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Design And Implementation Of Fuzzy Logic Based Autonomous Road Following Vehicle

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ABSTRACT

The Embedded control system is developed for autonomous road following system. Using fuzzy logic and co-design techniques, autonomous vehicle is guided by the embedded controller and uses the sensor to calculate the distance. The fuzzy reasoning take care of speed, the fuzzy logic system is developed based on two parameters depending on the parameter the speed of the vehicle and angle of rotation is verified by using MATLAB simulation rule viewer.

KEY WORDS: Fuzzy logic, Embedded control system, Co –design.

1. INTRODUCTION

A main issue in autonomous navigation is multifaceted environment, the significant research has been done for making a capable algorithm for vehicle navigation. Among them, adaptive control is made and performance based control are well accepted in control algorithms and driving research in autonomous vehicle navigation. Pre-defined equations are used in Adaptive navigation control which represents strong capability to well known environment and tracks the target of the moving vehicle (Nearchou, 1999; Fu, 2009). For a complex and unknown environment it is difficult to build precise path generalized equation. An alternative design method is provided by Evolutionary computation that adapts autonomous vehicle to behave correctly without requiring accurate specified model of the world. Fuzzy systems employs estimated reasoning, the decisions are made based on imprecise and incomplete information, this characteristic is similar to human beings. A linguistic concepts of fuzzy system does not requires the precision and complexity of logical or mathematical models. A relationship between conrol output and input information of a Fuzzy tool and is differentiated by its robustness with noise and variation of system parameters. Fuzzy logic controller provides the efficient speed control (Stafylopatis, 1998; Raffo, 2009; Harisha, 2008, Lee, 1990; John, 1996).

Fuzzy logic: The Boolean value is represented by two values, one and zero. This is not sufficient for estimating the human decision. The exact interval in Fuzzy logic is determined between zero and one, which represents human reasoning (Tsui, 2008). The Fuzzy logic system is separated into three stages

- Fuzzification
- Rule Evaluation
- Defuzzification

The fuzzification stage determines the fuzzy inputs which is given to the fuzzy controller. The membership function accepts the inputs which are fuzzified. The input values into degree values of Fuzzy membership for each function are changed by membership functions. The response of inputs are determined when fuzzified inputs are given to Fuzzy controller. The rule evaluation are converted into discrete outputs in defuzzification stage. This can be performed in different ways, using various kind of algorithms. A main process to defuzzification is Center-of-Gravity (COG) method (Yi, 2010, Karthi, 2013, Jasmin, 2015, Philomina, 2014).

Fuzzy controllers: For detecting obstacles on the path and control turning of the vehicle depending on the border distance are determined by two fuzzy controllers. Set of rules are related with input and output membership functions which needs to be defined. The fuzzy controller has three stages: fuzzification, rule evaluation and defuzzification. Information from surrounding decides the fuzzy controller selection. Fig. 1 shows the fuzzy logic based autonomous road following systems block diagram Two fuzzy inference systems are developed and combinely used to guide autonomous vehicle velocity of the vehicle is depends on the obstacle distance in straight path, And current angle of turning is depends on the border distance and current angle of vehicle. Structure of fuzzy inference system is shown in Fig 2 this is two input one output system This Fuzzy inference system controls the velocity of the vehicle and it takes two parameters as a input one is current speed of the vehicle and another one is obstacle distance of the vehicle output is desired speed (depends on the distance of the vehicle) (Saravanan, 2014, Gopalakrishnan, 2014).

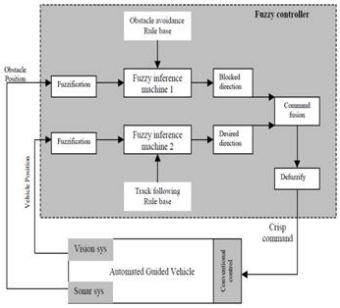

Figure.1. Block diagram of fuzzy road following system

The fuzzy inference engine consist of the input variables, output variables and fuzzy logic control model available models are Mamdani fuzzy model, Tuskamoto fuzzy model, Sugeno fuzzy model, here the triangular membership function is used for both input and output functions (Vijayaragavan, 2014; Kanniga, 2011, 2014, Karthik, 2013).

The Mamdani fuzzy model is used to design the control logic the two fuzzy controllers are combined by using command fusion technique (Karthik, 2013, Kanniga, 2011).

