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Review on Detection of Fake Currency using Image processing Techniques

Dr. S. V. Viraktamath, Kshama Tallur
Dept. of Electronics and Communication Engineering
SDM College of Engineering and Technology
Dharwad, India.

Rohan Bhadavankar, Vidya
Dept. of Electronics and Communication Engineering
SDM College Of Engineering and Technology
Dharwad, India.

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***Abstract*— Many countries are affected by the matter of fake notes. Indian is one among them. With the improved technology, anyone can print fake notes. These notes are produced without legal sanction of the state and continues production of such kinds of notes can degrade countries economy. When such counterfeited notes are produced and circulated, it becomes impossible for ordinary citizens to distinguish whether the money is real or fake because they differentiate according to physical appearance. The biggest challenge for many countries like India is the detection of fake currency. Even if banks and other big organizations have automatic machines designed to identify counterfeit currency notes, ordinary people can hardly differentiate between them. Nowadays recognition of fake currency has become challenging issue for many researchers. The identification involves many steps like edge detection, feature extraction, image segmentation, image acquisition, grayscale conversion, and comparison of images. This paper provides some related works of paper-currency recognition and has explained the spread of various currency recognition systems. Choosing the right feature would improve overall system performance. The goal of this work is to review previous papers and literature, identify the benefits and disadvantages of every method.**

Keywords—Fake currency detection, Image Processing, Matching Techniques.

I. INTRODUCTION

In today's new digitalization environment, people are bounded by technology, and that technology is rapidly developing. Of course, such inventions make life much easier for us. People can now complete their tasks with minimal effort, which is possible due to technological advancements. However, some people are abusing the benefits of such technologies to achieve their nefarious goals. There are numerous examples of this kind all around us. One of the most prominent examples of this is a counterfeit note. Counterfeit currency is described as currency produced without the government's legal approval. To print counterfeit money, the dishonest people use the most up-to-date scanning and printing techniques. The development of such counterfeit money has an effect on any country's economy. Indian currency is also the portion of such unwanted things. So the common people face a huge problem in differentiating the real and fake currency [1].

Mr. Narendra Modi, India's Prime Minister, declared in November 2016 that prevailing rupee notes of 500 and 1000 rupees would no longer be legitimate currency, and that steps would be engaged to combat black money and counterfeit currency in the world. The Prime Minister also announced the introduction of new rupee 500 and 2000 notes, as well as the discontinuation of existing rupee 500 and 1000 notes. According to Reserve Bank of India (RBI), the identification of fake currency notes decreased by 31.4 percent in 2017-18 compared to the previous year, owing to high-security features on notes that make forgery difficult [2].

Watermarking, latent picture, micro lettering, see through register optically variable connection, security threads, intaglio printing, fluorescence, identification mark and legal protections against counterfeiting are some of the techniques for identification implemented by many researchers. For detecting fake currency, there are also automated tools available. There is a need to build a reliable system that can identify currency with minimal processing time and accuracy. Many researchers use digital image processing for this purpose, in which authors extract various attributes after image acquisition and treat them as objects. These attributes may include watermarking, latent image, micro lettering, see-through register, optically variable connection, security threads, intaglio printing, fluorescence, identification mark and legal protections against counterfeiting. The authors used a variety of image extraction methods, but it must be a good and feasible image extraction in order to consider accurate data as input [3]. Both extrinsic and intrinsic properties are the paper currency. Scale, distance, colour etc. are dealt with by extrinsic properties while safety thread, I.D. label and panel number are dealt with intrinsically. Extrinsic properties are not sufficient to detect whether the note is original or false. During transportation or exchange currency can also be damaged. With the aid of image processing techniques the changes in image nature can be well understood and enhanced [4].

II. LITERATURE SURVEY

Due to a review of the most recent currency in India after denomination, it is important to determine if the arrival notes inside the type of currency are genuine or not. The recently arrived money is in Indian rupees, with notes in denominations of 10, 20, 50, 200, 500 and 2000 rupees. There is only a limited amount of research on fake currency. Several researchers have proposed various methods to determine the legitimacy of a note. Some of the most relevant sources are discussed in this section.

Sharan and Kaur [1], proposed a technique to distinguish between actual and duplicate notes where the mean intensity of RGB channels of an image is measured and three distinct features, like Latent image, RBI Logo and denomination numeral with Rupee symbol, are collected. The proposed system has a high rate of accuracy.

V. Saxena et al. [2], proposed a method called Principal Component Analysis (PCA) which was used to detect currency features and to recognise fake currency in the form of Indian currency note Rs. 2000. PCA is a method of recognising data patterns in which data is expressed to

illustrate similarities and dissimilarities. In addition to the comparison of results, graphs were also plotted to explain the approach.

