Efficiency Comparisons of Various Ann-Based and Svm-Based Techniques for Classification Problems: A Review

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Abstract
Both Artificial Neural Networks (ANN) and Support Vector Machines (SVM) are one of the best choices for performing the classification task. These techniques are backed with ample of algorithms for regression and classification work. Still, there is a great demand to analyze the applicability of their algorithms so that more refined and appropriate techniques could be used for empirical data analysis. This work may be considered as a noble attempt to check the efficiency of few popular algorithms used by ANN and SVM and finally give a proper justification of the studied algorithms for future scholars. [1]It was found that the previous research that uses SVM methods without feature selection with those SVM methods which uses feature selection based algorithm of SVR (Support Vector Regression) in terms of root mean square error and co-efficient error. K-means clustering is also confidently used by researchers for classification. [2]In the study it was also observed that for calculating the variance, it is good to find the hamming distance between the binary data before clustering process. [2]Moreover, by using the selection feature process, the dimension size of dataset was also reduced.

I. INTRODUCTION

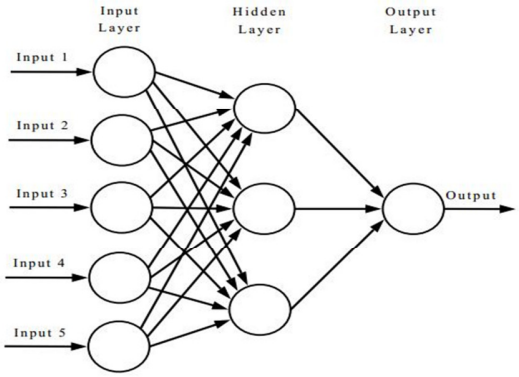
There is an immense need to perform empirical comparisons of back-propagation ANN and SVM based models for fruit grading analysis. In this work we will look into some research work already done and conclude with the results in terms of the degree of their efficiency. The objective is to provide the opportunity to its concerned users to classify their fruits more accurately and also in speedy manner. In this study, author wants to explore the work in this demanding field where artificial intelligence, more specifically BP-ANN and SVM, may be implemented successfully for fruit grading analysis in better way.

The objective of this work is to do review of literature from various sources such as research papers presented in conference, published in reputed journals, articles published, various periodicals and from books on related issues. Further, performance based comparison between the ANN and SVM based work will be conducted, which is the objective of the study. Finally, an empirical analysis will be made in between ANN and SVM and inference will be given as a result which will help the researcher to select the best algorithm towards their work. Needless to say that ANN is not in its infancy stage for developing strategies specially in the area of regression and classification. Still, there is lot of work to explore in this area. There are very interesting features which ANN based algorithms provide and are also usefulness for solving the classification problems. In ANN model there are three layers and are related as depicted in the diagram below:

Few of the capabilities of the ANN which must be considered as important factors for selecting ANN are:

1.1 Non-linearity:

Interconnection of neurons is not linear, but it is massively parallel. That is the only reason that human mind is very capable in quick applying reasoning and in a very short span of time. Non-linearity is distributed throughout in the artificial neural network.



1.2 Input-Output Mapping:

The learning in the ANN is considered as to 'learning with a teacher'. It has predefined set of output in advance and input is processed towards these outputs, which results in a classification research. Here, ANN is devised as teacher to monitor the characteristics of the object being processed and reverts back with which class it belongs to.

1.3 Adaptability: ANN is devised such a way that it can adapt free parameters. Free parameters are those

parameters which hardly belong to the early defined category of classification. In other words, ANN can easily adapt the changes in the surrounding environment.

1.4 Evidential Response: The result of the classification provided by the ANN can be measure with confidence. One need to be very clear while classifying the result classes and if the classes are clearly segregated, there is no or exponentially low probability of misclassification in the system. So, the response of the ANN is evidential.

1.5 Fault Tolerance: In ANN, once defined, there is very less human intervention. Resultantly, the fault tolerance in the system is gracefully degraded.

1.6 VLSI Implementable: ANN is VLSI level implementable as it has neurons as the smallest unit. Further various networks among these networks are developed and we look for patterns of these networks as a teacher. Thereafter, we classify the outcomes into various classes as final output. Also, those outputs which do not belong to any of the defined classes are called as error.

1.7 Neurobiological Analogy: In biology the neurons are of high degree of capability that gain experience by learning. In the same manner, the artificial neural networks are trained and their functioning is mirrored with the biological neurons. As in biological neurons apical dendrites. These inputs also known as synaptic inputs are further processed in cell body and these cells are connected with a set of outputs which is known as synaptic terminals.

