# *Efficient Image Processing Technique for Authentication of Indian Paper Currency*

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*Abstract*— **Now a days due to the development in color printing technology the rate of counterfeit notes production and distribution is increasing. This is a massive problem, faced by almost all the countries. It affects the economy, sine it compromises the security of the real economy. Such counterfeit currencies are used to fuel nefarious motives, usually involving terrorist activities. According to the research, developing countries like India have been impacted by this very negatively. Even after the steps taken in 2016 to remove the counterfeits, by executing the demonetization of 500 and 1000 rupees bank notes in India the counterfeits of the new notes have begun circulating. This is due to the highly advanced technology adopted by the counterfeiters which makes the tracking of these counterfeit notes hard. This has become a very critical issue and the negative impact due to the counterfeit currency keeps rising. The only one solution for this problem for a common man is to detect the fake currency, by using the fake currency detector machine. These machines are used in banks and large scale business, but for a small business or for a common man these machines are not affordable. This paper gives the complete methodology of fake note detector machine, which is affordable even for a common man. By implementing the applications of image processing techniques we can find out whether the currency notes are fake or not. Image processing technique consists of a number of operations that can be performed on an image, some of which include image segmentation, edge detection, gray scale conversion etc. The proposed system will have advantages like simplicity, reliability and costs less.**

***Keywords: Segmentation, Edge detection, Feature extraction, Grayscale conversion, pre-processing.***

## I. INTRODUCTION

The burning question all over the world is a counterfeit currency. In the last fiscal on the account of frauds the banks have lost Rs.16,789 crores. According to the Reserve Bank "The amount that has been lost on account of frauds in the year 2016-17 was Rs. 16,789 crores" which was as per the fraud monitoring report submitted by various banks and different financial institutions. The distribution of Fake currency even contributes to the growth of terrorism and it acts as life to terrorism. Now the notes will be printed with very high accuracy by making use of laser printer. Print houses were used for printing few years ago. The Crime Investigation Department(CID) says that even when the currency are printed with high accuracy by putting some effort they can be detected.

The fake currency Detector machine is the solution for this rising problem which can be used by a common man. Since this kind of detecting machines are available only in banks and are not affordable by common man. The usage of counterfeit detection tools/software are available to stop counterfeiting. They are also efficient in terms of cost, reliability and accuracy. Taking into consideration of overall scenarios, the common man need a solution to find out whether the currency is fake or not so that the value of currency is not lost.

This paper explains the method that has been followed in order to implement the fake note detector machine by the means of Image processing. Different operations can be performed on an image so that an enhanced version of the original image can be obtained. The technique used to do so is called Image Processing. An image can be processed in two ways namely, analog image processing and digital image processing. Analog image processing is generally used for acquiring the hard copy of the image such as photographs, banners and printouts. A digital image can be manipulated on a computer by applying various types of algorithms. By performing various available operations on the image, the resulting image can be enhanced as required on the computer[1]. There are 10 fundamental stages of digital image processing, which includes image acquisition, image restoration, image enhancement, color image processing, compression, wavelets and multiresolution processing, object recognition, morphological processing, segmentation, representation and description[1]. The result may be obtained in any of these stages. The number of steps the process requires increases when the complexity of the image

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processing task increases.

In our project we are detecting the authenticity of the currency notes with the help of a software tool, OpenCV along with the python as our programming language and various hardware tools, which includes 8MP raspberry Pi camera, raspberry Pi 3 B+ and a box setup.

## II. RELATED WORK

The staffs of the bank are specially trained to detect the currency, but the problem occurs when the notes are circulated in the markets. The note moves from one hand to another without even knowing whether they are original or fake. In order to solve these problems the note recognition tools are developed using image processing techniques. MATLAB is used for the processing of the currency. The camera is mounted on the machine which will scan the note and based on the character recognition, the image is segmented and the result can be obtained [2].

Due to the advancement in printing technology and scanning, it is been difficult to predict whether the note is fake just by looking at it. Trying to detect the changes and similarities manually, becomes time consuming. Hence automated process is required in such situation. Many techniques are being used in MATLAB and feature extraction has been done using HSV colors space [3].

If the common man without knowing goes to bank and try to deposit the money, and the money is detected to be fake in the counter machine, then that man will be blamed and he has to pay for the loss. Therefore the techniques are used in MATLAB to detect. First the image is captured, then the red, blue and green components are split. Test image is taken and its red, blue and green components are split. Based on the threshold value which is considered 40% compare both the original or test image [4].

