Control of motion stability of the line tracer robot using fuzzy logic and kalman filter

To cite this article: M S Novelan et al 2018 J. Phys.: Conf. Ser. 978 012066

View the article online for updates and enhancements.
Control of motion stability of the line tracer robot using fuzzy logic and kalman filter

M S Novelan ¹, Tulus ² and E M Zamzami ³

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

Abstract. Setting of motion and balance line tracer robot two wheels is actually a combination of a two-wheeled robot balance concept and the concept of line follower robot. The main objective of this research is to maintain the robot in an upright and can move to follow the line of the Wizard while maintaining balance. In this study the motion balance system on line tracer robot by considering the presence of a noise, so that it takes the estimator is used to mengestimasi the line tracer robot motion. The estimation is done by the method of Kalman Filter and the combination of Fuzzy logic-Fuzzy Kalman Filter called Kalman Filter, as well as optimal smoothing. Based on the results of the study, the value of the output of the fuzzy results obtained from the sensor input value has been filtered before entering the calculation of the fuzzy. The results of the output of the fuzzy logic hasn't been able to control dc motors are well balanced at the moment to be able to run. The results of the fuzzy logic by using membership function of triangular membership function or yet can control with good dc motor movement in order to be balanced

Keywords: Line Tracer, Robot Balance, Logika Fuzzy, Kalman Filter

1. Introduction

Robots are all something that can be programmed and reprogrammed, by having manipulator mechanical / propulsion designed to moving objects, components or special tools with various a flexible program / easy adapted to do various duties. The one example is the robot tracer a line. In general, tracer a line robot made by using a wheel three or four, two rear wheels connected to a DC motor serve as a drive and one or two front wheels acting as a guide but a fuzzy logic line robot will be created with the expected smooth movement compared to the PID method. This is because the line sensor that still no noise. The noise will be filled by using kalman filter method so that the noise from the line sensor output will be lost

2. Theoritical Basis

2.1 Robot Line Follower / Line Tracer Robot

Line follower or Line tracer robot is a robot that can move following the line guide path. The wave guide line used in this case is a white line placed on a dark surface, or vice versa, the black line placed on the surface is white. As for robot electronics that is a robot that includes the main controller circuit (main controller), the sensor circuit, and the driver circuit. And the important system in making the follower robot is the programmer language (software). There are two kinds of line follower robot is a regular line follower without using program and line follower with microcontroller program.
2.2 Definition of Robot
The word robot comes from the Czech language, meaning robota worker, began to become popular when a Czech national writer, Karl Capek, making a comedy show in 1921 entitled RUR (Rossum's Universal Robot). Robot can be interpreted as a machine that can work continuously either automatically or in control. Robots that are used to help human tasks do things that are difficult or do humans directly. For example handling radioactive materials, assembling cars in the car assembly industry, exploring planet mars, as a medium of defense or war, and so on.

2.3 Fuzzy Logic
Fuzzy logic was first introduced by Jan Lukasiewicz in the 1920s as a probability theory. This logic extends the range of truth values to all real numbers at intervals between 0 and 1. Selanjutnya further investigated by Max Black in the 1930s in his research on vagueness: an exercise on logical analysis. In 1965, Professor and head of the department of electrical engineering at the University of California at Berkeley, Lotfi Zadeh, rediscovered, identified, explored, promoted, and fought for fuzzy logic. Professor Zadeh expanded the work space of probability theory into a formal mathematical logic system, and a new concept for applying natural language terms to his research, the 'Fuzzy sets'. This new logic is called fuzzy logic. Fuzzy logic is widely used because fuzzy logic is similar to human thinking. Fuzzy logic systems can represent human knowledge in mathematical form by resembling human thinking. Fuzzy logic has membership degrees in the range 0 (zero) to 1 (one), in contrast to digital or discrete logic that has only two values, namely 1 (one) or 0 (zero). Fuzzy logic is used to translate a quantity expressed using language (linguistic), suppose the rate of speed of the vehicle is expressed slowly, so fast, fast, and very fast. Fuzzy logic can process uncertain values of limits, such as "very," "a little", "more or less."

