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Implementation of Artificial Neural Network for Pattern Detection in VHDL

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Abstract: ***Artificial Neural Network is basically a system which works on the functioning of human brain and nervous system. As it is an intelligent machine its demand is increasing in real time application. Here first we have implemented artificial neuron and then use it in artificial neural network for detection of pattern. The basic universal gates are used to build an artificial neural network. This paper suggests the implementation and behavior of artificial neuron and how it can be used to detect patterns. The pattern used here is digits or characters.***

Keywords: Artificial neuron, VHDL, simulation, artificial neural network

1. Introduction

Now a day's artificial neural network is being used in various applications due to its processing speed. It is basically derived from the human neural network. Earlier neural network was only used in medical research but now its working is emulated so as to use in various applications. Human brain can perform much faster than any other system. The main aim of emulating the behavior of biological neural network is to understand how it processes and then to use it in various applications. The processing element of artificial neural network is artificial neuron which is derived from the processing element of biological neural network i.e. biological neuron. These neurons are connected in parallel so as to form artificial neural network. To perform any application, artificial neural network are first trained by using certain examples. Basically artificial neural network adapts to changes in the environment, hence it develop its own rules so as to maintain the continuity of the work. Artificial Neural Network is called an intelligence system as it learns from its past experiences. The response time of any integrated circuit is 1 nanosecond while the response time of neuron is 1 millisecond. But the artificial neural network form a network of interconnected neurons, hence its processing speed is much more than integrated circuits. The artificial neural network is compared with black box. Certain inputs are applied to it and an output is obtained. Here without knowing the internal functioning we can use it in applications. This is one of the biggest advantages of artificial neural network. Artificial neural network simplify the function of human brain, hence it is used in various applications. The various applications in which artificial neural network is used is in aerospace as autopilot aircrafts, in automotive as automobile guidance system, in military as weapon orientation, target tracking, face recognition, object discrimination, signal identification, in electronics as IC chip failure analysis, in financial as loan advisor, currency value predictor, in industries as manufacturing process control, quality analyzer, in medical field as EEG and ECG analysis, in software as face recognition and many more. We will discuss how artificial neuron works. Section 2 deals with basic concept of artificial neuron, section 3 explains the proposed system and section 4 deals with result and conclusion.

2. Preliminary

Basically artificial neuron is inspired by biological neuron and artificial neural network by human brain. Biological neuron has three main parts. They are dendrites, soma and axon. It consists of certain inputs and a single output. The inputs are received by dendrites and the output is transmitted by axon terminal. Inside the biological neuron addition and comparison of inputs is performed in the soma. Similarly in artificial neuron certain inputs are taken through dendrites i.e. input terminals and output is provided through axon terminal. Also a single neuron is connected to other neurons and form parallel network. Hence the input to dendrite can be the output of previous connected neuron or stimuli from the environment and output of neuron is transmitted to dendrite of next neuron or as stimuli to external environment. One of the most important properties of neuron is its capacity to learn. Neuron learns by changing its physical connection from other neuron. This is replaced by taking weights in artificial neuron. This weight is variable quantity whose value can be changed by neuron. In artificial neuron weight is nothing but the multiplier. Since every input does not have equal importance. Some are more important while some are less important. So these weights are multiplied with respective input so as to maintain the importance of corresponding input. After multiplication all the inputs are added. This function is performed by summation block. The result of addition is compared with a threshold value which is predefined. This function is performed by activation block. If the result of addition is more than the threshold value then the spike is generated and if the result of addition is less than the threshold value then the spike is not generated. This entire process is carried out in the soma of the biological neuron. The certain usefulness and capabilities of artificial neural network are: non linearity, input output mapping, adaptive nature, evidential response and fault tolerance. The behavior of human brain is non linear, hence the behavior of artificial neuron is also non linear. Input output mapping means learning of neuron. Neuron learns by two ways, either by self or by a teacher. During this learning neuron changes its connection with other neuron which is called synapse. These connections are represented as weight in artificial

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neuron. Neurons are adaptive to nature, by learning they adapts certain features from surrounding such as fire. Evidential response denotes the confidence level of neuron. The output of neuron changes due to change in confidence level. Fault tolerance refers to graceful degradation. This means that the amount of degradation of input is equal to amount of degradation in output, the output will not be completely degraded. This complete knowledge is used in emulation of artificial neuron which we will discuss in the next section.

