Body Channel Communication based Patient Monitoring System

J. Lavanya, N. Syed Suhail Ahmed, S. Sai Prakash, T. Divya, A. Manikandan

Abstract--- Body channel communication or human body communication is a developing field and there are various methodology through which we can pursue and implement such a system. Health monitoring and prediction is of utmost concern since the number of patients and diseases are increasing over the years. The previously existing systems are mostly wired, generate a lot of additional noise and are expensive. To curb those differences and to produce a cost-effective system with real time implementation is the main objective. We can implement this system using different algorithms using MATLAB, Arduino, python and other image processing embedded systems. This can also be realised using deep learning and AI. For practical concerns we use MATLAB in front end and Arduino in back end along with Putty or hyper terminal.

Keywords--- Feature Extraction in Discrete Wavelet Transform, Signal Pre-process, Noise Analysis, Channel Estimation,MATLAB.

I. INTRODUCTION

Constant monitoring of a patient's health is a tedious process. Energy transmission using the human body as a medium has been quite a challenge due to various complications such as noise, frequency attenuation and so on. These parameters need to be carefully considered and the system needs to be designed with caution. Usually a wired wearable sensor is used to predict the patient's blood pressure, temperature, pulse rate etc.

We are going to design an embedded system to predict the patient's health and possible complications which might occur in the near future by using the human body channel communication. To simplify this process, we are proposing a system of health monitoring system wherein the human body acts as a communicating medium and the received data is stored in a server or cloud platform which can be accessed anytime and anywhere. As we are aware, the human body can be used as an electromagnetic medium of transmitting energy. The energy from the human body acts as a transforming medium which enable the sensors to provide faster information with less noise and better efficiency.

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Designing a system using human body would be difficult as there are no set of regulations of how to implement them. This paper is based on some existing theoretical content on body area network (BAN). Real time implementation of such a system would be very expensive and not very precise. The software which are used are open source(MATLAB,PUTTY, Realterm). Design constraint was to choosethe best algorithm for a precise estimate. This was overcome by designing a system which is the size of a laptop or tablet and this system can be used anywhere along with a display device.

II. BLOCK DIAGRAM

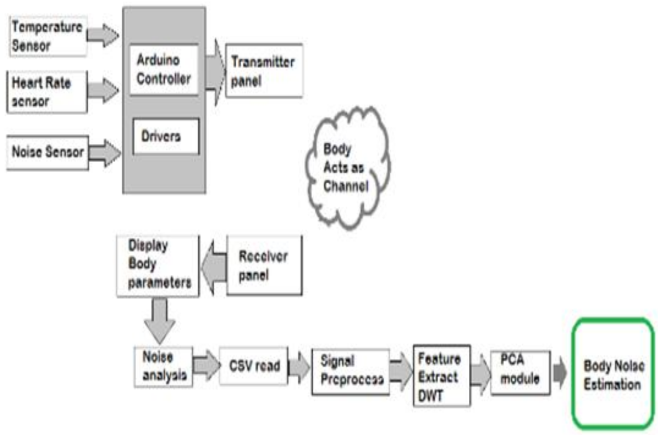

Figure: 2.1 Block diagram

III. RELATED WORKS

[1]In this system, the human body acts as a transmission channel for electrical signals. The body tissues are utilized to transmit profoundly conductive, at reduced frequencies without using antennas. Therefore, the system is applicable for size minimization and decrease in consumption. Human body communication (HBC) allows licensed gadgets to impart without wired or wireless associations. The HBC works in the near-field coupling, which reduces the radiation in the free space, hence it provides low data rate communication. All the factors affecting HBC is encountered during the measurement. Various transmission properties are studied in this paper. Therefore, these transmission properties are measured during the working of the system. The main objective this system is to investigate both the noise characteristics and the frequency response.

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This paper mainly focuses on the galvanic coupling intra-body communication.The output from the system using HBC technology are needed to estimate the performances of the wearable system.

