Journal of Engineering Technology (ISSN. 0747-9964)
Volume 8, Issue 1, Jan. 2019, PP.32-39

RESEARCH ARTICLE -ENGINEERNG TECHNOLOGY

Development a Novel Approach of Fuzzy Based FPGA System for Prediction of Jaundice in Rural Area

Sambit Satpathy[1*], Sanchali Das[2], Swapan Debbarma[3]

[123]Department of Computer Science and Engineering, National institute of technology, Agartala, India .
*Corresponding Author

Abstract: This article validates a fuzzy-FPGA based novel diagnosis system which predicts the pathological stage of jaundice disease by computing previous medical data of patients. This smart system consists of three different modules, such as medical data collecting and storing, the Second module contains disease diagnosis algorithm, and the final module is FPGA implementation of proposed algorithm and prediction the pathological stage of the disease. First, the medical data were taken by medical experts and store in a specific database. This data put in the fuzzy-based FPGA system and the outcomes show through test-bench simulation, which gives the disease status and the layout leading to chip design. An innovation of this work is to propose a novel fuzzy-FPGA system which predicts the jaundice disease with high accuracy then the other models and the FPGA implementation make the consumption power.

Keywords: Fuzzy-FPGA, disease diagnosis, pathological condition, Artix-7

1 Introduction

L. Zadeh in 1965 introduced the fuzzy logic concept for solving either true or false type problem [1]. Gradually it is useful to solve control system problems. Now a day fuzzy-logic is not only to solve control system problem but also rigorously used in critical decision-making problems. The goal is to address the complex Large number (N, $0<N<\infty$) of parameters problem dealing with a large number of constraints ($M<N$ $0<M<\infty$) or relations among these N number of parameters. It is impractical to deal with these issues and at the same time to understand the parameters regions of interest mainly when N and M are vast numbers [2] [3]. There are lots of data mining techniques and approaches by researchers for early and more accurate diagnosis of disease [4, 5]. Some researchers have implemented the various algorithm like particle swarm optimization on FPGA hardware for design a low power, portable system, which predicts pathological status for more accurate diagnosis of disease [6,7].

In this disease diagnosis method, we take some medical data means disease constraints and health issue or status. The same medical constraints put in our fuzzy-FPGA base system and predict the disease status. Then we have to compare our fuzzy-FPGA system output with the doctor's output or disease status. Ninety-four per cent of our system output is matched with doctors' decision, due to which we proceed to implement this work for layout design, which leads to chip design. This work is helping to develop the healthcare system and improve the quality of life of rural people.

Journal of Engineering Technology (ISSN. 0747-9964)
Volume 8, Issue 1, Jan. 2019, PP.32-39

2 The architecture of the Smart Diagnostic System

India is the world second greatest populated country, but. From the survey report, it observed, 68% of the total population is living in rural area and also in the semi-rural area, but 25% of total qualified doctors are available for healthcare. This thing makes the ratio of patient-doctor in the rural area about 4000:1 and the corresponding value in the urban area is about 610:1 [8]. To avoid this patient-doctor ratio and for improving the health care system, we implemented this fuzzy-FPGA system for prediction of disease [9].

