Synopsis of the Thesis entitled

Soft Computing Techniques in Diagnosis of some Regular Skin Disorders

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Introduction

Importance: An interesting and wide range of applied mathematics research is being done in medical science. Researchers of applied mathematics use soft computing techniques as tools in medical science. The Thesis is related to diagnosis of some regular (common) dermatological disorders using various soft computing techniques specially focused on kernel based techniques.

People in India, particularly in rural area and small town, are not much conscious about skin diseases and do not consult dermatologist in the initial stage. Unfortunately, in most of the rural area dermatologist are hardly available and people are generally treated by general practitioners, or paramedical staff at primary health centres, community health centres and referral hospitals etc. Many dermatological diseases such as Bacterial Infections, Fungal Infection, Eczema and Scabies have very similar features. So, to diagnose these diseases at the initial stage by non dermatologist is very difficult. Because of the improper diagnosis many times they are treated incorrectly by the mixture of antibacterial, antifungal and steroid preparation locally. Such treatment is perilous to the patient and it precipitates chances for relapse and side effects of local agents like steroids. There is definite need for proper diagnosis and treatment for such disorders. Modern medicine is looking for solutions, which help the doctors in making decisions. Machine learning techniques are very good tools which help the doctors in making decisions. It will make doctors more confident about their decision.

Related work on Skin disorders: More than thousand diseases are observed in dermatology and they are classified in different types of disorders. Much research work has been done on diagnosis of various skin diseases. Bapko *et al.* [6] have developed diagnostic system with 90% success rate using Artificial Neural Network to diagnose 17 types of skin diseases such as scabies, Acne, Vulgari etc. Naser & Akkila [42] have developed an expert system using CLIPS (C Lan-

guage Integrated Production System), which does not require intensive training to diagnose 9 different skin diseases namely, Psoriasis, Eczema, Ichthyosis etc. Major work has been done in diagnosis of differentiate Erythemato-Squamous Disease and skin cancer. Guvenir & Emeksiz [28] have used three algorithms namely, nearest neighbor classifier (NN), naive Bayesian classifier (NBC) and voting feature intervals-5 (VFI5) to diagnose erythemato-squamous diseases. For effective implementation of NN algorithm they gave weights to each features using Genetic Algoritm(GA). Karlik & Harman [37] used Artificial Neural Network using Back Propagation algorithm for early diagnosis of erythemato-squamous diseases and achieved 98 % success for 6 erythemato-squamous diseases. Danjuma & Osofisan [19] have used the same dataset and diagnosis the diseases with 97.4 % accuracy using Naive Bayes algorithm, 96.6 % accuracy using Multilayer Perceptron and 93.5% accuracy using J48 Decision tree. Olatunji & Hossain [43] diagnose the erythemato-squamous diseases using Extreme Learning Machine(ELM). Many researchers have predicted the diseases after applying various feature selection techniques ([4], [25], [49], [61],[62]). In [39] authors have used 3 layers back-propagation neural network classifier for automatic early detection of skin cancer. In [22] skin cancers are diagnosed using deep convolution neural network. In [5] Bakheet have developed computer aided diagnosis system using support vector machine (SVM) to optimize set of HOG (Histogram of Oriented Gradient) based descriptors of skin lesions.

Brief about our work: As mentioned in the above literature survey, most of the researchers have focused on diagnose differentiate Erythemato-Squamous Disease and Skin Cancer. But, very less focused was given on diagnose very common skin diseases such as Bacterial Infections, Fungal Infection, Eczema and Scabies. Our purpose is to develop some techniques which help general medical professional for proper diagnosis of these diseases and serve as a second opinion for dermatologist. For these purpose we have collected the data from Department of Skin & V.D., Shreekrishna Hospital, Karamsad, Gujarat, India. We have prepared detailed proforma under the guidance

of leading dermatologist and investigated 470 patients. To find the attributes deep investigation as well as doctor's ideas has been taken care of. The proforma includes 47 features. Out of 470 instances(patients) 139 instances are for Bacterial Infections, 146 for Fungal Infection, 98 for Eczema and 87 for Scabies.

