Detection of Counterfeit Indian Currency Note Using Image Processing

Vivek Sharan, Amandeep Kaur

Abstract*: Most of the country suffering from the problem of counterfeit note. Indian is also part of such problem. As advance in technology, it is possible for anyone to print counterfeit note. Such counterfeit notes are produced without the legal sanction of Government and production of such notes degrades the economy of any country. After demonetization in India Newly 500 and 2000 currency notes are launched but due to misuse of advanced technology, fake currency of such notes are produced by counterfeiter due to its high value and circulated in most of the part of our country. With the production and circulation of such counterfeit notes, it becomes difficult for common people to differentiate whether the currency is real or fake as they differentiate on the basis of physical appearance which effects the economy of our country. Here a system is proposed to differentiate between real and fake note which is based on the image processing technique and implemented in MATLAB. In this technique, first the image of 500 and 2000 rupee note is captured through the digital camera and perform preprocessing in order to remove noise and then mean intensity of RGB channels of image is calculated and further the three different features including Latent image, RBI Logo and denomination numeral with Rupee symbol are extracted to differentiate between real and fake note. The performance of the proposed system achieves good accuracy rate.

***Keywords* : Canny Edge, Image Processing, Image Segmentation, Morphological Processing, Mean Intensity.**

I. INTRODUCTION

Today in the modern digitalization world, we are surrounded by technology and such technology is growing day by day in rapid manner. Of course such technologies makes our life very easy. Today people can do their work with minimum effort and such thing are only possible because of the technology. But some people utilizing the advantages of such technology to fulfil their bad purposes. There are a lots of such examples that are surrounded around us. Counterfeit note is the one of the most important example of such things. Production of currency without the legal sanction of Government is termed as Counterfeit currency. Facing problem of counterfeiting money is not a new. This problem was found around 600 BC in Greek city of Lydia. During that period paper currency was not introduced and counterfeit problem can be seen in the form of coin. Mixing base metals with pure silver or gold was used to make such coin as counterfeit coin. Shave the edges of a coin called clipping, to get precious metal and make the counterfeit coinage by using that metal. In 1200s in China the paper money was introduced using the wood of mulberry trees. Guards used to look after that trees during that time and counterfeiting of money were punished by death.

The currency system is prevalent in India since a very long time. The Government of India introduced its first paper money issuing 10 rupee notes in 1861 and further year by year more currency were launched. In 1935, the Reserve Bank of India was established and issued the first paper currency note in January 1938. Authorization of printing currency in India is only done through Reserve Bank of India. But the corrupt people utilizing the latest scanning and printing techniques to print counterfeit currency. The production of such fake currency, affects the economy of any country. Indian is also the part of such undesirable things. During 2006-09, about 7.34 lakh of Rs100, 5.76 lakh of Rs500 and 1.09 lakh of Rs1000 notes have been seized as per the figure disclosed in Parliament due to found as fake notes. After the fake currency found in huge amount continuously year by year in rapid manner, The Government of India in 8th November 2016, announced that Rupees 500 and Rupees 1000 notes would no longer be legal in order to diminish the size of the order economy by rooting out black money and counterfeit currency used for funding illicit activities including terrorism and introduced new currency of Rupees 500 and Rupees 2000. But After Demonetization, counterfeit currency to the tune of Rupee 21.54 crore was seized by agencies include the recently introduced 2000, 500 and 200 currency notes. A total of 39,604 currency notes of 2000 denomination was seized across the country. Corrupted people involve in developing such fake note targeting such high denomination value notes. It leads major problem generally for common people to differentiate between real or fake note as they determine only on the basis of physical appearance of the note. Therefore an automatic technique based on image processing is introduced So that common people can easily differentiate between the real or counterfeit note.