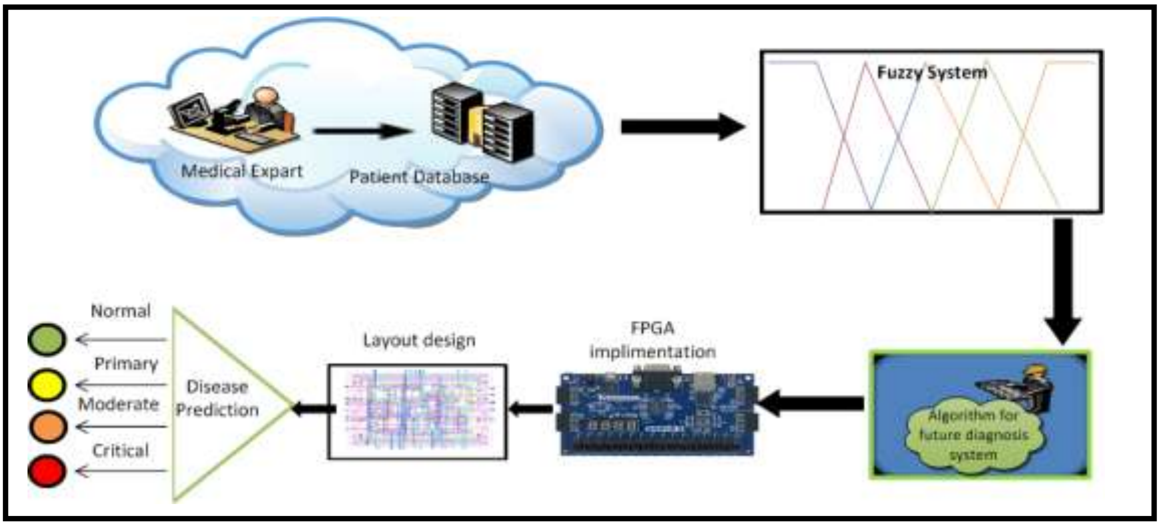


Figure.1 Novel architecture of the smart diagnosis system

Figure.1 describes the architecture of a smart diagnosis system. This smart system consists of three different modules. The first module collects the medical data and properly soring in a secure database called patient database. The second module contains disease diagnosis algorithm, and the final module is FPGA implementation of proposed algorithm and prediction the pathological stage of the disease. The outcomes of the forecast are a different medical state like normal, primary, moderate and critical of the jaundice disease.

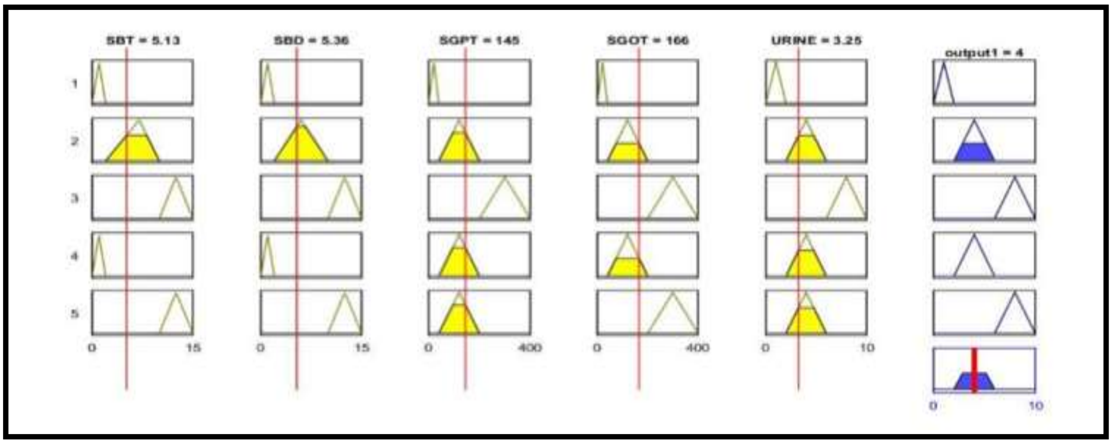


Figure.2 Fuzzy logic rule viewer

Medical expert takes patients data from their blood, urine reports and stores them in the hospital database, which called patient database. These stored data utilized by Fuzzy rules which are implemented on the FPGA system and weighted sum algorithm that helped for prediction the pathological condition of jaundice disease. The pathological condition is verified by test-bench simulation result. The predicted pathological condition compare with the known doctor's decision for checking the accuracy of our design system. We get that; our predicted value is 94% matched with the doctor's decisions. To verify our proposed model is better than other models like Naïve Bayes (NB), K fold Nearest Neighbor (KNN), Support Vector Machine (SVM), Decision Tree (DT) in term of accuracy. Due to this, we make a layout design of fuzzy rule module, which leads to chip design and helps to improve their health care system and overcome from the high patient-doctor ratio in the rural area.

2.1 Define Fuzzy Rules:

Below we defined six fuzzy rules for prediction of jaundice disease, from previous pathological data [10, 11]. Five different parameters we considered from the blood test and urine test of patients. These are sbt (serum bilirubin total), Sbd (serum bilirubin direct), Sgpt (serum glutamic pyruvic transaminase), Sgot (serum glutamic-oxaloacetic transaminase) and urine colour test. The ranges of parameters are sbt (0-15), sbd (0-15), sgpt (0-400), sgot (0-400) and urine (0-10) and output value (0-10) [12].

