Heart Attack Prediction System Based Neural Arbitration

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Abstract: Heart attack is an asymptomatic and epidemic medical condition that may suddenly occur and causes "death". Therefore, it is a life-threatening condition and it should be detected before it occurs. Heart attack is so far predicted using the conventional ways of doctor's examination and by performing some medical tests such as stress test, ECG, and heart CT-Scan etc. The coronary vessels constriction, the cholesterol levels in the arteries, and other attributes can be good indicators for making effective decisions. In this paper, a neural network based support decision system is developed for the prediction of heart attack. The proposed system uses 14 medical attributes, obtained from the Cleveland database such as sex, heart rate, and vessels narrowing etc. Two attributes have been emphasized in order to distinguish the heart attack from other heart diseases; the vessels constriction rate and the chest pain type. The testing results show high efficiency and capability for the designed system to predict heart attack and diagnose the three medical conditions: normal, abnormal, and imminent to heart attack.

Key words: Heart attack, asymptomatic, epidemic

Introduction

Heart is the basic part of the body. Heart-failure is a serious medical situation in which this vital organ doesn't operate properly. The malfunctioning of the heart may impact the whole body organs since it is affiliated with all the body parts through its arteries and veins. One of the most dangerous and insidious heart diseases is the heart attack. It can be delineated as a chest pain aligned with a constriction in the coronary vessels which is called atherosclerosis. The two main indicators for heart attack that/ have been focused on in this work are the type of chest pain and the coronary vessels clogging rate. The centre of disease control and protection (CDC) has estimated that about 720,000 Americans have a heart attack every year. 525,000 of these are a first heart attack and 190,000 happen in people who have already had a heart attack ("Every year about **720,000 Americans** have a heart attack", n.d.). Due to these dangerous upshots, there should be a way to predict a heart attack. The heart diseases can be diagnosed by their signs and symptoms. Heart attack is one of the riskiest heart diseases and it has the same signs and symptoms of other heart diseases, in addition to the plaques buildup in the coronary arteries which rupture inside of arteries, and the unstable angina which may be a warning sign for a heart attack.
Data mining is the automatic study (analysis) of stored data to elicit the results and find patterns beyond these data. Nowadays, various diagnostic and patient medical records devices which may store a huge amount of data are found (Nabeel Al-Milli, 2013). Therefore, these medical data that may indicate a heart attack must be stored and processed using data mining technique based neural network; in order to spring up a decision making system for the prediction of a heart attack.
The overall structural format of the paper is as follows. The first section is an introduction. The section 2 is a literature review which lists some studies related to the topic. The section 3 discusses the neural network and backpropagation algorithm. The section 4 discusses the data representation. The section 5 discusses the training and performance of the created neural network. Finally the section 6 is a conclusion of the whole work.

Literature Review

Nabeel Al-Milli (Nabeel Al-Milli, 2013) developed a heart disease prediction system using neural network. 14 parameters were used in this work with 4 output classes. The backpropagation algorithm was used for training the network and the experiments conducted in this work have shown the good performance of the proposed algorithm. Heart diseases dataset is analysed using Neural Network approach by Dr. K. Usha (K. Usha Rani, 2011). In this work a parallel approach is adopted in the training phase in order to increase the efficiency of the classification process.

Heart Disease Prediction system (HDPS) using neural network has been proposed by Chaitrali S. Dangare, Mrs. Sulabha S. Apte (Chaitrali S. Dangare, Sulabha S. Apte, 2012). The authors used 13 medical attributes such as sex, cholesterol level, and stress test in addition to two other attributes which are the smoking and the obesity in order to get a better accuracy. The HDPS system predicts the likelihood of patient getting a Heart disease. The accuracy of this designed system was nearly 100%.

Dilip Roy Chowdhury, Mridula Chatterjee R. K. Samanta (Dilip Roy Chowdhury, Mridula Chatterjee R.K. Samanta, 2011) applied an artificial neural network model for neonatal disease. The authors proposed a technique with a backpropgation algorithm for recognizing a pattern for the prediction of neonatal diseases. This proposed system was capable to predict and enhance the diagnosis accuracy of 75% of the neonatal diseases.

