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Intelligent Path Guidance Robot for Visually Impaired Assistance

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Abstract

Visually impaired has limited movement using the classic white cane. Currently, there are many designs for devices that can assist the blind moves better in unfamiliar environment. Then, controllers were applied in the devices' system so that it can improve the system's efficiency and accuracy in dealing with real-time situations. That's when the intelligent system was introduced in the field to handle nonlinear process of the devices. The purpose of this study is to control steering angle system for an intelligent path guidance robot by using Fuzzy Logic Controller with MATLAB applications. The methods includes the designing of the fuzzy controller for the robot system using Fuzzy logic toolbox, SIMULINK implementation with the results, and the step responses of the system. The fuzzy controller was used to give output for the robot's motor in terms of angle so it can be return back to its track. Two inputs for the system was introduced, error and change in error of the angle of the robot relative to the track given, while the output is the steering angle for the robot. Rule bases for the controller was developed based on the expert knowledge of the system which consist of 9 fuzzy rules. The step responses shows the overshoot, settling time, rise time and peak time after the implementation of the designed Fuzzy Logic Controller in the system.

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Keywords: visually impaired; path guidance; fuzzy logic controller, steering angle system

1. Introduction

Visual impairment is a functional limitation of an individual eye or both pairs of eyes or the visual system which is the neurobiological circuitry and processing that enable living things to see. According to the World Health Organization (WHO), there an estimated 285 million people to be visually impaired worldwide, which is a significantly enormous number. They are divided into blind people which has total loss sense of sight, and people

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with low vision which visual acuity is 20/70 or poorer in the better-seeing eye and cannot be corrected or improved with regular eyeglasses [1]. People with visual impairment have much problem on travelling alone especially when dealing with new and unfamiliar route. Safe mobility is among the greatest challenges faced by the visually impaired in day-to-day life [2]. In Japan, Pedestrian ITS (Intelligent Transport System) project was introduced to develop a system that allows safe, secure, and smooth travel by all pedestrians, including the elderly, the visually impaired, and wheelchair users, as well as cyclists [3]. The government and local authorities have built a special pedestrian lane with 'dimpled' pavement to assist them when walking with their cane however, this facility is not available everywhere, usually just in the middle of the city and suburban area. Therefore, an extensive fundamental research on novel intelligent path guidance robot to assist visually impaired people must be conducted. This would be useful for them to walk independently, reaching their desired destination safely as the obstacle avoidance system improved.

The robot can perform according to the system's specifications, however the implementation of a controller can improves the system's performance. A controller's efficiency was evaluated based on the responses obtained from the plant after its implementation. The evaluation of the controller is in terms of percentage overshoot, settling times, rise time and peak time [4]. The objective was to minimize the noise effects in the system. A fuzzy controller was introduced in the concept of a linguistic variable. The fuzzy logic approach offers a simpler, quicker and more reliable solution that is clear advantages over conventional controller [5]. The control action in Fuzzy Logic Controller can be expressed with simple "IF-THEN" rules. Besides that, fuzzy controllers are more efficient than classical controllers because they can cover a much wider range of operating conditions than classical controllers and can operate with noise and disturbances of a different nature [6].

This study focuses on the development of a fuzzy logic controller for the control of the steering angle of a path guidance robot. The Mamdani type of fuzzy interference system is proposed herein, where the controller will gives output of angle values to drive the robot back to its track.

The next section introduces the Fuzzy Logic Controller for the steering angle system. Section 3 describes the SIMULINK model for the robot's system, defining the inputs and output for the FLC. The simulation result is discussed in section 4, while section 5 states the conclusion and recommendations reached after finished this research.

2. Fuzzy logic control of the steering angle

An intelligent path guidance robot needs a controller that can handle the prevailing nonlinear trends and uncertainties associated with it. Fuzzy logic inference system (FIS) is based on fuzzy set theory, which is to model a complex nonlinear problems. Compared to traditional binary sets (true or false values), the variables may have a truth value that ranges in degree between 0 to 1 [7]. Fuzzy logic is a way to make machines more intelligent to reason in a fuzzy manner like humans [4].

Fuzzy logic control has been introduced to enhance and improve a system's performance, and was widely implemented in many real-time applications. A model of fuzzy logic is a logical-mathematical method which is based on "IF-THEN" rule system and has four main parts.

- Fuzzification
- Fuzzy inference
- Rule base
- Defuzzification

2.1. Modules of the Fuzzy Logic Controller

The components for a fuzzy logic controller can be seen in the Figure 1 which describes the flow of the processes in the controller.

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Fuzzification

Fuzzification is a process of converting real number of crisp variable into linguistic variable. It meaning that the process wants to assign linguistic value, which is defined by relative number of membership function to variable.