R1: If (sbt is critical) and (sbd is critical) and (sgpt is critical) and (sgot is critical) and (urine is critical (reddish)) then (jaundice output is critical).

R2: If (sbt is moderate) and (sbd is moderate) and (sgpt is moderate) and (sgot is moderate) and (urine is moderate (reddish)) then (jaundice output is moderate).

R3: If (sbt is primary) or (sbd is primary) or (sgpt is primary) or (sgot is primary) or (urine is critical (yellow)) then (jaundice output is primary).

R4: If (sbt is normal) and (sbd is normal) and (sgpt is normal) and (sgot is normal) and (urine is normal (light_yellow)) then (jaundice output is normal).

R5: If (sbt is normal) and (sbd is normal) and (sgpt is primary) and (sgot is primary) and (urine is normal (light_yellow)) then (jaundice_output is primary.

R6: If (sbt is primary) and (sbd is primary) and (sgpt is critical) and (sgot is critical) and (urine is primary (yellowish)) then (jaundice output is critical) [13].

Fuzzy logic rule box is generated in Figure. 2. In that figure, we can see that one satisfies the condition of fuzzy rule R3, where sbt, sbd, sgpt, sgot, urine five input parameter values are taken as 5.13, 5.36, 145, 166 and 3.25 respectively. Then Output comes for above-specified values as 4, which show the primary condition of jaundice disease.

2.2 Register transfer level (RTL) model using Xilinx EDA tool

The schematic representation of fuzzy rules is implemented by Xilinx Vivado EDA tool. This representation describes a graphics symbol rather than realistic pictures [14].
Figure.3 left-hand side shows five inputs like sbt, sbd, sgpt, sgot and urine and the output that comes due to the corresponding five input constraints that are present in the right-hand side. All fuzzy rules are implemented using Logic gates, mux, latches, and comparators. According to this fuzzy output, we get the future physiological condition like normal, primary, moderate, critical of jaundice disease [15].

3 Algorithm for medical diagnosis

Equation.1. Represent the weighted algorithm, which computes the weighted mean of the membership function. This function gives the result of the future pathological condition such as normal, primary, moderate, critical.

$$P_r(x) = \frac{\sum_{i=1}^{n} i\mu_i(x)}{\sum_{i=1}^{n} i} \qquad (1)$$

Where the summation is done from i = 1 to n, and 'n' signifies the number of times medical data were taken. The membership function μ(x) is divided into four membership functions, such as μn (x), μp (x), μm (x), μc (x) named as normal, primary, moderate and critical respectively. The future medical status of the patient is determined by P_r (x) function [15].

