FERAS SENJAB

CRYOTHERAPY SUCCESS RATE OF WARTS TREATMENT USING MACHINE LEARNING NEU 2019

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
FERAS SENJAB

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Information Systems Engineering

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Approval of Director of Graduate School of

Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name Surname: Feras Senjab

Signature:

Date:

To my family...

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ABSTRACT

The present Master's thesis focuses on success of warts treatment with cryotherapy. Warts are ordinarily small in size, unpleasant, and hard developments that are comparative in color to whatever is left of the skin. They are caused by Human Papilloma Virus (HPV), basically the virus causes the growth and development of the warts in human bodies. The most common transmission of warts are in areas like feet, hands and genitals. It has different types which the usual ones are plantar and common warts. The virus is able to transmit to others via various ways like contact with patients, while the phase of children or adolescents and some vulnerable immune systems. There are multiple ways for treating warts which the most famous and recent one is cryotherapy. With improvement of technology and researches in medical, this study tried to develop and calculate the success rate of warts treatment with cryotherapy using Backpropagation, ANFIS, and NARX. The algorithms are trained with 90 patients record collected from Isfahan, Iran and downloaded from UCI repository website. The models have been evaluated with two evaluation matrixes namely Mean Squared Error and Root Mean Squared Error. The results showed that the ANFIS outperformed other two models and Backpropagation performed least among the three. The study although proved that the ANFIS can accurately predict the success rate of wart treatments with Cryotherapy.

Keywords: warts; cryotherapy; machine learning; artificial neural networks; backpropagation; ANFIS; NARX

ÖZET

Mevcut yüksek lisans tezi kriyoterapi ile siğil tedavisi başarısı üzerinde duruluyor. Siğiller normalde küçük, tatsız ve cildin kalanıyla renkli olarak karşılaştırılan sert gelişmelere sahiptir. Bunlara İnsan Papilloma Virüsü (HPV) neden olur, temel olarak virüs insan vücudundaki siğillerin büyümesine ve gelişmesine neden olur. Siğiller arasında en sık görülen bulaşma ayak, el ve cinsel organ gibi alanlardadır. Alışılmış olanların plantar ve yaygın siğiller olduğu farklı türleri vardır. Virüs, çocuklarla veya ergenler ve bazı hassas bağışıklık sistemlerinde, hastalarla temas gibi çeşitli yollarla başkalarına bulaşabilmektedir. Siğiller tedavisinde en ünlü ve en sonuncusu kriyoterapi olan birçok yöntem vardır. Tıpta teknoloji ve araştırmaların geliştirilmesiyle, bu çalışma Backpropagation, ANFIS ve NARX. kullanarak kriyoterapi ile siğil tedavisinin başarı oranını geliştirmeye ve hesaplamaya çalıştı. Algoritmalar, İsfahan, İran'dan toplanan ve UCI deposu web sitesinden indirilen 90 hasta kaydı ile eğitilmiştir. Modeller, Ortalama Karesel Hata ve Kök Ortalama Kare Hata olmak üzere iki değerlendirme matrisi ile değerlendirilmiştir. Sonuçlar, ANFIS'in diğer iki modelden daha iyi performans gösterdiğini ve Backpropagation'ın en az üçünde performans gösterdiğini gösterdi. Çalışma, ANFIS'in Kriyoterapi ile siğil tedavilerinin başarı oranını doğru bir şekilde tahmin edebileceğini kanıtlamasına rağmen.

Anahtar Kelimeler: siğiller; kriyoterapi; makine öğrenme; yapay sinir ağları; geriye yayılma; ANFIS; NARX

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
ANN	Artificial Neural Network
BPNN	Backpropagation Neural Networks
ANFIS	Adaptive neuro-fuzzy inference system
NARX	Nonlinear autoregressive exogenous
FS	Feature selection
GA	Genetic algorithm
RMSE	Root Mean Squared Error
MSE	Mean Squared Error
AI	Artificial Intelligence
HPV	Human Papilloma Virus

CHAPTER 1

INTRODUCTION

1.1 Background

Treatment of different diseases in medical is the main focus of scientific researchers, it is still an area which identify a broad range of studies to itself. Scholars, researchers and knowledgeable part of the society are always looking for new ways to treat confronted new and old diseases. In old ages most of the inventions in this field were based on experiments. They were intended to test everything to examine whether it is helpful for any treatment or not. A large part of these experiments were successful while there were some failed hypothesis as well. This process nowadays has changed completely. Experiments are being conducted on animals, on machines and different laboratory equipment's. the benefits are human safety which no one is at risk of his life while in the past the experiment might harm or even kill the first patient who treated by those new methods or drugs, and although with these machines and laboratories, the accuracy is very high that every properties of the drug or experiment is being monitored, it is very clear and accurate that would it cure the target illness or not. There is no danger and no one is at risk. Researchers would not test it on anybody until they are getting sure that the treatment would not harm the patients. Especially with the digital revolution and high speed computers which is processing millions of data records in a second.

This opportunity has brought many advantages which the medical community can use of them. They can collect millions of records from different hospitals and process them with huge various computer applications and algorithms to verify usefulness or harms or extract new findings that would have not been possible before without utilizing these computer applications.

Cryotherapy, literally refers to "Cold therapy" which is originally coming from two Greek words, cryo (κρύο) which means cold and therapy (θεραπεία) which means cure. It also sometimes called cryosurgery, is a method which the body placed to a very freezing and cold temperatures for a short time. It has been used for several purposes. The most common liquid

elements used in cryotherapy are nitrogen, oxygen and hydrogen. We can see an increase in using the technique to cure many disease. The most common disease which the technique used are removing many types of skin lesions, curing dysplastic precancerous tissue from the uterine cervix, and although for some of the prostate cancers which can be treated by this method. The success of the treatment is widely different from case to case, from one patient to another. Not to be forgotten that, it is possible to apply cryotherapy to a specific part of the body or to the whole body which is called body cryotherapy. It works well especially when there is an injury for reducing inflammation.

Since the topic is very large and has different aspects and effects, this study focuses on warts treatment. "Warts are the most common clinical manifestation of human papillomavirus (HPV) infection in skin and mucous membranes, mostly found in the hands, feet, face, and genitalia"(Khozeimeh et al, 2017; Rowson et al, 1967). To make the topic clear, it necessary to say: HPV is basically refers to a group of viruses. These viruses affects the human skin and mostly moist parts of the body. It is often called that there are more than 100 types of the HPV with 40 types of which affect the genital areas of the body both in men and women. These viruses spread in sexual intercourse which is caused direct contact of the skin to skin in those mentioned areas. Not to go far from the topic, warts are infections of these viruses in human's body.

There are various methods for treating the warts, they have been tested all along. These methods are intralesional injection of bleomycin, rubella (MMR) antigens, topical caustic acid, cryotherapy, measles, laser ablation, electrocautery, surgical removal, Candida albicans (C. albicans), purified protein derivatives (PPD), and mumps (Gibbs et al, 2002).

Notwithstanding the different modalities, there is still no single affirmed technique for the treatment of non-genital skin warts. Watchful waiting is additionally considered as an elective treatment of new warts. A large number of these injuries enhance unexpectedly; be that as it may, most patients still look for treatment because of the social disgrace or restorative reasons. In a perfect world, the treatment ought to be straightforward and cheap with minimal plausibility of undesired side effects. The present proof backings the adequacy of sali-cylic acid which acts gradually and needs repetitive use, even up to 12 weeks (Van Huijsduijnen et al, 1986).

Then again, cryotherapy with liquid nitrogen is a good and elective treatment in many patients, bringing about the treatment of up to 50–70% of lesions after three or four sessions (Godley et al, 1987). Intralesional immunotherapy is another present treatment that helps the insusceptible framework to perceive the candida antigen by means of the delay hypersensitivity response and accordingly removing the HPV. Candida skin test antigen is utilized as an immune modulator in this technique (Silverberg et al, 2000; Maronn et al, 2008). Expensive medicines are likewise accessible for resistant warts, which are given by numerous dermatology clinics (Russell et al, 2010).

Considering the above issues, for warts treatment the cryotherapy will examined to prove whether the method is fair enough to cure the patients or not. If so, how much is the success rate of the previous experiments.

Examining these topics getting more necessary by rising new advance technologies in computer industry. Super computers and new algorithms can efficiently process the data and extract new information which will help us decide which method to use for our treatment. The most common area of these type of technology is generally Artificial Intelligence (AI) and especially Machine Learning (ML).

Researchers tried to develop different ML systems to efficiently work on the records of the treatments to prove whether the method is able to cure the patient or not. This analysis is conducted based on previous data recorded from patients. Using the past data the system would be able to predict whether the method can treat the new patient or we have to test other methods.

The aim of this study is to predict whether the cryotherapy is able to cure the patient or not. Three ML models will be deployed to do the prediction task in a comparison way. The best model will also be suggested with conducted experiments. These models are Backpropagation, Adaptive Neuro Fuzzy Inference System (ANFIS), and Nonlinear Autoregressive Exogenous (NARX). The futures or attributes that are used in this study are sex, age, No of times, No of warts, type, area, and result of treatment.

1.2 The problem

There is a huge rise in some old and new diseases around the world. These illnesses are the result of many new civilization rules and accidents. They are happening all around the world while it claims that most of them are non-preventable at the moment. In the other hand, in medical industry experts are trying to find new ways of treatments. Related to the topic sexual relations are getting more common in societies, there are more sexual relation further that spouse relations more than ever before. These relations in societies spread many disease including warts, HIV, HPV, cancer etc. Warts are one of these common explored illnesses. For treating warts there are many solutions including immunotherapy, cryotherapy etc.

Cryotherapy has been tested broadly for treating warts, what is not clear is that, how we could understand the success rate of warts treatment via cryotherapy. Huge development in technology industry and especially ML enables us to predict the success rate and to whether the cryotherapy is able to cure this illness or not.

Therefore, ML technologies need to be utilized to estimate the treatment success rate using patient's data which is stored in the past. This has not been yet tested with many ML algorithms to verify the hypothesis and to prove it works fairly or not.

1.3 Aim of the Study

In order to predict the success rate and the flexibility of warts treatment using cryotherapy, ML algorithms being trained and used to verify whether the treatment will be succeed or not. Using the literature review many ML algorithms selected for predicting the task. Mostly the neural network algorithms are suggested, as they are hugely being used in every industry especially with upcoming deep learning technology. Therefore, neural network models alongside with fuzzy logic and others are used for forecasting our treatment. The models and algorithms used in this research are:

- Backpropagation
- Adaptive Neuro Fuzzy Inference System (ANFIS)
- Nonlinear Autoregressive Exogenous (NARX)

As each ML algorithm needs data to train in order to predict the new of future data, these algorithms need cryotherapy treated patients records. These records should be included success and failures as it is in real world. For this purpose a dataset from UCI Repository which is the record of these patients are collected from a hospital in Isfahan, Iran. The dataset is included the record of 90 patients which treated by cryotherapy.

Therefore, this is study aims to predict the cryotherapy treatment using three neural network models. The study will train and test these three models in a comparative way and will suggest the best model among the selected models.

1.4 Significance of the study

The spread of vast varieties of diseases are concerning the world. They harm human beings all around the world. In some cases it leads to death of millions of people. These diseases are many in numbers from cancer to heart attacks to brain illnesses etc. Medical society, researchers, experts, and technology experts are trying to create or find efficient ways of treating these diseases. Sometimes there are different options for curing a disease, it is crucial to efficiently examine which technique is more efficient for treating a specific one.

In the other hand, we see a rapid development in technology industry which is being utilized almost in all areas. You can see people use technology in every section of their lives. Mostly, scientific, business and medical fields are full of technology components which creates different opportunities and made the tasks much efficient and easy. For instance, ML is being used in all sections where there is data. Since we live in a digitized era, the data availability is an opportunity which makes us able to test ML tools and examine their effeteness in prediction tasks.

Based what has mentioned, while we have both tools like ML algorithms and the useful data which we can train them by. In the other hand, there is a necessary need for that, it is a good help to use these tools and data to make the process of treatment efficient and easy.

Therefore, if we can predict whether the cryotherapy can cure the warts in a patient, it would be a great achievement which helps the doctors to decide whether to use this technique or not. While at the same time, it would be great for patients because first, they will not suffer from

extra treatments and methods and one technique will help them to overcome their illness. Second, they will not spend that much money for the treatment. It will ensure them whether the cryotherapy is able to cure their disease or not.

Putting all these together, the study has a big impact on medical society especially for treating warts using cryotherapy.

1.5 The Limitations of the Study

Regardless of the fact that this study reaches to its objectives, it would have been increasingly precise and right if the dataset has more records than 90 patients, because as much as we provide more data with different properties, the result and accuracy for our algorithms will increase. An increase to the number of records and observations in the dataset would be a good help for the accuracy of the models.

1.6 Overview of the Study

The study includes six chapters which are as follows:

Chapter 1: An insight to the topic which is cryotherapy and the diseases which can be cured via the technique is discussed at first. Some of the machine learning techniques with a brief introduction to ML algorithms are added. Furthermore, it describes the problem, aim of the study, significance of study, its limitations, and although an outline of the whole research is presented.

Chapter 2: A review conducted on what have been done in the topic which presents the related studies with their results are presented.

Chapter 3: The main topic is explored, where it is used, which kind of disease it can cure and how it helps doctors to treat patients.

Chapter 4: This chapter discusses the ML topic in details. The techniques, types and its philosophy is explored.

Chapter 5: Algorithms or models which are being used in this research is presented with their usage, advantages, and mathematical formulas. Although the results and outcome of the study is presented in details.

Chapter 6: The study is finalized, while the result is concluded with best model suggestion among the models.

CHAPTER 2

LITERATURE REVIEW

The cryotherapy achieved attention in medical researches, hospitals and doctors are trying to test it with various disease to evaluate and verify whether the method is working well or not in different illnesses. Among those disease, wart treatment is also tested extensively to find an optimized way of treating warts. Cryotherapy has shown somehow good result for curing warts in human body. Thus warts are treated in many hospitals and health care centers with cryotherapy. The result shown for successful and failed treatments in patients are negotiable, it has been shown a good result to some extent but there are other methods invented around the world via health area researchers and doctors which may outperform cryotherapy. Since the world is a world of proofs and evidence, researchers tried to find out which methods works well or in the other word can cure this disease efficiently. Or how much is the cure rate of this method in order to treat warts? What the experiments and previous patient records tells us? For this purpose, past records of patients who treated with this method need to be examined and Scrutiny to understand and evaluate the usefulness and assurance of the treatment.