This Paper has been comprises into five different section. Section I contains the introduction of Counterfeit note, Section II contain the related work of Counterfeit note done by various researchers, Section III contain the methodology introduced in this domain with flow chart for the detection of counterfeit notes, Section IV contain the conclusion and future scope. As a last paragraph of the introduction provide organization of the paper. Rest of the paper is organized as follows

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II. RELATED WORK

A numerous researcher have introduced different methods for the detection of authenticity of note. In this section, Some of the work done by them are presented-

For banknote detection, a new point extraction and recognition algorithm proposed by Lee and Kims [1]. In order to particular point extraction, coordinate data extraction technique used for banknotes with similar color. Five neural networks trained for recognition purpose.

For the detection of Bangladeshi currency, Jahangir and Raja [2] employed neural network approach and trained through Back Propagation algorithm. Images of banknote are scanned with less expensive sensors. In pre-processing step the axis symmetric mask is used due to which the correct recognition is performed even the note is in flipped condition. In this method eight notes of TAKA are used and all were successfully recognized.

Debnath [3] for currency recognition they had employed ensemble neural network and trained through Negative correlation learning. They considered various denominations of 2, 5, 10, 20, 50,100 and 500 TAKA. Further convert that images of note into grayscale and compressed the image and used as input for recognition. The system can easily detect the currency with different condition like old or noisy.

With respect to the blind people, an Effective Component-Based banknote system using SURF (Speed up Robust Feature) proposed by Faiz M. Hasanuzzaman [4]. These images are selected from different conditions such as cluttered background, illumination change, scaling, rotation, viewpoint variation, occlusion variation, worn or wrinkled bills. The proposed algorithm achieves better result but for highly blurred images, the surf is not able to extract accurate local images features.

Nayana Susan Jose [5] introduced an Android Based Currency Recognition System for recognizing currencies of different countries and also their denominations mainly for visually impaired people. Image processing techniques like feature extraction and matching are used to identify currencies. But the limitation was as Limited processing power and memory issues. Also good Camera quality with proper lighting and internet required.

S. Surya [6] developed an interactive system based on image processing that generates Currency Recognition System with the help of MATLAB. RGB color model with mean intensity is used to recognize the Indian currency notes. But limitation in this paper as they used Sobel operator to detect edge which is not as sensitive to noise and it amplifies high frequency.

Chinmay Bhurke [7] recognize the currency of different countries based on color and feature analysis. They use five currencies of different country including Indian Rupees (INR), Euro (EUR), Australian Dollar (AUD), Saudi Arabia Riyal (SAR) and US Dollar (USD). They apply aspect ratio to find dimension of the currency and extract HSV values and compare between mean of target and ideal HSV using Euclidian distance. The proposed system works well for four INR, AUD, EUR, SAR currencies but fail to recognize USD banknote.

Prof. L.S Kalkonde1 [8] presents Embedded System for Note to Coin Exchange. After finding currency value equivalent number of coins are dispensed. They used UV LED and photodiode for counterfeit note detection. In order to identify the note they used color based detection method. But the limitations of this paper was that it work well for 10 and 20 rupee note but not surety of high note values.

Multispectral Imaging with Image Processing technique proposed by Pradeep Raj. R [9] for the detection of counterfeit note. They captured images under different wavelength lights –Red, Green, Blue, Infra-Red, Ultra-Violet – and their intensities, compare them with the values obtained for an original note to determine whether the note is authentic or not. In this paper for the denomination identification they use the concept of Aspect Ratio (the ratio of the width of the note to its height).

Furthermore review on various fake currency detection techniques presented by Megha Thakur [10] This paper present features like See through Register, Water marking, Fluorescence, Security Thread, Intaglio Printing, Latent image, Micro lettering, Identification Mark, Optically Variable Ink for detection method. Digital Image Processing Method to Detect Fake Currency, MATLAB technique, Counterfeit Detection Pen, Other techniques like UV detector.

Bit-plane slicing Technique proposed by Mohammad H Alshayeji1 [11] for the detection of counterfeit currency. When the bit-plane slicing technique with canny edge detector was applied on images of a genuine and a counterfeit banknote, 6^{th} and 7^{th} bit-plane provide better results in recognizing edges and hidden features of images with low error rate than original image. But the Limitation of this paper was that its failed detection with color bit-planes.

