Nat. Volatiles & Essent. Oils, 2021; 8(6): 3918-3931

Designing Intelligent Control System For Wheeled Robot Car For Handling COVID 19

W.Widhiada[1] , Y.A.Setiawan[2] , G.Risma B.P[3] , I.B.P.Pramana[4] , IG.K.Dwijana[5]

[1]Mechanical Engineering Department, University of Udayana,

[2]Electrical Engineering Department

[3,4]Medicine of Faculty of Udayana University

Abstract

Currently, the development of the COVID-19 outbreak continues to increase throughout the world, including in all provinces in Indonesia. The central and local governments in Indonesia have taken strategic policies on health protocols in handling the spread of the COVID-19 virus in a targeted and measurable manner, such as prevention policies and treatment policies. However, the development of this outbreak has not shown any signs of decreasing its spread. In general, the treatment of patients at this hospital, such as at the Udayana Hospital (RSPTN), is still done manually, so there are some medical circles that are also exposed to the COVID virus. Therefore, we conducted research on “Designing a Wheeled Robot Car Intelligent Control System for Handling COVID 19”. This paper discusses the effect of the PID parameter value on the overshoot signal of the dc motor rotation speed. Testing the movement speed of the assisting robot car of Udayana 02 (Ratna02) by using a variation of the control PID amplifier. This wheeled robot car is a robot car that has a function as a room neutralizer from the COVID virus by spraying oxygen, illuminating the room with ultraviolet (U.V) lights, helping transport patient logistics materials, and Standard Personal Protective Equipment (PPE). The robot will be controlled remotely by the operator using artificial intelligence. It is hoped that the use of robotic power can help reduce the impact of the COVID-19 outbreak in the hospital environment.

Keywords: Wheeled Robot, Intelligent Control, Covid19, Object Detection, PID

Introduction

The development of the COVID-19 outbreak is increasing worldwide. The increase in the Corona virus pandemic is caused by sub-optimal health services, and the behavior of people who do not comply with health protocols.[1]. This is a serious problem in handling health that affects the future of our generation. The government's attention through regulations and policies needs to be taken over to address this problem immediately. This pandemic has had a significant impact on economic developments, including the decline in stock market indexes. The economic development of the community has also decreased drastically because they are limited to staying at home so that the economic condition becomes minus [2].

In accordance with the advice from the UN WHO related to preventing an increase in cases of exposure to the Corona 19 virus, namely washing hands, physical distancing and wearing masks. One of the efforts that have never been and are not used to by the community is the limitation of distance. Restricting the distance in the crowd has given a pretty good result in reducing the spread of this covid 19. However, this behavior change is quite difficult for some people to do.[3]

Can the role of robots replace medical personnel to treat patients exposed to Covid 19? One of them is a robotic vehicle that functions to carry patient needs, illuminates the room with ultraviolet light and emits oxygen gas so that viruses can be removed and doctors can communicate remotely. The role of this robot is highly expected to be able to cut the cycle of the Covid 19 pandemic. In 2015 the White Office for Science and Technology Policy and the National Science Foundation held a seminar to identify three areas of work that robots could take over: clinical care such as telemedicine and decontamination, logistics delivery and handling of contaminated waste, and remote monitoring and communication. [4].

In handling the care of patients exposed to Covid 19, the robot system with a user interface can be used and controlled remotely by the operator. One of them is a telerobotic system technology that is designed to be sterilized by using a cleaning fluid so that the robot can spray oxygen gas into a room.[5].

The design of a collaborative robot system is made to be able to assist medics in dealing with patients in hospitals. This collaborative robot can be controlled remotely by an operator. This robot can carry out various tasks such as carrying out patient logistics needs, helping carry personal protective equipment against the spread of the coronavirus, this robot can also spray oxygen gas. This collaborative robot can work with patients where a doctor can communicate remotely because this robot is equipped with an LCD screen installed on the robot [6].

This collaborative robot system can be applied directly to work with users and medical personnel in hospitals. Thus, collaborative robots can also reduce the burden on health workers. Autonomous robotic systems are also implemented in hospitals that work independently by reducing interactions between health workers and patients around the room. This autonomous robot is a mobile robot on wheels that has been widely used in hospitals during the Covid 19 pandemic. The autonomous robot is also equipped with several ultraviolet lamps where U.V. light. This can kill the Covid 19 virus.