In biological neurons, if the response is different from one that is desired, then naturally we have to adjust the internal parameter of nerve cells. It may also be happen that we may actually not be able to reach to actual response. Here in case of ANN, the researchers have to develop such equivalent of synaptic inputs to adjust the free parameters for matching the desired outputs. Synaptic weight represents the strength of connection in ANN.

2 USEFULNESS AND CAPABILITIES OF SUPPORT VECTOR MACHINES

Support vector machine without kernel is like a single neural network but with different cost function. SVM was originally designed for classification and regression jobs and later other areas were included in it. However later has expanded in another directions. The following

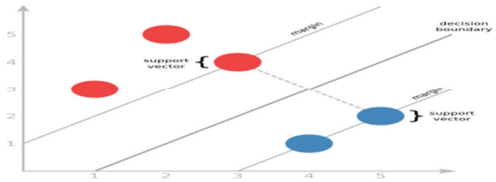


diagram depicts the case where optimal hyperplane is drawn between two classes

Figure: Support vector machine and decision boundary

Essence of SVM method is construction of optimal hyperplane, which can separate data from opposite classes using the biggest possible margin. Margin is a distance between optimal hyperplane and a vector which lies closest to it. SVM has the following features:

2.1 Kernel: If data is linear, a separating hyper plane may be used to dividing data into classes. However it is often the case that the data is far from linear and the datasets are inseparable. To allow for this kernels are used to non-linearly map the input data to a high-dimensional space. The new mapping is then linearly separable. This illustration is given in below figure where three types of kernels are mentioned.

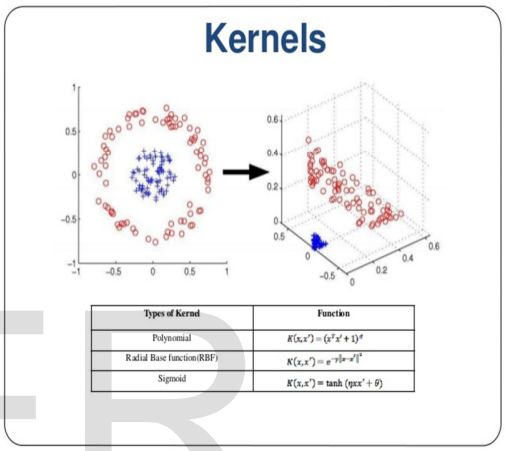


Figure: Kernal in SVM

2.2 Kernel functions: Kernal plays as vital role in SVM classification strategy. It has the following functions which helps in regression and classification tasks better as compared to ANN:

2.2.1 Polynomial: This kind of mapping is one of the popular strategy for non-linear modeling. The second kernel is usually preferable as it avoids problems with the hessian becoming Zero given below:

$$K(x,x') = (x,x')^d$$
$$K(x,x') = ((x,x')+1)^d$$

2.2.2 Gaussian Radial Basis Function: The following radial basis functions is used with a Gaussian form:

$$K(x,x') = \exp(-(\|x-x'\|^2)/2^2)$$

***2.2.2.1 Multi-Layer Perceptron*:** The long established MLP, with a single hidden layer, also has a valid kernel representation.

2.2.2.2 Controlling Complexity in SVM: Trade-offs

SVM is powerful to approximate any training data and generalizes better on given datasets. The complexity in terms of kernel affects the performance on new datasets [8]. SVM supports parameters for controlling the complexity and above all SVM does not tell us how to set these parameters and we should be able to determine these Parameters by Cross-Validation on the given datasets.

2.2.2.3 SVM for Classification

SVM is a useful technique for data classification. Even though it's considered that Neural Networks are easier to use than this, however, sometimes unsatisfactory results

are obtained. A classification task usually involves with training and testing data which consist of some data instances [21]. Each instance in the training set contains one target values and several attributes. The goal of SVM is to produce a model which predicts target value of data instances in the testing set which are given only the attributes.

2.2.2.4 SVM for Regression

SVMs can also be applied to regression problems by the introduction of an alternative loss function [8] [17]. The loss function must be modified to include a distance measure. The regression can be linear and non-linear. Linear models mainly consist of the following loss functions, e-intensive loss functions, quadratic and Huber loss function. Similarly to classification problems, a non-linear model is usually required to adequately model data. In the same manner as the non-linear SVC approach, a non-linear mapping can be used to map the data into a high dimensional feature space where linear regression is performed.

2.2.2.5 Strength and Weakness of SVM:

Excluding the other strengths and weaknesses of support vector machine, the major strengths of SVM is that the training in SVM technique is relatively easy as compared with ANN. It also has no local optimal which is not the case with neural networks. It scales relatively well to high dimensional data and the trade-off between classifier complexity and error can be controlled explicitly. The weakness includes the need for a good kernel function.