The currencies of different country are different and it‟s difficult to distinguish between original and fake. Here the technique uses MATLAB. The first step is to identify the currency. Then the currency is converted to gray scale, threshold is considered 30% and then it is converted to binary image. The total number of objects are counted and compared [5].

The counterfeit problem of currency is a worldwide problem. The process of detecting is done by comparing the original note with the test image. The process is, after the image is captured, it is sent for smoothening using gaussian filter, then the magnitude gradient and direction are measured, the image will be undergone through non-maxima suppression and edges are detected in canny algorithm. Then the characteristics of original image is compared with test image for results [6].

## III. FEATURES CONSIDERED

There are various security features that are considered in the Indian currency but we considered only some of the features. These features are for the benefit of the general public as well as the economy, so as to distinguish the original currency notes from the counterfeit. Each of the denominations vary in their dimensions. Currently the smallest notes is rupee 1 and the largest is rupees 2000 note. As the largest note, it also has the highest number of features present. Every denomination also have a unique color. Rupee 1 is a mixture of pink and green, rupees 10 chocolate brown, rupees 20 fluorescent green, rupees 50 fluorescent blue, rupees 100 lavender, rupees 200 orange, rupees 500 grey and rupees 2000 magenta. We have referred rupees 2000 to represent the various features below. The features considered are portrait of Mahatma Gandhi at the center, Ashoka pillar, security thread, guarantee clause, denominational numeral with rupees symbol, denomination numeral in devanagari, bleed lines, identification mark, see through register, latent image of denomination numeral, micro lettering and Omron feature.

### *A. Portrait of Mahatma Gandhi at the Center*

The intaglio printing of portrait of Mahatma Gandhi at the center of the currency, as shown in Fig. 1.


Fig. 1 Portrait Mahatma Gandhi at the center

### *B. Ashoka Pillar*

The Ashoka pillar image is present at the right side of currency, as shown in Fig. 2.


Fig. 2 Ashoka pillar

### *C. Security Thread*

The security thread is present at the left side of watermark which has "RBI" and "Bharat" written continuously on it, when it is held against light. It is shown in Fig. 3.

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Fig. 3 Security thread

*D. Identification Mark*

Identification mark is present right above the Ashoka‟s pillar emblem and on 100 rupees and above notes in different shapes in different notes, as shown in Fig. 4.


Fig. 4 Identification mark

*E. Guarantee Clause*

Guarantee clause consists of governor‟s signature with promise clause which is printed in intaglio and is to the right side of Mahatma Gandhi portrait, as shown in Fig. 5.

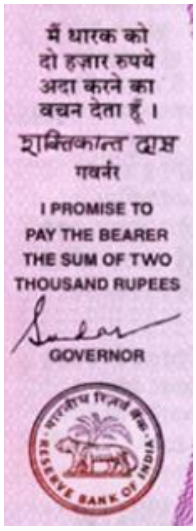


Fig. 5 Guarantee clause

*F. Denominational Numeral with Rupees Symbol*

It will be printed in fluorescent ink. The numerals change its color when viewed at various angles. It is shown in Fig. 6.


Fig. 6 Denominational numeral with rupees symbol

*G. Denomination Numeral in Devanagari*

The denomination numeral in Devanagari script is present on the left side of Mahatma Gandhi portrait, as shown in Fig. 7.


Fig. 7 Denominational numeral in Devanagari

*H. Bleed Lines*

Bleed lines are the protruded oblique lines that are present on the sides of currency, as shown in Fig. 8.

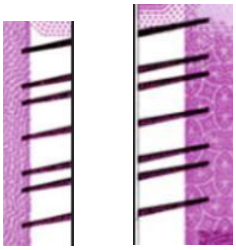

Fig. 8 Bleed lines on the right and left edges of note

*I. See Through Register*

The see through register indicates the denomination numeral. This register is printed on the both sides. Among two sides, one side is hollow shaped and one more side is filled up. This register has been written in the horizontal way along the micro lettering. On the left side of the note there is a latent image. This register is also present above the latent image. This register is appeared as a single design when viewed against the light. It is shown in Fig. 9.

Fig. 9 See through register

*J. Latent Image of Denomination Numeral*

On the other side of the denomination contains a vertical band which is at the right side of Mahatma Gandhi‟s portrait. It contains a latent image which shows the respective

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denominational value. This denominational value is present in the form of numeral. When the currency is held horizontally, the latent image can be viewed and also currency should be held at the eye level. In case of fake currency it‟s not visible, as shown in Fig. 10.

