

CONTROLLING CAR MOVEMENTS WITH FUZZY INFERENCE SYSTEM USING AID OF VARIOUS ELECTRONIC SENSORS

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ABSTRACT

The driver assistance system is a complex mobile robot system which was designed and built to help drivers to control a car. The system makes a car able to stop automatically within the distance to the obstacles around and reduced car accidents. This paper presents a miniature of a driver assistance system which was designed and built on 1:10 scale R/C car. The fuzzy car adapts fuzzy inference system as its control system. Fuzzy inference system help to simplify a complex driver assistance system by generating the control system from human experience and it allows to build a complex system easily. The fuzzy inference system is embedded on a micro-controller. The micro-controller control the fuzzy car by giving the instructions to the mechanical actuators. Fuzzy car could sense the distance and the track line with the aid of various electronic sensors. The design consisted of two main sections : software analysis for the fuzzy system with the programs which were integrated to the electronic components and electronic analysis which aid fuzzy system to take control of the mechanical actuators. The result of this research shows a complex control system can be built simply by using fuzzy inference system.

Keywords: Driver assistance system, Fuzzy car, Fuzzy inference system, Sensors.

INTRODUCTION

Driver assistance system is a complex autonomous mobile robot which previously has been developed. Currently, the driver assistance system becomes the facility which was offered by European car producers. Issues of traffic, vehicles parked, and even the physical condition of the driver into the factors which caused the number of research on driver assistance systems. Limitation of a driver, such as fatigue, visibility, and the factor of human error is inevitable and often result in traffic accidents. Advances in technology trying to solve this problems through a driver assistance system. This system aims to reduce the risk of car accidents. The driver assistance is also expected to assist in controlling vehicle speed, keep the distance with other vehicles or help the vehicle to be parked easily. This system could sense the track line and will guide the driver to stay on the track and serves to control the vehicle speed. The implementation of fuzzy inference system using aid of various electronic

sensors for control a car movements is a main issue in this paper. Controlling a car movements in an uncertain and complex environment are become a problem and considerable research has been done for making an efficient algorithm to build a good control system in navigation. Among them, adaptive control and behavior based control are most popular control algorithms and driving research in control system of navigation.

Implementation of the movement control system on the R/C car is expected to provide information about the performance of fuzzy inference system in controlling car movements. The goal of this paper is to create a miniature of a driver assistance system on 1:10 scale R/C car which implement a fuzzy inference system using aid of various electronic sensors. Fuzzy car will follow a track with specific color of line and accelerate depend on the car distance to the surrounding object.

EXPERIMENTAL METHOD

Fuzzy system is constructed in this research will serve to control the movement direction and speed of the fuzzy car. Membership functions as input and output will be interconnected with a set of rules that will be made to control the car movement. After the input of fuzzy system is obtained from the environment sensing by the sensors, the fuzzy system will perform a process that consists of three stages: fuzzification, rule evaluation and defuzzification. The output of this system will control the movement of both motors in fuzzy car. Figure 1 shows the fuzzy inference system with two inputs and two outputs.

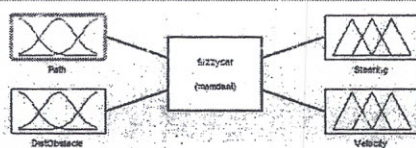


Figure 1: fuzzy inference table

Fuzzy system will control the motion of two dc motors in fuzzy car. Front motor will move based on the sensing value of black lines on the track by proximity sensors, while the rear motor will move based on the sensing value of the object distance by sonar sensors. The fuzzy system changed into the linguistic values both of sensing results. Linguistic values of input variable in fuzzy system consists of Path and DistObstacle (Obstacle Distance). The sensing value of the track line will enter into the Path input variables, and then incorporated into the terms or fuzzy sets of Path. The distance value will be entered into the DistObstacle input variables, and then incorporated into the terms or fuzzy sets of DistObstacle. Fuzzification of Path and DistObstacle inputs on fuzzy system is shown in Figure 2. The input path is defined with linguistic variables (RMC-Right Medium Curve, RLC-Right Low Curve, Straight, LLC-Left Low Curve, and Left Medium Curve). And the second input for detect the object distance around the fuzzy car is defined with linguistic variables (VeryClose, Close, Middle, and Far).