The University Hospital of Udayana University in Bali which handles patients exposed to COVID 19 is not yet equipped with automatic technology such as robotic power. The service for COVID-19 patients by health workers is still manual in accordance with the operating standards of the hospital. So there is a case that one of the nurses who participated was exposed to the Coronavirus. Medics are at the forefront of handling COVID-19 cases, so more facilities should be provided.

Seeing from this background, we as researchers want to design a wheeled robot car with an automatic control system that is able to help treat patients exposed to the Coronavirus. This paper discusses the effect of the PID parameter value on the overshoot signal of the dc motor rotation speed [7]. This robot car can be controlled by an operator remotely. In this study, the author will use the simulation method as a design reliability test and experimental method with real trials of the RATNA 02 prototype. The PID system and intelligent control (Intelligent control) will be used to get the best performance from this wheeled robot car. such as movement, position, velocity, acceleration, and torque using MATLAB / Simulink software [8]. The purpose of this study was to help medical personnel at the Udayana University Hospital (RSPN) such as bringing logistical needs, medicines, PPE for patients, and spraying oxygen air (Ozonization) in a room.

Research Method

State of Arts

Covid 19 is included in the category of infectious disease outbreaks that need serious handling by the government. The role of the university is very much needed to contribute to creating smart health products that are able to handle the spread of the Covid 19 virus. One example is the design of the covid robot car which is also called "Helper" which is used to anticipate the novel coronavirus pneumonia epidemic.

The health threat to health workers and patients who have been exposed to the Covid-19 virus is a very serious problem, so a new, effective breakthrough is needed. During the pandemic, many hospital staff were infected with the Corona Virus. At this time researchers have created many covid 19 robots using an intelligent control system. This intelligent robot is based on neural network control. An example of an intelligent robot is a teleoperated robot that can assist health workers in hazardous areas, such as delivering food or medicine, collecting specimens, and transporting the waste, with high accuracy and efficiency [9]. The advantage of using this intelligent robot is that one operator can control many robots and has the ability to communicate with patients via a virtual telepresence system 24 hours a day, 7 days a week. For example, a robot called TRINA (Tele-Robotic Intelligent Nursing Assistant) is used to help health workers with optimal performance. [10]. Several studies have specifically demonstrated the significance of using telemedicine in emergencies and public health disasters. [11].

The electronic monitoring program allows doctors and nurses to remotely monitor patient status in multiple hospitals. Virtually this intelligence program helps health workers to manage patients remotely. For example, in Houston, the ETHAN Project (Emergency Telehealth and Navigation) has used a telemedical surveillance program for patients exposed to COVID-19 in hospitals [12].

A new and reliable paradigm for health care services is to implement an Artificial Intelligence (AI) control system. Virtually unlimited AI performance is derived from its various algorithms and approaches. Systems that have adopted this AI program can help overcome the spread of the virulent SARS-CoV-2 virus around the world. The proper application of AI through the use of both existing machine learning approaches is expected to be able to eliminate COVID-19. Products using this AI system program are a bright future to be able to overcome various problems, especially problems caused by COVID 19 [13].

Currently, robotic car technology with intelligent control has been developed to help medical professionals treat patients exposed to COVID 19 in hospitals. This wheeled mobile robot is a robot car that is used to take on several tasks automatically such as carrying logistics, PPE, killing the Coronavirus by spraying disinfectant and oxygen into the room accompanied by UV lighting. The proposer has also donated a wheeled robot car unit to handle COVID 19 patients at the UNUD RSPTN called Robot Assistance Udayana (RATNA).

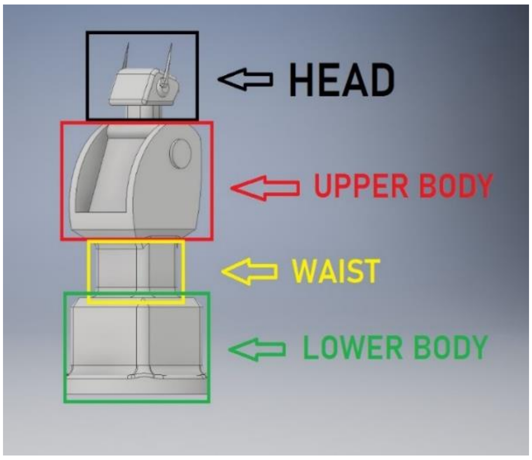
Research Description

This wheeled robot car can be used to help the medical team treat COVID-19 patients. This robot aims to minimize the transmission of the COVID-19 virus due to direct interactions between nurses/doctors and patients. The robot uses stainless steel as its robot body.

