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FPGA Based FNN for Accidental Fire Alarming System in a Smart Room

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Abstract: The main objective of the paper is to design and develop the Fuzzy Neural Network for increasing the efficiency of an application which is controlled by optimizing the area and power parameters based on FPGA. Fuzzy reasoning can express the qualitative aspect of human logic. It realizes the flexible reasoning corresponding to human logical reasoning, extensive research has been conducted into fuzzy reasoning. This paper describes the design and implementation of FNN for an embedded system for enhancing the performance using cognitive knowledge where in the proposed system a smoke sensor and a fire sensor is used to maintain the safety of a smart room driven by an FNN, where in an alarming system gives alarm for the safety measures and cuts off main power supply to avoid short circuits which may lead to huge destructions to property and lives .The paper describes the shortfalls of the different methods and the present technology are investigated to find out the advancements of new system. Also to analyse the scope for the performance enhancements with respect to present system. New architecture is simulated using Modelsim and Implemented on Spartan III FPGA and tested to reduce the power consumption and area on chip for the given system.

Keywords: Fuzzy Neural Network, Smart room, cognitive knowledge, Human logical reasoning, Fuzzy reasoning, Xilinx Spartan III FPGA, Modelsim

I. INTRODUCTION

Advent development in the Micro and Nano electronics paves way for sophisticated living of human using sensors. In Smart environment, human interaction with the computing system is not manual commands, the need of human is predicted by the system by means of data collected through sensors, thus human can enjoy automated sophisticated environment [3],[4]. The need of human is detected, analysed based on the information collected by sensors. Particularly the need is predicted only by recognizing the human activity. The human activity is recognized by means of efficient machine learning system using data collected by ambient sensors.

Fuzzy reasoning can express the qualitative aspect of human logic. It realizes the flexible reasoning corresponding to human logical reasoning, extensive research has been conducted into fuzzy reasoning [4]. Its practical applications are now being seen not only in various control fields but also in AI and operation research.

Artificial intelligence (AI) methods are generally used to solve complex problems in engineering. Sometimes these methods are incapable to solve some problems individually, thus the methods can be combined to create hybrid systems and solve more complex problems. Hybrid intelligent system generally involves two, three or more of these individual AI technologies that are either used in series or in an integrated way to produce advantageous results through synergistic interaction [7]. Fuzzy systems that have several inputs suffer from the curse of dimensionality. The Takagi – Hayashi (T-H) method is an automatic procedure to extract rules and can greatly reduce the number of rules in a high dimensional problem, making the problem tractable, thus [7] The method proposed here is to solve these problems by using an Fuzzy neural network, extensive application fields including not only control but also estimation, inference, prediction, and so on can be expected [6]. The aim of this method and its formulation are described, and its effectiveness is explained .The aim of creating this prototype is to develop automated machine learning system that does not need any manual interpretation for decision making. Thus the proposed machine learning system is based on Adjustable Fuzzy Clustering, for data grouping to ease the job of classification system and Fuzzy Neural Network for supporting incremental learning [2]-[6]. This proposed system resembles human intelligence in making accurate decision even in uncertain situation. By the implementation of this system shows higher accuracy of recognizing human activity even with large data from different sensors.

In this model the aim is to design and implement the smart room with FNN using T-H method. This work presents a hardware approach for implementation of fuzzy neural network modular architecture for embedded systems. The project is based on a Takagi – Hayashi (T-H) method [1] for the construction and tuning of fuzzy rules, this is commonly called neural network driven fuzzy reasoning. This method allows the construction of rules and membership functions through many different back propagation training methods the block diagram is shown for the smart room using FNN

The article is divided as follows: section two discusses the block diagram of the smart room using Fuzzy Neural

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Network (FNN) based on T-H method; section three deals with FPGA implementation of single neuron ; section four shows the flow graph of FNN and the complete design and implementation of the proposed design; section five discusses the hardware and software requirements where in a brief description about Xilinx and FPGA is provided[8],[12]; section six shows the FPGA area analysis; section seven presents experimental results and discussions about the project and finally, section seven contains conclusions and future projects involving the issue under study