Since the data for the patients who treated with cryotherapy is most likely available in hospitals, or at least if they want to take the data they can collect the data. Now if you are trying to work on the data, there tools and techniques that makes able to extract meanings from those data. As the technology rapidly growing, there are various tools and methods which can function on these data. The most important one among them are Machine Learning which is widely and rapidly used for extracting meaning from the data or use the data and understand it in order to predict the future. It has been used in different factors for prediction purposes. It uses the data for training an algorithm to make it able for predicting future or unseen data.

Therefore, ML researchers conducted few researches in this area. They tried to train algorithms with past data in order to understand whether the next patient with same properties will be cured with cryotherapy or not. How much would be the possibility of being cured with this method. Or they tried to compare this method with other methods. They developed and trained some algorithms to compare that which method is the best for treating the patient. Each of the

researchers suggested different methods some suggested fuzzy logic rule-based systems Khozeimeh et al, (2017) and some other methods. Thus the following is a review on the past researches that have been conducted in this regard.

Putra, Setiawan, & Wibirama, (2018) conducted a research on this field and examined and evaluated two methods which are cryotherapy and immunotherapy. The study selected two methods; one of them is strong learner and one of them is weak learner. The study aimed to identify the best method for wart treatment. Since there are many researches about the topic, they tried to review them and try to improve the accuracy and performance of the weak learner algorithms to propose an accurate model. Although to satisfy the patients with the methods of the treatment, they examined and evaluated the proposed model with 10-fold cross validation. The research selected the AdaBoost algorithm as strong learner while at the same time their focus was to select the weak learner which they considered Random Forest for this purpose. After implementing the improvement techniques the experiments results showed the accuracy of the models for both cryotherapy and immunotherapy which the accuracy was 96.6% for the cryotherapy and 91.1% for the immunotherapy. Not to be forgotten that both of the methods datasets contained 90 patients records from a clinic. While the cryotherapy contained 6 input features and one output but immunotherapy dataset contained 7 input features with one output. The dataset features of immunotherapy datasets is shown in details in table 2.1.

Table 2.1: Immunotherapy dataset features Putra, Setiawan, & Wibirama, (2018)

Attribute	Values	Mean ± SD
Gender	"1" = Male (41)	
	"0" = Female (49)	
Age (year)	Range between 15 and 56	31.04 ± 12.23
Time elapsed before treatment (month)	Range between 0 and 12	7.23 ± 3.10
Type of wart (count)	"1" = Common (47)	
	"2" = Plantar (22)	
	"3" = Both (21)	
Surface area of the warts (mm^2)	Range between 6 and 900	85.83 ± 131.73
The Number of warts	Range between 1 and 19	6.14 ± 4.2
Induration diameter of initial test(mm)	Range between 5 and 70	14.33 ± 17.22
Response to treatment	"1" = Yes (71)	
	"0" = No (19)	

Another research conducted by Akben, (2018) states that they continued previous researches on predicting success rate of the methods in wart treatment. It tried to improve the accuracy of findings and results of the researches that have conducted previously with the same goal. That being the case, easy interpretable fuzzy informative images created and although proposed to estimate and predict the success of two methods cryotherapy and immunotherapy methods on wart treatment. Decision trees method used to create fuzzy informative images.

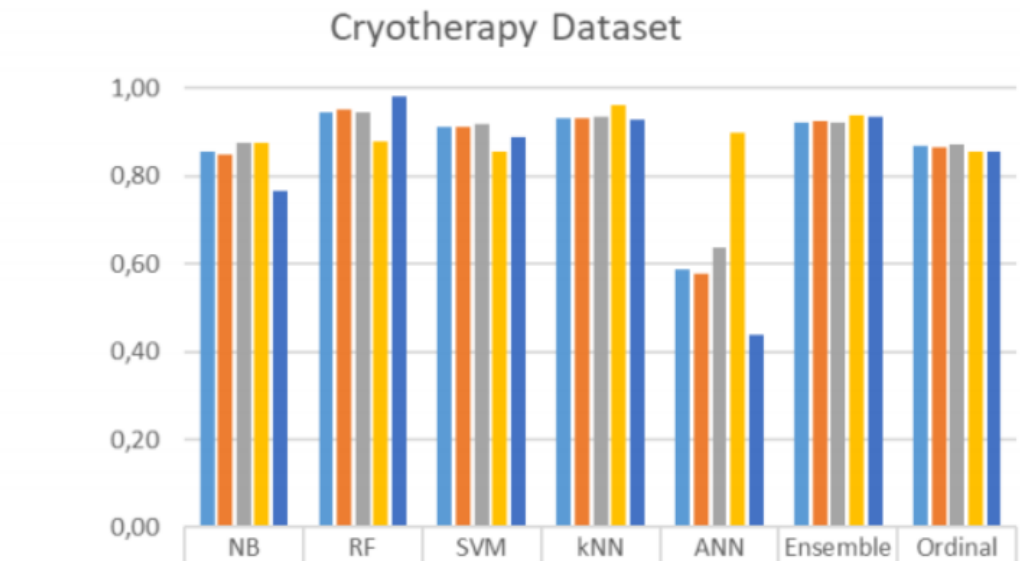
The experiments and results in this study showed that the accuracy for immunotherapy is 90% and for cryotherapy is 94.4%. The study claims that it performed better than the exact previous studies which the accuracy was higher than those studies. It says that accuracy improvement of 6.67% for immunotherapy and 13.74% for cryotherapy observed in experiments.

The author claims that decision trees algorithm and fuzzy informative images is so useful and accurate for wart treatment, it also can be used for other prediction in medical treatment. For instance, it can perform well in dermatological treatments using means of both side attributes from patient to disease. This study also says that the performance may improve in case of using hybrid classification methods which includes decision trees.

According to CÜvitoğlu & Işik, (2018), some machine learning algorithms can predict the wart treatment rates. The study claims that some treatments take long time and some of the warts get

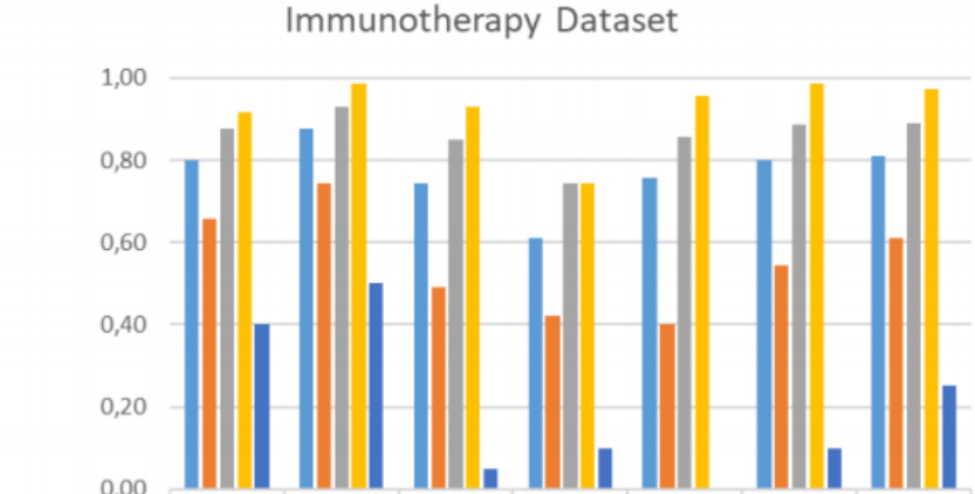
infectious thus selecting an appropriate treatment method is essential for patients. Therefore, the study choose several ML approaches to find appropriate treatment method among cryotherapy and immunotherapy. ML algorithms used in this research are namely k Nearest Neighbor (kNN), Naïve Bayes (NB), Support Vector Machine (SVM), Random Forest (RF), and Artificial Neural Network (ANN). At the meantime, dimensionality reduction and feature selection techniques applied for improving the success rate.

Basically, all the mentioned algorithms have been tested with two datasets which are cryotherapy and immunotherapy. The result is presented in a comparative manner to identify the best model and the best method as well. Some techniques used to handle the unbalanced sample classes for the data. The mentioned models gave a promising result but Random Forest (RF) achieved 95% accuracy, 98% specificity, and 88% sensitivity. The other method results are also close to RF. The comparative result of this study shown in Figures.



	NB	RF	SVM	kNN	ANN	Ensemble	Ordinal
Accuracy	0,86	0,95	0,91	0,93	0,59	0,92	0,87
AUC	0,85	0,95	0,91	0,93	0,58	0,93	0,87
F1-Measure	0,88	0,94	0,92	0,94	0,64	0,92	0,87
Sensitivity	0,88	0,88	0,86	0,96	0,90	0,94	0,86
Specificity	0,77	0,98	0,89	0,93	0,44	0,94	0,86

Figure 2.1: ML model results for two datasets CÜvitoğlu & Işik, (2018)



	NB	RF	SVM	kNN	ANN	Ensemble	Ordinal
Accuracy	0,80	0,88	0,74	0,61	0,76	0,80	0,81
AUC	0,66	0,74	0,49	0,42	0,40	0,54	0,61
F1-Measure	0,88	0,93	0,85	0,74	0,86	0,89	0,89
Sensitivity	0,92	0,99	0,93	0,74	0,96	0,99	0,97
Specificity	0,40	0,50	0,05	0,10	0,00	0,10	0,25

Figure 2.2: ML model results for two datasets CÜvitoğlu & Işik, (2018)

In another study by Khozeimeh et al., (2017) which is the original study that has been mentioned in previous research reviewed. The study covers two types of warts (common & plantar) with same exact two methods that has been mentioned many times. The study examined based on 180 patients data which is collected from Ghaem Hospital, Mashhad, Iran. Basically, 90 patients treated with cryotherapy and 90 patients treated with immunotherapy. The ML method selection was randomly, though, the study used fuzzy logic rule-based system for predicting the responses of the treatment. The result of the prediction and assessment showed 83.33% for immunotherapy and 80.7% for cryotherapy.

The study by DEGIRMENCI & KARAL, (2018) states that Support Victor Machine (SVM) is working well with classification problems. Therefore, the study focused on predicting the treatment method for warts. It also tested two datasets for the two most famous treatment methods; cryotherapy and immunotherapy. The study highly focused on SVM kernels and parameters which they wanted best result possible. Kernels used in this research are RBF, Sigmoid, Linear, and Polynomial. The experiments are conducted with four kernels and various

values for parameters. These results showed 93.11% accuracy in cryotherapy but with radial basis function (RBF) with parameters ($C=2^{6}$, $\sigma=2^{-9}$) while for immunotherapy the accuracy of 81.33% is achieved with linear kernel and parameter of ($C=2^{-2}$) with 90 patients in each method. Study claims that the parameter values and kernel type have high impacts on accuracy and performance of the models. Table 2.2 shows the parameter values and differences of the performance.

Table 2.2: kernel types and parameter values DEGIRMENCI & KARAL, (2018)

a) RBF

	$C = 2^3$	$C = 2^4$	$C = 2^5$	$C = 2^6$	$C = 2^7$	$C = 2^8$	$C = 2^9$	$C = 2^{10}$	$C = 2^{11}$
$\sigma = 2^0$	60,444	61,111	59,778	60,444	60,222	61,111	61,111	61,333	61,333
$\sigma = 2^1$	75,222	76,333	76,111	77,333	76,000	76,556	76,444	75,889	75,444
$\sigma = 2^2$	87,222	88,667	88,111	88,222	88,333	88,889	88,778	88,667	87,778
$\sigma = 2^3$	91,444	91,556	91,778	92,111	91,111	91,778	91,111	91,889	91,444
$\sigma = 2^4$	89,333	92,556	92,222	92,667	91,333	92,111	**93,111**	92,000	91,889
$\sigma = 2^5$	86,667	89,667	89,778	89,556	91,444	92,111	91,778	91,333	91,111

b) Sigmoid

	$C = 2^{-4}$	$C = 2^{-3}$	$C = 2^{-2}$	$C = 2^{-1}$	$C = 2^0$	$C = 2^1$	$C = 2^2$	$C = 2^3$
$\sigma = 2^{-10}$	53,333	**56,444**	50,556	48,889	42,667	39,444	37,556	37,556
$\sigma = 2^{-9}$	53,333	47,222	50,000	46,000	43,667	41,444	38,444	37,333
$\sigma = 2^{-8}$	53,333	53,333	49,444	45,667	46,667	42,000	41,444	40,667
$\sigma = 2^{-7}$	53,333	53,333	53,333	53,333	53,222	47,667	47,222	46,111
$\sigma = 2^{-6}$	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333
$\sigma = 2^{-5}$	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333

c) Linear

$C = 2^{-4}$	$C = 2^{-3}$	$C = 2^{-2}$	$C = 2^{-1}$	$C = 2^0$	$C = 2^1$	$C = 2^2$	$C = 2^3$	$C = 2^4$	$C = 2^5$
86,778	86,111	**88,222**	86,556	86,556	85,889	85,889	85,556	86,667	86

d) Polynomial

	$C = 2^1$	$C = 2^2$	$C = 2^3$	$C = 2^4$	$C = 2^5$	$C = 2^6$	$C = 2^7$	$C = 2^8$	$C = 2^9$
2	62,556	62,333	61,667	62,889	**64,556**	62,889	62,000	63,000	61,444
3	54,222	56,222	56,111	54,222	55,667	54,889	54,667	56,222	54,111
4	48,556	46,000	45,778	47,778	46,333	46,889	46,111	47,000	47,111
6	55,333	54,000	55,778	54,222	54,556	56,111	56,778	56,000	56,444
8	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333
10	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333	53,333

Another study conducted by Khatri, Arora, & Kumar, (2018) in order to distinguish the perfect treatment strategy for both specific plantar and ordinary warts, among immunotherapy and cryotherapy treatment techniques. Ramifications of machine learning systems are presently assuming an indispensable job explicitly in clinical determination toward distinguishing distinctive clinical examples, disease classification and its expectations. In that study, work creators have executed classifiers like Bayes Net, SVM, Multi-Layer Perceptron, k-NN, FURIA, Random Forest with the assistance of WEKA tool. The experimentation has been performed on informational datasets downloaded from UCI Machine Learning Repositories. The experimentation was performed with aggregate 180 patient examples having warts sickness present in immunotherapy and cryotherapy datasets separately. The outcome results have been talked about and contrasted and existing techniques referenced in the writing. It was seen that the decision tree based classifier random forest is having the best classification accuracy among the picked set of classifiers. The outcome indicated most accurate result on the off chance that random forest, 86% and 93% was noted for immunotherapy and cryotherapy treatment method datasets.

