperation system to be able controlled remotely and used as a representation of a human to carry out an activity.

This teleoperation system is run using a remote desktop connection which helps with remote control using mobile devices such as laptops, mobile phones, etc. Remote desktop allows users to access their computers remotely via the Internet, which is widely used in remote work, remote assistance, and remote administration. This software is designed to help users give real-time commands and interactive remote screen status for remote use.[10] The remote desktop used in the system is the NoMachine remote desktop.

NoMachine is a remote desktop solution that allows users to remotely access and control devices to work or manage their computers. NoMachine uses an NX server connection, which is a server that allows users to connect to a local network. To make it possible to connect anywhere, the NoMachine is connected to a VPN tunnel, ZeroTier.

B. Component

As the main system, the robot uses Jetson Nano devkit 4 GB as the main microcomputer that will be connected to the remote desktop. Jetson Nano devkit B01 is a microcomputer issued by Nvidia to process a computation that includes visual data.[11] In addition to the jetson nano devkit b01, an Arduino mega pro mini microcontroller is also used.

Arduino Mega Pro mini is a compact version of Arduino Mega 2560. The use of this mini-pro version of Arduino aims to make the system circuit more concise in terms of size. In the robot, the Arduino is tasked with being the driving link in the form of a DC motor with a microcomputer to be controlled remotely.

3. Methods

A. System Circuits

In the teleoperation robot, jetson nano devkit b01 is used which is connected to Arduino mega pro mini for the control of the robot. Jetson Nano connected to NoMachine will send commands via serial monitor to Arduino Mega pro mini to execute manual control commands.



Fig 3. 1 System circuit

As shown in Fig 3.1, in this setup, the Jetson Nano serves as the brains of the teleoperation system, leveraging its processing power and connectivity capabilities to send commands to the Arduino Mega Pro Mini. The Nano communicates with the Arduino over a serial connection, likely using UART or a similar protocol. By running NoMachine, the operator gains remote access to the Jetson Nano's interface, allowing for seamless control of the robot from a distance. This architecture enables efficient manual control of the robot's movements and functions.

B. Block Diagram

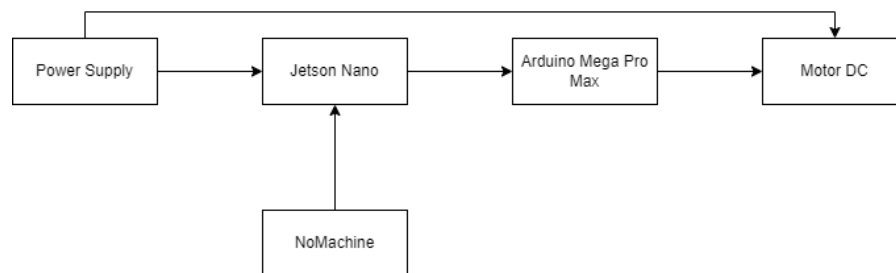


Fig 3. 2 System Block Diagram

Fig 3.2 is a system overview of the manual control of the robot. In this system, manual control is executed by receiving commands from Jetson Nano which is controlled by NoMachine. The command is then forwarded to the Arduino Mega Pro mini through the serial port.

C. Flowchart

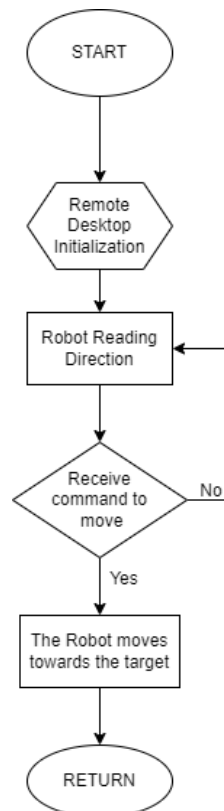


Fig 3. 3 Control flowchart

In Fig 3.3, the control system starts by initializing or starting the preparation of the remote device to connect remotely with Jetson Nano. After connecting, the robot will read what commands are on the serial port given by Jetson Nano, if a command is detected, the robot will run according to the destination.