Fuzzy inference

Fuzzy inference system is to calculate the truth value of each rule base designed. It can be shown in the Fuzzy logic toolbox in MATLAB, the developer of the fuzzy logic rule bases can get the truth value of the output by setting the value for the input.

Rule base

Mamdani was used for the interpretation of the rule bases. The rules was developed based on an expert knowledge of the system. For 3 membership functions of two inputs, the rule bases of the controller can be seen in 3x3 table form which result in 9 rule bases needed for the fuzzy controller can be implemented in the system.

Defuzzification

It is a process of converting back the fuzzy output to crisp number. This study used Centroid method for defuzzification which calculate the crisp value of the output by finding the value of the membership function gravity according to the fuzzy value obtained previously. Therefore, defuzzification needed to convert fuzzy value of two angle error and change in error, into the steering angle for the robot.

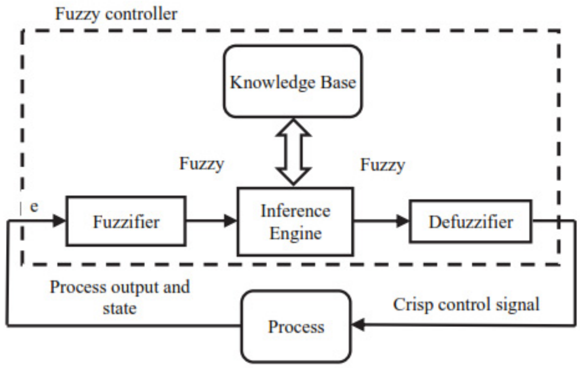


Fig. 1. Fuzzy logic controller processes flow chart. (M.A. Ayob et al, 2013)

2.2. Input and Output Parameters for the FLC

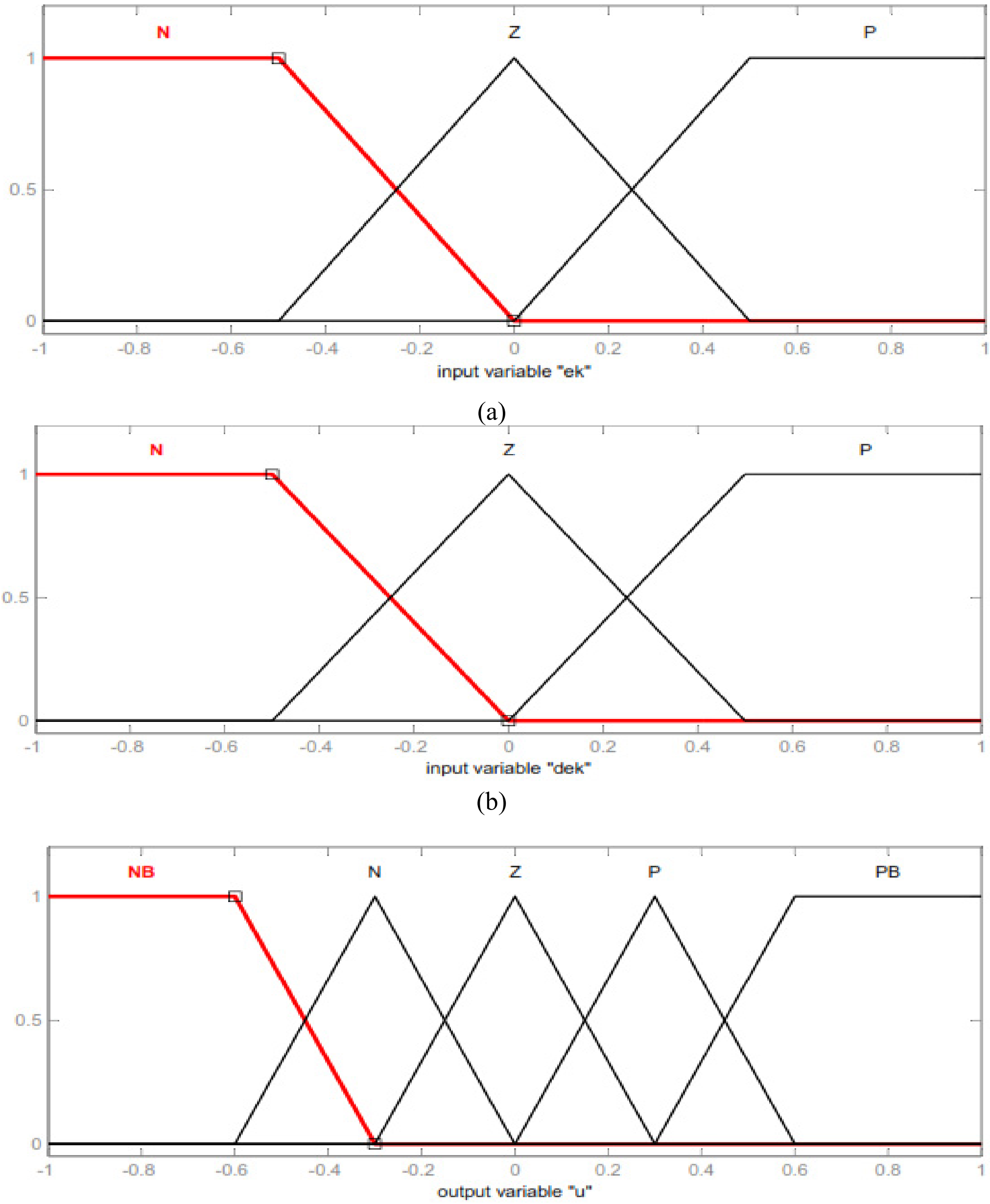
This study considered the error and change in error of current robot's direction angle relative to desired angle as inputs to the FLC structure. The output of the controller is the steering angle needed for the robot to return back to track given. The inputs and output parameters were normalized within the range of -1 to +1.