CHAPTER 3

WART TREATMENT

3.1 Introduction to the Warts

By growing and spreading many viruses in this century around the world, a virus which afoul human beings vastly is Human Papilloma Virus (HPV). This virus is getting common among people increasingly. Most HPV contaminations cause no indications and resolve spontaneously Garland et al., (2016). In a few people, a HPV disease continues and results in warts or precancerous lesions Ljubojevic & Skerlev, (2014). The precancerous injuries increment the danger of cancer growth of the cervix, vulva, vagina, penis, rear-end, mouth, or throat Ljubojevic & Skerlev, (2014). Nearly all cervical disease is expected to HPV with two kinds, HPV16 and HPV18, representing 70% of cases Garland et al., (2016). Between 60% and 90% of alternate tumors referenced above are additionally connected to HPV Gottlieb, (2018). HPV6 and HPV11 are normal reasons for genital warts and laryngeal papillomatosis Garland et al., (2016).

Warts are caused by this HPV virus, basically the virus causes the growth and development of the warts in human bodies. The most common transmission of warts are in areas like feet, hands and genitals. It has different types which the usual ones are plantar and normal warts. The virus is able to transmit to others via various ways like contact with patients, while the phase of children or adolescents and some vulnerable immune systems Bavinck, Eekhof, & Bruggink, (2011), Loo, & Tang, (2009).

Warts are ordinarily small in sized, unpleasant, and hard developments that are comparative in color to whatever is left of the skin. They commonly don't result in different manifestations, with the exception of when on the downside of the feet where they might be painful. While they for the most part happen on the hands and feet they can likewise influence other locations. One or numerous Warts may appear. They are not malignant Silva et al, (2016).

Without treatment, common sorts of warts cure in months to years. Various medications may speed goals including salicylic acid connected to the skin and cryotherapy. In the individuals

who are generally solid they don't regularly result in noteworthy problems. Treatment of genital warts varies from that of different kinds Silva et al, (2016). By the way, the density of the warts in all parts of the body is different. Sometimes they are very tiny, small and mangable to deal with but sometimes they are very big, painful and too awful in looks and shapes which makes the people so nervous and weak. An example of regular warts is shown in Figure 3.1.

Figure 3.1 : warts sample on hands (discovercbd.com, 2019)

3.2 Wart Types

Multiple types of warts have been identified till now. These range of warts are variant in size, shape and sites which they occur. As it is briefly mentioned before it can occur on hands, feet, and genitals or sometimes in other parts of the body but rarely. The identified wart types are as follows:

Common Warts: these warts are producing by HPV types 2 and 4 which are really vast; other types are 1, 3, 26, 29 and 57.

Genital dysplasia and Cancers: some HPV types have high risk, they are accompanied by cancers like cervical, vulvar, vaginal, penile and anal caners. It also has some low risk cancers like oropharyngeal etc.

Plantar Warts: these warts are from HPV types 1, 2, 3, 4, 27, 28, 58.

Anogenital Warts: also called venereal or condylomata acuminate warts which are from HPV types 6, 11, 42, 44, 13, 44, 43, 72 etc.

Verruca Plana (Flat Warts): HPV types 3, 10 and 28.

Butcher's Warts: HPV type 7.

Heck's disease (Focal epithelial hyperplasia): HPV types 13 and 32.

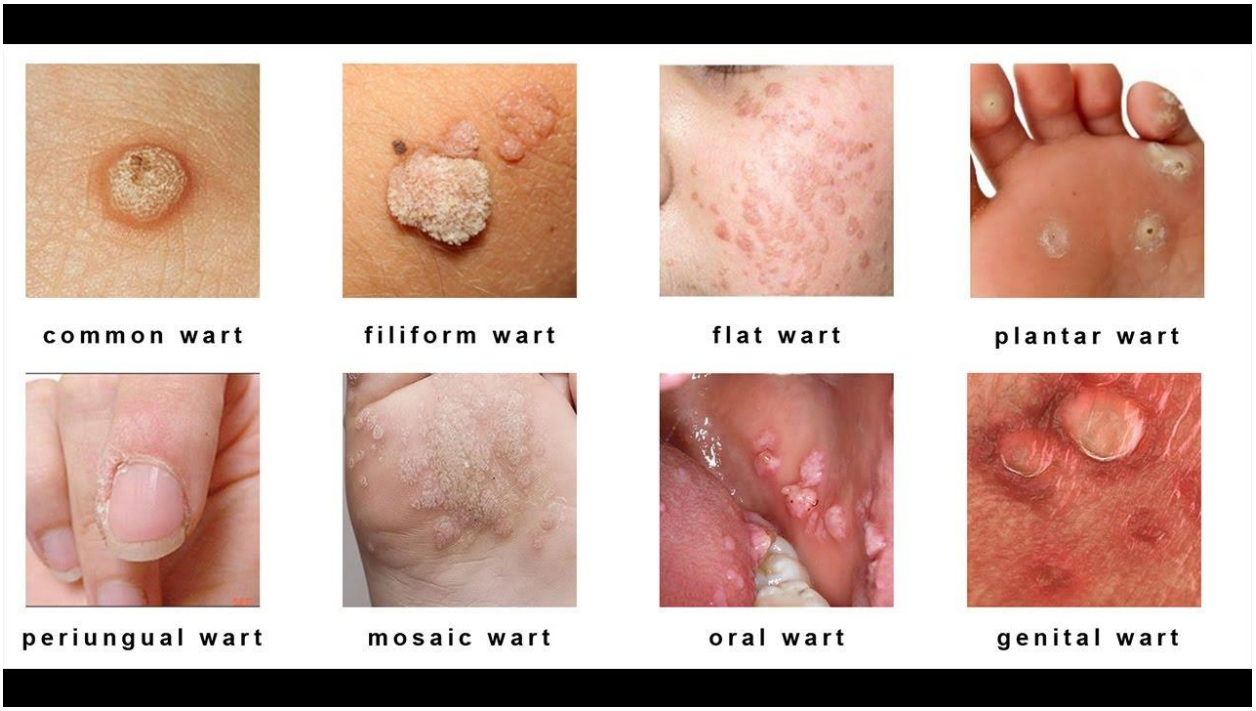


Figure 3.2: Wart types in different parts of the body

3.3 Medications

This disease has become common among the people. Researchers and medical experts are trying to find and test different medications to cure this disease. There are a lot of suggested medications that are tested and used for curing the warts. The well-known medications which have been suggested are listed as follows:

- Salicylic acid
- Imiquimod
- Cantharidin
- Bleomycin
- Dinitrochlorobenzene
- Cidofovir
- Benzoyl peroxide

3.4 Warts Treatment Methods

Experiments and doctors suggested many treatment methods based on the type of warts, area affected and other factors. Most common warts leave without treatment, however it might take a year or two and new ones may grow close-by. A few people have their warts treated by a specialist since home treatment is not working and the warts are troublesome, spreading or a corrective concern.

The objectives of treatment are to annihilate the wart, animate an immune system reaction to battle the infection, or both. Treatment may take weeks or months. Indeed, even with treatment, moles will in general repeat or spread. Specialists for the most part begin with the slightest difficult techniques, particularly while treating youthful kids.

Your doctor may recommend one of the accompanying methodologies, in light of the area of your warts, your side effects and your preferences. These strategies are now and again utilized in mix with home medications, for example, salicylic acid. Well know treatment methods are listed below:

Stronger peeling medicine (salicylic acid): Solution quality wart prescriptions with salicylic acid work by removing layers of a wart a bit at any given moment. Studies demonstrate that salicylic acid is progressively viable when joined with Freezing.

Freezing (cryotherapy): Cryotherapy treatment done at a doctor's office includes applying fluid nitrogen to your wart. Freezing works by making a rankle frame under and around your wart. At that point, the dead tissue bogs off inside a week or somewhere in the vicinity. This strategy may likewise invigorate your immune system to battle viral warts. You will likely need to repeat the procedure.

Different acids: On the off chance that salicylic acid or cryotherapy is not working, your doctor may attempt trichloroacetic acid. With this technique, the specialist first shaves the surface of the wart and afterward applies the corrosive with a wooden toothpick. It requires rehash treatment consistently. Side effects are consuming and stinging.

Minor surgery: Your doctor can remove the vexatious tissue. It might leave a scar in the treated zone.

Laser treatment: Pulsed-dye laser treatment burns (sears) little veins. The contaminated tissue in the end bites the dust, and the wart tumbles off. The proof for the adequacy of this technique is restricted, and it can cause torment and scarring.

Infrared coagulator: an exceptional wellspring of infrared light in a little pillar like a laser. This works basically on indistinguishable standard from laser treatment. It is more affordable. Like the laser, it can cause rankling torment and scarring.

Intralesional immunotherapy: with cleansed candida, MMR, and tuberculin (PPD) protein seems safe and successful.

Duct tape occlusion therapy: includes putting a bit of pipe tape over the wart. The component of activity of this method still stays obscure. In spite of a few clinical preliminaries, proof for the viability of pipe tape treatment is inconclusive. Despite the blended proof for adequacy, the effortlessness of the strategy and its constrained symptoms drives a few analysts to be hesitant to reject it.

3.5 Cryotherapy

Cryotherapy began in Japan in 1978, it was presented as a treatment alternative for those with genuine instances of rheumatoid joint inflammation, aggravation and muscle recuperation. Because of its abnormal state of accomplishment it rapidly spread to Europe being a staple for coaches, competitors, and physical specialists. Today, it has spread over to the United States, and is utilized by various games groups, chiropractors, and physical specialists to treat muscle hurts, increment recuperation time, recoup from medical procedures, and lessen torment.

Cryotherapy, once in a while known as cold therapy, is the neighborhood or general utilization of low temperatures in restorative treatment. Cryotherapy might be utilized to treat an assortment of tissue lesions. The most unmistakable utilization of the term alludes to the careful treatment, explicitly known as cryosurgery or cryoablation. Cryosurgery is the utilization of to a great degree low temperatures to obliterate anomalous or unhealthy tissue and is utilized most usually to treat skin conditions.

Cryotherapy is utilized with an end goal to mitigate muscle agony, sprains and swelling after delicate tissue harm or medical procedure. It tends to be a scope of medicines from the use of ice packs or submersion in ice showers (for the most part known as cool treatment), to the utilization of cold chambers.

While cryotherapy is generally utilized, there is little proof as to its viability that has been imitated or appeared substantial controlled investigations. Its long side effects have additionally not been considered.

But in cryotherapy for warts, most specialists utilize liquid nitrogen, which can achieve temperatures as low as - 320 F to freeze off the wart. Your specialist may shave off dead skin on the wart region with a cutting edge before doing the cryosurgery.

The specialist will utilize either a cotton swab or a splash "cryogun" to apply liquid nitrogen to the wart and a portion of the skin around it. This may feel like an ice cube touching the skin, however it just endures a couple of moments. The skin may feel numb quickly and may likewise hurt, turn red, at that point shape rankle.

Figure 3.3: Cryosurgery for wart treatment with its special purpose machine

On the off chance that the wart is on the forehead or sanctuary, liquid nitrogen may give a headache. When you leave your specialist's office, you ought to have the capacity to come back to your normal daily schedule, including showering and washing. The region normally should not get contaminated, however watch for indications of it, similar to redness or swelling.

In the long run, a scab will shape where the liquid nitrogen was connected. That will tumble off about seven days after the fact. Make an effort not to pick at it before it's prepared to tumble off.

Some specialists may request to do some readiness at home, for example, applying salicylic acid, another basic wart treatment, to the wart. They will give you guidelines in the event that they need you to do. An example of treating a wart by cryotherapy or cryosurgery is represented clearly with its machine and equipment’s in Figure 3.3.

3.6 Curing Other Illnesses and Side Effects

Cryotherapy can be conveyed to only one area, or you can decide on entire body cryotherapy. Limited cryotherapy can be directed in various routes, including through ice packs, ice massage, coolant sprays, ice baths, and even through tests regulated into tissue.

The hypothesis for entire body cryotherapy (WBC) is that by drenching the body in to a great degree cool air for a few minutes, you could get various medical advantages. The individual will remain in an encased load or a little fenced in area that encompasses their body yet has an opening for their head at the best. The fenced in area will drop to between negative 200– 300°F. They'll remain in the ultra-low temperature air for somewhere in the range of two and four minutes.

You can get profits by only one session of cryotherapy, yet its best when utilized frequently. A few competitors use cryotherapy two times per day. Others will go day by day for 10 days and afterward once per month a short time later.

Cryotherapy claims to has other benefits like Reducing migraine symptoms, Numbs nerve irritation, Helps treat mood disorders, Reduces arthritic pain, may help treat low-risk tumors, may help prevent dementia and Alzheimer’s disease, and Treats atopic dermatitis and other skin conditions. While at the meantime it has some side effects which need to be discovered more. Not to be forgotten that these effects are generally from the cryotherapy especially the whole body cryotherapy, because the warts cryotherapy which is mostly in a specific and small area may not have these site effects or the density is not that much. A few of the side effects are mentioned below:

- While cryotherapy can lessen undesirable pain and nerve irritation, it some of the time can leave the tissue influenced with unordinary sensations, for example, deadness or shivering.
- Cryotherapy can cause redness and irritation of the skin. Be that as it may, these impacts are commonly temporary.
- In the event that a confined cold pack or ice is left on the skin excessively long, it can cause integumentary harm (counting frostbite in extraordinary cases). In this manner,

confined cold therapy ought to never be conducted longer than 30 minutes, and the skin honesty ought to be checked during treatment.

- Entire body cryotherapy ought not to surpass five minutes (normal treatment sessions are a few minutes). Entire body cryotherapy causes diminished pulse, expanded circulatory strain, and brought down breath. The patient's crucial signs and demeanor ought to be checked previously, amid, and after treatment. Oxygen levels inside the chamber ought to likewise be checked.
- The patient ought to guarantee that all attire and skin are totally dry while venturing into a cryotherapy chamber. Additionally, metal or gems ought to be evacuated. Last, touchy body parts ought to be secured with a facemask, ear muffs, gloves, and socks or shoes. Consuming of the skin or frostbite can happen when a patient does not pursue legitimate convention when entering a cryotherapy chamber.

