JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Real Time ECG Signal Analysis using Artificial Intelligence Technique

[1]TANEERU HARI HARA VINAY, [2]JAKKA SPANDAN, [3]BARDAWAL SANGATHRAM,[4]THODUPUNURI SHARATH CHANDRA, [5]Dr.AVARU VENKATARAMANA

[1,2,3,4]Diploma in ECE, Government Polytechnic-Medchal, Telangana,India,
[5]Senior lecturer and HOD i/c, Government Polytechnic-Medchal, Telangana,India

Abstract: Electrocardiogram (ECG) is the measure of heart electrical activity. The electrical signals of heart are transformed into waveforms which are used to measure various heart conditions. ECG conveys information regarding the electrical function of the heart, by altering the shape of its constituent waves, namely the P, QRS, and T waves. ECG feature extraction plays a significant role in diagnosing most of the cardiac diseases. Analyzing ECG is very important aspect in heart monitoring. In this project, we have developed a low cost AD8232 based ECG and heart monitoring system using Arduino and MATLAB. It also identifies abnormality and detects the type of heart disease in the heart. The obtained ECG signal is demonstrated on the screen, and there after using MATLAB, heart beat calculation is done. Simulation results are carried out by considering standard ECG data from Popular ECG dataset Physionet ECG data downloaded from Internet. In this, we have downloaded dataset of Arrhythmia, Congestive Heart Failure, Normal Sinus Rhythm. The Alexnet is trained using "Train Network" funtion with training the scalogram images. The training phase has taken nearly 2 to 3 minutes. We also plotted the confusion matrix. We achieved the accuracy of 96.6% with 8 epochs and 95% with 4 epochs of training and testing for a database of size 150. The accuracy can be improved by increasing the size of database but it takes more time.

***Keywords*:** Electrocardiogram (ECG), AD8232 ECG Sensor, Arduino, Heart Beat Calculation, Convolution Neural Network, Alexnet

I. INTRODUCTION

An electrocardiogram (ECG) records the electrical activity of the heart. The heart produces tiny electrical impulses which spread through the heart muscle to make the heart contract. These impulses can be detected by the ECG machine. The ECG test is painless and harmless it does not put any electricity into body. The ECG consists of electrodes which are attached to the body of the patient and are connected by wires to the device. Each one of the sensors can detect a change in electrical charge in the skin that can only be the result of the impulses that are travelling through the heart and on to the rest of the body. By analyzing or monitoring the ECG signal at the initial stage this disease can be prevented.

In this paper, ECG Monitoring with AD8232 ECG Sensor and Arduino with ECG Graph is presented. The aim of this project is to get accurate ECG and heartbeat of the patient at low cost. Unlike as Diagnostic Center, we can observe and calculate our heartbeat as many times as possible. We interface AD8232 ECG Sensor with Arduino and observe the ECG signal on Arduino serial plotter or Processing IDE**.** Using deep neural network, we train and test the real time ECG signal. Since, it is computer-aided-diagnosis system, it has better accuracy then existing systems.

II. LITERATURE REVIEW:

In the literature, there exist many methods to analyze ECG signals. S Celin proposed method is used to classify the ECG signal by using classification technique first the input signal is pre-processed by using filtering method such as low pass, high pass and butter worth filter to remove the high frequency noise. Detect the R peak detection algorithm and classify the ECG signal by using SVM,ANN & Adaboost. In this method they have used machine learning algorithms and got 80-85% of accuracy, but using our system we got 97% of accuracy.

Assen Naaz et al proposed that morphological features give good results in arrhythmia classification while statistical feature were useful because of variation in ECG signal for different patients using wavelet transform. This motivates the requirement for a reliable, automatic and low-cost system for monitoring and diagnosis.

Neural Network (CNN) has been widely used for classification and prediction in different domains. Recently it has been noticed that CNNs are been developed sharply with a significant effect on the accuracy in classification for a wide range of medical tasks. Modern CADS systems leverage CNNs to detect arrhythmia, heart failure of captured ECG signal leading to decrease the cost of continuous heart monitoring and improving the quality of predictions.