Snehlata et al. [3], proposed a model which is an object-oriented used for designing of organized steps for identification purpose, which is implemented in MATLAB. Unified Modelling Language (UML) is a standard language which is used for software design based on the object-oriented technique. It is a tool for producing the pictorial designs which are classified as static or dynamic design. Later the images which have been in RGB colour are converted into the Hue-saturation-value (HSV) format. By this process the entire image has been separately looked as Red, Green, Blue component. Then some of the required characteristics are extracted and compared to display final output.

Yanyan Qin et.al. [4], proposed a method using Scale-Invariant Feature Transform (SIFT) algorithm. The scale spaces were originally designed to detect stable extreme points, which were then called feature points with variance-scale. Then with the Oriented Quick and Rotated BRIEF (ORB) descriptor, currency characteristics are described. Finally, the binary descriptors with scale and rotation in variance were created. SIFT is 65.28 times faster than the ORB. The experimental setup consists of 20 images with a 92.53 percent accuracy.

S. Kaur et al. [5], proposed a new technique to analyse internal features of the image. The strip values of the currency are the image's internal features. MATLAB was used to run the simulation. The proposed and current algorithms' peak signal to noise ratio (PSNR), root mean square error (RMSE), fault detection rate (FDR) and accuracy values are compared to validate the proposed method. The Bayesian classifier (BC) and the Discrete Wavelet Transform (DWT) method were used in combination with the SIFT technique. It has been discovered that detection accuracy has improved by 10% and the rate of fault detection has decreased by 8%.

Y. Neeraja et al. [6], proposed a novel structurally efficient method using the Dual Tree Complex Wavelet Transform (DTCWT), for the detection and identification of duplication in currency notes. To classify the false portions of the note and make the judgement of fake notes, the corresponding scores of all fake detection modules are combined. The device worked with two images: one is the original image of the paper currency, and the other is the test image that will be used for verification. The K-NN technique is used in this case.

D. Kumar et al. [7], used ORB and a Brute-Force matcher approach, to extract the function of paper currency, which helped to more accurately detect the denomination of the banknote on both the obverse and reverse. The main contribution is that by combining ORB and BF matchers in OpenCV, it was able to achieve a detection accuracy of up to 95.0 percent. They tested this approach on various Indian banknote denominations.

A. Kulkarni et al. [8], proposed a method where fake notes were categorized using an image processing algorithm. After performing a comparative study of various image processing algorithms like the SIFT, ORB, FAST, BRISK, SURF, BRISK and KAZE algorithms were implemented in Matlab software. The best algorithm for feature extraction and feature matching that extracts the most number of features was chosen based on the research and comparisons.

Anjana. P and Apoorva. P [9], proposed a new approach known as super resolution, which would aid in the improvement of currency transparency. To put it another way, a low-resolution image would be transformed to a high-resolution image. The platform used is MATLAB. When the currency input image is fuzzy or has a low resolution, the proposed device would assist in transforming it to a high clarity image. As a result, identifying the currency denomination is easy.

M. Patil et al. [10], proposed a system for detecting fake Indian banknotes based on their images. In order to display a currency image, the dissimilarity space, which is vector space generated by comparing the image with a set of prototypes, is used. Each dimension represents the difference between the picture in question and a prototype. In order to obtain a difference between two images, specific key points of each image were identified and described. Based on the currency's properties the matched key points between the images can be described efficiently. A post-processing technique is also suggested to delete key points that are mismatched. As in the real world the amount of fake money is limited, SVM detects fake currencies and the training of the classifier only requires genuine money.

Another methodology exhibited by T. Naveen Kumar et al. [11], according to the physical aspect of the Indian currency. Image processing algorithms were used to display the safety features of Indian currency notes, such as the security thread, RBI logo and distinguishing evidence imprint, all known to be safety features of Indian currency. The final score of all three highlights has been intertwined to distinguish between real and false monetary criteria, making the system more stable and precise. The mean square error, which is around 1%, is another parameter used to calculate the proposed framework's execution. On the pre-processed images, DTCWT is applied to hold the full features. This wavelet transform preserves the most essential features of images thus minimising losses. A pair of DWT trees make up this wavelet transform.

S. Surya [12], proposed an approach which had the interactive system based on image processing, which produces a currency recognition system, developed with the assistance of MATLAB. An RGB colour model with mean intensity is used to classify Indian currency notes. However, this article has an inconvenience by using the Sobel operator to detect borders.