Artificial Neural Network (ANN)

Artificial neural network is a remodelling of the human brain information processing system. It is a multilayer system in which each layer is composed of multiple nodes which represent the neurons. Each node is connected to the others by means of edges represent the weights which are the information transmitted (Adnan Khashman, 2011). ANN is principally composed of multilayers: input layer, one or more hidden layer, and output layer. The input from the previous layer is multiplied by the adjusted weights. At each node or neuron the weighted inputs are added and then the combined inputs pass through a non-linear transfer function in order to produce the desired output (K. Anil Jain, Jianchang Mao and K.M. Mohiuddi, 1996). ANN is basically developed to solve data mining applications. It is an adaptive learning technique in which it has a different and specific learning methodology; the learning by examples. Therefore; some complex tasks can be handled using neural networks such as prediction, recognition, and classification (R. Rojas, 1996). Various learning and training algorithms can be used to train the network. One of the most public used algorithms is the backpropagation algorithm. In order to produce the desired output, the input weights should be adjusted and the correction-error should be reduced. The most popular used learning algorithm for updating the weights and correcting the learning error is the backpropagation algorithm. Backpropagation is a learning technique for the feedforward multilayer neural networks. It has two passes through the different layers; the forward pass and the backward pass. In the forward pass the weights are summed and then combined in the output layer. In the backward pass the weights are corrected. The actual output is subtracted from the desired one in order to produce the error. The error is then propagated back to all previous layers in order to update the weights and get the desired output (Nabeel Al-Milli, 2013).

Heart Attack Prediction System (HAPS) based neural network

In this paper, we develop a heart attack prediction system based neural network using backpropagation learning algorithm. 14 parameters are used as inputs for the network such as sex, heart rate, and cholesterol level. The main parameters that have been emphasized on to predict heart attack are the chest pain type and the coronary vessels constriction rate. The dataset is obtained from Cleveland database. It is a well-known database available on the internet (Bache, K. & Lichman, M., 2013). 300 records are taken. They are classified as 3 output classes: Normal, Abnormal, and imminent to heart attack. The 300 records are divided into 2 sets: 150 for training and 150 for testing. The training set is also divided into 3 sets: 50 for normal, 50 for abnormal and 50 for imminent to HA. The testing set is divided into 3 sets also: 50 for normal, 50 for abnormal and 50 for imminent to HA.

Data Representation

Most research papers related to heart diseases prediction used these 14 parameters according to their description provided by Cleveland database. Here, we use the 14 attributes; however, we focus on two main parameters in order to distinguish heart attack from other heart diseases. Table 1 illustrates the medical data used as inputs for the networks. Table 2 illustrates the output classes according to our proposed system.

Table 1: Cleveland Parameters (Bache, K. & Lichman, M., 2013).

Parameters	Description	Range
Age	Age in years	Continuous
Sex	1=male,0=female	1,0
cp	Value 1: typical angina Value 2: atypical angina Value 3: non-anginal pain Value 4: asymptomatic	1,2,3,4
trestbps	Resting blood pressure(in mm Hg)	Continuous
Chol	Serum cholesterol in mg/dl	Continuous
fbs	(Fasting blood sugar .120mg/dl) (1=true; 0=false)	0, 1
ECG	electrocardiography results Value 0: normal Value 1: having ST-T wave abnormality(T wave inversions and/or ST Elevation or depression of >0.05mV) Value 2: showing probable or definite left	0, 1, 2
Thalach	Maximum heart rate achieved	Continuous
Exang	Exercise induced angina (1:yes; 0:no)	0,1
Oldpeak	ST depression induced by exercise relative to rest	Continuous
Slope	The slope of the peak exercise ST segment Value 1: up sloping Value 2: flat Value 3: down sloping	0, 1, 2
Ca	Number of major vessels(0-3) colored by fluoroscopy	Continuous
Thal	Normal, fixed defect, reversible defect	3, 6, 7
Num	Number of major narrowed vessels: 0:<50% narrowing 1:>50% narrowing	0, 1

