Forecasting of Disease with an EMD- based FPGA ensemble Learning Paradigm

Dr. Swapan Debbarma
Assistant Professor, Department of CSE,
NIT Agartala, Jirania, Tripura

Abstract : Analysis of doctors' reports in Agartala 56% people is affected by liver disease. The problem with most liver diseases is that is asymptomatic in early stages and by the time they detected; 70-80% of the liver is already damaged. So that detection of this disease is now more important than cure. We find out these diseases occur by viral hepatitis virus (A to E) and contaminated iron particles present in water. Prediction of liver disease occurs by finding out how the virus and polluted particle affected the liver, which got by taking the blood sample. It followed by four liver tests sbd, sbt, sgot, sgpt and a urine test. In this paper, we take the medical data of all five tests from Agartala Government Medical College, Tripura and Physionet database system. This database helps for prediction of jaundice using fuzzy system and EMD algorithm. Automatic identification of IMFS generated by this algorithm, which shows to slow varying trend in the data and makes it an application for analysis of Jaundice disease. Innovation of this paper is successful prediction, implemented the whole system into ARTIX-7 FPGA and design RTL model for leading to a prototype design. It overcomes the particular range of consecutive maxima or minima for find out IMF and applicable to high frequency.

IndexTerms - Empirical Mode Decomposition, Intrinsic Mode Function, FPGA, Artix-7

I. INTRODUCTION

Data This Liver has performed different biological synthesis and excretory function. So there is no single test which can detect the comprehensive function of liver [1]. Liver tests are helpful tools which are capable to detect jaundice disease. Here we consider various liver test like SBT, SBD, SGPT, SGOT and urine, through which we analysis proper functionality of liver [2].

The Hilbert–Huang transform (HHT) is a process to decompose a signal into small intrinsic mode functions (IMF) and having a trend. Empirical mode decomposition (EMD) is a main part of HHT algorithm [3]. Through shifting process signals are decompose into IMF with final residue. There have been many applications of EMD algorithm on biomedical, financial, Image processing, neuroscience, digital signal processing [4-5]. EMD algorithm has been implemented by using DSP processor but processing of more number of sequential signals make complex and slow the processing speed [6-7]. In this proposed system ARTIX-7 FPGA comprehends the parallel architecture and performing multitasks at the same time. Memory management and data storing capacity of FPGA is much more than other processor [8-9]. As FPGA has lots of benefit, so that many systems are implemented using FPGA, such as defense system [10], consumer electronics [11], scientific instruments as radio astronomy [12].

Current proposed system contains medical data base of the Agartala Government Medical College, Tripura. First this paper designs a fuzzy system which helps for prediction of disease depending upon various liver tests parameters. Second, this paper implements the medical signal (data base) on EMD algorithm by MATLAB tool. During analysis of EMD algorithm we got lots of IMFS with a residue. IMFS have period of oscillation w.r.to function of time. Initially they are almost periodic oscillation. But gradually it changed and residue of EMD will produce a monotone base function [13-14]. It helps to predict trend of the disease. Third, design a RTL model using Xilinx Vivado tool, which is leading to help for developing the prototype.

II FUNCTIONAL ARCHITECTURE OF PROPOSED SYSTEM

This paper consists of four different modules. In first module medical data are collected from Agartala government medical college and Physionet data base site [15]. Second and third module medical data are passes through fuzzy system, EMD algorithm and predict trend of jaundice. Fpga implementation is done in final module which leading to prototype development.

