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# ANN Based Technique for Assessment of Wellness of Human Heart

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***Abstract***

*This paper proposes the Artificial neural network-based heart care assessment system. As per the growing demand of smart health care system this Artificial Intelligence based diagnostic tool fulfill up to certain level. This neural network-based system detects and predict the healthy and unhealthy conditions of the heart. This system is trained with the various input parameters of ECG and PCG. As there are some correlation and coordination are being observed between the ECG and PCG in the same time interval. This enables to develop a smart heart assessment system at the primary level so that its early detection may increase the chances of proper diagnosis at the secondary level. It will be an economical as well as a time saving system.*

***Keywords:*** *ANN, ECG, PCG*

## 1 Background

As in the field of biomedical instrumentation, the cardiology is the most popular area in which many researches and the developments has been done. The heart is the most vital organ of the body on which the other function depends on it. For the overall condition assessment of heart, the person has to largely depend upon the skill and knowledge of the doctor. To improve the diagnostic accuracy in the measurement and to make system independent now days many advanced ECG machines, modern electronic stethoscope and different algorithms are used for the detection of the heart murmurs.

Many segmentation and detection algorithms are being developed to record the four individual heart sounds from the heart cycles. To get cardiac signal different parameters of the human body is considered. But still the problem persists during the segmentation of the cardiac signal. This is mainly due to noise and other external factors that are affecting the existing system badly. So, this paper aims to develop a more accurate, cost effective diagnostic system which will overcome all these drawbacks. The Artificial Neural Network (ANN) based diagnostic system is implemented as a tool for the assessment of wellness of human heart. This system also reduces the unnecessary medical tests, cost of several machines which are used by the doctors for monitoring the condition of heart.

Nowadays there are large number of sufferers of cardiac diseases. The maximum cases are acknowledged with the heart condition at last stage. This leads to an urgent need of a diagnostic system which can recognizes the heart condition at very early stage, it has become an ultimate goal of pediatrics. The efforts are involved in developing a cost effective and efficient diagnostic system. Prior lot of developments being done but they are quite expensive as well as complex in which certain trainings are needed for the evaluation. In reaching the desired objective the ANN is the most suitable and optimal tool which is acquired to get the responses effectively.



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## 2 Introduction

It has been stated in health survey reports that there is increase in the substantial growth in the death rates due to cardiovascular diseases. In present scenario the heart malfunctioning is the most common and major cause of mortality. Now day's persons in their early age becoming chronic to heart problems the major cause behind this is the lack of problem specific diagnostic platform and the high prices of the treatment pertaining to this. In related to this the major number of patient cases have been recorded in which delayed detection of illness was one of the prime factors[1-3]. Whenever the patient suffers from cardiac illness, the most common is that he visits to a physician. The Physician performs the basic auscultation, sometimes the illness is detected but sometimes not. As to increase the reliability and accuracy at this initial stage there must be a primary diagnostic platform.

To curb these types of problems and to eradicate the existing circumstances there is need of a low cost, reliable, accurate, early detection, portable and user friendly powerful diagnostic tool which must be able to detect the illness early in an accurate and cost-effective way so that diagnosis can be done accordingly. The proposed system will provide the initial status check of cardiac system so that he could visit to cardiologist for the second opinion on the basis of that primary reports. By keeping this view point we proceed further to develop such diagnostic system[4-6].Thus, it is obvious that the function of the heart is a complex combination of electrical, mechanical and hydraulic subsystem present in it. The assessment of the complex function of heart is mainly made using three techniques independently; The ECG, the blood pressure and the heart sound (through digital Stethoscope).

The ECG machine records the electrical signals at various locations near heart. It records the vectorized potentials with reference to a common ground. Diagnosis is made by the doctors based on changes observed in ECG pattern of individual. The blood pressure apparatus measures the blood pressures inside the heart during systolic and diastolic conditions. In systolic condition the blood is pumped out of the heart through aortic and pulmonary valves due to electrical conduction. While during diastolic condition the blood enters the ventricle chambers of the heart through mitral and tricuspid valve which open mainly due to hydraulic pressure difference[7-10]. The trained ears of doctors listen to the various sounds produce inside the heart due to flow of blood from one chamber to the other. Sophisticated advanced stethoscopes, though, are now available to precisely record the heart sounds[11-15].

