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Comparison of Two Types of Neural Networks for Classifying the Effects of Heart Diseases in Erbil City

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Classification, Neural Network, Radial Basic Function , Multilayer Perceptron Network and algorithms

Abstract

The main objective of this research is to compare two types of neural networks: the Radial Basis Function (RBF) network and the Multilayer Perceptron (MLP) network, to determine which provides better performance in classifying heart disease. The data were collected at the Surgical Specialty Hospital – Cardiac Center in Erbil City, comprising 196 observations recorded between January 1st, 2006, and April 30th, 2023. To evaluate model performance, the study employed common classification metrics, including Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE). Both neural network models were applied to the dataset. The RBF network demonstrated superior performance, achieving the lowest error values in both training and testing phases, while also requiring less training time. Therefore, the RBF network can be considered a reliable and highly effective method for classifying heart disease cases in Erbil City.

1. Introduction

A multilayer perceptron network is a simple type of neural network that can classify linearly separable patterns. It consists of a single layer of weighted inputs and a binary output. It is the most complex type of neural network capable of learning to classify non-linearly separable patterns (Graupe, 2007; Nicolas, 1999). However, the use of the radial basis function is one of the most recent topics of our time. It is considered one of the best and most commonly used networks for data classification. It is a type of artificial neural network that serves as an activation function. The network's output is a linear combination of the input radial basis functions and neuron parameters. This network can be used for a variety of tasks, such as function approximation, time series forecasting, classification, and system control (Bergson,1996; Hao et al., 2014). It can be concluded that the RBF network is a popular alternative to the well-known multilayer perceptron (MLP) since it has a simpler structure and almost faster training process.

2. Theoretical Part

2.1 Definition of Heart Disease: It is a type of disease that affects the heart or blood vessels. The risk of certain heart diseases may be increased by smoking, high blood pressure, high cholesterol, an unhealthy diet, lack of exercise, and obesity (Adelson et al., 1962). There are four main types of heart disease:

Coronary artery disease, also called coronary heart disease, is the most common type of heart disease. It develops when the arteries that supply blood to the heart become clogged with plaque. This causes them to harden and narrow. Plaque contains cholesterol and other substances.

Stroke effects occur when the blood supply to the brain is disturbed. The brain needs a constant supply of oxygen and nutrients to function properly. The brain receives oxygen from the blood, so if blood flow is restricted or stopped, brain cells begin to die. This can lead to brain damage and possibly death. The main stroke symptoms can be remembered with the word FAST, which stands for:

Face: The patient might have facial drooping on one side and be unable to smile, or their mouth or eye may appear drooped.

Arms: A person with a suspected stroke may not be able to lift their arm and keep it raised due to weakness or numbness.

Speech: The person’s speech may be slurred, garbled, or they may be unable to speak at all despite appearing awake.

Time: If any of these signs are present, it is crucial to seek emergency medical help immediately, as prompt treatment can reduce brain damage and improve outcomes.

Peripheral Aterial Diseases is also known as peripheral vascular disease, occurs when there is a blockage in the arteries of the limbs (usually legs). The most common symptom of this disease is pain in the legs while walking. This is usually in one or both thighs, hips, or calves.

Aortic disease: The aorta is the body's largest blood vessel. From the heart, it carries blood to the rest of the body. Aortic aneurysms, when the aorta's wall weakens and protrudes outward, the most prevalent form of aortic disease. Pain is typically felt in the back, chest, or abdomen (Adelson et al.,1962).

2.2 Artificial Neural Network

The Biological neural networks served as inspiration for artificial neural networks. The brain is composed of over 10 billion neurons with complex internal links, forming a large network of neurons that share some characteristics with other cells in the body. However, it is unique in its ability to receive and process the transmission of an electrical signal along the length of the nerve that makes up the brain's association system. The neuron is made up of components, including dendrites, which are structures through which the cell receives information from neighboring cells. The axon consists of impulses (Bora and Gabbouj, 1994). It is a singular nerve fiber that conveys a cell’s output to certain other cells’ nerve fibers.

An artificial neural network is a type of artificial intelligence technique that was inspired by the learning algorithm of the human brain. An ANN is composed of a large number of processing

elements with their connections, and it has three distinctive layers, namely input, hidden, and output layers. Synapses are the points between nerve cells and cells where signals are exchanged. The basic form of input and output units is shown, as well as a technique for synthesis weights, where x1,x2,…,xn represented the input, w1,w2,…,wn represented the weights, the activation function is represented by f(zi)=xiwi, and yi represented the output (Gershenson,1998; Saalh et al, 2023).

