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Diagnosing Common Skin Diseases using Soft Computing Techniques

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Abstract

In today's word skin diseases and lesions have become one among the most common diseases that people suffer across various age groups. Typical skin illnesses that people suffer throughout the world and more particularly in developing countries are Bacterial Skin infections, Fungal skin infection, Eczema and Scabies. Identification of the influential clinical symptoms that help in the diagnosis of these illnesses in early phase of the illness would aid in designing effective public health management. Keeping this as our main objective, this paper describes the two predictive models for our multiclass classification problem. The models are developed using popular soft computing techniques namely Artificial Neural Network and Support Vector Machine. These two approaches are applied on the multi class classification dataset and some comparative inferences are generated using F-scores.

Keywords: *Skin Diseases, Artificial Neural Network, Support Vector Machine*

1. Introduction

Skin diseases are regularly encountered in medical practice. Medical practitioners encounter these skin disorders on a daily basis in their O.P.D. (Out Patient Department). Among all the skin conditions, Bacterial skin infections, Fungal skin infection, Eczema and Scabies are the most common diseases. Such skin disorders are commonly encountered by medical and paramedical staff at primary health centers, community health centers, referral hospitals as well as specialized hospitals.

Bacterial infections, Fungal infections, Scabies and Eczema often present similar signs and symptoms. In order to differentiate them clinically it is very important to prevent wrong diagnosis and false treatment. In the absence of a qualified dermatologist, these diseases treated incorrectly and by a mixture of antibacterial, antifungal and steroid preparation locally. Such treatment is hazardous to the society and it precipitates chances for relapse and side effect of local agents like steroids. Hence to increase the diagnosing accuracy, such type of research is important.

Until now, diagnosing skin diseases has been performed by the specialist physician's self- experience and results of pathological tests. The models we derive may also assist the specialist physician in making diagnosis.

This paper is organized as follows. A survey of the related works for diagnosis of skin diseases using the soft computing techniques is presented in Section 2. While in Section 3

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Data description-Data preparations are described. Artificial Neural Network and Support vector machine are reviewed in Section 4.1 and 4.2 respectively. Experimental Setup and Implementation Process are discussed in Section 5. In Section 6, results are discussed and finally Conclusions representing the course of study is summarized in Section 7.

2. Literature Review

Based on the World Health Organization's (WHO) report in 2011, skin diseases still remain common in many rural communities in developing countries, with serious economic and social consequences as well as health implications. Directly or indirectly, skin diseases are responsible for much disability (and loss of economic potential), disfigurement, and distress due to symptoms such as itching or pain. During the last few years much research work is done to diagnosis skin diseases in an early stage using soft computing techniques.

