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Recognition and verification of Indian currency notes using digital image processing

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***Abstract*: The occurrence of counterfeit notes can be detrimental to the effective running of monetary systems of any nation. These counterfeit notes can be distributed by terrorist and other criminal organization and be used to fund illegal activities. This paper examines methods to enhance the security features of recently introduced Indian currency notes. The introduction of the INR 500 and 2000 notes in November 2016 resulted in some discourse concerning the security features of these new Indian currency notes. The wide occurrence of counterfeit Indian currency notes in the denominations of INR 10, 20, 50, 100, 500, 1000 has been reported over recent years. There is an expectation that these newly introduced INR 500 and 2000 may also be counterfeited and distributed illegally by criminal gangs and terrorist groups. This paper proposes a novel currency recognition system where the counterfeit currency is automatically recognized without any human intervention. The proposed system provides an interface to recognize the Indian currency notes and authenticate its validity. The system also identifies the counterfeit notes by using a scanner and various image processing methods for shape recognition. Various image features were used to distinguish between counterfeit and non-counterfeit notes. The study used an image database of Indian notes to access the accuracy of the proposed system. The experimental results show that the accuracy of the system proposed is close to 90% with a satisfactory level of sample processing. The accuracy of this identification was found to be diminished for sample notes which were damaged.**

***Keywords*:** counterfeit notes, feature extraction, image processing, Indian currency.

I. Introduction

India experienced one of the biggest financial operations ever executed after the country's independence in late November 2016 [1]. This operation carried out by the Indian Federal government was targeted at the massive flow of 'black money' in the Indian market economy. It has been reported that up to INR 400 crores of fake currency was circulating in the Indian cash economy [1]. This fake currency was found to be mostly of higher denomination notes which are INR 500 and 1000. The last decade has seen great disruption of the world economy, and changes in the regulation of the financial systems with the introduction of the Euro currency and the ever-increasing importance of the Asia economics [1], [2]. There has also been a deregulation on markers which has resulted in both the increased exchange of money between countries through electronic systems. Despite this, the cash economy still remains the principal economy of India where a large proportion of the population does not have bank accounts and live below the poverty line. The avoidance of tax in property and other industries also relies on large percentages of payments to be carried out through cash transactions where this cannot be easily traced by government and banking agencies [1]. The cash economy has also been the avenue for criminal gangs and terrorist organizations to fund their activities and to gain an advantage by the introduction of a large sum of counterfeit notes.

The last few years have seen the widespread use of currency note recognition systems by banks and other agencies. These systems have been used in ATMs and for the counting and identification of large quantities of currency notes. These systems are able to recognize and classify specific paper currencies and reject notes from other paper currencies. These currency recognition systems use a number of techniques to distinguish between notes. Some systems are based on the recognition of different serial numbers for different denominations [3]. The drawback of these systems is that they require datasheets of the serial numbers for each batch of currency notes. Other systems are based on the recognition of optical features. The earliest optical recognition machines were primitive mechanical devices with high failure rates. The current OCR devices provide a high accuracy and a based on the detection of various image features such as variations in color, shapes and other markings [4].

The use of optical recognition systems for the identification of counterfeit currency notes is one possible technique to assist government agencies and banks to remove these notes from circulation. This study proposes a system which uses image processing techniques and various optical features of Indian currency notes to detect analogies in these notes. This paper will evaluate the accuracy of this system and outlines the implications for using this system in reducing the circulation of fake currency notes in India.

II. Objective

In India the circulation of fake currency is more when compared to other countries. The latest government report shows that there has been a 400% increase in such counterfeit transactions. According to the Indian law, possessing fake notes is a punishable offence. Fake Indian currency note (FCIN) is a term used by officials and media to refer fake currency notes circulated in the Indian economy. The fake notes of newly introduce INR 2000 and INR 500 series are so perfect that it is hard to identify them from the real notes. So this paper makes an attempt to present detection techniques for finding whether a currency note is fake or real.