CHAPTER 4

MACHINE LEARNING TECHNOLOGIES

4.1 Introduction to machine learning

ML raised out of Artificial Intelligence. There was the only way is realization to be able to achieve these tasks was to allow machine learn from itself. The machine learning similar to child that is learning from its self continuously. So, as new capability the machine learning was developed. Finding model suitable in data on planet is possible only for our brains. Data going huger by time, the time is increasing to process that much huge data, and because of that the ML comes into impact and act, helping people with that huge amount of data with minimal time. Now ML is actual and the present in many sections of technologies, and we don't even realize it while using it.

4.1.1 Artificial neural network

ANN is based on human brain structure and relatively crude electronic models. The human brain basically learns from experience and so the neural network structure. Although, some problems that are behind the scope of actual computers are actually fixable by little energy. The human brains modelling is also do with less technical way to have system more accurate and efficient solution. The research shows of the biological research that human brain store information as patterns (Hawkins, J., & Blakeslee, S.2007). There are also some complicated patterns that give us the ability the recognizing faces from a lot of different angels. This operates and process start saving the information, using those patterns. Then solving the problems encompasses a new section in computing. It became the major part of artificial intelligence. Due the first arrive of the neural network back propagation, which allow us to modify the network hidden layer of neurons, when the result doesn't correspond with what we waiting for. Also, there is another advance of AI neural network that is extracting features until it can recognize what we are looking for.

4.1.1.1 Multi-layer perceptron model

MLP is feed forward model which can take the inputs data parameters linked with their weight to predict the output data. Which weight is basically is group of numbers that connect with the

input data to contribute to a different degree. The output can be determined by checking the weight, if the weight more than some certain threshold set by the model. So, if its greater that assigns it as 1, otherwise it will be 0. Training and learning in NN is searching for a set of values in the data for weights so that model can accurately map patterns input to their particular output (Schmidhuber, 2015). The ANN has two layers one is the input layer and the second is the output layer and the hidden layer in the middle of the input and output layers who can process the data. Each layer process the data by forwards, each layer process result to the next hidden layer, and finally after processing the result can be gained from the output layer (Yegnanarayana, 2009).

4.1.1.2 Structure of ANN

In the structure of NN we have 3 layers with number of neurons and they are coordinated in series of layers.

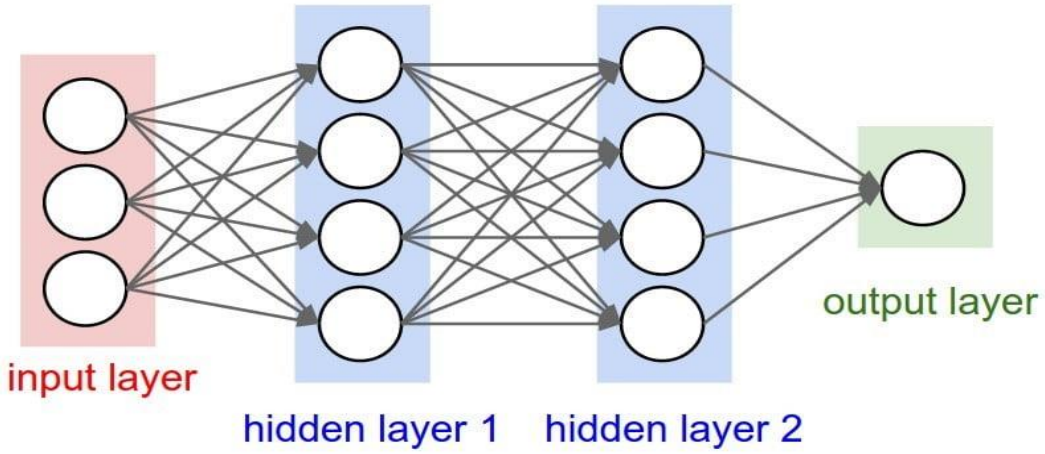


Figure 4.1: Multi-Layer Perceptron Feed Forward NN (Ahn, 2017)

INPUT LAYER First layer of neural network structure that takes inputs data for processing. So, it's the input layer.

HIDDEN LAYER the second layer of neural network structure that take the input data from the input layer (previous layer) for processing through neurons. Weight should always update to the data for accurate output.

OUTPUT LAYER the third layer of neural network structure. That process data to gain output data. Which is the result layer.

4.1.1.3 Weights

In Artificial Neural Network architecture, the network memory saves the information to gain the desired results. Through training, testing and validation the weight are modified in every step so the output network accuracy is gained; also, its store the information for a future processes.

4.1.1.4 Feedforward NN

The deep feedforward networks, it's called feedforward NN, or (MLPs) multilayer perceptron's, are essential deep learning model. The aim of this system is to approximate some function f*. For example, for a classifier, $y = f^*(x)$ explain input x to a category y. the system defines a $y = f(x;\theta)$ and learns value of the elements θ that output in the best accurate function approximation.

They call the models feedforward because the data go through function being rated from (x), by the average calculation used to define (f), lastly to output (y). The outputs of the model are fed back into oneself, which means there are no feedback connections in. They called recurrent neural networks for extended feedforward neural networks to include feedback connections.

4.1.1.5 Backpropagation algorithm

Backpropagation usually referred to as reverse mode differential, BPNN is the most openly applied algorithm for adjusting the artificial NN elements. In Backpropagation process, the adjusting is set and the data is given to the artificial NN network. BPNN has two types forward-pass and backward-pass. For the forward-pass, the dataset is given through the network, the presenting result of data mostly output incorrect result that is handled by the loss function, the results are then recover from output layer and transmit back to input layer known as the backward-pass to do operates again. By its processing that, the weight are modified to decrease

error among the goal output and the gained output by training the network (McGonagle et al., 2017). Successful backpropagation model the inputs to outputs should be a smooth mapping which should be explained by the internal attributes. The equation below shows the cost function for BPNN network, loss function binary cross-entropy (BCE).

$$BCE = -\frac{1}{N}\sum_{i=1}^{N} y_i log\big(h_\theta(x_i)\big) + (1-y_i) log\big(1-h_\theta(x_i)\big) \quad 4.1$$

When assumed that outputs layer is transformed using sigmoid activation function, with the binary classification the binary cross entropy loss function is used.

We can say the set of target outputs label 0 and 1, the network is trained tested to maximize the log conditional probability within every given sample x and y.

4.1.1.6 Neural Network nonlinear autoregressive exogenous (NARX)

From Autoregressive with Exogenous Inputs network the NARX model established. The NARX is a recurrent dynamic and nonlinear network. NARX is effective in gaining output precise results. it is a feedback by neural network. The gradient descent is obtained accurately with NARX. For learning with gradient algorithm NARX is the best.

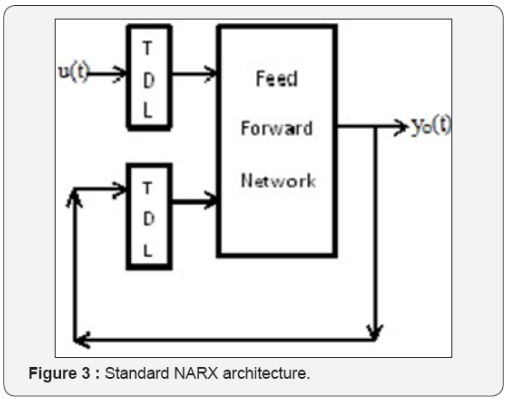


Figure 3 : Standard NARX architecture.

Figure 4.2: Architecture of NARX neural network (Abdullah, Nabilah, & Khamis, 2014)

$$y(t+1) = f[y(t),...,x(t-d_y+1); u(t-k), u(t-k-1),..., u(t-k-d_u+1)]. \quad 4.2$$

The above equation 4.4 clarify the algebraic expression of NARX

As above equation 4.5 clarify the NARX equation in the vector form that can be written

NARX is popular in recognizing and identification tasks. The forecasts are also be made efficiently by using the NARX models. This model uses feedback connections in the various layers of the system to increase the accuracy (Khamis, Nabilah, & Abdullah, 2014).

4.1.2 ANFIS

ANFIS is an adaptive neuro fuzzy, which is multilayer feedforward network, it utilize fuzzy logic to map an inputs spaces to an outputs spaces and it's also uses algorithm of NN machine learning. It has ability to merge verbal's power of fuzzy network with numeric power of the NN, ANFIS is powerful in modelling numerous operations and processes, like diagnosis and motor fault detection, and power systems.

ANFIS operations have perfect ability of learning, expensing, classifying data and constructing. ANFIS has advantages of authorize the extraction of fuzzy rules from numerical data or experienced knowledge and adaptively structure the rule base. Although, it can control complex transformation of people intelligence to fuzzy network. The biggest obstacle of ANFIS forecasting network is the long time that can take for training testing and checking structure and detecting attributes, detecting is taking a lot of time. Fuzzy under consideration for simple the fuzzy systems have x, y and z which x and y are inputs, y is an output. The top order of Sugeno fuzzy, a typical rule set with if–then rules and it shown below (Wahyuni, Mahmudy. & Iriany. 2017).

$$\begin{aligned} &\text{Rule 1: If } x \text{ is } A_1 \text{ and } y \text{ is } B_1 \text{ then } z_1 = p_1 * x + q_1 * y + r_1 \\ &\text{Rule 2: If } x \text{ is } A_2 \text{ and } y \text{ is } B_2 \text{ then } z_2 = p_2 * x + q_2 * y + r_2 \end{aligned} \quad 4.3$$

$$y(t+1) = f[y(t); \boldsymbol{u}(t)].$$

4.1.2.1 ANFIS architecture

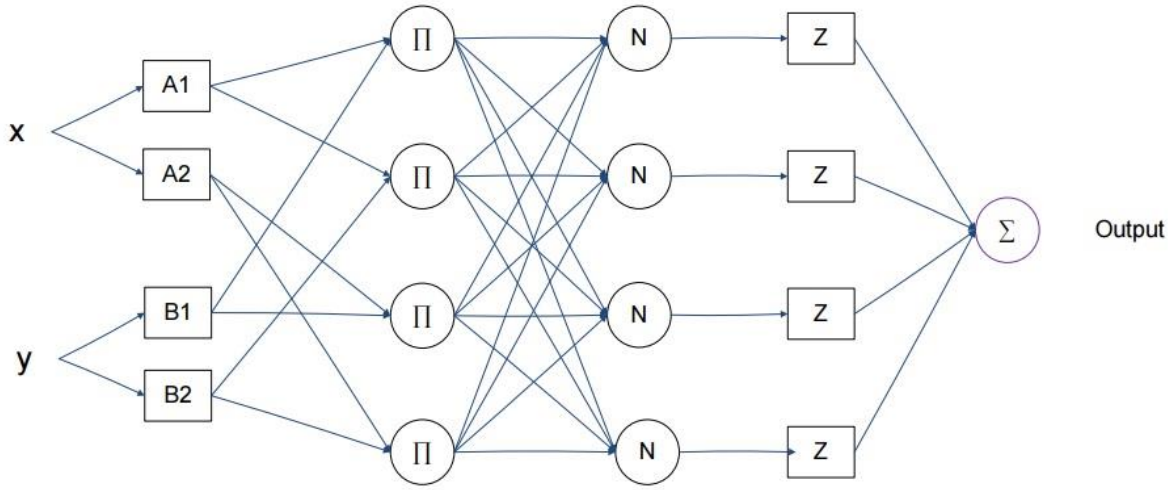


Figure 4.3: The architecture with x and y Input Parameter (Wahyuni, Mahmudy, & Iriany, 2017)

4.1.2.1.1 Layers 1 (Membership Function)

each one of node is an adaptive node to node i in the layer which is node to node function shown the equation below:

$$O_{1,i} = \mu A_i(x), \quad for\ i = 1, 2\ and$$
$$O_{1,i} = \mu B_{i-2}(y), \quad for\ i = 3, 4 \qquad 4.4$$

The equation at node i x, y are inputs. Ai, Bi is the linguistic label that is high and low. The membership functions of Ai is O1,i. O1.i-2 , Bi for specify the point of membership x and y against. In the equation the membership function $\mu A1(x)$, $\mu B1(x)$ established on equation linear curve with one min value 0 and one max value is 1.

$$\mu Ai\ (x) = \begin{cases} 0; & x \leq ai\ or\ x \geq c \\ \frac{x-ai}{bi-ai}; & ai \leq x \leq bi \\ \frac{bi-x}{ci-bi}; & bi \leq x \leq ci \end{cases} \qquad 4.5$$

4.1.2.1.2 Layer 2 (Rules Layer)

every node is nodes nonadaptive or fixed node. The gained output is the result of every inputs in the rules layer. calculating the output using this Equation below.

$$O_{2,i} = wi = Ai(x) \,.\, Bi(y) \quad where\ i = 1, 2 \tag{4.6}$$

Each node in the output firing strength of each generated fuzzy rule. The number of vertices in the second layer ctreated rules, under which the rules created, is four rules.

4.1.2.1.3 Layer 3 (Normalized Firing Strength)

Every node is nodes nonadaptive or fixed node that show the degrees normalized firing strength is the ratio of the output's node i on the second layer to all output of the secound layer. As shown below the normalized firing strength equation.

$$O_{3,i} = \overline{wi} = \frac{wi}{\sum_{i=1}^{16} wi} \quad where\ i = 1, 2, \dots, 4 \tag{4.7}$$

4.1.2.1.4 Layer 4 (Defuzzification)

Every node in layer 4 is adaptive node to other node function, the weight is gained from Normalized Firing Strength layer three and by linear regression function the two inputs attributes are gained of order 1 as the equation below.

$$O_{4,i} = \overline{w}ifi = \overline{w}i(p_i x + q_i y + r_i) \tag{4.8}$$

4.1.2.1.5 Layer 5 (Addition)

Layer five is create whole inputs. As showing below the sum function equation.

$$O_{5,i} = \sum_i \overline{w}ifi = \frac{\sum_i wifi}{\sum_i wi} \tag{4.9}$$

(Wahyuni, Mahmudy, & Iriany, 2017).

