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FPGA IMPLEMENTATION OF INTELLIGENT TRAFFIC SIGNAL CONTROLLER BASED ON NEURO FUZZY SYSTEM

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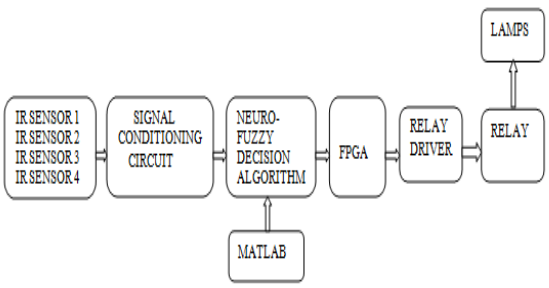
***Abstract*— The aim of this paper is to design, simulate, and synthesis a simple, suitable and reliable VLSI fuzzy processor for controlling the traffic lights. Fast, rapid, and vast transportation systems are nerves of economic development for any nation. This paper studies the deviation in traffic flow data and data bottleneck production problem, and provides a solution based on conjunction of mathematical statistics and time series analysis. The monitoring and control of city traffic is one of the key issues especially in metropolitan areas due to ever increasing number of vehicles and pedestrians. Present traffic controllers are based on microcontroller and microprocessor. These traffic light controllers have limitations because it uses the predefined hardware, which functioning according to program that does not have the flexibility of modification on real time basis. In traffic signal control system, detection of traffic variables at intersection is very important and is the basic input data to determine signal timing. The paper starts with an overview of FPGA in order to get an idea about FPGA architecture, and followed by an explanation on the hardware implementation with both type analogue and digital implementation, a comparison between fuzzy and conventional controller also provided in this paper. The "Intelligent Traffic Signal Controller using FPGA controller based on Neuro-Fuzzy system" is capable of taking decision to reduce delays at intersection. To develop the system, algorithm need to be developed using VHDL. The designing part of this controller into VHDL program eliminates the shortcomings of the other custom facilities and conventional controller design available today.**

***Keywords*—. FPGA, Level sensors, FPGA, Neuro-Fuzzy, VHDL, self study**

I. INTRODUCTION

The aim of traffic signal controller is to control the traffic at the traffic intersection points and at the heavy traffics. Traffic signal is an essential element to manage the transportation network. Now a day, a major research focus has been on application of artificial intelligent techniques, for example, expert systems, fuzzy logic, and neural network for intersection signal control. Traffic flow and safety of the current transportation system can be controlled by applying automation and intelligent control methods to roadside infrastructure and Vehicles. Complexity of traffic leads to the complexity of modern traffic control system and makes design & optimization of a system complex task. Fuzzy logic is a powerful tool to handle highly complex problems. It is equivalent to some of the characteristics of the human mind, which will get a required effect when it is embedded into reasoning technology. There are many conventional methods for traffic signal control but most of them sometimes fail to deal efficiently with the complex, time-varying traffic conditions and controller can't satisfy real-time character for traffic signal. There are many conventional methods for traffic signal control but most of them sometimes fail to deal efficiently with the complex, time-varying traffic conditions and controller can't satisfy real-time character for traffic signal. So various intelligent approaches have been proposed for designing real time traffic signal controllers, such as fuzzy sets, genetic algorithm and reinforcement learning and neural networks (NN).Even if the complexity of the simulation increases then also the Neural network based system can provide effective control of large scale traffic network even. The fuzzy control method instantaneously adjust the time of green light by comparing current green light phrase and other red green light phrase, so that the method will get relatively efficient scheme of time allocation. A fuzzy logic control scheme is proposed to overcome the drawbacks of conventional traffic controllers. 4 The goal of this paper is to design, simulate, and synthesis a simple and robust VLSI fuzzy processor for efficient Traffic light control. The level sensors and weighting time of the vehicles are the input parameters. The fuzzy controller can be used with the input variables of the weighted traffic flow at the current and neighboring intersections. The weighting fuzzy module is used to replace the communication among intersections.