This project proposes an image processing technique for currency recognition and verification. The image processing approach is discussed with MATLAB to detect the features of paper currency. Image Processing involves changing the nature of an image in order to improve its pictorial information for human interpretation. There are various techniques for currency recognition that involve texture, pattern or colour based. This project uses digital image processing techniques to find region of interest.

The proposed system will work on two images, one is original image of the paper currency and other is the test image on which verification is to be performed. A number of methods for banknote classification have been proposed.

III. Related Work

This section outlines the findings from existing studies related to this research. A number of studies have been proposed for the use of different techniques to identify currency notes and anomalies in these notes.

Sawant et al. [5] used image processing techniques and minimum distance classifier techniques of scanned currency images. The research used stand color extraction, segmentation, feature extraction using Fourier Descriptors and identification of the shapes through the extraction of the unique identification marks and latent image numbers using the Minimum Distance Classifier. The method reported accuracy close to 90%.

Manikandan [6] proposed a currency recognition system for mobile application for visually challenged people based on currency localization techniques. The study used the Matlab image processing toolbox libraries. The system captured images with the mobile camera and uses morphological techniques, to identify the different currency notes. The currency recognition system provided an accuracy of 93% based on a data set of 165 images.

The authentication of Currency Notes using printing technique verification has also been shown to be a valid method. Roy et al. [7] verified the notes checking physical dimensions, paper quality, design, and the printing technique. A K-mean algorithm was used to check whether the cluster was linearly separable. The classification accuracy was also checked using a Neural Network (NN)-based classifier

Other techniques such as edge detection of grayscale images of the currency have proved to be satisfactory. A study by Prasanthi et al. [8] proposed a system which used six different characteristic features of the paper currency. The characteristics of the paper were extracted from these attributes. Comparison of notes was carried out with the original pre-stored image in the system. If the conditions were satisfied, then the currency was said to be genuine otherwise counterfeit.

Shyju et al. [9] proposed solution based on three shape recognition, feature extraction, and digital recognition. The system used ROI (Region of Interest) extraction method based on solidity, minor axis length, extent, and eccentricity. The Gray Level Co-occurrence Matrix (GLCM) was used to extract the second order statistical texture features. The system also used mean, skewness and kurtosis features to represent color. The SVM (Support Vector Machine) with polynomial kernel function was used as the classifier.

Satish et al. [10] described a system which could detect if notes deposited into an account in ATM were counterfeit notes. Two methods including advanced mixed signal and an advanced pattern recognition system were used in the system. The first method used 1-D analog signals were acquired from infrared and laser sensors followed by the processing of the discrete, analog and mixed signals. The second method used a mixed signal processing, pattern recognition, and image processing to develop an expert system based on generation on Go or NoGo signal which then would determine if the currency is accepted or rejected.

Yadav et al. [3] implemented a fake note detection unit using Matlab image processing library algorithms. Feature extraction was done with the HSV color. The system used an input device CCD camera and output device LCD display. The study reported good accuracy and reliability of the system.

Sannakki et al. [4] used standard image processing and classification techniques. The system extracted image features using Discrete Wavelet Transform (DWT). Images were rotated by converting image to binary image and then the Region of Interest (ROI) was determined. The Canny method was used for edge detection. DWT was then applied to decompose the image and transformed coefficients were then used to calculate statistical features. The accuracy of this approach was 90.38% based when the PNN classifier was used to validate the approach.

Other studies have reported on the use of the SIFT techniques for fake note detection. Kavya et al., [11] used a digital camera to acquire the images of the notes acquisition Segmentation was carried using discontinuity and similarity indices. Features were segmented using a 3x3 grid with the SIFT method and based on these features the currency note was determined to be genuine or fake.

Sharma et al., [12] explored the recognition of Indian Paper Currency by using the application of LBP (Local Binary Pattern) methods. This technique was considered to be suitable for practical application of currency detection as it is based on an algorithm with low computational complexity and reduced the time for identification. LBP method uses the neighborhood pixels which are converted to binary code 0 or 1 by using the gray value of the center pixel as a threshold. This method has been shown to provide good performance and noise reduction.