Using image processing technique B.Sai Prasanthi [12] presents Indian Paper Currency Authentication System. The Sobel operator with gradient magnitude is used for characteristic extraction. The complete methodology works for Indian denomination 20, 50, 100, 500 and 1000. But the hardware part that is designed, used for capturing image is challenging task because of presence of noise.

Another technique proposed by Pujar [13]for recognition and verification of paper currency. For currency recognition detection and isolation of denomination of the currency with the help of image processing is done and for currency verification extract texture features (HAAR) of the currency is done.

Another approach proposed in the same area by Anuprita B. Harugade [14] that can classify and subsequently verify Indian paper currency using Principal component analysis (PCA) technique. It uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. Result is finally displayed as note is valid or not valid.

Further Ms. Monali Patil [15] also developed a system to deal with fraud currency for Indian Notes. They use k-means clustering algorithm to forms the clustering of feature one by one. After that recognized the

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input image as a 200, 500, or 2000 and compare the features of the image and classified it as original or fake with the help of SVM algorithm. The experimental results indicate that use of SVM Algorithm having better performance than KNN Algorithm for accuracy.

III. METHODOLOGY

The proposed method is based on the image processing technique for the detection of counterfeit Indian currency note. As the high denomination value, recently introduced 500 Rupee Note and 2000 Rupee Note is considered here. There are various different features that are present in the currency of 500 Rupee Note and 2000 Rupee Note, which are used by common people for differentiating currency denomination. In the proposed model three features i.e Latent image, Logo of RBI and denomination numeral with Rupee symbol with color feature of currency note are used for detection of real or fake note. Color has been used widely as a prominent feature by banknote designers for the differentiation between denominations. The algorithm which is applied for the detection of counterfeit Indian currency note is as follows:

- Acquisition of currency note using digital camera.
- Preprocess the captured image
- Convert the image to grayscale
- Perform edge detection.
- Perform segmentation on the image and extract feature.
- Identify the currency based on condition satisfied.

The proposed system will work in the following steps:

Acquisition of Image: Image will be captured through digital camera in the way that it will acquire its features.

Pre-processing: This is the step that is required before the image process. In this method resize the captured image in a standard format, here this is done by using imresize function. After resizing the image one more task is required. When the image is captured then there be chance of noise and such noise degrades the further processing task. Therefore in order to process the captured image in proper way, need to remove such kind of noise. Different filters are used by different author, but in this method median filter is used to remove such noise

Grayscale Conversion: The image acquired is in RGB color. In order to process image in efficient way need to convert into grayscale image as it carries only intensity information which is easy to process instead of processing three channel R(Red), G(Green), B(blue) that is complex and also leads to time consuming.

Edge Detection: It is a technique used for finding boundaries of objects within images. The points at which brightness changes sharply are organised as set of curved line segments called edges. In this method canny edge detection is used. This technique uses two thresholds, so can easily detect strong as well as weak edges in the output, if the weak edges are connected to strong edges. This method gives better results compared to the other technique in presence of noise. The canny edge detection has the following steps:

- Smooth the image with a Gaussian filter.

$$F(I,j)= G*I(I,j)$$

Where F represents the smoothed image, I(i,j) is input image and G is Gaussian filter

- Compute the gradient magnitude and orientation Sobel masks (3*3) are convolved with F and gets gradient in i direction and j direction.

$$D_i = \begin{Bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{Bmatrix} \text{ And}$$

$$\begin{Bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{Bmatrix}$$

Here D_i and D_j are sobel masks in I and j direction

$$G_i = D_i * F(i,j) \text{ and } G_j = D_j * F(i,j)$$

G_i and G_j represents the gradients in the i direction and j direction.

Now, edge strength or magnitude of gradient is given by,

$$|G| = |G_i| + |G_j|$$

Gradient direction is given by

$$\theta = \text{arctan}\left({G_j}/{G_i} \right)$$

- Apply nonmaxima suppression to the gradient magnitude and to detect and link edges double thresholding is used.
- Contents of the paper are fine and satisfactory. Author (s) can make rectification in the final paper but after the final submission to the journal, rectification is not possible.