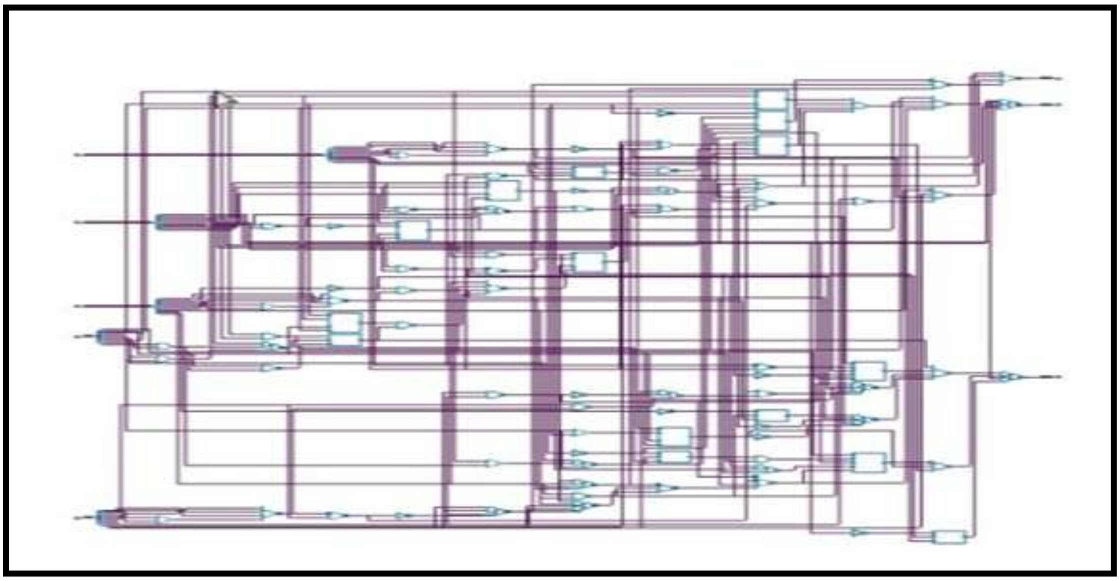


Figure.3. Schematic diagram of fuzzy rules having five inputs and four outputs

Journal of Engineering Technology (ISSN. 0747-9964)

Volume 8, Issue 1, Jan. 2019, PP.32-39

RESEARCH ARTICLE -ENGINEERNG TECHNOLOGY ASEE

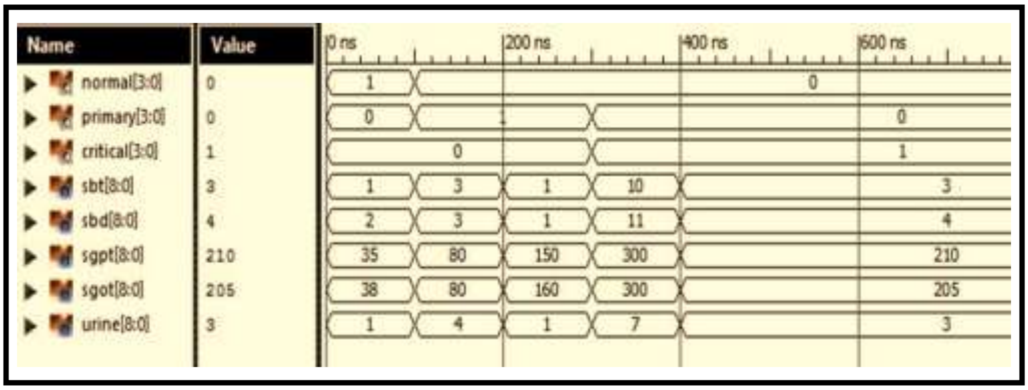
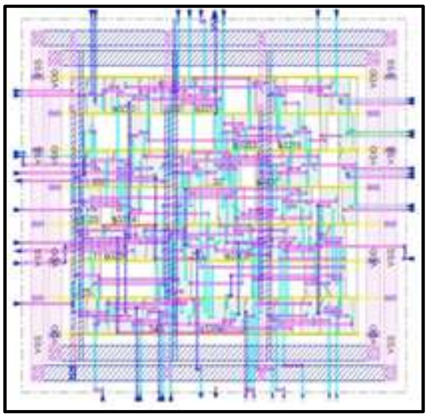


Figure.4.Test_bench simulation result with five inputs and four output

4.1 Experiments and Results

There are five different health parameters such as SBT, SBD, SGPT, SGOT and Urine are taken by the medical expert. This medical data are used as input to the fuzzy-FPGA based system, and the output comes in the form of the future medical stage such as, normal, primary, moderate and critical [16]. This fuzzy-FPGA system output is shown through test_bench simulation. The test_bench is a HDL code that permits us to provide a standard, repeatable set of stimuli [17]. It consists of a clock, input data, and output and it verifies that our design, work properly or not. In Figure.3 and Figure.4 we consider five different inputs and corresponding four outputs which are associated with six fuzzy rules. Out of six fuzzy rules are one rule defines for normal condition, two rules for the primary condition, one rule for moderate and two rules for critical condition of jaundice disease [18]. In Figure.4 five different examples are there, out of which describe the second one that satisfied the primary condition of jaundice disease status. For this case disease parameter sbt, sbd, sgpt, sgot and urine 3, 3, 80, 80, and 4.This input data satisfied the primary condition of jaundice so that we get output ‘1' for primary condition and ‘0', ‘0', ‘0' for



Journal of Engineering Technology (ISSN. 0747-9964)
Volume 8, Issue 1, Jan. 2019, PP.32-39
RESEARCH ARTICLE -ENGINEERNG TECHNOLOGY ASEE

(a) (b)

Figure.5. (a) Hardware implementation using Spartan3E (b) Layout of fuzzy rules

normal, moderate, critical condition respectively. Similarly, we considered different inputs values, which satisfied the five other conditions of fuzzy rules that helpful for prediction of disease. For first, third, four, fifth input values we got '1' for normal, '1' for primary and '1', '1' for critical condition respectively [19-20].