II. METHODOLOGY

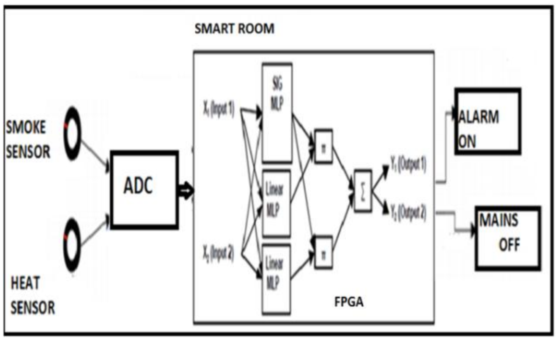

Fig 1: Block diagram of the proposed design

The input comes from any real time sensor to ADC Model. The ADC model converts analog data to digital data. This input data taken by ANN model perform operations, gives updated trained outputs. The trained outputs are input to Fuzzy interface model. It mainly contains fuzzy controller and register. It performs the fuzzy operation of data and we obtain the controlled cognitive outputs. With the help of this output we can control any embedded applications like DC motor, Stepper motor, fan, light etc. In the proposed design we use a Smoke sensor and a Heat sensor where in the areas like Hospitals have restrictions on smoking and there are more chances of fire accidents.

The proposed design gives alarm based on the smoke intensity and the fire severity with the cognitive thinking wherein the FNN does the work by the learning process through weight adjustments of neurons and clusters the incoming data based on fuzzy rules.

In a Fuzzy Neural Network - FNN of Takagi Hayashi method (T-H) there are two types of neural network Multilayer Perceptron – MLP [1]. the first is a neural structure for the arrangement of the FNN membership functions, a network with one hidden layer with tangent sigmoid activation function in neurons and the output layer with tangent sigmoid activation function, we call this structure "SIG MLP" in this paper, the second is a neural structure to determine the consequent parameters of an FNN, which consists of a neural network with one hidden layer with tangent sigmoid activation function in neurons and the output layer with pure activation function, we call this structure "LINEAR MLP" in this paper.

Both structures process data in sixteen-bit fixed point representation.

III. FPGA IMPLEMENTATION OF NEURON

The neuron proposed by McCulloch and Pitts was used as a reference, and the neuron architecture proposed in this study followed the implementation model created in VHDL by [1], as described in Register Transfer Level Design[1] shown in Figure 2. The neuron divided into two functional blocks.

The first is a linear combiner, responsible for summing weighted synaptic inputs and the second is responsible for calculating the activation function, denoted blocks NET and FNET respectively. The proposed VHDL Neuron processes numerical data only in fixed point arithmetic. Figure 2 shows the RTL schematic of a single neuron [1]

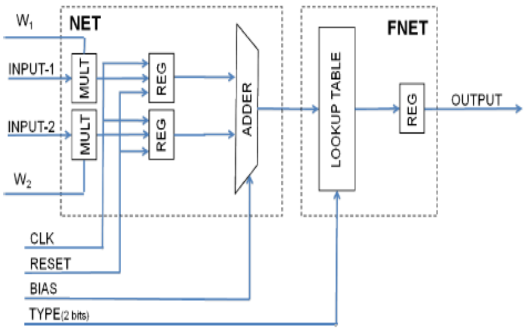

Fig 2: Basic Neuron described in Register Transfer

IV. FLOW GRAPH

The flow diagram shows the method or procedure of the project. Here spartan3s400 tool will be used to work on this project, it has the operating speed of 10MHZ on board, and it also has soft processor Micro Blaze Xilinx ISE 12.2 tool is used and is simulated using ModelSim6.3c.