RATNA02 is a medical robot that functions to help medical personnel in hospitals reduce physical interactions with people with Covid-19. This robot can carry logistics to patients, measure temperature with sensors, and can neutralize rooms using a combination of Ozone Generator and UV Light.

RATNA02 can work automatically with the help of a series of sensors such as a Camera, Ultrasonic, and Rotary Encoder. This robot will use a combination of Deep Learning algorithms in the form of Object Detection and PID to be able to navigate autonomously in the Hospital. The robot only needs to be commanded remotely via the operator's laptop or computer to perform certain actions. The inner body of the robot is made of aluminum profile for easy assembly and is coated with plywood as outer body is shown in figure 1

Figure 1. Robot Body Division



In RATNA02, the robot body consists of 4 parts, namely Lower Body, Waist, Upper Body, and Head. This section will be made of different materials as needed.

Research Procedure

In RATNA02, there are several electronic circuits needed to be able to move and control the robot properly, this circuit was made using Easy EDA software, and printed manually using PCB and Ferycloride. Some of these circuits are:

a. Master Controller

The Master Controller is a circuit that functions to receive all data from slaves in the robot and process it to get output that is in accordance with the conditions around the robot. This Master Controller uses STM32F103C8T6 as its microcontroller to process the data. There are 8 connectors for ultrasonic sensor input, 2 connectors for Incremental Encoder input, 3 connectors for serial communication so that the Master Controller can communicate with other slaves and there is a connector for relays, and there is 1 power connector for providing power to the circuits.

b. Slave MPU6050

The Slave MPU6050 is a circuit consisting of an Arduino Nano as a microcontroller, and an MPU6050 sensor. The MPU6050 is a sensor that functions as an accelerometer as well as a gyroscope which is packaged into 1 module. This sensor serves to determine the direction of motion of the robot. The direction of motion of the robot is very important to know because the robot will move autonomously so the robot must know the position and direction of its motion in order to move properly.

d. Jetson Nano

The Jetson Nano is a minicomputer that allows developers to easily implement robotic capabilities on smart devices. In this robot, the Jetson Nano functions to process data from the webcam camera in the robot. By using the Object detection algorithm, the robot will be able to navigate well.

e. Power Supply Circuit

This circuit serves to receive power from the battery and distribute it throughout the circuit from the robot. In this circuit, there is a Step-Down that serves to lower the voltage from the battery to a voltage of 5V and 12V that can be used by the circuit in the robot.

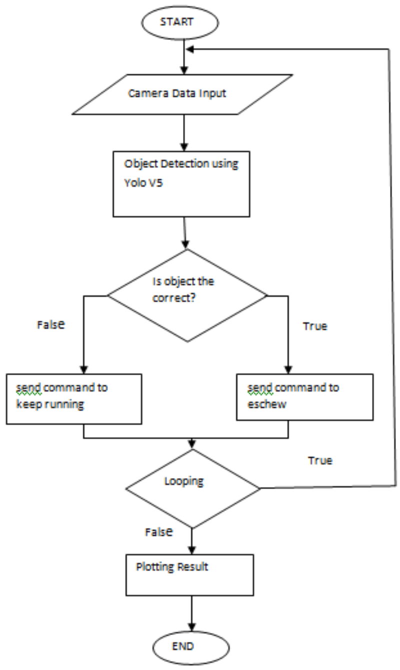
f. Battery

The battery on the RATNA02 is a custom battery made with a LifePo4 battery with an 8S3P configuration so that it produces a voltage of 29.2V and a total capacity of 18Ah. This battery is also protected using Daly's BMS 8S 80A, so the battery is safe from unwanted symptoms such as Overvoltage, Under voltage, Short Circuit, and others.

D. Flowchart

RATNA02 will have several systems that work independently or collaboratively, the flow diagram in RATNA02 is shown in figure 2:

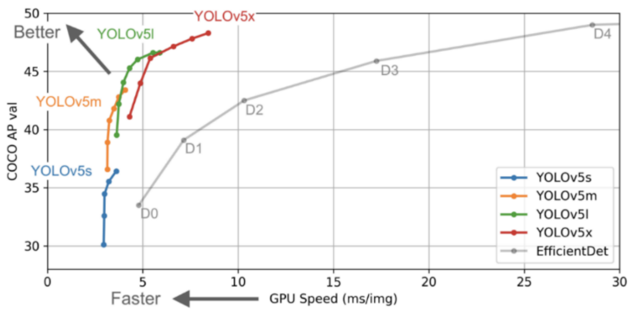
Figure 2. Object Detection Flowchart



E. Mathematic Modeling

In RATNA02, an architecture called YOLO is used to detect various objects that can block the robot is shown in figure 3.