Bhagat and Patil [13], proposed a method using ORB, a fast binary descriptor based on BRIEF that is noise resistant, which is applied on both sides of the currency element. The samples that were recognised for lighting shifts, rotation and scale changes. A total of 210 Indian currency notes were sampled, with 15 of each denomination (5, 10, 20, 50, 100, 500, and 1000 rupees) being used in the experiment. The average success rate achieved is 97.14%.

K. Sawant and C. More [14], proposed a method using Image processing techniques which focuses more on extracting denomination value using Minimum distance

classifier. Their system focuses more on security features present in Currency notes. They have considered 4 important features like Aspect ratio, Dominant colour, ID mark and Latent image. It is observed that the experimental result shows the accuracy close to 90%.

Kalpna Gautam [15], proposed a method using Local binary patterns (LBP), Principal component analysis (PCA) and Euclidian distance algorithm for combining the metrics which has simple measure computations. The features of note are extracted and stored in MAT files and then these stored features are matched with the input paper currency to recognize whether it is genuine or duplicate, MATLAB is used for this purpose. The currency is recognized with the combination of both LBP and PCA.

III. Methodology & Result Discussion

Some of the algorithms used in detection of fake currency are discussed in this section.

A. Calculation of Mean intensity of RGB channels

The proposed approach for detecting counterfeit Indian currency notes is based on image processing techniques. To distinguish between real and fake notes, the mean strength of the Red, Green and Blue channels of the image is determined and mainly three different features like the Latent image, RBI Logo and denomination numeral with Rupee symbol, are extracted. Colour being a common feature used by banknote designers to distinguish between denominations. The following are the step involved to detect counterfeit Indian currency notes: Acquisition of currency note using camera, Pre-processing the image, Converting into grayscale, Accomplish edge detection, Performing image segmentation and extracting the required features, finally identifying the currency based on condition satisfied.

To begin, the image is captured using a camera in such a way that it retains its features and the mean intensity of RGB channels is calculated. The average amplitude of these channels is then compared to the conditions. When the requirements are met, the algorithm performs a pre-processing stage, followed by feature extraction. Following that, the mean intensity of the latent image (MI LI), the mean intensity of the RBI logo (MI LOGO) and the mean intensity of the denomination numeral (MI DV) with the Rupee symbol are compared.

This approach was used on 30 input test images and 23 of them yielded right results. This proposed methodology can be used to detect new Indian bank notes of 500 and 2000 rupees. This may be expanded in the future to verify the validity of newly issued Indian banknotes such as the 200, 100, and 50 rupee notes. The technique solves admirably and has a accuracy of **76.66%**. Limitation in the proposed model is that it applies to the newly issued Indian Currency Notes of 500 and 2000 only. In future, the validity of the newly released Indian paper currency such as 200, 100, 50 etc. can be verified. Further, work can be extended to improve the precision of the method [1].

B. Using Unified Modeling Language (UML) and HSV Image

The model proposed here is an object-oriented used for designing of organized steps for identification purpose, which is implemented in MATLAB.

There are numerous security features of Indian currency, most of which are based on color, dimensions and some sort of identification mark. The most important characteristic of currency identification is its hue. Different classes of Digital Image Processing steps are developed using the MATLAB technique, including Image Acquisition, HSV conversion, Detection of Edges, Image Segmentation, Extraction of Characteristics and Comparison of Image. Each class has its own set of methods and attributes.

UML is a standard language which is used for software design based on the object-oriented technique. It is a tool for producing the pictorial designs which are classified as static or dynamic design.

The Hue-saturation-value (HSV) format was used to transform the RGB color images later acquired. Using this method, the entire image was examined separately for each Red, Green and Blue part.

The UML activity model was created to reflect the complex aspects of detecting counterfeit currency and was successfully implemented on a newly issued Rs. 2000 note by the Indian government.

Here, they have selected security thread as region of interest, based on it they have compared to original currency. So, only based on security thread one cannot decide between real or fake, hence this can be the limitation [3].

C. Enhancement of Sift algorithm

Here a new technique is proposed to analyse internal features of the image, where the accuracy values of peak signal to noise ratio (PSNR), root mean square error (RMSE), fault detection rate (FDR), of proposed and current algorithms are compared to validate the proposed method. It has been discovered that detection accuracy has improved by 10% and the rate of fault detection has decreased by 8%. The proposed technique combines the SIFT technique with the Bayesian classifier (BC) and the DWT method.

