An Efficient Technique for Detection of Fake Currency

Snehlata, Vipin Saxena

Abstract*: During the past years, some of the researchers are using the matching techniques for identification of the fake currency either by using the Mathematical formulation or by using the readymade simulation tools. A lot of methods namely edge detection, segmentation, feature extraction, pattern matching has been used for finding and identification of the fake currency. In the present work, Principal Component Analysis (PCA) is used to detect the feature of currency through modeling and a proposed algorithm is elaborated to recognize the fake currency in the form of note Rs 2000 of Indian currency. Graphs are also designed to justify the present approach along with the comparison of results.

***Keywords*: Eigenvalues, Eigenvectors, Fake Currency, Matching Techniques.**

I. INTRODUCTION

Technology is rapidly growing for the conversion of the physical currency into the digital currency due to the availability of fake currency in the business market. In some of the countries, it has been implemented but in some countries around the world is suffering due to the availability of the fake currency. Currency replication is the most important threat in the business market. Currency replication is also known as counterfeit currency which is presently questioning due to sophisticated techniques such as printing and scanning. Due to the counterfeit note, India is facing many problems and challenges in the business market. Many researchers have been encouraged to develop robust and effective currency detection machine.

On November 2016, Prime Minister of India Mr. Narendra Modi announced that existing rupee notes of 500 and 1000 cease to be valid currency and that step is taken to rein black money and forged currency in the country. Prime minister also launched new rupee 500 and 2000 notes and discontinued existing rupee of 500 and 1000 notes. In the year 2017-18, according to an annual report published by Reserve Bank of India (RBI), fake currency notes detection has been dropped 31.4% as compared to the previous year due to high-security feature of notes making forged difficult. In Indian economy; Fake Indian Currency Note (FICN) is a term used official and media to refer to forged currency notes.

In 2012, in response to a parliamentary inquiry, the Finance Minister, P. Chidambaram stated that there was no confirmed estimate of forged currency in India. However, there are several states and central agencies work together and the Minister of Home Affairs have included the Fake Indian Currency Notes Coordination Centre (FCORD) to check the problem.

II. RELATED WORK

Due to an evaluation of new currency after denomination in India, it is necessary to check whether the arrival notes in the form of currency are genuine or not. The newly arrived currency is in Indian rupees of notes of 10, 20, 50, 200, 500 and 2000. Limited literature on the study of fake currency is available. However, some of the important references are described below in brief. Takeda and Omatu [2] proposed a neural-based acknowledgment and check strategies utilized in a banknote machine. The approach has been applied on Euro currency by the use of its dummy and implemented to the banking machine for getting the euro currency from the machine. Effective results have been proposed by the use of the reduced data set of Fourier power spectra. Frosini et.al. [3] described neural network-based currency verification of 23 distinct countries. The produced results are based on the lowest sensors by reducing the computational load with 98% accuracy. Leelasantitham et al. [4] have also proposed a strategy for investigating the water stamp on currency note by utilizing relationship mapping and background neural system. In this strategy, the area of water stamp is identified by interrelation mapping technique. Five types of notes like 20, 50, 100, 500 and 1000 of Thai cash note were prepared for 20 tests. The produced results have 100% of accuracy for recognizing the true currency notes.

In the year 2003, Zang et al. [5] have described paper currency which is broadly connected in numerous fields, for example, bank framework and programmed offering merchandise framework. The proposed technique gives high ascertaining speed, evident characters of unique, great vigorous to various types notes of 10, 20, 50, 100 with the desired accuracy. Yoshida et al. [6] have designed a machine vision-based framework for constant recognition of fake Bangladeshi monetary orders. The proposed framework based on five hundred and one hundred takas. The depended include is not conceivable to reproduce for the fake creators or makers. In the method, the framework captures the segments of the notes with a restrictive scanner called Grid Scanner. The captured image is then prepared by a microcontroller PIC-16F648A or ATMega88 (AVR) and decides the legitimacy of note in the light of an OCR strategy.

