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FAKE CURRENCY DETECTION USING IMAGE PROCESSING AND DEEP LEARNING

Dr.M.Aravindkumar Professor, Department of CSE, West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. drmaravindkumar@gmail.com
D. Haritha, Assistant Professor, Department of CSE, West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. haritha.darisi@gmail.com
M.Chilakaiah, Assistant Professor, Department of CSE, West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. m.chilakaiah@gmail.com
J.Sri Mahalakshmi, Assistant Professor, Department of CSE, West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. Jagu.mahalakshmi@gmail.com
B.Pujitha, Student of CSE Department, 19PD1A0504,West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. pujitha.bandi305@gmail.com
Y.Eswara Lakshmana Kumar, Student of CSE Department, 19PD1A0546, West Godavari Institute of Science and Engineering,Affliated to jntuk, AndhraPradesh,India. eswarayyamalla@gmail.com

Abstract
The one important asset of our country is Bank currency and to create discrepancies of money miscreants introduce the fake notes which resembles to original note in the financial market. In general, by a human being, it is very difficult to identify forged note from the genuine not instead of various parameters designed for identification as many features of forged note are similar to original one. To discriminate between fake bank currency and original note is a challenging task. So, there must be an automated system that will be available in banks or in ATM machines. To design such an automated system there is need to design an efficient algorithm which is able to predict weather the banknote is genuine or forged bank currency as fake notes are designed with high precision.

Keywords –Support Vector Machine, Bank currency, Supervised Machine Learning

1. INTRODUCTION

Financial activities are carrying out in every second by many persons in which one most important asset of our country is Banknotes [3]. Fake notes are introduced in the market to create discrepancies in the financial market, even they resemble to the original note. Basically they are illegally created to complete various task [12]. In 1990 forgery issue is not much ofconcernbutasinlate19thcenturyforgeryhasbeenincreasing drastically [13]. In 20thcentury technology is increasing very vastlythatwillhelpthefraudstogeneratefakenotewhoseresemblance is like genuine not and it is very difficult to discriminate them [1]. This will lead to financial market to its lowest level. To stop this and to conduct smooth transaction circulation forged bank currency must be conserved [16]. As a human being it is very difficult to identify between genuine and forged bank currency. Government have designed banknote with some features by which we can identify genuine [9]. But frauds are creating fake note with almost same features with niceaccuracythatmakeitverydifficulttoidentifygenuinenote [5]. So, now a days it is required that bank or ATM machines must have some system that can identify the forged note from the genuine note [12].

To determine the legitimacy of the banknote artificial intelligence and Machine learning(ML) can play a vital role to design such a system that ca identify forged note from the genuine bankcurrency[6,7,12].

Now a days, supervised machine learning (SML) approaches for classification problem is widely used. For medical disease its shows even promising results [2]. Few authors have only applied SML algorithms on bank currency authentication [6-9, 12]. To identify weather a note is genuine or fake we have to develop an automation system. Initially, the input is an image of note and from different image processing techniques we can extract the features of note. Further these images are given as an

input to the SML algorithms to predict whether note is original or fake. In review we can see that not much of work is done on this side.

Contribution of the paper: First we have visualized the dataset taken from UCI ML repository using different types of plotting, pre-processed the data. Further, SML algorithms Logistic regression (LR), Naive Bayes (NB), Decision tree (DT), Random tree (RT), KNN, SVM are applied on the data set which contains the features extracted from the bank currency to classify them as whether it is original or not. For analysis of their result, we have applied SML algorithms on dataset with three different train test ratio and their results are compared on the basis of different SML algorithms standard evaluation parameters like MCC, F1 Score, NPV, NDR, accuracy and others.

In section II literature review of papers is discussed followed to that in Section III description of dataset is given.

Further Results of various classification algorithms are analysed on the basis of standard quantitative analysis parameter and Conclusion are drawn in Section IV.