2.3 Radial Basis Function

It is one of the most common of the best networks that can be used to classify the data. A radial basis function network is an artificial neural network that uses radial basis functions as activation functions. The output of the network is a linear combination of radial basis functions of the inputs and neuron parameters. Radial basis function networks have many uses, including function approximation, time series forecasting, classification, and system control (Bianchini and Scarselli, 2014; Hagan and Beale,1996).

2.3.1 Algorithm of Radial Basis Function: The Network Architecture typically has three layers: the first layer is the input layer, the second layer is the hidden layer, and the third layer is the output layer, which are a special category of feed-forward neural networks, as shown in Figure 1.

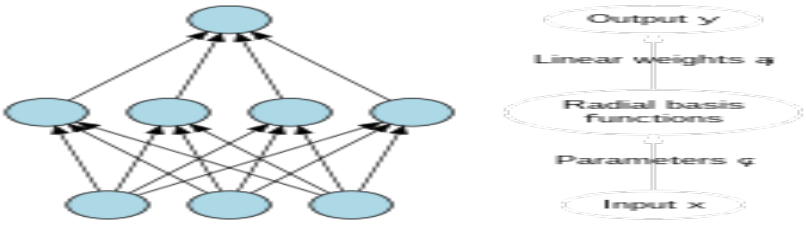


Figure 1. The Structure of Radial Basis Function (Hagan and Beale, 1996)

2.3.2 Training of Network

net = in it RBF Network (in, out, hidden);
find the vector data that produces the highest error
i = find Max Network Error (data, net); / / i = index vectors
add a layer of RBF neurons in the same place where
the vector data add RBF Neuron (net, width, data (i));
data (i) = midpoint
find the overall network error
Net Error = train Output Weights (net, data);
While (Net Error> Max Error)

It must be trained in three stages: The first step is selecting the centers. They can be picked at random from the training data set or by applying techniques such as k-means clustering, which are employed as the centers for the RBF neurons, which is a widely used center selection method, grouping the input data into k clusters. The second step is selecting the spread parameters for each RBF neuron's area of effect and determining the width of the network. The final step is training the output weights. A common approach for estimating the output layer weights is to minimize the error between the anticipated output and the actual target values (Dan, 2002; Hasan, 2022).

Multilayer Perceptron Network

A perceptron is a simple type of neural network that can learn to classify linearly separable patterns. It is a single-layer feedforward neural network, which means that information flows in one direction from the input layer to the output layer. We feed our input data into the input layer and get the results from the output layer. The neural network can learn to classify non-linearly separable patterns (Hao et al, 2014; Principe and Lefebvre, 2000).

2.4.1 Algorithm Multilayer Perceptron Network

The neural network's architecture refers to its structural design, which is comprised of three layers of units, as can be seen in Figure 2.

Layer of input units

The second layer is the hidden unit layer, which leads to the third layer.
Layer of output (Gershenson, 1998; Graupe, 2007).

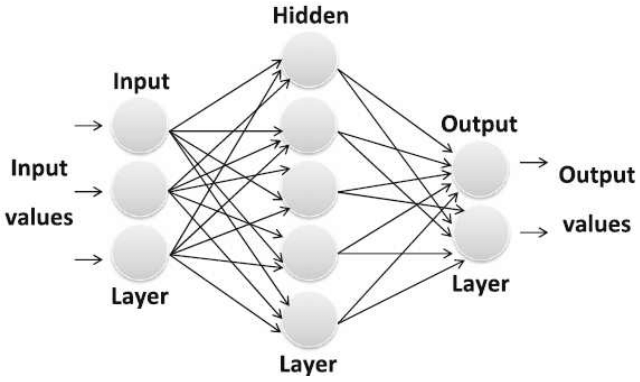


Figure 2. The Structure of Multilayer Perceptron Network (Nitin, 2018)

2.4.2 Training of Network

Network Construct Network Layers ();
Network weights Initialize Weights (Network, Problem Size);
For i = 1 to iterations max do
Pattern I Select Input Pattern (Input Patterns);
Output i Forward Propagate (Patterni, Network);
Backward Propagate Error (Pattern I, Output i, Network);
Update Weights (Pattern i, Output I, Network, learn rate);

The first step is inputting the data set and initializing the width; the second step is selecting the spread parameters for each neuron's area of effect and determining the width of the network. The final step is training the output weights. A commonly used method to estimate the output layer weights is to minimize the error between the anticipated output and the actual target values (Graupe, 2007; Zurada and Cholew, 1994).

