ISSN 2229-5518

Indian Paper Currency Authentication System-A Quick Authentication System

B.Sai Prasanthi , D.Rajesh Setty

Abstract- Automated paper currency recognition system can be a very good utility in banking systems and other field of commerce. Since many years counterfeiting of paper currency challenges the financial system of every country in different sectors, India is also one of them. In this article, recognition of paper currency with the help of digital image processing techniques is described. Six characteristics of Indian paper currency are selected for counterfeit detection included identification mark, security thread , watermark ,numeral watermark, floral design and micro-lettering. The characteristic feature extraction is performed on the image of the currency and it is compared with the characteristic features of the genuine currency. The decision making is done by calculating the black pixels. This article is aimed to design a low cost system and quick decision making system.

Index Terms- Background image subtraction, Characteristic Feature Extraction, Decision making, Image processing Techniques, Latent image extraction , Serial number extraction, Thresholding.

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1 INTRODUCTION

With development of modern banking services, automatic methods for paper currency recognition become important in many applications such as in automated teller machines and automatic goods seller machines. The needs for automatic banknote recognition systems encouraged many researchers to develop corresponding robust and reliable techniques. Processing speed and recognition accuracy are generally two important targets in such systems. Modernization of the financial system is a milestone in protecting the economic prosperity, and maintaining social harmony. Automatic machines capable of recognizing banknotes are massively used in automatic dispensers of a number of different products, ranging from cigarettes to bus tickets, as well as in many automatic banking operations. The needs for automatic banknote recognition systems encouraged many researchers to develop corresponding robust and reliable techniques [1-5]. Processing speed and recognition accuracy are generally two important targets in such systems. The technology of currency recognition aims to search and extract the visible and hidden marks on paper currency for efficient classification. Until now, there are many methods proposed for paper currency recognition. The simplest way is to make use of the visible features of the paper currency, for example, the size and color of the paper currency [1]. However, this kind of methods has great limitations as banknotes are getting worn and torn with the passing of time and they are even dirtier when holding by dirty hands or in dirt. If any banknote is dirty or it may be changed into any other color then the color content of banknote may change largely.

The edge information on paper currency have extracted [2] and then used a three-layer BP NN for recognition. Although the NN technology has the ability of self-organization, generalization and parallel processing, and has a good fit for pattern recognition, it also has some weakness. First, it needs a large number of training samples, which are used to avoid over fitting and poor generalization. Second, if the distribution of training sample is not uniform, the result will probably converge to a local optimal or will even diverge unreasonably. Therefore, the selection of the training set is a crucial issue for the NN. In currency circulation, the original information on paper currency may have a loss because paper currency may be worn, blurry, or even damaged. Furthermore the complex designs of different kinds of paper currencies make automatic currency recognition difficult to work well. So it is important how to extract the characteristic information from currency image and select proper recognition algorithms to improve the accuracy of currency recognition. The method we present here is simple, less complex and efficient and can meet the high speed requirements in practical applications.

Digital image processing is an area characterized by the need for extensive experimental work to establish the validity of proposed solutions to the given problem. It has become economical in many fields of research and in industrial and military applications. Digital image processing encompasses processes whose inputs and outputs are images and encompasses processes that extract attributes from images up to and including the recognition of individual objects. The method we proposed in this paper is inspired by the analysis of hidden marks on the image of the paper currency. How to extract the hidden attributes of paper currency is a challenging task in image processing. The algorithm we apply here is very simple and works properly. The image of the paper currency is acquired through camera by applying white backlighting to the paper currency so that the hidden marks of currency is appeared on the image. Now the image is further processed by applying the image processing techniques like image pre-processing, edge detection, image segmentation, characteristics extraction.