4.2 Layout of implemented module

Figure.5 (b) explains the layout design of fuzzy rules using cadence Innovus tool [21]. Its architecture minimizes design repetitions and provides the runtime boost which makes our system faster. It will help to build integrated, and the massively parallel architecture that can handle big application is based on the industry-leading embedded processor having with shallow nanometer technology [22]. Making layout is the initial steps for chip design, to find out the pathological stage of jaundice disease so that the rural people are aware of the disease and take necessary action to overcome the critical health issue.

5. Comparison:

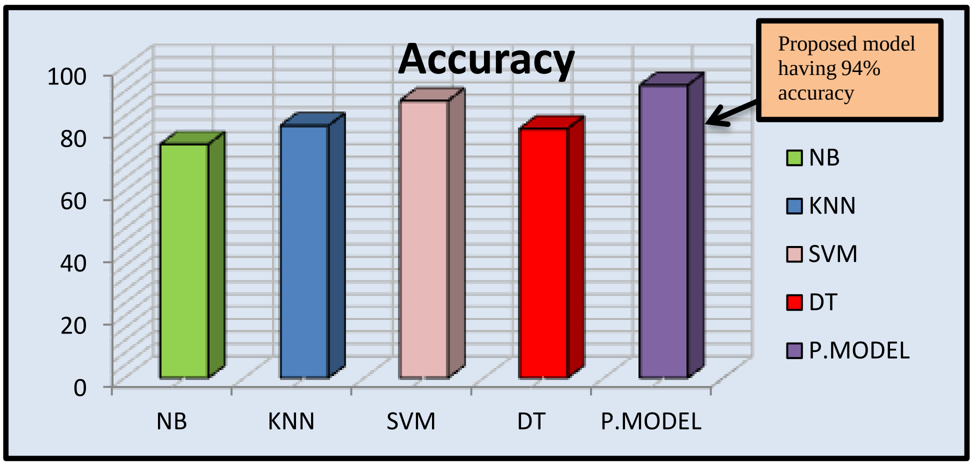
In Figure.4 describes the jaundice disease constraints, such as sbt, sbd, sgpt, sgot, urine and future pathological status like normal, primary, moderate and critical. Here we have taken 100 number of reading of input constraints and predict the output according to our fuzzy-FPGA smart health system. We compare the prediction accuracy of our model with other algorithms, such as Naïve Bayes (NB), K fold Nearest Neighbor (KNN), Support Vector Machine (SVM), Decision Tree (DT) in Figure.6. This figure demonstrates that our model accuracy 94%, which is more the other method.

Table.1: Utilization of resources for hardware implementation of fuzzy unit

SPARTAN3-E				
No	Logic Utilization	No of Used	Available	**Utilization**
1.	Number of slice flip-flop	22	9318	**0.92%**
2.	Number of 4 I/P LUTS	253	9132	**2.3%**
3.	Number of I/O blocks	170	222	**74%**
4.	Power Consumption	**0.099 w**		

6. Conclusion

In this research article, we proposed a fuzzy FPGA based smart system which will compute the past medical data and predict the pathological condition of jaundice disease. The accuracy of our proposed model is 94 % which is more than the other algorithm such as NB, KNN, SVM, and DT. The FPGA implementation is making the whole system faster, and the power consumption for FPGA implementation is 0.099 watt, which makes our system energy efficient. All the advantages like high



accuracy, fast computation, and low power consumption can improve the healthcare system of the rural area.

Figure.6 Comparison of proposed model with other algorithms

References

[1]. Zadeh L. A., "Fuzzy logic computing with words". IEEE Transactions on Fuzzy Systems 1996; 4(2): 103-111.

[2]. Farag W.A, Quintana V.H, Lambert-Torres G, "A genetic-based neuro-fuzzy approach for modeling and control of dynamical systems". IEEE Transactions on Neural Networks 1998; 9 (5): 756-767.