Figure 3. YOLOV5 . comparison



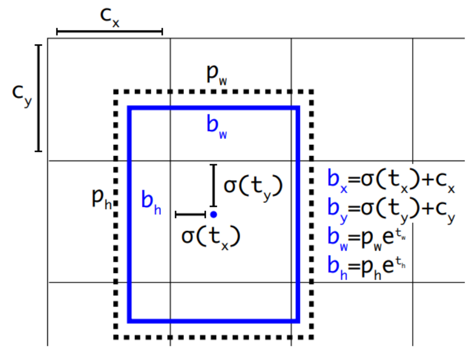
The picture above is the result of modeling from YOLOV5 compared to other object detection architectures. YOLO can detect various kinds of objects and create bounding boxes for these objects with the formula:

$$b_x = \sigma(t_x) + c_x$$
$$b_y = \sigma(t_y) + c_y$$
$$b_\omega = p_\omega e^{t\omega}$$
$$b_h = p_\omega e^{th}$$

…………………………..(1)

The above formula will help the program to draw a bounding box from the detected object and provide the position of the object's location relative to the camera pixels so that it can be observed properly. Figure 4 shows the laying of bounding box on an object.

Figure 4. Laying the Bounding Box on the Object



The YOLO model also consists of many Convolution and Residual layers which function to extract the information contained in the input image. The YOLO model architecture is shown in figure 5.

Figure 5. YOLO. Model Architecture

	Type	Filters	Size	Output
	Convolutional	32	3 × 3	256 × 256
	Convolutional	64	3 × 3 / 2	128 × 128
1×	Convolutional	32	1 × 1	
	Convolutional	64	3 × 3	
	Residual			128 × 128
	Convolutional	128	3 × 3 / 2	64 × 64
2×	Convolutional	64	1 × 1	
	Convolutional	128	3 × 3	
	Residual			64 × 64
	Convolutional	256	3 × 3 / 2	32 × 32
8×	Convolutional	128	1 × 1	
	Convolutional	256	3 × 3	
	Residual			32 × 32
	Convolutional	512	3 × 3 / 2	16 × 16
8×	Convolutional	256	1 × 1	
	Convolutional	512	3 × 3	
	Residual			16 × 16
	Convolutional	1024	3 × 3 / 2	8 × 8
4×	Convolutional	512	1 × 1	
	Convolutional	1024	3 × 3	
	Residual			8 × 8
	Avgpool		Global	
	Connected		1000	
	Softmax			

With this architecture, YOLO can detect objects with high accuracy and low latency.

E. Kinematic MechannismModeling

Mechanism Wheel is one type of wheel that is often used in robots where the roller on the wheel is made in such a way as to form an angle so that the wheel can move in all directions without the need for steering.

Assuming that the robot moves on a flat horizontal plane and there is no slip on the wheels, the inverse kinematics formula of RATNA02 is as follows:

$$V_w = J(\alpha) \cdot V_o,$$

Where Vw = [w1, w2, w3, w4]T is the speed of each wheel. V0 = [vx, vz, w0]^T is the general velocity of the robot's center point with the XOZ coordinate system. J(α) is the Jacobi matrix of the inverse kinematics equation.

$$J(\alpha) = \frac{1}{r}\begin{bmatrix} 1 & \frac{1}{\tan\alpha} & \frac{-L_1\tan\alpha + L_2}{\tan\alpha} \\ 1 & \frac{-1}{\tan\alpha} & \frac{L_1\tan\alpha + L_2}{\tan\alpha} \\ 1 & -\frac{1}{\tan\alpha} & -\frac{L_1\tan\alpha + L_2}{\tan\alpha} \\ 1 & \frac{1}{\tan\alpha} & \frac{L_1\tan\alpha + L_2}{\tan\alpha} \end{bmatrix}$$

………(2)

In this robot the angle of the wheel roller is 45° so the following formula is obtained:

$$\begin{bmatrix} v_x \\ v_z \\ \omega_0 \end{bmatrix} = \frac{r}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & -1 & 1 \\ \frac{1}{L_1+L_2} & \frac{1}{L_1+L_2} & \frac{1}{L_1+L_2} & \frac{1}{L_1+L_2} \end{bmatrix}\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} \text{....(3)}$$

F. Controller

RATNA02 uses several types of controllers and communication systems, these systems work together with each other to send and receive information to each other. Some of the controller and communication technologies used in RATNA02 are:

1. Arduino Nano

The definition of Arduino Nano is a small developer circuit board in which a microcontroller is already available and supports the use of a breadboard. Arduino Nano is specially designed and manufactured by the Gravitech company using a microcontroller based Atmega328 (for Arduino Nano V3) or Atmega168 (for Arduino Nano V2). Arduino Nano is used in the Slave MPU6050 circuit to read sensor data.