2.4 Kalman Filter
Kalman filter is a digital filter that is able to estimate any process very effectively. In the process state, the filter calm algorithm is believed to provide an estimated condition. Kalman filters can also minimize square errors in noise-sensitive control systems and can reduce the noise-exposed measurements of sensors before entering the control system.

\[
x_k = F_k x_{k-1} + G_k u_k + w_k,
\]

\[
y_k = H_k x_{k-1} + v_k,
\]

Where \(x_k\) expressed as a state or state of the system, \(y_k\) is the measurement of output, \(u_k\) is an input that is known by the system, \(w\) is the process of noise, \(v\) is the measurement noise, \(k\) is an index of time and \(F, G\) and \(W\) is a matrix. Each number is a vector containing more than one element. On algorithm kalman filter writer will make \(u\) as input result acceleration, \(z\) as the output corner and \(x\) as actuator speed and position. Noise and noise measurements can be presented oleh matriks konvarian \(Q\), and \(R\) value \(Qw\) and \(Rv\) plays an important role to determine the ability or output performance of the filter calm. To get the value of matrix authors use advanced statistic equations or manually tuned so that will get the desired output.

3. The Scheme Of System
This research has several stages in the form of a system scheme to create a model that will be used for robot line tracer. To get optimal result in stability of robot wheeled two researcher do some stages before giving input value which will be used for control of robot of tracer line of two wheeled that is by testing robot using original input data of sensor used. After the sensor data input value is obtained, the researcher will implement the kalman filter to smooth the noise on the sensor, Then the researchers will get the appropriate values to minimize noise on the sensor, From the test results will then get the value to be combined with the method to be studied and will get the robot response value to stay
balanced in the event of noise and disturbances that occur in the robot. The system scheme of the stages in this study is illustrated in Figure 1.

![System Scheme](image)

**Figure 1.** Stages of Line Tracer Robot Research Using Fuzzy Logic with Kalman Filter

### 3.1 Flowchart Program

In the flowchart this program describes the stages of how the system works the program used in starting the robot through the black line by taking into account the speed and stability of the robot in fuzzy logic algorithm. Flowchart program to run Line Tracer Robot is illustrated in Figure 2:

![Flowchart](image)

**Figure 2.** Flowchart program BASCOM AVR Line Tracer
3.2 Flowchart System

In order to see the structure of the way the system will be created and in carefully made flowchart (flowchart). Flowcharts are used as the basic reference in making a system or program flow designed. The implementation flowchart of the line tracer robot system is illustrated in Figure 3:

![Flowchart](image)

**Figure 3.** Flowchart Implementation of robot line tracer algorithm using fuzzy logic with kalman filter

4. User Interfaces

4.1 See the preview

The graph of the difference between the raw sensor values and the filtered sensors values of the filter cylinders is illustrated in the Figure 4:
4.2 Process Control Using Fuzzy Logic

Graph of dc motor response in reading input and output data

5. Conclusions
From the results of research and discussion undertaken conclusions can be drawn as follows:
1. Test results from the fuzzy logic method is not too good for the balance control system on the two-wheeled robot when passing through the interference.
2. Test results from the Kalman filter method can reduce the original value or the raw value of the sensor.
3. Test results from a combination of fuzzy logic and PID methods can pass through disturbances as high as 1 cm.
4. Better rule-based is required for a two-wheel balance control system that is able to maintain balance while passing through interference
References

[1] Bakdi A and Hentout 2017 Optimal Path Planning and Execution for Mobile Robots using Genetic Algorithm and Adaptive FuzzyLogic Control International Journal of Fuzzy Systems, 16(3)

[2] Dwisaputra I, Sulistijono I A and Nugraha M I 2015 Two Wheels Balancing Line Tracer Robot Using Fuzzy Logic Control, The 13th Industrial Electronics Seminar 2011 (IES 2015), Electronic Engineering Polytechnic Institute of Surabaya (EEPIS), Surabaya.

[3] Apriliani E, Subchan F, Yunaini and Hartini S Estimation and Control Design of Mobile Robot Position Far East Journal of Mathematical Sciences (FJMS) (Puspha Publisher, Surabaya).

[4] Farooq U, Amar M, Asad M U, Abbas G and Hanif A 2014, Fuzzy Logic Reasoning System for Line Following Robot IACSIT International Journal of Engineering and Technology, No. 4, Vol. 6, Hal. 244-248

[5] Holland J M 2015 Designing Autonomous Mobile Robot, Inside the Mind of an Intelligent Machine (Elsevier Inc, US America)

[6] Nguyen H-N, Zhou J, Kang H-J 1990 A calibration method for enhancing robot accuracy through integration of an extended Kalman filter algorithm and an artificial neural network IEEE International Conference on Robotics and Automation, Proceedings, vol. 2, 1990, pp. 1032–1037