[2]Systems that use capacitive coupling produce electromagnetic signals which transmits through the human body, have been studied earlier in digital communications, or in interaction projects, or active sensing. But the previous projects have used touch-controlled data transfer. Applications have been developed now with independent hardware prototype designs with unique parameters. One such parameter is BCC(Body Channel Communication), which operates around 21MHz. Frequency plays a crucial role in BCC, it determines the featured of the BCC systems. Groundless systems cannot function in the lower frequency range, they are bound to their limitations. Systems that operate under higher frequencies which result in stronger signals.

The important aspect of the BCC is that the behaviour of the human body when exposed to electric fields are not studied or not fully understood.This paper has three major contribution:

- The property of the human body are carried by EM fields. The outputs are studied through the charts of EM fields.
- The design procedure of the BCC systems connect both the physical and technical view from the application designer's perspective, which provide ideas on design procedures.
- The output from the BCC system suggests that it can work on any specific body position and not just to operate as on body sensors.

[3]The timely detection of unusual symptoms are monitored with sensor nodes, that are sent to supervising devices like smart-phones, in the wearable systems using wireless body area network(WBAN). This system uses the human body as the transmission medium. In order to improve the features of HBC (Human Body Communication), the applications of the performances are studied thoroughly. This system is totally body dependant, purely depends n the posture of the body, locations of the modules. The HBC is divided into capacitive coupling and galvanic coupling. It is noted that capacitive coupling works better at the range of 60kHz for higher data rates than galvanic coupling.

The previous studies have concluded their development of measurement with their measured data. With the statistical analysis of measured data, the impulse response of HBC are determined.

The objective of this system is to provide accurate values of minimum code-length based on the measurements. This experiment was conducted in RF shielding room to prevent interference signals. The major causes of errors are found using the results of power spectral density (PSD).

IV. METHODOLOGY

This paper mainly focuses on using human body as a communicating medium and noise estimation-based patient monitoring. All the data obtained are in the form of milli volts hence the values need to be amplified.

Heart Rate Sensor

The pulse measure unit can be utilized to screen pulse of a patient. The outcome can be shown on a screen through the sequential port and can be put aside for examination. The whole framework has a low power utilization and is truly versatile. Heart rate sensor is associated utilizing jumper wires between the arduino and transmitting side. The capacities creates when the patient's body is in contact with the sensor, the sensor gets the pulse and it is displayed in the LCD screen. Likewise,the pulse can be comprehended when external noise is included amid the transmission of the signal. Accordingly, pulse is identified adequately since every one of the segments are interfaced with one another and furthermore the data can be utilized for each estimation. Also, since it has low power consumption it can be instantly used as an emergency response system.

Temperature Sensor

The LM35 temperature sensor is essentially used to distinguish the temperature in our body as this parameter is critical for medicinal purposes. The temperature sensor resembles a chip like mounted on a little board and the setup includes an arduino UNO where the supply is given. The temperature is distinguished utilizing a probe, connected to this setup.The LM35 sensor provides a precise estimate when compared to a thermistor.Through the capacity of sensor, the temperature is assembled utilizing the probe which is in contact with the body and the value is shown on a screen – a LCD display. It takes around 5-10 seconds to distinguish, accumulate and displays the normal temperature of our body. Conditions at various body temperatures:

- Hot-The typical inclination hot temperature would be 38°C where perspiring, feeling very uncomfortable, feeling parched and hungry. The most noteworthy body temperatures were meant as 43°C-44°C where amid this range there might be a cerebrum harm or in all likelihood winding up in death.
- Ordinary - 36.5°C-37.5°C this range is regularly revealed for ordinary body temperature.
- Cold- 36°C would be felt as gentle shuddering. 24°C or less - Death as a rule happens because of unpredictable heart beat and respiratory capture.

Noise Sensor

An Arduino board is used to gather the signals from the sensors. A stepdown transformer is utilized in the circuit. A test probe is independently utilized for noise sensor. At the point when the patient interacts with this test the body noise produced will be recorded as an input document.

A test probe is considered and using the body as a communication channel, the noise generated within the body is sent to the receiver.The noise examination is evaluated in our structure so it influences us to see how temperature is estimated with an external noise created in the body.

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The same patient will be attached with a transmitter and a receiver wherein the body of the patient goes about as a conveying channel for data exchange.