3 K-NEAREST NEIGHBORS ALGORITHM

The closest neighbor rule is used to classify the unknown data point based on the closest neighbor in a known class. M. Cover and P. E. Hart purpose k nearest neighbour (KNN) in which computation is done on the basis of estimation of k which indicates the number of nearest neighbor which are to be considered for classification. KNN utilizes more than one neighbor which are nearer to determine the class in which the given data point belongs to. These data samples are also termed as memory-based techniques. This algorithm is also very useful to do classification task.

4 DETAILED WORK ANALYSIS ON ANN BASED MODELS

In this section we have shown some of the relevant work done in the area of ANN and SVM. It will guide us to know-how of the strategies of ANN and SVM and will develop a good knowledge base. Out of various papers studied, following papers are given the higher importance as they are closely related to the research area in which we want to explore further. The detail of the paper is given below:

The paper entitled "An analysis of the performance of Artificial Neural Network technique for apple Classification" was studied in detail. The detailed analysis of the paper is given in this section. This work aims to develop ANN-based apple classifier. The system has two modules. In the first module the surface level parameters from the different sources was collected. Visual Basic programming language is used for this level and uses web camera, weighing machine etc. In the second module, ANN simulator was used to classify the apples based on variations in the apple characteristics. This paper shown the excellent agreement between the experimental data and produced output. Error prediction was very low and it has been observed that the ANN model is an effective instrument of the apple quality estimation. Even, there was very low misclassification cases occurred. The work was an alternative method for quality assessment of apple and consumers may be provided a better and safer food supply using is.

5 METHODOLOGY USED IN THIS WORK

The methodology used in this work is described in this section. The web camera is used to extract the features like color, damage, size etc. Data input captured was under the controlled light to avoid noise. The weight machine is used input the apple weight. Then a visual basic program was developed for refining the extracted information such as volume, colors viz. red, green and blue. Bad spots and density of the fruit. Then the results are stored in excel sheet. Next, an ANN-based system was developed for classification purpose for which the inputs were taken for the excel sheet as a pre-processor sub-system in the first phase.

5.1 The Detail

To go into the detail, total of 159 apples were taken for the training sample. After undergoing with the proper training the confusion matrix gives the result as shown in table below. The classifier performs very good result for grade A categories (100 % recognitions), while for the grade B, C, and D, the accuracy is 97.5, 73.8, and 92.1 %, respectively. The overall performance is 90.6 % and overall error is 9.4 %. There is no confusion in grading A category, while the maximum misclassification occurs in category C (26.2 %). The overall confusion is only 9.4 %; it means only 9.4 % apple are misclassified during training. Ultimately, we can say that the network is classifying apple with minimal error during training.

Table: Confusion matrix of the best multi-category apple grading result during training[37]

Categories	A	B	C	D
A	39	1	0	0
B	0	39	5	0
C	0	0	31	3
D	0	0	6	35
Apple	39	39	31	35
Accuracy (%)	100	97.5	73.8	92.1
Overall Accuracy (%)	90.6			

Three performance criteria, namely MAPE, RMSE and MSE, were used to find out the ANN's performance. They were used in this study to select the best network structure. These criteria are given below:

MSE = 1/n * [Actual-Forecast]]2
MAE = abs(Actual-Forecast]/n
RMSE = SQRT(MSE)

For doing training, validation, and testing authors have considered 199 apple as a sample. Table below displays the overall confusion matrix. The results performed by the ANN classifier was very good especially for grade A and B categories which was 100% and 98 % recognitions respectively.

Table: The magnitude of classification errors[38]

	Samples	MSE	%E	RMSE
Training	159	3.87160e-2	9.43396e-0	0.1968
Validation	20	4.57759e-2	10.0000e-0	0.2140
Testing	20	1.12183e-2	0	0.1059

The below table shows the overall confusion matrix shows the overall performance is 91.5 % and error only 8.5 %. Ultimately, we can say that the network is classifying apple with minimal error.

Table: Neural Network train, test, and validation performance[38]

Graded in	**A**	**B**	**C**	**D**
A	50	1	0	0
B	0	49	5	1
C	0	0	37	3
D	0	0	7	46
Apple	50	49	37	46
Accuracy (%)	100	98	75.5	92
Overall Accuracy (%)	**91.5**			