2. STM32

STM32 is one of the microcontroller boards made by STMicroelectronics which is quite popular in use today. The microcontroller used is STM32F103C8 based on ARM Cortex M3. This microcontroller is used in the Master Controller and Slave Motor circuits.

3. Jetson Nano

The Jetson Nano is a minicomputer that allows developers to easily implement robotic capabilities on smart devices. The RATNA02 Jetson Nano functions to get input from the camera and performs object detection processes.

All of these devices can work together using the Serial communication system. Serial communication is one of the methods of data communication in which only one bit of data is transmitted over a strand of cable at any given time. This communication system was chosen because it is very simple in terms of wiring and programming.

In addition to the Serial communication system, RATNA02 also implements a communication system using the Restful Api, where the REST client will access data/resources on the REST server where each resource is. This allows the operator to control the robot through a browser on a laptop or computer.

C. Coding

RATNA02 uses 2 main programming languages, namely Python and Arduino, where Python itself functions to perform very heavy data processing such as Object Detection and RESTFUL APIs. The Arduino programming language is used to control the actuators on the robot and can receive input from various types of sensors. Coding from Robot RATNA02 can be accessed via the link:

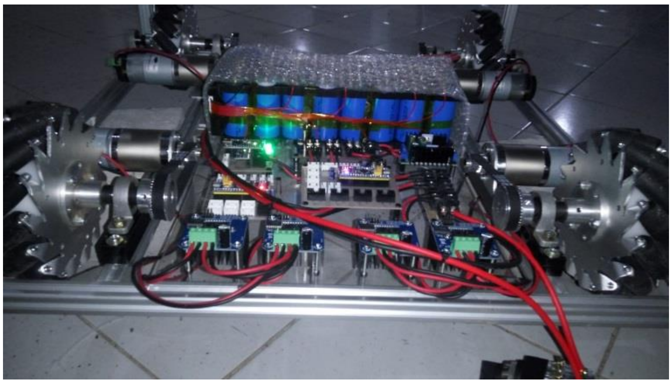
https://github.com/andre44s/RATNA02-Object-Detection

Results and Discussion

A. Prototype Design Results

Ratna 02 robot uses four for omniweels where this robot can move 360 degrees an shown in figure 6.

Figure 6 Electronic circuit of Ratna Robot 02



B. Object Detection

Figure 7 Object detection test

Figure 7 shows the mapping object detection for the RATNA02. These some of pictures mapping are used to define some objects.

Table 1 shows the maximum overshoot of motor speed signal (rpm) at 25 rpm, 50 rpm, 75 rpm, and 100 rpm immediately.

In the first testing the parameters of PID is setup at KP=5, KI=0 and KD=0.

Tabel 1 Maximum Overshoot angular speed 1st testin

No	Setup RPM	DC Motor	Max Oversoot
1	25	DC Motor 1	35
2		DC Motor 2	34
3		DC Motor 3	34
4		DCMotor 4	31
5	50	DC Motor 1	51
6		DC Motor 2	56
7		DC Motor 3	52
8		DC Motor 4	51
9	75	DC Motor 1	77
10		DC Motor 2	76
11		DC Motor 3	76
12		DC Motor 4	75
13	100	DC Motor 1	101
14		DC Motor 2	100
15		DC Motor 3	100
16		DC Motor 4	100