In the scanned image, searching these characters dasiaBpsila,

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Snehlata*, Computer Science, Babasaheb Bhimrao Ambedkar University, Lucknow, India. Email: snehlatasingh361@gmail.com

Vipin Saxena, Computer Science, Babasaheb Bhimrao Ambedkar University, Lucknow, India. Email: vsax1@rediffmail.com

dasiaApsila and dasiaNp. The achievement rate of the fake location with the legitimately caught image is 100% with handling time is 250 milliseconds. Hassanpour et al. [7] have proposed a new strategy for paper currency identification with three qualities of paper currencies forms which include size, shading, and surface or texture. By the use of image histogram, wealth of various hues in a paper currency is computed and compared with the one in the references paper currency with the help of chain idea utilized to show surface of the paper currencies forms as an arbitrary procedure with a strategy that can be utilized for perceiving paper currencies from distinct countries. In this technique, utilizing a single example of paper currency from every division is sufficient for training framework and tested the techniques on an excess of 100 divisions from various nations, and the framework could perceive 95% of data, accurately.

In the year 2010, Roy et al. [9] have discussed an image analysis based example arrangement strategy that proposed to real the printing procedure used in printing different text on currency notes. Linear Discriminate Analysis (LDA) is proposed for validating the printing procedure. The proposed technique gives a very accurate framework for verifying the printing procedure in monetary orders. Further, Fan et al. [10] have described the database end up outdated quickly and find out that different estimation of a similar substance exits in a database related to the currency. Bhattachary et.al [11] discussed a comparative analysis with two sophisticated approaches to information mining for better identification of card fraud through logistical regression. The study is based on real-life data of a transaction from international credit card operation. New technology was proposed by Qian et.al. [12] for the detection of currency based on electromagnetism which uses the basic principle of eddy current technology, the inspection equipment design, experimental results analysis and the characteristics quantity extraction.

Garcia-Lamont et al. [13] have described the recognition method of Mexican banknotes through artificial vision and is generally based on color and texture concerning with respect to RGB space and Local binary patterns. The proposed method applied to other countries banknotes. Hasanuzzaman et al. [14] have described that due a rapid increase of blind employees and uses in the bank, a novel camera-based computer vision technology has been used to identify the banknotes for visually impaired people. The system helps for capturing the image by the blind users. The proposed algorithm has been evaluating the dataset on the based on positive and negative images of U.S. banknotes. The recognition rate of the algorithm is true for 100% and false for 0%. Bruna et al. [15] have proposed the system that detects the counterfeit of euro banknotes and calculate its performance based on speed and accuracy. Feng et al. [16] have also proposed a new system for identification of Renminbi Banknote (RMB) character from RMB images with two different methods namely skew correction and orientation identification. After applying these two methods the binarization technique was used to compute the performance. Jain and Vijay [17] have described the image processing technique that extract the region of interest of image and also denomination of paper currency by considering the scanning image and further adjust size and pixel of the scanned image. This technique was used to match the value of a paper currency. Santhanam et al. [18] have proposed two types of methods; one is ultraviolet detection and second is the polarization of light that passed through currency for Identification of Counterfeit Currency and it is based on only physical property. Yan and Lin [19] have described the Feedforward Neural Network for the identification of the fake currency. Feedforward Neural Network has been taken with all the common features of banknotes then it compares with a suspect note. Yan et.al. [20] designed a prototype for automated currency detection which is based on generally color feature and texture feature and also proposed the Feed Forward Network (FNN). Also, it measured the similarity between a real and fake banknote.