6 Conclusion of the work

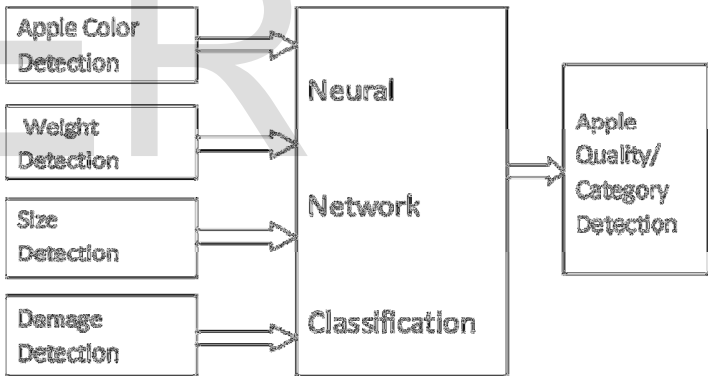
After analyzing this paper it was observed that the author has used the ANN classifier wisely specifically SCG technique using neural network model architecture. The results were also good and the system is also automatic. The work also illustrates that using ANN provides an inexpensive and easy technique for the assessment of apple category which results in quality too. Training of the ANN is found very efficient which confirmed by zero differences between results obtained in the test series. Negligible misclassification was found during the testing process. The overall performance is also found good. As per the method given in this paper, the Artificial Neural Network can be used for the classification of many other fruits in the agree-food industry in future.

The work "Automatic apple grading model development based on back propagation neural network and machine vision, and its performance evaluation" was published in 2015 which also uses ANN as classifier. It introduces a new classification system which works in real time. The classification of apples were based on physical parameters such as size, color, defect, external surface level defects etc. The authors have developed a specific hardware subsystem. The hardware subsystem is interfaced with the software to make the whole system automatic. The aim of this work is to develop an automatic apple classifier. Back Propagation ANN algorithm was used in this work. It uses two set of variables which are the set of independent variable used for surface level apple quality parameter and the set of dependent variable which is the quality of the apple. The works done was remarkable as it has various advantages such as high determination coefficient, very good performance, fewer parameters, shorter calculation time and lower prediction error. The accuracy achieved in the classification was high which results that neural network is capable of making such classification. The errors were too negligible.

7 Methodology used in this work:

The methodology is classified into two phases. In the first phase, to proper start, the in-depth survey of fruit quality assessment techniques in India and abroad was carried out. Its helps in standardizing the parameters and equipment to be used in the process used in this work.

Figure: Apple classification stages



The main emphasis is given to the use of low-cost components and processes as shown above. Various algorithms were studied for doing the above processing in the current work.

8 The detail

This work is about the initial level development of a system of neural network classification models. This model has been developed for assessing the quality of apple. The attention has been focused on developing methods to
minimize waste and to detect apple quality. This work enhanced the apple grading system by adding features such as increases the speed of sorting and eliminates human error in the apple grading process.

9 Input data

In this work, the most important quality parameters employed in subjective apple inspection can be easily and

rapidly measured. The most important physical parameters identified for grading fresh apple are color, size, damage and weight. Paper also describes the previous work done by many authors based on image analysis to estimate the external features of the fruits such as size (Tao et al. 1990; Varghese et al. 1991; Okamura et al. 1991; Sarkar and Wolfe 1985), shape (Guyer et al. 1993; Dickson et al. 1994), color (Alchanatis et al. 1993) and skin defects (Growe and Delwiche 1996; Miller and Delwiche 1991; Molto´ et al. 1996).

Table: Results obtained by ANN for apple classification[38]

	Samples	MSE	%E	RMSE
Training	159	1.55169e-2	1.24567e-2	3.77358e-0
Validation	20	2.50421e-2	1.58247e-2	5.00000e-0
Testing	20	1.78720e-2	1.33686e-2	0

10 Conclusion of the work:

The system developed in this research has demonstrated its ability to achieve the objectives proposed. The automatic
sorter has 96 % accuracy during overall confusion matrix. This automated analysis for quality assessment of apples using ANN will serve as the pilot project that will be further extended on a larger scale. Apart from apple, this research becomes the role model for classifying other fruits and vegetables. This development will accelerate the growth of the quality assessment of other fruits and vegetables. So it will be helpful in higher earning for other fruits and vegetables also.

Conclusion

The naked eye defect detection is no more appreciable these days. Such detection usually requires continuous monitoring, which is time consuming and very expensive on large scale. Therefore, some automatic expert system is needed to minimize the human intervention and maximize the quality classification by seeking rapid, automated, economical, and accurate methods of fruit classifications. Supervised pattern recognition aims to establish a classification model based on experimental data in order to assign unknown samples to a previously defined sample class based on its pattern of measured features. In a broader sense, two techniques are popular in classifying the fruits first is Artificial Neural Network (ANN) and the second is Support Vector Machine (SVM). Even there are various fruit classifier available for classification of fruits but it is a difficult challenge to pick the best algorithm which may either be based on ANN or SVM. No doubt, both the Back Propagation-ANN and the SVM are effective tools that support the process of perfect identification of fruits and finally give the best fruit classifiers in their area.

This paper reviewed the potential of ANN with that of SVM and results in opting out that which is more effective tool and where. In both cases, the classification accuracy achieved is high, showing both techniques are capable of making such classification.

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