The main aim of our project is to provide, low-cost monitoring system. It can be easily transportable and it of very low cost. It can be used at any time and any number of times. These electrodes are used to obtain ECG signal from our body. The received signal also can have noise but this received noise can be removed by AD8232 sensor. Using AD8232 module and Arduino the ECG signal is obtained, the obtained signals can be observed by using serial plotter in Arduino IDE.

In this, we have used using the software systems like MATLAB, Alexnet and Cool term. We used Artificial Intelligence (AI) with deep neural network ALEXNET for identification of heart disease. After writing MATLAB code we have tested it on standard database from Physio net ATM bank. Finally, we took real time ECG signal and applied to the system.

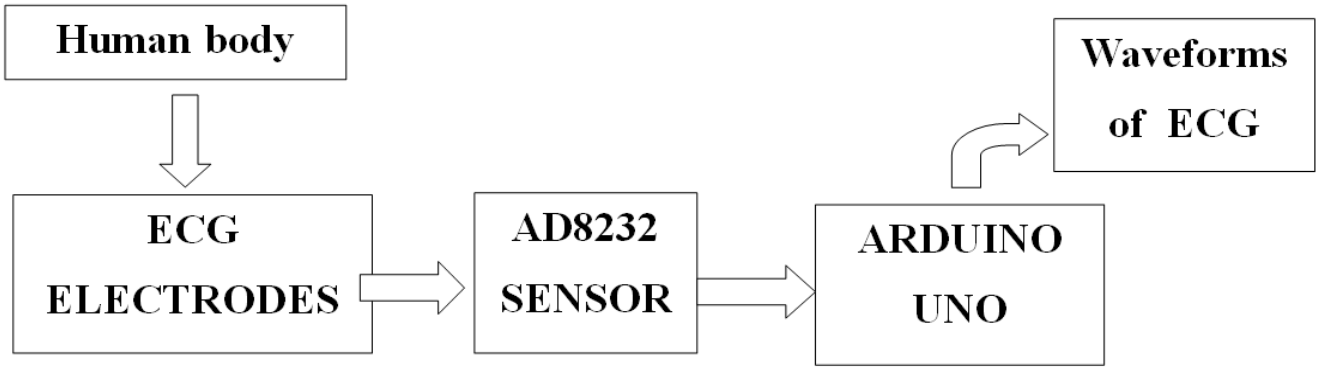
III. HARDWARE IMPLEMENTATION

❖ ECG & Heart monitoring system is designed using Arduino and AD8232 ECG Sensor.

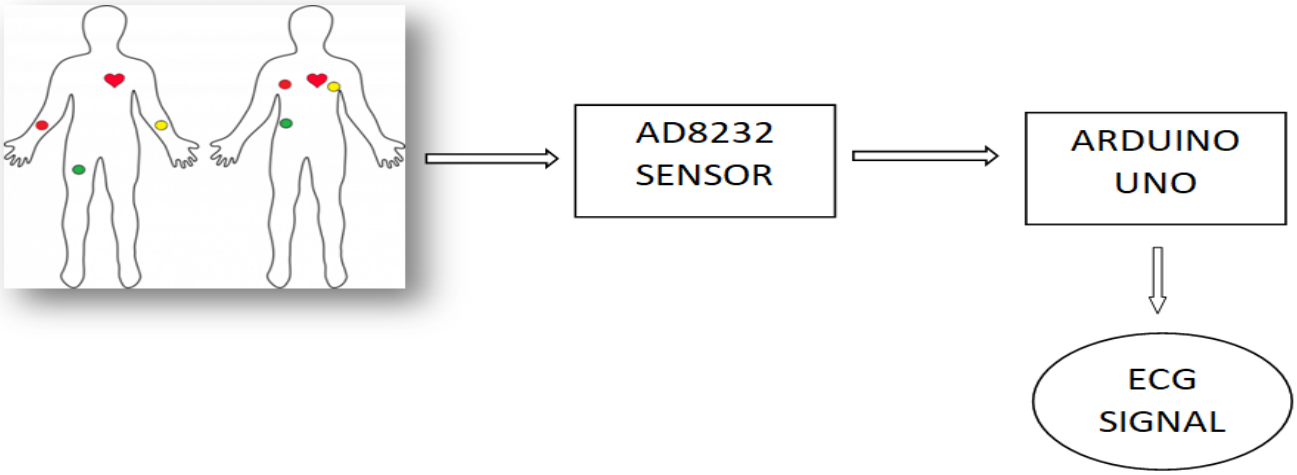
Components used:

1) Arduino Uno
2) ECG Module (AD8232)
3) ECG Electrodes - 3 pieces
4) ECG Electrode Connector -3.5 mm
5) Power supply
6) Connecting Wires

BLOCK DIAGRAM



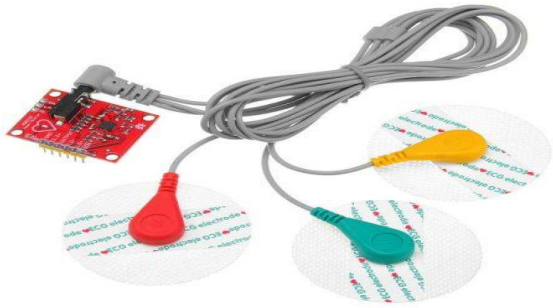
PROPOSED SYSTEM



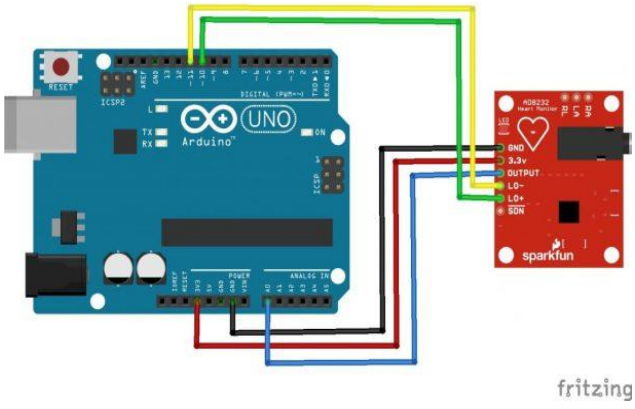
ARDUINO UNO: Arduino UNO is based on an ATmega328 microcontroller The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP header. It is programmed based on IDE.

AD8232ECG Sensor: This sensor is a cost-effective board used to measure the electrical activity of the heart. The AD8232 module breaks out nine connections from the IC

Connecting wires and Electrodes: Using connecting wires, AD8232 sensor and Electrodes are connected. ECG electrodes are placed on the body of the patient. In this project we use 3 electrodes, these electrodes are used to obtain ECG signal from our body. The received signal may also contain noise. Noise is filtered and exact ECG is obtained by AD8232 Sensor.



Connection between Arduino and AD8232 ECG Sensor: The AD8232 Heart Rate Monitor breaks out nine connections from the IC. We'll connect five of the nine pins on the board to Arduino. The five pins you need are labelled GND, 3.3v, OUTPUT, LO-, and LO+.



Board Label	Pin Function	Arduino Connection
GND	Ground	**GND**
3.3v	3.3v Power Supply	**3.3v**
OUTPUT	Output Signal	**A0**
LO-	Leads-off Detect -	**11**
LO+	Leads-off Detect +	**10**
SDN	Shutdown	**Not used**