Feature Selection based on Linguistic Hedges Neural-Fuzzy classifier is presented by Ahmad, *et al*., [1] for the diagnosis of Erythemato-Squamous diseases. Performance evaluations were taken on four training-testing partitions and achieved the best classification accuracy with Root Mean Square Error of 6.5139e-013 for 80–20% training-test partition using 3 clusters and 18 fuzzy rules. Sunday and Hossain in [19] proposed extreme learning machine(ELM) to diagnosis Erythemato-Squamous Diseases and compare the results with classical Artificial Neural Network and conclude that ELM can achieve high learning speed, good generalization performance, and ease of implementation. Dinesh, *et al*., in [8] used two data mining techniques, Support Vector Machine and Artificial Neural Network for classification of different categories of Erythemato-Squamous diseases. They combined the two techniques by using a confidential weighted voting scheme and achieved the highest accuracy of 99.25% and 98.99% at training and testing stages respectively.The comparative analysis of the Naive Bayes, Multilayer Perceptron and J48 decision tree induction was performed by Kwetishe and Adenike in [13]. Their comparative study shows that the Naïve Bayes performed the best with accuracy of 97.4%. To classify Erythemato - Squamous diseases datasets Madhura, *et al*., [14] used Bayesian technique. They used Best First Search techniques of feature selection. Using this technique they have eliminated 20 features from dermatology dataset taken from University of California, Irvine repository site and then using Bayesian technique obtained 99.31% accuracy. Ammara and Adel [3] in their paper provide a framework that represents a comprehensive guideline for selecting suitable algorithms needed for different steps of automatic diagnostic procedure for ensuring timely diagnosis of skin cancer. F. Bapko and L. Kabri in [9] used Artificial Neural Network for diagnosis of various skin diseases and achievd 90% success. There are certain features unique for skin cancer regions. J. Abdul, *et al*., [10] used 2D Wavelet Transform method to extract such features and then used Back-Propagation Neural (BPN) Network for classification purpose. It classifies the given data set into cancerous or non-cancerous. ABCD rule has become a standard practice by many dermatologists. Damilola, *et al*., [7]characterize the ABCD rule into quantitative attributes measured by image analysis, and implore texture analysis technique with Gabor wavelet (to make scale, translation and rotation invariant) in order to automate the classification process, and then lesion are classified as benign or malignant using Multilayer Perceptron Classifier (MLP). Combination of Markov Random Fields (MRFs) with support vector machines using an appropriate feature space can solve a wide range of scaling segmentation problems that include variations in lighting conditions, variations in skin type and variations in the types of psoriatic lesions. A general framework for automatic localizing scaling in psoriasis images was discussed by Kodeeswari, *et al*., [12]. Manjusha, *et al*,. [15] use Naïve Bayesian algorithm to predict different dermatological condition. For automatic recognition of ring worm skin disease feature extracted using LBP (Local Binary Pattern) from the affected skin images, and for

classification Srimanta, *et al*., [17] used three different classifiers viz., Bayesian, MLP and SVM and found that MLP classifier gives maximum average success rate of 95.71% with 13.55 standard variations. Whereas, Bayesian classifier gives lowest average success rate of 70% with 17.10% standard deviation. SVM provides 74.28% success rate for these. Rouhollah and Mohammad in [16] used Artificial Neural Network for diagnosis and prediction of oral diseases such as Lichen Planus, Leukoplakia and Squamous cell carcinoma and get training error of 0.0199 of the intelligent system. Stephen, *et al*., [18] have achieved an average sensitivity and specificity for melanoma diagnosis of 0.86 and 0.72, respectively using Support Vector Machine to support clinical decision making of the disease melanoma. Karol, *et al*., [11] have discussed decision-support system based on semantic analysis of melanoma images and used Artificial Neural Networks and Support Vector Machines for classification and conclude that best performance is achieved with linear kernel of support vector machine.

The literature survey shows that most of the research work is done on two types of skin diseases - diagnosis of skin cancer in an early stage and classification of different categories of Erythemato – Squamous skin disease. But, yet no one has focus on classification of common skin diseases such as Bacterial Skin infections, Fungal skin infection, Eczema and Scabies which affect a majority of the population.

3. Data Description-Data Preparation

The database for this study was obtained from Department of Skin & V.D., Shrikrishna Hospital, Karamsad, Gujarat, India. We have prepared detailed Proforma under the guidance of a leading dermatologist and investigated 470 patients. To find the attributes deep investigation as well as doctor's ideas have been taken care of. The proforma includes 47 features.

The study includes 47 features and 470 instances. Out of 470 instances 139 instances are for Bacterial Infections, 146 for Fungal Infection, 98 for Eczema and 87 for Scabies. The following table shows various features which are investigated during our data collection. Patient's identity is removed from training and testing Dataset.

