Currency Recognition Using Image Processing and Minimum Distance Classifier Technique

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***Abstract*— *As a result of the great technological advances over the past few years in duplicating and scanning, counterfeiting problems have become more and more serious. Fake banknotes have become so deeply embedded in the Indian economy that even bank branches and ATMs are disbursing counterfeit currency. Estimation of fake currency in Indian economy is about 10-20 percent of total notes in circulation. From petrol stations to the local vegetable vendors, everybody is wary of accepting banknotes in denomination of 500 and 1000. It is difficult for people to recognize and detect the notes. To solve these problems a currency recognition system is implemented to reduce human power to automatically recognize currency without human supervision. The software interface that has been proposed in this paper is to recognize the Indian currency notes and authenticate to certain extent. Digital image processing is one of the most common and effective techniques used to distinguish counterfeit banknotes from genuine ones. This paper introduces a recognition and detection method for Indian currency using Image Processing. It is shown that Indian currencies can be classified based on a set of unique non discriminating features such as dominant color, dimension, latent image and Identification Mark mentioned in RBI guidelines. Firstly, the aspect ratio and the dominant color of the note are extracted. After this the segmentation of the ID mark and latent image is done. Segmented features are then processed and classified using Minimum Distance Classifier.*

***Keywords*— Image processing, classifier, segmentation, latent image.**

I. INTRODUCTION

Monetary transaction is an integral part of our day to day activities. The strength of societies with regards to trading with other societies depends highly on the value held by their currency. There are 6 currency notes in India, with each of them looking different. For instance, the size of the paper is different, the same as the color and pattern [1]. People have to detect and recognize different types of currency denomination and that is not an easy job. They have to remember the symbol and other security features for each currency note. This may cause some problems (e.g. wrong recognition), so they need an efficient and exact system to help them in this task. Moreover, such a system could be of great help to visually impaired section of the society.

In banks, there are Currency Sorting Machine which helps recognize different currency notes. Technique used in such machine are optical, mechanical and electronic integration, integrated with calculation, pattern recognition, currency anti-fake technology, and lots of multidisciplinary techniques [2]. It is accurate and highly-efficient. But problem with this machines are that they are not mobile and it is difficult for people to use it in daily routine. Even for that, no one can ever be 100 per cent confident about the manual recognition. Our system is based on image processing, techniques which include filtering, transforms, segmentation, etc.

Currency Recognition (CR) system consists of 4 main parts: Image Acquisition, Image Preprocessing, Segmentation, Feature Extraction, Recognition [1]. Among these the Segmentation and Recognition is the most important stage and also the most difficult part. This is the mostly because every note has unique identification features which are difficult to detect, recognize and classify. This paper aims at recognizing Indian currencies and authentication at certain extent. To implement the system in order to detect and recognize the Indian currency we have to extract the data from the currency image by using digital image processing and then recognize the image of the currency amount by using Minimum distance classifier. The study is limited to the features which of a note which can be detected using scanned images of currency notes. The paper is organized as follows. Related work on currency recognition is briefly discussed in Section 2. In Section 3, the methodology used in our currency recognition is presented. In Section 4, the proposed algorithms used at various stages are given. Section 5 shows the experimental results and section 6 concludes the paper with a summary and some directions for future research.

II. RELATED WORK

Automatic Indian Currency Denomination Recognition System based on Artificial Neural Network [1] proposed that Indian currencies can be classified based on a set of unique non discriminating features such as color, dimension and most importantly the Identification Mark (unique for each denomination) mentioned in RBI guidelines. At the beginning the dominant color and the aspect ratio of the note are extracted. After this the segmentation of the portion of the note containing the unique I.D. Mark is done. From these segmented image, feature extraction is done using Fourier Descriptors. As each note has a unique shape as the I.D. Mark, the classification of these shapes is done with the help of Artificial Neural Network. After feature extraction, the denominations are recognized based on the developed algorithm. The success rate of the proposed system was 97% requiring a processing time of 2.52 seconds.