A Digital Image processing is an area characterized by the need for extensive experimental work to establish the validity of proposed solutions to a given problem. It encompasses processes whose inputs and outputs are images and

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encompasses processes that extract attributes from images up to and including the recognition of individual objects. MATLAB is the computational tool of choice for research, development and analysis. Characteristic extraction of images is challenging work in digital image processing. It involves extraction of visible and some invisible features of Indian currency notes. A good characteristic extraction scheme should maintain and enhance those characteristics of the input data which make distinct pattern classes separate from each other. The approach consists of a number of steps including image acquisition, gray scale conversion, edge detection, feature extraction, image segmentation and comparison of images.

Image acquisition is the creation of digital images, typically from a physical scene. In the proposed work, the image will be acquired by using simple digital camera by providing some backlighting so that all the features of the currency can appear on the image properly. The image is then stored in the computer for further processing. Edge detection and image segmentation are the most important tasks performed on the images.

2 CHARACTERISTIC FEATURES

i. Ashoka Pillar Banknotes:

The first banknote issued by independent India was the one rupee note issued in 1949. While retaining the same designs the new banknotes were issued with the symbol of Lion Capital of Ashoka Pillar at Sarnath in the watermark window in place of the portrait of King George.

The name of the issuer, the denomination and the guarantee clause were printed in Hindi on the new banknotes from the year 1951. The banknotes in the denomination of `1000, `5000 and `10000 were issued in the year 1954. Banknotes in Ashoka Pillar watermark Series, in `10 denomination were issued between 1967 and 1992, ` 20 denomination in 1972 and 1975, ` 50 in 1975 and 1981, and `100 between 1967-1979. The banknotes issued during the above period, contained the symbols representing science and technology, progress, orientation to Indian Art forms. In the year 1980, the legend "Satyameva Jayate", i.e., truth alone shall prevail was incorporated under the national emblem for the first time. In October 1987, `500, banknote was introduced in October 1987 with the portrait of Mahatma Gandhi and the Ashoka Pillar watermark.

ii. Mahatma Gandhi (MG) Series 1996:

The banknotes in MG Series – 1996 were issued in the denominations of ` 5, (introduced in November 2001) ` 10 (June 1996),` 20 (August 2001), ` 50 (March 1997), `100 (June 1996), ` 500 (October 1997) and `1000 (November 2000). All the banknotes of this series bear the portrait of Mahatma Gandhi on the obverse (front) side, in place of symbol of Lion Capital of Ashoka Pillar, which has also been retained and shifted to the left side next to the watermark window. This means that these banknotes contain Mahatma Gandhi watermark as well as Mahatma Gandhi's portrait.

iii MG series – 2005 banknotes

MG series 2005 banknotes are issued in the denomination of 10, 20, 50, 100, 500 and 1000 and contain some additional / new security features as compared to the 1996 MG series. The `50 and `100 banknotes were issued in August 2005, followed by `500 and `1000 denominations in October 2005 and `10 and `20 in April 2006 and August 2006, respectively.

The security features in MG Series 2005 banknotes are as under:

i. Security Thread: The silver coloured machine-readable security threadin ` 10, ` 20 and ` 50 denomination banknotes is windowed on front side and fully embedded on reverse side. The thread fluoresces in yellow on both sides under ultraviolet light. The thread appears as a continuous line from behind when held up against light. `100, `500 and `1000 denomination banknotes have machine-readable windowed security thread with colour shift from green to blue when viewed from different angles. It fluoresces in yellow on the reverse and the text will fluoresce on the obverse under ultraviolet light. Other than on `1000 banknotes, the security thread contains the words 'Bharat' in the Devanagari script and 'RBI' appearing alternately. The security thread of the ` 1000 banknote contains the inscription 'Bharat' in the Devanagari script, '1000' and 'RBI'.

ii.Intaglio Printing: The portrait of Mahatma Gandhi, Reserve Bank seal, Guarantee and promise clause, Ashoka Pillar emblem, RBI's Governor's signature and the identification mark for the visually impaired persons are printed in improved intaglio.

