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Counterfeit Currency Note Detection using Multispectral Imaging and Image Processing

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***Abstract*— Automatic currency recognition and authentication has become an impending challenge today particularly because of the prevailing fraudulent activities as it hampers our economy. In the light of the recent stunt of demonetization by Prime Minister Narendra Modi, it is essential to build tools to identify the new fraudulent notes. Millions of fraudulent money in the form of new currency notes has already been seized, and it would be appropriate to say that more is being circulated or kept in possession. This scenario demands for an easy recognition of the authenticity of the currency notes. The objective is to use a replacement for manual recognition of the fraudulent notes as it is cumbersome and unreliable, with a more reliable software tool. We used Multi-spectral imaging, to determine and compare the intensity levels of thus obtained images with that of the original notes, in order to determine their authenticity. We combine this approach with image processing with the help of MatLab.**

***Index Terms*— Multi-spectral imaging, Counterfeit currency notes, Image Processing, MATLAB, Currency Recognition, Currency Authentication.**

I. INTRODUCTION

With significant advances in printing and production equipment, the production and circulation of inauthentic documents have become increasingly sophisticated. Manual testing of all notes in transactions is very time consuming and untidy process and also there is a chance of tearing while handing notes. Therefore Automatic methods for bank note recognition are required in many applications such as automatic selling-goods and vending machines. Extracting sufficient monetary characteristics from the currency image is essential for accuracy and robustness of the automated system. This is a challenging issue to system designers. Every year RBI (Reserve bank of India) faces the counterfeit currency notes or destroyed notes. Handling of large volume of counterfeit notes imposes additional problems. Therefore, involving machines (independently or as assistance to the human experts) makes notes recognition process simpler and efficient.

Automatic method for detection of fake currency note is very important in every country. In this project we have made fake currency note detection technique using the 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, and then determine whether the note is authentic or not. This will be aided by the process of image processing for added reliability.

Our project is designed to test for the higher denominations in the form of the new Indian currency notes of Rupees 500 and Rupees 2000 released in 2016, November by our current Prime Minister Narendra Modi.

A. Existing Unreliable Methods

Manual Inspection is the most widely prevalent way of detecting the authenticity of currency notes. It requires the exact knowledge of the security features, and even then it is unreliable besides being time consuming. There is no affirmation regarding the notes authenticity.

Counterfeit currency pen is a device that is designed to determine whether the note under consideration is fake or genuine. The pen contains iodine as ink which is brown in color. The iodine when reacts with starch, which is a primary component that makes white paper looks brighter. The commercial paper is generally brown in color unless it is bleached and starched. The ink will turn black if the note is a counterfeit but will remain amber or brown when the note is genuine. The major limitation of this pen is that when a fake note made from the paper which is not bleached or starched, the pen will detect it as a genuine note. Also, the counterfeiter can wash a smaller denomination bill in bleach and use it for printing a higher denomination note, and the pen will be unable to detect the note as a counterfeit. The counterfeiter can also use currency paper itself, if he wishes to invest so. Vitamin C is also used to mask the reaction from happening.

Existing counterfeit note detectors test for very basic features that can easily be imitated, for example watermark or security thread. Such detectors still require

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physical examination of the note, which pertain uncertainty.

B. Security Features Of An Indian Currency Note

The following security features enable the identification of the currency note:

a) Watermarks: The Mahatma Gandhi series of banknotes contain Mahatma Gandhi watermark. The banknote paper has a quality of varying density and is printed in a controlled manner. When bright light is illuminated on the rear side of the note, the watermark becomes visible on the other side of the note due to varying light intensity due to varying density of the note's particular feature.

b) Ultraviolet fluorescence: The security thread, some of the fibres embedded on the note between watermark & the denominational value, and the serial number of the note are printed in fluorescence ink which becomes bright when illuminated with UV led from the rear side of the note. These features are especially useful in detecting the authenticity of the note, but such features are also replicated through of the use of the fluorescent inks and dyes.

c) Intaglio printing: In intaglio printing the note is subjected to high pressure printing process which raises the paper surface. The portrait of Mahatma Gandhi, Ashoka pillar emblem, Bleed lines and Identity marks are printed in intaglio, which can be felt by touch in Rs 500, Rs 2000 currency notes. A special feature in intaglio known as identification mark has been introduced on left of the watermark window on all notes except Rs 10. This feature is in different shapes for different denomination (Rs 20-Vertical rectangle, Rs 50-Square, Rs 100-Triangle, Rs 500-Circle, Rs 1000-Diamond, Rs 2000-Horizontal Rectangle). It helps visually impaired to identify the denomination by touching

d) Micro-lettering: Some texts are printed in less than 1 point size. It is readable only with magnifying glass. In Rs 500 and Rs 2000 notes, the word "RBI" and the number "2000/500" are present.

e) Security thread: The security thread appears to the left of the Mahatma Gandhi portrait. Usually, it is made of metal foil, but sometimes of plastic. Often, it has some text or numbers (e.g., the denomination) engraved. Threads are embedded within the paper fiber and can be completely invisible or have a star burst effect, where the thread appears to weave in and out of the paper when viewed from one side.