Segmentation: The aim of this step is to simplify or change the representation of an image into sub region that is more useful and easier to analyse. For this morphological operators (dilation and erosion) are employed. This verify the image with a small template called structuring element (here 3*3 matrix is taken) that identifies the pixel in the image that is being processed. The aim of dilation operation is to add pixels at the boundaries of the objects that leads to grow the object size. Dilation process consider two parts as data, first is input image which is to be dilated and other is structuring element also called kernel that define how much image to be dilated. Boundaries of the object becomes thick after performing dilation process now use fill operation on the image with arguments holes in such way that it automatically fills the holes of object with different image in image. So, after performing dilation and filling the holes of object in some images the boundaries get mixed up so to somewhat separate the boundaries erosion is applied so as to make the boundaries of the objects thinner for better output.

Feature extraction: Extracting feature is a very challenging technique of image processing where the dimension of the data is reduced. When the input data is too large to be processed and contain less information then input data will be transformed into reduced representation set of features. If the attribute features are chosen carefully then it is expected to extract relevant information instead of processing whole input data which are very important for recognition of currency as real or fake. In the proposed technique currency features like Latent Image, Logo of RBI and denomination numeral with Rupee symbol of both high denomination value with currency color are considered for extraction. The mean intensity of features are extracted from the segmented object.

Output: Now mean intensity of both color components of currency note and extracted features of currency note are compared with threshold value to conclude that the currency is real or fake.

Proposed workflow Diagram

The work flow flow diagram of the proposed model shown in fig.1. At first, the image is captured through the camera in such a way that it contains its features and calculate the mean intensity of RGB channels, here R1 represents the mean intensity of red channel, G1 represents the mean intensity of green channel and B1 represents mean intensity of blue channel. Now the mean intensity of such channels are compared with conditions given in the flow diagram i.e if R1 lies between value 170 to 180, G1 lies between value 148 to 160 & B1 lies between value 123 to 143 or if R1 lies between value 149 to 156, G1 lies between value 148 to 160 & B1 lies between value 155 to 168 then goes for further steps otherwise conclude that currency is fake.