Ahmad et al. [21] have proposed a software system that detects the counterfeit currency along with its features like micro-printing, optically variable ink, watermark, iridescent ink, security thread and ultraviolet lines using OCR (Optical Character Recognition), Contour Analysis, Face Recognition, Speeded Up Robust Features (SURF) and Canny Edge and Hough transformation algorithm of Open CV. Alekhya et.al. [22] have studied fake currency detection using image processing and other standard methods and explained some other methods to detect fake currency through security features of currency using MATLAB. Gates and Matthews [23] have discussed the privacy and ownership of data. The data could be related to personal, finance, online transfer and social media with three laws of the data value and data ownership. Ismail and Makone [24] have studied the fake currency of India and introduced software for identification of fake currency identification with the help of feature extraction classification based on an image by machine. That machine was equipped with a camera to scan the image of a currency note and the image is processed by the software with the help of character recognition methods and developed software by the use of MATLAB tool. In the year 2014, R and Omman [25] proposed a currency identification system which is based on the principle feature of currency and compared the result using WEKA classifier. WEKA classifier produced the high performance of that algorithm. Singh et al. [26] have developed a system of currency identification through mobile phones for visually impaired users. The approach has been applied to other currencies to check its speed and accuracy which is 96.7% on 2584 images. Thakur and Kaur [27] presented a different fake currency detection techniques and reviewed different fake currency detection system. This approach was based on different methods and algorithms used for the counterfeit currency detection system and compared them. Yadav et.al. [28] described the fake currency Identification method with feature extraction using MATLAB. This approach has been designed as a system to verify Indian currency using image processing. It described two characteristics of Indian currency to identify counterfeit notes which are identification mark and currency serial number. Generally, the image processing technique applied on currency using Sobel Operator.

The system has followed the number of steps including

image processing, edge detection, image segmentation, characteristic extraction, and comparison.

Ahmad et.al. [29] designed a machine-based system for the identification of Bangladeshi currency in the form of taka and presented a core software system to build a robust system for the detection of counterfeit currency through the extraction of important features like security thread, ultraviolet lines, watermark contour analysis, face recognition etc. with the advantages and disadvantages of the proposed system for improving currency authentication system. Bhurke et. al. [30] designed an algorithm for currency recognition. The proposed algorithm has based on Image processing technique using MATLAB. The basic requirement for an algorithm has simplicity, less complexity, high speed and efficiency and proposed an algorithm design an easy but efficient algorithm that useful for a maximum number of currencies. To work on this project authors used five currencies and selected currencies are Indian Rupee (INR), Australian Dollar (AUD), Euro (EUR), Saudi Riyal (SAR) and US Dollar (USD) and in this regard, Hijazi and Kumar [31] have proposed Convolution Neural Network (CNN) for image and pattern recognition.

Sarfraz [32] also described paper currency recognition which has been studied by many of the researchers and the main object of the work is dealing with 110 images that are a combination of a tiled and non-tiled image for computations of the performance. Most of the methods were used for pattern recognition. Vora et.al. [33] designed an algorithm for fake currency detection based on feature extraction methods and also used two-dimension discrete wavelet transform (2D DWT). Walke and Chanwadkar [34] designed a machine which recognizes counterfeit currency using SVM with to coin exchanger and presented a machine to provide a coin for genuine note. Firstly, an image is taken then used image processing technique to process. If the note is genuine then the machine will provide coin to its equivalent value.

Abdallah et.al. [35] is an excellent source of information on Fraud Detection System (FDS) and described the challenges and issues during fraud detection on electronic commerce and emphasized that fraud detection system is important as same as fraud prevention system. Rashmi, C. and Kumar, H [36] proposed an algorithm to recognize currency note number using image processing for an Automated Teller Machine (ATM) and explained the algorithm that has automatically saved the currency number on the server and it is also easier to currency recovery and also explained their proposed algorithm makes ATM more reliable and user friendly. Pilania and Arora [37] designed a system that recognized the fake currency based on a security thread feature of currency and also described that counterfeit notes are a very big problem for every country hence presented a system that verified the Indian currency & other countries using Image Processing technique with less time and fast speed.