OS has a role as a link between the microcomputer and the microcontroller as a device that drives REBOT. The implementation of this manual control system must be done by paying attention to the accuracy through the delay that occurs between the communication of mobile devices, microcomputers, and microcontrollers.

This system test was carried out in the INACOS Lab using the Telkom University TUNE network on the mobile device and the GSM network provider By. U on REBOT. This delay test was carried out at a distance of 200 m from the INACOS lab to the hallway of the P Telkom University building.

Table 4. 1 Delay Classification

Delay Category	Large Delay (ms)
Very good	<50
Good	50-100
Bad	>100

Based on the tests carried out, the delay is obtained as follows:

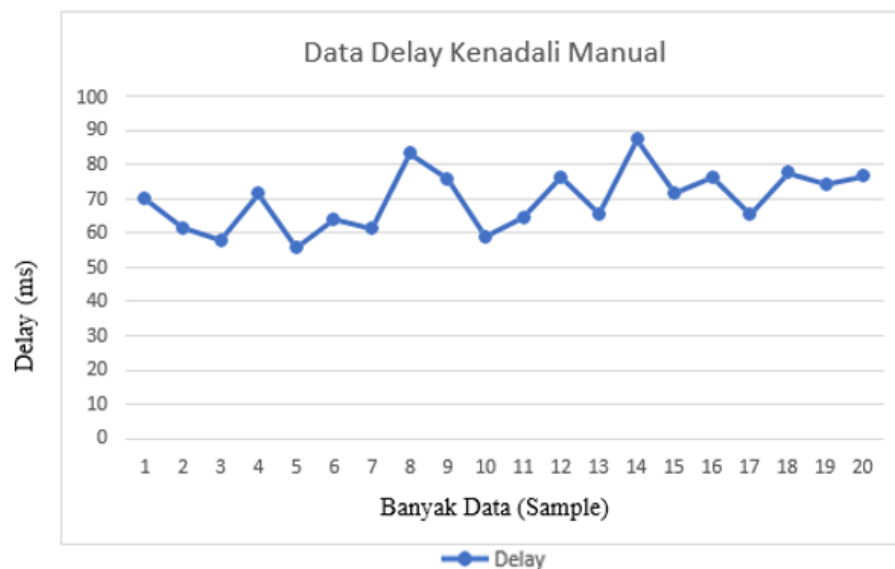


Fig 4. 3 Control Delay Data

Based on graph 4.3, where X is a lot of data and Y is a lot of samples obtained, the average delay of the system is 69.875 ms. The average value obtained is included in the good category.

- Control Command Testing

Testing is done with 3 different commands alternately and in 2 different places, namely indoor and outdoor. The first command is a forward movement as far as 1 meter from the Starting Point, the second command is a movement to rotate left by 90 °, and the third command is a movement to rotate right by 90 ° from the Starting Point. To get the accuracy value, you can use the accuracy formula as follows.

$$\text{Accuracy} = \frac{x-e}{x} \cdot 100\% \quad (4.1)$$

Description: x = distance/degree of rotation (°)

e = difference in rotational degree

Based on equation 4.1, accuracy is obtained from x which is the distance/degree of rotation minus e which is the error or difference between the distance/degree of rotation and the realization, and then multiplied by 100. From this equation, the output can be produced in the form of accuracy in percent.

- Indoor Testing

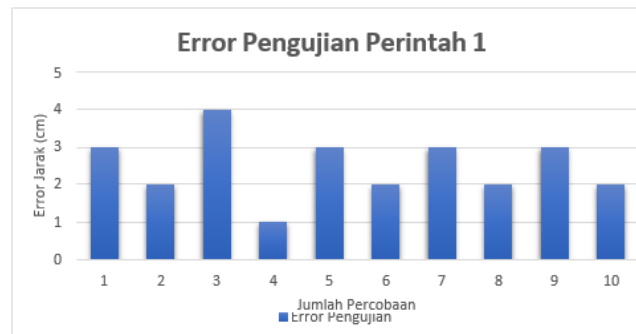


Fig 4.4 Command Error Graph 1

Average Error distance (cm) 2.5

Accuracy (%) 97.5

Fig 4.4 is a graph of the results of testing the first command using a delay of 3 seconds. Testing is done by running REBOT to a predetermined point manually with a distance setting of one meter. In the test results, the average error on the first command was 2.5 cm out of 100 cm and an accuracy of 97.5%.

