

IMPLEMENTATION OF FUZZY PID CONTROLLER FOR TRANSPORTATION ON THE INTERNET OF VEHICLES (IOV)

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ABSTRACT

This paper describes the designing of PID-type (Proportional-Integral-Derivative) controller based on Fuzzy algorithm using Verilog to use in transportation cruising system. The cruising system with Fuzzy concept has developed to avoid the collisions between vehicles on the road. The developed Fuzzy Logic Controller (FLC) provides a reference for controlling the vehicle speed either increase or decrease. The controlling speed depends on the distance of the preceding vehicle when it gets too close or alert the driver when necessary. The Mamdani Fuzzy Inference theory is studied, and developed in Matlab package at first for designing the PID-type FLC hardware system. The behavioral of the PID-type FLC algorithm is then simulated using Verilog language. The comparison of simulation results between Matlab and Verilog are presented for designing the PID-type hardware implementation. The synthesis tool from Quartus-II environment is chosen to synthesize the designed VHDL codes for obtaining the Register Transfer Level (RTL) hardware architecture of the PID modulus. The developed and designed Fuzzy based PID-type cruising controller is cheaper in cost compare to conventional PID controller system, and, thus we can propose this developed chip to use to the entry-level vehicles such as the national car. This can be further reduced the road accident and ensure the safety of the road users in the future.

Keywords: VHDL, FLC, RTL, PID, Fuzzy, WHO, Traffic accidents.

I.INTRODUCTION

The recent study of WHO, approximately 1.2 million people lost their lives in road accident per year, and about 50 million got injured in the traffic accident.80% accidents occurred due to drunk driving or mechanical failure. Nowadays vehicles increasing day by day lead to traffic accidents. Today vehicles play a major role in our day to day life. Before a couple of decades, the

internet has been all around the world. And is used to connect computers together, sharing data, sharing information and also to interact

people around the world. All the surrounding smart devices (things) that are connecting to the internet are simply called internet of things. Smart devices are any mechanical or electronic devices that can make intelligent decisions on its own. It would be the Smartphone, smart TV, smart washing machine etc. when these smart things connected to the internet are limited to vehicles are called internet of vehicles [1]. Regarding the development of next-generation intelligent transportation system, internet of vehicles is intended to play an essential role.IOV improve the operating performance and reducing the manpower and fuel costs. The ultimate goal is to achieve a more efficient, safe and green world transportation. There are a lot



of systems that support the drivers to avoid accidents such as adaptive cruise control, traffic sign recognition Etc. An integrated hardware and software design method is developed to implement on the FPGA chip. They are the integrated circuits can reconfigure or reprogrammable. They are widely popular due to rapid advancement and also it can modify the device functions. Simulation is done in VHDL language [2]. Is very deterministic and strongly typed and harder to make typo type mistakes and more verbose than Verilog. The automotive industry going through a massive transformation driven by grateful digital technology as the growth of technology from the consumer electronics and information technology cross over to automotive industry. Now the modern vehicle is equipped with powerful sensors and networking and communication drivers. In connected vehicle technology, each vehicle can talk to the driver when the driver is away from the vehicle or inside the vehicle through the internet and also can communicate with infrastructure. Fuzzy system is well known with its non-linearity characteristic behavior [4]. Therefore, the non-linear characteristic of the conventional PID controller can be improved greatly using fuzzy logic algorithm. Besides, most of the research works have done on the Fuzzy PID controller, which are, focusing on the conventional two-input PI (Proportional-Integral) or PD (Proportional-Derivative) type as proposed by Mamdani [5]. This is because the three-inputs of PID controller are a complex task, as more parameters have to be considered in building the fuzzy rule base [6]. It is difficult to determine the control rules for the Integral mode input define [6]. Therefore, the three inputs of the controller are defined as error (e), change in error ("H Derivative), and the rate of change of error as acceleration error), [6].

Besides it, there is no proper way of tuning method available until now. Trial-and-error tuning method is required in optimizing the controller [7]. Furthermore, the number of rule base increase exponentially with the increase of membership function [7]. If the number of input is m, and the number of membership function for each input is n, then the total number of the IF-Else rules is equal to mn.

