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FPGA Implementation of Fuzzy PID Controller for Transportation on the Internet of Vehicles (IOV)

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ABSTRACT: Implementation of Fuzzy PID controller for transportation on the internet of vehicles (IOV) using field programmable gate array technology (FPGA) technology. The IOV based traffic management enables the vehicle to communicate with their internal and external environment, supporting the interaction of vehicle to human, vehicle to vehicle, the vehicle to third-party. In vehicle to human communication, the driver will receive the warning message about vehicular speed, fuel level, door lock condition etc when the driver is inside the vehicle or away from the vehicle. In the vehicle to vehicle communication, a fuzzy PID controller is developed for avoiding collisions. If the vehicle undergoing accident it will send a notification message to the third party like police patrol, ambulance. They can find the exact location of the vehicle through the GPS coordinates which are sent by the vehicle. The chip developed in this way is cheaper and can be introduced to national cars. These cars can avoid the driver from the dangers ahead before he can react.

KEYWORDS: Fuzzy, FPGA, IOV based traffic management, Membership function, PID algorithm, Synthesis, VHDL

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

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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.

II. RELATED WORK

Now the road accidents are in an increasing nature, so the traffic accidents are accepted as a serious problem. For avoiding accidents there have been many attempts through the years to develop an effective accident avoidance system. Several systems are there for providing warning information related to the collision. Many vehicular innovations have been implemented in recent years for protecting the vehicle from the collisions. A smart cruise control on S- class Mercedes Benz vehicle is incorporated into many collision avoidance systems. But is very expensive.

A Fiat vehicle manufacturing company has developed an intelligent cruise control. This system is a combination of sensors to detect an obstacle on the road. Vehicle control is done through an electronic braking and a throttle actuator. Laser radar is used as the distance sensor, and the microwave radar, which guarantees visibility in adverse conditions, is used as the collision avoidance sensor. As long as no target is detected, the Autonomous Intelligent Cruise Control system provides speed control. If a target is detected, the Autonomous Intelligent Cruise Control system switches automatically to distance control.

In the work on a vehicular accident detection and avoidance system for protecting passengers and vehicles [9], has been developed a system of Robust Sensors and Actuators coupled to a Rugged Microprocessor the Ultrasonic Sensors installed in the front end of the vehicle. Analog proximity measurements for various collision hazards were taken and at 40 kilometres per hour and above, the system will be activated. The use of a microcontroller for the generation of ultrasonic signal and the control logic enables the prediction of imminent collision when the vehicle approaches an obstacle within 7meters range, thereby enabling some controls which ensure a warning alarm and an activation signal to the automatic brake system when the collision range of 5meters is reached.

III. SYSTEM ARCHITECTURE

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

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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_P, K_I, K_D are the proportional, integral, derivative constants respectively. The equation can be represented in frequency domain [3].

$$V_S = E(S) \left[K_P - \frac{K_I}{S} + K_D S \right] \quad (2)$$

Equation can be transformed into discrete version by applying the bilinear transformation.

$$S = \frac{2}{T} \left[\frac{1-Z^{-1}}{1+Z^{-1}} \right] \quad (3)$$

Where $T > 0$ in the sampling Period. Then it becomes.

$$U_{PID}(Z) = K_P e(t) - \frac{K_I T}{2} + \frac{2K_D}{T} + \frac{K_P T}{1-Z^{-1}} + \frac{KD}{S} + \frac{1}{1+Z^{-1}} \quad (4)$$

$$K_P = K_P - \frac{K_P T}{2} - \frac{2K_D}{T}, K_I = K_I T, K_D = \frac{KD}{T} \quad (5)$$

PID Controllers can be described by the equations

$$U(K) = K_P e(K) + K_I \delta e(K) + K_D d(e(K)) \quad [4]$$

$U(K)$ = Output control signal,

$e(K)$ = error,

$\delta e(K)$ = 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 ($\Delta^2 e$) [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 membership function [2]. Where $e, de, \delta e$ are the input variables and $K_P, K_I,$ and K_D are the constants same as in the conventional PID controller equation.