4.1.2.2 Hybrid learning algorithm

There is five layers in ANFIS architecture as explained before. The first layer and fourth layer include attributes that can be changed by the time. The fourth layer is linear while the first layer is nonlinear. Thus, for the two layers, the attributes required to be update always into learning method, that is suitable and can training nonlinear and linear together, ANFIS model inserted in 1993 by Jang, which can train two layers at the same time (Faulina & Suhartono, 2013). ANFIS model is trained tested checked by the hybrid algorithm. ANFIS utilize descent gradient to denote errors by backward-pass and forward-pass in order to train the first layer and the fourth layer at the same time. The error is calculated using the equation below.

$$E_p = \sum_{m=1}^{\#(L)} (T_{m,p} - O_{m,p}^{L})^2 \qquad 4.11$$

T m,p is the mth component of the pth target

OL m,p is the mth component the actual output vector

The total error as below,

$$E = \sum_{p=1}^{P} E_p \qquad 4.12$$

4.2 RMSE and MSE

RMSE is root-mean-square-error and MSE is mean-square-error

We can calculate rmse and mse with formula below:

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{y}_i\right)^2 \qquad 4.13$$

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{y}_i\right)^2} \qquad 4.14$$

CHAPTER 5

SIMULATION

5.1 Data processing

Figure 5.1: Cryotherapy treatment

The aim of this study is the forecasting of the patients result of cryotherapy. The dataset information contains wart treatment results of 90 patients using cryotherapy. The dataset includes attributes of treatment result like sex of the patient, age of the patient, time elapsed before treatment, number of warts, type of warts, surface area of warts and the output is the result of treatment. The dataset will train, test, and validation with artificial intelligence machine learning to predict the result treatment. The forecasting will be with ML such as neural network back propagation and adaptive neuro-fuzzy inference system.

By the cause of infection with other people papillomavirus (HPV) warts are benign swelling, it can be classified for 3 types: Mucosal, Cutaneous and Epidermodysplasia Verruciformis (EV). The warts although can spread by direct connect with people, via common areas they can also be spread. According to the wart risk level the warts types can be classified. Also, immunocompromised people patients are especially prone to wart infections. Warts are small most of times. Harmless skins and rough growths that are typically painless. Clinical

appearances of wart (the type of wart) are the prevalent, plantar, periungual, genital, and filiform etc. Most of times the common warts can be seen on toes and fingers; sometimes, warts also can be seen elsewhere else. Warts are greyer than surrounding human skin. wart may have rounded top and a grainy appearance a rough. There is another wart type called plantar, which can make walking uncomfortable because it appears into the soles of the feet. Spontaneously the warts may pass away in years or maybe in months (without any treatment). Since they visually unappealing, the patients prefer the medicinal treatment; patients request removing warts by painful way more urgently than painless ones.

Cryotherapy has been tested broadly for treating warts, what is not clear is that, how we could understand the success rate of warts treatment via cryotherapy. Huge development in technology industry and especially ML enables us to predict the success rate and to whether the cryotherapy is able to cure this illness or not.

As each ML algorithm needs data to train in order to predict the new of future data, these algorithms need cryotherapy treated patients' records. These records should be included success and failures as it is in real world.

Therefore, ML technologies need to be utilized to estimate the treatment success rate using patient's data which is stored in the past. This has not been yet tested with many ML algorithms to verify the hypothesis and to prove it works fairly or not.

5.1.1 Data Pre-Processing for cryotherapy

From UCI Repository which is the record of these patients are collected from a hospital in Isfahan, Iran. The dataset is included the record of 90 patients which treated by cryotherapy.

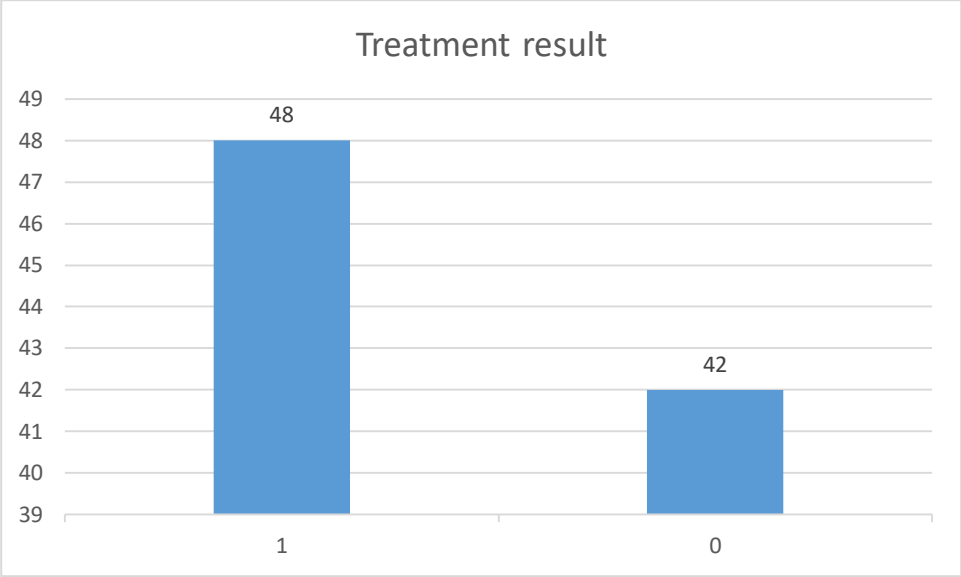


Figure 5.2: Trends in the distribution of treatment result

Figure 5.2 showing the treatment result distribution for 90 paitnet. The graph outlines that the treatment result is 0 for unsuccful treatment and 1 for successful treatment varying for all 90 paitnet.as we see that we have 48 out of 90 of succful result of treatment and 42 un succful treatment. The treatment result depends on 6 parameters that can effect on result, the paitent sex, the paitnet age, the treatment time, number of warts, the wart type, the wart area. All of the 6 parameters can effect the result of the treatment.

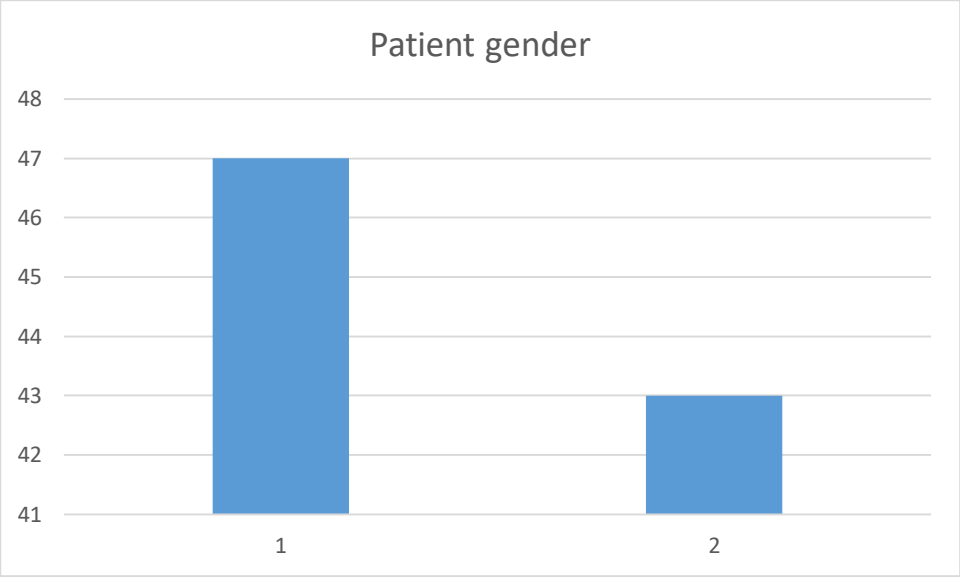


Figure 5.3: Trends in the distribution of patient sex

Figure 5.3 shows the distribution of patients sex, for 90 patients. The graph outlines that 47 of the paitent 1 which it means most of paitents male and on the other side we see 43 paitent of female paitents.

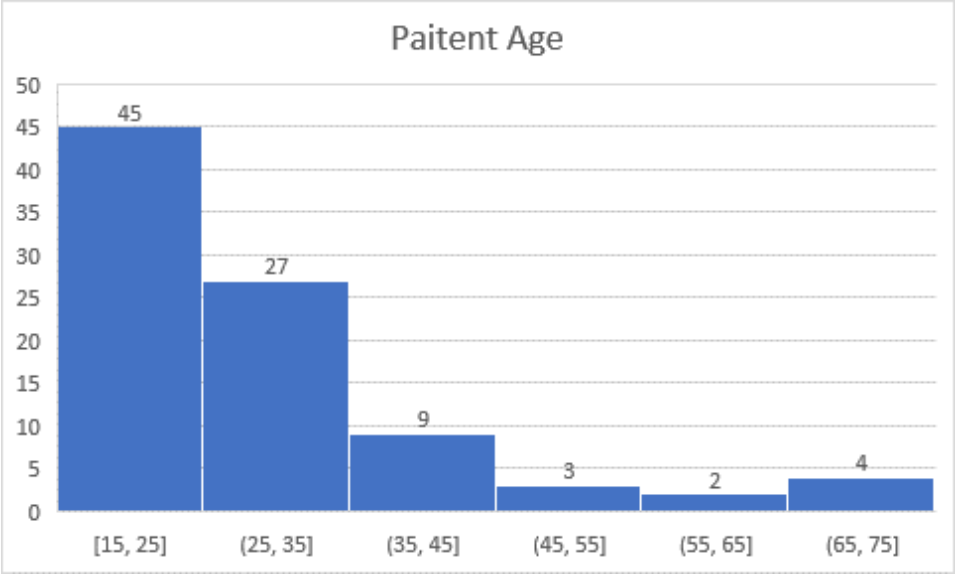


Figure 5.4: Trends in the distribution of patient age

Figure 5.4 shows the distribution of patients age, for 90 patients. The graph outlines that there is 45 patients between 15-25 years old, 27 paitents between 25-35 years old, 9 paitents between 35-45 years old, 3 between 45-55, 2 between 55-65 and 4 between 65-75. Which is the most paitent between 15-25 which is 45 paitents, the less paitents is 2 between 55-65, the biggest person who subject treatment is 67 and the less age is 15 years old.

Figure 5.5 shows the distribution of treatment time, for 90 patients. The graph outlines that 9 of the paitent there treatment was between 0.25-2.95, 22 paitent the time was between 2.95-5.65, the most treatment time took 11.75 and the less time 0.25, and the most treatment used between 8.35-11.05 of time.

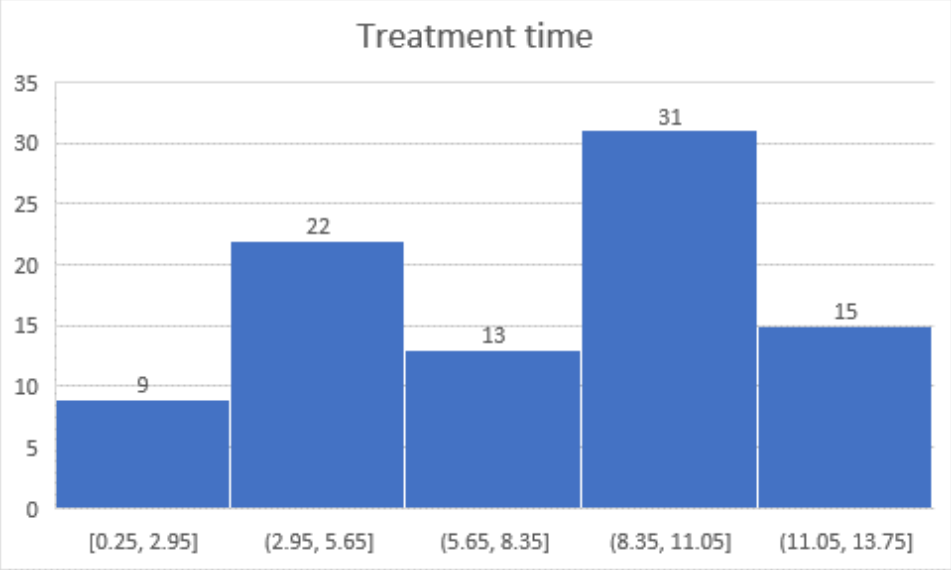


Figure 5.5: Trends in the distribution of treatment time

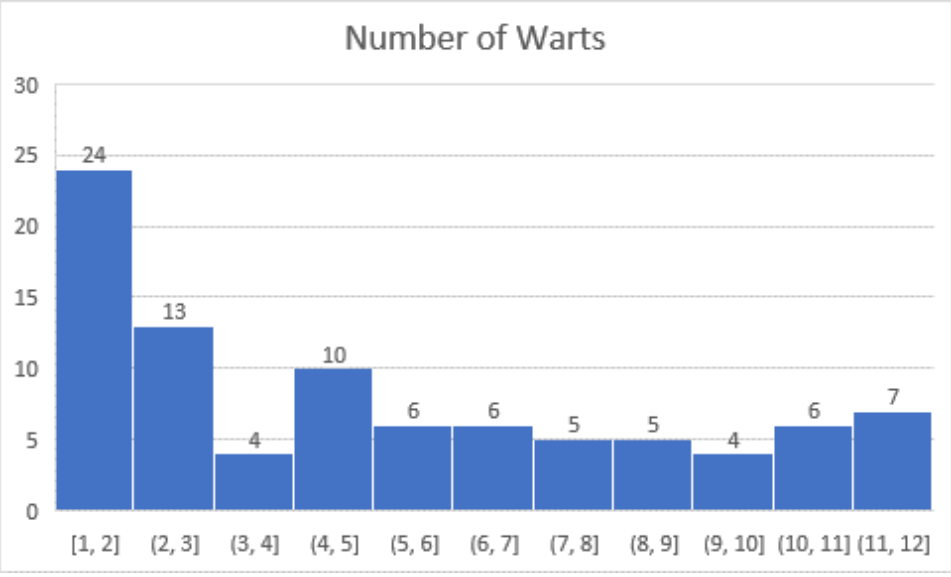


Figure 5.6: Trends in the distribution the number of warts

Figure 5.6 shows the distribution the numbers of warts, for 90 patients. The graph outlines that most of the paitent have 1 wart,24 paitent from 90, and the less paitents number of warts is 3 and 9. As we can see also the number of warts between 1 and 12 wart in paitent.