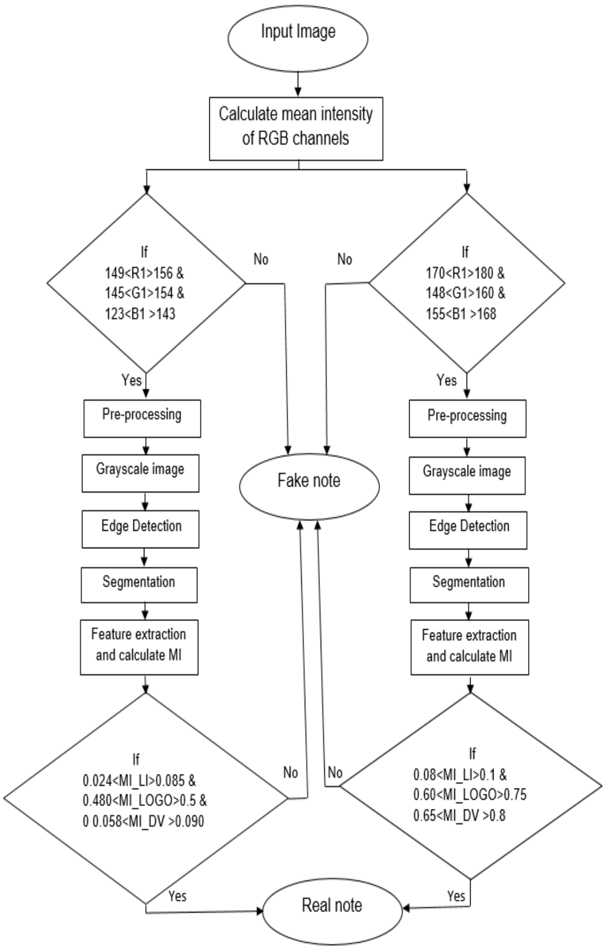

Fig. 1. Proposed Workflow Diagram

As criteria is satisfied then algorithm execute pre-process step followed by feature extraction. Now Mean Intensity (MI) of extracted features are compared, here MI_LI represents the mean intensity of latent image, MI_LOGO represents the mean intensity of RBI logo and MI_DV represents the mean intensity of denomination numeral with Rupee symbol are compared. If MI_LI lies between 0.024 to 0.085 & MI_LOGO lies between 0.480 to 0.5 & MI_DV lies between 0.058 to 0.090 then conclude that currency value is Rs 500 and it is real or if the If MI_LI lies between 0.08 to 0.1 & MI_LOGO lies between 0.60 to 0.75 & MI_DV lies between 0.65 to 0.80 then conclude that currency value is Rs 2000 and it is real otherwise currency is fake.

IV. RESULTS AND DISCUSSION

In this section, result of the proposed technique along with the performance of the proposed technique in term of accuracy rate are discussed. Proposed technique is implemented in MATLAB 2017a. The different parameter employed to differentiate between the real note and counterfeit note are observed individually as calculating mean intensity of RGB channels of both 500 currency note and 2000 currency note and further mean intensity of three extracted feature (Latent Image, RBI logo and Denomination numeral with rupee symbol) from 500 currency note and 2000 currency note. On the basis of observed value, a standard value is taken as threshold value to compare and finally conclude that whether the currency is real or counterfeit. The observed mean intensity of different channels for 500 currency note and 2000 currency note are shown in Table- I and Table- II

Table- I : Mean Intensity of RGB channel for different 500 note

Denomination value	Input Image	Mean Intensity Red channel (R1)	Mean Intensity Green channel (G1)	Mean Intensity Blue channel (B1)
500	1	151.5894	148.6215	124.2137
	2	153.6523	151.3484	132.3412
	3	154.2963	151.2220	127.5341
	4	149.8085	149.8280	136.6912
	5	149.8089	147.6719	141.8512
	6	153.4913	152.6978	142.9582
	7	149.4215	147.5603	138.1294
	8	151.4693	148.9342	141.4693
	9	150.9415	151.9458	142.4546
	10	155.2493	153.7819	128.3587

From the Table- I, it is observe that mean intensity for different channels are varies from the specific range. Here 10 currency note of 500 are taken as input image and processed in MATLAB to calculate the mean intensity of RGB channels. In the table R1 represents the mean intensity of red channel of the image, G1 represents the mean intensity of green channel of the image, and B1 represents the blue channel of the image. On the basis of observed values, the standard threshold value for individual channels for 500 note are considered. For 500 note mean intensity of red channel (R1) is taken from

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range 149 to 156 as threshold value for R1 channel, mean intensity of green channel (G1) is taken from 145 to 154 as threshold value for G1 channel, mean intensity of blue channel (B1) is taken from range 123 to 143 as threshold value for B1 channel.

The observed mean intensity of different channels for 2000 currency note are shown in Table- II

Table- II: Mean Intensity of RGB channel for different 2000 note

Denomination value	Input Image	Mean Intensity Red channel (R1)	Mean Intensity Green channel (G1)	Mean Intensity Blue channel (B1)
2000	1	171.5694	151.3456	160.1345
	2	174.5378	153.8712	161.4582
	3	179.3412	157.9810	165.5679
	4	172.9812	154.4129	167.4512
	5	175.5214	158.3459	162.6734
	6	172.1569	153.4918	162.0877
	7	176.8712	158.0156	165.1178
	8	179.5618	152.5011	167.1509
	9	178.1458	155.4218	162.1155
	10	179.1257	157.7895	164.0916

From the Table- II, it is observe that mean intensity for different channels are varies from the specific range. Here 10 currency note of 2000 are taken. On the basis of observed values, the standard threshold value for individual channels are considered. Mean intensity of red channel (R1) is taken from range 170 to 180 as threshold value for R1 channel, mean intensity of green channel (G1) is taken from 150 to 159 as threshold value for G1 channel, mean intensity of blue channel (B1) is taken from range 160 to 168 as threshold value for B1 channel.