Rathee et.al. [38] studied the physical and chemical properties of counterfeit currency and presented a core software system to build a robust system for the detection of counterfeit currency using physical properties. In the proposed algorithm authors used the some features: - security thread, intaglio printing (RBI LOGO), identification marks which were adopted as a security feature of Indian currency and also explained the difference between real and fake currency based on the above three security features, the performance of the proposed system was also measured based on accuracy and mean square errors. Agasti et.al. [44] have used the Image processing method for currency recognition which is the most important method for feature extraction. After extracting the valuable features, the intensity has been computed. Sharma and Narang [45] have explained the currency of different currency. Many researchers have been worked on currency recognition system using different methods. Snehlata and Saxena [46] have provided an object-oriented model for currency identification system by the use of MATLAB. Jara et al. [47] have described the falsification of currency banknotes which are a frequent illegal activity and proposed aspects generally identify the false banknote using portable X-ray Fluorescence spectrometer (pXRF). Tigani and Saadane [48] also proposed the statically predictive model to estimate the financial market stability based on historical data.

III. MATERIALS AND METHODS

A. Indian Currency

Money is any object or record that is typically time-honored for the payment of items and services and the repayment of money owed in a particular socio-economic context or country. The currency of India is the Indian Rupee (INR). The word “rupee” originates from the Sanskrit word rup or rupa meaning silver. Sher Shah Suri (1486-1545) introduced the very first rupee, which has a ratio of 40 copper pieces (Paisa) per rupee. The name derived from Sanskrit word raupyakam, which means silver. In the 18th century private banks such as - the Bank of Bengal, the Bank of Bombay and the Bank of Madras began the process of issuing paper currency. The Indian government was provided the monopoly on printing currency after the paper currency act of 1861. India's government (GOI) printed currency until RBI was established in 1935, assuming that accountability. In 1938 only Rs 10, Rs 100, Rs 1000 and Rs 10000 were issued. RBI currently issued notes Rs 5, Rs 10, Rs 20, Rs 50, Rs 100, Rs 500 and Rs 2000, also known as banknotes. The printing of notes in Rs 5 demonetization was also stopped.

B. Security feature of Indian Currency

The Fake currency detection system varies depending on specific features of banknotes of country (21). For Indian Banknotes, features are considered. For testing purpose Rs 2000 note. There are some important security features of Indian currency: - Watermark, Security thread, Latent Image, Intaglio Florescence Micro lettering, Identification Mark, Optically Variable Ink.

C. Legal provisions against counterfeiting

Printing and circulation of forged notes are offences under section 489A to 489 E of Indian Penal Code (IPC) and are punishable by fine or imprisonment or both in the courts of law.

The currency has great significance in everyday life. Therefore, many researchers have

become interested in the recognition of currencies and have proposed various approaches.

According to literature, image processing is the most efficient method in currency recognition area. A banknote has safety features mainly in the design and printing of paper. The identification and examination of currency notes are mostly carried out by the following aspects:

(1) Physical dimension
(2) Paper quality
(3) Design
(4) Printing Technique

The physical dimension of the note depends on its cutting size, length, width, thickness and grammage. The paper on which currency note is printed has a high level of security. Watermark and Security thread are the most important components of currency note paper security.

D. Storage of Image of Currency

A rupee 2000 real note first scanned by scanner and outlook of notes are represented in the figures 1 and 2, thereafter, the scanned image is the input in MATLAB.

Fig.1. Image of Real Currency

Fig.2. Image of Fake Currency

E. The Reasons for Selecting the Feature

Micro-printing is widely used for a robust feature of Indian banknotes. The advantage of micro-printing is that they cannot be visible without a magnifying glass or appropriate focus of the camera, this feature is very tough to replicate in fake notes by the normal printing process and actually require a very high cost and the other reason is Optically Variable Ink (OVI), which is very costlier ink and is impossible to forge through printer or ordinary printing machines. In real notes, the printing quality of watermark is very good, perfect and unmutilated. That is the reason why it is very hard to knock off for the counterfeits. The stitching technique of the security threads and the pattern around the security thread are clearly identifiable. A new dimension in stopping counterfeit notes is created by the presence of ultraviolet lines in the banknotes. Therefore, these features are used to perform forgery detection.

