Mobile robot painted dashed lines as road markings

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Abstract. Painting road markings is one of the infrastructure works that can provide road markings on roads. The fuzzy method is used as a value to determine the midpoint of the width of the road and the robot is on the middle side of the road, then produces a velocity value on the robot that is maintained by the PID method. The result is that the robot can detect the sidewalk with an ultrasonic sensor on the difference of the right sensor error 0.2 cm and the left sensor 0.5 cm through comparison of detection by the sensor and the ruler. The robot can maintain speed and the output value produced by fuzzy speed is 30, then used as input by the PID method with constant values \( K_p = 2.5 \), \( K_i = 0 \), and \( K_d = 0.8 \). The process of painting using a roll model paint tool produces a length of painting 29-31 cm and a long line breaking range of 25-27 cm with a white line width of 8.5-9 cm.

Keyword : tracer, follower, traffic, system, microcontroller

1. Introduction
The high level of accidents that occur in Indonesia is caused by road markings. The use of road markings on the highway can regulate traffic conditions so as to reduce the number of traffic accidents. This is related to the existence of wear and tear on road markings caused by the technical age of road markings that have been long. The work of painting road markings that still require a long period of preparation cannot directly update the road markings that have worn out as well as being an influence, which cannot be done suddenly.

Road markings are signs that can be lines, symbols, or writing that have the function to regulate, warn and guide traffic. Road markings and signs are part of the road equipment. The difference between road markings and signs is that road markings are located attached to the pavement surface while signs are located above or beside the road body. The purpose of road markings and signs to improve traffic safety and smooth traffic. Road markings are more likely to convey information to road users than signs. Road markings are more used as special information to commemorate, guide and control the traffic of drivers and pedestrians. Road users are directed to a special lane that must be used when to overtake another vehicle or change lanes and where to stop when there are signs and traffic signals [1].

Painting road markings is one of the infrastructure works that can provide road markings on roads. Painting can be done using a brush or with a spray machine. Before doing the painting, the steps that must be done are to prepare the implementation of painting and traffic security then to work on the marking application. There are still many road markings that use manual painting systems that require operator guidance on the road that will be marked as road markings and still require the design of the markers to be painted. Preparations made are still inefficient so it requires a long time to do painting.
At the time of painting road markings must block the road so that painting can be done perfectly. The impact of painting the road can cause inconvenience to road users. Painting of dotted road markings has previously been done by an automated system without humans as operators. The results of the study only painted the highway in the middle of the road, namely the dotted markers. At the time of painting of robot road markings still require adjustments to spray to get perfect results and the size of the results of painting, however, the results obtained from the spraying process of the road markings cause areas that are not painted get the effect of painting so as to produce a straight line [2]. In this study, the same painting is dotted line markings with different road widths.

Control of the robot navigation system in accordance with the terrain faced by the robot can be controlled by using hybrid fuzzy-PID (Proportional Integral Derivative) control. The control system is able to control the robot's navigation system. Fuzzy method is used to set the parameter values to the PID (Proportional Integral Derivative) control based on two inputs, namely error and error change. The error value is obtained from the distance set point difference determined by the distance sensor reading value, while the error change value is obtained from the difference between the current error value and the previous error value when the robot is navigating. Fuzzy logic output will determine the value of proportional constants and derivative constants in the PID (Proportional Integral Derivative) control. The results of testing the fuzzy-PID (Proportional Integral Derivative) method produce a robot system that is able to navigate by following a walled field compared to using only one of these control methods [3].

Based on the existing problems, this research makes a system with intelligence that can paint the markers of the dotted line at different widths of the road automatically with a roll painting system that will not cause areas that should not be painted will not get the impact of the painting. In this research, a robot with a hybrid fuzzy-PID (Proportional Integral Derivative) control system was created to be able to navigate the surrounding location and then paint it.

2. Literature Review

This road marking robot automation system can reduce the shortcomings of some existing road markings painting systems. Researches related to automatic painting systems have been carried out, however, for painting road markings still need to be redeveloped. Here are some studies that can support this research, namely the research that makes the development of semi automatic automatic road painting vehicles in the form of electric bicycles. The selection of electric bicycles is used as the main movers driven by humans as operators to do road markings. The painting system is monitored through a computer screen that can be adjusted based on road requirements and can monitor the results of painting. The results of the study at the time of painting require special treatment to get perfect results. If the operator rides an electric bicycle at low speed, the operation will be slow. Stable conditions of operation are obtained when the speed is high but the painting results are poor. Then if the operator rotates the paint valve too much, the paint quality becomes poor and results in painting that is incompatible with the area that must be painted. If the operator consistently rotates the paint valve, the painting results are inconsistent. Therefore, the operating system for speed must be constant and must be optimized to get the appropriate painting results [4].

