

Medical Robot Covid Orientation using IMU with PID Controller

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Abstract—The COVID-19 pandemic has caused the world to be in serious trouble, the government has implemented a physical distancing policy in order to reduce the rate of transmission of this virus, robot technology is used to assist medical personnel in carrying out their duties so that they do not need to interact directly so as to reduce the risk of contracting the Covid virus-19, robots with navigation systems can be maximized by using the Inertial Measurement Unit (IMU) sensor with PID tuning in order to adjust the speed on different surface slope conditions.

Index Terms—Medical, Covid, IMU.

I. INTRODUCTION

COVID-19 was declared a pandemic after spreading very quickly to various parts of the world because of the ease with which it spreads through droplets that come out of the nose or mouth of an infected person, there are several symptoms in infected people including cough, fever, easy fatigue, loss of taste and smell. There are serious symptoms such as difficulty in breathing if the infected patient has a congenital or comorbid disease. The ease of transmission makes the government issue a policy to implement physical distancing where people must maintain a safe distance greater than or equal to 1 meter, use masks, and wash their hands regularly. The challenges are the Health workers who treat exposed patients have a very high risk of contracting this, this has forced researchers to find technological innovations that can reduce interactions between medical personnel and patients. Medical Robot-Controlled Intelligent Assistive Technology (MR-IAT) is one of the robot technologies that is used for the benefit of the medical world. This robot can perform automatic navigation using LiDAR 2D and 3D by reflecting laser beams [1][2], Lidar will map by firing a laser beam which will then be reflected back so that it can map the environment that is in the range of LiDAR. With this, the robot can walk without crashing into surrounding objects.

Inertial Measurement Unit (IMU) is added to the robot to maximize localization mapping [3] and also the IMU can measure the slope of the road which information will be used to adjust the speed of the DC motor with a rotary encoder in order to adjust the speed on certain slope conditions [4][5],

where at when the robot passes through an uphill road it will increase speed, and a downhill state will reduce speed.

The IMU has an accelerometer, gyro, and magnetometer, each of which has 3 axes, namely the x axis (roll axis), y axis (pitch axis), and z axis (yaw axis). The IMU measures the angle of roll, pitch, yaw that will be tuned, if the roll value is changed and the pitch value changes. It indicates an error in the formula, which is used in aircraft technology, where pitch measures the plane's slope, roll measures speed, pitch measures slope, and yaw measures the gravity of the aircraft against the earth [6][7]. The IMU can also be used on vehicles to detect obstacles in front of it [8][9] and is also used on tractor robots for position sensors and development of navigation systems that produce high and stable navigation accuracy values [10][11] the data obtained by the IMU will be used for the motor speed control system using the Proportional-Integral-Derivative (PID) controller.

The method commonly used for PID controller tuning is the Ziegler Nichols method by making several plant assumptions and the output needed to select the controller settings [12]. The tuning needs to be done several times because the set controller has overshoot and oscillatory response. The Fuzzy Linear Controller method can be used for tuning the PID parameters by calculating the gain error on the proportional, integral, and derivative parameters. Fuzzy Proportional-Derivative+Integral (FPD+I) receives inputs of error value and change of error [13]. The previous studies that support the experiment can be found in published papers [14-18].

The purpose of this paper is to orientate the robot using an IMU with a PID controller to adjust the speed of the robot at a certain slope by tuning it with the fuzzy linear controller method.

II. METHOD

The robot used in this study has a navigation system using 2D and 3D LiDAR scanners that make the robot able to run optimally. LiDAR performs mapping by firing a laser which is then reflected to detect objects around it. The robot is also equipped with several sensors such as voice, vision and imaging, ultrasonic, raspicam, and IMU as a measure of the speed and angle changes of the robot. The image of the developed robot can be seen in Fig. 1.

The design of a speed control system for the slope of the road surface using an IMU sensor which will produce pitch, roll, and yaw data from the accelerometer and gyro sensors that have been integrated in the IMU, the data obtained will then be processed by the Arduino UNO R3 microcontroller, the angle pitch data is data that used as a reference for uphill,

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horizontal, and downhill surfaces. Then the program on the Arduino is given an if function, where if the pitch angle is negative it can be assumed that the path or surface traversed by the robot is decreasing, and vice versa, if the pitch angle is positive then the path traversed is uphill. In this phase, the PID control will provide input on the rotary encoder based on the error obtained to adjust the speed of the DC motor will increase when the robot passes through an uphill surface, and the speed decreases on a descending surface.