The picture is loaded into the software and converted to grayscale. The SIFT algorithm was used to analyze the image and detect image edges in order to detect the font of the character. The next move was to apply image segmentation to the input image in order to detect numeric. The numeric text is extracted and compared to the real numeric in the final step to determine if the currency is genuine or counterfeit. The proposed and current algorithms PSNR, RMSE, FDR and accuracy values are compared to validate the proposed method.

Table 1: Table of Comparison [5].

Parameters/Techniques	Existing Method	Proposed Method
	SIFT+NNC	SIFT+BC+DWT
PSNR	9.1620	17.48
RMSE	31.04	34.08
FDR	0.498	0.502
Accuracy	**70.33**	**87.74**

It can be seen that the PSNR, RMSE, FDR and accuracy for the proposed system is more than the existing method. So it can be said that, the method proposed was better than the previous methods.

For testing the originality of currency notes, a method based on the SIFT algorithm with Bayesian classifier and DWT has been proposed. To validate the proposed scheme, the proposed and current algorithms (SIFT algorithm with nearest neighbour classifier) are compared in terms of PSNR, RMSE, FDR and accuracy values. The results showed that the proposed technique is superior to the current technique for verifying currency note authenticity [5].

D. K-NN Technique

A novel structurally efficient method is proposed using the DCWT with K-NN for the detection and identification of duplication in currency notes.

The K-nearest-neighbor is an algorithm which is extremely straightforward. To evaluate the K-nearest neighbours, the shortest distance between the query instance and the training samples is used. The data for the K-NN algorithm is made up of a number of multivariate attributes that will be used to identify images. K nearest neighbours is an algorithm which stores all the available cases and sort the new ones using a similarity metric (e.g., distance functions). The K-NN algorithm can be said as type of neural network, which has been used for recognition of pattern and also for statistical estimation.

The algorithm applied here is as follows: The image is acquired under UV light by Camera or scanner, the acquired Image is RGB image which is converted to grayscale image and later on applying Edge detection, the required characteristics features of the currency will be cropped and then segmented, then the characteristics of currency notes are extracted, calculation of Intensity of each feature, finally the conditions are checked and then determined the currency as original otherwise fake.

This approach can be an effective method of assessing the physical appearance of fake money. This is helpful for reducing the counterfeit currency. In the future, a mobile app that is useful both for ordinary and visually impaired people, can be created, with the same system being used for the remaining Indian currency notes and currency notes of other countries [6].

E. ORB and BF matcher in OpenCV

ORB and Brute-Force matcher approaches are used to remove features from paper currency, allowing for more precise detection of the banknote's denomination on both sides. The main contribution is that by using ORB and BF matchers in OpenCV, the average detection accuracy can exceed 95.0% and this approach has been tested on various denominations of Indian banknotes.

The method applied here is as follows: Image Acquisition by simple digital camera or scanner, Image is converted from RGB image to Gray-scale image, then Edge detection, next the features of the paper currency both observe and reverse will be cropped and segmented, after segmentation, extraction of features and finally BF matcher matches the database features with test image notes, then the test note is said as original otherwise fake.

Table 2: Table of Accuracy [7].

Denomination	Image Datasets	Test Pass	Test Fail	Accuracy
200 Rupee notes	30 Training and 30 Test Banknote Image	29	01	96.6%
500 Rupee notes	30 Training and 30 Test Banknote Image	28	02	93.3%
Accuracy		**95.0%**		

By using this technique it is found that extraordinary results can be completed less time. This is an OpenCV based using effective computer vision methods and algorithm which provide accurate and reliable result. The experiment is the cost-effective Indian banknote detection method. This method has a 95.0% accuracy which means an efficient operation of the device. This technique is experimented on Rs. 200 note and can be extended to the newly launched notes. In future, an android app may be developed by them [7].

F. Super resolution method

Super resolution is a tool for improving the clarity of a currency. To put it another way, a low-resolution image would be transformed to a high-resolution image. The framework used in this project is MATLAB.

This method is a novel image processing technique in which the transparency of an input image is zoomed out. It changes the resolution of a low-resolution image to a high-resolution image. As a consequence, the image's clarity is enhanced. This algorithm aids in image enhancement when the image is blurred or the resolution is poor. The dataset used here is of Indian currency photos. It includes illustrations of paper notes worth 10, 20, 50, 100, 500 and 2000 rupees. Following the application of the algorithm, it will classify the currency denomination as well as attempt to determine if the note is genuine or not.

Algorithm follows these steps: Reading an input image, Conversion of image into Grayscale, after that the super-resolution method will be applied, then Watershed segmentation method is used to segment the image, next is feature extraction. And it's done by using the Optical Character Recognition (OCR) method to extract the text in the currency, after this currency denomination will get identified and displayed, after identification of the currency image it will also verify that the image is a fake one or genuine one.

