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Design and Implementation of Indian Paper Currency Authentication System Based on Feature Extraction by Edge Based Segmentation Using Sobel Operator

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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. Three characteristics of Indian paper currency is selected for counterfeit detection included identification mark, security thread and watermark. The characteristics extraction is performed on the image of the currency and it is compared with the characteristics of the genuine currency. The sobel operator with gradient magnitude is used for characteristic extraction. Paper currency recognition with good accuracy and high processing speed has great importance for banking system. The proposed method has advantages of simplicity and high speed. The experimental results show that this approach is effective and efficient and clearly meet the system requirements.

Keywords—Paper currency recognition, Characteristics extraction, Digital image processing, Counterfeit detection, Sobel operator with gradient magnitude.

I. INTRODUCTION

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.

II. FEATURE EXTRACTION

In pattern recognition and in image processing, feature extraction is the special form of dimensionality reduction. It is the method of capturing the visual content of images for indexing and retrieval. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (much data but not much information) then the input data will be transformed into a reduced representation set of features (also named feature vector).

If the attributes extracted are carefully chosen, it is expected that the attributes set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves simplifying the amount of resources required to describe the large set of data.

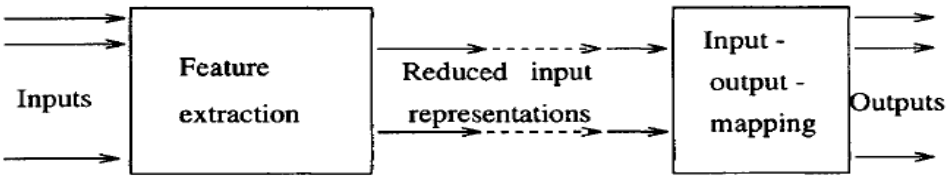

Fig. 1 Feature Extraction Approach.

Visual attributes of images are of two types-

A. Domain specific attributes which include fingerprints, human faces.
B. General attributes which include color, texture, and shape.

There are two types of attributes categorized under the shape attribute extraction-

A. Global attributes include moment invariant, aspect ratio and circularity.
B. Local attributes include boundary segments.

In this approach we extract the general attributes of the paper currency that is shape including identification mark, security thread and watermark. These features are extracted by detecting the edges and estimating the gradient of the image at every point to generate a gradient image and thresholding the gradient image to accomplish image segmentation.

III. THE APPROACH

In order to design the complete system in a proper way graphical user interface is used in MATLAB. A graphical user interface provides the user with a familiar environment in which to work. In this approach, the implementation is done for denomination 100, 500 and 1000. The authentication process is performed on these three denominations. The design of complete system consists of three interfaces each for one denomination. Every interface has two sections one for original currency and other for test currency. The interface of denomination 500 is shown below:

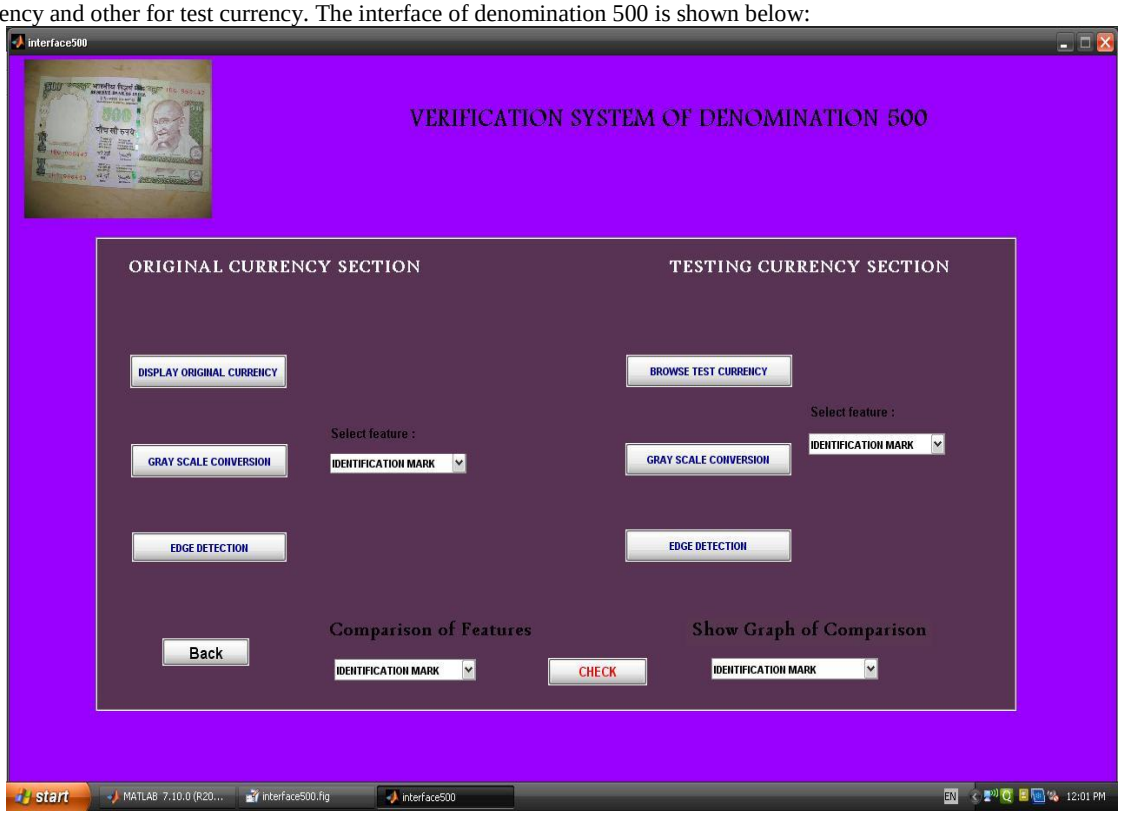

Fig. 2 Interface for Denomination 500

Our currency authentication system has four important parts-

1) Edge detection of currency image.
2) Segmentation after edge detection.
3) Feature Extraction.
4) Comparison of features.

The approach consists of the following steps-

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. 2 Original Indian 500 denomination

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.3 Indian 500 denomination after resizing the original 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) Edge detection: edges are detected of the gray scale image of paper currency using Sobel operator. It smoothes the image and calculate the gradient of the image.

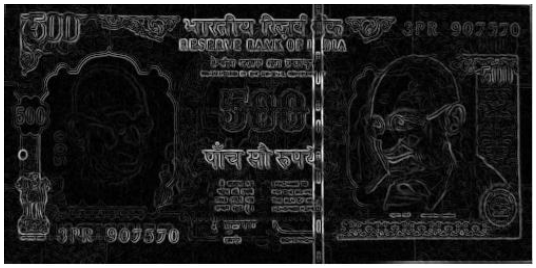

Fig.4 Edge Detection (Gradient magnitude of the image)

5) Image segmentation: segmentation is the process of partitioning a digital image into multiple segments. It is typically used to distinguish objects from backgrounds. Here edge based segmentation is performed on the image.

6) Feature extraction: Now the features are extracted using edge based segmentation and objects and background are separated.

Fig.5 Edge based segmentation of Identification mark of 500 denomination.

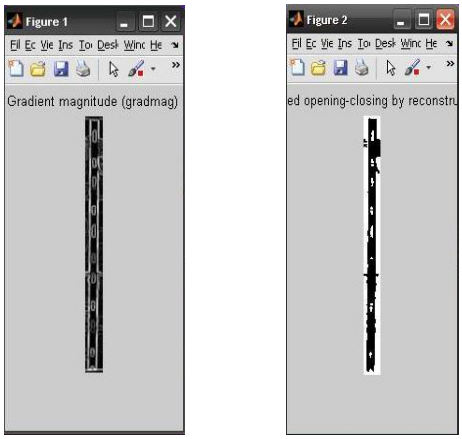

Fig.6 Edge based segmentation of Security Thread of 500 denomination.

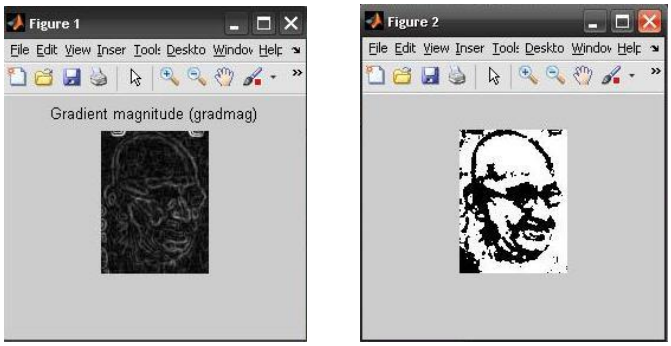

Fig.7 Edge based segmentation of Watermark of 500 denomination.

7) 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.

IV. EXPERIMENTAL RESULTS

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. The graph is plotted between the numbers of pixels in the image and the number of zeros and ones.

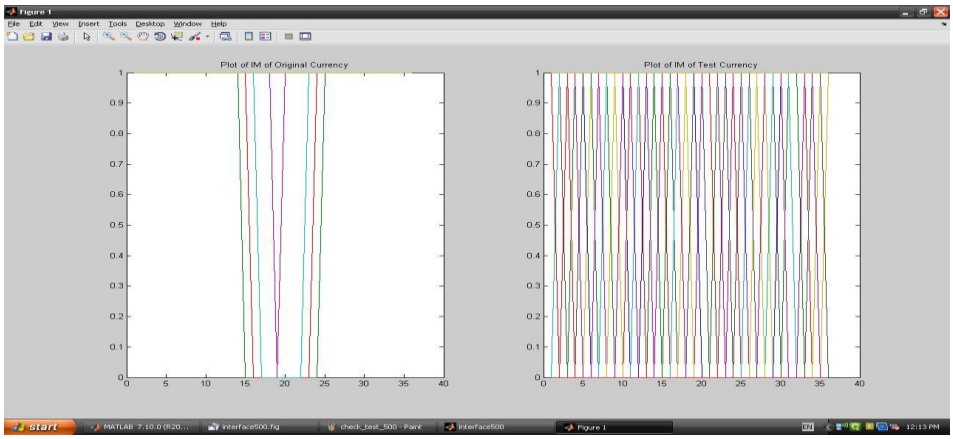

Fig. 8 Graph of number of black and white pixels in identification mark of original and test currency