At the receiver end, a software such as putty or hyper terminal is used to gather the required information. Along with the required data a lot of junk data is also collected. This data is given as an input text file to MATLAB where the body parameters are displayed along with graphical representation of each sensor. Before we send the data to MATLAB, it is converted to csv read format for maximum support. This CSV document is completely dependent on the analysis of noise sensor. Various signal pre-processing techniques such as sampling, scaling and so on are performed. Feature extraction using discrete wavelet transform is performed and the wavelets are categorised according to high- and low-level signals. These signals are then analysed using complex deep learning algorithms such as PCA.Finally, the body noise estimation is displayed.

CSV READ

PuTTy.exe file is run over the CSV files or database sheets. Putty is used as a serial communication port and also for SSH/Telnet/Rlogin.Putty process the data in a consolidated file, which easily obtains the sensor data for further analysis.

Csv – It is abbreviated as Comma separated values. It is the most common format, which is used for importing and exporting formats in databases and spreadsheets. The CSV provides different functions and classes, one of the function is csvread(). To read data from CSV files, a function has to be created with an object.The 'csvread' is developed to take each row of the file and make a list of all columns. Then, the column is chosen for the variable data to be formatted.

The output from the noise analysis sensor is fetched by the CSV files for further pre-processing function. Thus, the output noise is analysed by the csv files, whether the modulated signal has to be scaled or not. The Csv file output is totally dependent on the noise from the noise analysis sensor.

Signal Pre-Process

We can pre-process the signals and perform various signal processing techniques to obtain desired results. Signal Processing Toolbox is a feature in MATLAB that gives capacities that let youdenoise, smooth, and detrend signals to prepare them for further examination. Remove noise, exceptions, and unwanted substance from information. Improve signals to picture them and find patterns.Change the sample rate of a signal or make the example rate relentless for sporadically examined signal or signals with missing data. Measured signals can demonstrate generally speaking examples that are not characteristic for the information. Smoothing is the means by which we find critical examples in our information while ignoring things that are insignificant. The objective of smoothing is to deliver moderate changes in value with the goal that it's less demanding to see trends in our information. We can process a signal with missing sample values by re-sampling the signal. We can resample both consistently sampled signals and non-consistently sampled signals.

The performance characteristics of epoch vs cross entropy can be determined that validation loss is excessively near training loss the model is excessively broad. In the event that the validation and training loss areexcessively separated then the model overfits information. The model concentrated a lot on the details in the information. The general standard is to not overfit the training information an excess of in light of the fact that it would suck on concealed information (test or in the live application). Hence just a little gap is required. Be that as it may, in the event that the gap is excessively little, at that point the capability of the model is absent for the information. Another factor is to check if the model can deal with a wide range of circumstances. on the off chance that the information will be like training precedents, at that point the information can be overfit.

Feature Extract in Dwt

Discrete Wavelet Transform is also known as DWT. DWT is utilized for both stationary and non-stationary signals. It gives total 3-dimensional data about any signal for instance the diverse recurrence segments that exist, the sufficiency and time factors for that specific recurrence. Discrete wavelet transform has high time and recurrence goals and these qualities can be adjusted. The signal is changed over into scaled and deciphered form of the mother wavelet. It is utilized in signal coding to represent a discrete signal in a progressively excess structure, regularly as a preconditioning for data compression. A series of high and low values are obtained according to the threshold value and this value is classified in a similar way until the last point of the signal. This classified signal is processed using DWT algorithm.

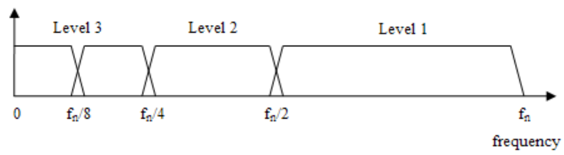

Figure 4.1: Representation of dwt in frequency domain

PCA Module

Principal Component Analysis (PCA). It is an Algorithm. It detects the noise level information whether it is high level or low-level noise inside the body. It is one of the top techniques in machine learning.

There are numerous sorts of vector-space data are compressible, and that pressure can be most proficiently accomplished by sampling. They are improved data representation and enhancement of resource by the learning algorithm.