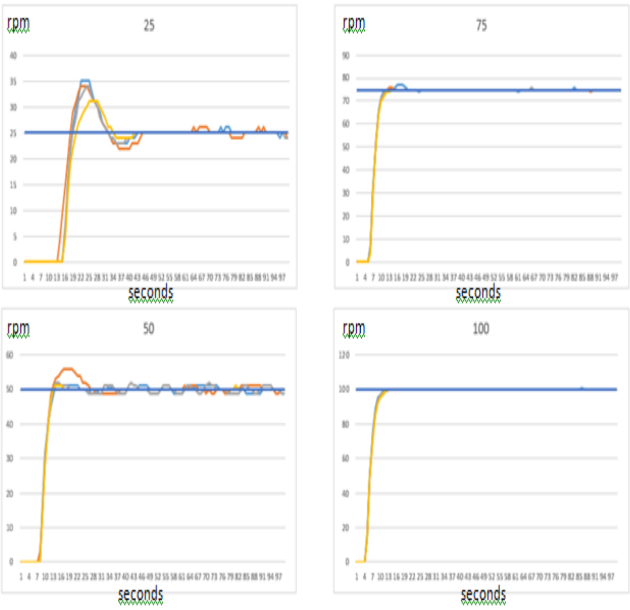
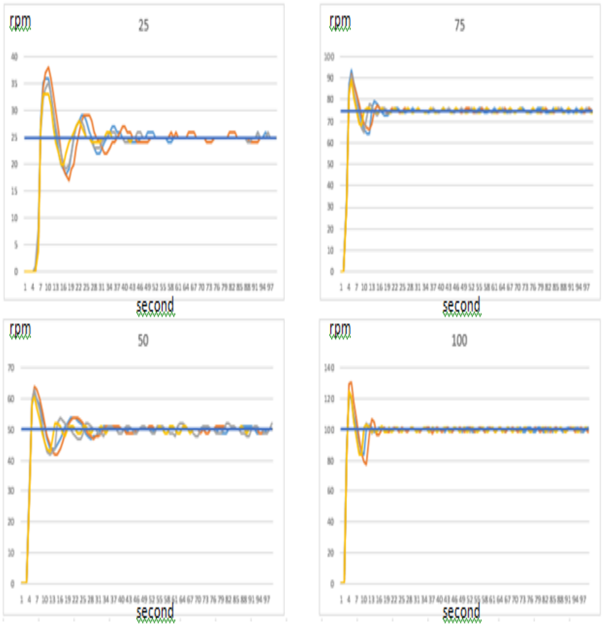


Figure 8 The 1st Setting PID Control

Figure 8 shows the angular speed of dc motor first testing with setting the value of P = 5, I = 0, D = 0. The average overshoot at 25 rpm is 33.5 rpm. The average overshoot at 50 RPM is 52.5 rpm. The average overshoot at 75 rpm is 76 rpm. The average overshoot at 100 rpm is 100.25 rpm.

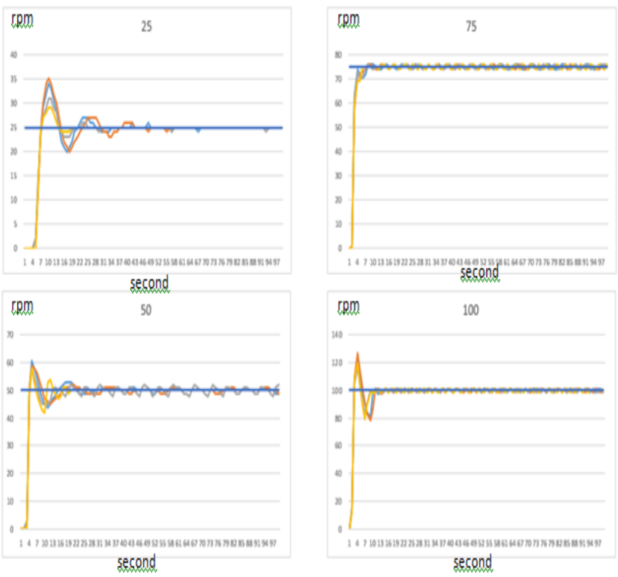
The second test is shown in figure 9 by varying the proportional parameter by 15, the integral parameter by 0, and the derivative parameter by 0. The data is shown in table 2 below.