2.3. FLC Membership Functions

Types of membership functions used in this research were Triangular and Triangular with Trapezoidal shoulders. The considered number of MFs for both inputs was 3 while the output has 5 MFs. For inputs, the MFs were consist of Negative (N), Zero (Z), and Positive (P). Then, there were 5 MFs introduced for the output that consist of Negative Big (NB), Negative (N), Zero (Z), Positive (P), and Positive Big (PB). Figure 2 shows the graphs of the fuzzy logic for the inputs and output, using the Fuzzy logic toolbox. Table 1 describes the rule bases made for the system. Then, Figure 3 shows the 9 rule base developed for the fuzzy controller and surface viewer of the fuzzy inference system.

Table 1. Rule table for output variable, steering angle of the robot.

Error (ek) / Change in error (dek)	N	Z	P
N	NB	N	Z
Z	N	Z	P
P	Z	P	PB



(c)

Fig. 2. Triangular membership functions for (a) error (ek); (b) change of error (dek); (c) steering angle (u).

3. SIMULINK Model: FLC with the steering angle system

The overall output from the controller is a new steering angle for the robot. As indicated in figure 4, it shows the model of the controller implementation into the system which results in the steering angle system module takes the FLC output and convert it to steering angle needed for the robot to return back to its track.

In this section, transfer function for the steering angle system is used to find out the response of the system with applying step function as the input for the model.

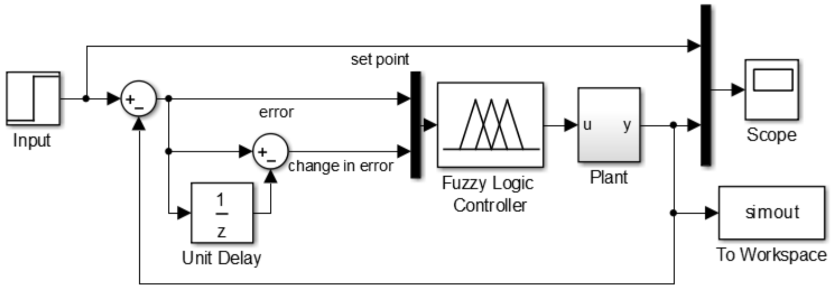


Fig. 3. SIMULINK implementation for the steering angle system.

4. Results and Discussions

Simulation output from Simulink is shown in Figure 5 with simulation time of 100 seconds. It can be seen that the fuzzy controller resulted in giving angle needed for the robot to return back to the track provided. The closed loop response shows the robot's movement on the track in regaining back zero difference in angle of direction relative to the track's angle from its point of view. The fluctuations explain the wobbling movement of the robot to return back on the track. Table 2 shows the output responses after the implementation of fuzzy logic controller into the robot's system.