As a result, it offers the highest level of accuracy in both identifying the currency and checking if the obtained currency picture is genuine or not. It can check whether the image is of a false or genuine one by extracting the multiple colors in the currency images. Future analyses of the current methodology used by the proposed arrangement will be carried out, ensuring 99 percent accuracy rate [9].

G. K-means algorithm and SVM algorithm

In this case a method is proposed for detecting fake Indian banknotes based on their images. In order to display a currency image, the dissimilarity space, which

is vector space generated by comparing the image with a set of prototypes, is used. Each dimension represents the difference between the picture in question and a prototype. The local key points on each image are detected and defined in order to obtain the dissimilarity between two images. The matched key points between the two images can be efficiently defined based on the currency's characteristics. A post-processing technique is also suggested to eliminate key points that are mismatched.

A system for detecting fraud Indian Notes is established. The input from the given image will be first taken and the image pre-processed and the RGB image will be transformed into a grey image. The sobel algorithm is used for removal of the inner and outer edges of the image after preprocessing. Clustering is achieved using an algorithm of k-means, in which it forms the clustering of feature one by one. Then compare image characteristics with the aid of SVM algorithm and classify them as original or fake.

K-means Algorithm: The K-Means algorithm is an unsupervised algorithm which divides data input into several groups, on the basis of its inherent distance. The aim of k-means is to reduce to a minimum possible value the number of squared distances between all points and the cluster core.

SVM Algorithm: Support vector machines are supervised learning models with associated learning algorithms for machine learning analysis for classification and regression analysis (SVMs, also called support vector networks).

The precision and accuracy of a system was measured using data from a dataset and observations. These experimental findings show that the SVM Algorithm outperforms the K-NN Algorithm in terms of accuracy. The mixture of original and fake notes is 97%, according to the precision and accuracy of the method. These figures are derived from a sample of 50 notes and the findings are observed. In future, Application based system can be designed to differentiate between fake and original note and the same system can be designed to check other Indian currency [10].

H. Dual Tree Complex Wavelet Transform (DTCWT)

A fake currency identification method for Indian notes is proposed in this approach. Initially, a database of genuine Indian banknotes of various denominations is developed and a test is run to compare the input image to the database images. To begin, the input currency images are preprocessed to convert from RGB to grey for ease of processing; additionally, noisy input images are median filtered to reduce noise. On the preprocessed files, DTCWT is applied to hold the full features. This wavelet transform preserves the most important features of images thus minimizing losses. A pair of DWT trees make up this wavelet transform. In addition to the wavelet transform, a k-means segmentation algorithm is used to cluster the input images, such as 200, 500 and compare the features of the image to determine if it is an original or fake note.

DTCWT: The DTCWT is made up of two Discrete Wavelet Transform (DWT) trees, each of which corresponds to real and imaginary parts of the transform. Every channel in both DWTs is genuine and these two genuine trees use two different channel arrangements. In DTCWT, a genuine flag is attached to both remade trees for decay and the yields of both remade trees are found to be the same value near the end of the recreation point. The DTWCT was developed to overcome the traditional DWT's lack of move in variance property.

The proposed approach illustrates a successful technique for detecting counterfeit Indian currency notes based on their physical appearance. The analysis of a currency image using digital image processing is more precise, as well as more cost-effective and time-consuming than existing techniques [11].

IV. CONCLUSION

For various algorithms used to detect counterfeit notes, feature extraction methods remain more or less unchanged. The most rapid and reliable method of detecting fake notes can be used by different combinations of features. The different techniques like Calculation of Mean intensity of RGB channels, UML and HSV Image, K-NN Technique, Super resolution method, DTCWT which provide good accuracy whereas Enhancement of Sift algorithm provides 87.74%, ORB and BF matcher in OpenCV provides 95%, K-means algorithm and SVM algorithm provides 97% accuracy, which are better compared to the previous said. Most of these algorithms use images of original currencies taken from camera to create their own datasets and compare these values with the test images to differentiate between original and counterfeit.

The limitation is that most of the algorithms are used on only one or two different currency denomination, which in future can be improved by them. Also the currency image is taken from only one side or maximum of both the sides that is front and back, which can be further improved by taking the images from different angles in order to increase the accuracy. Circulation of fake currency leads to degradation of countries economy, hence identification of fake currency becomes very important. As some of the techniques discussed in the above section are cost efficient and take less time, the suitable approach for identification can be selected based on the application. This must not be only limited to banks but also in shops or places where transaction in cash occurs.

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