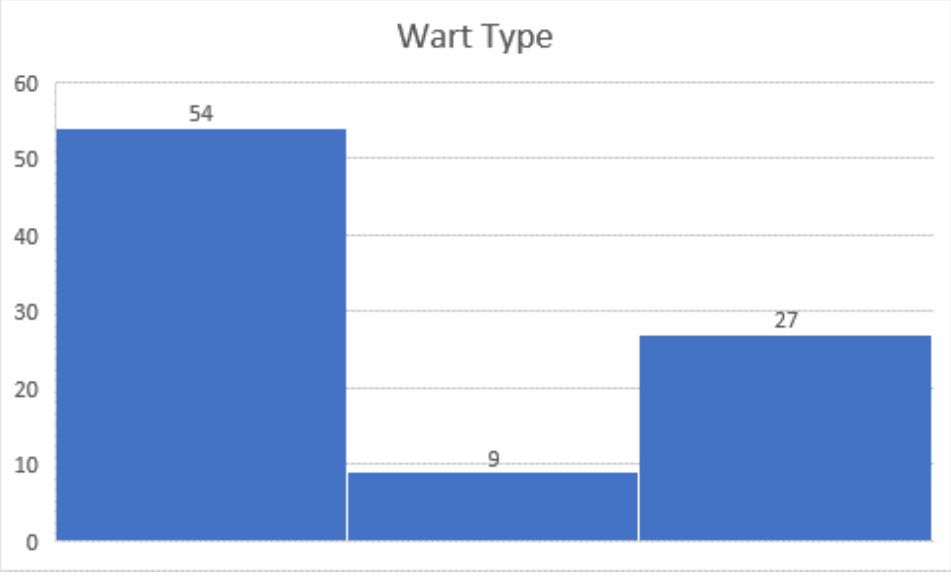


Figure 5.7: Trends in the distribution of warts type

Figure 5.7 shows the distribution of warts type, for 90 patients. The graph outlines that most of the paitent have type 1 of warts which is 54 paitent, 9 paients with type 2 and 27 paients with third type.

Figure 5.8 shows the distribution of warts area by mm^2, for 90 patients. The graph outlines that most of the paitent have warts area between 4-104 mm^2 and the less paitents have the largest area between 704-804, which is very big, the warts area may depends on the number of warts or warts type or both of them, the biggest area is 750 in one paitnent and the less area is 4.

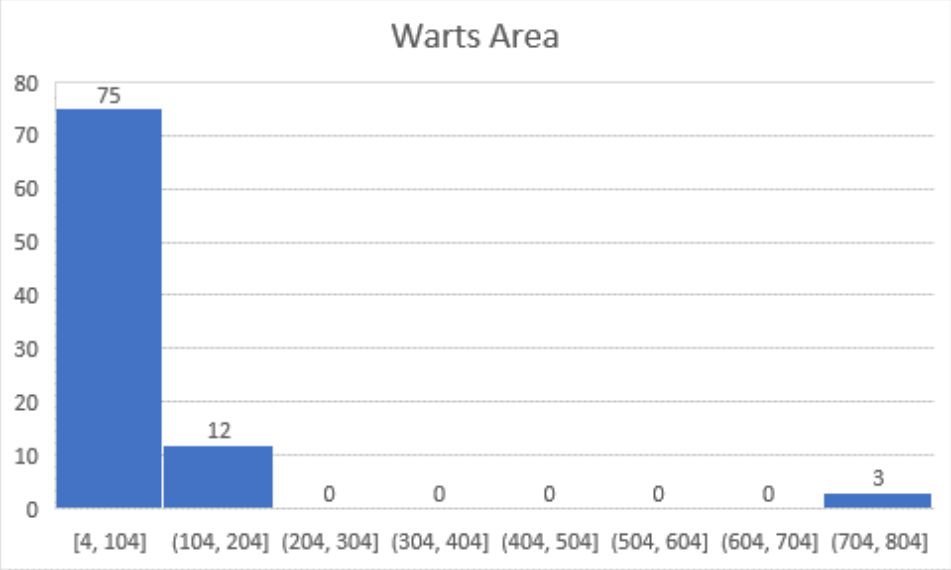


Figure 5.8: Trends in the distribution of warts area in patients

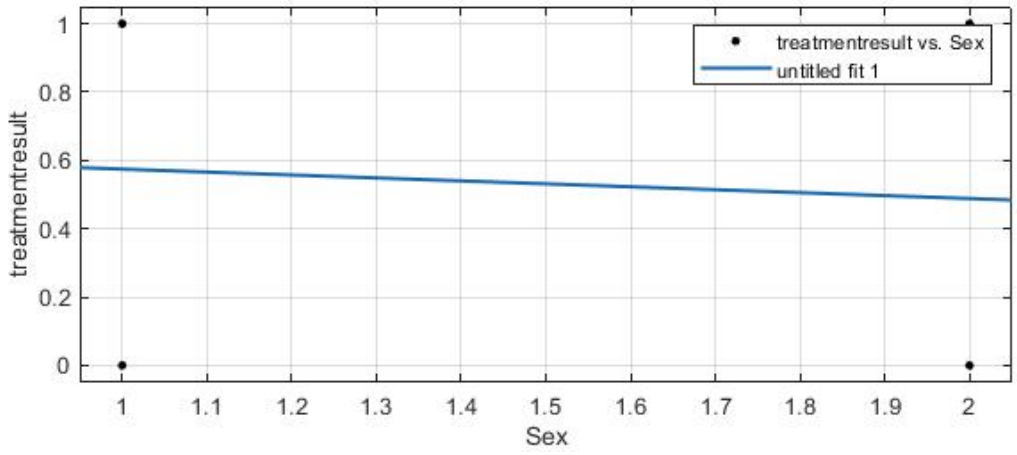


Figure 5.9: Correlation for treatment result with patient sex

The figure above 5.9 illustrates using plot chart the correlation for treatment result with patient sex. The correlation between the treatment result and patient sex is 0.086 out of 1, which is 8.6% as outlined by the data. This correlation is somehow normal but not important as much as other parameters for predicting the treatment result. As we can see in figure most of the males have better chance with healing then females.

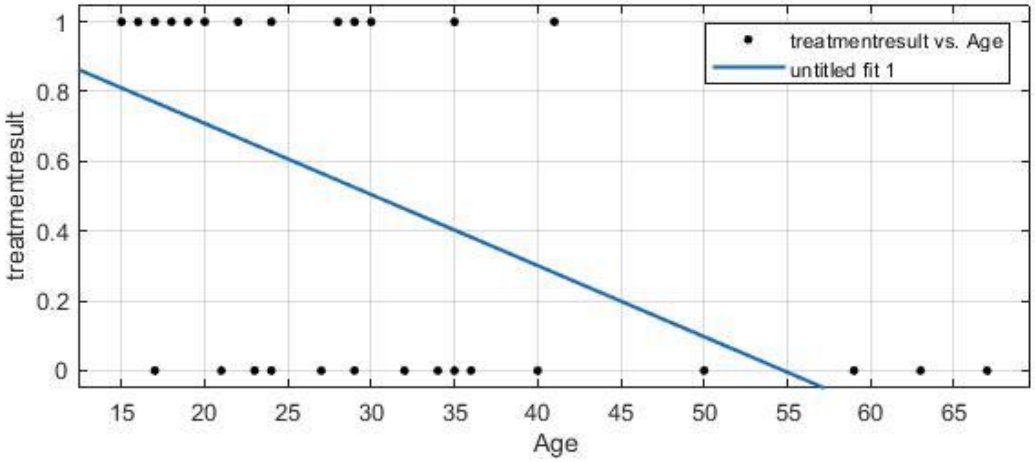


Figure 5.10: Correlation for treatment result with patient age

The figure above 5.10 illustrates using plot chart the correlation for treatment result with patient age. The correlation between the treatment result and patient age is 0.54 out of 1, which is 54% as outlined by the data. This correlation is good and important for predicting the treatment result. As we can see in figure most of the patients that get treatment under 55 years old, the healing was successful. The smaller age, the greater chance of success.

The figure above 5.11 illustrates using plot chart the correlation for treatment result with the time elapsed before treatment. The correlation between the treatment result and the time elapsed before treatment is 0.65 out of 1, which is 65% as outlined by the data. This correlation is very good and important for predicting the treatment result. As we can see in figure the patients who have less than 4 months' time elapsed before treatment have better chance for healing. Less before treatment, the greater chance of success.

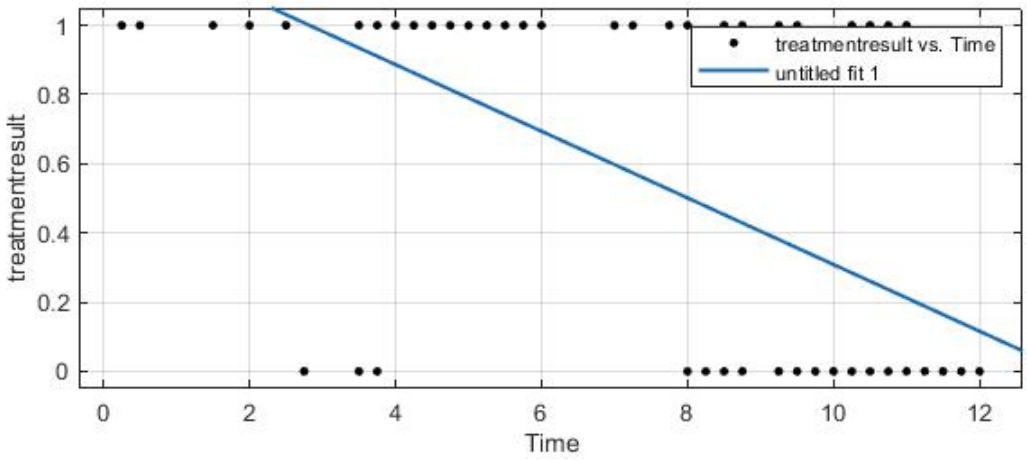


Figure 5.11: Correlation for treatment result with time elapsed before treatment

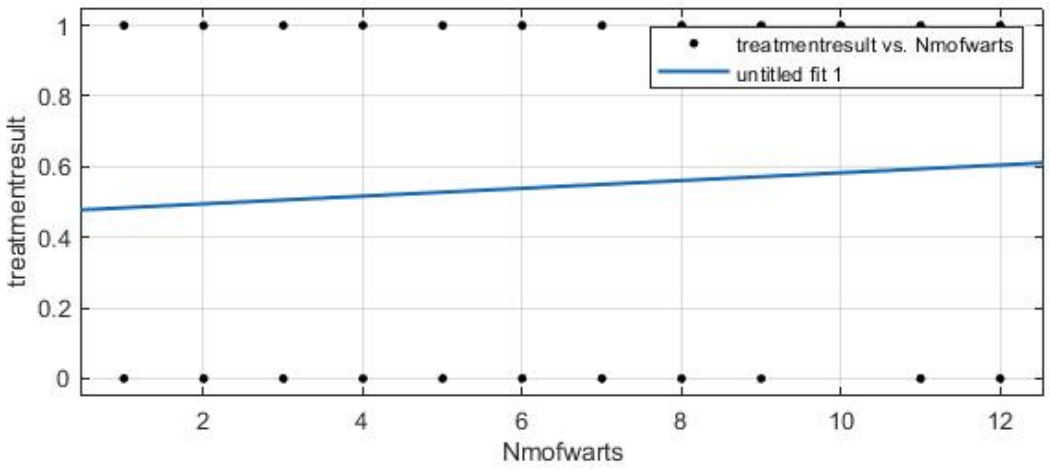


Figure 5.12: Correlation for treatment result with number of warts in patient

The figure above 5.12 illustrates using plot chart the correlation for treatment result with number of warts in patient. The correlation between the treatment result and number of warts in patient is 0.078 out of 1, which is 8% as outlined by the data. This correlation is somehow normal but not important as much as other parameters for predicting the treatment result. As we can see in figure the number of warts in patients would not change anything for better chance for healing.

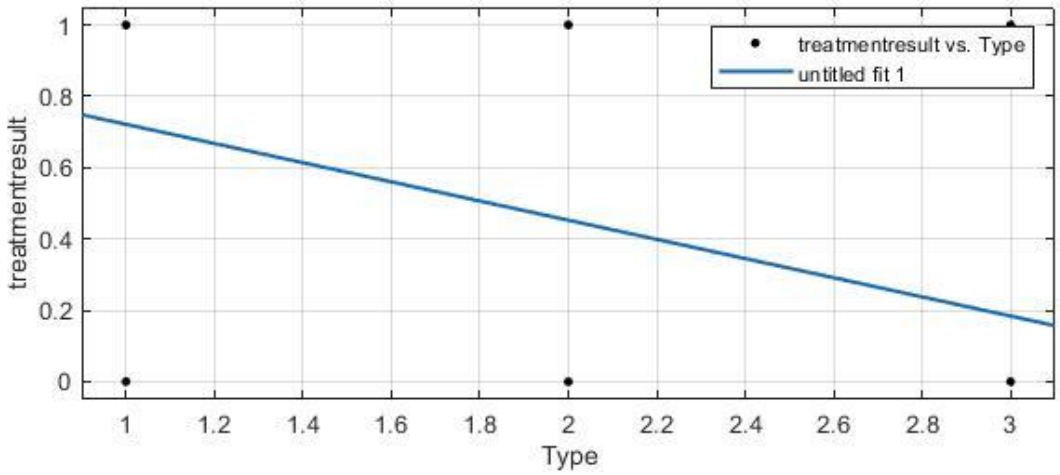


Figure 5.13: Correlation for treatment result with wart type

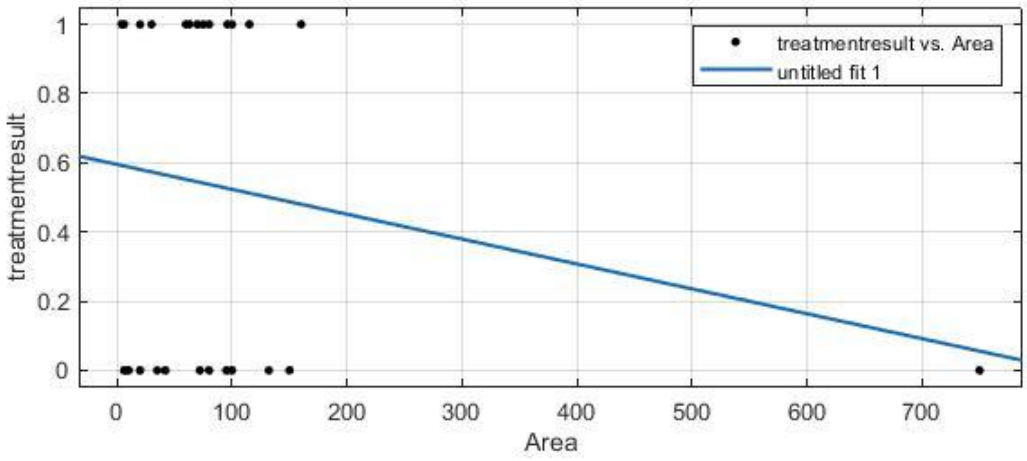


Figure 5.14: Correlation for treatment result with surface area of warts

The figure above 5.13 illustrates using plot chart the correlation for treatment result with wart type. The correlation between the treatment result and wart type is 0.485 out of 1, which is 48% as outlined by the data. This correlation is very good and important for predicting the treatment result. As we can see in figure the patients who have type 1 of warts have better chance for healing than the second type and third type, also the second type have better chance for healing than third type. Type 1 then type 2 the greater chance of success.