Figure 9 The 2nd Setting PID Control



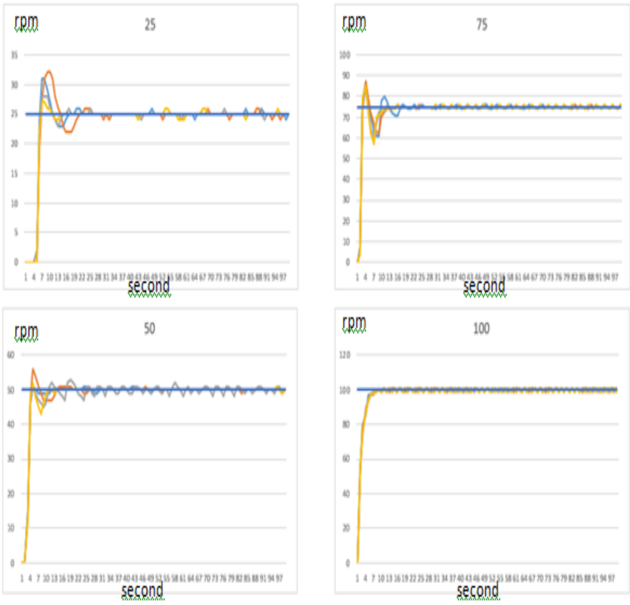
The third of speed testing is shown in figure 10 on setting the value of P = 15, I = 0, D = 0. The average overshoot at 25 rpm is 35.5 rpm. The average overshoot at 50 rpm is 62.5 rpm. The average overshoot at 75 rpm is 91.5 rpm. The average overshoot at 100 rpm is 125.25 rpm.

Figure 10 The 3rd Setting PID Control



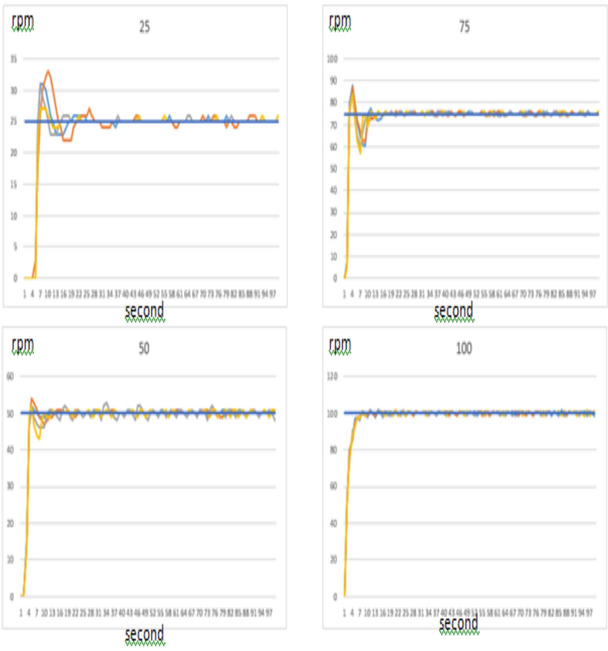
At setting the value of P = 15, I = 0, D = 5, the overshoot value is obtained as shown in Figure 10. The average overshoot at 25 rpm, 50 rpm, 75 rpm, and 100 rpm is 32.5 rpm, 59 rpm, 76 rpm, and 121.5 rpm respectively.

Figure 11 The 4th Setting PID Control



In setting the value of P = 15, I = 0, D = 5, the overshoot value is obtained as shown in figure 11. The average overshoot at 25 rpm is 29.5rpm. The average overshoot at 50 rpm is 53 rpm. The average overshoot at 75 rpm is 85.75 rpm. The average overshoot at 100 rpm is 100.75 rpm.

Figure 12 The 5th Setting PID Control



In setting the value of P = 15, I = 0, D = 10, the overshoot value is obtained as shown in the figure 12. The average overshoot at 25 rpm is 30.5 rpm. The average overshoot at 50 rpm is 52.75 rpm. The average overshoot at 75 rpm is 85.75 rpm. The average overshoot at 100 rpm is 101.75 rpm.

Figure 13 The Comparison Overshoot signal

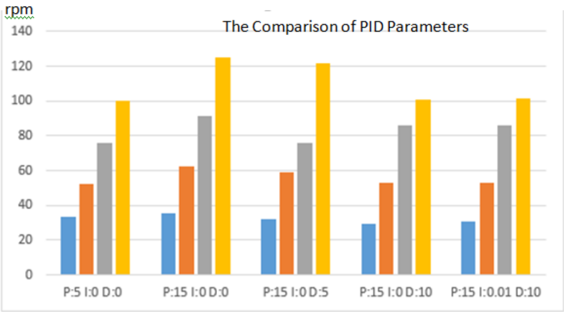


Figure 13 shows the comparison overshoot signal of angular speed of dc motor into Ratna02. Based on the data above, a bar chart is obtained as follows. For rpm 25 the best results were obtained using the configuration (P:15, I:0, D:10). For rpm 50 the best results were obtained using the configuration (P:15, I:0, D:0). For rpm 75 there were 2 configurations that had the best values, namely (P:5, I:0, D:0) and (P:15, I:0, D:5). For 100 rpm the best results were obtained using the configuration (P:5, I:0, D:10).