Table 1. Input Attributes used for Analysis

Chief Complaints & OPD:		Associated With	
1.	Pain	23.	Lichenification
2.	Fever	24.	Oozing
3.	Itching	25.	Crusting
Seasonal relation		26.	Scaling
4.	Summer	27.	Excoriation
5.	Winter	28.	Discharge
6.	Monsoon	Shape	
Past History		29.	Linear
7.	Diabetes Mellitus	30.	Annular
8.	Family History	31.	Grouped
Occupational History:		Sites	
9.	Hot and humid environment	32.	Webspaces
10.	Exposure to irritants	33.	Wrist
11.	Excessive sun exposure	34.	Forearm
Type Of Lesion		35.	Arm
12.	Macules	36.	Chest
13.	Patches	37.	Abdomen
14.	Papules	38.	Genitals

15.	Pustule	39.	Thigh
16.	Nodule	40.	Legs
17.	Plaques	41.	Dorsa of feet
18.	Vesicles	42.	Back
19.	Bullae	43.	Buttocks
Colour		44.	Palms & Soles
20.	Erythematous	45.	Hair
21.	Hyperpigmented	46.	Nail
22.	Hypopigmented	47.	Face

4. Soft Computing Techniques

4.1. Artificial Neural Network (ANN):

An artificial neural network (ANN), often just called a neural network, is a mathematical model that is inspired by the structure and function of biological neural networks in the brain. An ANN consists of a number of artificial neurons (*i.e.*, nonlinear processing units) which are connected each other via weights that can be used for training and prediction. ANN can "learn" a task by adjusting weights. ANN have been successfully used in classification problems of various fields such as biological, medical, industrial, control engendering, software engineering, environmental, economical and social applications.

A multilayer perception is a feed forward ANN model that is used extensively for solving of a number of different problems. The Back propagation network which is also sometimes called multilayer network is currently the most general purpose and commonly used neural-network paradigm which use Gradient Descent technique to train the network.

The Back propagation network is a layered feed-forward network comprising of one input layer, one or more hidden layers and one output layer.

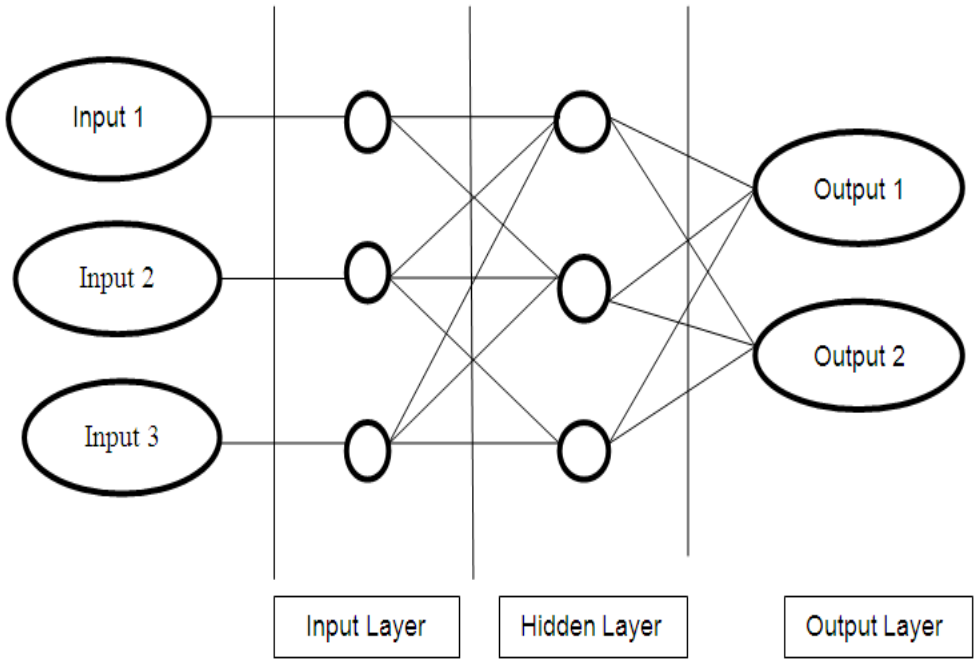

Figure 1. A Feed-Forward Neural Network

Training inputs are applied to the input layer of the network, and desired outputs are compared at the output layer. During the learning process, a forward sweep is made through the network, and the output of each element is computed layer by layer. The difference between the output of the final layer and the desired output is back-propagated to the previous layers, usually modified by the derivative of the transfer function, and the connection weights are normally adjusted. This process proceeds for the previous layers until the input layer is reached. The iteration is stopped until certain stopping criterion like minimum error; maximum number of iteration *etc.*, is achieved.