Chinmay et al. [13] used the technique of digital image processing to find region of interest, after that Neural Network

and Pattern Recognition Technique is used for matching the pattern by Obtaining the image of the target currency using one of the possible methods and uses Image Pre processing algorithms to change the nature of the image in order to extract required Information. Detect the boundaries and extract the ROI (Region of Interest) using cropping. Extract the desired features. Compare the extracted feature values with ideal feature values that are calculated. Display the outputs.

Ingulkar et al. [14] considered two proposed system firstly, Currency Recognition which considers Feature such as Identity Mark and optical variable link are used. Pixel value for each feature is calculated and Secondly Currency Verification where, Currency features such as watermark, security thread, Fluorescence and latent image is used. An original image is read from database. A captured image has dimensions 866×356, vertical and horizontal revolution 96dpi. Edges based segmentation is performed on the image.

Surya et al. [15] build a system based on based on MATLAB with a user-friendly interface. Using image-in-image search, we can able to compare images. The aim of system was to help the people who need to recognize different currencies and with convinces and efficiency.

Alekhya et al. [16] has enabled a layman to identify a fake note and empower every citizen to detect fake notes. It uses the MATLAB technique which can split the red, blue, green components of a picture. If equivalence is above 40% then it can consider the currency as original note. Parameters for measure of comparing images are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR in dB), and structural Content (SC). When we combine two various components of two images then if note to be tested is original then only at the place of number we get variation. But in this example we took a fake note and applied the same code, we can observe that the image overlapping is not done correctly. We can also see that the resultant image is blurred indicating fake note. So we can confirm that it is a fake note.

Roogi [17] considered notes with the bar code which contains a unique serial numbers, and it is easily detectable of fake notes by using bar code reader. Here bar code readers are of many types which can be installed easily in Banks. It will be check from the note database and will check whether it is fake or real. The main motivation behind development of this paper is to make a system for easy and quick detection of genuine and fake currency notes. One should be cautious while detecting a fake note.

Shah et al. [18] an algorithm based on the frequency domain feature extraction method is discussed for the detection of currency. This method efficiently utilizes the local spatial features. The textural features are extracted using DWT (Discrete Wavelet Transform). Histogram equalization is used to adjust contrast based on the image histogram. Filter is performed. Statistical features such as mean, standard deviation, skewness and kurtosis are extracted from the approximate Coefficient matrix and lastly SVM is used as a classifier. Fake currency recognition is done after the currency denomination is recognized.

Chakraborty et al. [19] uses reliable currency recognition system which could be used in any sector wherever monetary transaction is of concern. Thus, there is an ardent need to design a system that is helpful in recognition of paper currency notes correctly. Image Acquisition, Edge Detection, Image Segmentation, Feature Extraction, Matching Algorithm. These algorithms include Sobel, Prewitt, Roberts, and Canny. After binarization, black pixels touching the boundary of the image were regarded as background. One of the most common classification techniques that had been used recently is Artificial Neural Network. A Neural network based recognition scheme was used for currency recognition.

The issue of efficiently verifying counterfeit banknotes from real ones via automatic machines has become more and more important. Babar et al. [20] used the method where the currency will be checked out by using image processing techniques. The image processing software is a collection of functions that extends the capability of the MATLAB numeric computing environment. The result will be whether note is real or fake.

IV. Research Methodology

A. Introduction

The system is based on digital camera and load image on the pc and implement with algorithm. Once the image loads on the computer we applied technique and also image compares have been done.

The research methodology used for currency recognition system consists of the following steps:

1. Image Acquisition
2. Gray Scale Conversion
3. Edge Detection
4. Image Segmentation
5. Feature Extraction
6. Comparison
7. Output

Step 1- Image Acquisition:

Image acquisition is the creation of digital images, typically from a physical scene. The image considered here is Indian currency note and is generally acquired by using a digital camera. The image is then stored for further processing.

