FPGA Based Diabetic Patient Health Monitoring Using Fuzzy Neural Network

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Abstract: *This is a FPGA based system and this system employs a fuzzy interface cascaded with a feed-forward neural network in order to obtain an optimum decision regarding the future pathology physiological state of a patient. The neurons that are considered in the proposed network are devoid of self-connections instead of commonly used self-connected neurons. Applying the methodology, the chance of forecasting of critical diabetic condition of a patient can be predicted accurately, 30 days ahead of actually attaining the critical condition. The fuzzy interface discussed here performs fuzzification of patient data. The data from the patient such as height or weight data cannot always be trusted as they are subjected to the quality and accuracy of measuring units and the skill of the technician. Moreover, based on a single data, it would be highly uncertain to make an accurate decision about the future physiological state of the patient. So the patient data have been fuzzified with the objective of transformation of periodic measures into likelihoods that the body mass index, blood glucose, urea, creatinine, systolic and diastolic blood pressure of the patient is high, low or moderate.*

Keywords: FPGA, fuzzification, diabetic

1. Introduction

One of the few things about which everyone can agree is that our health care system is not performing the way we want it to. In the public arena, most of the attention is on the structure and financing of care. However, there is another deeper problem. It concerns the content of care – the tests, treatments and other things providers do to try to prevent and manage diseases. In the end, it is content of care that determines the actual quality and generates the actual costs of the care that people receive.

Due to the large number of patients at the nodal center which are being diagnosed by the physician, it is not possible for the physician to efficiently monitor and diagnose each patient along the time. An unwarranted imbalance in patient–doctor ratio has necessitated the development of an equipment which can predict an imminent health hazard and can red alert the patients to contact doctor for necessary care. Profiling and storage of sets of patient data in non-volatile memory of the instrument is an additional advantage in rural areas of third world countries where archiving of medical records is poor.

The notion of an instrument for first order clinical diagnoses of chronic cases, in particular, becomes important when patients and doctors are physically apart from each other and doctor needs to remain vigilant about early signal of deterioration of health of patients. However, in the backdrop of scarcity of physicians especially in the rural areas, an instrument with some auto-decision making support can be used for early diagnosis of problems related to specified systems of patients' bodies. These systems can aid the physicians or the health care professionals in absence of the physicians to predict the pathophysiological state of a patient knowing the past pathophysiological data and red alert the physician or the health care professionals in case a critical condition of the patient occurs so that the health care professionals can communicate with the physician at the remote location in time and the physicians at the remote referral centers can provide medical ailments to the patient.

2. Why Use Neural Networks?

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyse. This expert can then be used to provide projections given new situations of interest and answer "what if" questions.
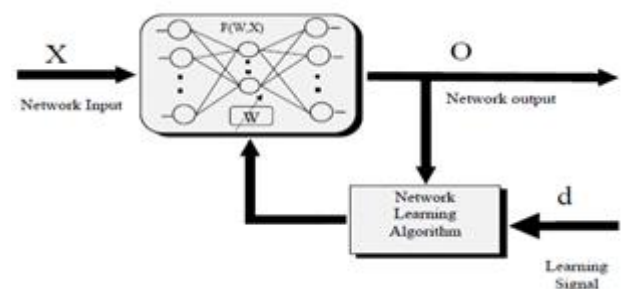

Figure 1: Supervised Learning Rule

3. Why use FPGA

The design and training of a fuzzy neural network used for early diagnosis of a patient through field programmable gate array (FPGA) based implementation of a smart instrument. A large numbers of fuzzy control applications with the physical systems require a real-time operation to interface high speed constraints; higher density programmable logic devices such as FPGA can be used to integrate large amounts of logic in a single IC