Smartphone Recognition of the U.S. Banknotes Denomination, for Visually Impaired People [3] developed the prototype of a system that recognizes the denomination of the largest U.S.A. currency notes in circulation in Ecuador, aimed at visually impaired people. First step is, digital processing of the image, obtained by the mobile phone camera to locate a particular region of interest within that image. Next, a recognition stage is implemented on the Region of Interest, making use of the Face Recognition using Eigenfaces method, which in turn, is based on the mathematical technique known as Principal Component Analysis (PCA). Finally, results of tests made on the system implemented on two mobile phones, are presented. One of the main limitation of the system developed in this paper is that, the background of the image containing the object to identify (i.e. the banknote), must be contrasting with that object. Another constraint is that the illumination conditions over the image must be uniform.

Kuldeep Verma, Bhupesh Kumar Singh and Anupam Agarwal [2] proposed Indian Currency Recognition based on Texture Analysis. They proposed a system based on the intrinsic feature of the currency. They extracted texture as intrinsic features for currency recognition and evaluated the class discriminating capability of these features for Indian currency. They used a texture feature extraction tool called Mazda, to extract the texture features of the captured currency images. First they captured the scanned images of the front side of the currencies in three denominations of Rs. 10, 100, & 500. Such images were loaded in Mazda texture analysis system and the texture feature was captured for five ROIs decided on the basis of domain knowledge to yield the maximal discriminating texture features. The texture features of each class of the images was reduced using the built in Fisher discriminate analysis of Mazda system. Features are ranked as per their discrimination percentage for three class i.e. 10 vs 100, 10 vs 500 and 100 vs 500. The result for the present instance was not only promising but encouraging as well yielding the 96% classification. However, the scope of the work was limited to the extraction and evaluation of such intrinsic feature (texture) for currency recognition and evaluation of the classification capability of those features.

III. PROPOSED METHODOLOGY

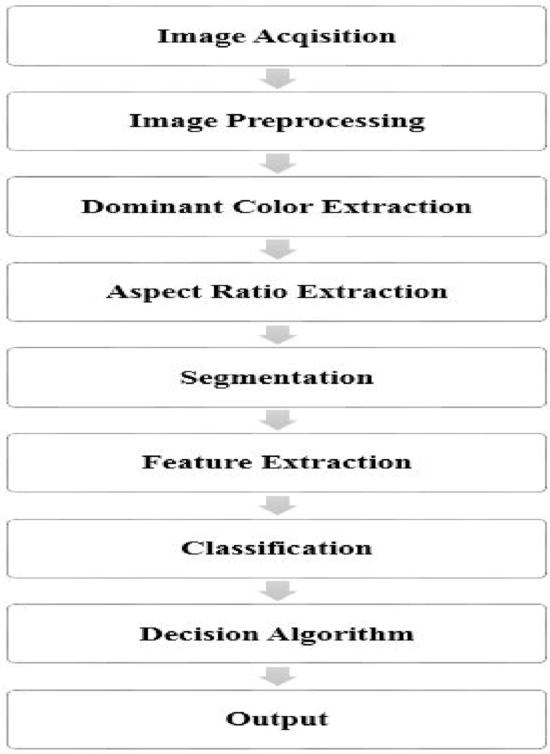

Fig. 1: General Flow diagram of proposed methodology

3.1 Image Acquisition

Image Acquisition is the first step in Currency Recognition System. It is a process of acquiring image from a currency note by using scanner. The image is stored for further processing. Image of currency is taken in such a way that all details in note are captured [4].

3.2 Image Preprocessing

3.2.1 Foreground Extraction

Only image of Currency is extracted from the acquired image. Background is removed from the image by Edge based Foreground Extraction. Thus finally we get only the image of currency note with no background.