Table I represents the existence of these features in various Indian banknotes based on the experiment and is shown below:

Table-I: Features in the Indian Currencies

Features	Availability Among Note
Watermark	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Security Thread	All notes
Latent Image	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Intaglio Printing	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Fluorescence	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Micro Lettering	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Identification Mark	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000
Optically Variable Ink	Rs 5, Rs 10, Rs 100, Rs 500, Rs 1000, Rs 2000

F. PCA Technique

Principle Component Analysis (PCA) is a method of identification of data patterns in which data are expressed in order to highlight similarities and differences. Once the pattern is found in the data, it can be compressed i.e. reduced the number of dimensions without losing much information. PCA transforms the 'p' which is the original correlated variable into 'p' uncorrelated components (also called orthogonal components or principle component). These components are original variables of the linear function.

The transformation is given by

$$Z=X\,A \qquad (1)$$

Where

X denotes n*p matrix of n observations on p variables;
Z denotes n*p of n values for each of p components;
A denotes p*p of coefficient defining the linear transformation.

PCA is a measurement quantity reduction technique in which image is represented in higher dimensions. The processing of an image in higher dimensions requires more time of the processor. A weight vector is obtained, after the projection of higher to a lower dimension. A weight vector represents original data (higher dimension) in term of Eigenvectors (lower dimension). The phase contains the following stages:

1) Information is extracted from the Image and data is acquired;
2) The covariance matrix is constructed from the acquired data;
3) To find Eigenvalues & Eigenvectors;
4) Short Eigenvectors and find principle Eigenvectors;
5) Data is mapped and stored.

G. Image Processing with MATLAB

MATLAB (MATrix LABoratory) is a very significant tool designed with a mathematical background and capable of doing numerical computations, display data graphically and solving many other technical and scientific issues [8].

While working with a MATLAB image, there are many different things to remember, for example loading an image in the right format, saving the data as various conversions between various image formats and so on.

Let's discuss some of the commands for different operations. A digital image consists of pixels that on the screen can be considered as tiny dots. A digital image is a coloring instruction for each pixel [8]. Normally, an m-by-n image is made up of m pixels in the vertical direction and n pixels in the horizontal direction. Suppose an image on format 512 by 512 pixels. That means the data for the image contain information about 262144 pixels, which require a lot of memory. Hence, image compression is the most important technique of image processing. There are different formats supported of an image like BMP, HDF, JPEG, PCX, TIFF and XWB. If an image stored as a JPEG format, firstly read the image into MATLAB. Then it used the different formats as follows:

Gray Scale Image: An Image is always represented in the form of a matrix with a value for each component that represents the corresponding value to bright and dark that is colored. There is the two way to a representation of the brightness of the pixels: One is a double class that assigns the floating number ("a number with decimals") between 0 and 1 to each pixel. Then the value 0 is black and the value 1 is white. Another class that assigns the value between 0 and 255 is called uint8.

Binary Image: An image is stored as a matrix by this image format, but can only color (and nothing in between) a pixel black or white. It assigns 1 for white and 0 for black. The image is generally stored in matrix form but this image format pixel represents in black or white. It represents as 0 for black and 1for white.

RGB Image: This is another color image format. It is an image with three size matrices that match the image format. Each matrix matches one of the colors red, green or blue and shows how many of these colors a certain pixel should use.