2. RELATED WORK

In this section, review of some papers is discussed those applied machine learning approaches to classify whether not is original or not. Yeh et. al. implemented SVM based on multiple kernel to reduce false rate and compare d with SVM (single kernel) . To classify real and forged network. Author's Hassanpour et. al. used texture based feature extraction method for the recognition and to model texture Markov chain concept is used. This method is able to recognize different countries' currencies [5]. To classify whether the note is forged or not global optimization algorithms are applied in Artificial Neural Network (ANN) training phase, and they have observed good success in classification of note [8,11]. Decision tree and MLP algorithms are used to classify the bank currency in [7]. Further multi-classification was done using wavelet for feature extraction by [4] BPN and SVM machine learning algorithms are used to classify the bank currency and it's found that BPN is giving more accuracy than SVM. [6,]. In [2] for the counterfeit type of currency notes classification is done using segmentation for the feature extraction based on different regions of the note

3. PROPOSED FRAMEWORK

Fake currency is serious issue worldwide, affecting the economy of almost every country including India. The counterfeit currency is one of the major issues faced throughout the world nowadays. The counterfeiters are becoming harder to track because of their use of highly advanced technology. One of the most effective methods to stop counterfeiting is the use of counterfeit detection software that is easily available and is efficient. The background of our topic is image processing technology and apply it for the purpose of verifying valid currency notes. The software will detect the fake currency by extracting features of notes. The success rate of the software can be measured in terms of accuracy and speed. So our aim is to work on those parameters which will be impossible to implement on counterfeit notes so we started working on parameters which will be enough to differentiate between fake and original n

4. EXPERIMENTAL RESULTS

4.1 Description of data set and results of machine learning algorithm for prediction of forged and genuine bank currency.

Description of dataset: Dataset is taken from machine learning repository of UCI to train the models [18]. The features of data is extracted from the forge and genuine images of banknote. Total instance in dataset are 1372 and 5 attributes are present. In dataset 4 are the features and one is target. The dataset is divided into two classes forge and genuine, ratio (55: 45 percent) of both the classes are balanced. Two values are present in the target attribute i.e., 0 and 1 where 1 represent the fake note and 0 is represented as genuine note.
In this section, results of various SML algorithm is discussed in detail. SVM, LR, KNN, DT, RF and NB is applied on bank currency authentication data to classify whether the note is genuine or forge. To accomplish this task three train test ratio are considered 80:20, 60:40, 70:30 and further above algorithms are applied to test their accuracy and to also derive various other quantitative analysis parameter for evaluation of the ML models performance.
The following results are observed after applying various SML algorithm:

A SML algorithms description with the ROC and Learning curves to measure accuracy for train test ratio 80:20.

SVM: It is SML model to classify the data on the basis of pattern recognition. To separate the two classes a decision boundary is created in the data. Dataset items are plotted on the graph then classification is performed for differentiating the two classes using hyperplane concept. Kernel function is used to convert in linearly separable data from the non-linearly separable data. For less number of features linear kernel is used for classification and number of large test cases [6]. SVM is applied on dataset by considering three different train test ratio (80:20, 60:40 and 70:30) to predict whether the bank currency is forge or genuine. For train test ratio 80:20 ROC curve and learning curves are drawn. From Fig. 1. Accuracy of SVM is observed around 98% see Fig.1

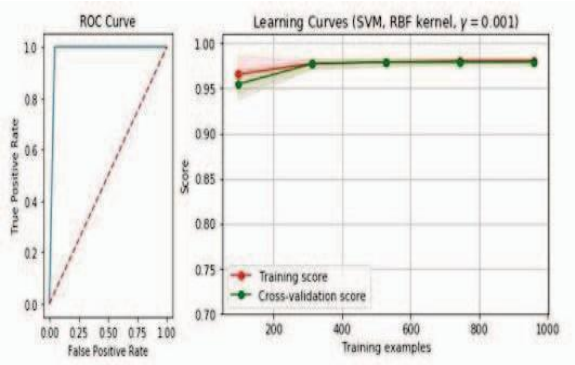

Fig.1SVMROCandLearningcurvefortraintestratio 80:20.