3.2.1.1 Noise Reduction by Median Filtering

Captured picture of currency note might get blurred. Due to this problem many edges might not get detected during processing thus we don't get proper results. For processing image of Currency note edges play a major role. To preserve edges Median filter is used. In a median filter, a window slides along the image, and the median intensity value of the pixels within the window becomes the output intensity of the pixel being processed. The

ISSN: 2349-6495(P) | 2456-1908(O)

median filter is a sliding-window spatial filter, but it replaces the centre value in the window with the median of all the pixel values in the window [4]. The kernel used is square having N x N Dimension.

3.2.1.2 Color to Gray Scale Conversion

Grayscale algorithms is three-step process:

- Get the red, green, and blue values of a pixel
- Use fancy math to turn those numbers into a single gray value
- Replace the original red, green, and blue values with the new gray value

Averaging method is most common grayscale conversion routine

$$gray = \frac{red+green+blue}{3} \quad (1)$$

This is fast and simple to generate a reasonably nice grayscale equivalent, and its simplicity makes it easy to implement and optimize. As color information is not needed for further processing we convert image to grayscale for faster processing. This is preprocessing step in Canny Edge Detection algorithm.

3.3 Dominant Color Extraction

To determine the dominant color of Indian Currency notes, HSV color model is used. Based on study of research paper the dominant color of each currency is as tabulated in Table 6.1

Table.1: Dominant Color of Indian Currency Notes

Denomination	Notation	Dominant Color
Rs.20	DC_{20}	RED || YELLOW
Rs.50	DC_{50}	MAGENTA
Rs.100	DC_{100}	GREEN ||CYAN
Rs.500	DC_{500}	GREEN ||YELLOW
Rs.1000	DC_{1000}	RED

3.4 Aspect Ratio Extraction

Each Indian denomination has a unique dimension. This can also be considered as one of the feature for Classification. However, wear and tear due to handlings sometimes reduces the original size of note, so we have to consider a threshold value based on experimentation. Unlike height and width, the aspect ratio of a currency note is independent of the distance from which the image is taken. In our experiment we have calculate the aspect ratio as

$$Aspect\ Ratio(AR) = \frac{Height\ of\ the\ note}{Length\ of\ note} \quad (2)$$

The AR for different currencies are calculated and a threshold range for each denomination is set. The standard value according to RBI guidelines and the obtained threshold after experimentation is mentioned in Table 6.2.

Table.2: Threshold value of AR and RBI standard

Denomination	Notation	MinValue	MaxValue	RBI Standard
Rs.20	AR_{20}	0.40	0.43	0.42
Rs.50	AR_{50}	0.47	0.50	0.49
Rs.100	AR_{100}	0.45	0.48	0.46
Rs.500	AR_{500}	0.42	0.44	0.43
Rs.1000	AR_{1000}	0.39	0.42	0.41

3.5 Segmentation

Segmentation involves the partitioning of an image or volume into distinct non-overlapping regions in a meaningful way. Segmentation is done to

- Identifies separate objects within an image
- Finds regions of connected pixels with similar properties.
- Finds boundaries between regions
- Removes unwanted regions

Before we start with Segmentation, first image of currency is converted to grayscale. Gray Scale is an image in which the value of each pixel is a single sample i.e. it carries only intensity information. A mathematical function is used to obtain a gray value based on the RGB component of a pixel. Actually this is to be done in preprocessing phase but since we extract color feature from image, we convert image to grayscale after Color Extraction phase [4].

3.5.1 Segmentation of ID Mark

A window of a particular dimension is selected in the note where the ID mark is present. Then based on this dimension the portion of the currency where the region of interest is cropped. Then Segmentation of ID is done using Otsu Method.

3.5.2 Segmentation of Latent Image

Latent image consists of vertical and horizontal lines. To segment the denomination present in latent image, we have to remove all horizontal lines but keeping all vertical lines. This is done by calculating gradient using Sobers Operator. This will give only vertical lines. Then Morphological operation erosion and dilation is performed to fill the gaps between two lines. Thus we will get detailed segmented image of denomination value which was present in latent image [5].