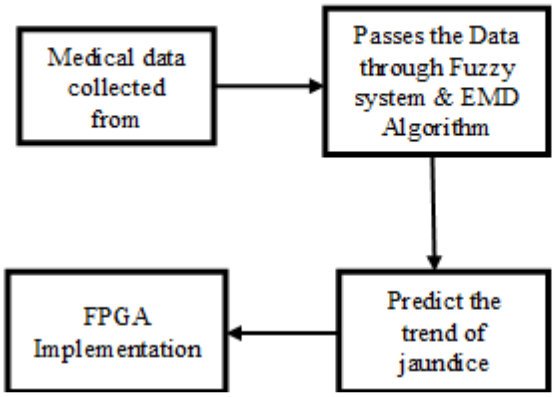

Fig-1 System architecture the whole system

III PROPOSED WORK

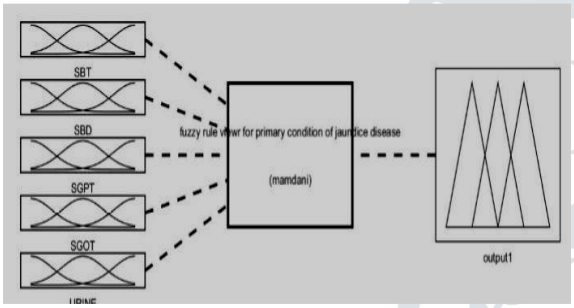

Fig-2 Fuzzy system input & output

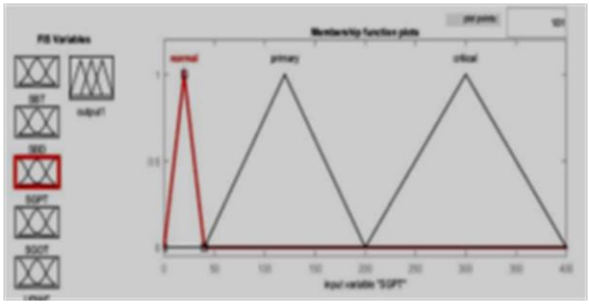

Fig-3 Fuzzy membership system

In fig.2 and 3 Fuzzy system consists of five input and three output parameter. Input parameters are sbt (serum bilirubin total), Sbd (serum bilirubin direct), Sgpt (serum glutamic pyruvic transaminase), Sgot (serum glutamic-oxaloacetic transaminase) and urine. The output consists of three parameters normal, primary, critical condition of disease. This system defines some fuzzy rules, according to which forecasting about the disease [16].

In EMD algorithm any complicated data set can be decomposed into a finite and often small number of IMF Algorithm for EMD

1. Find out local extrema for given signal X (t).
2. Individually connect all maxima and minima (extrema) with the help of cubic spline lines to form upper and lower envelopes U(t) and L (t) respectively.
3. Find mean as, M (t) = [U (t) + L (t)] /2.
4. Obtain the mean subtracted data from the signal data as a-IMF, H1 (t) = X (t) – M (t).
5. Check the early-IMF for the definition of the IMF.
6. If early-IMF H1 (t) does not satisfies the IMF definitions i.e. it is not IMF repeat Step I to step V on H1 (t) till it does not meet the definitions of being IMF after summing up all above steps, we obtained [17].

$$x(t) = \sum_{i=0}^{n} c_i(t) + r_n(t) \quad (1)$$

Where n is the number of extracted IMFs and r_n is the residue.

IV EPERIMENTS AND RESULTS

The proposed system is implemented using the bottom up approach. First the basic modules such as Extrema Identification Module, Circular Buffers, Envelop Modules, and Arithmetic Module etc. are implemented using Verilog-HDL [18]. Then these modules have been integrated to form the top module. The software Xilinx vivado is used to design two layers EMD which decomposed a signal into IMF1, IMF2 and residue r [19]. The whole system is design with Verilog-HDL code and synthesized using Xilinx tool. The target devices are Artix-7 FPGA from Xilinx.

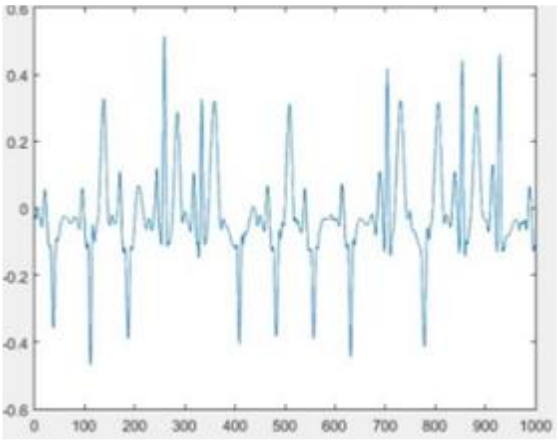

Fig-4 Jaundice data of 1000 person

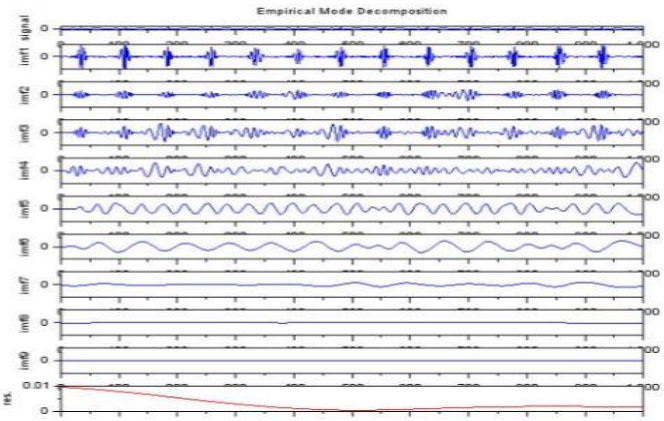

Fig-5 Original signal with all IMF & residue

Jaundice medical reports of 1000 patient are given in fig-4. In fig-5 get all values of IMF generated in SGPT liver test by Matlab software. First IMF is created from original signal by filtering out using cubic spline. After getting the first IMF, substrate it from original signal and the difference is residue for outer loop of process. Construction of an IMF is continuous for a residual signal. The continuous process is stop when residue is monotone or constant.

