Stability Of Line Follower Robots With Fuzzy Logic and Kalman Filter Methods

Ali Sanjaya\textsuperscript{1,*}, Herman Mawengkang\textsuperscript{2}, Syahril Efendi\textsuperscript{3} and Muhammad Zarlis\textsuperscript{4}

\textsuperscript{1}Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan 20155, Indonesia
\textsuperscript{2}Department of Mathematics, Faculty of Math and Science, Universitas Sumatera Utara, Medan 20155, Indonesia
\textsuperscript{3}Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan 20155, Indonesia
\textsuperscript{4}Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan 20155, Indonesia

\textsuperscript{*}alisanjaya99@gmail.com

Abstract. Line Follower Robot is a wheeled robot that has two wheels on the right side and two on the left side that can follow the line automatically. The robot is designed to navigate and move automatically following a line made and this robot should be able to maintain its stability. This line follower robot uses fuzzy logic method with accelerometer and gyroscope. To gain a good noiseless accelerometer response, Kalman filter is used. Kalman filter can minimize the error of the box in the noise sensitive control and level of noise in sensor before entering the control system. The results shows that robots are succesfully balances then selves, though interruped.

Keywords: Robot Line Follower, Accelerometer, Fuzzy logic, Kalman Filter

1. Introduction
Line Follower robots have the ability to move along the guide line, the development of line follower robots is in great demand for those who are just learning robot technology. The researcher uses fuzzy logic with three membership functions and reduce noise processing using the kalman filter method, so that the sound from the sensor output will disappear, which can maximize and maintain the stability of the line follower robot. The fast movement of the robot when it finds a bend will cause the robot to get off track. This stability setting is important if you face a change of track from a straight track to a bend or vice versa from a bend to a straight track.

2. Supporting theory
2.1 Robot
Robot development has existed since ancient Greece as a classic robot, Japan's rise in the robot industry in 1967 with the release of versatran robots from AMF, continued in 1970 kinematic configuration as a standard robotic arm was introduced by Prof. Victor Scheinman from Stanford...
University, lastly in 2000 several companies exhibited robots with the names ASIMO and AIBO. Mechanical work and physical work are now widely used by robots, with human supervision and control. Robot mobility that keeps on moving and moving because of the presence of the motor as a prime mover.

2.2 Line Follower Robot.
Line follower robots are moveable robots along the line guide path. The wave guide line used is in white placed on a dark surface. The basic principle of working this line sensor is reflecting light. The intensity of light received is in the form of voltage, the amount of voltage produced is influenced by the amount of light intensity received, this voltage is in the form of an analog signal to be processed by the microcontroller. DC motors are generally used as the driving force for wheeled robots, DC motor is a direct current motor, which can produce motion power in the form of rotation on the motor, the speed of rotation of the DC motor shaft is determined by the amount of voltage applied.

2.3 Fuzzy Logic
The use of fuzzy logic has been applied in various fields of science such as medicine, economics, marketing, technical research, various predictions, classification and matching of image patterns. Theory of fuzzy logic is written by Lotfi A. Zadeh, Unclear logic does not mean fuzzy logic but how fuzzy logic is used to describe uncertainty, Users can create commands on the fuzzy logic controller and process the rules made on the target system control, which can be easily modified for performance improvements and changes.

2.4 Kalman Filter
The least squares estimator to minimize the approximate square of the stochastic linear system can use the kalman filter. The recursive concept can distinguish kalman filters from certain data processing concepts, the recursive nature of the kalman filter is done by not having to store all previously generated data, the data that has been generated is then processed again to get new measurements, with the aim of estimating the dynamic state of the system. In a robotic system the use of kalman filters is widely used and has a major influence on the development of robots, especially in resolving the uncertainty of localization of robots, visual navigation, object tracking, robot control and robotic manipulation in situations where GPS is inaccurate and inertial sensors are not available.

3. Related Work
The steps that the author designed in analyzing the data using fuzzy logic and the Kalman filter method on linefollower robots is by entering the original data from the sensors used, the result of filter sensor is gained by minimize of the value in data sensor. fuzzy logic and kalman filter method will test the results of this data, how to get the response value on the robot linefollower if there is noise to maintain balance. the system testing phase used by the author can be seen in Figure 1.