Depending on the field of work, a major factor involved in image acquisition in image processing sometimes is the initial setup and long-term maintenance of the hardware used to capture the images. One of the forms of image acquisition in image processing is known as real-time image acquisition. This usually involves retrieving images from a source that is automatically capturing images.

There are some advanced methods of image acquisition in image processing that actually use customized hardware. Three-dimensional (3D) image acquisition is one of these methods.

Step 2 - Gray Scale Conversion:

In photography and computing, a grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.

While digital images can be saved as grayscale (or black and white) images, even color images contain grayscale information. This is because each pixel has a luminance value, regardless of its color. Luminance can also be described as brightness or intensity, which can be measured on a scale from black (zero intensity) to white (full intensity).

A grayscale (or gray level) image is simply one in which the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel Grayscale images are very common, in part because much of today's display and image capture hardware can only support 8-bit images. In addition, grayscale images are entirely sufficient for many tasks and so there is no need to use more complicated and harder-to-process color image.

Step 3 - Edge Detection:

It is a fundamental tool in image processing, particularly in the area of feature detection and extraction, which aims at identifying points in a digital image at which the image brightness changes sharply. Here, the aim of edge detection is basically to localize the currency note that is the region of interest.

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.

Edge detection includes a variety of mathematical methods that aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges.

Step 4 - Image Segmentation:

This method subdivides the image into its constituent regions or objects. Segmentation algorithm for monochrome images generally is based on two properties- discontinuity and similarity.

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze

Segmentation techniques are either contextual or non-contextual. The latter take no account of spatial relationships between features in an image and group pixels together on the basis of some global attribute, e.g. grey level or colour. Contextual techniques additionally exploit these relationships, e.g. group together pixels with similar grey levels and close spatial locations.

Step 5 - Feature Extraction:

It is a challenging work in digital image processing. In any currency recognition system, feature extraction is one of the most challenging tasks. The aim here is to analyze and identify the unique and distinguishing features of each denomination under various challenging conditions such as old notes, worn out notes, also under different illumination and background.

Feature extraction is a special form of dimensional reduction. When the input data to an algorithm is too large to be processed and it is suspected to be very redundant then the input data will be transformed into a reduced representation set of features. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

Step 6 - Comparison:

It is done through matching algorithms. This step classifies or recognizes currency notes of different denomination based on the various unique features extracted.

B. Data Set

The currency notes considered for this research work are Indian new currency notes of denomination INR 500 and 2000.

C. Data Set Features

1) INR 2000 features

The new currency notes have different colors compared to the earlier notes. The INR 2000 note's paper is in magenta color. The INR 2000 note is part of the Mahatma Gandhi (New) series, with a motif of Mars orbiter Mangalyaan on the reverse side. Size of the note is 66mm x 166 mm. [2]

Other features of the new INR 2000 note are as follows:

Front Side features:

1. See-through register where the numeral 2000 can be seen when the note is held up against the light.
2. The latent image of 2000 can be seen when the note is tilted.
3. Color shift security thread with 'RBI' and '2000'.
4. Watermarks of Mahatma Gandhi and electrotype 2000 numeral.
5. Number panel with numerals growing from small to big on the top left and bottom right sides.

Reverse side features:

1. Swachh Bharat logo.
2. Mangalayan motif and year of printing, 2016.

2) INR 500 features

The INR 500 note is in stone gray in color. The new INR 500 note is 63mm x 150mm smaller in size than previous one.

Front Side features:

1. See-through register in denomination numeral.
2. The latent image of the denomination numeral.
3. The orientation of Mahatma Gandhi’s portrait changed.
4. Portrait and electrotype watermarks.
5. Number panel with numerals growing from small to big on the top left and bottom right side.
6. Features for visually impaired like a circle with INR 500 are raised on the right.

Reverse side features:

1. Swachh Bharat logo.
2. Red Fort image with the Indian flag.

3. Circle with INR 500 in Devangiri on the right.

3) Currency Note Image features:

Optical Variable Ink:
The color of the numeral 500 appears green when the banknote is held flat but would change to blue when the banknote is held at an angle. The font size is also reduced.