f) Optically variable ink: A new security feature has been added to notes of Rs 500 and Rs 1000 in November 2000. The same has been carried into the new notes after demonetisation. The numerals are printed with optically variable ink viz, a colour shifting ink. The colour of the numeral is green when note is held flat but changes to blue when note is held at an angle.

g) Identification mark: An identification mark has been introduced in the note for the benefit of the visually impaired people. This mark is in intaglio printing & it is in different geometrical shapes for various denominations as mentioned earlier.

h) Latent image: It is a vertical band present on the right side of Mahatma Gandhi's portrait showing the respective denominational value in numeral when the note is held horizontal at the eye level.

i) Colour scheme and Aspect Ratio: Every denomination has a different base colour, for example Rs 500 has a stone grey base colour and Rs 2000 has magenta.
Aspect Ratio is the ratio of the width of the note to its height. The size of the Rs 2000 note is 66mm*166mm and the size of Rs 500 note is 63mm*150mm.

j) Bleed lines: There are raised (Intaglio printed), angular bleed lines in specific different numbers, printed on the left and the right sides on the front side of the currency note for easy identification. For Rs 2000 note, the number is seven and for Rs 500 it is 5.

k) Slogans and motifs: The Rs 2000 note has a Mangalyaan motif on its back side and the Rs 500 note as a Red fort motif on its back side. The Swacch Bharat logo along with its slogan is also printed on these notes.

C. Multi-Spectral imaging

A multispectral image is one that captures image data at specific frequencies across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, such as infrared. Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. This enables us to see the security features with detail and compare the images of the original and the counterfeit note using the values of intensity.

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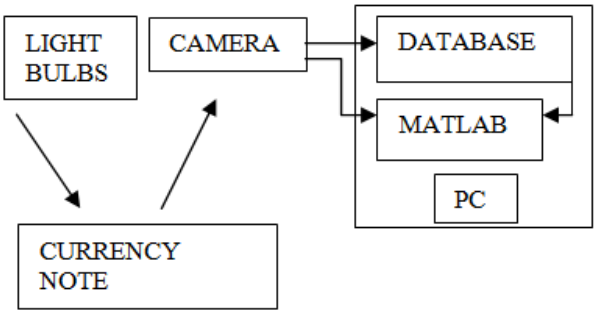
II. BLOCK DIAGRAM



The images for all wavelengths previously mentioned will be acquired manually for the front side, for the purpose of the Multi-Spectral imaging results. A pair of images of the front and back side of the note, captured under white light, is also required for the sake of the Image Processing.

III. PROCEDURE AND METHODS USED

A. Denomination Identification

After the images are acquired, before any processing can be done, we need to identify the denomination of the currency note under consideration. This can be done through several ways such as color scheme identification, size or area, or by using the Identification mark on the notes. We use the aspect ratio in our project to do this. Aspect ratio is the ratio of the width of the note to its height. The aspect ratio for the Rs 2000and Rs 500 notes are estimated and notes within their respective ranges will be identified by their denominations and further processed in comparison with their respective databases.

B. Image Processing

Under this method, the images acquired under white light go through the following procedures:

a) Pre-processing: Histogram equalization is carried out here in order make the image clearer, improve contrast, reduce noise, and make it more suitable for further processing. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

b) Grey scale conversion & Background subtraction: The image acquired is in RGB color. It is converted into gray scale because it carries only the intensity information which is easy to process instead of processing three components R (Red), G (Green), B (Blue).

c) Segmentation: Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Region of interest extraction is also done.

d) Feature extraction: Feature extraction is a special form of dimensional reduction. It involves extraction and selection of some effective and important features out of many features which are extremely important in recognition of notes. The required features are extracted using edge based segmentation and objects and background are separated.

e) Creating a database: Several reference images are taken previously and stored in a database. The required values are then taken for the purpose of comparison.

f) Matching: Features such as Entropy, metrics such as PSNR (peak signal to noise ratio) and MSE (mean squared error rate) are used for the comparison of the features and to ascertain as to the authenticity of the note.

C. Using multi-spectral imaging to determine authenticity of the notes

The images under the illumination of different wavelengths are obtained and the average intensity value is calculated and plotted against their respective wavelengths. A database is created here too, and from the graphs plotted for previous notes whose authenticity we were aware of, we establish a threshold. This enables us to determine whether the currency note under consideration is an original or a counterfeit, based on the graph that has been plotted for it.

IV. RESULTS

When the images are captured under white light, we first identify the denomination. This enables us to use the right databases for comparison. Further, multispectral images are captured for further use.