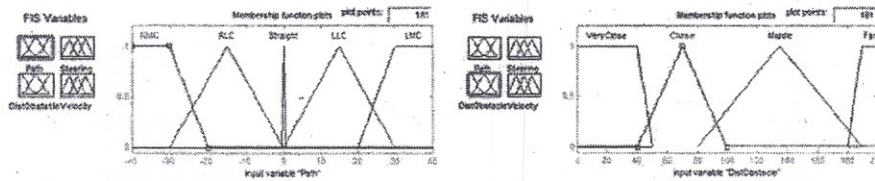


Figure 2: Membership function for input path and obstacle distance

Steering and Velocity Controller: Figure 3 shows the membership function for the Steering and Velocity output variables. The fuzzy controller for steering output is denoted by linguistic variables (Strong Turn Right-STR, Turn Right-TR, Straight Forward-SF, Turn Left-TL, Strong Turn Left-STL). And the fuzzy controller for velocity output is denoted by linguistic variables (Zero, Slow, Medium, and Fast).

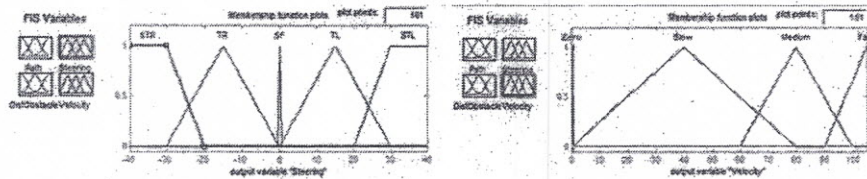


Figure 3: Membership function for output steering and velocity

Fuzzy controller Rules to control steering and velocity: Fuzzy controller has total 20 rules for navigation, speed acceleration, automatic distance control and following the black strip path. To realize these navigation skills, following rules are defined.

1. If (Path is Straight) and (DistObstacle is Far) then (Steering is SF) (Velocity is Fast)
2. If (Path is Straight) and (DistObstacle is Middle) then (Steering is SF) (Velocity is Medium)
3. If (Path is Straight) and (DistObstacle is Close) then (Steering is SF) (Velocity is Slow)
4. If (Path is Straight) and (DistObstacle is VeryClose) then (Steering is SF) (Velocity is Zero)
5. If (Path is LLC) and (DistObstacle is Far) then (Steering is TL) (Velocity is Medium)
6. If (Path is LLC) and (DistObstacle is Middle) then (Steering is TL) (Velocity is Medium)
7. If (Path is LLC) and (DistObstacle is Close) then (Steering is TL) (Velocity is Slow)
8. If (Path is LLC) and (DistObstacle is VeryClose) then (Steering is SF) (Velocity is Zero)
9. If (Path is LMC) and (DistObstacle is Far) then (Steering is STL) (Velocity is Slow)
10. If (Path is LMC) and (DistObstacle is Middle) then (Steering is STL) (Velocity is Slow)
11. If (Path is LMC) and (DistObstacle is Close) then (Steering is STL) (Velocity is Slow)
12. If (Path is LMC) and (DistObstacle is VeryClose) then (Steering is SF) (Velocity is Zero)
13. If (Path is RLC) and (DistObstacle is Far) then (Steering is TR) (Velocity is Medium)
14. If (Path is RLC) and (DistObstacle is Middle) then (Steering is TR) (Velocity is Medium)
15. If (Path is RLC) and (DistObstacle is Close) then (Steering is TR) (Velocity is Slow)
16. If (Path is RLC) and (DistObstacle is VeryClose) then (Steering is SF) (Velocity is Zero)
17. If (Path is RMC) and (DistObstacle is Far) then (Steering is STR) (Velocity is Slow)
18. If (Path is RMC) and (DistObstacle is Middle) then (Steering is STR) (Velocity is Slow)
19. If (Path is RMC) and (DistObstacle is Close) then (Steering is STR) (Velocity is Slow)
20. If (Path is RMC) and (DistObstacle is VeryClose) then (Steering is SF) (Velocity is Zero)