The algorithm uses randomization techniques to identify a feature subspace that captures most of the information in the complete feature matrix. Hence, the transformed data matrices capture the variance in the original data while reducing the effect of noise and minimizing the risk of overfitting.

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V. EXPERIMENTAL ANALYSIS& RESULTS

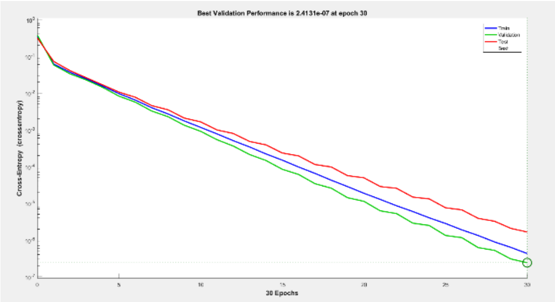

Figure 5.1: Epoch vs cross entropy

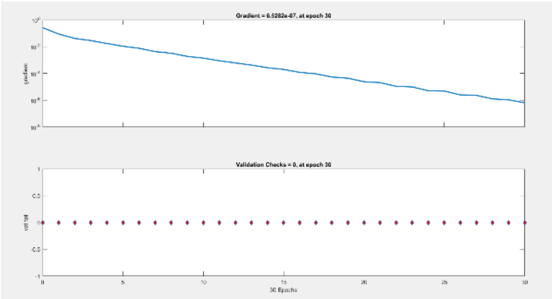

Figure 5.2: Gradient vs epoch, validation vs epoch

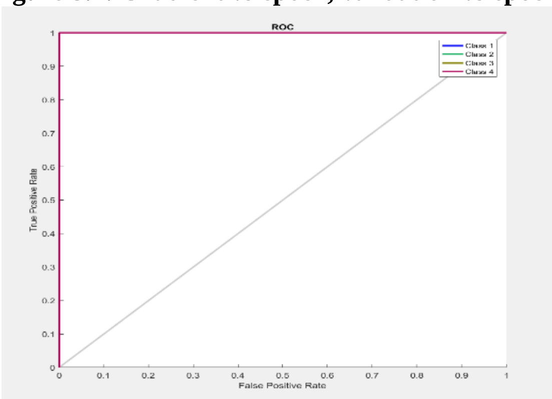

Figure 5.3: True positive value vs false positive values

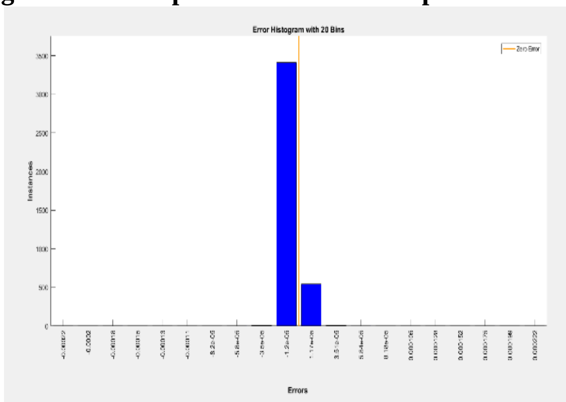

Figure 5.4: Error histogram

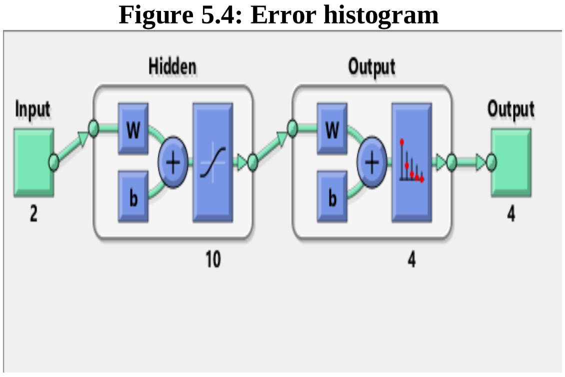

Figure 5.5: Signal Analysis

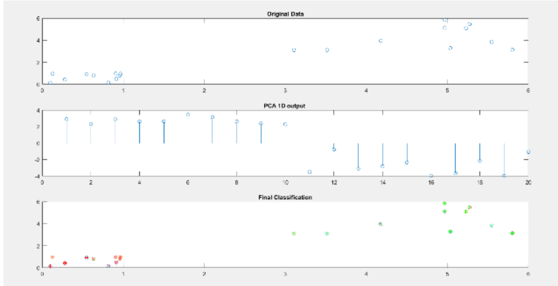

Figure 5.6 PCA Analysis

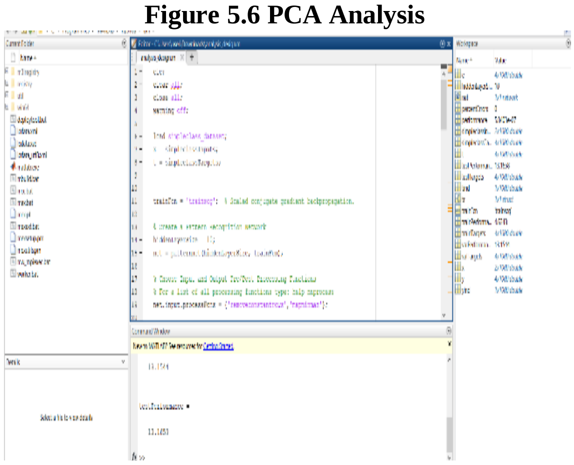

Figure5.7 Sample Code

The neural network training tool in MATLAB is taken advantage of and the following results are observed. Epoch is calculated for the number of times the algorithm is run. The performance, training state, error histogram, confusion, receiver operating characteristic is obtained.

1. (Figure 5.1) The best validation performance is characterised over test, validate and train performance. Each epoch is considered for best performance and the desired output for validation performance is obtained at 2.4131e-07 at epoch 30.
2. (Figure 5.2) In the training state, gradient and validation checks are evaluated. The required gradient is observed as 6.5282e-07 at epoch 30. Hence the validation checks leading until epoch 30 is plotted.
3. (Figure 5.3) The receiver operating characteristic plot is very important as it helps to understand the efficiency of the proposed system. A graph is plotted against true positive rate (indicated in pink) and false positive rate (indicated in green) where the results obtained were completely true positive rate thus proving the efficiency of the system.
4. (Figure 5.4) The error histogram is used to determine the accuracy of the proposed system. The error values are obtained against instances and errors. Minimum values of error is obtained in the plot for 20 bins.It has two types of bin, right most bin and left most bin. Right most bin has the value of 550 instances to the errors of 1.17e-05 and whereas the left most bin has the value of 3300 instances to the errors of -1.2e-05. Hence, both the incoming data and the data stored in the database are compare together to obtain an error rate of 1.17e-05.