II.LITERATURE SURVEY

1. Clive Max field, Design Warrior Guide to FPGAs, Elsevier publications 2004. Fuzzy Logic Controller (FLC) systems have emerged as one of the most promising areas for Industrial Applications. The highly growth of fuzzy logic applications led to the need of finding efficient way to hardware implementation. Field Programmable Gate Array (FPGA) is the most important tool for hardware implementation due to low consumption of energy, high speed of operation and large capacity of data storage. In this paper, instead of an introduction to fuzzy logic control methodology, we have demonstrated the implementation of a FLC through the use of the Very high speed integrated circuits Hardware Description Language (VHDL) code. FLC is designed for an armature control DC motor speed control. VHDL has been used to develop FLC on FPGA. A Sugeno type FLC structure has been used to obtain the controller output. The controller algorithm developed synthesized, simulated and implemented on FPGA Spartan 3E
2. Dr. Peter R. Wilson, Design recipes for FPGAs, Embedded technology series, Elsevier publication 2007. Fuzzy Logic Controller (FLC) systems have emerged as one of the most promising areas for Industrial Applications. The highly growth of fuzzy logic applications led to the need of finding efficient way to hardware



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3. sameep and Kuldip S. Rattan, "Implementation of a Fuzzy Controller on an FPGA using VHDL", 22nd International Conference (NAFIPS), pp. 110-115, March 2003. The past few years have witnessed a rapid growth in the number and variety of application of fuzzy logic. The application ranges from consumer products such as cameras, washing machines, cars and in industry for medical instrumentation, underground trains and robots. Unlike the conventional controller FLC design is not based on the mathematical model of the plant or system. A FLC is an automatic controller that controls an object in accordance with desire behaviour. For a complex system whose mathematical model is very difficult to define or the transfer function of a plant is undefined, fuzzy logic controllers are very useful in that case [1,3]. The control action of FLC is defined in terms of simple human friendly —if – then rules. These set of rules are describe the system behaviour. These set of rules are called the knowledge base of fuzzy controller. We can easily change the rules accordance

with our desire output. So the development time for a new controller can be significantly reduced as compared to conventional one [7]. The motivation behind the implementation of a FLC in VHDL was driven by the need for an inexpensive hardware implementation of a generic fuzzy controller for use in industrial and commercial applications [13]. We have taken a simple FLC for an armature control DC motor speed control. Error and change in error in speed has been used as two inputs to FLC. For both the inputs 5 triangular membership function has been selected and coded in VHDL. An algorithm has been developed in VHDL to fuzzifie the crisp digital values of speed error and rate of change of error.

III.WORKING METHODOLOGY

In this paper focus on the internet of vehicles based traffic management system [1][7]include 3 communications:

1. Communication with the vehicle to human.
 2. Communication with the vehicles.
 3. Communication with the vehicle to the third party.
1. Communication with the vehicle to human. Few attributes of the vehicle like vehicular speed, fuel level, tyre pressure, the vehicular lock condition are directly reported to the user through onboard Screen and also active updates about the vehicle are getting from mobile. When the user is away from the vehicle.
 2. Communication between the vehicles A fuzzy-based PID controller is developed in order to avoid collisions. When the vehicle is on the road or even when the vehicle is parked. The system sense distance between two adjacent vehicles and decreases the speed in accordance with the distance between them in a decreasing nature. If the two vehicles getting

close to each other then the system will apply sudden break [2]. PID controller is widely used in industrial process control systems. The popularity of PID controller is because of their robust performance [9] in wide range of operating conditions and functional simplicity. PID algorithm consists of three basic coefficients. Proportional, integral and derivative. Which are varied to get optimal response. The PID control algorithm has sufficient flexibility to yield the excellent result. And is linear in nature. Conventional PID controller is not suitable for the non-linear system [10][11]. So introduce a fuzzy-based approach to it. Fuzzy logic has been successful to control non-linearity and uncertainty of a system. Fuzzy based PID controller has better stability and fast response compared with conventional PID controller. The fuzzy logic controller can work with less precise input and it doesn't need a fast processor, this is the reason for choosing fuzzy logic controller. The fuzzy controller is the optimal discrete time version of the conventional PID controller. The control signal generated by a PID controller in the continuous time domain [3][4] is described by,

$$u(t) = K_p e(t) + K_I \int_0^t e(\tau) d\tau + K_D \frac{de(t)}{dt} \quad (1)$$

Where $e(t)$ is the error signal K , K_I , K_D are the proportional, integral, derivative constants respectively. The equation can be represented in frequency domain [3]

$$U(K) = K_p e(K) + K_I \delta e(K) + K_D d(e(K))$$

Equation can be transformed into discrete version by applying the bilinear transformation. PID Controllers can be described by the equations

$$U(K) = K_p e(K) + K_I \delta e(K) + K_D d(e(K))$$

$U(K)$ = Output control signal,

$e(K)$ = error,

$e(K)$ = accumulative error (rate of change in error),

$d e(K)$ = derivative error (change in error)

Non-linearity in PID controlling algorithm can be achieved by using fuzzy logic into it. In a PID controller there is 3 input as proportional, integral, derivative because of more Parameters are needed to be considered in building the fuzzy control rule base [6]. So 3 input of the controller is defined as the error (e), change in error (Δe) and rate of change of error ($\Delta \delta e$) [2]. The component of FLC is an interface engine and a set of linguistic if-then rules. That encode the speed of the vehicle with the distance from the other vehicle or obstacle the main difficulty is designing a fuzzy logic controller is the efficient formulation of fuzzy if-then rules. Rule base increase with increase in member ship function [2]. Where e , de , δe are the input variables and K_P , K_I , and K_D are the constants same as in the conventional PID controller equation.