2.4.3 The Measurement

The Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) are used here as performance measures. They define it as:(Hagan and Beale, 1996; Nicolas, 1999).

$$MSE=1/n \sum_{i=1}^{n} [(Xi-Fi) \quad (1)]$$

Where Fi is the forecast at time t, Xi the actual observation at time (t) and n is the sample size (Hagan and Beale, 1996).

$$MAPE=1/n \left(\sum_{i=1}^{n} |Xi-Fi|\right)/Fi \quad (2)$$

3. Application Part

In this part, actual data were used to classify the effects of heart disease in Erbil city. Ten variables (age, sex, chest pain, resting blood pressure, serum cholesterol, fasting blood sugar, resting electrocardiographic, maximum heart rate, exercise-induced angina, and old peak) are defined as x1, x2,..., x10. The computer programs SPSS (Version 28) and MATLAB (R2013a) were used for the analysis.

3.1 Apply Radial Basis Function

Figure 3 shows the structure of the RBF network. There are 196 data sets: 128 are selected as the training set, and 68 are used as the testing set. After normalizing the data using the Softmax activation function (Nicolas, 1999), the network has 9 input variables. There is one hidden layer containing 4 nodes, and the output depends on this single hidden layer.

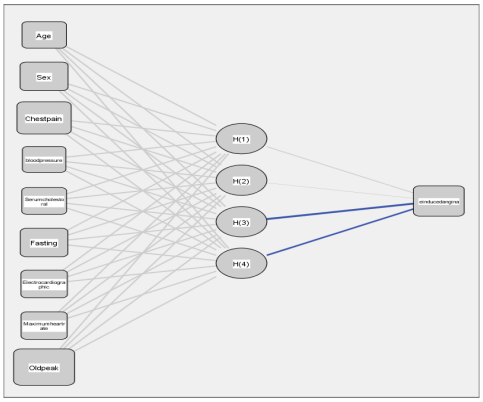


Figure 3. Structure of RBF Network

Table 1 below shows the percentage of training and testing of the Radial Basis Function Network, depending on the training percentage is 65.3% with the training value 128, and the testing percentage is 34.7% of 68 values.

Sample	Number	Percent
Training	128	65.3%
Testing	68	34.7%
Total	196	100.0%

Table 1. Percentage of Training and Testing

In Table 2 below, it can further be seen that the Mean Squares Error of training is equal to 0.191, the mean Percentage Error is equal to 0.126 for Radial Basis Function Network, and the time indices for the training nets are 00:00:00.160 sec, while the Mean Squares Error of testing is equal to 0.019, and the Absolut Percentage Error is equal to 0.081.

Table 2. The Measurement of the RBF Network

Model	MSE	MAPE
Training	0.191	0.126
Testing	0.019	0.081

Table 3 below displays parameter estimates of the RBF Network, the center vector for each hidden unit, and the hidden layer. Further, Figure 4 below shows the Normal Distributed value Radial Basis Function Network.

Table 3. Parameter Estimates of RBF Network

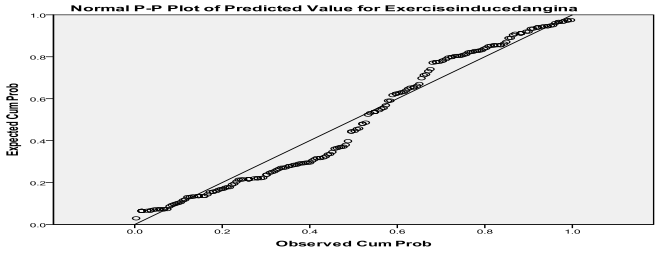
Variable		Hidden Layer				Output Layer
		H(1)	H(2)	H(3)	H(4)	Exerciseinducedangin
Input Layer	Age	.073	.220	.059	-.038	
	Sex	1.000	-1.000	-1.000	1.000	
	Chestpain	-.742	-.778	-.159	-.319	
	Blood pressure	-.494	-.235	-.461	-.446	
	Serumcholestoral	-.265	.015	-.225	-.328	
	Fasting	-.903	-.333	-.786	-.891	
	Electrocardiographic	-.581	-.778	-.429	-.370	
	Maximum heartrate	.403	.359	.481	.522	
	Old peak	-.208	.144	-.819	-.642	
	Hidden Unit Width	.586	.591	.548	.557	
Hidden Layer	H(1)					.625
	H(2)					.337
	H(3)					-1.085
	H(4)					-1.072

