A Review Paper on Currency Recognition System

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ABSTRACT
In this paper, an algorithm based on the frequency domain feature extraction method is discussed for the detection of currency. This method efficiently utilizes the local spatial features in a currency image to recognize it. The entire system is pre-processed for the optimal and efficient implementation of two dimensional discrete wavelet transform (2D DWT) which is used to develop a currency recognition system. A set of coefficient statistical moments are then extracted from the approximate efficient matrix. The extracted features can be used for recognition, classification and retrieval of currency notes. The classification result will facilitate the recognition of fake currency mainly using serial number extraction by implementing OCR. It is found that the proposed method gives superior results.

Keywords
Feature extraction, classification, discrete wavelet transform, textural feature, currency recognition, OCR, fake currency, security thread, serial number, RBI marks.

1. INTRODUCTION
The currency recognition system is used in many scenarios such as bank, business firms, railways, shopping malls, departmental stores, government organization, etc. But recognition is done majorly using hardware device. Also common man cannot find it feasible to use it as hardware. So there is a need to computerize the human effort to recognize the currency. Consider the example of a bank; it needs to recognize the denomination every now and then they use the device which consist of ultraviolet light .The banker keeps the currency note on the device and try to find whether the watermark symbol, serial number and some other characteristics of the notes are proper to get the denomination and check its authenticity. This increases the work of the banker. Instead if the banker uses the system and computerizes his work, the result will be much more accurate. Same is the case with areas such as shopping malls, investment firms where such systems can be used. So there is needed to make easier way to recognize the currency notes.

Fig 1: Prominent features of notes are encircled.

2. METHODOLOGY
Humans cannot recognize currencies of different countries easily. The modern technologies make it necessary to develop an automated system and check its authenticity (validity). The proposed approach that was implemented acquires the image. The image is then pre-processed .The process then proceeds by extracting the textural and non-textural features. The textural features are extracted using DWT (Discrete Wavelet Transform). The non-textural features are used to usually check authenticity. They are such as serial number, color, etc. Textural features are used to classify them. According to classification result i.e. pattern matching we get the required result (Denomination). After the denomination is known authentication is done. The authentication process consists of checking the security thread, RBI microprint and recognizing serial number to determine whether the currency is fake or not.

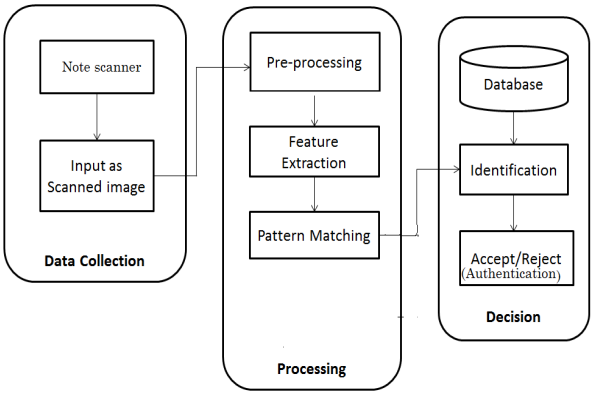

Fig 2: Project Methodology

3. PROPOSED MODEL
The image is acquired from the scanner which is used as input image. The image should be of decent quality i.e. it should be at least greater than 1000x700 pixels and 150 dpi. The images of similar quality and size are stored in the database. The input image and the stored image are used for pattern matching to get the result .i.e. denomination. The image is usually stored in jpg, tiff or png file format.

Pre-processing consists of image enhancement, removing noise, filtering etc. The image is resized to standard size i.e. the size common to all notes. This is because the notes have different dimensions.

Image enhancement first starts with converting the colored image to grayscale image. The grayscale image represents different shades of gray. This image is binarized further.

Fig 3(a): Original Image

Fig 3(b): Grayscale Image

Histogram equalization is used to adjust contrast based on the image histogram. Histogram of image provides a global description of the appearance of an image. It represents the relative frequency of occurrence of the various gray levels in an image. Histogram equalization is used to adjust contrast of image which has background and foreground that are both bright or both dark.