LR: It is a SML model that is very commonly or widely used for the classification. Performance of LR model for linearly separable classes is very well and even easy to implement. Specially, in industry it is most commonly used. In general LR is used for binary classification as it is a linear model but using technique OvR it may be used for classification of multi class [9]. LR is applied on dataset by considering three different train test ratio (80:20, 60:40, and 70:30) to predict whether the bank currency is forge or genuine. For train test ratio 80:20 ROC curve and learning curves Accuracy of LR is observed around 98%
DT: It is a classification model having a structure like a tree. DT is incrementally developed by breaking down the data set into smaller subsets. DT results is having two types of nodes Decision

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nodes and leaf nodes. For an example consider a decision node i.e., Outlook and it have branches as Rainy, Overcast and Sunny representing values of the tested feature. Hours Played i.e., a leaf node it gives the decision on numerical targeted value. DT can handle both numerical as well as categorical data [8]. DT is applied on dataset by considering three different train test ratio (80:20, 60:40, and 70:30) to predict whether the bank currency is forge or genuine. For train test ratio 80:20 ROC curve and learning curves are drawn. See Fig.2 Accuracy of DT have been observed around 99% see Fig. 2.

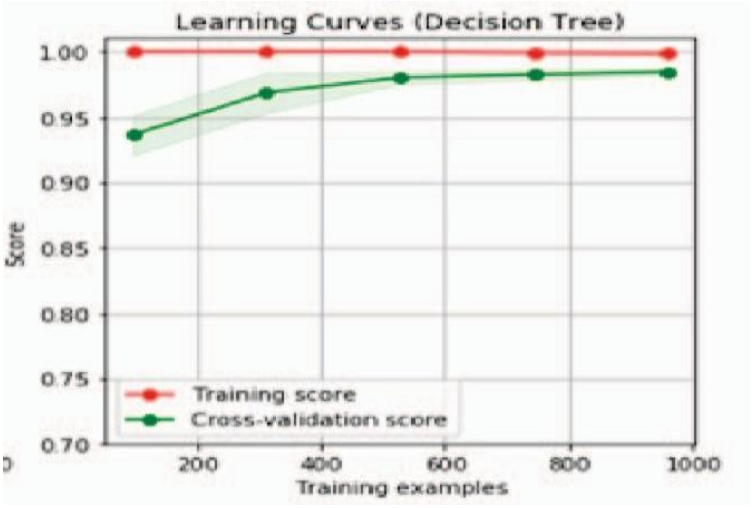

Fig.2DTROCandLearningcurvefortraintestratio80:20.

NB:NBisaclassifierinwhichclasslabelsareassignedtothe probleminstancesthatarerepresentsasfeaturevaluesvector andwhereasfinitesetareusedtoderivetheclasslabel

Evaluation Parameter to measure performance of SML algorithm:

To evaluate the efficiency and to analyze which classification algorithm performs better.Quantitative analysis can be done for Machine Learning algorithms on the basis of various evaluation parameter like Accuracy, Recall, F1-score, etc. parameter to identify. All the evaluation parameter that are used to determine the efficiency of classification algorithm are measured through Confusion matrix (CM). CM is used to determine thesemeasures:

TABLE I. CONFUSION MATRIX

		Predicted/Classified	
		Negative	**Positive**
Actual	**Negative**	True Negative	False Positive
	Positive	False Negative	True Positive

Analysis results of Machine Learning Algorithm

Inthissubsectionthreedifferenttraintestratioisconsidered80:20.60:40and70:30.Foreachtraintest ratio we have applied six machine learning algorithm SVM, LR, NB, DT, RF and KNN on dataset to identify whether the Banknote is genuine or forged. And to measure the performance of these algorithms quantitative analysis parameter are considered discussed in detail in section3.2.1.

To visualize all evaluation parameter and their performance for six different t machine learning algorithms.

TABLE II. EVALUATION PARAMETER VALUE OF SVM, LR, NB, DT, RF AND KNN FOR TRAIN TEST RATIO 80:20.