iii.See through register: On the left side of the note next to the watermark window, half the numeral of each denomination (10, 20, 50, 100, 500 and 1000) is printed on the obverse (front) and half on the reverse. The accurate back to back registration makes the numeral appear as one when viewed against light.

iv.Water Mark and electrotype watermark: The banknotes contain the portrait of Mahatma Gandhi in the watermark window with a light and shade effect and multi-directional lines. An electrotype mark showing the denominational numeral 10, 20, 50, 100, 500 and 1000 respectively in each denomination banknote also appear in the watermark widow and these can be viewed better when the banknote is held against light.

v.Optically Variable Ink (OVI): The numeral 500 & 1000 on the ` 500 and ` 1000 banknotes are printed in Optically Variable Ink viz., a colour-shifting ink. The colour of these numerals appears green when the banknotes are held flat but would change to blue when the banknotes are held at an angle.

vi.Fluorescence: The number panels of the banknotes are printed in fluorescent ink. The banknotes also have dual coloured optical fibres. Both can be seen when the banknotes are exposed to ultra-violet lamp.

vii.Latent Image: In the banknotes of ` 20 and above, the vertical band next to the (right side) Mahatma Gandhi's portrait contains a latent image, showing the denominational value 20, 50, 100, 500 or 1000 as the case may be. The value can be seen only when the banknote is held horizontally and light allowed to fall on it at 45°; otherwise this feature appears only as a vertical band.

viii.Micro letterings: This feature appears between the vertical band and Mahatma Gandhi portrait. It contains the word 'RBI' in ` 10. Notes of ` 20 and above also contain the denominational value of the banknotes. This feature can be seen better under a magnifying glass.

ix.Serial Numbers : Every banknote has its own serial number, so it is more important to check whether the number is wrong or repeated. The serial numbers are currency Issuance numbers, which are used as the identifiers (IDs) of the banknotes.

3.APPROACH

1) Image acquisition: Image is acquired by digital camera by applying the white backlighting against the paper currency so that the hidden attributes are able to appear on the image of the currency. Here image acquisition of 500 denomination is shown below-

Fig.1. Original image

2) Image pre-processing: Pre-processing of image are those operations that are normally required prior to the main data analysis and extraction of information. Here image resizing is performed because the currency image is too large to process.

Fig.2.Resized image

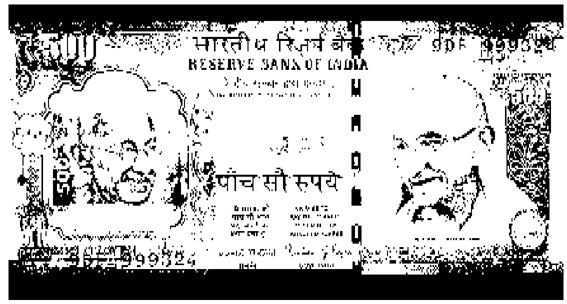
3) Gray-scale conversion: The image acquired is in RGB color. It is converted into gray scale because it carries only the intensity information which is easy to process instead of processing three components R(Red), G(Green), B(Blue).

Fig.3. Gray scale image

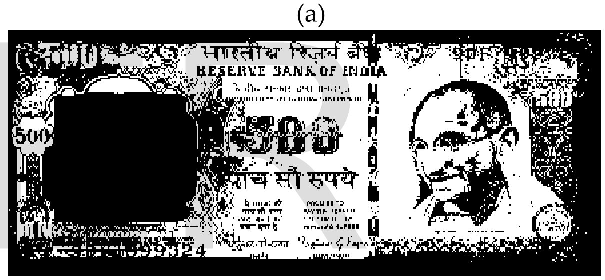
4) Background subtraction: Background estimation is done using morphological opening and background is subtracted from the gray scale image to produce foreground image.

Fig.4.Background subtracted image

5)Binary conversion: The back ground subtracted image is converted to two binary images using two threshold values in order to extract six characteristic features of the currency note. So we obtain two different binary images each containing different features to be extracted.