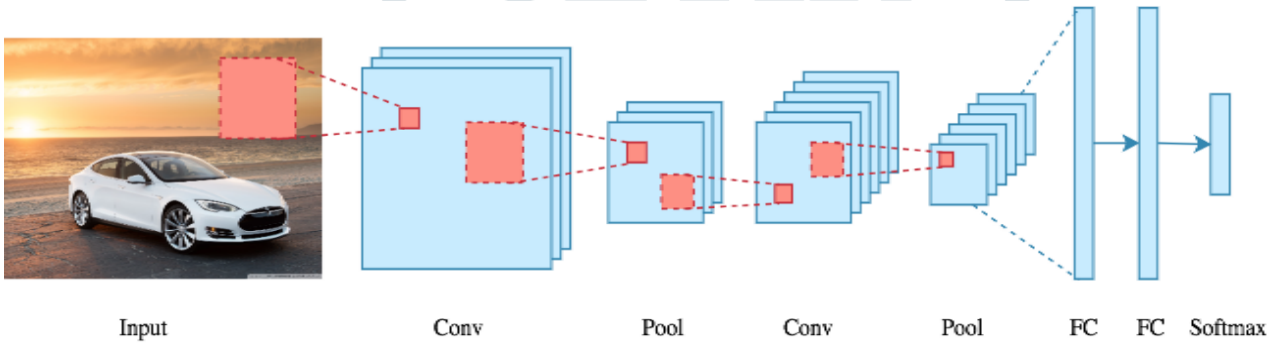
Working principle of hardware:

An ECG Sensor with disposable electrodes attaches directly to the chest to detect every heartbeat. The electrodes of ECG sensor will conversion heart beat to electric signal. ECG Sensors is very light weight, slim and accurately to measures continuous heart beat and give rate data of heart beat. This device always used by trained doctor and medical assistances.

Electrodes of ECG Sensor have 3 pins and connected by cable with 30 inches in length. It is makes ECG sensor easy to connect with controller and placed at the waist or pocket. In additional, the plug-in for the cable is a male sound plug which will make the cable to easily removed or inserted into the amplifier board. The sensor receives the ECG signal detected by ECG electrodes. The AD8232 from Analog Devices is a 3 lead ECG sensor, which has been converted into various breakouts and modules by Spark fun and other 3rd party electronics manufacturers. The shutdown pin is used to send the AD8232 sensor into standby mode, during which it only consumes a current of 200nA. Generally, that mode is not used because the ECG sensor data are to be taken continuously, but we can code in such a manner that the module enters standby mode when electrodes are removed or on a button press. Using Arduino IDE software, dumped program into Arduino. In this program we assign pin mode to be connected and using if else statement, digital and analog readings to be taken. And we assigned serial begin value that is broad rate. Thereafter using Serial Plotter, the ECG signal is displayed. Now these Signal is observed and using parameters of ECG, the heart disease is identified. Using **COOLTERM** software, we can download the serial monitor data. Using this data, further analysis of heart is done.

IV SOFTWAREIMPLEMENTATION

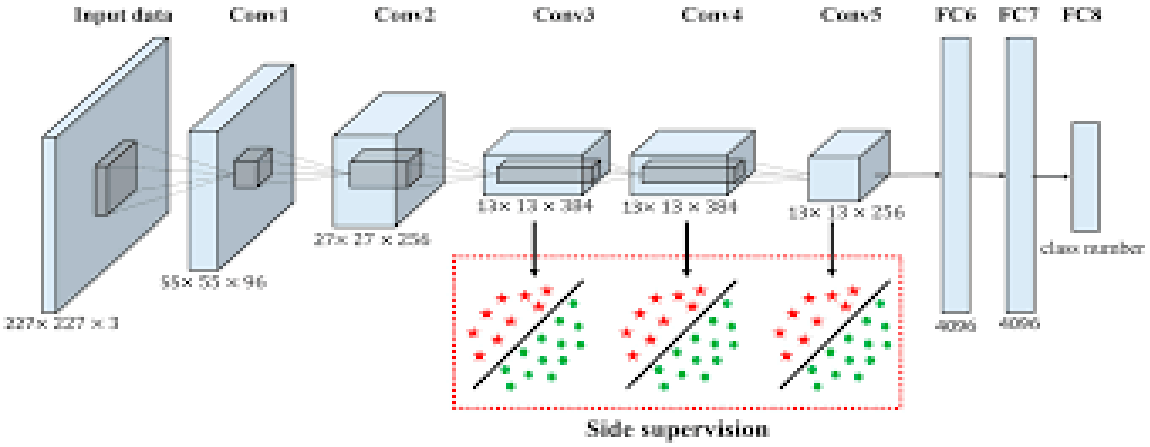
Convolution neural network:



In deep learning, a **convolutional neural network** (**CNN/ConvNet**) is a class of deep neural networks, most commonly applied to analyize visual imagery. Now when we think of a neural network we think about matrix multiplications but that is not the case with ConvNet. It uses a special technique called Convolution. Now in mathematics **convolution** is a mathematical operation on two functions that produces a third function that expresses how the shape of one is modified by the other.