The figure above 5.14 illustrates using plot chart the correlation for treatment result with surface area of warts. The correlation between the treatment result and surface area of warts is 0.18 out of 1, which is 18% as outlined by the data. This correlation is very good and important for predicting the treatment result. As we can see in figure the patients who have lesser surface area of warts have better chance for healing than the bigger surface area. The small surface area of warts, the greater chance of success.

5.2 Flowchart for success of wart treatment prediction

The data below flowchart clarify selection of inputs and process to get the result, the output that in this resarch is treatment result forcasting. Flowchart highlights the initially step as a selection of input that are atribiutes, operating the inputs and processing it for training, testing and validation for obtaining precise and accurate outputs that is success of wart treatment prediction.

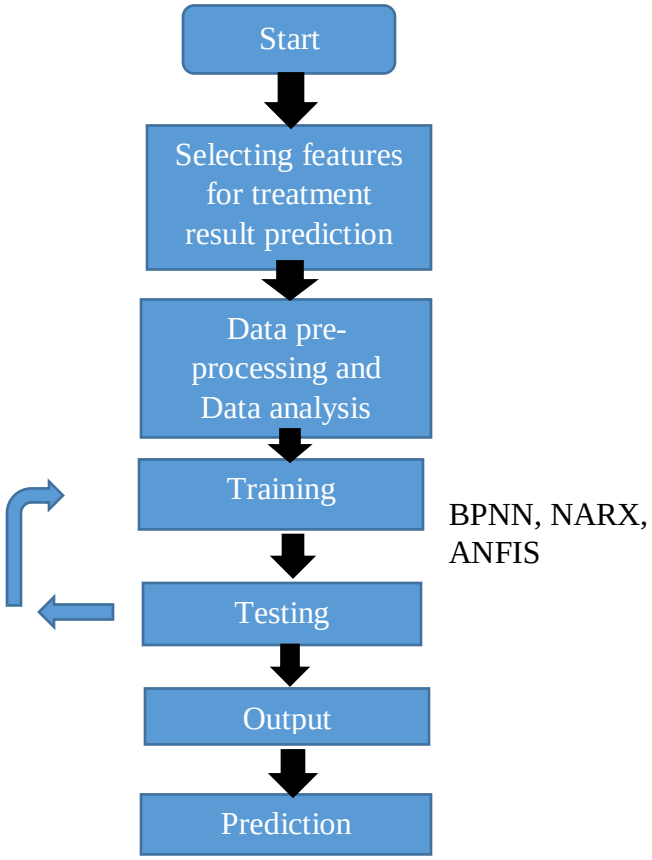


Figure 5.15: Flowchart for predicting the treatment success

5.3 Selection inputs and output data

In this resarch the database is collected directly from UCI Repository which is the record of these patients are collected from a hospital in Isfahan, Iran. The dataset is included the record of 90 patients which treated by cryotherapy. The inputs are highlighted as gender of the paitent, age of the paitent, time elapsed before treatment by months, number of warts, type of warts, and the area, the output is the treatment result. Therefore, forcasting the treatment result for paitents with parameters mentioned above will be considered as presumed inputs to predict precipitation. The dataset consists of patients cured with cryotherapy and six parameters. These parameters are patient gender, patient age, number of the warts, elapsed time before the treatment, the surface area of the warts type of the wart. It consist of 43 women and 47 men. 21 patients in females 27 patients in males subject to the cryotherapy treatment. the accuracy of the cryotherapy treatment was 53.33% in total. For the both type of warts has 30%, for the common

wart has 60% and for planter warts has 10%. The patients age range was between 15-67 years old. The average time elapsed before treatment by months is 7.66 months. The surface areas of the warts in patients vary between 4-750 mm^2. The maximum number of warts in a patients was 12. The average number of warts in patients is equal to 5.51.

5.4 Feature Extraction

The resarch focused on sex of the patient, age of the patient, time elapsed before treatment by months, number of warts, type of warts, and the surface area of wart. The parameters are defined as:

5.4.1 Gender of the patient

The gender parameter is male or female. In the dataset the 1 value for male and 2 value for female. It consist of 43 women and 47 men. 21 patients in females 27 patients in males subject to the cryotherapy treatment.

5.4.2 Age of the patient

The patients ages who will be treated. The age range was between 15-67 years old.

5.4.3 Time elapsed before treatment by months, number of warts

The time before Before undergoing treatment with number of months. The average time elapsed before treatment by months is 7.66 months.

5.4.4 Number of warts

The number of warts that patient has in skin.The maximum number of warts in a patients was 12. The average number of warts in patients is equal to 5.51.

5.4.5 Type of warts

There is 3 kind of warts in our resarch. Type 1,2 and 3. For the both type of warts has 30%, for the common wart has 60% and for planter warts has 10%.

5.4.6 The surface area of wart

The surface areas of the warts in patients skin by mm^2. The surface areas of the warts vary between 4-750 mm^2.

5.5 Training, Testing and Validation

The designation of a dataset from inputs and output, the achieving step is the training inputs through ANFIS, BPNN algorithm and NARX algorithm. By MATLAB2018 programe the training testing and validation has done. And using NN and ANFIS tools. Training is the forcasting step. the testing inputs data with accepted error is gained. NN model in matlab hold 70% of inputs dataset for training and 30% of inputs dataset for testing and validation and its retain automatically. ANFIS model ask for manual retention of the inputs dataset for the train, test and validat. Manually the ANFIS model fed with 40% of inputs for testing and 60% for training.

5.6 Neural network

The neural networks are multipurpose feasible and multipurpose. When the input is given to neural network during training of data; the effective training then propose neural network that are qualified for forcasting the outputs. NN are qualified of classifying an object, relative a function, even configuration and recognizing particular pattern of multifactorial. This resrach focusing on learning algorithm feed- forward BPNN and NARX systems to forcast the success of wart treatment (Mitchell, 1997).

5.6.1 Applying BPNN for predicting the success of wart treatment

This research focusing on BPNN to obtain accuracy for training, testing and validation of inputs and output data.

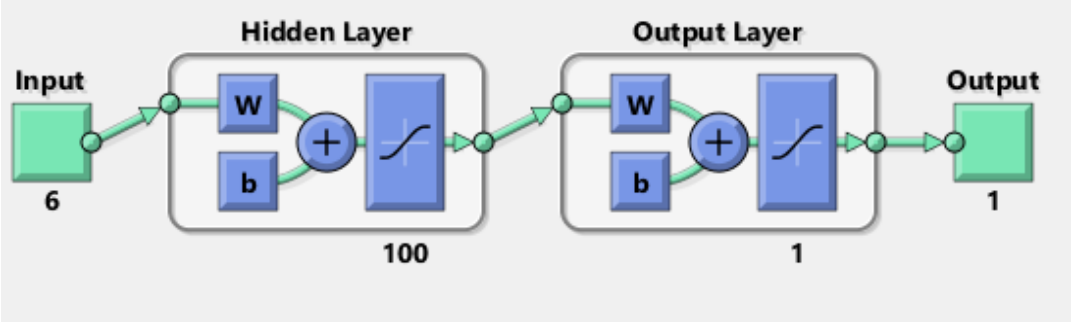


Figure 5.15: shows back propagation system architecture

The figure 5.15 highlight the architecture of backpropgation system for predicting the success of wart treatment. By back propgation network architecture the network awarded 6 inputs parameters for operating the prediction, gender of the paitent, age of the paitent, time elapsed before treatment by months, number of warts, type of warts, and the area. With two hiden layers and 100 neruons tolal number of neurons for backpropgation. Bayesian regularization(trainBR) algorithm is one of the most efficient and fast for traing, testing and validation. trainBR used to train the inputs data. Because of its high efficiency of bayesian regularization algorithm its proposed by back propagation system architecture.Training data with 50 epochs.

Figure 5.16 highlits the accuracy of the training, testing and validation after processing the dataset and its obtained to check the result. The accuracy of training is 0.914 which is accurate accuracy, the accuracy of testing is 0.918 which is good for prediciting, in the last the accuracy for validation is 0.987.

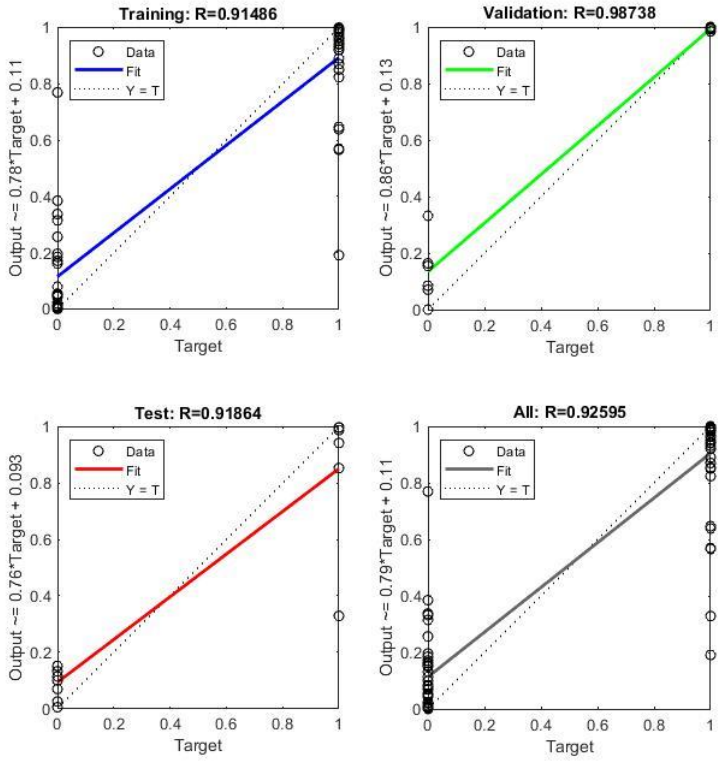


Figure 5.16: The regression using BPNN

5.6.2 Applying NARX for predicting the success of wart treatment

The nonlinear autoregressive exogenous (NARX) network architecture contain input layer two hidden layers in the middle and an output in the last. For neurons processing, the NARX network has a feedback connection. In these networks, there is 6 input parameters for operating the prediction, gender of the paitent, age of the paitent, time elapsed before treatment by months, number of warts, type of warts, and the area. The number of neurons is 100 neurons for NARX. Tapped delay lines as we see in figure 5.17 TDL that are; 0:1 and 1:2 at inputs side. Are supposed of length two. Its concurrently reducing the complexity of the network by sorting the predicted values during the training phase.so it's really useful.

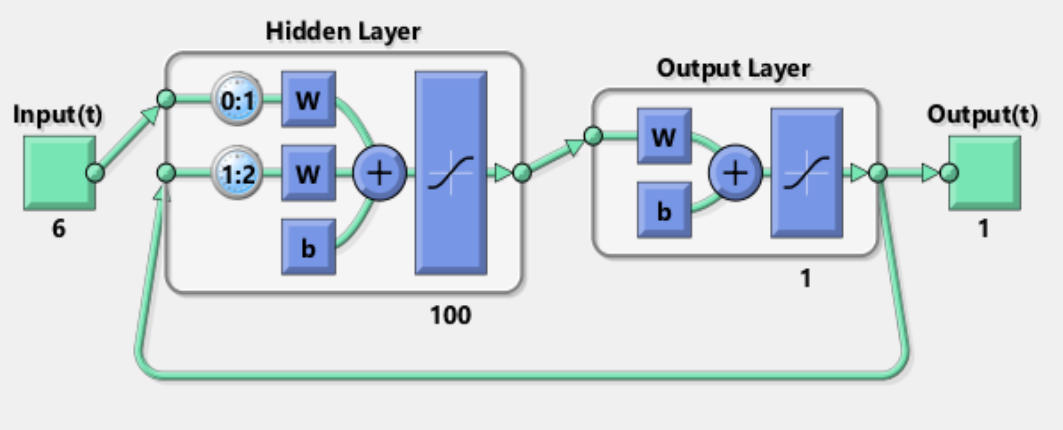


Figure 5.17: shows NARX system architecture

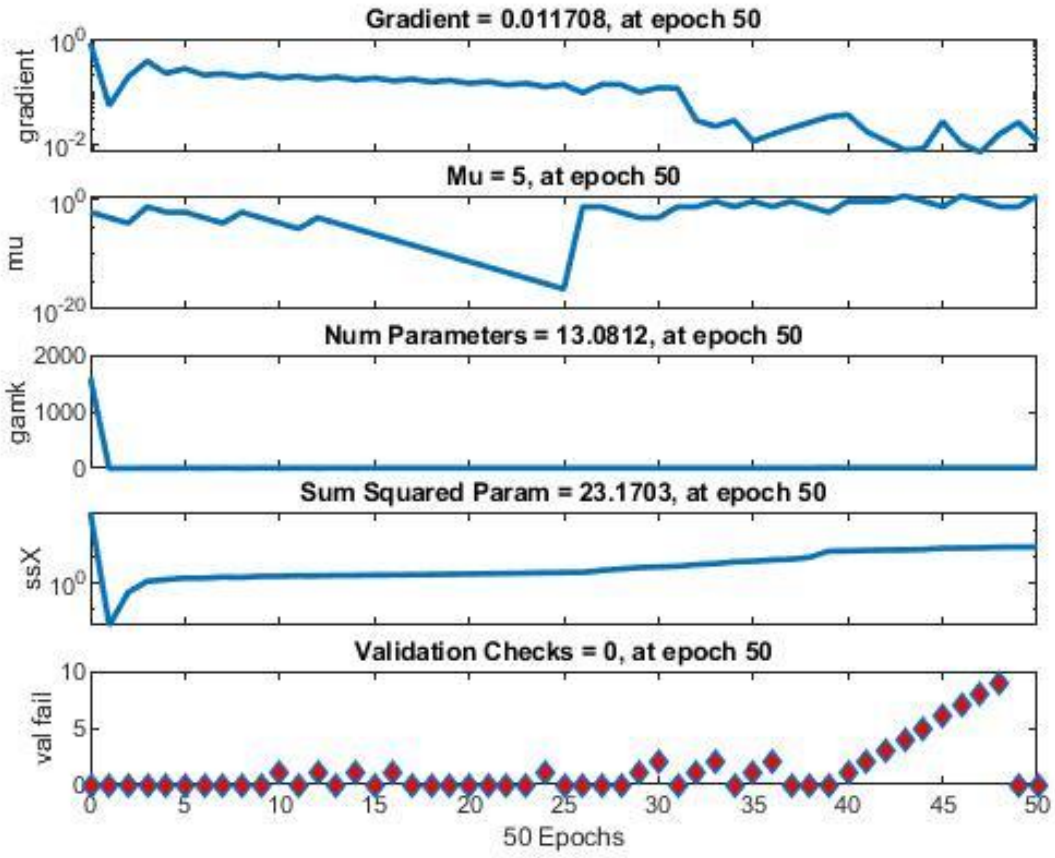


Figure 5.18: Training state using nonlinear autoregressive exogenous

Figure 5.23 shows result using the function Bayesian regularization(trainBR) we trained the data using a nonlinear autoregressive exogenous. The gradient that we achieved with 50 epochs is 0.011. The Mu is 5. The validation checks that is equal to 0 at 50 epochs.