Thus, the interdependent complex electrical, mechanical and hydraulic activities of the heart are observed by separate instruments. The measurements of ECG, Blood pressure and heart sound depends on the skill of the person taking these observations. The doctor diagnoses the condition of the heart, based on these observations, some other profiles, and the general condition of a person. Thus, the overall condition assessment of heart largely depends on the doctor's skill, knowledge and precision in measurements etc. The above discussion reveals that the heart, which is the most vital organ, operates due to simultaneous superposition of various complex electrical, mechanical and hydraulic activities. No work has so far been reported for making assessment wellness of heart in a manner which is independent of personal skills in taking observations and of personal expertise in making interpretations based on those observations.

## 3 Artificial Neural Networks (ANN)

There are lot of involvement of ANN has been seen in the field of medical sectors specifically in the field of the cardiology. There are various works have been done before for the detection of the ailment of heart based on different signals as parameters but all are much complex and specifically addressed by trained personnel but to make it easy to handle and multidimensional, a distinct methodology with



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the same optimization technique is implemented in this work. ANN is the most suitable and powerful tool used in the area of pattern recognition and classification-based tasks. ANN can learn complex interactions and also able to establish the relations among provided input data which may not be easily adaptable by human analysis. In our work the ANN consists of three basic processing layers namely the input layer, output layer and the hidden layer. These layers are interconnected of each other in a sequential manner as shown in below figure 1.

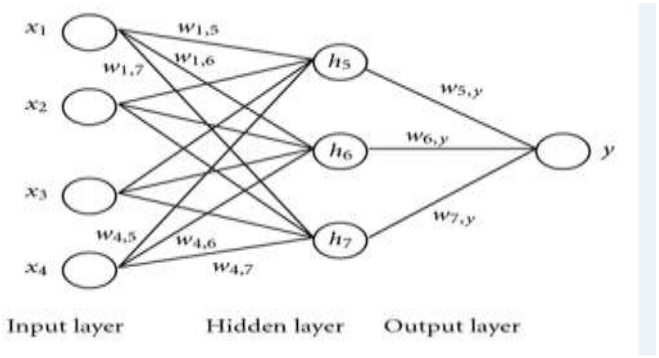


**Figure 1** Network Layers of proposed ANN System

## 4 Methodology to Develop the Proposed Diagnostic System

A thorough study were carried out to understand and analyze the functional and physiological behavior of heart. This includes the study of heart structure, functioning of different parts and correlation among them. It is obvious that various physical parameters and conditions of human body have an effect on the performance of heart.

The two major indicators of well-being of heart are electrocardiogram and phonocardiogram. While majority of the abnormalities got reflected in an ECG signal, certain abnormalities are detected only through heart sounds. Abnormalities getting reflected through heart sounds are called murmurs and are represented as S1, S2, S3 and S4 sounds. Not all the ears are trained to distinguish and to identify these murmurs there is one and only method is through stethoscope. Thus, a unique technique is developed to identify the presence of murmurs.

ANN is a tool that helps in classifying the given data and predicting the targeted outcome. As its basic nature resembles the function of brain, it is capable of correlating the input data (which are independent of each other and are also not directly/mathematically connected to the targeted output) in a complicated manner to predict the targeted output.

## 5 Steps Involved in Designing the Proposed ANN System

### 5.1 Design of ANN Architecture & Data Preparation

Eight input neurons with one hidden layer comprising of two neurons was used to obtain one single output. Back Propagation method was used for training and TRANSLIG method used for simulation in the MATLAB environment. A group of 50 persons including both healthy and unhealthy heart cases were investigated and their data corresponding to the 8 input nodes were generated. The information fed to input nodes are age, height, weight, body mass index, blood pressure (systolic and diastolic), Heart beat per minute, duration of QT interval. The QT interval was obtained for all the cases



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individually through their ECG records taken at the time of data preparation. ECG record taken at the time of data presentation. The data was then normalized. Whereas the output mode represented the 1st heart sound for all the cases recorded at time of data generation.

### 5.2 Training and Validation of the System

The ANN network is trained with data of the person's different physical parameters including their ECG values and also taking their 1st Heart sound as the targeted output. The network is trained with large number of iterations till its performance curve exactly meets its desired value. The regression and the curve plot become accurate. In the whole process of training the network only the data of healthy person which is 42 out of total 50 person is being taken so that the system can easily detect any unhealthy data pertaining the 42 cases having healthy heart. The Table1 shows the normalized datasets at different parameters of some healthy persons to train the neural network.