Mathematically outputs are calculated as,

$$y(k) = F\left(\sum_{i=0}^{m} w_i(k).x_i(k) + b \right)$$

where, $x_i(k)$: the i[th] input value, $w_i(k)$: weight value, b :bias,

F: a transfer function, $y(k)$: output value

4.2. Support Vector Machine (SVM):

Support vector machines are supervised learning model used for classification and regression analysis. It is a widely used classifier in bioinformatics. Support vector machine construct an optimal hyper plane $w^T x + b = 0$ in higher dimension future space, which can separate data from opposite classes using the maximum possible margin. Margin is a distance between optimal hyper-plane and a vector (instance) which lies closest to it.

Classification is done using the decision function given by $f(x) = \text{sign}(w^T x + b)$, where x denote the test data variables, w and b are coefficients of a plane.

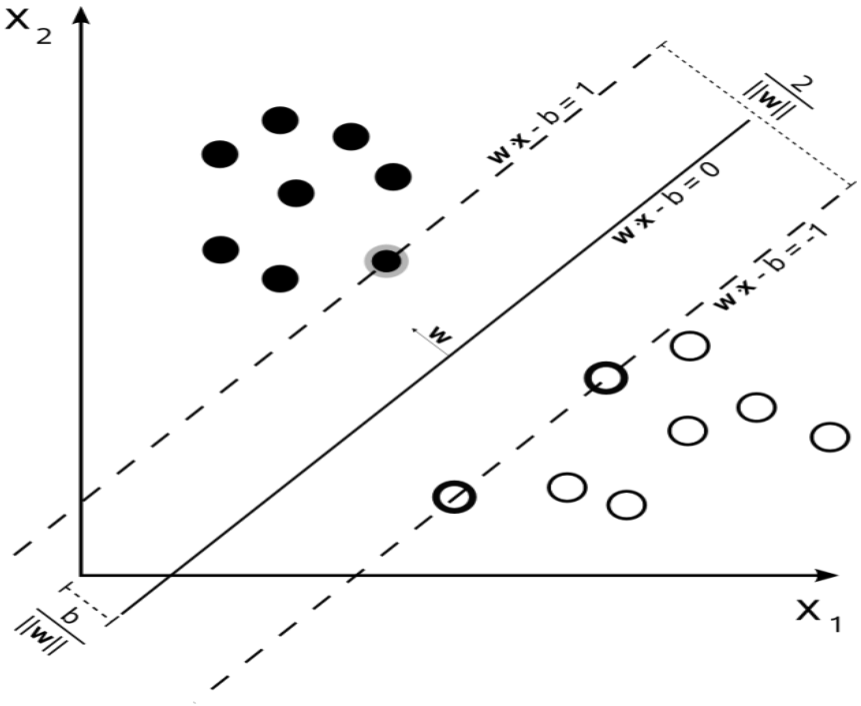

Figure 2. Maximum-margin Hyperplane, (Samples (Instance) on the Margin are Called the Support Vectors)

For each training example (x_i, y_i), $i = 1, 2, \ldots m$, separating hyperplane has to provide the following conditions for both classes.

$$\left(w^T x + b\right) \geq 1, \quad y_i = 1,$$

$$\left(w^T x + b\right) \leq -1, \quad y_i = -1, \quad \text{where} \quad i = 1,2,..., \quad m$$

The distance between $\left(w^T x + b\right) = 1$ and -1 is 2/||w||, which is to be maximize

To make algorithm work for non-linearly separable datasets as well as be less sensitive to outliers, optimization problem is formulated as:

Minimize $\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{m} \xi_i$, where *C* is a positive constant parameter used to control the

tradeoff between complexity and classification accuracy.