ALEXNET:

- It has 8 layers with learnable parameters.
- The input to the Model is RGB images.
- It has 5 convolution layers with a combination of max-pooling layers.
- Then it has 3 fully connected layers.
- The activation function used in all layers is Relu.
- It used two Dropout layers.
- The activation function used in the output layer is Softmax.
- The total number of parameters in this architecture is 62.3 million.



V. Simulation Results:

R-peak detection and Heartbeat calculation:

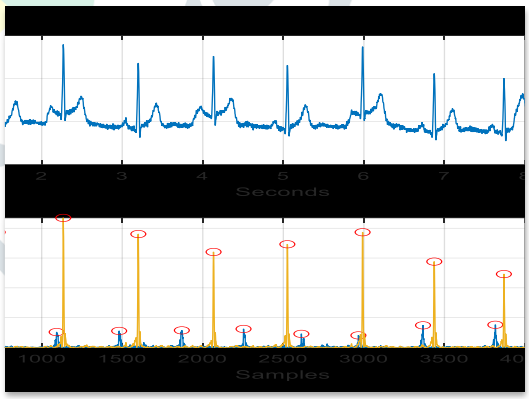
- R peaks detection and heart beat calculation is done by considering different ECG signals downloaded from standard datasets ECG_1D data and BIT MIH Data as well as real time ECG signals acquired using AD8232 module and Arduino.
- The obtained ECG can be observed by using serial plotter in Arduino IDE.
- Considering different parameters of an ECG, Heart diseases can be identified.
- Using this signal R-R interval can be calculated, which is very important aspect for heart beat calculation.
- The obtained ECG from Arduino is recorded and saved as a file.
- Now this file is given to MATLAB program.
- First sampling rate has to be entered. Higher the sampling rate, better the quality of signal.
- Now peak heights and peak distance is founded.
- From that R-R interval is concluded.
- By using the formula of heart beat/second, heart beats are determined.
- Heart Beat inBeats/second=60 x Sampling Rate / R-R interval

According to this principle MATLAB program is written and Heart beat calculation is done. Based on the heart beat rate precautions to be taken. The results executed using MATLAB program is shown below

1. Standard Data base:

>>RpeaksDetection_FFT

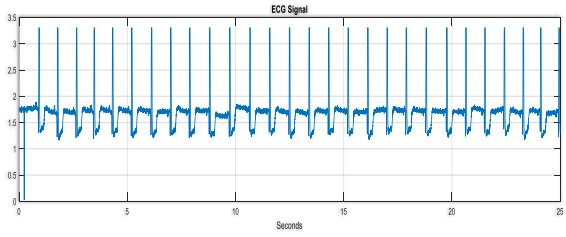
Heart Rate=66

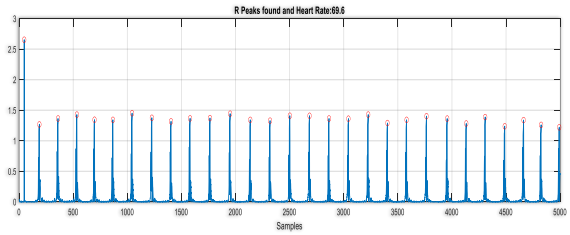


2.Real time ECG signal:

>> RpeaksDetection_RealTimedata

Heart Rate=69.6

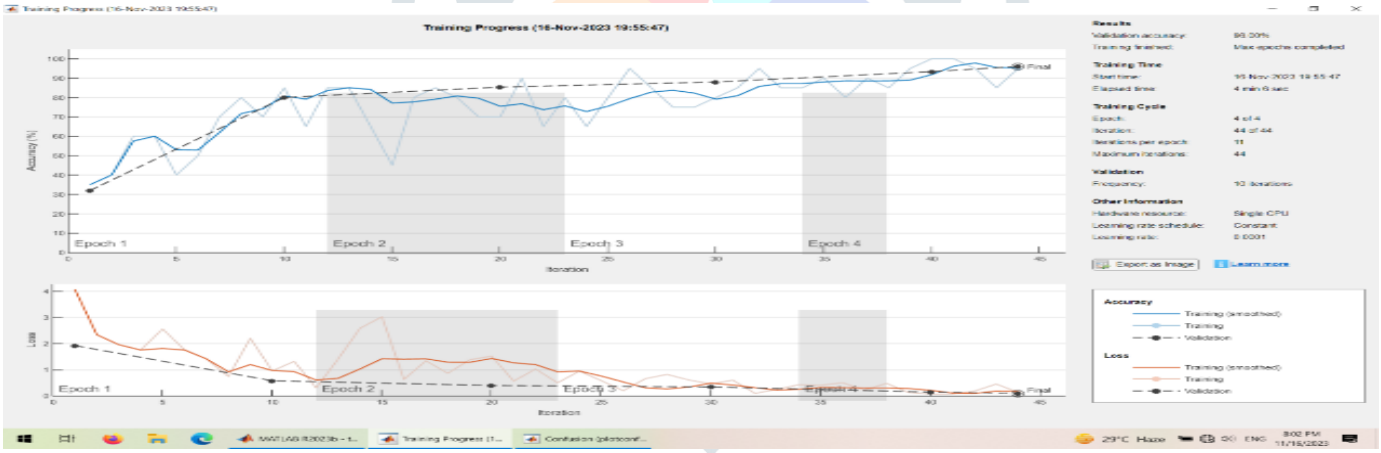




Heart disease classification: In order to verify the applicability of proposed ECG signal analysis system, we have downloaded Popular ECG dataset. Physio net ECG data downloaded from internet. We have extracted "ECG Data. mat" file and placed in the current working directory. This data set has 162 to ECG recordings each of length 65,536 samples. 1st 96 rows correspond to Arrhythmia (ARR) type of diseases. 97th row to 126 consists of 30 members recordings having Congestive Heart failure (CHF). From row 127 to 162 consists of 36 recordings of the type Normal Sinus Rhythms (NSR). We took each signal of length 500 samples. We took 5 recordings of ARR,CHFand NSR and each recording contains 10 pieces of length and 500 samples. Hence, each categories contains 50 ECG signals which of size 500 samples. We have selected 3 classes classification and hence the size of database is 150 signals and we have created a database main folder with current directory ECG.dataset.
We have created 3 sub folders within the main folder:
Ecgdataset\arr
Ecgdataset\chf
Ecgdataset\nsr
For three categories is classification ARR,CHF and NSR with respectively.
For each ECG type we computed wavelength transform with analytical Morlet which has got single fixed spectrum with 12 wavelet band pass filters. Output is the wavelet band pass filters is scalogram with color mapping of jet(128). The scalogram of 150 ECG signals are desired to [227X227] and saved in the sub folders of each categories.

The reason for selecting 227X227 scalogram is input suitable of Alexnet deep neural network we have trained the Alexnet with input corresponds to 227X227X3.Out of 150 scalograms stored in a database we have use 30 scalograms each is of 90 samples for training and remaining 20 each that is the 60 samples for testing purpose. Using "Add Ons" facility in MATLAB software, we have added Alexnet deep neural network into the MATLAB environment. In our simulation we have used MATLAB software since MATLAB is a high-performance computing language for scientific and engineering applications. Pretrained alexnet network into the MATLAB program. We have used the transfer learning via alexnet. All the layers are preserved expect last three and we have set the number of outputs class 3 (ARR,CHF and NSR).