Fig. 10 Latent image of denomination numeral

*K. Micro Lettering*

Micro Lettering is appeared between the vertical band as well as Mahatma Gandhi portrait . It contains the word „RBI‟ and the denominational value in micro letters. In the case of fake currency the micro letters are not printed correctly, as shown in Fig. 11.

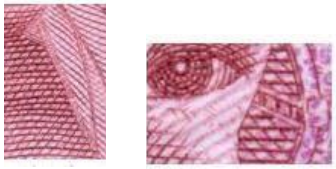

Fig. 11 Micro Lettering

*L. Omron Feature*

Omron feature refers to the circle-shaped anti-copy feature located on the left side of the note just above the latent image, as shown in Fig. 12.

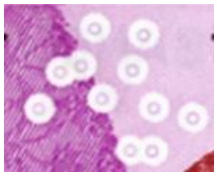

Fig. 12 Omron Feature

*M. Government of India*

The printing of „Government of India‟ at the top of 1 rupee note, which is right above the 1 rupee written in Devanagari script. Currently, 1 rupee is the smallest Indian currency note in circulation and the only one being issued by the Government of India and not the Reserve Bank of India like the rest. Which is why it is the only one that has the signature of the Finance Secretary and not the signature of Governor of the RBI. It is shown in Fig. 13.


Fig. 13 Government of India

## IV. METHODOLOGY

Fig. 14 shows the overall flow of the data around the different components of the machine. The user will input the currency to be tested. Based on the dimension of currency, the machine should identify the denomination of the currency given as input. Then the processing of test currency is carried out.

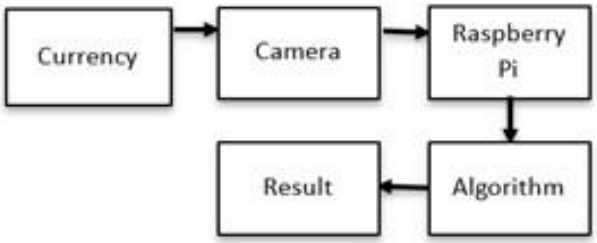


Fig. 14 Dataflow of the machine

Fig. 18 shows the overall algorithm of the proposed methodology. In the methodology the first step is image acquisition where the image is captured using 8MP raspberry pi camera. The acquired image is then processed, using OpenCV, with python as the programming language, where the next step is segmentation of the acquired image. Then the edges of image are detected by edge detection using canny edge detection algorithm. The resulting image from edge detection is then sent for feature extraction where each of the significant features are extracted from the test image. These extracted features are then compared with the features of previously recorded original image. Based on the threshold value of intensities of white pixels, the comparison is performed and the detection of whether the currency is fake or not is conducted and the result obtained is displayed.

Fig. 15 Box setup

The first step is image acquisition and in-order to execute that step, we need a hardware setup i.e., the box to which the raspberry camera is mounted on the top. The raspberry pi camera is connected to raspberry pi via a ribbon cable attached to the Camera Serial Interface (CSI) through which the signal is sent to capture the image. Since the box is closed, we have mounted a light source on the top of the box, so that the image when clicked produces a clear output. The paper currency is placed inside the box from an opening (which can be closed after placing the note) created at one of

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the ends of the box. The raspberry pi camera mounted on top of the box at a fixed position along with the light source. It is attached to the Pi module through a ribbon cable. A 5v 2A power is supplied to the Pi module which is also placed on top of the box with the pi module. Fig. 15 shows the box setup with all the hardware modules used in place.

*A. Image Acquisition*

There are many means to acquire an image, such as scanners, sensors, cameras etc [7]. Here we are using Raspberry Pi 8MP camera. The currency note in question is to be placed inside the box setup showed in Fig. 15. The image of the currency under the light is captured. This camera is controlled with the help of Raspberry Pi 3 B+ model that receives the commands from OpenCV. This is the basic and the most important step in image processing technique. Fig. 16 shows the result of image acquisition.


Fig. 16 Result of image acquisition

*B. Segmentation*

Image segmentation is a demanding and important process of image processing. This method is used to categories an image which has the same features into meaningful parts or pixels [8]. With respect to some of the characteristics, the pixels in a region that are similar are grouped together. The characteristics may be texture, color or intensity. So the main goal of this method is to represent images in easily understandable and meaningful ways. Segmentation, partitions the image into useful segments. This method partitions images into many segments that have similar attributes or features.

Various methods for segmentation are used in: Medical imaging i.e., radiology, medicine, radiography, x-ray, and diagnostic technique; Content-based image retrieval and Recognition Tasks etc.