Latent Image:
When the note is held horizontally, the vertical band on the right shows an image of the number 500.

Security Thread:
The note also has a three-millimeter wide security thread with the inscriptions: one thousand, the word 'Bharat' in Hindi and RBI.

Micro lettering:
The 'RBI' and the numeral, which can be viewed with the help of a magnifying glass - are between the Mahatma Gandhi portrait and the vertical band.

Watermark:
When the note is held against the light, the picture of Gandhi and an electrolyte mark showing the number 500 appears in the white space. The best way to identify a note is the silver bromide thread that runs vertically through a currency note. Fake currency notes tend to have silver-colored band painted in place of the silver thread. A real note has a prominent thread with raised 'RBI' markings made on it in English and Hindi. Also, in a real note, the color of the thread shifts from green to blue when viewed from different angles.

4) Methods Used:
Image recognition is done by considering the hue, saturation and intensity values. The properties of the HSV (Hue, Saturation and Value) color space are analyzed with emphasis on the visual perception of the variation in Hue, Saturation and Intensity values of an image pixel. The HSV color space is fundamentally different from the widely known RGB color space since it separates out the Intensity (luminance) from the color information (chromaticity).

The following Image Recognition Algorithm was used to obtain the desired results.

Step 1: Obtain the image of the target Indian currency note using one of the possible methods (Ex.: Camera, Scanner, etc)
Step 2: Use image pre-processing algorithms to change the nature of the image in order to extract the required information.
Step 3: Detect the boundaries and extract the ROI (Region of Interest) using cropping. Extract the desired features.
Step 4: Compare the extracted feature values with ideal feature values that are calculated.
Step 5: Display the outputs.

V. Data Presentation

1) Material used
Image of Indian Currency of INR 100, INR 2000 and INR 500 can be acquired by scanning. Here, about 40 samples of currency with front side and reverse side image are scanned. Images of good quality and bad quality with good clarity, i.e. with good brightness and contrast, for training as well as testing purpose are scanned with the help of scanner.

2) Size of the Image
Each image is scanned with the following settings:
File type - JPEG (.jpg)
Output type - Color
Resolution - 600dpi
Size – 6.03*2.08 inch
210*297mm

Table 1. Currency Table

	INR 2000	INR 500	INR 100
Original Notes	10	13	4
Fake Notes	3	3	3

VI. Proposed System

In this section describes the implementation of paper currency recognition system using the proposed method. The steps followed are discussed below.

4.1 Pre-processing

It is a common name for operations with images at the lowest level of abstraction; both input and output are intensity images. The aim of pre-processing is to improve the image data that suppresses unwanted distortions or enhances some image features important for further processing. Image pre-processing methods use the considerable redundancy in images. Neighboring pixels corresponding to one object in real images have essentially the same or similar brightness value. Thus, the distorted pixel can often be restored as an average value of neighboring pixels. In this case for pre-processing, the scanned image of Indian currency INR 2000, 500 and 100 are considered as shown in figure 2, 3 and 4 respectively.

Figure 2.INR 2000 currency

Figure 3.INR 500 currency

Figure 4. INR 100 currency

4.2 Gray-scale transformation

A grayscale or luminance image can be considered to be one of the components of a different parameterization. Its main advantage is it captures most of the image information. The emphasis in this class will be on general processing. Hence, this work mainly uses grayscale images in order to avoid the various nuances involved with different parameterizations. Grayscale transformation does not depend on the position of the pixel in the image. Grayscale transformation can be performed using look-up tables. Grayscale transformation is mostly used when the result is viewed by a human.

Figure 5. Grayscale Conversion output

Boundary and Edge detection

Edge detection is a classic problem in computer vision and a fundamental tool for many algorithms. The goal of such algorithms is to find all relevant discontinuities in an image. This is because what constitutes a relevant discontinuity can vary highly among even humans, edge detection is considered to be a difficult problem. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision. The Sobel operator sometimes called the Sobel–Feldman operator or Sobel filter is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasizing edges.