Table 2: Output Classes

Classes	Description
Class 1	Normal
Class 2	Abnormal
Class 3	Imminent to HA

Normal: all parameters are normal
Abnormal: all parameters are out of their normal ranges (abnormal) except the chest pain type and vessels constriction in which they don't indicate a heart attack
Imminent to HA: all parameters are not normal, as well as the chest pain type and the vessels constriction rate which indicate heart attack. For instance, for a case, the chest pain type is typical angina and the coronary vessels constriction rate is greater than 50%.

ANN Topology

The network was created on matlab software using the back propagation algorithm. The first step was to create a basic network and train it for simple operation such as 'AND" or 'OR' in order to reduce the mean sum error value to 0.01. All training is done using backpropagation with both adaptive learning rate and momentum; with the function 'traingdx' and with the transfer function 'logsig'. The network was fed with the normalized datasets for the three sets and their output targets respectively. Figure 2 illustrates a multilayer neural network with 14 neurons in the input layer, 5 neurons in the hidden layer, and 3 neurons in the output layer. We ran the experiments for 10000 iterations.
Table 3 represents 5 records data of the 14 attributes before normalization. Table 4 represents the same data after normalization.

Table 3: ANN Parameters Setting

Parameters	Value
Number of neurons in input layer	14
Number of neurons in output layer	3
Number of neurons in hidden layer	5
Iterations number	10000
Learning rate	0.001
Momentum rate	0.5
Error	0.001
Activation Function	Sigmoid

Table 3 shows all the parameters used when training the network. The network ran for 10000 iterations with a learning rate of 0.001, a momentum rate of 0.5 and a minimum error of 0.001 since it is a medical application.

Table 4: Normalized attribute values for 4 patients

Attributes	Patient 1	Patient 2	Patient 3	Patient 4
1	0.4308	0.446	0.492	0.523
2	1	1	0	0
3	0.5	0.5	0.5	0.5
4	0.4667	0.35	0.583	0.5
5	0.396	0.383	0.457	0.398
6	0	1	0	1
7	1	0	0	0
8	0.45	0.533	0.6	0.633
9	1	0	0	0
10	0.475	0.25	0.3	0.7
11	0.5	0	0.25	0.25
12	0	0	0	0
13	0.4286	0.857	0.428	0.428
14	0	0	0	0

Table 5: Attribute values for 4 patients before normalization

Attributes	Patient 1	Patient 2	Patient 3	Patient 4
1	28	29	32	34
2	1	1	0	0
3	2	2	2	2
4	130	140	105	130
5	132	135	198	161
6	0	0	0	0
7	2	0	0	0
8	185	170	165	190
9	0	0	0	0
10	1.3	0.5	0.2	0.8
11	1	1	1	2
12	0	0	0	0
13	3	3	3	6
14	0	0	0	0

Figure 1 illustrates the designed neural network architecture for our proposed system. (x1,…x14) represent the medical parameters which are the inputs of the network. The connections between the neurons called the weights. Each neuron in the input layer is connected to the succeeded neurons in the hidden layer. Moreover, each neuron in the hidden layer is connected to the three output neurons. Sigmoid function is used as a transfer function for the network.