Segmentation of the image can be divided into two segmentation types: Local segmentation and Global segmentation[8]. Based on the features of images, it can be categorized as Discontinuity detection based approach and Similarity detection based approach. Fig. 17 represent the contour of currency being scanned.

In the image segmentation there are four things that take place.

*a) Edge Detection*

Here we first load the captured image and then resize it so that the height is 500 pixels. This is done because it is easier to process a smaller image. We keep track of the original dimensions of the test image by using the shape function. Later the image is converted from RGB to greyscale. Using this grayscale image gaussian blurring can be performed, in order to remove high frequency noise. Closely following this, canny edge detection operation is performed on the image. At the end of this step edge detected image is obtained.

*b) Finding the Contours*

Indian currency notes ( most of the currency notes) are rectangular in shape. So we have to find the four corner points of the note. So we make use of simple heuristic to scan. We assume that exactly four points (pixels) forming the largest rectangular region is our region of interest. We find those four points in the edge detected image. These points will be separated based on the area and smaller ones are removed, keeping only the largest pixels. We start looping and find the four pixels and form the largest rectangle. This means we have found the currency.


Fig. 17 The contour (outline) representing the paper currency being scanned.

*c) Draw the Edges*

Using the four corner pixels the width and height of the image is found. The largest distance from the bottom right and bottom left (or top right and top left) x coordinates will give the width. Similarly the largest distance from top right to bottom left (or bottom right to top left) y coordinates will give the height. Using wrapping transform all the four points are joined. The result is shown in Fig. 17.

*d) Cropping*

The last step in image segmentation is cropping. Here the foreground is separated from the background. This is done such that only the part of image that we want to process (foreground) is cropped. Perspective transform is applied to get a to-down view of the segmented image. Fig. 19 shows the result at the end of the segmentation process.

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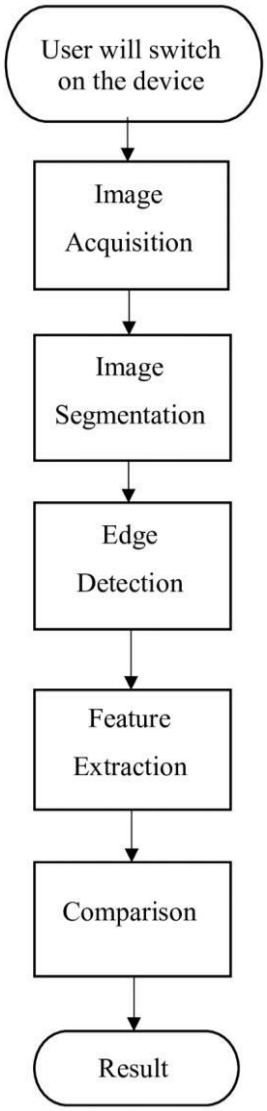


Fig. 18 Methodology of Fake Currency Detection.


Fig. 19 Segmented image of paper currency.

*C. Edge Detection*

Edge detection is one of the image processing techniques. It is used for finding the boundaries of objects within the image. It works by detecting discontinuities in brightness. There are various types of edge detection algorithms such as, Sobel, Roberts, Prewitts, Canny, fuzzy logic method etc. Here canny algorithm is used or edge detection. Since Indian currency is very detailed, canny algorithm is the most suitable.

The Canny edge detection technique is considered to be one among the most powerful methods for edge detection. In the Canny algorithm there are many sub steps such as noise reduction, finding intensity gradient, non-maximum suppression and hysteresis thresholding[9]. Canny edge detection algorithm has the following 5 steps:

- In order to smooth the image and also to reduce the noise, Gaussian filter is applied. 5x5 gaussian filter is applied, since edge detection is susceptible to noise.
- The image‟s intensity gradients are calculated by applying Sobel kernel is applied in both horizontal and vertical directions.
- In order to dispose the spurious response to edge detection, the application of non- maximum suppression is carried out.
- Double threshold is applied with the intentions of finding the potential edges.
- Tracking edge by hysteresis: This step finalizes the detection of edges. This is done by suppressing all the other edges that are weak. These edges should also not be connected to strong edges. cv2.Canny() is the function used in OpenCV to detect the edges.

Fig. 20 shows the result of edge detection.


Fig. 20 Result of edge detection

*D. Feature Extraction*

In the feature extraction each feature of currency are extracted based on the features present in the respective denomination. Hence we are considering different amount of features for each denomination. We consider 5 features for rupee 1, 7 features for rupees 10 and 20, 8 features for rupee 50, 11 features for rupees 100 and 200 and 12 features for rupees 500 and 2000 where at least the minimum number of features should match in order for that currency to be deemed original. The minimum number of features that needs to be matched correctly are 3 for rupee 1, 5 for rupees 10,20 and 50, and 8 for rupees 100,200,500 and 2000. The intensity of each feature is measured by counting the number of white pixels.