Next is the research by discussing a robot marking a road marking system that can move slowly following the separator wall then spraying paint on the separator according to a predetermined distance of 10 cm between the right sensor and the left sensor of the object. The results of the study are the movement of robots that have to go straight and forward and then paint the separator. The robot testing is carried out with three different positions between the right sensor and the left sensor of the object so that the robot can determine the value of the distance of 10 cm between the right sensor and the left sensor on the object then do its job to walk forward and paint the separator by spraying it for 2 seconds and the robot will stop when the right sensor and the left sensor read a distance of 20 cm [5].

Another research on the development of robot navigation controls in the room with intelligence control using fuzzy logic. The development is to produce a navigation system and avoid obstacles so that the robot is able to do its job as desired. The study created a system in the form of simulations and
tools using infrared sensors as a barrier detector for robots to navigate. In the application simulation system used by using MATLAB and SIMIAM, the application produces a graph that shows the effectiveness of good navigation performance by using fuzzy logic controls. While the results of the movement of the robot is able to navigate and avoid obstacles that have been set [6]. The next research is about autonomous mobile robot navigation. The robot is equipped with various sensors as input fuzzy values to determine robot navigation and avoid obstacles including the LiDAR sensor, IR and ultrasonic sensors. The robot can navigate in accordance with predetermined paths using the fuzzy inference system method. Fuzzy logic algorithm can process data that can ensure a high level of accuracy for detecting obstacles and avoiding collisions [7].

Other studies discuss how to make a wall follower robot using the following wall algorithm using the PID (Proportional Integral Derivative) tuning control method as a robot control system. The robot navigates through the left and right walls while maintaining the robot's distance from the wall. Full PID (Proportional Integral Derivative) applied to the robotic navigation system results in the robot being able to navigate safely, stable and responsive by determining the PID (Proportional Integral Derivative) parameters, namely Kp = 10, Ki = 2, and Kd = 67 [8]. Furthermore, research that discusses intelligent control to improve the performance of mobile robots. The robot used is the MSI Ihomer robot which is equipped with DSP control, 16 infrared sensors, 24 supersonic wave sensors and two DC motors. The intelligent control used in the study is fuzzy PID (Proportional Integral Derivative). The purpose of the study is to find out that the hybrid fuzzy PID (Proportional Integral Derivative) method produces better robot stabilization than using only one of these methods [9]. Whereas in 2017 there is research to utilize the capabilities of the PID (Proportional Integral Derivative) and fuzzy controllers to control mobile robots on an autonomous straight path. Fuzzy PID (Proportional Integral Derivative) control is used to adjust the motor speed automatically. The results of research on controlling these methods get a very good motor speed so that the robot can achieve the desired goals. The study also simulates movement using the Matlab / Simulink application with the result that the fuzzy PID (Proportional Integral Derivative) method is better than using only the PID (Proportional Integral Derivative) method [10].

Based on researches that have been done before, the research created a dotted line road marking system that can adjust to the width of the road and uses a fuzzy-PID (Proportional Integral Derivative) control method as a completion of the marking system. This research can narrow down the deficiencies in previous studies so as to produce a road marking painting system that suits the traffic needs.