3.1 Functional architecture of fuzzy neural smart agent based medical diagnostic system

Fig. 2 shows the functional architecture of the fuzzy neural smart agent based medical diagnostic system. At least two entities, viz. patient and smart agent are required in this concept of smart agent based diagnostic system. The patients are the providers of data under the assistance of health care

professionals who need not be physicians. The smart agent is represented by a weakly coupled fuzzy neural system that can predict the future pathophysiological state of a patient in presence of past pathophysiological data. The weakly coupled fuzzy neural network is basically a two unit composite system comprising of a fuzzy system placed before a neural network. The fuzzy interface makes an approximate inference about the current state of the patient from the current patient data being entered into the smart agent. The membership values obtained from the output of the fuzzy interface are supplied to the input of the neural network for making a decision regarding the future pathophysiological state of the patient.
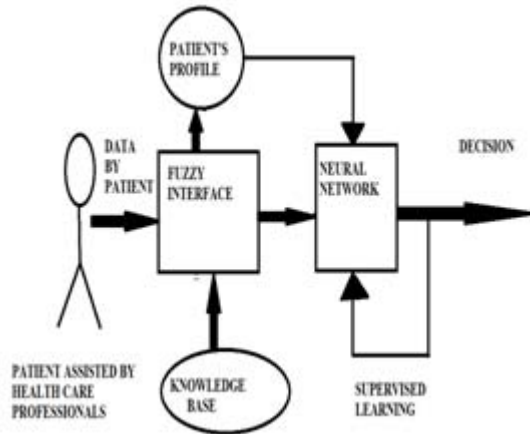

Figure 2: Functional architecture of the fuzzy neural smart agent

3.2 Architecture of the fuzzy neural network

The architecture of the fuzzy neural network is shown in Fig. 3. The left most layer is the input layer which accepts the membership function values which are presented to the hidden layer. The input layer consists of 50 neurons, the hidden layer consists of 15 neurons and the output layer consists of 3 neurons. The neural network calculates the possibilities of the pathophysiologicalparameters to be low, moderate or high at the next instant of time.

The connection between the input layer and the hidden layer is shown as interconnection network box. There is a connection between every neuron in the input layer and every neuron in the hidden layer .The weighted sum of the possible values from the hidden to the output layer indicates the criticality of the current condition of thepatient which is indicated as an output to the neural network .The inputs are presented to the input layer in the form of a 50 tuple {b(1), b(2),……..b(10), g(1), g(2),……,g(10), c(1), c(2),…….,c(10), s(1), s(2),…….,s(10), d(1), d(2),…….,d(10)}. Initially only b(1), g(1), c(1), s(1) and d(1)have non-zero values, while others have zero values. At the next instant oftime (after10 days), when a new set of data is entered, b(2), g(2), c(2), s(2) and d(2) are updated to non-zero values and soon. As new sets of data are entered ,the old sets of data are updated .Thus after 10 sets of data collected at 10 days interval are entered ,when the 11th set of data is entered ,the new set of data goes to b(10), g(10), c(10), s(10) and d(10) and b(9), g(9), c(9), s(9) and d(9) are updated with the previous values of b(10), g(10), c(10), s(10) and d(10) and so on.
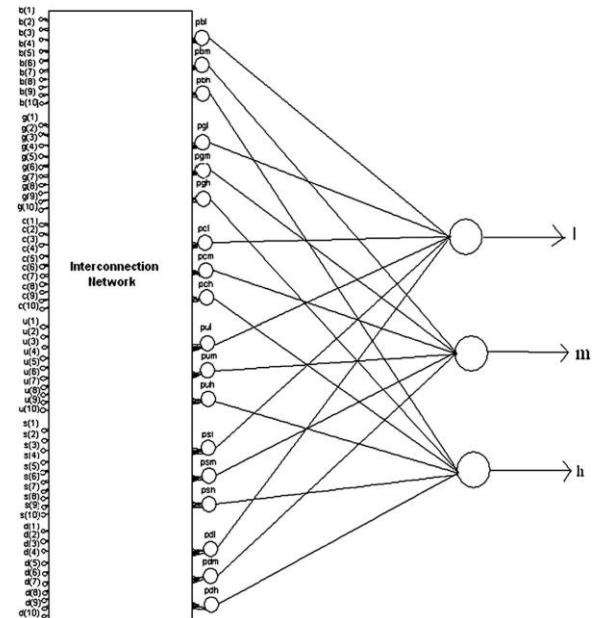