Our main problem is classification of the above mentioned skin diseases. For this purpose we have used various soft computing techniques. Components of soft computing includes machine learning techniques such as Artificial Neural Network (ANN), Support Vector Machine (SVM), Extreme Learning Machine (ELM) etc. Soft computing techniques simulate biological processes. Basic problem of soft computing techniques is to train the network which gives minimum error between actual output and network output. So, fundamentally all soft computing techniques have strong bonding with mathematical optimization.

Brief Introduction about Machine Learning: Machine learning is a core subarea of artificial intelligence. Machine learning techniques try to simulate function of human brain. The goal is to develop algorithm which can learn automatically without human assistance. In machine learning, programs are developed using known data to determine the best values of the parameters of the optimization problems. These values of parameters are used to predict or classify new unknown data. Machine learning algorithms are data driven and giving more accurate results than that of direct program. It will provide insights into the general phenomenon of learning.

Diagnosis of skin diseases means classify the diseases in various categories. Classification can be done using various machine learning techniques. In machine learning techniques the network is trained using some data set called training data set. During training, parameters of the network are adjusted such that the network will give minimum error between actual output and the network output of the training data set. The adjusted parameters are used to classify new data set, called testing data set.

If output is provided during training then it is called supervised learning otherwise unsupervised learning. If output is divided into two classes then it is called binary classification problem. If there are more than two outputs then it is called multi classification problem. If during training all classes contain almost same number of data then it is called balanced classification problem otherwise called imbalanced classification problem.

Our data set has features as well as corresponding output. So, in our work we have used various supervised learning algorithm. we have used several soft computing techniques and methodologies. Most of our work is focused on kernel based techniques which gives better results for non linear data.

Our main problem is for classification. The following methodologies (soft computing techniques) we have used in solving the problem.

1 Artificial Neural Network(ANN) for Classification.

An Artifical Neural Network(ANN) is a non-parametric, non linear computational model. It has provided the first step towards the Artificial Intelligence. It simulates the working of brain. When data represent non linear relationship, ANN methodologies are very much useful compared to classical statistical techniques. Due to its effectiveness in pattern recognition it is widely used in medical field. The history of ANN started in 1890 with the paper of William James about brain activity patterns. In 1943 McCulloch and Pitts had created simple model of neural network to describe how neurons in brain might work. But, ANN became popular from 1986 [54], with multiple layered neural networks with Widrow-Hoff rule which can separate non linear data.

In Multilayer perceptron there is one input layer, one output layer and one or more hidden layers. During training of the network, training data are applied to the input layer and initial weights are provided. A forward sweep is made through the network and output of each element is computed layer by layer. The difference between the calculated output of the final layer (output layer) and the desired output is calculated which is called error. If this error is greater than tolerance then weights are updated using delta rule. Weights of each layer is updated by back propagation. This process of updating weights of the previous layers is proceed until the input layer is reached. This is called back propagation algorithm.

We use ANN with back propagation algorithm to diagnose skin diseases under study. To diagnose diseases classification accuracy is measured by general formula as well as by F-score, taking different hidden layers. Despite of its drawback to stuck algorithm in local optimum we obtained very good classification accuracy.

2 Support Vector Machine (SVM): Classification using Positive (Semi) Definite Kernels.

Support vector machine is the most widely used soft computing technique for non linear data. It's good generalization ability, better performance and robust mathematical theory makes it popular among other machine learning algorithm. It is the combination of machine learning theory, optimization algorithms from operation research and kernel functions from functional analysis. It is also known as large margin classifier.