Fig. 1. Medical Robot-Controlled Intelligent Assistive Technology (MR-IAT)

IMU is used to detect the level of the slope of a surface that is passed by the robot, with the addition of a PID controller to determine the precision of a system, a DC controller is used to control the speed of a DC motor based on the error value obtained so that it is able to adjust the speed close to the required value. The Error value is the difference in value between the set point and the real value. Fig. 2 shows the flowchart of the control system that will be used in this study.

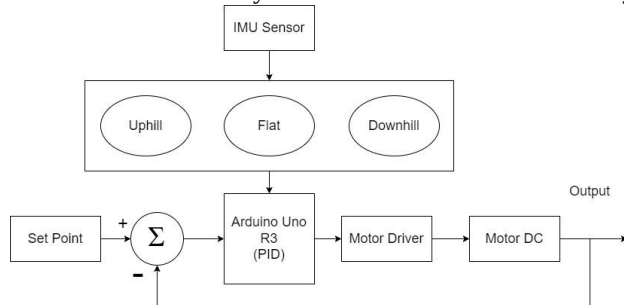


Fig. 2. Control System

PID tuning is done in order to obtain the PID controller values, namely K_p , K_i , and K_d to correct errors in the system with feedback on the system. PID tuning is carried out in 3 different conditions, namely uphill, horizontally, and downhill, the method used for tuning is the Fuzzy Logic Controller method by calculating the gain error value on the parameters K_p , K_i , and K_d . Fuzzy proportional-Derivative+Integral will be given a variable error and change of error and will have a result based on the gain error on the

PID controller, in Fig. 3 is the fuzzy control design contained in Simulink.

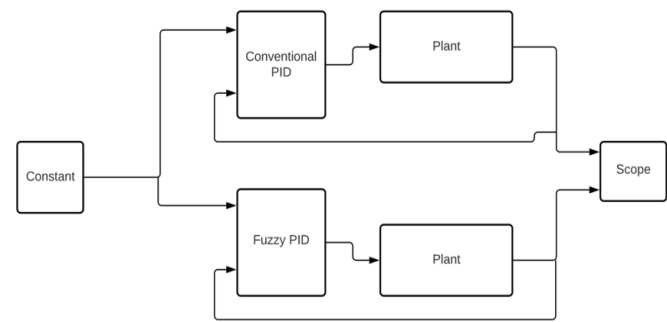
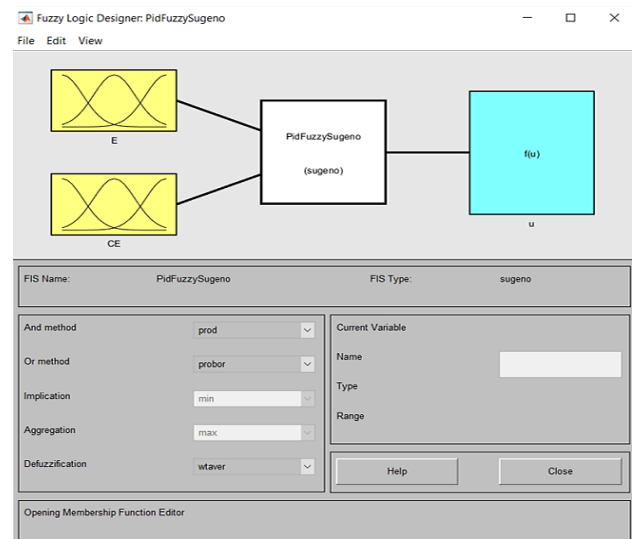
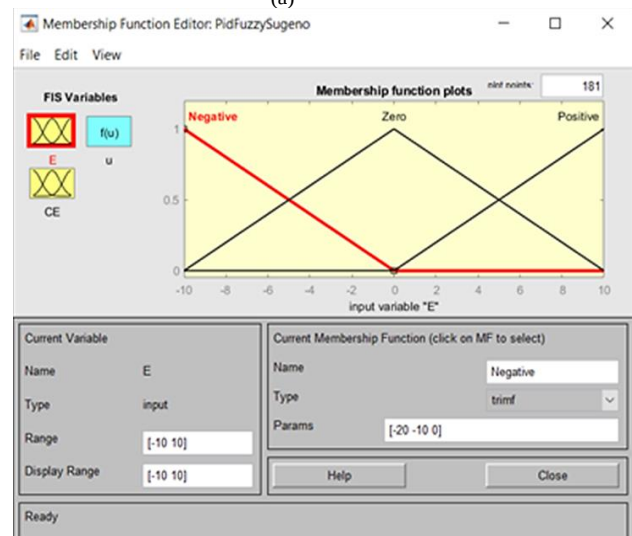