3.6 Feature Extraction

Once the segmentation is done, feature extraction is done using "Fourier Descriptor". We mainly focus on the shape of the I.D. Mark and numbers in Latent image. The

ISSN: 2349-6495(P) | 2456-1908(O)

Fourier descriptor is used to describe the boundary of a shape in 2D space using the Fourier methods. This method uses shape signature and transform shape signature to frequency domain using Discrete Fourier Transform. Transformed shape signature coefficients are used to describe shape [6].

3.7 Classification

The identification of the shapes obtained by extracting the unique identification mark and latent image numbers is done by using Minimum Distance Classifier. In minimum distance classifier we compute the Euclidean Distance (ED) between the test sample and the mean values for the classes, and then allocate the test sample to that class with the shortest Euclidean distance [7].

IV. PROPOSED ALGORITHMS

4.1 Proposed Algorithm for Background Removal

Input**:** Image with background

Output**:** Image with no background

Steps**:**

1. Get the width and height of the original image
2. Set a threshold value. Initialize two arrays horizontal and vertical and left=0, down=0, top=0,right=0
3. Grayscale the original image.
4. Compare the pixel from top, left, right and bottom and calculate the difference in threshold in between the pixels in the following way
5. while i<wid do
    - 5.1. Top:
        - 5.1.1. while j=2 and j<ht/2-1 do
        - 5.1.2. P=gray value at i,j+1
        - 5.1.3. Q=gray value at i,j
        - 5.1.4. Diff=p-q
        - 5.1.5. if Diff>threshold then do
        - 5.1.6. Increament ver[j] , exit loop
        - 5.1.7. Increament j goto 5.1
    - 5.2. Bottom:
        - 5.2.1. while j=ht-2 and j<ht/2 do
        - 5.2.2. P=gray value at i,j-1
        - 5.2.3. Q=gray value at j,j
        - 5.2.4. Diff=p-q
        - 5.2.5. If Diff> threshold then do
        - 5.2.6. Increament ver[j] exit loop
        - 5.2.7. Decreament j goto 5.2
        - 5.2.8. Increament I goto 5
6. while J<ht
    - 6.1. Left:
        - 6.1.1. while i=2 and i<wid/2-1 do
        - 6.1.2. P=gray value at i+1,j
        - 6.1.3. Q=gray value at i,j
        - 6.1.4. Diff=p-q
        - 6.1.5. If Diff>threshold then do
        - 6.1.6. Increament hor[j] exit loop
        - 6.1.7. Increament i goto 6.1
    - 6.2. Right:
        - 6.2.1. while i=wid-2 and i>wid/2 do
        - 6.2.2. P=gray value at i-1,j
        - 6.2.3. Q=gray value at i,j
        - 6.2.4. Diff=p-q
        - 6.2.5. If Diff>threshold then do
        - 6.2.6. Increament hor[j] exit loop
        - 6.2.7. Decreament i goto 6.2
        - 6.2.8. Increament j goto 6
7. Assign to top and down new values by following
    - 7.1. Compare ver[current pixel] with ver[top] if greater than assign top=current pixel.
    - 7.2. Compare ver[current pixel] with ver[down] if greater than assign down=current pixel.
8. Assign to left and right new values by following
    - 8.1. Compare hor[current pixel] with hor[left] if greater than assign left=current pixel.
    - 8.2. Compare hor[current pixel] with hor[right] if greater than assign right=current pixel.
9. The dimensions of the new image are left, right, down and top.

4.2 Proposed Algorithm for Dominant Color Extraction

Input**:** Image with background

Output**:** Dominant Color

Steps**:**

1. For each pixel in image get RGB value of pixel and store it integer variable P.
2. Extract Red, Green and Blue component from P and store in integer variables R, G and B respectively.
3. Convert this R, G and B components into HSV components.
4. Keep track of Hue component from HSV of each pixel to determine dominant color of image.