The history of SVM started in the beginning of 1960s when Vapnik *et. al.* [58] have developed an algorithm to construct an optimal separating hyperplane for separable data. In 1992 Boser *et. al.* [9]

have constructed the optimal separating hyperplane in Hilbert space using Mercer's theorem, which explicitly map the input vectors into higher dimension Hilbert space. In 1995 Cortes *et. al.* [16] generalized the maximum margin classifier in feature space for nonseparable data, which is known as Support Vector Machine(SVM).

We have used SVM to diagnose some regular skin diseases. From the data set 70% of our data is randomly selected as training data while rest of 30% data is used for testing. SVM is basically developed for binary classification problem. Here we have used it for four classes. Also, since kernel plays a very important role in the performance of SVM, we have used various kernels to train our data set, so that comparison can be done. For each kernel we have calculated accuracy using confusion matrix and also use other performance measure viz., F-score and G-score. We have obtained more than 90% classification accuracy to diagnose skin diseases.

3 Support Vector Machine: Classification using Novel Indefinite Kernel.

For classification of non linear data, Support Vector Machine (SVM) is a good classifier with appropriate choice of kernel. Measuring similarity among training samples is the fundamental step of classification. Kernels measure similarity between samples and provide classification of data. Though positive definiteness is the traditional requirement of SVM, in many applications indefinite kernels gives better classification accuracy.

Unlike Mercer's kernels, indefinite kernels are defined in an inner product space endowed with a Hilbert topology called kerĭn space [44], which is Pseudo Euclidian space. Since, the kernels are indefinite, instead of minimizing the lose, the focus is on stabilize it. Bernard [29] has shown that Support Vector Machine with the indefinite kernels are optimal hyper plane classifiers.

In our study we have developed a novel indefinite kernel which is modified Gaussian kernel and used this kernel to diagnose some regular skin disorders of our collected data set and Erythemato-Squamous Disease (ESD). Similar analysis has been carried out by considering various types of non Euclidean distances in Radius Bases kernel Function and non standard inner products in Polynomial kernel. We have checked positive definite/indefinite property of the various kernels we use. The results exhibits good classification accuracies by these kernels. The classification accuracy obtained by our novel kernel function which is indefinite is better than that obtained by traditional Mercer's kernels.

4 Probabilistic Approach in Feature Selection.

In many data sets, number of features are very high which increase the dimensionality. If we use some classifier for such data set, we may have to face over fitting problem and good generalisation may not be obtained. So, it is necessary to remove these types of features from the data set before applying any classification technique to reduce dimensionality and hence to achieve good generalized classification accuracy. Statistical analysis reveal high correlation among some features which can be exploited to reduce the dimensionality of the classification problems. There are three methods for feature selection: Filter method, Wrapper method and Embedded method.

In our study we have used novel approach of feature selection. To overcome drawbacks of filter techniques and wrapper techniques we have combined both techniques which we called Filter technique and Partial Forward Search (F_PFS) algorithm. Our method works for both balanced and imbalanced data sets as well as binary and multiclass data sets. To verify our method, we have used two skin data sets. Data set-I is our collected data set for common skin diseases and Data set-II is

the bench mark data set for Erythemato-Squamous Skin Disease taken from UCI (University of California Irvine) machine learning database [3]. We have also given comparison analysis of our method with the method discussed in [61]. The results show that our new approach of feature selection (F_PFS) reduced 26% features from data set-I and it reduced 39% features from data set-II with good classification accuracy and also reduced the computational effort.

5 Kernel Based Extreme Learning Machine (ELM) for Classification.

The major drawback of feedforward neural networks is their slow speed due to gradient descent based learning methods. In 2004 Haung *et.al.* [32] have proposed a new learning algorithm called Extreme Learning Machine(ELM) which is a single layer feedforward neural network. ELM based on empirical risk minimization theory [21]. The major advantage of ELM is that the weights are not needed to be trained. so, learning is very fast.