Fig. 3. Design fuzzy controller

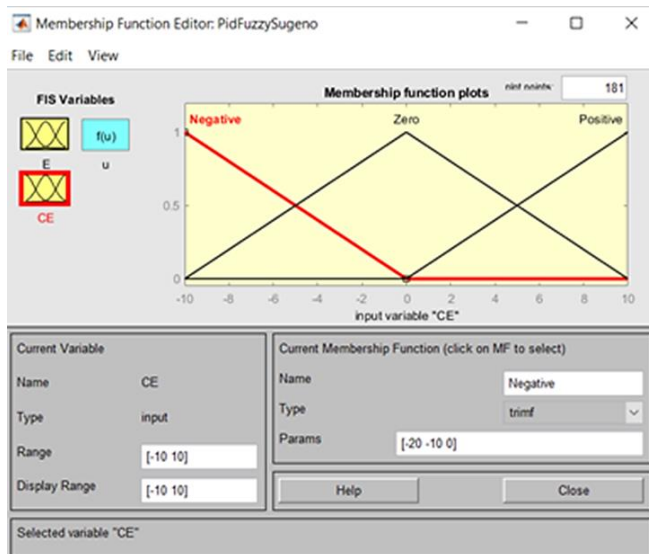
In fuzzy logic there is an output variable that has a member of a function which will later be used to make rules from fuzzy logic, the error value and change of error are used to gain PID and each variable has a member of a function as shown in Fig. 4.



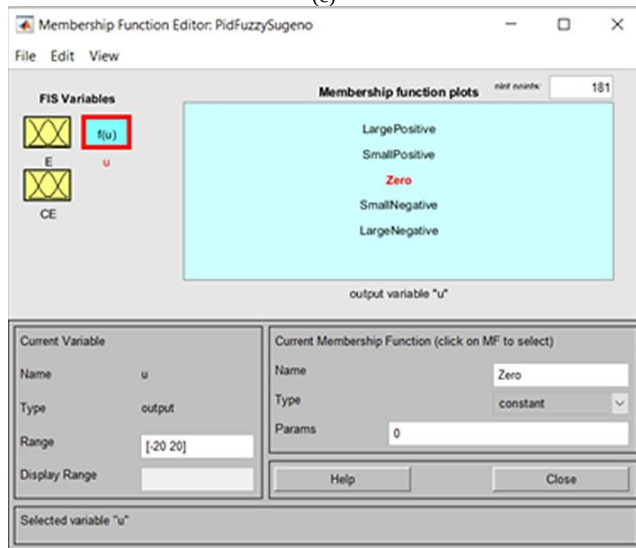
(a)



(b)



(c)



(d)

Fig. 4. (a) PID Fuzzy controller (b) Variabel E (c) Variabel CE (d) Variabel u

In modeling this system, an example is carried out where the negative gain value is negative, the zero gain is zero, and the positive gain is positive. This model uses basic fuzzy control rules as shown in Table 1.

TABLE I
ECG BASIC RULES FUZZY CONTROL

	Negative	Zero	Positive
Negative	Big Negative	Small Negative	Zero
Zero	Small Negative	Zero	Small Positive
Positive	Zero	Small Positive	Big Positive

The data obtained were then tested by conducting experiments on uphill, horizontal, and downhill surfaces by making the values of K_p , K_i , and K_d as PID parameters which made the robot able to adjust the speed in 3 different slope angle conditions.