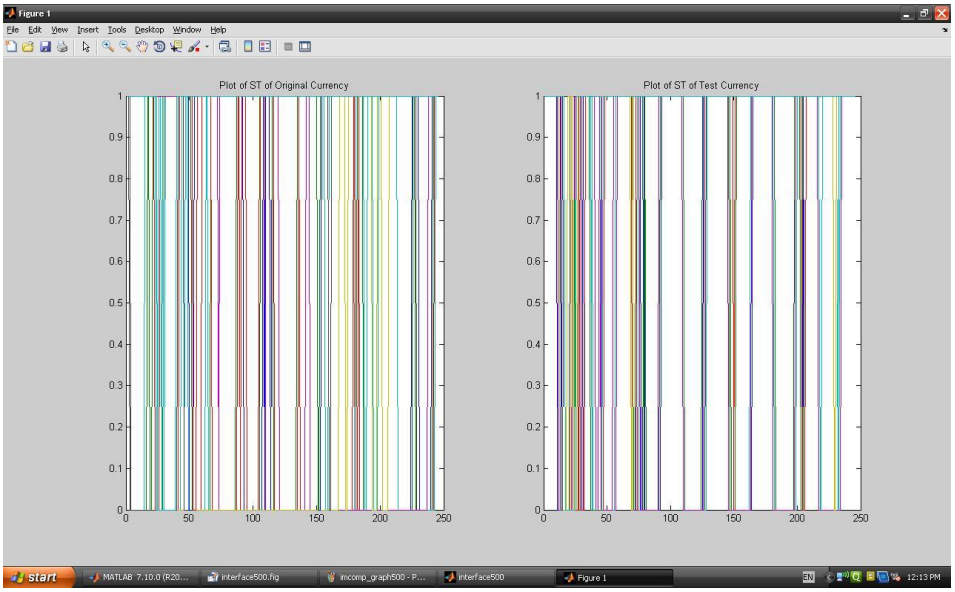

Fig. 9 Graph of number of black and white pixels in security thread of original and test currency

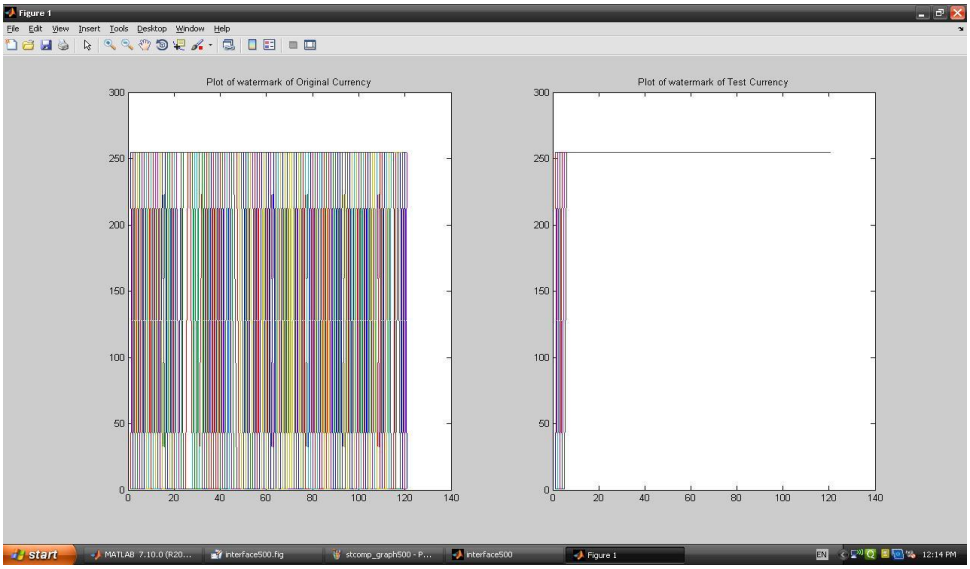

Fig. 10 Graph of number of black and white pixels in watermark of original and test currency

Table I: **Currency Recognition Time**

CURRENCY TYPE	100	500	1000
ELAPSED TIME OF RECOGNITION	0.21135	0.22134	0.22311

V. CONCLUSION

In this paper, the authentication of Indian paper currency is described by applying image processing techniques. Basically three features are extracted including identification mark, security thread and watermark from the image of the currency. The process begins from image acquisition and end at comparison of features. The features are extracted using edge based segmentation by sobel operator and works well in the whole process with less computation time. The complete methodology works for Indian denomination 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.

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