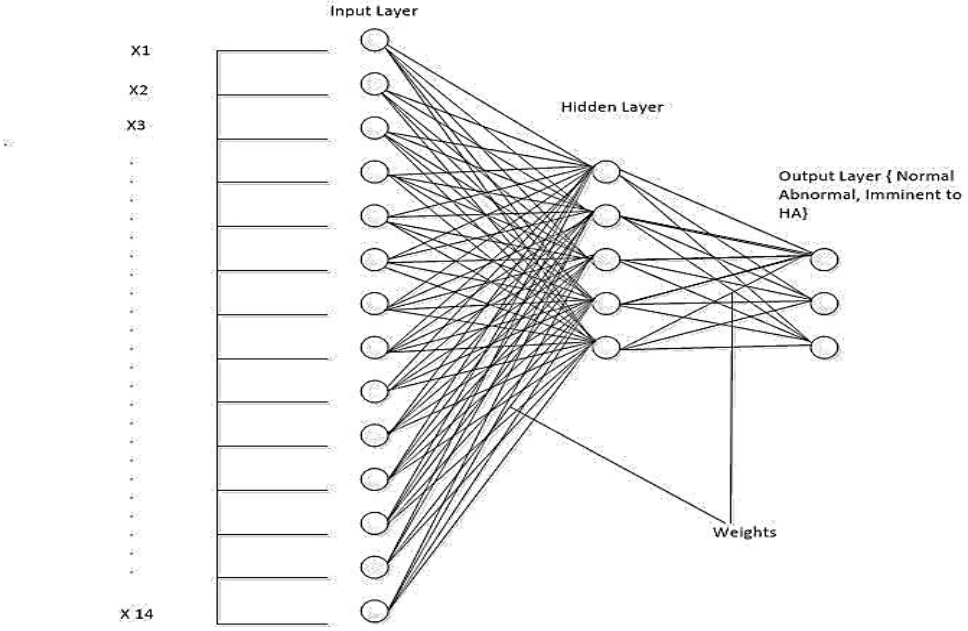

Figure 1: ANN Model

System Training

The network was trained on three different sets; first set is for the normal values and it contains 50 records, second set is for the abnormal values and it contains 50 records and the last set is for the imminent to HA values and it contains 50 records. The following is the training results of the three sets (learning curve).

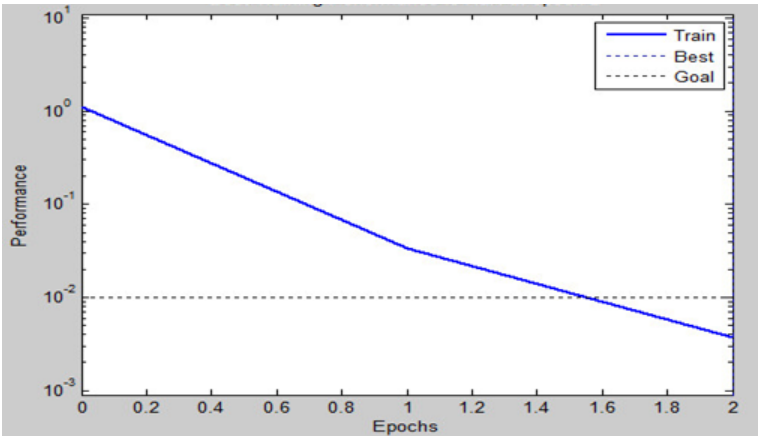

Figure 2: Variation of the MSE with the iteration number.

This curve below represents the regression plot of the desired output (dotted line) and the actual output. As the actual output is far from the target as the error is increased. In this figure, it is remarked that the target and the actual output are very close which means that the error is minimized and the network well trained (training ratio = 96%).

