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VLSI based System for Predicting Ventricular Arrhythmia

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Abstract: ***Arrhythmia affects millions of people nowadays. About 80% of deaths are due to ventricular arrhythmias. Arrhythmias may occur at any age but are more common in aging people. Due to this explosive growth of the sudden cardiac death, we should also have jumped on techniques and methods used for alertness and care to avoid the sudden death of the people because of the ventricular arrhythmia. There is a need to develop a dedicated system for accurate ECG analysis and classification in real time to avoid ventricular arrhythmia. This paper gives the different methods or strategies used by the researcher for early detection to avoid the sudden death of the people.***

Keywords: Ventricular Arrhythmia, VLSI, VERILOG, Xilinx ISE, Real-Time ECG Values, Prediction of Ventricular Arrhythmia.

I. INTRODUCTION

An arrhythmia is a group of conditions in which the electrical activity of the heart is irregular or is faster or slower than normal. Ventricular arrhythmia [10][11]] is an abnormal ECG rhythm and is responsible for 75%–85% of sudden deaths [3] in persons with heart problems unless treated within seconds. The reason behind sudden cardiac death is due to ventricular arrhythmias, including ventricular tachycardia (VT) [10][12]or ventricular fibrillation (VF) [10][13].

ECG devices provide real-time monitoring of cardiac activities and prediction systems could alert patients prior to any critical situations. In order to perform detection or prediction the first step is to extract ECG features and define parameters that could generate accurate classification results. ECG features include P, QRS and T wave that could be utilized to define factors and intervals for prediction or detection systems. The normal heartbeat and ECG signal as illustrated in figure 1.

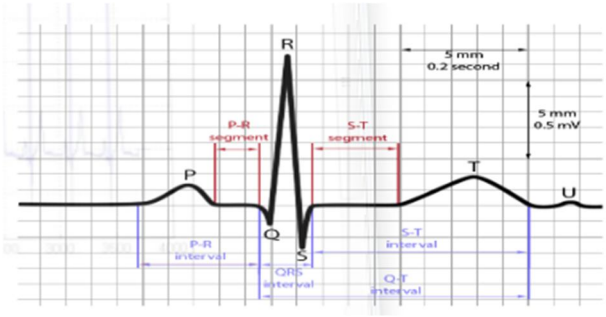

Figure: 1 ECG Signals with Intervals

The normal resting heart rate ranges from 60 to 100 beats per minute for the adults. Ventricular tachycardia (VT) is when the heart rate exceeds 100 beats a minute. This can cause palpitations or a fluttering sensation [11] in the chest or even fainting. If the tachycardia is too fast, the pump function of the heart is slow down and may lead to sudden death.

Arrhythmia can be divided into two main groups: arrhythmias that are occurred in the atria are called atrial arrhythmias [11]. Arrhythmias that are occurs in the ventricles are known as ventricular arrhythmias. Examples of ventricular arrhythmias consists of ventricular tachycardia, ventricular fibrillation (VF) and premature ventricular complexes (PVC)[11]. Between these types of arrhythmias, ventricular fibrillation is considered as a more severe form of arrhythmias, a condition that is resulted from rapid, irregular and unsynchronized contraction of the muscle fibers of the heart and thus resulted in the heart failing to pump blood and causing sudden death to the patient.

There are various methods available for prediction of ventricular arrhythmias using real-time QRS detection. Several algorithms have been reported for the detection and classification of ECG beats.

II. LITERATURE REVIEW

J. W. Schleifer et al. [1] gives a method for the automatic processing of the electrocardiogram (ECG) for the classification of heartbeats. Five beat classes recommended by ANSI/AAMI EC57:1998 standard, i.e., normal beat, ventricular ectopic beat (VEB), supraventricular ectopic beat (SVEB), the fusion of a normal and a VEB, or unknown beat type are detected.

M.Sangeetha et al.[3] propose a design of ASIC architecture for electrocardiogram (ECG) signal for the prophecy of ventricular arrhythmia. The unique set of ECG feature and an SVM Classifier is used. Real-time adaptive techniques are used for the recognition and the demarcation of the PQRS - T waves which were examined to extract the fiducial points.