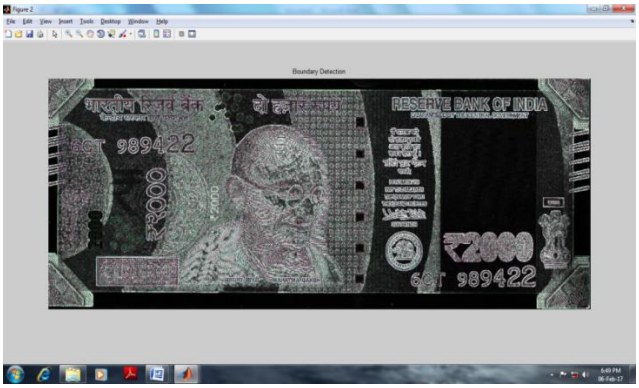

Figure 6. Boundary and edge detection output

4.3 Feature Extraction

Different type of feature extractions methods is used to extract features. The different features are shape features, texture features and color features. In this work, snake algorithm is used to detect the complete image and test the shape pixel by pixel. The bounding box technique is used to find the edges which are already pre-processed in the technique before.

Security thread: Each note has a security thread with similar visible features and inscription. When held against the light, the security thread on INR 2000, 500 and 100 can be seen as continuous line.

Identification mark: Each note has a unique mark on it. A special feature in intaglio has been introduced on the left of the watermark window.

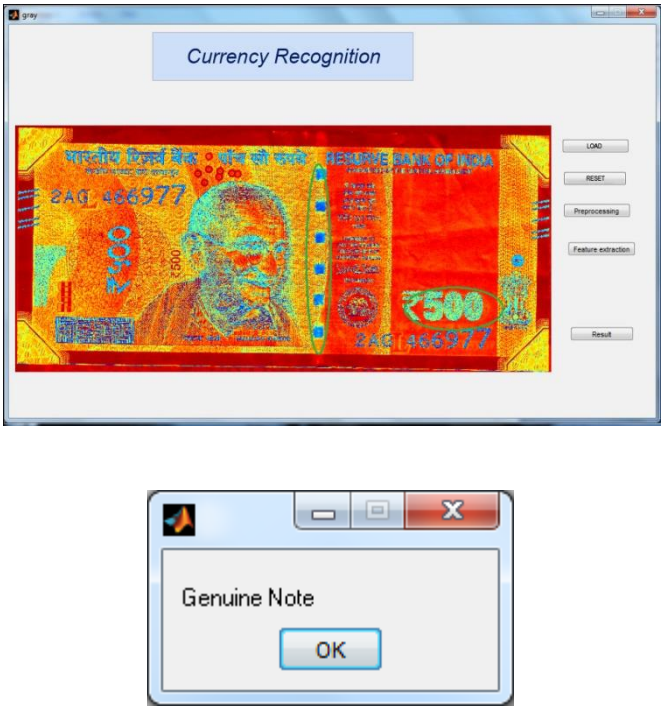

Figure 7. Currency Recognition System output

VII. Result

The developed Currency Recognition System uses different image processing technique of the Matlab tool. The Indian currency notes have been successfully recognized. With the experimental results show that the accuracy of the system proposed is close to 90% provided with good throughput and depends on the quality of the scanned currency notes.