The fuzzy car is a custom-made from 1:10 scale R/C car, which is mounted with two independent front and rear driving wheels driven by two DC motors. The steering mechanism control by the velocity of the front DC motor which drives the front wheel. The direction of fuzzy car movement depends on the front wheel. If the front wheel turn to the right than the fuzzy car move to the right too. And the speed acceleration control by the velocity of the rear DC motor which drives the rear wheel. If the rear wheel run fast than the fuzzy car run fast

too. Using micro controller with the input from sensors controls the two motors of fuzzy car. A DC battery set is used to provide power to the motors and the control system. The control circuit and the driver circuit are provided on the board. The fuzzy car uses six proximity sensors at the bottom front to sense the black strip path and two sonar sensor at the front and back side to sense the object distance to the fuzzy car. The proximity sensors are tuned to corresponding black colors to keep the car stay on the true path. And the sonar sensors are tuned to corresponding the obstacle to keep the fuzzy car distance to the object around the car. The rules for the fuzzy car stay on the track and keep the distance to the objects around is feed to the micro controller in the form of programme, micro controller decides the next move according to the algorithm. Figure 4 shows proximity and sonar sensors are used on the fuzzy car.

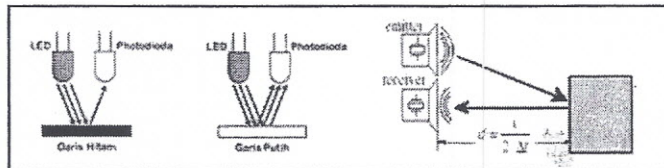


Figure 4: Proximity and sonar sensors

RESULTS AND DISCUSSION

Testing is done by checking the suitability of the fuzzy car performance when through the development environment that has been determined. The fuzzy car moves on a black striped path that leads the car moves to the right, left, and straight. Fuzzy car will be faced with a few curves in different degrees. And the car should not be out or strayed far from the track. Testing is performed with test scenarios that have been made. The car steering works fine when the fuzzy car tries to maintain the position to stays on the straight path. But is not the same when the fuzzy car through the turned path, only a few turned path able to be passed and most are failed. It is caused by the car steering which could not be controlled properly by the system when the car passes the turned path. The value of the input voltage for the front motor is greater than the standard value of operating voltage of the front motor. It causes the front wheel movement becomes poor and the steering angle is difficult to control. Besides, the poor mechanical state of the front wheels also causes bad performance of the car steering. Performance of fuzzy control system functionally shows a good result. However, to capable for controlling the car movement on the path, some adaptation and restoration should be done to improve the optimal performance of the car movement control system. Figure 5 shows the fuzzy car.

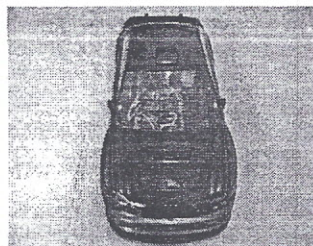


Figure 5: Fuzzy car

CONCLUSION

Fuzzy Inference System which is implemented on the car movement control system has succeeded in creating a control system on the car. Performance of fuzzy inference system functionally showed good results on movement control system which has been made on the car. But the difficulty in controlling the steering make the performance of the system is still lack when confronted with the environmental turned path. This happens because of movement control system of two car's motors are still made in a single fuzzy system, it causes the process of controlling the direction of the car movement is still very rough because possibility of the movement direction is too small. Furthermore, the higher input voltage at the front motor is also a cause of poor performance due to a car steering makes the car difficult to control on the turned path.

In building the car movement control system could not be overlooked that all components are must be mutually supportive and are in the best condition. Weakness in the electrical, software, and mechanical factors in this research make a control system on the car could not work properly on development environment.

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