In this project logic design will be used to design a High Speed Adder. Verilog language will used for the implementation of CLA in Xilinx ISE 12.2. After combining, tested, implemented and physically dumped onto FPGA

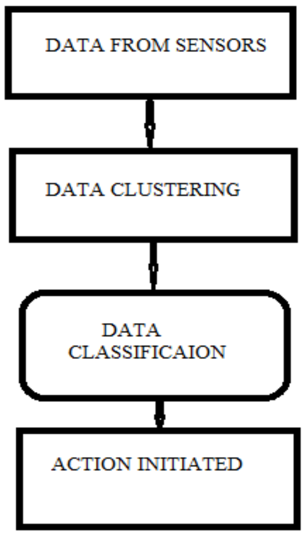

Fig 3: Flow diagram for FNN

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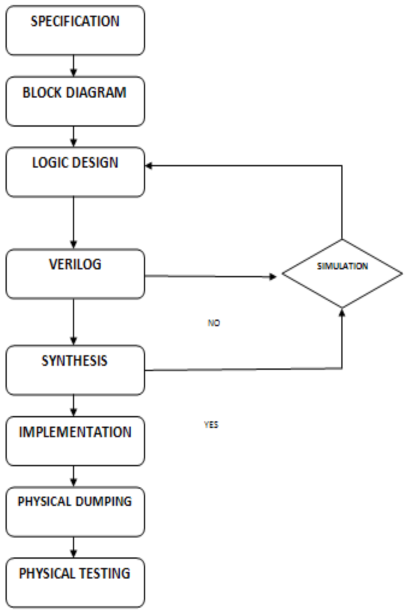

Fig 4: Flow diagram for Design and Implementation

V. XILINX ANDFPGA

Xilinx, Inc. is the world's largest supplier of programmable logic devices, the inventor of the field programmable gate array (FPGA) and the first semiconductor company with a fables manufacturing model. The programmable logic device market has been led by Xilinx since the late 1990s.

Xilinx's sales rose from $560 million in 1996 to almost $2 billion by 2007. The company aims to use the approach to capture greater market share from application-specific integrated circuits (ASICs) and application-specific standard products (ASSPs).

Creating a new ISE project for the FPGA device on the Spartan-3 Kit.To create a new project:

Select File > New Project, The New Project Wizard appears Creating a VHDL Source ;Create a VHDL source file for the project as follows :Click the New Source button in the New Project Wizard ;Select VHDL Module as the source type ;Type in the file name counter ;Verify that the Add to project checkbox is selected; Click Next; Declare the ports for the counter design by filling in the port information as shown below

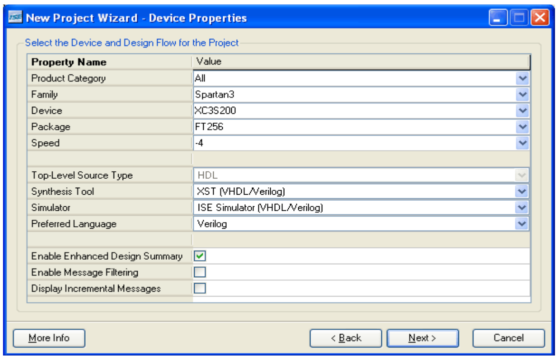

Fig 5: Creating a new ISE project for the FPGA device on the Spartan-3

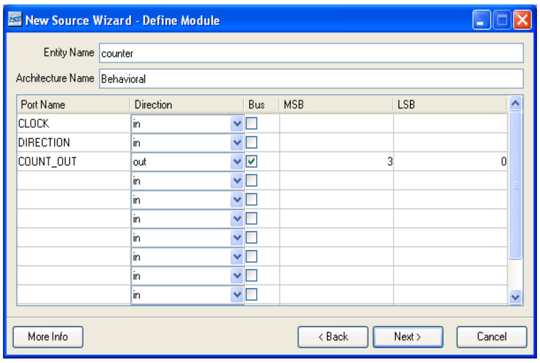

Fig 6: Declare the ports for the counter design by filling in the port information

Specify the pin locations for the ports of the design so that they are connected correctly on the Spartan-3 Start-up Kit demo board.