The comparison of proposed system in terms of objective, model used and results with the existing work is as follows:
The software interface proposed by Sawant et al. [5] is to reduce human resources to automatically recognize currency without human supervision using Mobile. Image Acquisition, Image Preprocessing, Dominant Color Extraction, Aspect Ratio Extraction, Segmentation, Feature extraction is performed using Fourier Descriptors. The identification of the shapes obtained by extracting the unique identification mark and latent image numbers is done by using Minimum Distance Classifier. It has considered 4 important features for currency recognition. They are Dominant Color, Aspect ratio, ID Mark and Latent Image. Experimental results show that the accuracy of the system proposed is close to 90%. The limitation of this work is it does not consider the whole image. It works only on analysis of ID marks.
When the paper currency notes are being accepted as the most appropriate agent of monetary transaction then the challenge of counterfeit is on a large. Therefore, it would be of great help if the solution can involve machines for automatic authentication of bank notes. The work done by Roy et al. [7] is on printing technique as a security feature in Banknotes. Examination or verification of currency notes is mostly conducted by checking the following aspects: i) physical dimensions, ii) paper quality, iii) design, and (iv) printing technique. Feature extraction in this experiment is largely dominated by the input from the forensic experts. Altogether nine features are extracted which can be broadly classified into three as (i) gray level features (ii) color features and (iii) structural or geometric features. To check whether these two clusters are linearly separable, a K-means algorithm is implemented and clusters the m+n labeled samples into two classes. Further, support vector machines (SVM) are used aiming at determining the location of decision boundaries that produce the optimal separation of classes. The classification accuracy is also checked with a Neural Network (NN)-based classifier. The features used in this experiment are quickly computable and therefore, the proposed method provides a quick (and possibly low cost too) solution to the problem. It needs a magnified image. Uses odd dimensions hence a neural network method is needed.
The issue of efficiently distinguishing counterfeit bank notes from genuine ones via automatic machines has become more and more important. Prasanthi et al. [8] explored the image of paper currency that is acquired by simple scanner or digital camera. The image acquired is RGB image and then it is converted into grayscale. Edge detection of the whole grayscale image is performed. After detecting edges, the six characteristic features of the paper currency is cropped and segmented. After segmentation, the characteristics of the paper currency is extracted. The characteristics of test image are compared with the original pre-stored image in the system. If the conditions are satisfied, then the currency is said to be genuine otherwise counterfeit. The features are extracted using edge based segmentation by Sobel operator and works well in the whole process with less computation time. The decision making is done within 0.5 seconds. The system designed is a low cost system. The system is able to extract the features even if the note has scribbling on it. It uses only one technique, while the proposed system have four different techniques.

VIII. Conclusions

There are many methods for identifying fake notes which are discussed in this paper and each one has its own significance. One should be cautious while detecting a fake note. This paper describes a currency recognition system that enables a layman to identify a fake note and empower every citizen to detect fake notes which may reduce corruption in India. The Matlab methods when deployed in a mobile phone with a scanner or a camera it will allow detecting a fake note, which helps any layman to control, fake currency circulation in the country. In future, extracted features of currency image can be used for currency value recognition as well as for its verification. The application-based system can be designed to get a more accurate result to detect whether the currency image is fake or genuine.

IX. Other recommendations

An interactive system has been developed that generates Currency Recognition System using some different technique with the help of MATLAB. The Indian currency notes have been recognized.

The future study will be done by applying different filters. In this paper the images were scanned with help of scanners and in the future the images will be scanned with different angles using all the methodology. Different currencies could be used for recognition like dinar, USD, euro etc. Similarly different features can be used for recognition.

Current System implemented using image processing techniques focuses more on extracting denomination value only. Thus our system focuses more on security features present in new currency notes and using those security features it recognizes the Indian currency.
In future accuracy can be increased by using other classification methods or by extracting other features [21][22].

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XI. References

[1] Saiyed Mohammed Arshad, Devdatt Sawant Sudagar & Nausheeda B S: Fake Indian Currency Detection Using Image Processing., *International Journal of Latest Trends in Engineering and Technology* Special Issue SACAIM 2017, 598-602.

[2] Reserve Bank of India's Financial Education initiative https://www.rbi.org.in/financialeducation/currencynote.aspx.

[3] Yadav, Binod Prasad, C. S. Patil, R. R. Karhe, and P. H. Patil. "An automatic recognition of fake Indian paper currency note using MATLAB." *International Journal*

of Engineering Science and Innovative Technology 3, no. 4 (2014): 560-566.