80:20	SVM	LR	KNN	DT	RF	NB
Specificity	1	0.99	1	0.99	0.99	0.81
Sensitivity	0.97	0.98	1	0.99	0.99	0.86
Accuracy	0.98	0.98	1	0.99	0.99	0.84
Precision	0.98	0.98	1	0.98	0.98	0.83
FPR	0.032	0.024	0	0.018	0.008	0.044
FNR	0	0.01	0	0.01	0.02	0.032
NPV	1	0.99	1	1	0.99	0.83
FDR	0.026	0.019	0	0.022	0.01	0.209
F1- Score	0.99	0.99	1	0.99	0.99	0.69
MCC	0.97	0.97	1	0.99	0.98	0.687

Now, second train test ratio 60:40 is selected and machine learning algorithm SVM, LR, NB, DT, RF and KNN are applied on data set of Bank currency. To evaluate the performance of these algorithm Section III*B* evaluation parameters are considered. For train test ratio 60:40 highest accuracy is seen in Decision

TABLE III. EVALUATION PARAMETER VALUE OF SVM LR,NB, DT, RF ANDKNN FOR TRAIN TEST RATIO 60:40.

60:40	SVM	LR	KNN	DT	RF	NB
Specificity	0.997	0.995	0.9967	1	0.99	0.8
Sensitivity	0.98	0.98	1	0.99	1	0.858
Accuracy	0.98	0.98	0.9981	1	0.98	0.833
Precision	0.99	0.99	0.9959	1	0.99	0.83
FPR	0.02	0.02	0.004	0.01	0.09	0.099
FNR	0.006	0.003	0.0032	0	0	0.11
NPV	0.99	0.99	1	1	1	0.8
FDR	0.016	0.016	0.004	0.01	0.01	0.18
F1- Score	0.99	0.99	0.9979	0.99	0.99	0.67
MCC	0.97	0.97	0.9963	1	0.98	0.66

Lastly we have taken 70:30 train test ratio to measure the accuracy and the performance of SVM, LR, NB, DT, RF and KNN machine learning algorithms on bank currency datasetfor the prediction whether the note is genuine or forged. From Table IV we have observed that KNN algorithm is giving the highest accuracy and also the MCC value for KNN is nearer to 1.

TABLE IV. EVALUATION PARAMETER OF SVM, LR, NB, DT, RF AND KNN FOR TRAIN TEST RATIO 70:30.

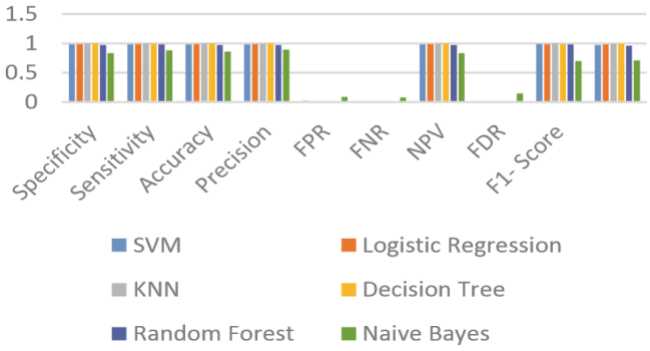

Fig .3 Histogram Graph on Evaluation Parameter value of SVM, LR, NB, DT, RF and KNN for train test ratio 70:30

5. CONCLUSION AND FUTURE WORK

In this study, there are several things that can be concluded from the results of machine learning using Error Level analysis [6] and Convolutional Neural Network.

1. Convolutional neural network uses two convolutional layers, one MA Pooling layer, one fully connected layer, and one output layer with SoftMax that can achieve above better accuracy.
2. The use of error level analysis can increase efficiency and reduce the computational costs of the training process. This can be seen from the reduction in the number of layers from the previous method [7] and the number of epochs needed. In the proposed model, the number of epochs needed to achieve convergence is only 9.

FUTURE SCOPE

- In future we will try to include all the security features of currency by employing suitablestructural design and with suitable training data.
- And Mobile app can be developed which would be useful for normal as well as visually impaired persons, the same system can be developed for the remaining Indian currency notes and other countries currency notes.

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