3. Concept of Control System

3.1. PID Flowchart

PID control is a method used on a robot marking a dashed highway markings so that the speed of the robot remains stable at the midpoint of the road with the input value used is the value generated by the fuzzy method. Following the flow of the PID control system used can be seen in Figure 1. The PID control flow is a flowchart for the PID method process used in the robot speed process. The PID control flow in Figure 3.8 has an initial constant value given to Kp, Ki, Kd, Ts, Vnormal is the speed determination of a DC motor, set point and ultrasonic sensor. The output fuzzy value in this process becomes the input value for the PID method then processed to get the motor speed value. When the robot reads US A is greater than US D, the robot is closer to the right side of the road and must make a left turn, if the US A sensor is smaller than the US D sensor, the robot is said to be closer to the left side of the road and the robot must make a turn right. But if the right sensor and the left sensor have the same value, the robot will run straight.
3.2. Flowchart System
Flowchart on the prototype of the dashed line marking robot is used to determine the flow of the existing system on the marking robot with the working system shown in Figure 2. Based on Figure 2 the working system of the line marking robot painting robot which starts with the initialization of the detection of paint, photodiode sensor, ultrasonic sensor and push button. On the push button there are three choices namely start, setting and stop, if the start button is pressed it will proceed to the process of detecting the volume of the paint, photodiode sensor and ultrasonic sensor. If there is paint detection will continue to detect the photodioda sensor, however, if the paint detection runs out then the robot will not run or finish. Then if the photodioda sensor detects more than 500 will proceed to the detection of the ultrasonic sensor but, if less than 500 robots will not run or finish. Furthermore, the ultrasonic sensor reading distance is not equal to zero will be continued in the fuzzy process because the input value of the fuzzy process is the reading value of the ultrasonic sensor, after obtaining the fuzzy output continued in the PID process with the PID input value is the output value of
fuzzy. PID output value to get the output value from the right and left PWM motors and the robot will
do the painting so that it produces a dotted line marking painting value. The robot will finish painting
if the user presses the stop button if it is not pressed, the robot will continue to detect the detection of
paint, photodiode sensors and ultrasonic sensors. Then if the user presses the settings button it will
appear on the calibration and data selection LCD. If the user chooses calibration then there are auto
and manual options, if the user chooses auto then the robot's position must be closer to the sidewalk
and the robot will look for the midpoint then after finding the midpoint the robot will detect paint,
photodiode sensor and ultrasonic sensor readings. Furthermore, if the user selects the manual
calibration displayed by the LCD ultrasonic sensor readings right and left. Then if the user does not
select the calibration button, there is a data button that contains information about the width of the
road and the volume of the paint is still there or has run out. If the user presses the stop button, the
robot will remain silent or finished.
3.3. Mobile Robot

The finished product of the design of the automation system of the highway marking robot painting on the dashed line can be shown in Figure 3 with the dimensions of the robot 45x30 cm and several components needed according to their respective functions.
4. Implementation and Testing

Testing the fuzzy method to find out the fuzzy values obtained in testing different road widths as shown in Figure 4. The method is used for the stability of the detection of the midpoint of the road by detecting the width of the road. The input of the fuzzy method used in the robot are two ultrasonic sensors, one sensor on the right side of the robot and one sensor on the left side of the robot. The output value of the fuzzy method is the speed value of the motor used to control the speed of the robot's course so that the robot stays at the midpoint of the road.

Fig. 4. The painted dashed line as marking road

In Figure 5 is the reading value of the ultrasonic sensor used to get the output speed value from fuzzy. The output value obtained corresponds to the set point value. The speed is generated from fuzzy calculations in accordance with the input. In data 134 to data 158, data 213 to data 233, data 261 and data 284 to data 324 US A sensors detect distances smaller than US D sensors. This means that the robot is closer to the left side so that the fuzzy output value also changes. The US A sensor value always detects a lower value because the changed road width is on the left side of the road. While on the 499th data up to the 501th data the US D sensor detects 41-48 distances and US A detects lower distances so the US D sensor graph rises, as well as the set point value when the road width changes, the set point will also change.

5. Conclusion
The final results of the research of the automation system of the highway marking robot painting on this dashed line that starts from the design process until the test results show that:
1. The applied system runs as desired, ie the robot can paint dashed line markings according to different road widths.
2. The robot can determine the midpoint if the initial position of the robot is on one side of the road with an automatic calibration process by the user.
3. The ultrasonic sensor reading value has the difference between the reading of the direct sensor reading with the actual measurement results using a ruler that has the reading error difference value on the right sensor 0.2 cm and the left sensor 0.5 out of 10 attempts.
4. The robot can detect the width of the road and can stabilize the speed according to the width of the road detected using the fuzzy and PID methods. Fuzzy input values from the ultrasonic sensor readings of the right and left sides of the robot with a straight ramp speed output 30 and a PID input value from the fuzzy output values. The PID constant value is $K_p = 2.5$, $K_i = 0$, and $K_d = 0.8$.
5. The process of painting uses a roll model paint with the result of painting lengths ranging from 29-31 cm and cut lines 25-27 cm.

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