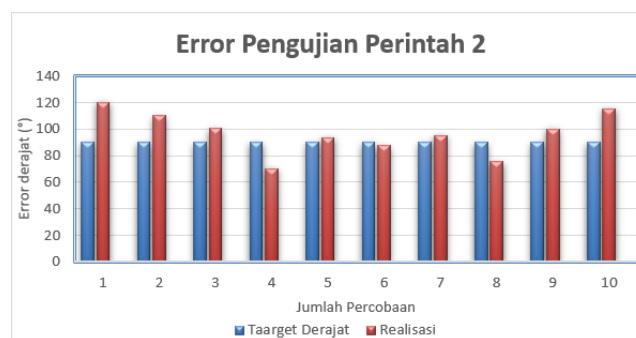


Fig 4. 5 Command Testing Error Graph 2

Average Error (°) 14.2

Accuracy (%) 85.8

The second test is done by positioning the robot in its motion space, then the robot will be ordered to rotate according to the degree. In this test, a serial monitor is used to see the angle of rotation. This serial monitor displays an angle that will change to 0 ° after the robot has finished moving. Based on Fig 4.5, this test produces data as in the graph, where the target degree of rotation and its realization are sampled. Based on this data, an error of 14.2° was obtained with an accuracy of 85.8%.

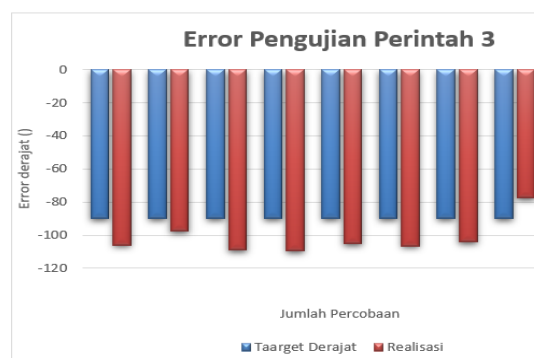


Fig 4. 6 Command Error Graph 3

Average Error (°) 12

Accuracy (%) 87

In the third test in Fig 4.6, the same thing is done as before, which is to position the robot in its motion space and order to rotate according to the degree. This test produces data as in the graph, where the rotating degree target and realization are sampled. Based on this data, an error of 12° with an accuracy of 87%.

- Outdoor Testing

Testing was carried out on outdoor applications precisely in front of the hallway of Gd. P Telko University with a paving block surface texture. In this test, the same thing is done with indoor testing to know the accuracy of robot movements on uneven surfaces. The results of this test will show whether the robot is optimal for use in outdoor locations or not.

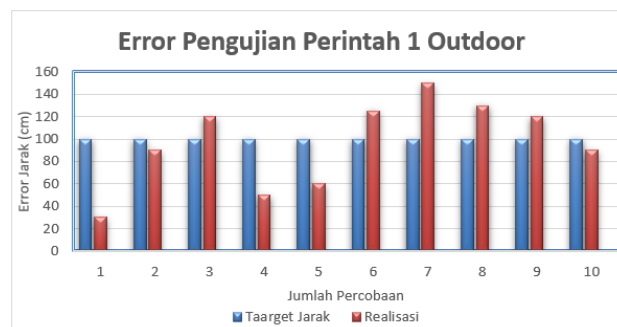


Fig 4.7 Outdoor Command Error Graph 1

Average Error distance (cm) 32.5

Accuracy (%) 68

Fig 4.7 is a graph of the results of testing the first command using a delay of 3 seconds. The test was carried out by running REBOT to a predetermined point manually with a distance setting of one meter/100 centimeters on the paving block. In the test results, the average error on the first command was 32.5 cm out of 100 cm and an accuracy of 68%.