4.3 Proposed Decision Algorithm

If (DC == DC_{20} and AR == AR_{20} and IDMark == Rectangle and LatentImage = 20) then Rs.20 Note Detected

else if (DC == DC_{50} and AR == AR_{50} and IDMark == Square and LatentImage = 50) then Rs.50 Note Detected

else if (DC == DC_{100} and AR == AR_{100} and IDMark == Triangle and LatentImage = 100) then Rs.100 Note Detected

else if (DC == DC_{500} and AR == AR_{500} and IDMark == Circle and LatentImage = 500) then Rs.500 Note Detected

else if (DC == DC_{1000} and AR == AR_{1000} and IDMark == Diamond and LatentImage = 1000)

then Rs.1000 Note Detected

else Unable to Recognize Note

V. EXPERIMENTAL RESULTS

Experiments were conducted on the notes of denomination 20, 50, 100, 500 and 1000. Experimental results here show the output after each step on a particular note followed by problems encountered.

5.1 Background Removal

Fig. 2: Foreground Extraction

5.2 Aspect Ratio Computation

In this step the aspect ratio of the image is computed and displayed.

Fig. 3: Aspect Ratio Calculation

5.3 Dominant Color Computation

The dominant color of the image is computed and displayed.

Fig. 4: Dominant Color Extraction

5.4 Grayscale

Fig. 5: Grayscale Image

5.5 ID Mark Extraction

The ID Mark of the currency note is extracted. A window of a particular dimension is selected in the note where the ID mark is present. That part of image is cropped and stored in new file and used for further processing.

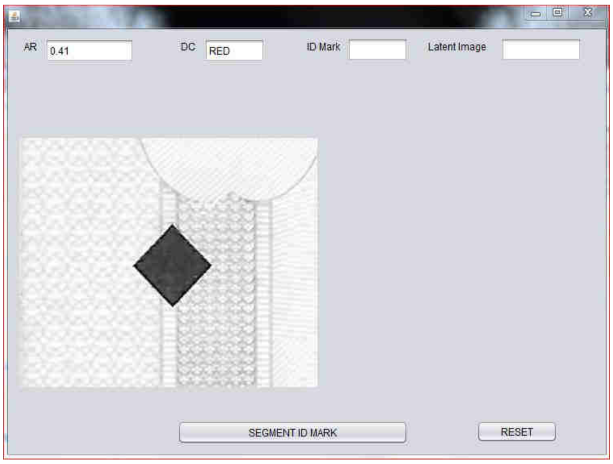

Fig. 6: Extracted ID Mark

5.6 ID Mark Segmentation

The ID Mark of the image is segmented and displayed. Otsu's automatic thresholding method is used for separating ID Mark from background.

ISSN: 2349-6495(P) | 2456-1908(O)

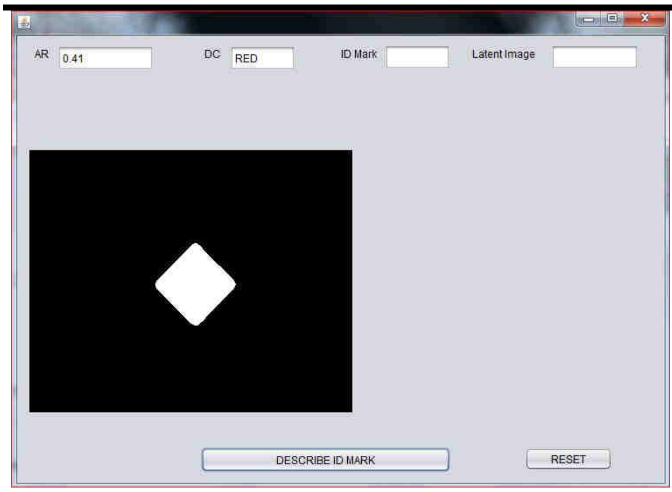

Fig. 7: Segmented ID Mark

5.7 ID Mark Description and Recognition
Boundary of the ID Mark is traced using Moore Boundary tracing algorithm and then described using Fourier Descriptor. These Descriptors are used to classify the ID Mark using Minimum Distance Classifier.