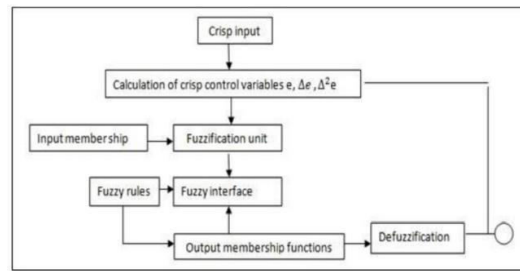


Fig. 1: PID Fuzzy Controller Algorithm

Fuzzy implementation can be performed by taking the product. Total no of the if-else rule can be obtained by taking the

product of total no of inputs and the total no membership function[3].

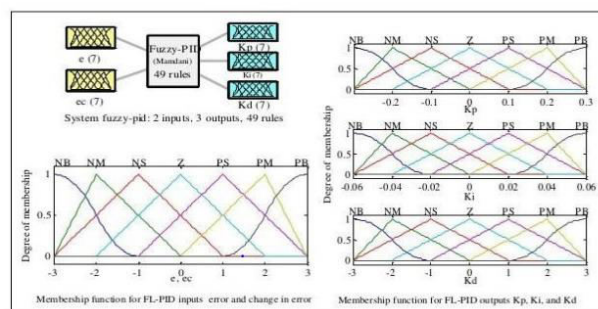
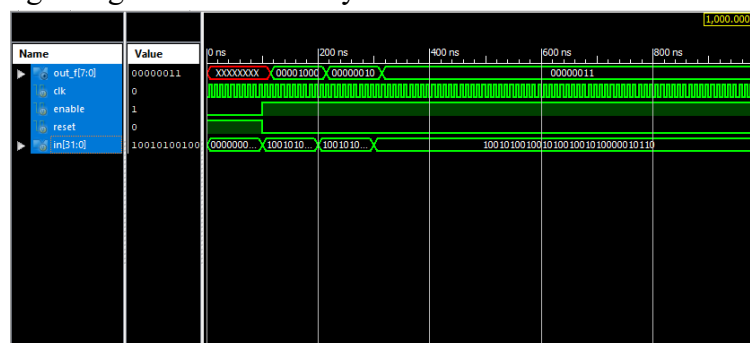


Fig. 2: input output member ship functions

3. Communication between the vehicle and the third party The data regarding the vehicular collisions or accident are sent to the server from the chip that is integrated into the vehicle through a communication device. From this server, the data is forwarded to a third party like police patrol, ambulance. These third parties take the vehicle into consideration and provide essential service. Server decides when this third party need to be triggered and the information regarding how to classify

the incoming data with primary importance. These are predefined on the server's decision-making algorithm. Server stores the data in the database and analyses it for the crack party need to be triggered and the information regarding how to classify the incoming data with primary importance. These are predefined on the server's decision-making algorithm. Server stores the data in the database and analyses it for the crack [1].





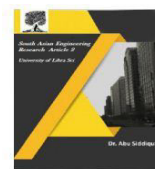
IV. CONCLUSION

The implementation of a Fuzzy PID controller for transportation in the Internet of Vehicles (IoV) demonstrates a significant improvement in vehicle control, stability, and real-time decision-making. By integrating fuzzy logic with a traditional PID controller, the system enhances adaptability to dynamic traffic conditions, reducing response time and improving overall vehicle performance. The fuzzy inference system refines PID parameter tuning, ensuring optimal speed regulation, fuel efficiency, and smoother driving experiences in IoV networks. Additionally, the proposed approach effectively mitigates traffic congestion and enhances vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication,

contributing to safer and more efficient transportation. The results indicate that the Fuzzy PID controller outperforms conventional PID controllers in handling nonlinearities and uncertainties in IoV environments. Future work can focus on further optimizing the fuzzy rules, integrating advanced machine learning techniques, and testing the system in real-world IoV scenarios to enhance its robustness and scalability.

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