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This is the important step because the detection of currency is completely grounded on it. countNonZero() function is used to count the pixel value.

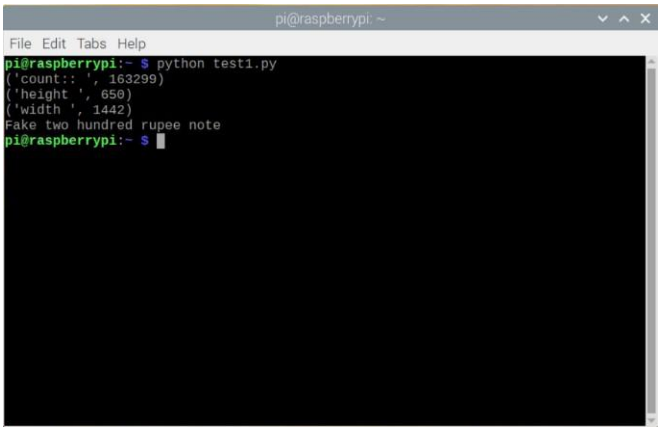
*E. Comparison*

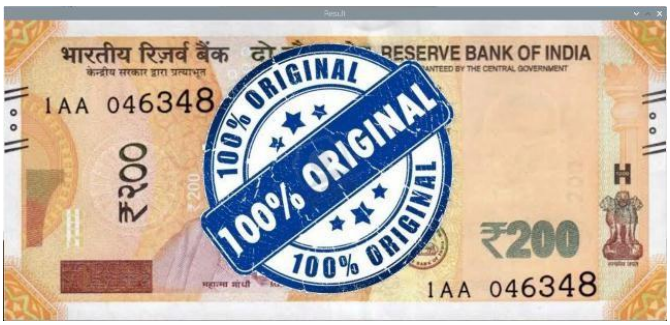
This is the last step of this process here the features extracted from original currency are compared with features extracted from testing currency. After the features are extracted from original currency the white pixels are calculated an recorded. Then the features of testing currency are extracted and their respective white pixels are calculated.

Now the calculated pixels (count) of both original and tested currency are compared by providing a liberty of 18%, this is because the currency might not be in the best condition.

*F. Result*

The features are compared based on the intensities of the features (pixel count). Based on the number of matched features, the results are obtained on whether the currency is original or fake. Fig. 21, shows the results for the detection of currency.

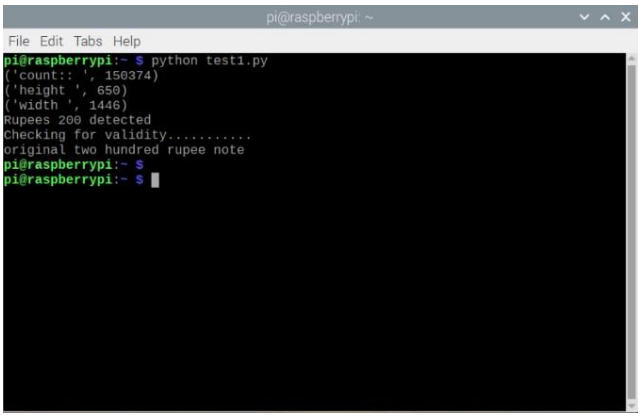




Fig. 21 Result saying whether the note is fake or original.

## V. CONCLUSION

There are different methods to detect whether the currency is fake or not, but all methods use some common steps. They are Image acquisition, edge detection, segmentation, grayscale conversion, binarization. The tool chosen to do the computations in most of these papers is MATLAB, but we ended up using OpenCV along with python as our programming language. A set of features are considered which distinguish the original currency from the counterfeit ones in order to make comparisons and decide the result. These features include identification marks, see through register, optical variable ink, currency color code, security threads, watermark, latent image and micro- lettering and some of them.

We are aware that these types of fake currency detection machines are used in banks and shops to help identify the fake currency, but a common man who does not have these resources falls prey to this. Our aim is to provide a low cost system with less computation time where the decision making is done within seconds. The complete methodology should work for Indian denomination 1, 10, 20, 50, 100, 200, 500 and 2000 and the extraction of features should be effective, even if the test image sizes are different when compared to reference image. Here the extraction of features should be effective, even if the test image size slightly differ when compared to reference image. It would be easy to use to the general public, very portable and affordable.

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