II. THE PROPOSED SYSTEM



III. HARDWARE OVERVIEW

A) SYSTEMTEM ARCHITECTURE

The proposed traffic signal control system consist of IR sensor, signal conditioning circuit, nuro fuzzy decision algorithm, reley driver, reley lamps and matlab

1) IR SENSOR:

An infrared sensor is an electronic device that emits and/or detects infrared radiation in order to sense some aspect of its surroundings. Infrared sensors can measure the heat of an object, as well as detect motion. Many of these types of sensors only measure infrared radiation, rather than emitting it, and thus are known as passive infrared (PIR) sensors.

2) SIGNAL CONDITIONING CIRCUIT:

The reflected IR signal detected by the photo diode is fed to a signal conditioning circuit that filters the unwanted signals and boost the desired pulse signal.

3) NEURO FUZZY SYSTEM:

The Neuro-Fuzzy logic controller performs better than the fixed time controller due to its real time adaptability. The easiness of selecting the initial settings can be the advantage when real time signal controller is implemented. A functional Fuzzy Traffic Controller (FTC), which utilizes fuzzy logic algorithm. To develop the system, the behavior level of FTC algorithm has developed using VHDL under MAX+PLUS II CAD environment. The Finite State Machine (FSM) of the FTC has coded in VHDL program for controlling the specific Traffic flow application. Later on, the FPGA Express (Synthesis tool) has used to get a fully gate level synthesis architecture for the whole Fuzzy based VLSI chip and then the optimization step has been applied for minimizing the VLSI chip's timing delay, clock speed, and area to get the correctness of FTC design.

4) RELAY:

Relay is essential for automation systems and for controlling loads.Also, relays are the best way for galvanic insulation between high and low voltage portions of a circuit. Each relay has two mechanical parts inside. The first one is contact(s) of the relay. The contacts are:

1. IR sensors
2. FPGA kit
3. Relay
4. Lamps

5) FPGA (FIELD PRORAMMABLE GATE ARRAY):

This denotes an integrated circuit which is programmed in the field, i.e. by the system manufacturer. FPGAs can be characterized by the following items:

- High production cost
- Low design density
- Programmable fabric adds significant overhead
- No NRE and Re-Spin cost
- Low development effort
- Low dead-time
- simplified timing
- No test vectors
- Relaxed verification
- Physical design is "hands-off"

B.THE MATHEMATICAL MODEL:

When creating a functional model of the biological neuron, there are three basic components of importance. First, the synapses of the neuron are modeled as weights. The strength of the connection between an input and a neuron is noted by the value of the weight. Negative weight values reflect inhibitory connections, while positive values designate excitatory connections [Haykin]. The next two components model the actual activity within the neuron cell. An adder sums up all the inputs modified by their respective weights. This activity is referred to as linear combination. Finally, an activation function controls the amplitude of the output of the neuron. An acceptable range of output is usually between 0 and 1, or -1 and 1.

Mathematically, this process is described in the figure

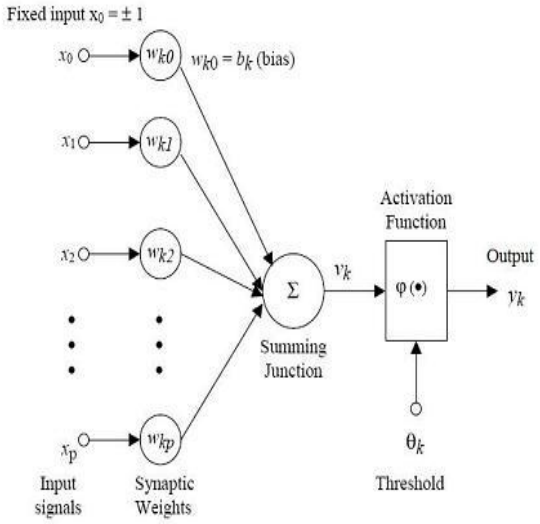


FIG.2: THE MATHEMATICAL MODEL

From this model the interval activity of the neuron can be shown to be:

$$v_k = \sum_{j=1}^{p} w_{kj} x_j$$

I. The output of the neuron, yk, would therefore be the outcome of some activation function on the value of vk.

C) ARCHITECTURE OF FUZZY PROCESSOR

Figure 3, shows the Fuzzy processor's logical architecture for VLSI simulation and mentioned by Giuseppe ascia. The internal organization includes the following blocks: Fig. Fuzzy Rule Architecture for VLSI Simulation

Fuzzy set base- A digital memory that contains the fuzzy sets related to input variables with codes stored in the rule memory. Its internal organization allows the fuzzy set base to directly supply the core with the membership degrees (alpha values) of the input variables during the

computation of a premise for each rule. Likewise, during conclusion processing, the fuzzy set base supplies the relative fuzzy set.

Core- it assesses a stream of fuzzy rules in the pipeline and possesses an internal organization that allows parallel assessment of up to four antecedents per rule. The core can also store partial processing results if more than one rule involves the same inference.

Defuzzifier- This unit forms the defuzzification block and provides an output value proportional to the Maximum of fuzzy inference output.

Control unit- Coordinator of the processor's internal activities, this unit also interacts with components outside the processor through the signals mentioned earlier. Rule memory- For passing information about a rule to the processor, this memory through which the processor receives information it needs to identify the membership function in an active rule's premise and conclusion;

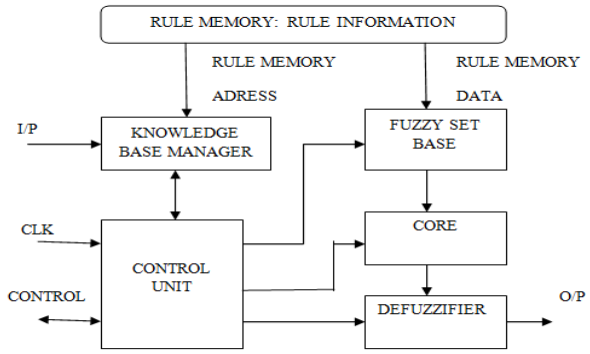


FIG.3: ARCHITECTURE OF FUZZY PROCESSOR

D) TRAFFIC LIGHT CONTROLLER:

Fig.3 depicts a general four road structure which consists of north, east, west and south direction search with a set of three lights namely green, yellow and red. Green light in a direction will be ON when left, straight and right side is set to be free for traffic in that direction.

The figure shows the design of traffic light model. To distinguish each lane and the traffic signal lights, they are labeled separately with North, East, South and, west. Signal light sat each lane have their set of traffic light signal "Red, Yellow, and Green". Operation of this signal light is similar to common traffic light signal.

Along with these specifications, each lane has a light to represent a sensor of the corresponding road. Line is sensor or electromagnetic sensor is suitable for design of areal traffic light the two sensors, we will know the expected time for greet system. The first sensor detects the presence of vehicles and this condenser determines the volume of the traffic corresponding to that lane. Through n signal ON and when the signal light at each lane should be changed to green.

The traffic flow has the characters of continuity and fluidity. When vehicles run to an intersection, the vehicles flow meets with obstruction because of the running conflict coming from the traffic flow in several directions. The vehicles flow slackens and even stops. The shock wave will affect the movement of the following traffic flow, even the clearing of vehicles *at* the upstream intersection. Therefore we must consider the influence of the neighbouring traffic flow. So evaluation of affected current traffic flows will consider the influence of traffic flow at neighbouring intersections which is imposed on signal timing at current intersection. So achieve the aim of the harmony between signals among multi intersections. The weighting coefficient can be used to indicate the imposed influence. Therefore the signal timings can harmonize each other among the neighbouring intersections. So the signal controller considering the neighbouring flow can give the effective real-time signal timing, and improve the total performance index of the system because of the coordination of the signals between intersections. For the synchronization between current intersection and neighbouring intersection it is important to understand 32 different conflicts at the intersection which is shown in figure below:

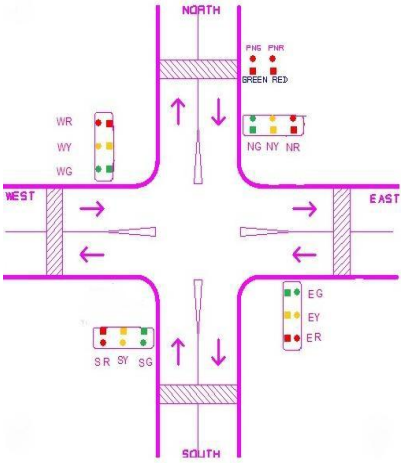


FIG.4): STRUCTURE OF TLC

IV .SOFTWARE OVERVIEW

1) MATLAB:

MATLAB is a software package for high performance numerical computation & visualization. It provides an iterative environment with hundreds of built in function for technical computation, graphics & animations.

MATLAB is an abbreviation of Matrix Laboratory. It is a popular Mathematical Programming Environment used extensively in Education as well as in Industry. The trick behind MATLAB is that everything is represented in the form of arrays or matrices. Mathematical Operations starting from simple algebra to complex calculus may be conveniently carried out using this environment. The main use of MATLAB in Software Development is Algorithm Design and Development. Code developed in MATLAB can be converted into C, C++ or Visual C++. Additionally MATLAB may be called as ActiveX Object from still higher level languages like Visual Basic, etc. Using MATLAB it is easy to manipulate matrices by addressing of individual element, complete row addressing, and complete column addressing and transposing one matrix to another required matrix. Saving and loading data, defining functions and m-files is user friendly in MATLAB. Commonly used commands in MATLAB are Who's, Help, Clear, Path, Cd, Dir, Look for.

2) FLOW CHART

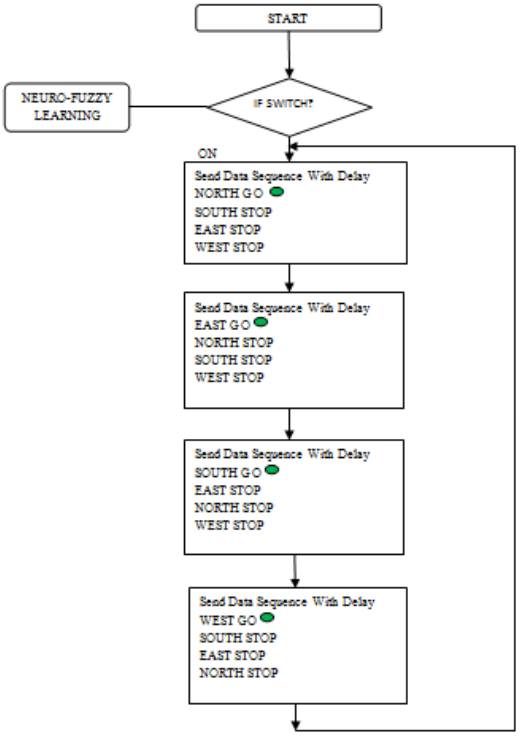


FIG.5 FLOW CHART FOR TLC

V. CONCLUSION

Designing the intelligent traffic signal controller based on Neuro-Fuzzy neuro controller implemented on FPGA will provide effective solution for Traffic Control. The average performance closely follows the performance of system developed by MATLAB simulation. This paper uses the method of fuzzy logical control to predict in advance with prediction data to solve the problem. The method implements intersection signal control and precise countdown timing function during the whole journey. By the studyof the neural network, we the fuzzy model can be adjusted .It can overcome the drawbacks of the conventional traffic controllers with the accuracy of providing variation in green cycle intervals based on the heavy traffic loads that changes at every lane in a four way junction control.

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