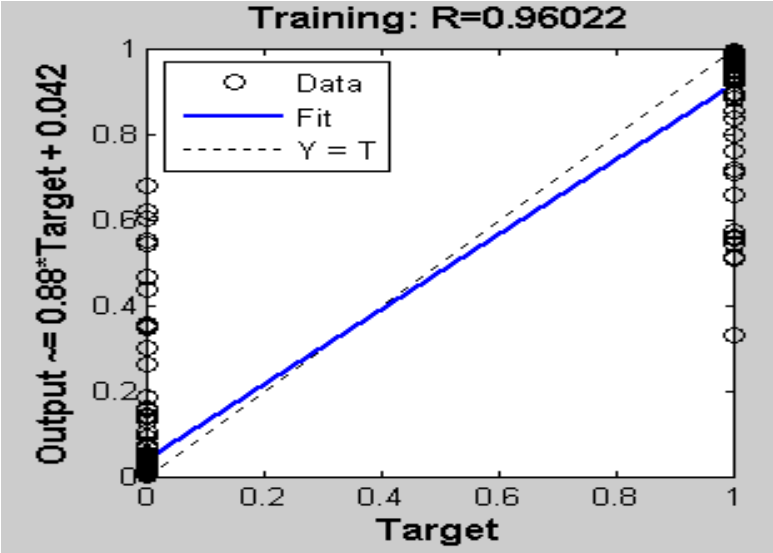

Figure 3: Actual versus target output

Network Performance

The network was tested on a dataset of 150 records; 50 for normal, 50 for abnormal and 50 for severe cases. Table 6 represents the results obtained from two runs for the three different classes (Normal, Abnormal and imminent to HA). This table below represents the number of records that were recognized by the network in the training and the testing phase. The number of recognized records was divided by the total number of records with respect to each case set (Normal, Abnormal, and imminent to HA). The result of this fraction is called the recognition rate.

Table 6: Recognition rate

	Runs	Classes	Training Sets (150)	Testing Sets (150)	Total
Recognition rate	1	Normal	99%	95%	97%
		Abnormal	96%	91%	94%
		Imminent to HA	97%	90%	93%
	2	Normal	94%	94%	94%
		Abnormal	97%	90%	95%
		Imminent to HA	97%	92%	93%
		All classes	96%	92%	94%

The total recognition rate for the training set is 96% and for the testing set is 92% which means that some records were not recognized correctly. The difference of training results of both runs is due to the changes in the set learning and momentum rate. As a result, the total recognition rate is 94% and it is a satisfying result for such medical application. Table 6 presents some recognized records of three different cases (Normal, Abnormal,

Imminent to HA) during the testing phase.

Conclusion

In this study, a heart attack prediction system based neural network was developed. Data mining technique was used to discover knowledge beyond a simple analysis of some medical data related to heart attack. The designed system was capable of diagnosing the three medical conditions: Normal, Abnormal and imminent to HA. The developed system used 14 medical parameters that may indicate heart attack if their values are out of normal ranges. The experimental results of the neural network were satisfactory for such prediction task and they can be furthermore improved.

References

Centre for Heart Disease Control and Prediction. Retrieved from http://www.cdc.gov/heartdisease/facts.htm

Nabeel Al-Milli, 2013. A backpropogation neural network for prediction of heart disease. In Journal of Theoretical and Applied Information Technology, vol.56, no.1, pp. 131-135.

Dr. K. Usha Rani, 2011. Analysis of heart diseases dataset using neural network approach. In International Journal of Data Mining & Knowledge Management Process (IJDKP), vol.1, no.5, pp. 1-8.

Miss. Chaitrali S. Dangare, Dr. Mrs. Sulabha S. Apte, 2012. A data mining approach for prediction of heart disease using neural networks. In International Journal of Computer Engineering and Technology (IJCET), Vol. 3, Issue 3, pp. 30-40.

Dilip Roy Chowdhury, Mridula Chatterjee R.K. Samanta, 2011. An Artificial Neural Network Model for Neonatal Disease Diagnosis. In International Journal of Artificial Intelligence and Expert Systems (IJAE), vol. 2, Issue 3, pp. 96-106.

Adnan Khashman, Credit risk evaluation using neural networks: Emotional versus conventional Models. In Elsevier, 2011.

K. Anil Jain, Jianchang Mao and K.M. Mohiuddi, 1996. Artificial Neural Networks: A Tutorial, IEEE Computers, pp.31-44.

R. Rojas, (1996). Neural Networks: a systematic introduction, Springer-Verlag.Davis

Bache, K. & Lichman, M. (2013). UCI Machine Learning Repository [http://archive.ics.uci.edu/ml]. Irvine, CA: University of California, School of Information and Computer Science.