Now the mean intensity of each extracted features of 500 note and 2000 note are mentioned in Table- III and Table- IV respectively.

Table- III: Mean Intensity of extracted feature for different 500 note

Denomination value	Input Image	Mean Intensity Latent Image (MI_LI)	Mean Intensity RBI Logo (MI_LOGO)	Mean Intensity denomination numeral with Rupee symbol (MI_DV)
500	1	0.0573	0.4839	0.0709
	2	0.0257	0.5186	0.0879
	3	0.0374	0.4922	0.0672
	4	0.0248	0.5134	0.0797
	5	0.0784	0.4897	0.0883
	6	0.0814	0.5063	0.0836
	7	0.0783	0.4993	0.0896
	8	0.0462	0.4956	0.0629
	9	0.0847	0.5156	0.0592
	10	0.0813	0.5043	0.0783

In Table- III, show the value of mean intensity of each extracted feature. Here 10 note of 500 is taken. Value of such intensity of extracted feature are varies from different range, so a standard threshold value for individual features are considered. Mean intensity of latent image (MI_LI) is taken from range 0.024 to 0.085 as threshold value, mean intensity of RBI logo (MI_LOGO) is taken from 0.480 to 0.520 as threshold value and mean intensity of denomination numeral with rupee symbol is taken from 0.058 to 0.090 as threshold value.

In Table- IV, show the value of mean intensity of each extracted feature. Here 10 note of 2000 is taken. Mean Intensity of Latent Image is represented by MI_LI, mean intensity of RBI logo is represented by MI_LOGO and mean intensity of denomination numeral with Rupee symbol is represented by MI_DV. Value of such intensity of extracted feature are varies from different range, so a standard threshold value for individual features are considered. Mean intensity of latent image (MI_LI) is taken from range 0.08 to 0.1 as threshold value, mean intensity of RBI logo (MI_LOGO) is taken from 0.60 to 0.75 as threshold value and mean intensity of denomination numeral with rupee symbol is taken from 0.65 to 0.8 as threshold value.

Table- IV: Mean Intensity of extracted feature for different 2000 note

Denomination value	Input Image	Mean Intensity Latent Image (MI_LI)	Mean Intensity RBI Logo (MI_LOGO)	Mean Intensity denomination numeral with Rupee symbol (MI_DV)
2000	1	0.0982	0.6948	0.6948
	2	0.0894	0.7091	0.6647
	3	0.0853	0.7165	0.6592
	4	0.0915	0.7358	0.7390
	5	0.0836	0.6915	0.7812
	6	0.0891	0.6391	0.7736
	7	0.0846	0.7412	0.6983
	8	0.0968	0.6479	0.7537
	9	0.0873	0.6915	0.7880
	10	0.0973	0.7392	0.7994

Implemented Results of Proposed Model

Implemented results for the detection of note as real or fake is as follows:

- Test Image_1
- Acquired Image

- Pre-processed image

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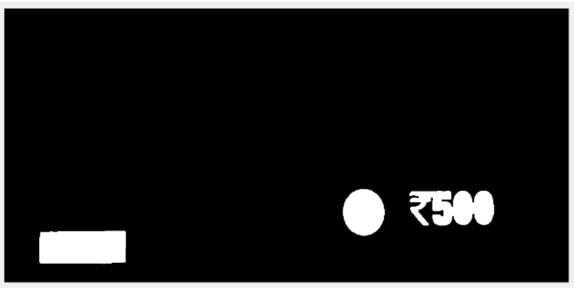
- Gray scaled image