(a)



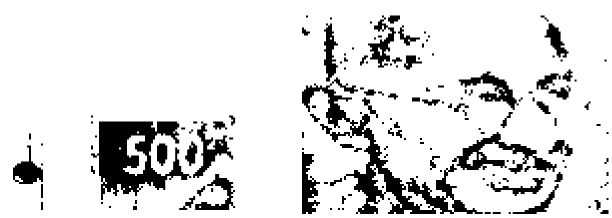
(b)

Fig.5.(a),(b) Binary images

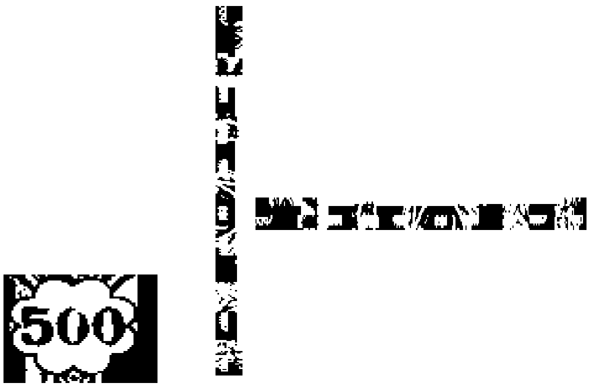
5) Cropping: The characteristic features are cropped.

6) Segmentation: Segmentation is the process of partitioning a digital image into multiple segments. It is typically used to distinguish objects from backgrounds.

7)Feature Extraction: The features are extracted based on segmentation process.



(a) (b) (c)



(d) (e) (f)

Fig.6.(a) Identification mark (b) Numeral(c) Watermark (d)Floral design (e) Security thread (f) Microlettering in security thread.

8)Lastly the extracted features are compared with the extracted features of original currency by calculating the number of black pixels of segmented image. If the pixels of segmented image of test currency are approximately equal to the pixels of segmented image of original currency then the currency is found to be genuine otherwise counterfeit. The number of black pixels are tabulated for reference note and test currency.

8) Count: For authentication, we count black pixels for all six features. The error difference(e) is difference between number of black pixels in original currency and number of black pixels in test currency. The error difference(e) is calculated for each and every feature of the note. If the error difference is less than 500 pixels then the count(c) is incremented by one or else previous value of c is retained. Initially the count(c) is assigned to zero. The count (c) tells us how many features have error difference (e) less than 455 pixels. The count loop is repeated six times because features extracted are six for any currency note.

9) Decision making: The final decision depends on the count (c).If the count is greater than or equal to 4,then the note is found to be Genuine which means out of six features, four features are found to have error difference less than 455 pixels. If the count(c) is less than 4, then the note is found to be Fake or Counterfeit.

4 PROPOSED WORK

The additional feature which can be extracted is Latent image. The Latent image is also an important security feature of Indian paper currency. The following steps are used to extract Latent image:

1)Image acquisition: Image is acquired by digital camera by applying the white backlighting against the paper currency so that the hidden attributes are able to appear on the image of the currency. Here image acquisition of 500 denomination is shown below-

Fig.7 Original image

2) Image pre-processing: Pre-processing of image are those operations that are normally required prior to the main data analysis and extraction of information. Here image resizing is performed because the currency image is too large to process.

Fig.8 Resized image

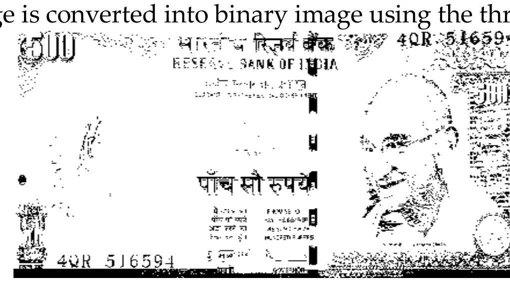
3) Gray-scale conversion: The image acquired is in RGB color. It is converted into gray scale because it carries only the intensity information which is easy to process instead of processing three components R(Red), G(Green), B(Blue).