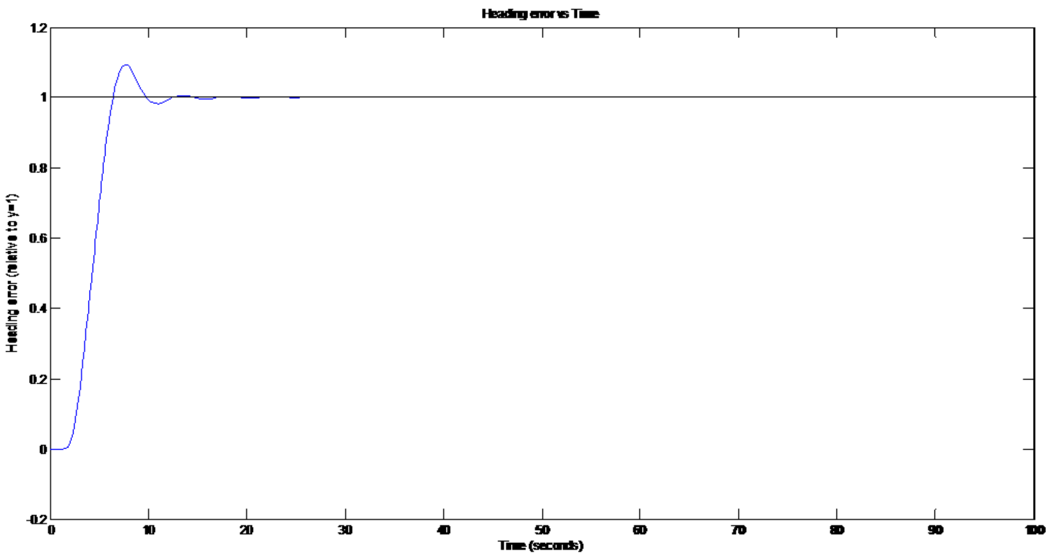


Fig. 4. Step response of the system using fuzzy logic controller.

Table 2. Output responses for the FLC.

Title	Values
Rise time (sec)	3.1620
Peak time (sec)	7.7569
Settling time (sec)	9.2950
Percentage overshoot (%)	9.4423

5. Conclusion and Recommendation

This paper has described the development of a fuzzy logic controller based on the Mamdani scheme. It stated the indices used in identifying the performance of the developed controller. In addition it gave a brief description of the workings of the plant model. It proved the capability of FLCs in handling complex steering angle systems such as those for intelligent path guidance robot system.

The results of the simulation were obtained using MATLAB and SIMULINK. They show the effect of applying fuzzy logic controller into the robot's steering angle system. The proposed fuzzy controller can be evaluated through the output responses of the system.

Two recommendations for further work are proposed here. The first is on the consideration of comparing performances between controllers, PID, Fuzzy, PID-Fuzzy and etc. Thus, we can see the effects of each controller into improving the performance of the system. Next, we can implement the best controller into the intelligent path guidance robot system.

The second recommendation is to focus in optimizing the controller. There are two method to optimize fuzzy logic controller, first by optimize the gain of the input and output, second is to optimize the membership function itself. After finished all those techniques, evaluation should be done to decide which method can optimize the system in increasing the accuracy and efficiency to function in rel0time situation. Then, we can bring the development of the robot prototype into the next level.

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References

1. Visual impairment and blindness. Retrieved August 17, 2014, from http://www.who.int/mediacentre/factsheets/fs282/en.
2. Singh V., Paul R., Mehra D., Gupta A., Sharma V. D., Jain S., Agarwal C., Garg A., Gujra; S. S., Balakrishnan M., Paul K., Rao P. V. M., Manocha D.. 'Smart' Cane for the Visually Impaired: Design and Controlled Field Testing of an Affordable Obstacle Detection System, 2009.
3. Ando T., Tsukahara R., Seki M., Fujie M. G. A Haptic Interface "Force Blinker 2" for Navigation of the Visually Impaired. *In IEEE Transactions on Industrial Electronics,* Nov 2012.
4. Resha Kushwah, Sulochana Wadhwani. Speed Control of Separately Excited DC Motor using Fuzzy Logic Controller. *In International Journal of Engineering Trends and Technology (IJETT), Vol 4:6*, 2013..
5. Zadeh L. A. Outline of a New Approach to the Analysis of Complex Systems and Decision Processes. *In IEEE Transactions Systems, Man and Cybernetics, SMC-3,* 1973, pp. 28-44.
6. Zeyad Assi Obaid, *Member*, IAENG, Nasri Sulaiman, M.H. Marhaban, M. N. Hamidon, *Member,* IAENG. Analysis and Performance Evaluation of PD-like Fuzzy Logic Controller Design Based on Matlab and FPGA. *In IAENG International Journal of Computer Science, 37:2, IJCS_37_2_04,* 2010.
7. Adeyinka Oluwo, Md Raisuddin Khan, Momoh Jimoh E. Salami. Intelligent Temperature Control of a Tropical Post-harvest Storage System.
8. M.A. Ayob, D. Hanafi, A. Johari. Dynamic Leveling Control of a Wireless Self-Balancing ROV using Fuzzy Logic Controller. *In Intelligent Control and Automation, Vol. 4 No.2*, 2013, pp. 235-243.