In this method, the rectangular system of linear equations to obtain network weights can be solved using the Moore-Penrose inverse. i.e. no need to train the network to find weights, instead they can be obtained analytically. This makes the algorithm very fast. The Moore-Penrose inverse gives minimum norm least-squares solution of a linear system [56]. Hence, the network weights are not only minimum but with smallest norm which is unique. So, the best generalised solution is obtained.

In our work we have used ELM with Polynomial kernel, Radial Bases Gaussian kernel and Exponential Chi-square kernel. We have observed that good generalized performance with extremely high speed is achieved using Exponential Chi-Square kernel in ELM to diagnose skin diseases. A comparison analysis of Extreme Learning Machine with Artificial Neural Network and Support Vector Machine is also done.

Conclusion:

Results from the Thesis can be utilized by general practitioner and dermatologist for proper diagnosis of the common skin diseases viz. Bacterial Infections, Fungal Infection, Eczema and Scabies, which in turn may reduce the risk of over/improper medications for the above mentioned diseases.

Future Scope:

With the availability of large number of data for the above mentioned common skin diseases, the results of the Thesis can be used to develop an expert system, which automatically diagnosis the regular(common) skin diseases, once we insert features in the system.

Layout of the Thesis:

The Thesis is organized as follows:

Chapter 1 deals with general introduction of the thesis.

Chapter 2 focuses on the Mathematical Preliminaries.

In Chapter 3 we have used Back Propagation Neural Network Algorithm taking different hidden layers for classification of four common skin diseases. The results exhibit a very good classification accuracy for our training-testing data.

In Chapter 4, we have used the Support Vector Machine -

a Large Margin Classifier, with different Mercer's Kernels to diagnose several skin diseases and more than 90% classification accuracy is achieved. The classification accuracy is obtained by different statistical measures.

In Chapter 5, we have discussed indefinite kernel in Kreĭn Space. we have proposed a novel indefinite kernel which gives better classification accuracy for our data set under study. We have used various distances and different inner products as similarity measures in Radial Basis Kernels function and Polynomial Kernel function to diagnose skin disorders and also determined positive definite/indefinite property of these similarity measures.

In Chapter 6, we have proposed a new algorithm of feature selection named Filter technique and Partial Forward Search (F_PFS) algorithm. We have applied our proposed algorithm on two different skin data sets to reduce features from both data sets and achieve good classification accuracy on both data sets with reduced features.

In Chapter 7, we have used the Extreme Learning Machine(ELM) with different kernels for classification. It gives global optimum with extremely high speed. We have obtained good classification accuracy with Exponential Chi-square kernel. We have also given comparison of learning speed of Artificial Neural Network, Support Vector Machine and Extreme Learning Machine.

List of our Publications:

1. Krupal S Parikh, Trupti Shah, Rahulkrishna Kota, Rita Vora, "Diagnosing Common Skin Diseases using Soft Computing Techniques", International Journal of Bio-Science and Bio-Technology, volume 7, issue 6, pp.275-286, 2015. http://dx.doi.org/10.14257/ijbsbt.2015.7.6.28.

2. Krupal S Parikh, Trupti Shah, "Support Vector Machine-a Large Margin Classifier to Diagnose Skin Illnesses", Procedia Technology, Elsevier, pp.369-375, volume 23, 2016. Doi: 10.1016/j.protcy.2016.03.039 .

3. Krupal S Parikh, Trupti Shah, "Kernel Based Extreme Learning Machine in Identifying Dermatological Disorders", International Journal of Innovative Science, Engineering & Technology, volume 3, issue 10, pp.370-375, 2016.

4. Krupal S Parikh, Trupti Shah, "Feature Selection Paradigm using Weighted Probabilistic Approach" ,International Journal of Advanced Science & Technology, Volume 100, issue, 3, pp.1-14, 2017. http://dx.doi.org/10.14257/ijast.2017.100.01.

5. Krupal S Parikh, Trupti Shah,"Novel kernel to Diagnose Dermatological Disorders"(Communicated).

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