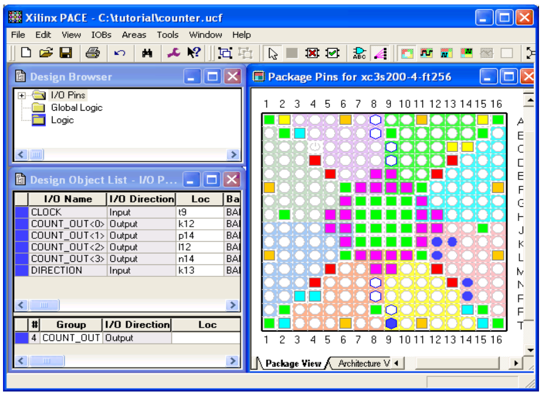

Fig 7: Pin locations for the ports

A field-programmable gate array (FPGA) is an integrated circuit designed to be configured by the customer or designer after manufacturing—hence "field-programmable". The FPGA configuration is generally specified using a hardware description language (HDL), similar to that used for an application-specific integrated circuit (ASIC) .The Spartan-3 family builds on the success of the earlier Spartan-IIE family by increasing the amount of logic resources, the capacity of internal RAM, the total number of I/Os, and the overall level of performance as well as by improving clock management functions. Because of their exceptionally low cost, Spartan-3 FPGAs are ideally suited to a wide range of consumer electronics applications including broadband access, home networking, display/projection and digital television equipment.

The Spartan-3 family is a superior alternative to mask programmed ASICs. FPGAs avoid the high initial cost, the lengthy development cycles, and the inherent inflexibility of conventional ASICs. Also, FPGA programmability permits design upgrades in the field with no hardware replacement necessary, an impossibility with ASICs. The Spartan-3 family architecture consists of five fundamental programmable functional elements

Configurable Logic Blocks (CLBs) contain RAM-based Look-Up Tables (LUTs) to implement logic and storage elements that can be used as flip-flops or latches.

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Input/output Blocks (IOBs) control the flow of data between the I/O pins and the internal logic of the device. Block RAM provides data storage in the form of 18-Kbit dual-port blocks. Multiplier blocks accept two 18-bit binary numbers as inputs and calculate the product. Digital Clock Manager (DCM) blocks provide self-calibrating, fully digital solutions for distributing, delaying, multiplying, dividing, and phase shifting clock signals.

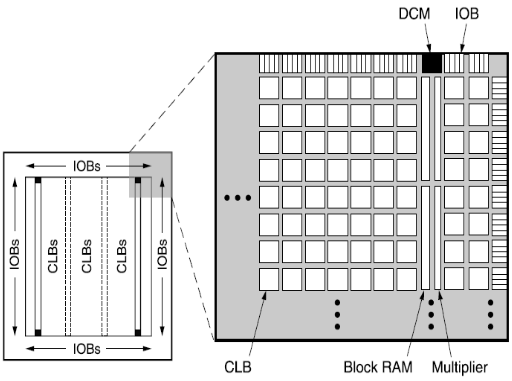

Fig 8: Internal structure of FPGA Configuration

V. EXPERIMENTAL RESULTS AND SNAPSHOTS

The aim of thispaper is to develop automated machine learning system that does not need any manual interpretation for decision making. Thus the proposed machine learning system is based on Adjustable Fuzzy Clustering, for data grouping to ease the job of classification system and Fuzzy Neural Network for supporting incremental learning.

This proposed system resembles human intelligence in making accurate decision even in uncertain situation. By the implementation of this system shows higher accuracy of recognizing human activity even with large data from different sensors.