5.7 ANFIS

The adaptive neuro-fuzzy inference system is focused on forecasting on the success of wart treatment the dataset is collected from UCI Repository which is the record of these patients are collected from a hospital in Isfahan, Iran. The dataset is included the record of 90 patients which treated by cryotherapy. The inputs are highlighted as gender of the paitent, age of the paitent, time elapsed before treatment by months, number of warts, type of warts, and the area, the outut is the treatment result. ANFIS is suitable through training by this system as the testing with various functions. The network generated and tested with different FIS algorithm and with

confirmed error tolerance and epochs. The atribiutes are analysed to have better RMSE than before and how it's effecting on the RMSE and epochs to have the best prediction.

5.7.1 Applying ANFIS for predicting the success of wart treatment

The datasets inputs trained with 6 inputs to obtain the result. Training the input data through ANFIS model, the inputs attributes through ANFIS algorithm it's manually fed into it. And its specified 60% for training and 40% for testing.

Figure 5.24 highlights ANFIS model architecture. ANFIS model based on number of parameters. the dataset is collected directly from UCI Repository which is the record of these patients are collected from a hospital in Isfahan, Iran. The dataset is included the record of 90 patients which treated by cryotherapy, parameters are gender of the paitent, age of the paitent, time elapsed before treatment by months, number of warts, type of warts, and the area. Using ANFIS model with 50 epochs and 0 error tolerance. In this study for ANFIS, the generated FIS as inputs using gauss2mf type and FIS linear type. According to this to gauss2mf and linear type, the inputs data and outputs data trained tested and checked. The error obtained 0.0015 which is accurate and suitable for ANFIS network. The result is absolutely accurate for making predicting the success of wart treatment.

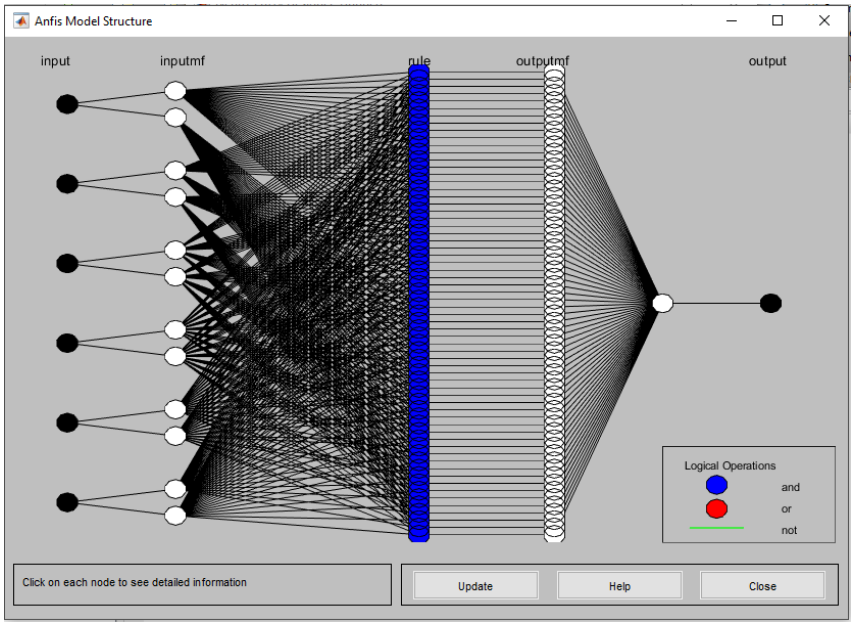


Figure 5.19: ANFIS model architecture

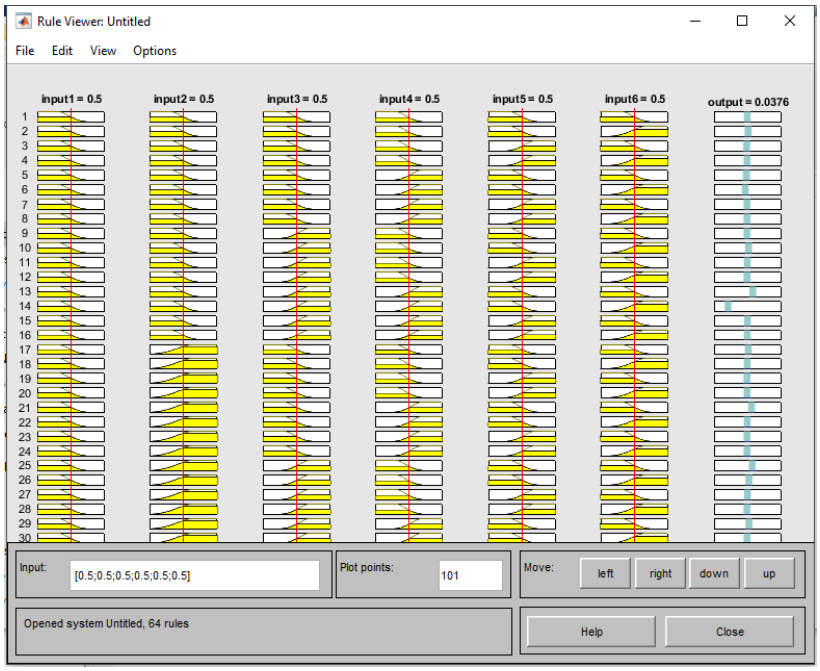


Figure 5.20: ANFIS rule viewer

Figure 5.25 highlits ANFIS after training the dataset, By the inputs ANFIS model automatically generate the rules and each input has different set of the rules. It gives output of the success of wart treatment forecasting. The achived accuracy from ANFIS model is 0.98 out of 1, which is the best model to predict the success of wart treatment.

The table 5.1 highlits the training, testing and validation accuracy for predicting the success of wart treatment using Backpropagation NN

Table 5.1: The training, testing and validation by BPNN

Treatment	Neurons	Epoch	Inputs	Output	Function	Training	Testing	Validation
Cryotherapy	100	50	Gender,num,age, area,type,time .	Success of wart Treatment	trainBR	0.914	0.918	0.98

The table 5.2 highlits the training, testing and validation accuracy for predicting the success of wart treatment using NARX

Table 5.2: The training, testing and validation by NARX

Treatment	Neurons	Epoch	Inputs	Output	Function	Gradient	Mu	Validation checks	Accuracy
Cryotherapy	100	50	Gender, num,age ,area, type,time	Success of wart Treatment	TrainBR	0.011	5	0	0.87

The table 5.2 highlits the training, testing and validation accuracy for predicting the success of wart treatment using NARX

Table 5.3: The training, testing and validation by ANFIS

Treatment	MF type	Epoch	Inputs	Output	Function	Error tolerance	Obtained error	Accuracy
Cryotherapy	Linear MF	50	Gender,num,age, area,type,time.	Success of wart Treatment	gauss2mf	0.00	0.0015	0.997

5.7.2 Computer properties & Training Time: the PC that we used for training the algorithms has 8 Gigabytes of RAM with Core i7 processor, 2 Gigabytes graphic and 256 SSD hard drive. During the training BPNN took 2 minutes and ANFIS took 1 hour in order to train our models.

CHAPTER 6

DISCUSSION AND RESULT

The research localizes using the artificial neural networks for forecasting the success of wart treatment. It based on UCI Repository which the record of these patients are collected from a hospital in Isfahan, Iran. The research proved that using BPNN, NARX and ANFIS models can obtain accurate and precise predictions.

In this research the data trained, tested and validated with dataset is included the record of 90 patients which treated by cryotherapy. The study localizes on NN with neuro-fuzzy. With NNTOOL and ANFISTOOL using MATLAB2018 programme. The research tested the success rate of wart treatments using cryotherapy.

6.1 Comparison

Since three algorithms have been trained and tested. Now for concluding the result, they need to be evaluated with evaluation matrixes. The result of the evaluation is presented in details in

Table 6.1: RMSE after training and testing using ANFIS NN, NARX AND BPNN

Treatment	No. of neurons	RMSE			MSE		
		BPNN	NARX	ANFIS	BPNN	NARX	ANFIS
Cryotherapy	50	0.1917	0.1826	0.0017	0.0368	0.033	0.0000028

The table 6.1 above shows the obtained root mean square error (RMSE) and (MSE) for cryotherapy treatment. It highlights that most efficient model with less RMSE result equals to 0. 0017, which is gained for cryotherapy treatment for 90 patients from ANFIS model. Therefore ANFIS performed the best and Backpropagation performed least. The accuracy for ANFIS is too high that we can say, it predict the success rate of warts treatment accurately.

CHAPTER 7

CONCLUSION

In this research BPNN, NARX, and ANFIS model for predicting the success of wart treatment are used based on Feature Selection strategy. The goal is creating an intelligence system to predict the success rate of warts treatment using neural network and ANFIS model effectively and accurately with a minimum error in prediction. The research included the record of 90 patients which treated by cryotherapy. The data trained with different algorithm artificial neural network (ANN) and hybrid system (ANFIS). To have a system more accurate and precise the system used feature extraction to conclude an accurate output prediction with different algorithms and functions. The result was compared after training, testing and validation in the network to obtain an accurate effective system; the root-mean-squared-error and mean-squared-error was listed and checked to make sure the precise result obtained and not to just make the prediction with large RMSE. The research used NARX, ANFIS and BPNN.

Finally, the the success of wart treatment forecasting obtained quite precise and over the comparison table with predicted data and the actual data for cryotherapy treatment. The study has got the best result utilized obviously with various parameters of cryotherapy treatment features with minimal error achieved using AFNIS. The ANFIS model defined itself the most effective predicting algorithm in estimating the success rate of warts treatment.

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sex	age	Time	Number_of_Warts	Type	Area	Result_of_Treatment
1	35	12	5	1	100	0
1	29	7	5	1	96	1
1	50	8	1	3	132	0
1	32	11.75	7	3	750	0
1	67	9.25	1	1	42	0
1	41	8	2	2	20	1
1	36	11	2	1	8	0
1	59	3.5	3	3	20	0
1	20	4.5	12	1	6	1
2	34	11.25	3	3	150	0
2	21	10.75	5	1	35	0
2	15	6	2	1	30	1
2	15	2	3	1	4	1
2	15	3.75	2	3	70	1
2	17	11	2	1	10	0
2	17	5.25	3	1	63	1
2	23	11.75	12	3	72	0
2	27	8.75	2	1	6	0
2	15	4.25	1	1	6	1
2	18	5.75	1	1	80	1
1	22	5.5	2	1	70	1
2	16	8.5	1	2	60	1
1	28	4.75	3	1	100	1
2	40	9.75	1	2	80	0
1	30	2.5	2	1	115	1
2	34	12	3	3	95	0
1	20	0.5	2	1	75	1
2	35	12	5	3	100	0
2	24	9.5	3	3	20	0
2	19	8.75	6	1	160	1
1	35	9.25	9	1	100	1
1	29	7.25	6	1	96	1
1	50	8.75	11	3	132	0

2	32	12	4	3	750	0
2	67	12	12	3	42	0
2	41	10.5	2	2	20	1
2	36	11	6	1	8	0
1	63	2.75	3	3	20	0
1	20	5	3	1	6	1
1	34	12	1	3	150	0
2	21	10.5	5	1	35	0
2	15	8	12	1	30	1
1	15	3.5	2	1	4	1
2	15	1.5	12	3	70	1
1	17	11.5	2	1	10	0
1	17	5.25	4	1	63	1
2	23	9.5	5	3	72	0
1	27	10	5	1	6	0
1	15	4	7	1	6	1
2	18	4.5	8	1	80	1
2	22	5	9	1	70	1
1	16	10.25	3	2	60	1
2	28	4	11	1	100	1
2	40	8.75	6	2	80	0
2	30	0.5	8	3	115	1
1	34	10.75	1	3	95	0
1	20	3.75	11	1	75	1
2	35	8.5	6	3	100	0
1	24	9.5	8	1	20	1
2	19	8	9	1	160	1
1	35	7.25	2	1	100	1
1	29	11.75	5	1	96	0
2	50	9.5	4	3	132	0

2	32	12	12	3	750	0
1	67	10	7	1	42	0
2	41	7.75	5	2	20	1
2	36	10.5	4	1	8	0
1	67	3.75	11	3	20	0
1	20	4	3	1	6	1
1	34	11.25	1	3	150	0
2	21	10.75	7	1	35	0
1	15	10.5	11	1	30	1
1	15	2	11	1	4	1
2	15	2	10	3	70	1
1	17	9.25	12	1	10	0
1	17	5.75	10	1	63	1
1	23	10.25	7	3	72	0
1	27	10.5	7	1	6	0
1	15	5.5	5	1	6	1
1	18	4	1	1	80	1
2	22	4.5	2	1	70	1
1	16	11	3	2	60	1
2	28	5	9	1	100	1
1	40	11.5	9	2	80	0
1	30	0.25	10	1	115	1
2	34	12	3	3	95	0
2	20	3.5	6	1	75	1
2	35	8.25	8	3	100	0
1	24	10.75	10	1	20	1
1	19	8	8	1	160	1