Fig.9 Gray scale image

4) Background subtraction: Background estimation is done using morphological opening and background is subtracted from the gray scale image to produce foreground image.

Fig.10 Back ground subtracted image

5)Binary image conversion: The back ground subtracted image is converted into binary image using the threshold.



ISSN 2229-5518

Fig.11 Binary image

6.Cropping: The vertical band of the Indian paper currency note is cropped and segmented.

Fig.12. Cropped image

7.Rotation: The cropped image is rotated through an angle of 270º in order to have proper visibility of the image.

Fig.13 Rotated image

8.Complement: The rotated image is complemented.

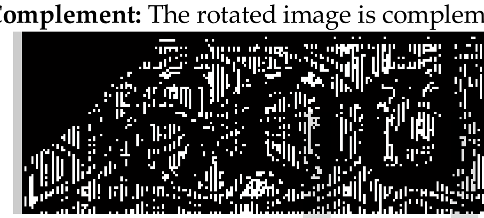


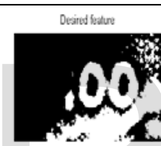
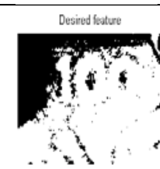
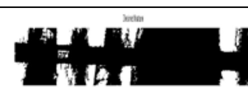
Fig.14 Latent image

5 EXPERIMENTAL RESULTS

The feature extraction process can also be extended to 100 Rupees denomination note. The above steps holds good for the 100 Rupees denomination note also. The results are shown below-

(a) Reference image

(b) Test image

Security feature	Reference note	Test note
Identification mark		
Watermark		
Security Thread		
Numeral		
Floral design		
Micro-lettering in security thread		

ISSN 2229-5518

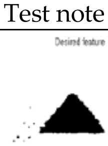
Table 1: Black pixels of reference note and test currency

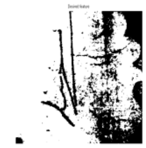
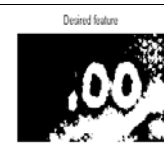
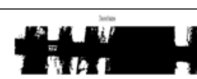
Feature	Reference note (pixels)	Test currency (pixels)	Error (e) (pixels)	Count (c) (pixels)
Identification mark	60	53	7	1
Watermark	4675	1898	2777	
Security thread	589	528	61	2
Numeral	783	369	414	3
Floral design	1072	849	223	4
Micro lettering	2838	2344	494	

In the table 1, the blackpixels count for each feature are tabulated.The count(c) is taken into consideration only when error difference is less than 455 pixels.In the above table the count(c) is equal to 4, so we can conclude that note is genuine.

(a)Reference image

(b)Test image

Security features	Reference note	Test note
Identification mark		

Watermark		
Security thread		
Numeral		
Floral design		
Microlettering in security thread		

We can observe that Watermark,Security thread,Numeral are different from original features.It is also known that security thread is a continuous line but the extracted feature of test image feature is discontinous image.

Table 2: Black pixels of Reference note and test currency

Feature	Reference note (pixels)	Test currency (pixels)	Error (e) (pixels)	Count (c) (pixels)
Identification mark	60	156	-96	
Watermark	4675	2141	2534	
Security thread	589	214	375	1
Numeral	783	1970	-1187	
Floral design	1072	1101	-29	
Micro lettering	2838	1217	1621	

In the table 2, the blackpixels count for each feature are tabulated.The count(c) is taken into consideration only when error difference is less than 455 pixels.In the above table the count(c) is equal to 1, so we can conclude that note is counterfeit.

GRAPHS:

The experimental results shown in the form of graph after comparison of the features and calculating the number of black pixels in the segmented features of original currency and test currency.