In this model the aim to design and implement the fire and smoke alarming system of the smart room with ANN using T-H method is achieved. The results obtained for linear and sigmoidal neuronal implementation are shown

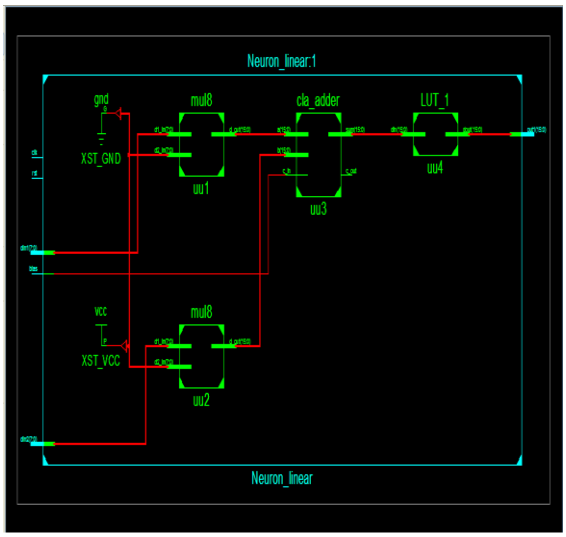

Fig 9.RTL schematic for single layer linear neuron

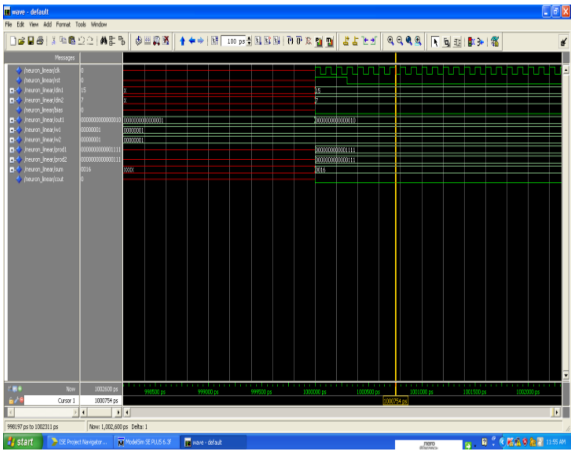

Fig 10: Single layer linear neuron output

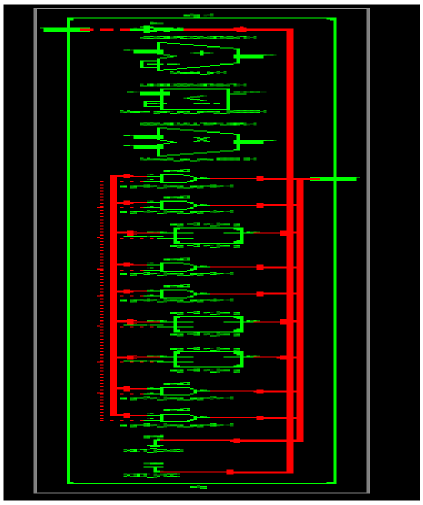

Fig 11: RTL schematic for single layer sigmoidal neuron

VII. CONCLUSION

The paper proposes an FPGA based Fuzzy neural network architecture using Takagi Hayashi method for a smart room was implemented successfully. The hardware architecture proposed allows FNN T-H on FPGA devices to be embedded and can be used for applications in the control area, prediction problems, interpolation and other problems. The MLP networks provide a soft computation to generate the parametric equations of membership functions and consequents equations. The training method proved to be efficient, including the Self-Organizing Map for data clustering and back propagation to train all MLP networks. The proposed architecture will be used to develop a system with online training to embed control problems using FNN T-H. The main intention is to update the weights if the system has a complex dynamic that changes over time.

The project proposed uses the FNN to control and interpolate the incoming data i.e. from the sensors and to maintain the safety of a smart room , where in an alarming system gives alarm for the safety measures and cuts off main power supply to avoid short circuits which may lead to huge destructions to property and lives . With this proposed system it is possible to embed the FNN to control a smart room in a chip to solve many problems with simple topology configuration.

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