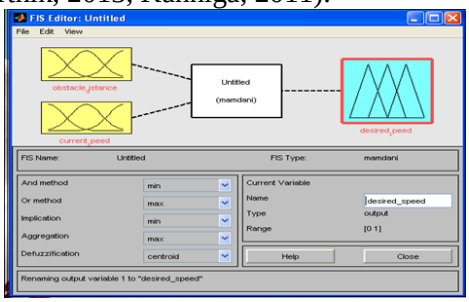

Figure.2. Fuzzy Inference System

Fuzzy rule base to find the velocity: Velocity control Fuzzy controller has totally 9 Fuzzy controller Rules for navigation to avoid obstacles and follows the pre-defined path. The following rules are defined (Lee, 1990) to obtain the navigation skills.

<Rules for desired speed> (velocity)

Rule 1: If (current speed is max) and (if obstacle is absent) then (Velocity is Max)
Rule 2: If (current speed is max) and (obstacle distance is high) then (Velocity is max)
Rule 3: If (current speed is max) and (obstacle distance is medium) then (Velocity is medium)
Rule 4: If (current speed is medium) and (obstacle distance is high) then (Velocity is max)
Rule 5: If (current speed is medium) and (obstacle distance is medium) then (Velocity is medium)
Rule 6: If (current speed is medium) and (obstacle distance is low) then (Velocity is low)
Rule 7: If (current speed is low) and (obstacle distance is low) then (Velocity is slow)
Rule 8: If (current speed is low) and (obstacle distance is medium) then (Velocity is medium)
Rule 9: If (current speed is low) and (obstacle is high) then (Velocity is high)

The fuzzy rule viewer is shown in figure 3 in which the desired speed variation is easily found and it is totally depends on the rule base

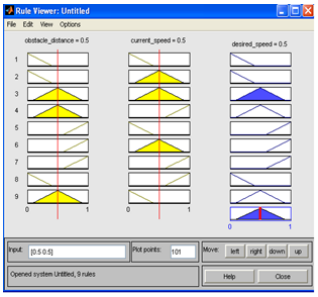

Figure.3. Rule Viewer For Velocity Control

Surface viewer: 3D graph to visualize input out dependency here the MATLAB GUI (graphical user interface tool) is used. The graph of desired speed with respect to current speed and obstacle distance is plotted, the variation of speed found on straight path. The speed is maximum for long distance obstacle.

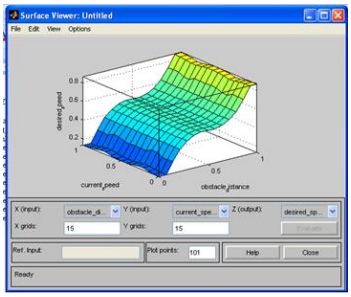

Figure.4. Surface Viewer For Velocity Control

Fuzzy inference engine for angle calculation: The rotating angle of the vehicle is depends on the current angle of tuning and the border distance of the vehicle the rule base is designed and output is visualized in surface viewer shown in figure.5 .

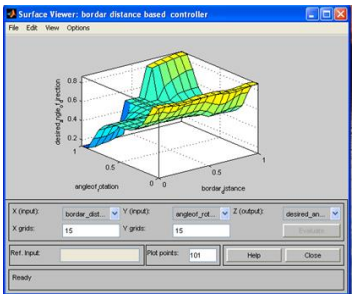

Figure.5. Surface Viewer for Angle Of Rotation

Defuzification method: The output of the fuzzy controller which is lower control component calculates exact angle to execute. This observation demands the controller to output commands. Dezification is such a process that converts fuzzy commands into crisp commands (Harisha, 2008).

Many methods of defuzzification are available: Min Max method (used in the Mamdani fuzzy system), Mean of Maximum (MOM) Weighted sum method (used in Sugeno fuzzy inference system) Center of Gravity (Centroid) method. All the methods have their own use in different models. The MOM method determines the average of this method and assigns the fuzzy command with the highest membership degree. The Min Max method first find the minimum of membership degree for each rule, finds the maximum as defuzzification set. However, both Min Max and MOM methods are not taken into consideration of all information by the fuzzy command, and difficulty in generating commands is encountered that turns the robot smoothly. The COG method have problems when applied to mobile robot (John, 1996). Those situations causes rare trouble. So we decided to use the centroid method.

4. CONCLUSION

An autonomous road following vehicle equipped with commercially available sensor and which are tuned to the black and white color in order to trace the predefined path. Fuzzy logic reasoning is adapted to the navigation control of the autonomous vehicle and it is tested. The experimental result shows the vehicle navigates in straight path with different speeds when vehicle approaches obstacle, the design is did in software. The future work is design of embedded fuzzy controller by using co design technique for cost effective design and better performance.

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