C.C. Lin et al.[4] proposed a multi-step linear prediction(MLP) modeling to estimate all of the unpredictable intra-QRS potentials (UIQP) for evaluating the risk of ventricular arrhythmias. The prediction error signal can reflect the variations at slope discontinuities of QRS complex, including onset, offset, sharp R wave and AIQP. The results have also shown that the significant reduction of UIQP in patients with ventricular tachycardia may be new promising evidence of ventricular arrhythmias.

As Electrocardiography (ECG) represents features like QRS complex, P-wave and T-wave that provide critical clinical information for detection and prediction of cardiac diseases. Temesghen Tekeste et al.[5] provides a novel ECG feature extraction which is optimized for ultra-low power applications. The architecture is based on Curve Length Transform (CLT) for the detection of QRS complex and Discrete Wavelet Transform (DWT) for the delineation of TP waves. Features extracted from two consecutive ECG cycles are used to set innovative parameters for VA prediction up to 3 hours before VA onset. Two databases of the heart signal recordings from the American Heart Association (AHA) and the MIT PhysioNet[15] were used as training, test, and validation set to evaluate the performance of the proposed system. VA prediction can be done based on Naïve Bayes based classifier [15].

CLT signal is used to evaluate the thresholds required for the detection of QRS peaks. When CLT is applied to ECG it enhances the QRS complex and relatively suppresses the TP waves [5] as shown in figure 1.

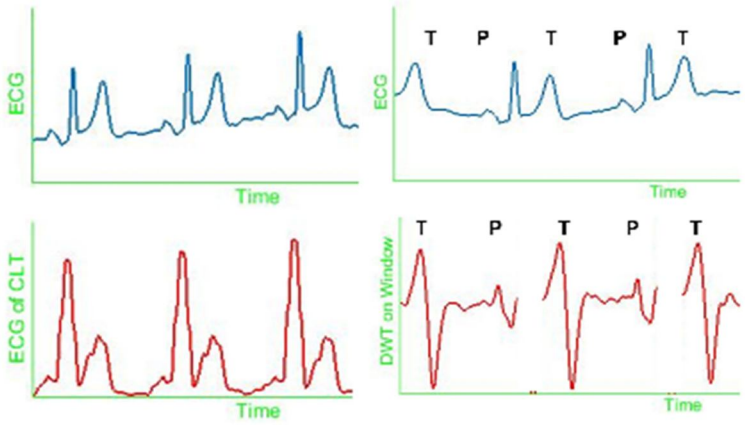

Figure: 2 CLT (left) and DWT on a window (right)[5]

Mohammed Ismail et al.[6] gives first System-on-Chip (SoC) implementation of an ECG-based processor that is capable of predicting ventricular arrhythmia hours before the onset.

Yongwoo Cho, et al.[7] introduce a cardiac telemetry system, based on cellular IoT technology that achieves low latency without compromising the diagnosis quality a system using long-term evolution (LTE) machine type communication (MTC) technology for analysis of the timing aspects for real-time ECG monitoring. A system able to identify and eliminate three major sources of significant nondeterministic delays, largely caused by unnecessary buffers.

M. Trivedi et al.[8] investigate the recurrence of minor ventricular arrhythmias to predict the occurrence of ventricular fibrillation episodes in patients with ICD(Implantable cardioverter defibrillators). By calculating the mean duration and the mean ventricular cycle of the non-sustained ventricular tachyarrhythmias (NST) it is found that VF (ventricular fibrillation)[10][13] patients had a significantly higher incidence of ventricular tachycardia(VT) [10][12]compared to the no-VF patients.

Ventricular tachycardia causes rapid heartbeat as a result of the improper electrical activity of the heart. It is potentially life-threatening arrhythmia because it can cause low blood pressure and may lead to ventricular fibrillation. Ventricular tachycardia occurs when the fast heart rhythm begins in the ventricle when the contraction is disrupted and electrical signals are sent quickly due to contraction. Instability was analyzed by unstable QT segment in ECG for each subject. ECG is taken from linear and non-linear stability of both ventricular tachycardia and healthy subjects.

S. Vinurajkumar et al.[[10] gives a method for predicting ventricular tachycardia (VT) by analyzing QTI (QT interval) stability from ventricular repolarization variability by using Autoregressive Exogenous (ARX) and Autoregressive Moving Average Exogenous (ARMAX) model in ECG recording.