In this case each separating hyper plane has to satisfy the conditions:

$$\left(w^T x + b\right) \geq 1 - \xi_i, \quad y_i = 1,$$

$$\left(w^T x + b\right) \leq -1 - \xi_i, \quad y_i = -1,$$

$$\xi_i \geq 0, \quad \text{where} \quad i = 1,2,..., \quad m$$

By introducing Lagrange's Multiplier, and by making appropriated substitutions, dual optimization problem of the above formula is:

Maximize $\sum_{i=1}^{m} \alpha_i - \frac{1}{2}\sum_{i,j=1}^{m} \alpha_i \alpha_j y_i y_j (x_i, x_j)$

subject to $\sum_{i=1}^{m} \alpha_i y_i = 0, \ \alpha_i \geq 0, \forall i$ and the decision function is

f(x) = sign($\sum_{i=1}^{m} \alpha_i y_i (x_i, x_j) + b$) where, $\text{sign}\,(x) := \begin{cases} -1, & \text{if} \quad x < 0 \\ 0, & \text{if} \quad x = 0 \\ 1, & \text{if} \quad x > 0 \end{cases}$

SVM is not optimal for hyper plane construction in the input space but rather in high-dimensional so called feature space Z. Using a kernel function to substitute the dot product of data points can construct an optimal separating hyper plane in a higher dimensional space. So, the decision function is formulated as

f(x) = sign($\sum_{i=1}^{m} \alpha_i y_i (x_i, x_j) + b$), where k is kernel function.

The most popular used kernel function is Radial Basis Function(RBF):

Given by: $k(x, x') = \exp\left(\frac{-\|x - x'\|^2}{\sigma^2}\right)$ where σ is a positive real number.

Polynomial kernel is also popular kernel which is defined as:

$k(x, x') = ((x, x') + c)^d$, where, d is the degree of the polynomial , $c \geq 0$ is a free parameter trading off the influence of higher-order versus lower-order terms in the polynomial.

Both these kernels are mercer's kernels [2].

5. Experimental Setup and Implementation Process

The Neural Network is designed and implemented using the MATLAB 14 with Neural Network toolbox. In ANN the popular Back propagation (BP) learning algorithm used where gradients can be computed efficiently by propagation from the output to the input. The network is created using newff () matlab inbuilt function. Activation function is 'logsig'. Training is done using Levenberg -Marquardt algorithm. Results are taken using 1 hidden layer and 2 hidden layers. Results are finalized after taking averages of 50 trials.

In support vector machine, classification was done using LIBSVM 3.20 with MATLAB interface. We have used RBF kernel and Polynomial kernel for classification. To decide parameters we have used 10 fold cross validation.

For both classification models, we have calculated confusion matrix and using this matrix we have determined number of true positives (TP), false positives (FP), false negatives(FN) and True negatives(TN). Accuracy is an important evaluation for assessing the classification accuracy of any classifier. The accuracy of a classifier is given by,

$$\text{Accuracy} = \frac{(TP + TN)}{(TP + FP + FN + TN)}$$

But, for imbalanced data, a model can predict the value of the majority class for all predictions and achieve high classification accuracy. So, it is required to evaluate a classifier using F-scores which balance between precision (the proportion of the predicted positive cases that were correct) and recall (the proportion of positive cases that were correctly identified).

$$\text{F-Score} = \frac{2 * (\text{Precision} * \text{Recall})}{(\text{Precision} + \text{Recall})} \text{ where,}$$

$$\text{Precision} = \frac{TP}{(TP + FP)} \text{ and Recall} = \frac{TP}{(TP + FN)}$$

6. Results and Discussion

The below tables & plots represent the result obtained from both classifiers ANN and SVM. To evaluate the performance of the classifiers, the dataset described earlier is randomly divided into 80-20% and 70-30% partitions, *i.e.*, 80% and 70% data for training and 20% and 30% for testing respectively.