[4] Sannakki, S. S., and Pallavi J. Gunjale. "Recognition and Classification of Currency Notes using Discrete Wavelet Transform." *International Journal of Emerging Technology and Advanced Engineering* 4, no. 7 (2014): 253-257.

[5] Sawant, Kedar, and Chaitali More. "Currency Recognition Using Image Processing and Minimum Distance Classifier Technique." *International Journal of Advanced Engineering Research and Science* 3, no. 9 (2016): 1-8.

[6] Manikandan, Sumithra T.: Currency Recognition in Mobile Application for Visually Challenged., *Special Issue on IEEE Sponsored International Conference on Intelligent Systems and Control* (ISCO'15)

[7] Roy, Ankush, Biswajit Halder, and Utpal Garain. "Authentication of currency notes through printing technique verification." In *Proceedings of the Seventh Indian Conference on Computer Vision, Graphics and Image Processing*, pp. 383-390. ACM, 2010.

[8] Prasanthi, B. Sai, and D. Rajesh Setty. "Indian paper currency authentication system using image processing." *Int. J. Sci. Res. Eng. Technol* 4 (2015): 973-981.

[9] Shyju, S., and A. Thamizharasi. "Indian currency identification using image processing." *Int. J. Adv. Eng. Manag. Sci* 2 (2016): 344-349.

[10] Satish, K., Y. K. Viswanadham, and I. Leela Priya. "Money to ATM–Fake Currency Detection." *IJCSIT) International Journal of Computer Science and Information Technologies* 3, no. 5 (2012): 5046-5050.

[11] Kavya, B. R., and B. Devendran. "Indian currency detection and denomination using SIFT." *Int. J. Sci. Eng. Technol. Res* 4 (2015): 1909-1911.

[12] Sharma, Bhawani, and Amandeep Kaur. "Recognition of Indian paper currency based on LBP." *International Journal of Computer Applications* 59, no. 1 (2012).

[13] Chinmay Bhurke, Meghana Sirdeshmukh, M.S.Kanitka: Currency Recognition Using Image Processing., *International Journal of Innovative Research in Computer and Communication Engineering*, 3, no.5, (2015): 4418-4422.

[14] Ingulkar Ashwini Suresh, P.P.Narwade: Indian Currency Recognition and Verification Using Image Processing., *International Research Journal of Engineering and Technology (IRJET)*, 3, no. 06, (2016).

[15] Surya, S., and G. Thailambal. "Comparative Study on Currency Recognition System Using Image Processing." *International Journal Of Engineering And Computer Science* 3, no. 08 (2014).

[16] Alekhya, D., G. Devi Surya Prabha, and G. Venkata Durga Rao. "Fake currency detection using image processing and other standard methods." *IJRCCT* 3, no. 1 (2014): 128-131.

[17] Roogi, Ravikumar H. "Fake Currency Detecting using bar code system." *Journal of Computer Science and Technology*4, no. 8 (2014): 1-2.

[18] Shah, Ami, Komal Vora, and Jay Mehta. "A review paper on currency recognition system." *International Journal of Computer Applications* 115, no. 20 (2015).

[19] Chakraborty, Kishan, Jordan Basumatary, Debasmita Dasgupta, Jagadish Chandra Kalita, and Subra Mukherjee. "Recent developments in paper currency recognition system." *Int. J. Res. Eng. Technol* 2 (2013): 222-226.

[20] Babar, Ajinkya, Swapnil Jawalekar, Kiran Yadav, and D. B. Salunke. "Counterfeit currency detector." *Int. J. Tech. Res. Appl* 3 (2015): 106-108.

[21] Mohamed Taha, Hamed Nassar, Tarek Gharib and Ajith Abraham, An Efficient Algorithm for Incremental Mining of Temporal Association Rules, Data and Knowledge Engineering, Elsevier Science, Netherlands, Volume 69 (2010):800-815.

[22] Lizhi Peng, Bo Yang, Yuehui Chen and Ajith Abraham, Data Gravitation Based Classification, Information Sciences, Elsevier Science, Netherlands, 179, No. 6 (2009): 809-819.