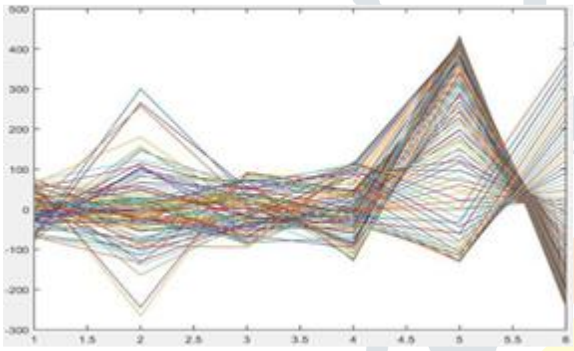

Fig-4 Jaundice data of 1000 person

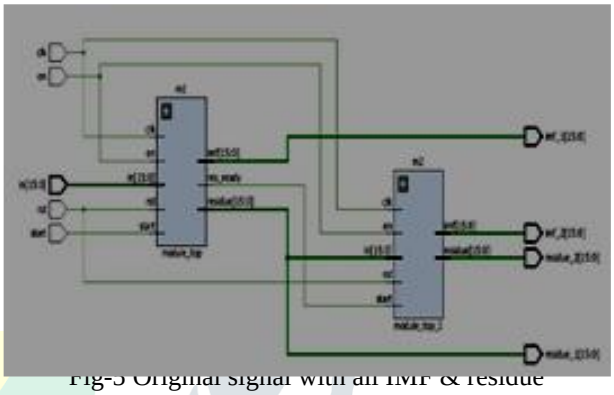

Fig-5 Original signal with all IMF & residue

Fig.6 and 7 has shown the total EMD module. It consists of two sub-modules, which combines to give the residue and IMF [20]. Each sub-module consists of five inputs and four outputs. The five inputs are clock (clk), enable (en), input (in) having 16 bit, reset (rst) and start. The outputs are IMF and residue for each sub-module.

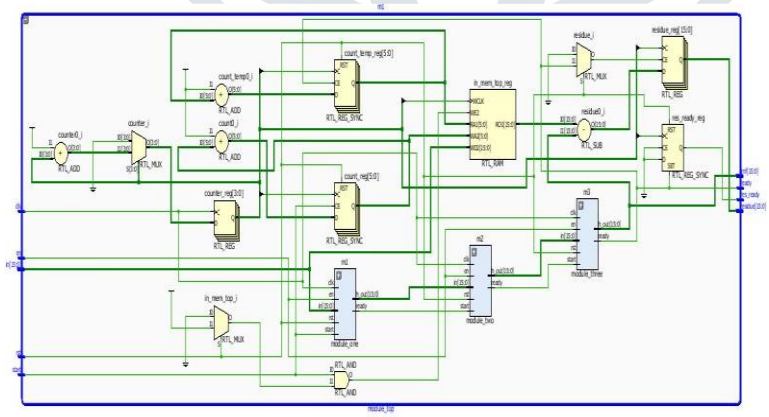

Fig -8 RTL model of EMD algorithm

V CONCLSION

In this work, Efficient FPGA implementation of Empirical Mode Decomposition for real time application has been done. In this the data is divided into sections of 1000 samples so they suffer from the end effect occur near initial and final data of each section. Recent work on FPGA implementation was solely based on the FPGA hardware but it has a restriction that the span between two consecutive maxima or minima should not exceed a predefined value. The proposed design in this work has overcome all above mentioned problem in the proposed method the end effect occurs only at initial and finals stage of the whole data set. It is also applicable on high frequency signal.