In the first and second experiments, the P-value was increased by 10 while the I value and D value was dropped by 0. This caused the second experiment to have a higher overshoot value than the first experiment. The third experiment added a D value of 5, this made the overshoot more damped than the second experiment. In the fourth experiment, the value of D was changed to 10 and caused the average overshoot to decrease again compared to the third experiment. In the fifth experiment, and I value of 0.01 was added, this did not have much effect on the overshoot but had a small effect on the stable rpm.

Conclusion

The stability of the rotational speed of the dc motor for each variation of motor rotation (rpm) depends on the setup of the PID gain. With the right value for the PID parameter, it provides the right rotation speed response with minimal overshoot, minimal error signal, and fast stability achievement time.

REFERENCES

J. J. Cavallo and H. P. Forman, “The Economic Impact of the COVID-19 Pandemic on Radiology Practices,” Radiology, vol. 296, no. 3, pp. E141–E144, Sep. 2020, doi: 10.1148/radiol.2020201495.

S. Galea, R. M. Merchant, and N. Lurie, “The Mental Health Consequences of COVID-19 and Physical Distancing: The Need for Prevention and Early Intervention,” JAMA Intern Med, vol. 180, no. 6, p. 817, Jun. 2020, doi: 10.1001/jamainternmed.2020.1562.

G.-Z. Yang et al., “Combating COVID-19—The role of robotics in managing public health and infectious diseases,” Sci. Robot., vol. 5, no. 40, p. eabb5589, Mar. 2020, doi: 10.1126/scirobotics.abb5589.

M. Agostini et al., “Telerehabilitation and recovery of motor function: a systematic review and meta-analysis,” J Telemed Telecare, vol. 21, no. 4, pp. 202–213, Jun. 2015, doi: 10.1177/1357633X15572201.

M. Tavakoli, J. Carriere, and A. Torabi, “Robotics, Smart Wearable Technologies, and Autonomous Intelligent Systems for Healthcare During the COVID-19 Pandemic: An Analysis of the State of the Art and Future Vision,” Advanced Intelligent Systems, vol. 2, no. 7, p. 2000071, Jul. 2020, doi: 10.1002/aisy.202000071.

J. Adiluhung, M. Rochmad, and F. Arifin, “Alat Pengukur Tekanan Darah Otomatis Berbasis Mikrokontroler Untuk Pasien Rawat Jalan dengan SMS Gateway,” p. 6.

I. W. Widhiada, I. N. Budiarsa, I. M. Widiyarta, and T. Coglitore, “Comparison of PID and fuzzy logic to control the motions of robotic prosthetic limbs,” IOP Conf. Ser.: Mater. Sci. Eng., vol. 673, p. 012109, Dec. 2019, doi: 10.1088/1757-899X/673/1/012109.

W. Widhiada, T. G. T. Nindhia, I. M. Widiyarta, and I. N. Budiarsa, “Control of Bionic Robot Leg Performance with Proportional Integral and Derivative Controller,” IJMERR, pp. 1447–1450, 2020, doi: 10.18178/ijmerr.9.10.1447-1450.

M. Li and X. Pan, “Practical Research of Intelligence in Epidemic Prevention Product Design,” E3S Web Conf., vol. 179, p. 02040, 2020, doi: 10.1051/e3sconf/202017902040.

M. Panzirsch, B. Weber, L. Rubio, S. Coloma, M. Ferre, and J. Artigas, “Tele-healthcare with humanoid robots: A user study on the evaluation of force feedback effects,” in 2017 IEEE World Haptics Conference (WHC), Munich, Germany, Jun. 2017, pp. 245–250. doi: 10.1109/WHC.2017.7989909.

Z. Li, P. Moran, Q. Dong, R. J. Shaw, and K. Hauser, “Development of a tele-nursing mobile manipulator for remote care-giving in quarantine areas,” in 2017 IEEE International Conference on Robotics and Automation (ICRA), Singapore, Singapore, May 2017, pp. 3581–3586. doi: 10.1109/ICRA.2017.7989411.

Hong Z, “Telemedicine During the COVID-19 Pandemic,” J Med Internet Res, doi: doi: 10.2196/19577.

W. Widhiada, I. G. N. Santhiarsa, and C. G. I. Partha, “Design of Motion Control for Mobile Robot Manipulator,” IJMERR, pp. 1509–1514, 2020, doi: 10.18178/ijmerr.9.11.1509-1514..