3. Proposed System

The schematic block diagram showing the artificial neuron is shown in below figure 1. The block diagram contains four inputs, one adder, one activation function and an output signal. For the implementation of artificial neuron we have considered four dendrites. For each input a weight is taken. Hence in proposed system we have consider four multiplier one for each input and a single output. The basic function of biological neuron is to generate action potential and to add and compare inputs with the threshold value. Hence in the proposed system the inputs are first multiplied with specific value which denotes the weight for particular input. The multiplier block has a single input and single output. Then the output of each multiplier is send to adder block where each output of multiplier is added. The adder block also has a single input and single output. After that the output of this adder block is send to activation function block. The activation function block has single input and single output. The activation function is of many types such as sigmoid function, linear function or hyperbolic tangent. Depending on the application these functions are selected, here we have use the linear function. In activation function a value is fixed, if the output of adder is more than the fixed value then the output will be high i.e. logic 1 otherwise low i.e. logic 0.

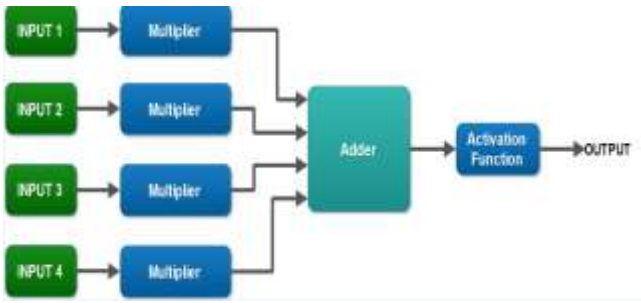


Figure 1: Artificial Neuron

The output of activation function is the final output of the artificial neuron. These neurons in a large scale form artificial neural network. For the application of pattern recognition we have use four input and seven outputs. The block diagram of artificial neural network is shown in below figure 2. It contains four inputs, three hidden layer and output layer. Here three hidden layer is used so as to increase the flexibility. These inputs are digits from zero to nine and outputs are from character a to g. The output for each input is predefined, hence no training is required. For the flexibility of the system three hidden layers are used. Each hidden layer consists of fifteen neurons. Each neuron consists of a multiplier, four input adder and an activation function. Here multiplier performs and operation. The multiplier is used so as to increase the strength of the input signal. This is not possible in digital circuits. Therefore multiplier block is used to increase the value of signal. It converts 1 bit input to 16 bit output. The adder provides addition operation. The activation function used is linear function. Here a certain value is fixed. If the output of addition is more than this value then output will be 1 otherwise 0.

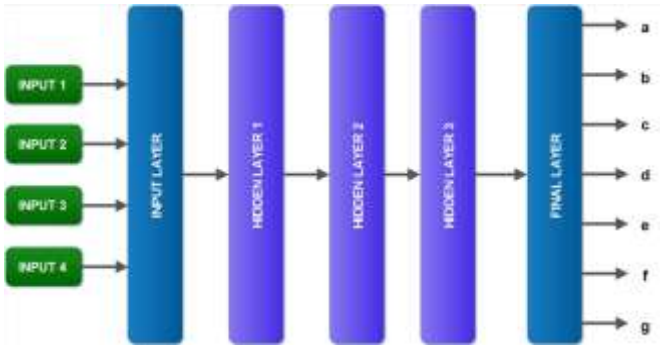


Figure 2: Artificial Neural Network

4. Results and Discussion

The proposed system has been simulated in ISE Xillinx 14.7 software. The simulation result has been shown in figure 3 and the RTL schematic in figure 4 below. Here we have four inputs and seven outputs.

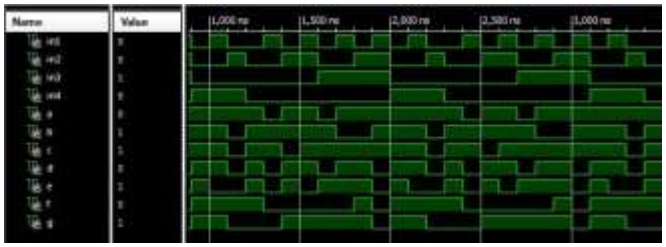


Figure 3: Simulation Result

The four inputs shown here are input 1 to input 4 which denotes digits from zero to nine and outputs are letter a to g. Using these output, we can display the digits on seven segment display. These output can even be implemented on FPGA as well.

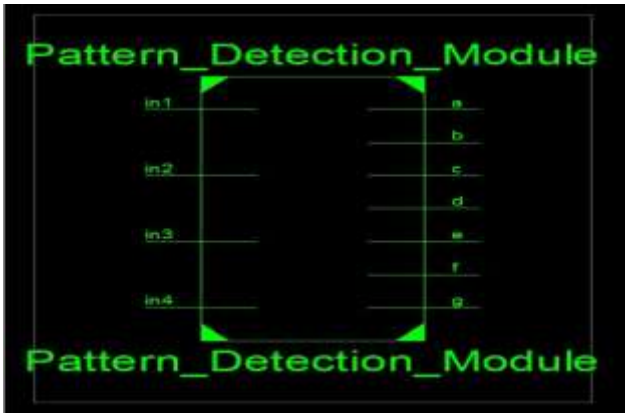


Figure 4: RTL schematic of artificial neural network

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