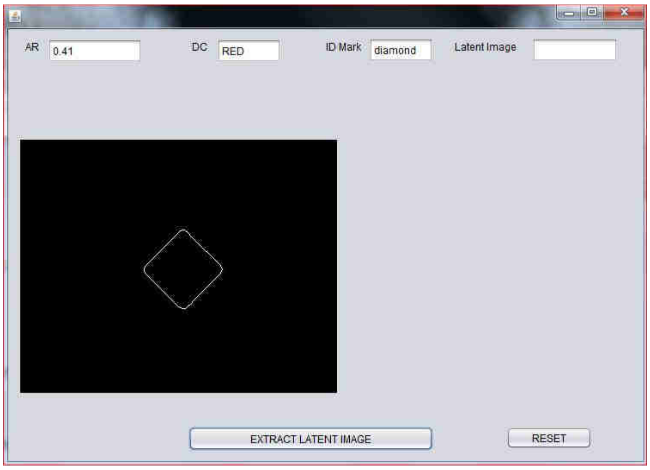

Fig. 8: ID Mark description and Recognition

5.8 Latent Image Extraction
Latent image of the currency is extracted and displayed. A window of a particular dimension is selected in the note where the Latent image is present. That part of image is cropped and stored in new file and used for further processing.

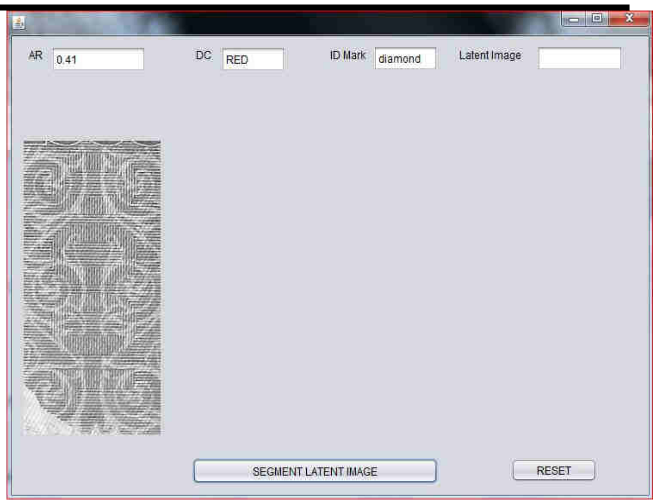

Fig. 9: Latent Image Extraction

5.9 Latent Image Segmentation

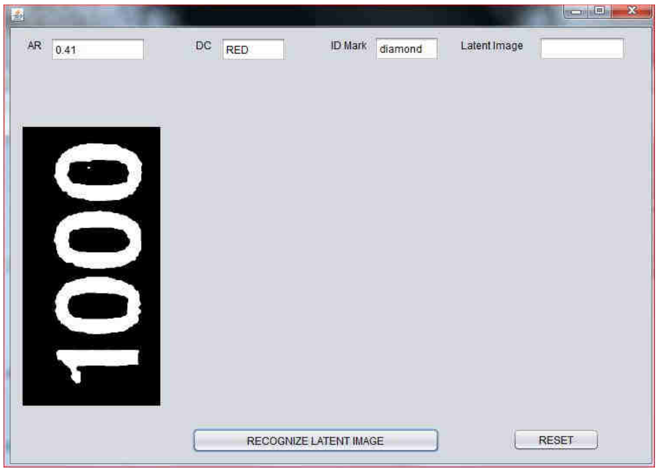

Fig. 10: Segmented Latent Image

5.10Latent Image Recognition
Boundary of each digit is traced using Moore Boundary Tracing Algorithm and then each digit is described using Fourier Descriptor.