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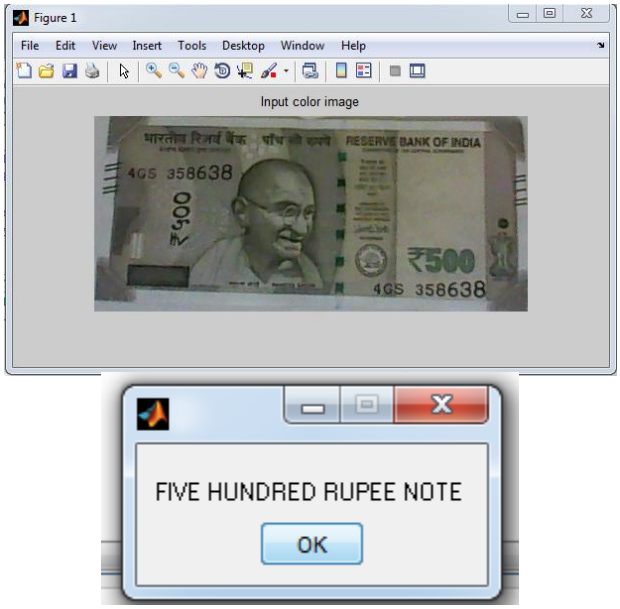

Fig. 1. Denomination Identification

Image processing and Multi-spectral methods are both carried out separately.

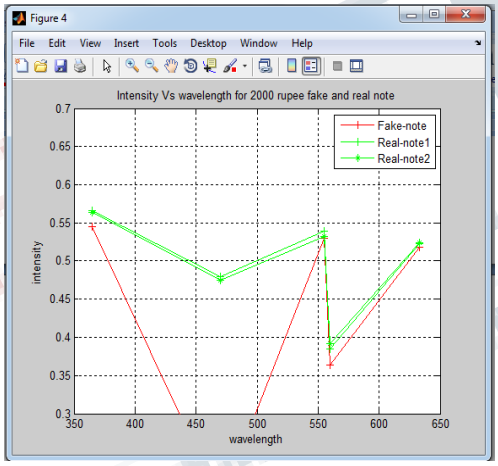

Fig.2. Comparison of real and fake notes for Rs 2000

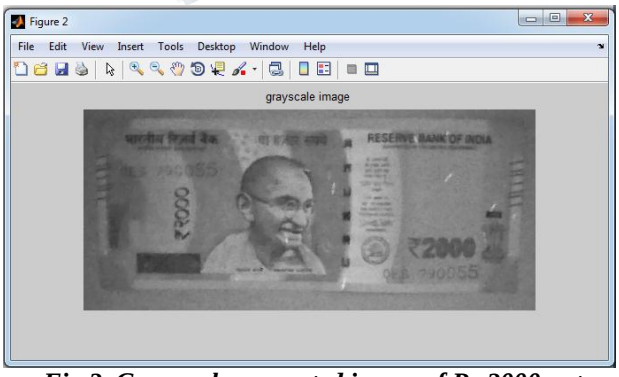

Fig.3. Grey scale converted image of Rs 2000 note

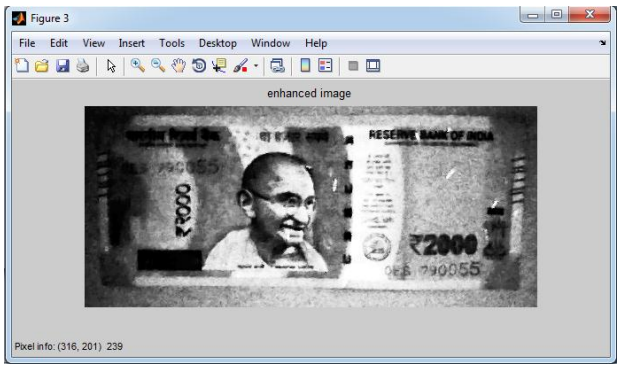

Fig.4. Histogram equalized image

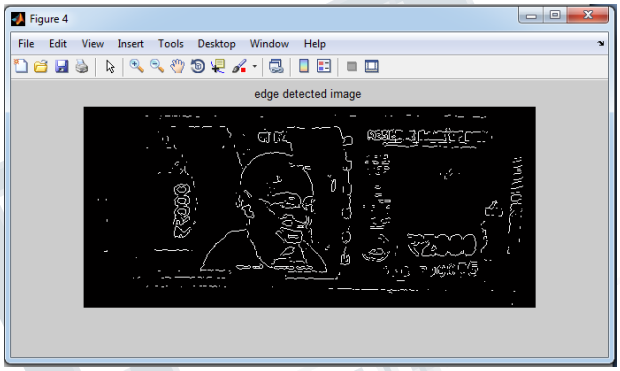

Fig.5. Edge detected image

Once the results are obtained through both methods, a sound is played to inform us about the authenticity of the note being tested.

V. CONCLUSION

The main motivation behind development of this project was to make a system for easy and quick detection of genuine and fake Indian currency notes. This is a MATLAB based system for automatic recognition of security features of Indian currency. The cost of the system is reasonable, considering its helpfulness. Our project uses effective and efficient image processing techniques and algorithms to provide accurate and reliable results. The developed algorithm works for Indian denominations Rs 500, Rs 2000.

Our project will be useful to vendors, shops and high end stores alike. The tool we propose can be further developed to improve the speed, exclude the need of manual interruption for the process of capturing the necessary images, and include counting function to be of further purpose.

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