**Table 1 -** Normalized Dataset of Persons used in the Training and Validation Process

| **S. No.** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| **Patient ID** | 64 | 65 | 66 | 67 | 70 | 68 | 69 | 73 |
| **Age(Year)** | 0.97 | 1.09 | 1.46 | 0.58 | 1.04 | 0.78 | 0.87 | 0.53 |
| **Height(m)** | 1.03 | 0.99 | 0.98 | 0.92 | 0.98 | 0.91 | 1.01 | 1.05 |
| **Weight(kg)** | 0.66 | 0.95 | 0.88 | 0.79 | 0.98 | 0.88 | 1.19 | 1.17 |
| **B.M.I.(Kg/m2)** | 0.62 | 0.96 | 0.92 | 0.92 | 1.01 | 1.06 | 1.16 | 1.06 |
| **Heart Rate(BPM)** | 1.06 | 1.04 | 0.95 | 0.98 | 1.01 | 0.87 | 0.98 | 1.08 |
| **B.P.(diastolic)** | 1.07 | 0.9 | 0.97 | 0.83 | 1 | 1.19 | 0.92 | 1.19 |
| **B.P. (systolic)** | 0.96 | 0.98 | 0.86 | 0.9 | 0.96 | 1.06 | 1.04 | 1.06 |
| **QT Interval (ms)** | 0.94 | 0.95 | 1.12 | 0.87 | 0.97 | 1.07 | 1.01 | 0.92 |

**Table 2 -** Obtained Validated Output from the System

| **S. No.** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| **PatientID** | 64 | 65 | 66 | 67 | 70 | 68 | 69 | 73 |
| **Validated Value** | 0.90 | 0.90 | 1.01 | 0.94 | 0.91 | 1.27 | 0.86 | 1.20 |
| **Measured Value** | 0.90 | 0.88 | 1.01 | 0.93 | 0.91 | 1.27 | 0.85 | 1.20 |

The ANN thus developed is validated by using the input and output data of 8 cases selected randomly out of 50 cases. The validation results are shown in Table 2. It reveals that the proposed ANN is perfectly trained to give the correct values of the output information (duration of 1st heart sound based on the other physical parameters and QT duration) as input information.



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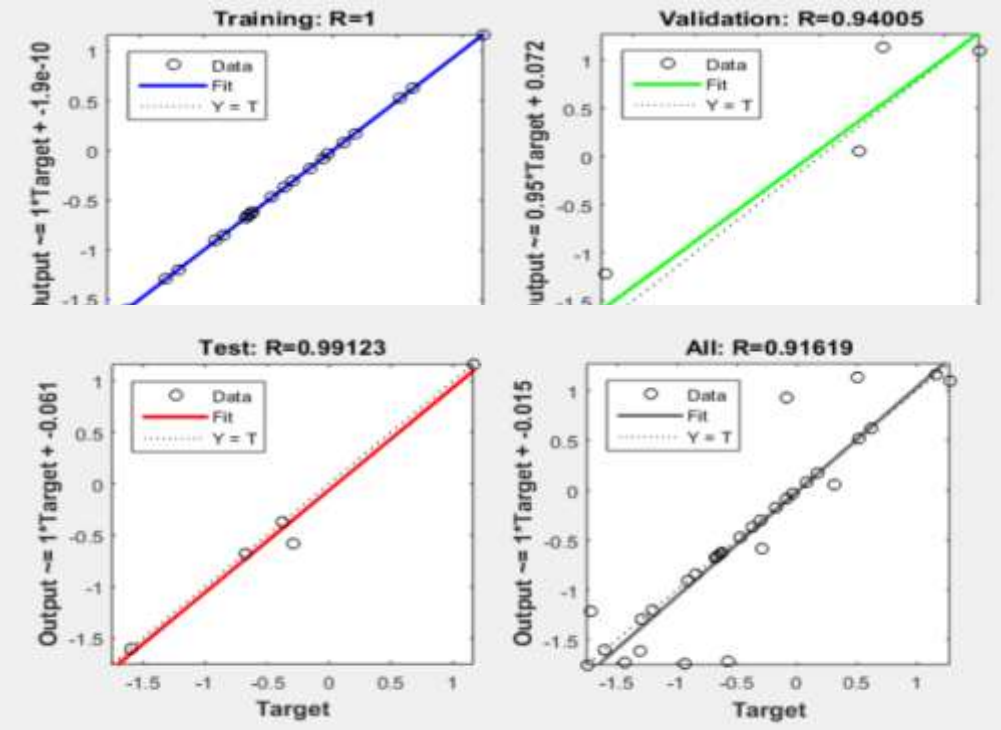