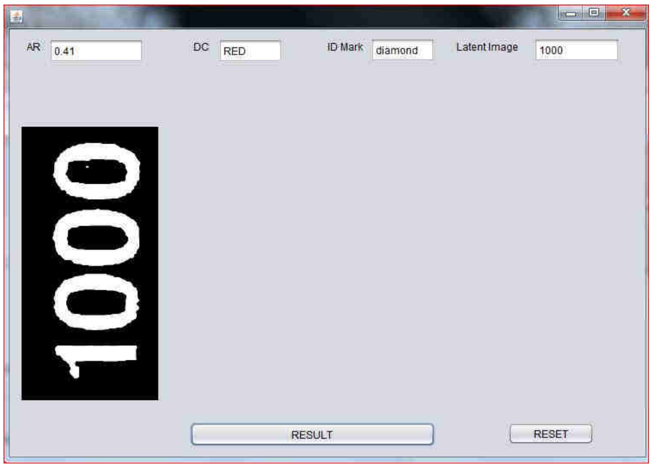

Fig. 11: Latent Image Recognition

ISSN: 2349-6495(P) | 2456-1908(O)

5.11Decision Algorithm

The decision algorithm checks for all attributes considered to recognize the currency note. The attributes considered by the Decision Algorithm are Aspect Ratio, Dominant Color, ID Mark and Latent Image.

Fig. 12: Decision Algorithm Output

5.12Results of INR 1000

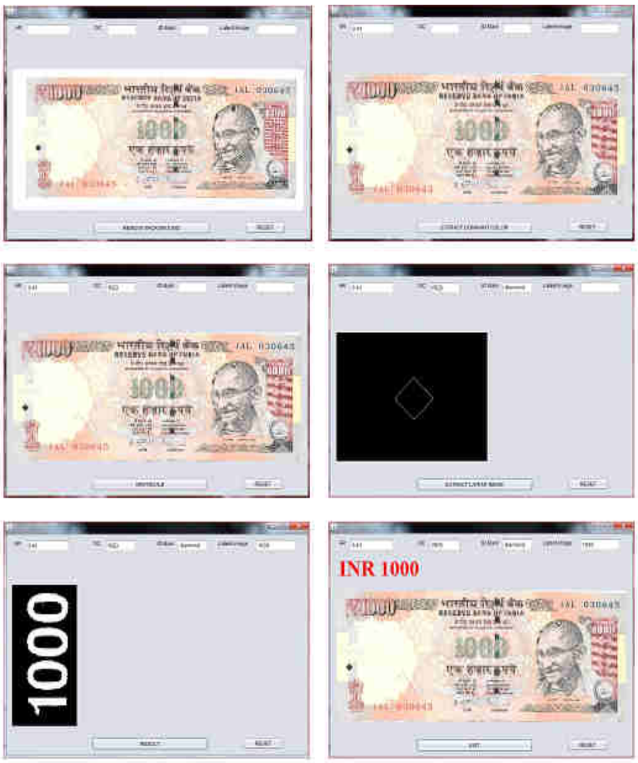

Fig. 13: INR 1000 Recognition

It was observed that out of ten notes of INR 1000, nine were classified properly thus assuring 90% of accuracy. Similar experiments were carried out on other denominations and accuracy was close to 90% for them too. However, the major problems that we faced while carrying out experiments were of orientation of the image with respect to its background. It greatly varies the outputs obtained in the currency recognition system. Next was background removal. It is based on abrupt change in intensity i.e. edge based. The change in intensity i.e. the difference between adjacent pixels is set manually to detect the foreground. Finally, the quality of the currency notes cause problem in recognition system. Very old and worn out notes may have distorted latent images and ID Marks leading to improper recognition of the note.

VI. CONCLUSION

The motivating insight on this research is that recognizing the notes manually becomes time-consuming and untidy process hence there is need of automation techniques with which currency recognition process can be efficiently done. Using image processing techniques this process becomes more software oriented rather than depending on machines thus aiding a person to recognize and detect fake (counterfeit) notes at some extent. However, blind people particularly suffer in monetary transactions. Such a system will help visually impaired people finding it difficult to distinguish different currency denominations and also unable to recognize counterfeit currency. Current Systems implemented using Image processing techniques focuses more on extracting denomination value only. Thus our system focuses more on security features present in Currency notes and using those security features we recognize the Indian Currency. We have 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 above is close to 90%. The future scope could be to work with any note clicked with any orientation and to extend it to detecting currency denominations of other countries.

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