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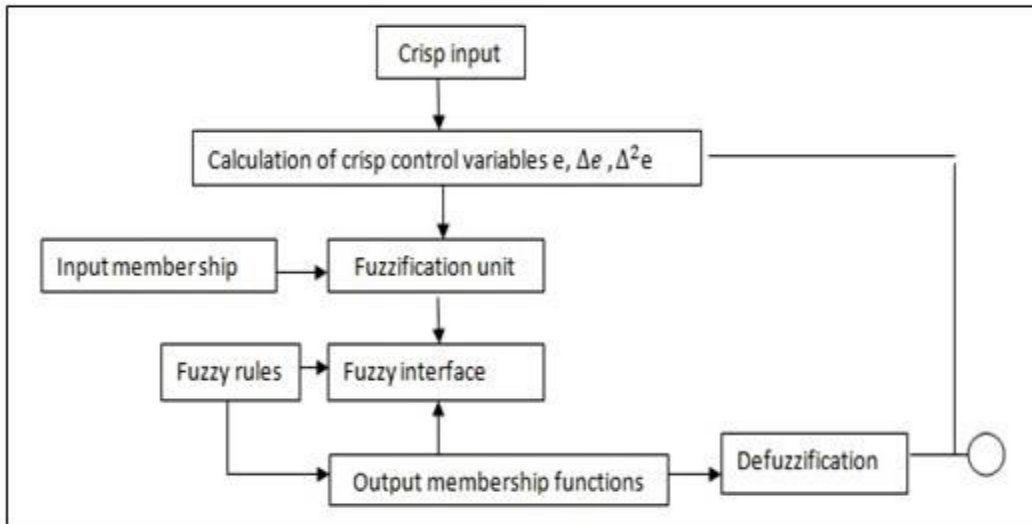


Fig. 1: PID Fuzzy Controller Algorithm

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].

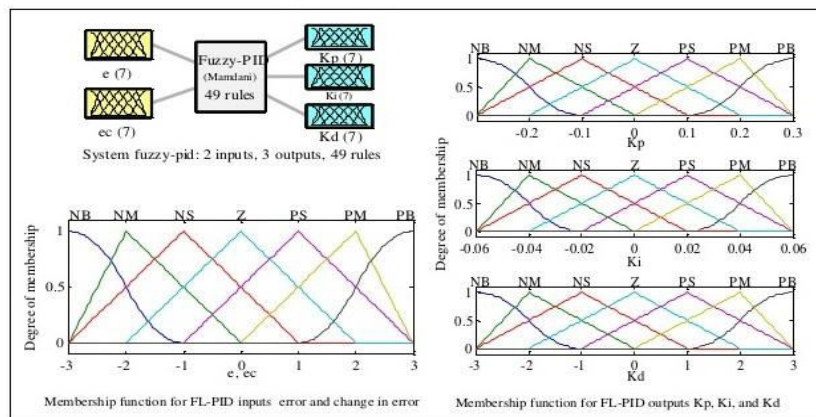


Fig. 2: input output membership functions

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.

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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].

VI. RESULTS AND DISCUSSION

Synthesis is the process by which representation of the desired circuit behaviour. And this process is done using synthesis tools. In synthesising the compiled code of VHDL is turned into a design implementation in terms of logic gates [2]. The RTL view of fuzzy based PID controller on the internet of vehicles is shown in below.

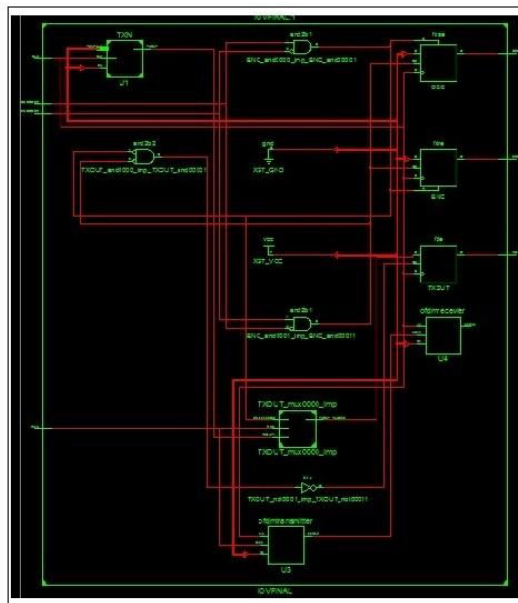


Fig. 3: The RTL view of fuzzy based PID controller on internet of vehicles

VI. CONCLUSIONS

This paper has presented a novel way to implement a fuzzy based PID controller for Transport applications of the internet of vehicles using FPGA. The application of FPGA structure is very suitable for the high-speed process. The main aim of this project is that the chip developed in this way is cheaper and can be applied to national cars. This can reduce the road accidents and ensure safety the of the road user in future.

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