Figure 4. The Normal Distributed value of the RBF Network

3.2 Multilayer Perceptron Network

Figure 5, as displayed below, shows the MLP network structure using 124 data sets for the training set and 72 data sets which are used for the testing set. The network uses the hyperbolic tangent (Tan Function) activation function, which is very similar to the sigmoid/logistic activation function. The number of input variables is 9, and the network uses a single hidden layer containing 6 units, along with the output layer.

Figure 5. Structure of MLP Network



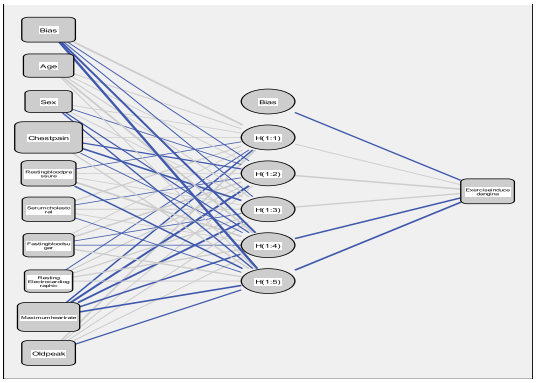


Figure 5. Structure of MLP Network

Table 4 below shows that the percentage of training and testing of the Multilayer Perceptron Network, depending on training percentage, is 63.3%with the testing being 36.7%for the value 124 to training and 72 to testing.

Table 4. Percentage Training and Testing

Sample	Number	Percent
Training	124	63.3%
Testing	72	36.7%
Total	196	100.0%

In Table 5 below, it can be seen that the Mean Squares Error of training is equal to 0.254735, Mean Absolute Percentage Error is equal to 0.193 of the Radial Basis Function Network, and time indices for the training nets models 00:00:00.280 sec, while the Mean Squares Error of testing is equal to 0.10301, Mean Absolute Percentage Error is equal to 0.132.

Table 5. The measurement of the MLP Network

Model	MSE	MAPE
Training	0.25473	0.193
Testing	0.10301	0.132

Table 6 below displays the parameters of the center vector for each hidden unit, input layer, and hidden bias of the RBF Network.

Table (6): Hidden Layer of MLP Network

Variable		Hidden Layer 1					Output Layer
		H(1:1)	H(1:2)	H(1:3)	H(1:4)	H(1:5)	Exerciseinducedangin
Input Layer	(Bias)	.015	-.133	.202	-.392	-.559	
	Age	.390	.010	.201	-.081	-.449	
	Sex	.304	.318	.394	.044	-.370	
	Blood pressure	.381	.055	.149	-.221	-.450	
	Serumcholestoral	.080	-.191	-.301	.414	-.126	
	Fasting	-.228	-.060	.005	.113	.008	
	Electrocardiographic	-.463	.092	.017	-.375	-.254	
	Maximum heartrate	-.458	-.378	-.413	-.209	-.354	
	Old peak	.424	.260	.070	.209	.272	
	Chestpain	-.235	.180	-.487	.114	-.392	
Hidden Layer 1	(Bias)						.156
	H(1:1)						.218
	H(1:2)						.195
	H(1:3)						.257
	H(1:4)						.397
	H(1:5)						.438

Figure 6 below shows a plot of normally distributed values of the Multilayer Perceptron Network.

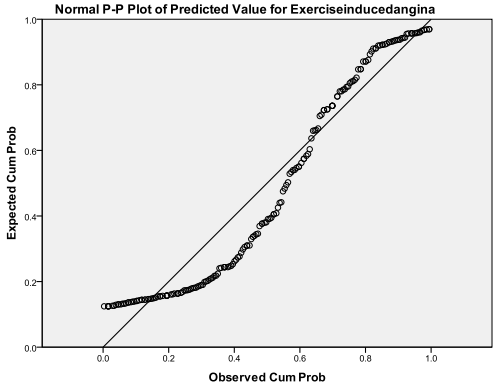


Figure 6. The Normal Distributed Value of the MLP Network

4. Conclusion and Recommendations

4.1 Conclusion

The research concludes that the first neural network (RBF) is a popular type compared to the well-known multilayer perceptron (MLP), as it has a simpler structure and a generally faster training process. It further shows that the structure and learning analysis of the RBF network, based on time, require less training time, making the network better than MLP networks for structural learning. To estimate the parameters using the RBF method in comparison with the other method, the results

with the lowest values are better, and the RBF includes four hidden layers, while the MLP includes five hidden layers. The radial basis function (RBF) network has the lowest values for both measurements, MSE and MAPE, in the training and testing of the network models.