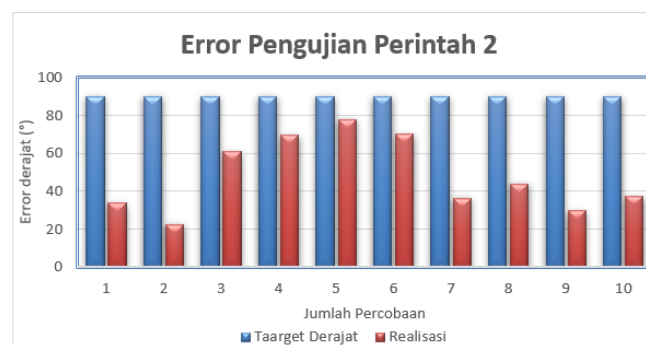


Fig 4.8 Error Graph of 2 Outdoor Commands

Average Error (°) 41.8

Accuracy (%) 58

The second test is carried out by positioning the robot in its motion space, namely outdoors on paving blocks, and then the robot will be ordered to rotate according to the degree. In this test, a serial monitor is used to see the rotating angle, this serial monitor displays an angle that will change to 0° after the robot has finished moving. This test produces data as shown in graph 4.8, where a sample of the rotary degree target and realization is taken. Based on this data, an error of 41.8° is obtained with an accuracy of 58%.

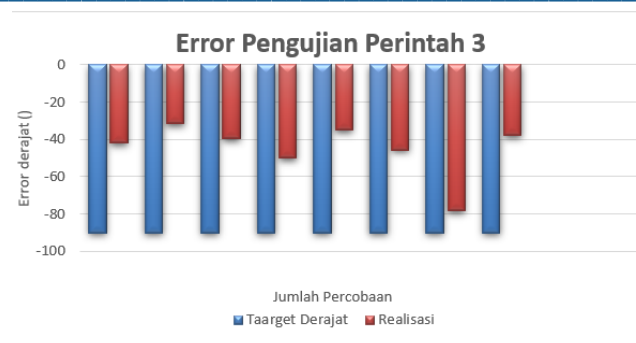


Fig 4.9 Error Graph of 3 Outdoor Commands

Average Error (°) 46.12

Accuracy (%) 53.88

In the third test, the same thing is done as before, which is to position the robot in its motion space and order to rotate according to the degree. This test produces data as shown in graph 4.9, where the rotating degree target and realization are sampled. Based on this data, the error is 46.12° with an accuracy of 53.88%.

5. Conclusion

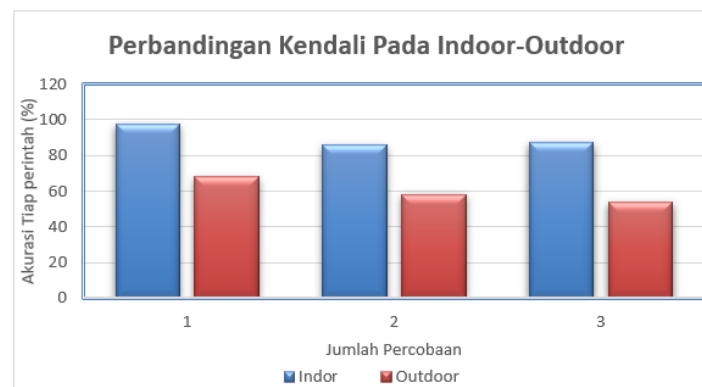


Fig 4.10 Indoor and Outdoor Accuracy Comparison Chart

Based on the data that has been obtained, the average error generated by the manual control system in indoor and outdoor conditions on each command shows that control in indoor conditions produces higher accuracy. Based on Fig 4.10, the accuracy of indoor control reaches 90.1% while the accuracy of outdoor control reaches 60%. This is due to the uncertainty of the caster coupled with the unevenness of the surface in outdoor conditions.

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