IV. PROPOSED METHOD

An easy approach to extracting data contained in a currency image is to capture the variation in an image collection, regardless of any judgment of feature and use this data to encode and compare with fake currency images. In figure 3, the proposed approach to detecting the false currency as shown below:

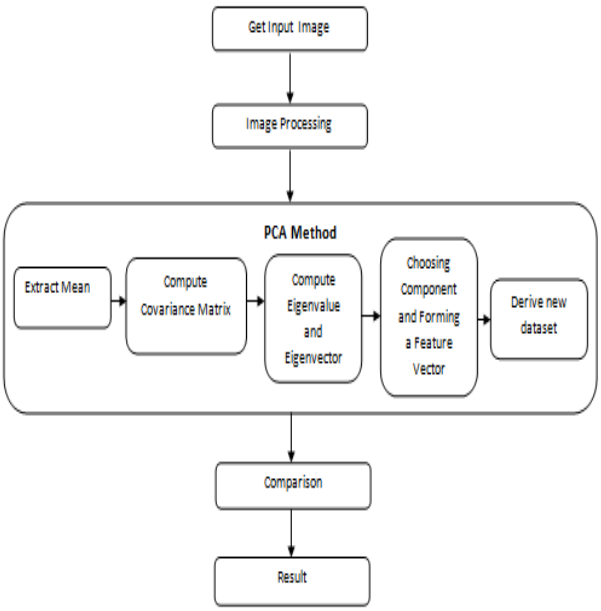


Fig.3. Proposed Approach for Detection of Fake Currency

These eigenvectors can be considered as a collection of the feature that characterizes together and the difference between real and fake currency images. Each image location contributes to each eigenvector more or less. This approach to recognition involves the following initialization operation:

A. Get Input Image:

This process acquires the real and fake image of currency using imread () function.

B. Image Pre-processing:

The acquired image is in RGB color. The RGB image has been converted to HSV (Hue-Saturation-Value) and Gray. After getting an RGB image then it converts into a binary image.

C. PCA Method

a) Extract the mean

To make PCA work properly, the First step is to normalize the data which is done by subtracting the respective means from the given number in the column. Therefore, for given two dimensions P and Q, all P will change to p- and Q will change to q- then:

$$Mean(\overline{P}) = \frac{1}{n}\sum_{i=1}^{n} P_i \qquad (2)$$

b) Compute the Covariance Matrix

As the dataset taken is 3-dimensional, this results in a covariance matrix of 3*3. A numerical measure of the degree of correlation is denoted by S_{pq} between two variables which were introduced by the great statistician Karl Pearson (1857-1936) and that's called coefficient of correlation and given by:

$$S_{pq} = \frac{\text{cov}(p,q)}{\sqrt{\text{var}(p)\,\text{var}(q)}} = \frac{\sum (P_i - \overline{P})(Q_i - \overline{Q})}{\sqrt{\sum_{i=1}^{n} (P_i - \overline{P})^2 \sum_{i=1}^{n} (Q_i - \overline{Q})^2}} \quad (3)$$

The covariance is measured between two dimensions. If there is a dataset with more than two dimensions, it is possible to calculate more than one covariance measurement. For example, calculate cov(1,2), cov(2,3) and cov(3,1) form three dimensional data sets. For the m-dimensional data set, different covariance values can be used by the following formula:

$$C_2^m = \frac{m!}{(m-2)!*2!} \quad (4)$$

Suppose, three-dimensional data set, then to make covariance has three rows and three columns with dimensions <p, q & r> is given below as:

$$\sigma = \begin{bmatrix} \sigma_{pp} & \sigma_{pq} & \sigma_{pr} \\ \sigma_{qp} & \sigma_{qq} & \sigma_{qr} \\ \sigma_{rp} & \sigma_{rq} & \sigma_{rr} \end{bmatrix} \quad (5)$$

c) Calculate the Eigenvalues and Eigenvectors

Calculation of eigenvalues and eigenvectors is possible only if it is a square matrix, λ is an Eigenvalue for a matrix A if it is a solution of the characteristic equation [43]:

$$\det(\lambda I - A) = 0 \quad (6)$$

Here, ***I*** is an identity matrix with the same dimension as ***A*** and the determinant of the matrix is denoted by ***'det'***. For each Eigenvalue λ, there will be a corresponding Eigenvector v, can be find by solving equation given below [47]:

$$(\lambda I - A)v = 0 \quad (7)$$

d) Selecting Component and Forming a Feature Vector

Firstly, order the eigenvalues from largest to smallest to arrange the components in order with dataset of n variables. For the corresponding n eigenvalues and eigenvectors, the eigenvector corresponds to the highest eigenvalue will be the principle component of the dataset and it will be our call to choose the number of eigenvalues to proceed our analysis. For reducing dimensions, choose only to say p Eigenvalues and ignore the rest [43].

For forming a feature matrix which is a matrix of vectors i.e. eigenvectors (in this case). Actually, only those eigenvectors want to proceed with. Since three dimensions in the current example, it can either choose the one corresponds to the higher value of Eigen or simply take both and given by [43]:

$$FeatureVector = (eig_1, eig_2) \quad (8)$$

e) Derive the new dataset

It will be the final step forms the principle components. For that purpose, take the transpose of the feature vector and left-multiply with the transpose of scaled data [47]. The resulting equation will be given by:

$$NewData = FeatureVector^T * ScaledData^T \quad (9)$$

Here,

NewData is the Matrix consisting of the principle components,

FeatureVector is the Matrix formed using the eigenvectors then choose to keep and

ScaledData is the scaled version of the original dataset.

According to the theory of eigenvalues and eigenvectors, eigenvectors provide information about the pattern exist in the data. In the above-discussed example, if plot the eigenvectors on the scatter data plot and find that the principle eigenvector actually fits the data. The other Eigenvector will not carry much information as it perpendicular to the principle vector. Therefore, it will not lose much while reducing the dimension.

f) Comparison

In this step, the comparison between real and fake currency through histogram represented in figures 4 and 5 which is clearly represented the relative frequency of the different gray levels of real and fake currency.

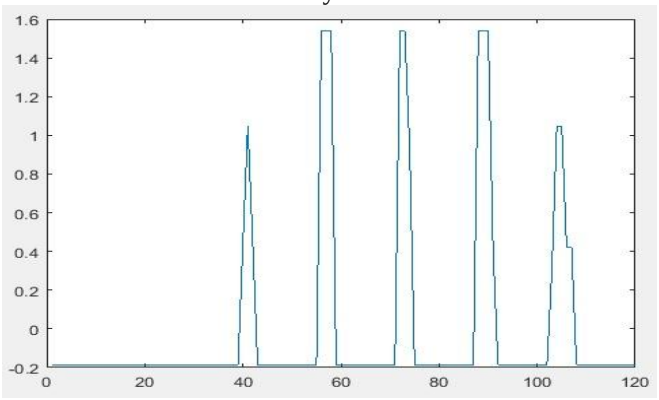


Fig.4. Histogram of Real Currency

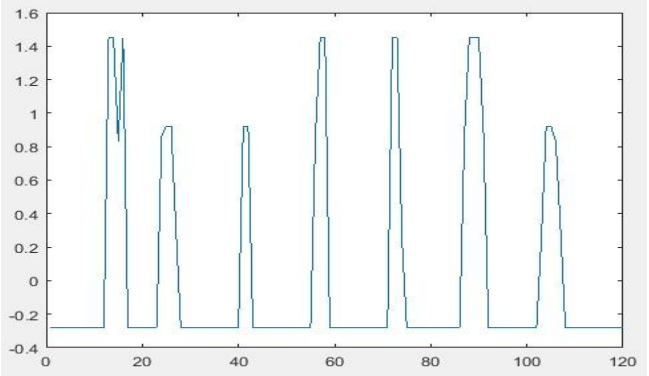


Fig.5. Histogram of Fake Currency

g) Experimental Result

The proposed technique is implemented using MATLAB to get evidence of a difference between real and fake image. After finding the eigenvalue and eigenvector then it plots in figures 6 and 7. All eigenvectors of a matrix are perpendicular to each other. Therefore, in PCA, instead of the normal x- and y-axes, the original data set is transformed using these perpendicular eigenvectors. Then classified data points are obtained by combining x and y contributions. The difference will be observed when ignoring many Eigenvectors.