- Detected edge

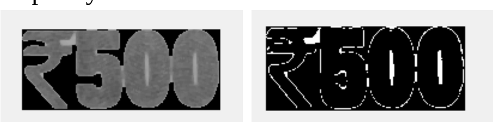
- Segmented image



- Extracted feature:
- Extracted feature of Latent Image

- Extracted feature of RBI Logo

- Extracted feature of denomination numeral with Rupee symbol



- Final Output

```
Currency value : 500
Currency is Real
fx >>
```

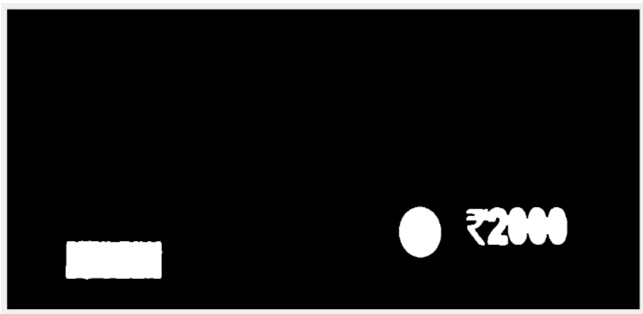
- Test Image_2
- Acquired Image

- Pre-processed Image

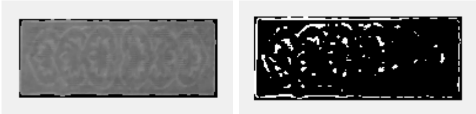
- Gray Scaled Image

- Edge Detected Image

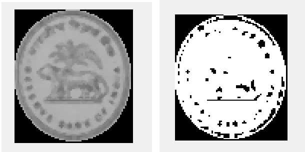
- Segmented Image



- Extracted Feature:
- Extracted feature of Latent Image



- Extracted feature of RBI Logo



- Extracted feature of denomination numeral with Rupee symbol

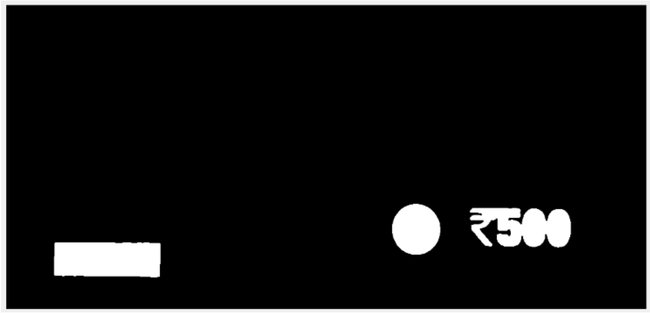
- Test Image_3
- Acquired Image

- Pre-processed Image

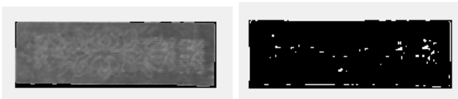
- Gray Scaled Image

- Edge Detected Image

- Segmented image



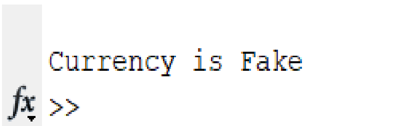
- Extracted feature :
- Extracted feature of Latent Image



- Extracted feature of RBI Logo

- Extracted feature denomination numeral with Rupee symbol

- Final Output



Performance evaluation of the Proposed technique

Performance of the proposed technique is evaluated in term of accuracy rate which is shown in Table- V. It shows the experimented results as correct or incorrect note with respect to 30 input images. We get 23 images as correct detection while 7 images as incorrect detection. Therefore accuracy rate of the proposed method is as:

Accuracy rate = (No. of Correct readings/Total No. of readings)*100

= (23/30)*100 = 76.66%

Table- V: Table of experimented results

Test denomination	Test result	Test denomination	Test result
1	Correct	16	Correct
2	Correct	17	Incorrect
3	Incorrect	18	Correct
4	Correct	19	Correct
5	Correct	20	Correct
6	Correct	21	Correct
7	Incorrect	22	Incorrect
8	Incorrect	23	Correct
9	Correct	24	Correct
10	Correct	25	Correct
11	Correct	26	Correct
12	Correct	27	Incorrect
13	Correct	28	Correct
14	Incorrect	29	Correct
15	Correct	30	Correct