Mohd Afzan Othman et al.[11] presents a semantic mining approach to an electrocardiograph (ECG) signals so as to extract its significant characteristics (frequency, damping coefficient, an input signal) for prediction of the onset Ventricular arrhythmias. Real data from an MIT-BIH arrhythmia database [5] [12] are used after noise filtration. The semantic algorithm can be used to classify the patients into three groups like normal (N), normal patients (PN) and patients with ventricular arrhythmia (V).

Mr. Vaibhav Umale et al.[14] provide Extreme learning machine (ELM) methods for classification and prediction of cardiac arrhythmia with enhanced performance. This method comes in the Neural Network which is a well-suited algorithm for greater prediction accuracy.

III. EXPERIMENTAL RESULTS

Temesghen Tekeste et al.[5] used American Heart Association (AHA) and the MIT PhysioNet as training, test and validation sets to analyze the significant difference between ECG signals for normal patients and patients with ventricular arrhythmia. The system is coded in verilog, verified using simulations and emulated in FPGA. Simulation results shown in Fig. 4 gives the results obtained from ECG processing system-on-chip architecture using Naive Bayes classifier. In the top part of the figure automatically detected ECG features are annotated and the bottom part shows the result of a classifier for the distribution of intervals to predict ventricular arrhythmia (VA).

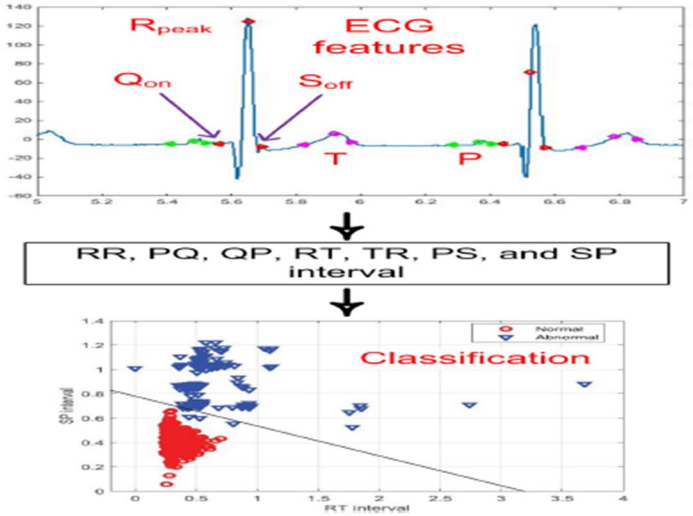

Figure: 4 Automatically Detected ECG Features and Result of Classifier [5]

S.Vinurajkumar et al.[[10] gives a method for Heart rate variability. The PQRST wave is prominently seen for a healthy patients as shown in below figure 5.

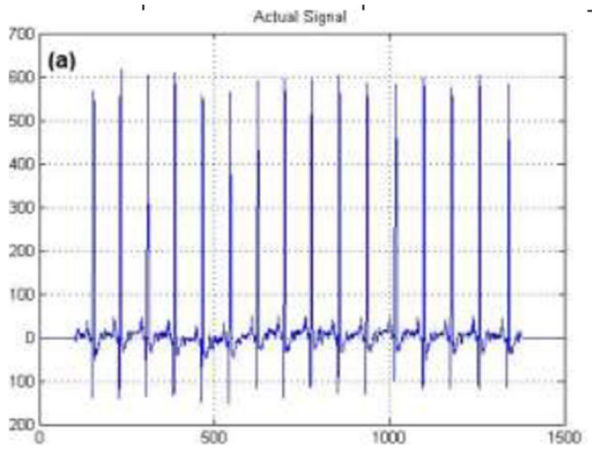

Figure: 5 ECG signal of a Healthy Patient [10]

A clear observation shows that In case of VT patients the QRS complex is clearly visible and T wave seems to be prolonged as shown in figure 6.

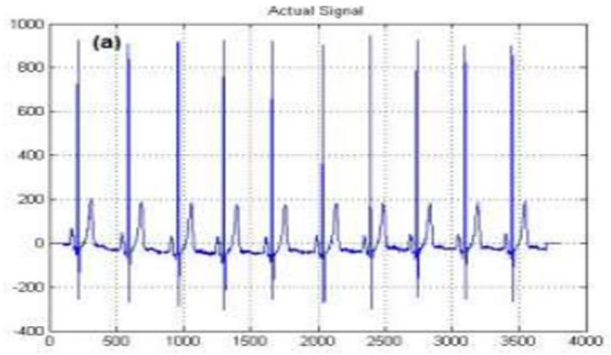

Figure: 6 ECG signal of a VT patient [10]

IV. CONCLUSION

Arrhythmias may occur at any age but are more common among older people. Due to this explosive growth of the sudden cardiac death, it is important to the development of a dedicated system for accurate ECG analysis and classification in real time to avoid ventricular arrhythmia.