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5. (Figure 5.5) The noise signal sent as input to the system classified as two types w(high) and b(low). Here it forms a continuous wave signal. It is again split into 2 types. Here the continuous wave form is converted into discrete wave form. The threshold value should lie in between -10mv to +10mv. If the obtained signal exceeds +10mv the maximum threshold value is obtained, when the signal obtained lies below -10mv then minimum threshold value is obtained. The value of the discrete wave form is similar to the value of the output.
6. (Figure 5.6) There is some pre-existing data in the database. The PCA output in one dimensional data is obtained. Hence the final classification of the signals existing below and above the threshold level are obtained for each instances of the signal process. Refer Figure: 12.6

VI. CONCLUSION

To get to know any changes in the human body, a contact is made either physically or through a device. The human body is used as a communication medium to characterize the noise estimations and this information is thus utilized to monitor the patients effectively. Here we analyse the signals to find the electromagnetic interference and monitor the noise analysis using PCA algorithm which is complex in nature. This algorithm helps us study the noise interference in the human body, detect the maximum and minimum noise which can be obtained. The noise interference can be processed using MATLAB. There is a certain threshold set for the noise interference exceeding which it would be difficult to differentiate the noise from the signal. An aggregate of the interference of noise is calculated and the estimate is provided. This signal is further processed using the DWT algorithm for effective use in the wireless band. Thus a noise estimation is provided along with analysis of body channel communication for efficient monitoring of the patients. The main advantage in this implementation is that it is cost effective and very accurate compared to the existing systems. We can customise this according to the requirements of the patient.

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