Figure 3: Design of the fuzzyneural network for diagnosing criticality of patients

4. Result

The system has been tested with the data of 40 patients taken at 10 days interval of time and the results are compared with decisions being given by the medical practitioner. The data of a sample patient of 30 years have been analyzed and the accuracy of 70% was achieved.
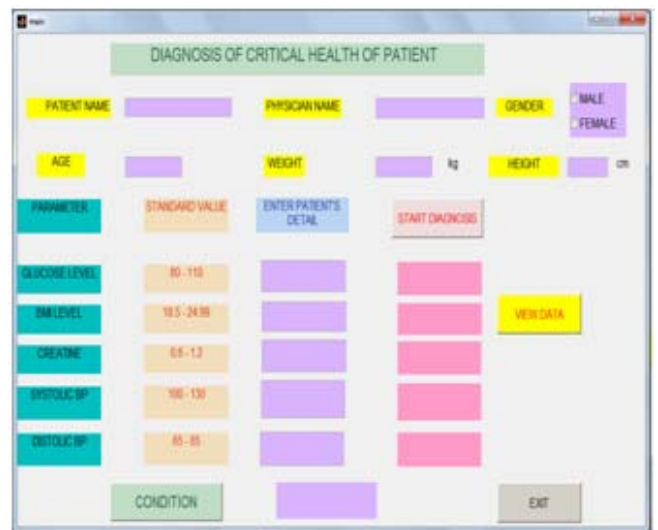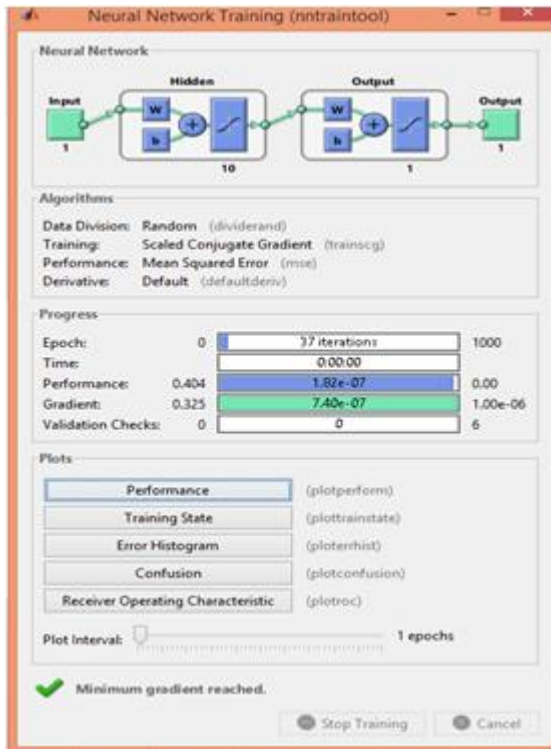

Figure 4: Main GUI

Figure 5: Training network

5. Conclusion

The current work focuses on the application of neuro-fuzzy synergism to detect at an early stage the probable approaching critical condition of a patient. It explains the usage of fuzzy neural networks in medical diagnosis systems and the extended example on the problem of early detection of approaching critical condition of patients.

The developed system gives a crisp decision regarding the future physiological state of the patient, the essence of the system lies in that the system predicts state of criticality of the patient much before the condition of criticality occurs. This also elucidates that such type of system when implemented in portable hardware can be deployed in telemedicine environments in rural areas, where the healthcare professionals often provide support services in absence of the physician.

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