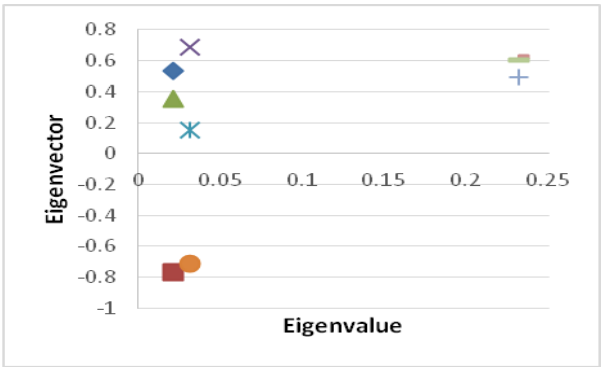
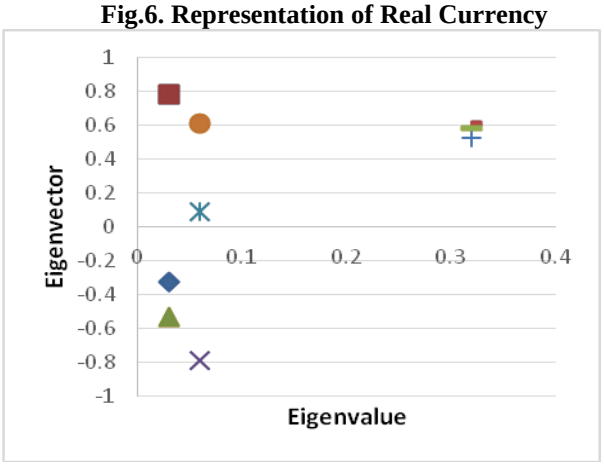


Fig.6. Representation of Real Currency



(b)

Fig.7. Representation of Fake Currency

From the above work, it is concluded that PCA is an excellent approach to detect fake currencies in Indian scenario as well as worldwide. Many researchers have implemented this approach on notes of various kinds but not for Indian Currency. In the works, an efficient model is proposed through which results are presented in the form of the graph. The converged result has been obtained by computing mean, covariance, eigenvalues, eigenvectors and new data set has been generated for Identification of fake currency.

V. CONCLUSION

From the above work, it is concluded that PCA is an excellent approach for the detection of fake currency in the Indian scenario as well as worldwide. Many researchers have implemented this approach on notes of various kinds but not for the Indian currency. In the present work, an efficient model is proposed through which results are presented in the form of the graph. The converged result has been obtained by computing mean, covariance, eigenvalues, eigenvectors and new data set has been generated for identification of fake currency.

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AUTHORS PROFILE

Snehlata, Research Scholar in the Department of Computer Science, Babasaheb Bhimrao Ambedkar University Lucknow. She received her B.Tech Degree in Computer Science & Engineering in 2012 from B.B.S. College of Engineering & Technology Allahabad, affiliated to Uttar Pradesh Technical University. She received her Master of Science degree in Cyber Law and Information Security (MSCLIS) in 2014 from Indian Institute of Information Technology (IIIT), Allahabad, India. Her research interests include Image Processing, Information Security.

Dr. Vipin Saxena, is a Professor in Department of Computer Science in Babasaheb Bhimrao Ambedkar University Lucknow. He received his M.Phil. Degree in Computer Application in1992 and Ph.D. Degree in 1997 from Indian Institute of Technology, Roorkee. His research area includes Scientific Computing and Software Engineering. He has distributed in excess of 130 International and National Publications.

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