REFERENCES

[1] Melvyn G. Korman, M.B.B.S., Ph.D., M.R.A.C.P., Alan F. Hofmann, M.D., and W. H. J. Summerskill, M.D.N Engl J Med," Assessment of Activity in Chronic Active Liver Disease — Serum Bile Acids Compared with Conventional Tests and Histology," The New England Journal of Medicine, .290(25): pp. 1399- 1402 , 2009.
[2] B.R. Thapa and Anuj Walia, "Liver Function Tests and their Interpretation", Indian Journal of Pediatrics, Volume 74, pp 663–671 , July 2007
[3] Pradhan, M. C., Satpathy, S., & Bhoi, B. K. (2015, May). An improved FPGA based model for automatic traffic sign detection. In 2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM) (pp. 291-298). IEEE.
[4] L. Wang, M. I. Vai, P. U. Mak and C. I. Ieong, "Hardware-accelerated implementation of EMD," 2010 3rd International Conference on Biomedical Engineering and Informatics, Yantai, 2010, pp. 912-915.
[5] Abhay upadhya, Manish sharma, Ram Bilaspachori, "Determination of instantaneous fundamental frequency of speech signals using variational mode decomposition", in Computers & Electrical Engineering, vol.62, no., pp.630-647,August 2017.
[6] Russell J. Petersen, Brad L. Hutchings, "An assessment of the suitability of FPGA-based systems for use in digital signal processing", in Moore W., Luk W. (eds) Field-Programmable Logic and Applications, Lecture Notes in Computer Science, vol 975. Springer, Berlin, Heidelberg, 1995.
[7] Huiyan Cheah, Fredrik Brosser, Suhaib A. Fahmy, And Douglas L. Maskell, "The idea DSP block based soft processor for FPGAs", in ACMTrans.Reconfig.Technol.Syst.7,3,Article19(August2014).
[8] Chi Zhang, Viktor Prasanna, "Frequency Domain Acceleration of Convolutional Neural Networks on CPU-FPGA Shared Memory System", in Proceedings of ACM/SIGDA International Symposium on Field-Programmable Gate Arrays, Pp- 35-44,2017.
[9] T. Tran Ngoc, T. T. Hieu, H. Ishii and S. Tomiyama, "Memory-efficient signature matching for ClamAV on FPGA," 2014 IEEE Fifth International Conference on Communications and Electronics (ICCE), Danang, pp. 358-363, 2014.
[10] Pradhan, M. C., Satpathy, S., & Bhoi, B. K. (2016). An Intelligent Fuzzy Based Technique of Making Food Using Rice Cooker. Asian Journal of Electrical Sciences, 5(1), 1-7.
[11] Kun-Wah Yip and Tung-Sang Ng, "Partial-encryption technique for intellectual property protection of FPGA-based products," in IEEE Transactions on Consumer Electronics, vol. 46, no. 1, pp. 183-190, Feb 2000.
[12] M.A. Clark, PC La Plante, L.J. Greenhill, "Accelerating radio astronomy cross-correlation with graphics processing units", in The International Journal of High Performance Computing Applications Vol 27, no. 2, pp. 178 - 192 may 2012.
[13] Pradhan BK, Satpathy S. A Smart Fuzzy based system design for future prediction of medical condition.
[14] Satpathy, S., Das, S., & Debbarma, S. (2019). Development a Novel Approach of Fuzzy Based FPGA System for Prediction of Jaundice in Rural Area. Journal of Engineering Technology (ISSN. 0747-9964), 8(1), 32-39.
[15] Biomedical data base which is used in jaundice disease. https://physionet.org/cgi-bin/atm/ATM.
[16] S Roy Chowdhury, Dipankar Chakrabarti, "FPGA realization of a smart processing system for clinical diagnostic applications using pipelined data path architectures," Microprocessors and Microsystems Vol. 32, Issue 2, March 2008, Pages 107-120.
[17] Satpathy, S., & Sahu, A. P. (2015, December). A Graphical User Interface, Fuzzy Based Intelligent Rice Cooker. In 2015 International Conference on Computational Intelligence and Communication Networks (CICN) (pp. 1216-1220). IEEE.
[18] Xilinx vivado technology and Matlab system generator for DSP https://www.xilinx.com/products/design-tools/vivado/integration/sysgen.html.
[19] S. D. Hawley, L. E. Atlas and H. J. Chizeck, "Some Properties of an Empirical Mode Type Signal Decomposition Algorithm," in IEEE Signal Processing Letters, vol. 17, no. 1, pp. 24-27, Jan. 2010.
[20] Sengupta, A. S., Satpathy, S., Mohanty, S. P., Baral, D., & Bhattacharyya, B. K. (2018). Supercapacitors Outperform Conventional Batteries [Energy and Security]. IEEE Consumer Electronics Magazine, 7(5), 50-53.

.