4.2 Recommendations

Using the radial basis function (RBF) network and comparing it with other networks.
Depending on the radial basis function model for learning, it needs less time to process.
The radial basis function network is highly effective for forecasting in this research.

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بەراوردکردنی دوو شێوازی تۆڕی دەماری بۆ پۆلێنکردنی کاریگەریە کانی نەخۆشییەکانی دڵ لە شاری هەولێر

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پوختە
ئامانجی سەرەکی ئەم توێژینەوەیە بەراوردکردنی نیوان دوو شێوازی تۆڕی دەمارییە، یەکەمیان تۆڕی کارکردی بنەڕەتی Redial و دووەمیان تۆڕی پەرسێپترۆنی فرە چینە، بۆ ئەوەی بزانین کامیان باشترین ڕێگایە بۆ پۆلێنکردنی نەخۆشییەکانی دڵ. داتاکان لە نەخۆشخانەی پسپۆڕی نەشتەرگەری سەنتەری دڵ لە شاری هەولێر کۆکراونەتەوە. قەبارەی بزاردە پێکهاتبوو لە (١٩٦) بزاردە لە نێوان ١ی ڕیبەندان ٢٠٠٦ تا ٣٠ی جۆزەردان ٢٠٢٣. هەمان پێوانە بەکارهێنراوە بۆ ئەنجامدانی داتاکان بۆ پۆلێنکردنی حاڵەتە تووشبووەکان وەک هەڵەی چوارگۆشەی ماماوەند (MSE) و هەڵەی ڕێژەی سەدی ڕەهای ماماوەند (MAPE) لە ئالوودەبووندا، تۆڕی ئەرکی بنەمای تیشکی (RBF) نزمترین بەهاکانی هەیە لە پێوانەکانی سەرەوە بۆ مۆدێلی تۆڕەکانی ڕاهێنان و تاقیکردنەوە و پێویستی بە کاتێکی کەمتر بوو بۆ کۆمەڵە داتاکانی ڕاهێنان. دەتوانێت پشت بەو تۆڕە ببەستێت چونکە کاریگەرییەکی زۆری هەیە لە پۆلێنکردنی کاریگەرییەکانی نەخۆشییەکانی دڵ شاری هەولێر.

وشە سەرەکییەکان: پۆلێنکردن ،تۆڕی دەمار، ئەرکی بنەڕەتی دووبارە پەیوەندیکردنە، تۆڕی پیرسێپترۆنی فرە چین وە ئە لگۆریتم

مقارنة نوعين من الشبكات العصبية لتصنيف تأثيرات أمراض القلب في مدينة أربيل

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المخلص
الهدف الرئيسي من هذا البحث هو مقارنة نوعين من الشبكات العصبية: شبكة دالة الأساس الشعاعية (Redial Basic Function) وشبكة المدرك متعدد الطبقات (Multilayer Perceptron Network) وذلك لتحديد أفضل طريقة للتصنيف أمراض القلب جُمعت البيانات في مستشفى الجراحة التخصصية – مركز القلب في مدينة أربيل، وبحجم عينة 196 مشاهدة، وذلك في الفترة من 1 يناير 2006 إلى0 3 أبريل 2023. في هذا البحث استخدمت بعض مقايس لتصنيف البيانات للحالات المصابين، مثل متوسط مربع الخطأ المطلقة للخطأ ، والنسبة المئوية للخطا المطلق تمتلك شبكة دالة الأساس الشعاعي أقل قيم للمقياسين (متوسط مربع الخطأ ، متوسط النسبة المئوية للخطا المطلق) في حالة التدريب وايضا يحتاج الى وقت أقل، يمكن اعتماد على هذه الشبكة لانها فعالة للتصنيف حالات تاثير أمراض القلب في مدينة أربيل.

الكلمات المفتاحية: تصنيف،الشبكة العصبية، شبكة دالة الأساس الشعاعي ، وشبكة بيرسيبترون متعددة الطبقات والخوارزميات