V. CONCLUSION

Production of currency without the legal sanction of Government is illegal and it causes serious threat for any country. Due to the advancement in the technology, Counterfeiter produces counterfeit notes easily and circulate in our country and it becomes difficult for the common people to differentiate between original or counterfeit note. Therefore Image processing based technique is proposed for the detection of such notes. The proposed technique is implemented on MATLAB. In this technique, images of 500 and 2000 currency note is taken and then preprocessing (median filter) is used to remove noise. Three features i.e. Latent image, Logo of RBI and denomination numeral with Rupee symbol are extracted and further calculate the Mean Intensity of each extracted feature along with Mean Intensity of RGB channels of currency note. This technique is applied for 30 input test images and found correct result for 23 images. The algorithm processed very well and achieves good accuracy rate(76.66%)

This proposed model is applicable to detect newly 500 and 2000 Indian Currency note. In future this can be extend to check the authenticity of recently launched Indian paper currency like 200, 100, 50 etc. Further work can also be done to increase the accuracy of the system.

REFERENCES

1. J-K Lee, Il-H Kim, "New recognition algorithm for various kinds of Euro banknotes," IEEE, pp. 2266--2270, 2003.
2. Jahangir, N. Chaudhary, A. Raja, "Bangladeshi banknote recognition by neural network with axis symmetrical masks", IEEE, pp. 1--5, 2007.
3. K.K Debnath, S. Ahmed, Md. Shahjahan, K. Murase, "A paper currency recognition system using negatively correlated neural network ensemble," Journal of Multimedia, vol. 5, p. 560, 2010.
4. Hasanuzzaman, M. Faiz, X. Yang, Y. Tian, "Robust and effective component-based banknote recognition for the blind," IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), vol. 42, pp. 1021--1030, 2012.
5. N.S. Jose, S. Siby, J. Mathew, M. Das, "Android Based Currency Recognition System for Blind," International Journal of Engineering Research in Computer Science and Engineering (IJERCSE), vol. 2, 2015.
6. S. Surya, G. Thailambal, "Comparative study on currency recognition system using image processing," IJECS, vol. 3, pp. 7723--7726, 2014
7. C. Bhurke, M. Sitrdeshmukh, M.S. Kanitkar, "Currency recognition using image processing," Int. J. Innov. Res. Comput. Commun. Eng, vol. 3, pp. 4418--4422, 2015.
8. L.S. Kalkonde, R.G. Paturde, S.S. Kolaskar, "Detection of Fake Note Using Image Processing and Implementation of Embedded System for Note to Coin Exchange," Imperial Journal of Interdisciplinary Research, vol. 2, no. 5, pp. 953-957, 2016.
9. Pradeep. Raj. R, Soundarya. M, Y. Sreelekha, "Counterfeit Currency Note Detection using Multispectral Imaging and Image Processing," International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE) , vol. 4, no. 6, pp. 275-279, 2017.
10. M. Thakur, A. Kaur, "Various fake currency detection techniques," International Journal for Technological Research in Engineering, vol. 1, pp. 1309--1313, 2014.
11. M. H. Alshayeji, M. Al-Rousan, D. Hasson, "Detection method for counterfeit currency based on bit-plane slicing technique," International Journal of Multimedia and Ubiquitous Engineering, vol. 10, pp. 225--242, 2015.
12. B.S. Prasanthi, D.R. Setty, "Indian paper currency authentication system using image processing," Int. J. Sci. Res. Eng. Technol, vol. 4, pp. 973--981, 2015.
13. M.R. Pujar, "Indian Currency Recognition and Verification using Image Processing," International Journal of Advance Research and Development, vol. 3, 2018.
14. A. B. Harugade, A. N. Mirje, S.S. Tingare, A.G. Patil, "Fake Indian Currency Detection Using Image," International Journal of Innovative Research in Computer and Communication Engineering, vol. 6, 2018
15. M. Patil, Jayant Adhikari, R. Babu, "Fake Currency Detection using Image Processing," International Journal on Future Revolution in Computer Science & Communication Engineering , pp. 865-868, 2018.

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