![Figure 1. Shows the system testing phase](image-url)
3.1 Flowchart Design
Flowchart design for runs the robot line follower used in research as in figure 2:

![Flowchart Design](image)

Figure 2. Robot movement flowchart

3.2 Flowchart System
The balance of the robot system can be implemented and illustrated in figure 3:

![Flowchart System](image)

Figure 3. Flowchart System
4. Evaluation

4.1 Process Control Using Kalman Filter

Before entering the control process of the actuator or DC motor, the author must obtain the input value of the sensor used in the stability of the two-wheeled robot. The sensor value obtained will be minimized or minimized the value or noise that occurs in the sensor and is able to smooth the movement of the robot by the Kalman filter method. The graph of the response of the original value and the filtered value can be illustrated in Figure 4:

![Figure 4. Sensor Value Graph and Sensor Filter Results](image)

From the results of Figure 4.1 above it can be seen that the result of the Kalman filter process is the result of the original input data or raw data from the sensor used. Kalman filter is a filter that blocks the up and down values so that the value does not rise and fall drastically but can be regulated how fast and how slow the value changes. The sensor value contained in the calculation is taken from the sensor data filter table. To clarify the results of the Kalman filter, each value can be seen in the table and can be illustrated in Table 1:

**Table 1. Nilai Data Sensor dan Hasil Filter Sensor**

| Sensor Value | Sensor Filter Results |
|--------------|----------------------|
| 60.02        | 56.12                |
| 22.42        | 27.27                |
| -12.43       | -6.64                |
| 46.82        | 39.02                |
| -25.79       | -16.33               |
| 52.34        | 42.32                |
| 9.17         | 14                   |
| 8.6          | 9.39                 |
| -6.38        | -4.08                |
| 9.74         | 7.72                 |

From table 1 above can be seen the results of the value filter can minimize or be reduced again by changing the values that have been determined. From testing the sensor data filter it can be concluded that the Kalman filter method is able to minimize or minimize the value or noise that occurs in the
sensor and is able to smooth the robot's movement according to the control model used for the control actuator or DC motor.

4.2 Process Control Using Fuzzy Logic

In fuzzy testing to get an actuator or dc motor control value, three membership functions will be used. The first thing to note is to determine the precision and accuracy of the robot body before getting the control values for actuators or dc motors. Then the writer will look for values for actuator or dc motor control using fuzzy logic. Sensor input value that will be used as the main value or input value taken from the reading of photodiode line sensor data can be seen in Table 2.

| Sensor Input Value | Fuzzy Value Results |
|--------------------|---------------------|
| 164.51             | 120                 |
| 164                | 120                 |
| 163.01             | 120                 |
| 161.78             | 120                 |
| 161.82             | 120                 |
| 166.6              | 120                 |
| 172.4              | -7.33               |
| 174.84             | -180                |
| 178.8              | -180                |

Table 2 shows that the fuzzy output response values that have been issued are not optimal for controlling actuators or dc motors. The graph of the actuator or dc motor response can be seen in Figure 5:

In Figure 4.2 shows the results of the response of an actuator or dc motor that is not good because the response of the actuator or dc motor control is still far from the expected results to be able to maintain the balance of the robot when the robot follows the line. The value of the data from Fuzzy that is applied actually makes the robot's response to the line become less good, this condition is seen in the initial process of the robot. So that the addition of fuzzy methods in this experiment is far from the expected results.
5. Conclusions

in accordance with the test data, the authors take several conclusions:
1. Based on the data, the balance of the robot cannot be maximized by measuring it using fuzzy logic but the noise value from the original graph on the sensor can be reduced by the kalman filter method.
2. Stability during robot movements in lines requires a better algorithm.
3. The greater filter coefficient value and the faster the sampling time will speed up the time constant in the complementary filter algorithm. The magnification of the filter coefficient will cause an increase in noise in the output signal. Whereas the acceleration of sampling time will cause the output signal to more quickly follow the response of the actual slope angle.

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