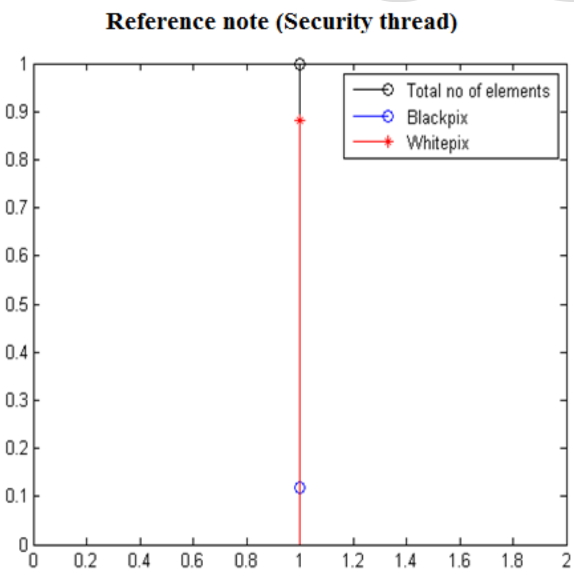


Fig.15. Graph of number of black and white pixels in security thread of original currency

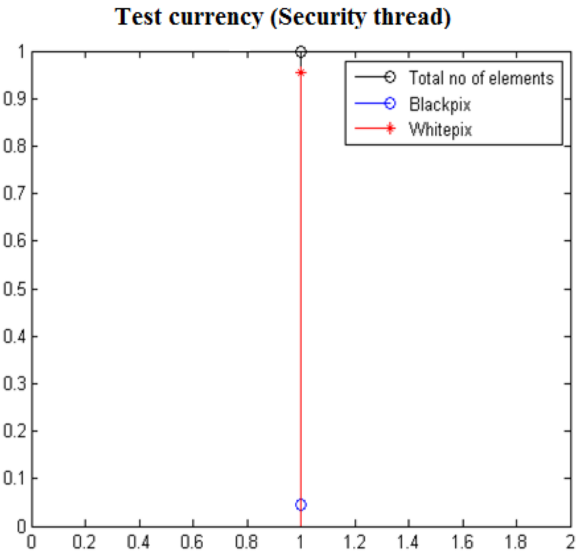


Fig.16. Graph of number of black and white pixels in identification mark in test currency.

From the graphs(Fig.15 and Fig.16), we can observe that the black pixels of original currency and black pixels of test currency(Security thread feature) are not equal.

6 CONCLUSION

In this article, the authentication of Indian paper currency is described by applying image processing techniques. Basically six features are extracted including identification mark, security thread, watermark, numeral, floral design, micro lettering from the image of the currency. The process begins from image acquisition and end at comparison of features. The system designed is a low cost system and works well in the whole process with less computation time. The six features are extracted within 1sec. The complete methodology works for Indian denomination 20,50,100, 500 and 1000. The method is very simple and easy to implement. If the hardware part of image acquisition is designed then it is surely help us to minimize the problem of counterfeiting currency. This technique is used to extract six characteristics of paper currency including identification mark, security thread, floral design, numeral watermark, watermark and micro-lettering in security thread. The system also extracted the hidden features i.e. latent image of the paper currency. The proposed work is an effort to suggest an approach for the characteristic extraction of Indian paper currency. The serial number can also be extracted using latent image extraction procedure. The system is able to extract the features even the note has scribblings on it. The system can extract features even the test image sizes are different when compared to reference image.

ACKNOWLEDGEMENT

I would like to express my gratitude to Sri.D.Rajesh Setty, Professor, ECE Department for his excellent guidance and encouragement. I would like to thank Sri. K. N. H. SRINIVAS, Head of the Department of Electronics and Communication Engineering, Sri Vasavi Engineering College for his valuable suggestions in completing this work successfully.I would like to thank other faculty members for their support and encouragement.

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