III. RESULT AND DISCUSSIONS

PID control testing was done by comparing the results between the conventional PID and the fuzzy control system to determine the speed of the given gain error. The experiment was carried out by entering the PID parameter value K_p of 30.6495, K_i of 25.1789, and K_d value of 9.0206 as intended in Fig. 5.

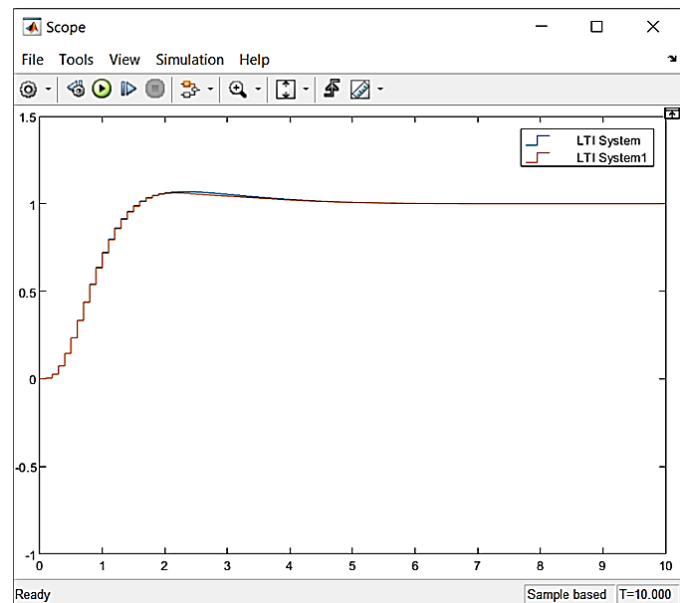


Fig. 5. Curve result

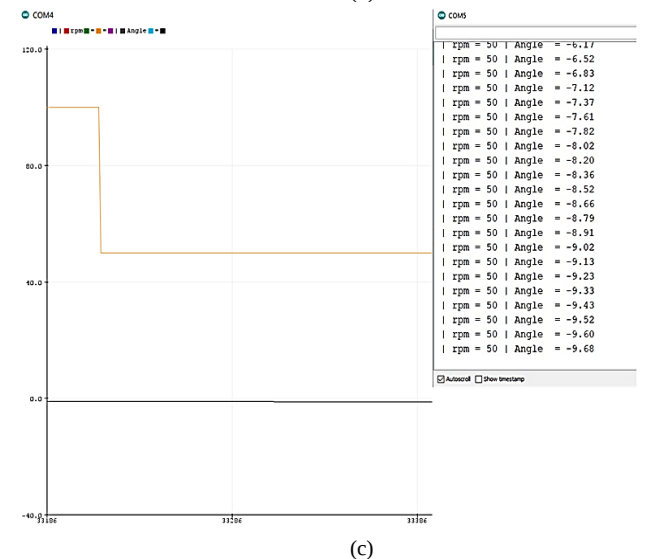
Based on the results of the plot in Fig. 5, the comparison between the conventional PID and the fuzzy controller produced a stable output with a rise-time value of 2 seconds, but there was a difference in the conventional PID which had an overshoot of 1 second. Next, testing motor speed was conducted using Arduino with 3 different surface conditions, namely uphill, horizontally, and descending. The PID parameters for 3 conditions have different values of K_p , K_i , and K_d as follows:

- uphill condition ($K_p = 30.6495$, $K_i = 25.1789$, $K_d = 7.0206$),
- horizontally ($K_p = 30.6495$, $K_i = 25.1789$, $K_d = 9.0206$),
- decreased ($K_p = 30.6495$, $K_i = 25.1789$, $K_d = 9.0206$).

The plot that displays the speed on 3 different surfaces as shown in Fig. 6.

On uphill surface conditions, the angle data shows the number > 2 which indicates that the IMU sensor is in an uphill state with the motor speed resulting from a constant experiment of 100 RPM.

On a horizontal surface, the angle data shows the number 0 which indicates that the IMU sensor is in a horizontal state with the motor speed resulting from a constant experiment of 100 RPM. In decreasing surface conditions, the angle data shows the number < -5 which means that the IMU sensor is in a decreasing state with the speed resulting from a constant experiment of 100 RPM.



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