Several algorithms have been reported for the detection and classification of ECG beats. This paper gives the survey of different methods used by the researcher to predict the ventricular arrhythmias.

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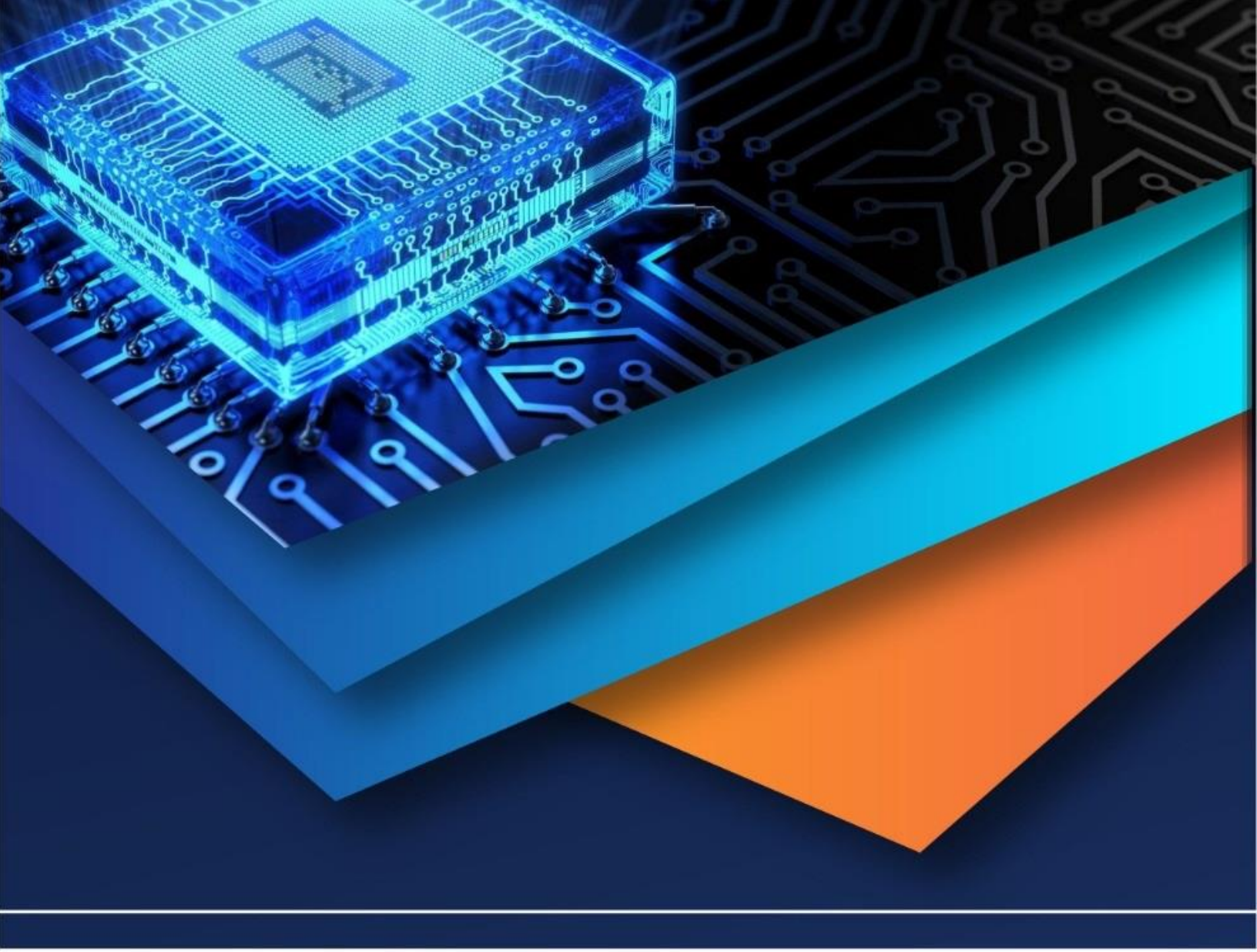

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