Table 2. Performance Results for 70-30% Training-Testing Data Partition

		Accuracy	F-score
ANN	1-hidden layer	95.82%	0.9359
	2-hidden layers	96.23%	0.9423
SVM	RBF Kernel	94.04%	0.9078
	Polynomial Kernel of degree 3	92.71%	0.8865

Table 3. Performance Results for 80-20% Training-Testing Data Partition

		Accuracy	F-score
ANN	1-hidden layer	96.20%	0.9419
	2-hidden layers	97.17%	0.9570
SVM	RBF Kernel	93.15%	0.8936
	Polynomial Kernel of degree 3	93.15%	0.8865

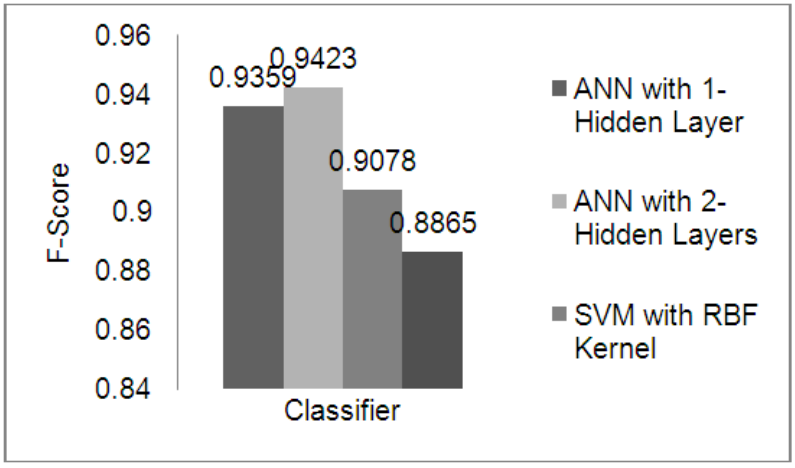

Figure 3. F-Score for 70-30% Data Partition

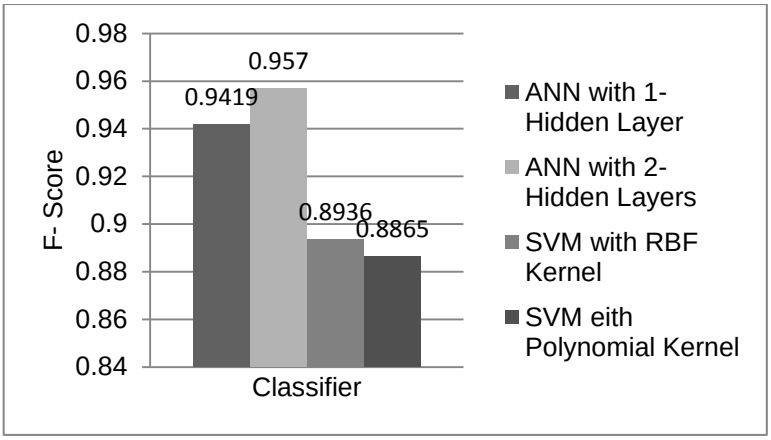

Figure 4. F-Score for 80-20% Data Partition

7. Conclusion

From the studies it has been found that the traditional classical gradient-based learning algorithm which uses artificial neural network may face several issues like local minima, improper learning rate and over fitting *etc*. But from the observations it may be inferred that the performance of ANN is more accurate for two hidden layers than SVM with RBF kernel for our data set. Its behavior is still to be tested against other transfer functions and network parameters like number of hidden layers, number of nodes in each hidden layer, changing learning rate parameter and bias. The future scope of the proposed work is still open to analyze the effect of number of feature attributes and predicting attributes and how it behaves towards the sequential dataset. The features having fuzzy values or missing values in the data set can also be taken up as the future plan of study.

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