**Figure 2** Training and the Validation curve of the proposed system

**Figure 3** Sampling data curve of the proposed system

The performance analysis of the proposed ANN trained system is being observed through the different curve fits. The performance curve includes four curves. These curves are plot between the output and the target data with reference of input data. Figure 2 shows the training and validation curve of the proposed ANN system. we can observe from the curve that the regression values are exactly fit and very close to desired value. Figure 3 shows the sample testing curve and the overall output of the whole datasets fed to the proposed system. Here also we can observe from the curve that the regression values in both the cases is very close to desired value which indicates the system is perfectly trained to perform successfully and provide the exact results. These curves exactly fit to the best value.

## 6 Hardware Setup & Simulation Results

A hardware setup is being developed to obtain the real time data for input data parameters that is used to train the ANN network. The ECG and PCG signals are taken from the ECG machine and with the help of digital stethoscope then both the data is synchronized in real time MATLAB environment. Certain other input parameters like age, height, body mass index, systolic and diastolic blood pressure are also taken for consideration with the specific instruments. The datasheet of each person with their parametric value mentioned above is taken with this setup, which is further utilized in training the datasets of neural networks and also to verify the obtained simulation result from the developed ANN system Once the ANN system is trained and validated, set of various sample data including only healthy, unhealthy as well as both healthy and unhealthy heart persons is provided to this developed diagnostic system for the testing the system response. The sample dataset of the successfully tested data of all the three respective cases as shown in table below. The value clearly indicates the accuracy and reliability of the system. In the case of healthy person, the developed system gives the positive value and it indicates the negative values in case of unhealthy person. The obtained result from the ANN system is similar to the results taken by experimental setup. Table 3 shows the sample data of healthy persons fed to trained system and the obtained output indicates them as healthy persons with their positive value of QT 1$^{st}$ heart sound. Table 4 shows the sample data of some unhealthy person fed to trained system and



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the obtained output indicates them as unhealthy persons with their negative value of QT 1st heart sound.

**Table - 3** Obtained Tested Results of 30 Healthy Persons from the Designed ANN System

| S.NO. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Patient ID** | 64 | 65 | 66 | 67 | 70 | 71 | 72 | 55 | 10 |
| **Simulated 1st Heart Sound** | 0.90 | 0.90 | 1.01 | 0.94 | 0.91 | 0.98 | 0.80 | 0.84 | 0.91 |
| **Measured QT Interval** | 0.94 | 0.95 | 1.12 | 0.95 | 0.97 | 1.01 | 0.94 | 1.09 | 0.96 |
| **QT- 1st Heart Sound** | 0.04 | 0.05 | 0.11 | 0.01 | 0.06 | 0.03 | 0.14 | 0.25 | 0.05 |

**Table - 4** Obtained Tested Results of Unhealthy Persons from the designed ANN system

| S. No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Patient ID** | 68 | 69 | 73 | 89 | 96 | 106 | 107 |
| **Simulated 1st Heart Sound** | 1.27 | 0.86 | 1.20 | 0.90 | 1.09 | 0.96 | 0.82 |
| **Measured QT Interval** | 1.07 | 1.01 | 0.92 | 0.96 | 0.95 | 0.91 | 0.80 |
| **QT – 1st Heart sound** | -0.2 | -0.15 | -0.28 | -0.06 | -0.14 | -0.05 | -0.02 |

## 7 Conclusion

The paper highlights the involvement of Artificial Intelligence techniques in the field of biomedical engineering specifically to the wellness of human heart. As there is coordination between the ECG and PCG signals so for testing the condition of human heart both ECG and PCG signals have to be taken under consideration. If there is any mal-functioning in the activities of heart then their corresponding ECG and PCG intervals will also reflect some disturbances. So, this being a need of an assessment system which can work at the primary level and it can detect and indicate the healthy and unhealthy conditions of human heart so that an immediate action can be taken as per the result obtained by initial stage and also decision can be taken for further diagnosis. It will be a life savior as well as economical because of early detection of status of human heart. This ANN based diagnostic system performs successfully as it indicates the healthy and unhealthy heart of the person with respect to input variables that is provided to the trained system.



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