[3]. Ashrafi M, Hock Chye Chua L, Quek C, Qin X, "A fully- online Neuro-Fuzzy model for flow forecasting in basins with limited data". Journal of Hydrology 2017; 545: 42-435.

[4]. Ananth C, Karthikeyan M, Mohananthini. N, "A secured healthcare system using private blockchain technology". Journal of Engineering Technology 2018; 6(2): 42-54.
[5]. Bouazza S.H., Khalid A, Zeroual A, "Fuzzy expert systems (FES) for medical diagnosis". Journal of Engineering Technology 2018; 6 (2): 98-113.
[6]. Al-Haija A.Q, Syed Ahmad S.M, Alfarran I. "FPGA Implementation of Variable Precision Euclid's GCD Algorithm". Journal of Engineering Technology 2017; 6 (Special Issue): 410-422.
[7]. Thiyagarajan M , Bharathi N. "Hybrid neuro-fuzzy system for prediction of stages of lung cancer based on the observed symptom values". Biomedical Research 2017, 28(2).
[8]. Madhav G.D. "Doctor Population ratio for India - The reality". Indian Journal of Medical Researc 2013; 137(4): 632-635.
[9]. Das S, Chowdhury S. R , Saha H, "Accuracy Enhancement in a Fuzzy Expert Decision Making System Through Appropriate Determination of Membership Functions and Its Application in a Medical Diagnostic Decision Making System". Journal of medical systems 2012; 36:1607-1620.
[10]. Khare S, Gupta D, "Association rule analysis in cardiovascular disease".
Cognitive Computing and Information Processing (CCIP), Second International Conference on 2016; 1-6.
[11]. Hong T.P, Lin K.Y, Wang S.L, "Fuzzy data mining for interesting generalized association rules". Fuzzy sets and systems 2003; 138 (2): 255-269.
[12]. Mitra S, Hayashi Y, "Neuro-fuzzy rule generation: survey in soft computing framework". IEEE Transactions on Neural Networks 2000; 11(3): 748-768.
[13]. Ahmad A, Beg M.T, Ahmad S. N, " Measuring inter-class fairness in wireless networks using a fuzzy approach". Journal of Engineering Technology 2018; 6 (1): 119-128.
[14]. Huang W, Sankaranarayanan K, Skadron K, Ribando R. J, Stan M.R, "Accurate, Pre-RTL Temperature-Aware Design Using a Parameterized, Geometric Thermal Model". IEEE Transactions on Computers 2008; 57 (9):1277-1288.
[15]. Chowdhury S R, Chakrabarti D, "FPGA realization of a smart processing system for clinical diagnostic applications using pipelined data path architectures". Microprocessors and Microsystems 2008; 32(2):107-120.
[16]. Keller J.M, Hunt D.J, "Incorporating Fuzzy Membership Functions into the Perceptron Algorithm". IEEE Transactions on Pattern Analysis and Machine Intelligence 1985; 7(6): 693-699.
[17]. Xilinx Technology Xilinx, Matlab combine application on dsphttps://in.mathworks.com/solutions/fpga-design/simulink-with-xilinx-system-generator-for-dsp.html.
[18]. Wu S, JooEr M, Gao Y, "Afast approach for automatic generation of fuzzy rules by generalized dynamic fuzzy neural networks". IEEE Transactions on Fuzzy Systems 2001; 9(4): 578-594.
[19]. Pradhan M.C, Satpathy S, Bhoi B.K, "An improved FPGA based model for automatic traffic sign detection". International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Chennai, 2015: 291-298.
[20]. Gharghory S.M , Dalia El-Dib A. D, "Fuzzy Control System for Regulating the Blood Glucose Level of Diabetes Patients Implemented on FPGA". Journal of Circuits, Systems and Computers 2016; 25(12).
[21]. Hunt M, Rowson J A, "Blocking in a system on a chip". IEEE Spectrum 1996; 33(11): 35-41.
[22]. Bora D, Thomas B, Nandi S, Trivedi G, "Application specific processor design implementation to monitor seismic activity". International Conference on Accessibility to Digital World (ICADW) 2016.