We set 3 classes for fully connected output layer, SoftMax layer followed by classification layer. The alexnet is trained using "train Network" with training the scalogram images. So with the database the training phase has nearly took 4 to 5 minutes, "classify" function is used to classify the trained alexnet with trained images. Scalogram images with 60 images and it was validated for its accuracy. Accuracy is computed using formula The total no. of correctly classified signals divided by the number of test signals applied. We also plotted the confusion matrix we achieved the accuracy of 95% for 4 training epochs and 96.6 % for 8 epochs The accuracy can be improved by increasing the database but it takes more time. We also computed the heart beat rate for three test signals from ECG 1D dataset which was downloaded from physio net Atm bank. Real time signal is obtained using our hardware implementation and simulation s are carried out. We obtained accurate results.



VI. Conclusions and Scope for Future Work:

In this project, we have developed a Low cost AD8232 based ECG and heart monitoring system using Arduino and MATLAB. It also identified abnormality and detects the type of heart disease in our heart. The obtained ECG signal is demonstrated on the screen, and there after using MATLAB, Heart beat calculation is do**ne.**

We have downloaded standard data set ECG data from Popular ECG dataset Physionet ECG data from internet. In this, we have downloaded dataset of Arrhythmia, Congestive Heart Failure, Normal Sinus Rhythm. We took 5 recordings of ARR,CHF and NSR and each recording contains 10 pieces of length and 500 samples. Hence, each category contains 50 ECG signals which of size 500 samples. The scalogram of 150 ECG signals are resized to [227X227] and saved in the sub folders of each category. Out of 150 scalograms stored in a database we have use 30 scalograms each is of 90 samples for training and remaining 20 each that is the 60 samples for testing purpose.

The popular Deep Neural Network Pretrained Alexnet network is used in MATLAB program. We have used the transfer learning via Alexnet. All the layers are preserved expect last three and we have set the number of outputs class 3 (ARR, CHF and NSR). The Alexnet is trained using "Train Network" with training the scalogram images. The training phase has taken nearly 2 to 3 minutes. We also plotted the confusion matrix. We achieved the accuracy of 96.6% with 8 epochs and 95% with 4 epochs of training and testing. The accuracy can be improved by increasing the size of database but it takes more time. After training, we have tested it with standard MIT-BIH data, and results were true and accurate. Thereafter, we tested with our real time ECG signal acquired from Arduino and sensor circuit. From the simulation results, it is observed that the accuracy is high.

The future scope of the project is the classification rate can be further improved by increasing size of data base. Further, we would like to add Arduino support packages into MATLAB using Add-Ons facility and acquire real time signals using MATLAB program.

ACKNOWLEDGEMENT:

It is our pride privilege to thank Dr. A.VENKATARAMANA ,Senior Lecturer in ECE and HOD i/c for his excellent guidance and constant inspiration for developing this innovative project. We are highly thankful to him for sparing his valuable time.

We take this opportunity to express our sincere thanks to G.ARUNDHATHI, Principal, Government Polytechnic, Medchal for providing all the necessary facilities to carry out this project work.

We extend our sincere thanks to Honourable Commissioner of Technical Education, Telangana, Joint Director of Technical Education, Telangana and Secretary, SBTET, Telangana for initiating Srujana Techfest for Polytechniic students which brings out hidden talents and innovative ideas from students.

References:

1. World Health Organization Cardiovascular Diseases. [(accessed on 16 March 2020)].

2. European Cardiovascular Disease Statistics 2017. The European Heart Network (EHN); Brussels, Belgium: 2017. [(accessed on 15 March 2020.

3. Preejith S.P., Dhinesh R., Joseph J., Sivaprakasam M. Wearable ECG platform for continuous cardiac monitoring; Proceedings of the 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); Lake Buena Vista, FL, USA. 16–20 August 2016; pp. 623–626.

4. Sanghavi D.R., Athawale S.V., Professor A. An IoT Based Low-Cost ECG Monitoring System for Remote Patient. *Int. J. Res. Trends Innov.* 2018;3:70.

5. Hamid Khorrami, Majid Moavnian. A comparative study of DWT, CWT and DCT transformations in ECG arrhythmias classification; Expert systems with applications 37(2010) 5751-5757

6. S Celin, K Vasanth. ECG signal classification using various machine learning techniques; Journal of medical systems (2018) 42:241