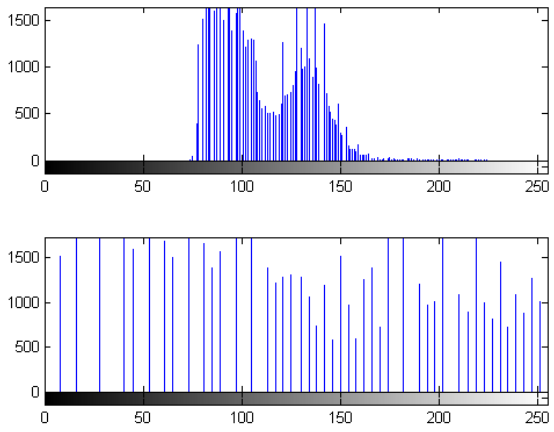

Fig 4: Histogram Equalization

The filtering can be done using various types of filters such as average filter, median filter or highpass filter .Out of these filters, the median filter is most commonly used to remove salt and pepper noise. The average filter leads to blurring of image and highpass filter cannot be used as we have to preserve low frequency component.

Discrete wavelet transform maps data from the time domain (the original or input data vector) to the wavelet domain. The result is a vector of the same size. Wavelet transforms are linear and they can be defined by matrices of dimension (n x n), if they are applied to input of size n .The images are decomposed into four sub-bands or sub-sampled, after applying DWT as shown in Figure 5(a). These sub-bands are labeled as LL1, LH1, HL1 and HH1. LH1, HL1 and HH1 sub-bands represent the finest scale wavelet coefficients, i.e., image details and the sub-band LL1 corresponds to the coarse level coefficients i.e., image approximation. To obtain the next coarse level of wavelet coefficients, the sub-band LL1 can be decomposed and sampled. Two-level wavelet decomposition is shown in

Fig.5 (b). Similarly, LL2 can be further decomposed. This process continues until the final scale. The transformed coefficients, image approximation and image details are exploited for texture analysis, discrimination and texture feature extraction [2].

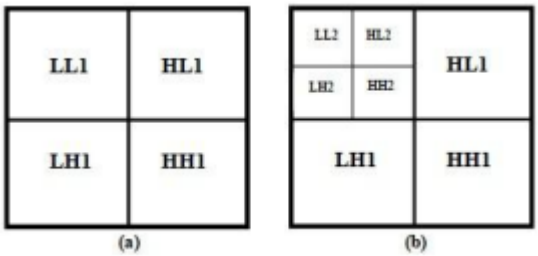

Fig 5: Image Decomposition (a) One Level (b) Two level

In this section, we present an approach to extract the features of currency notes. It is essential to describe a currency note by its attributes or properties in order to have better recognition, classification and retrieval of features. Several features like color, texture and size can be used to describe currency notes. Color is the most natural feature to describe currency notes. However, it fails to discriminate a number of the currency note having the same color. On the other hand each currency notes can uniquely be characterized by its texture. Therefore, the textures of the currency notes are considered as an important feature to describe and discriminate currency notes from each other. The proposed method begins with the pre-processing of currency notes via applying 2D adaptive noise removal to enhance the images.

The methodology is to apply the Discrete Wavelet Transform (DWT) on the currency notes. The approximate coefficient of the transformed image is obtained. Next, the following statistical features such as mean, standard deviation, skewness and kurtosis are extracted from the approximate Coefficient matrix, Equation (1-4). For each currency note, the extracted features are stored in a feature vector. The feature vectors of different currency notes can be used for recognition, classification and retrieval of currency notes [1].

$$\text{Mean} = \frac{\sum_{i=1}^{N} F_i}{N} \qquad (1)$$

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{N} (F_i - \mu)^2}{N}} \qquad (2)$$

$$\text{Skewness} = \sqrt[3]{\frac{\sum_{i=1}^{N} |F_i - \mu|^3}{N}} \quad (3)$$

$$\text{Kurtosis} = \sqrt[4]{\frac{\sum_{i=1}^{N} (F_i - \mu)^4}{N}} \quad (4)$$

The weight increases the interclass separatability while they decrease the Intraclass dissimilarity.Classification is the problem of generating decision boundary that can distinguish various classes in the feature space. In most of the classification problems of practical significance features are linearly not separable.

The minimum distance classifier uses the distances between the input pattern and a set of reference vectors. The n reference vectors r1, r2… rn, are associated with the pattern class ci. A minimum distance classification scheme with respect to reference vector rc is to classify the input vector xi as belonging to class c i.e. xi belongs to class ck if |xi – rk| is the minimum. This gives the class to which vector belongs and thus classifies it [6][7].

The different classifiers that can be used are SVM, K-means, Bayes, knn classifier, etc. Support Vector Machines are based on the very concept of decision planes. A decision plane is OSH that separates between a set of objects having different class memberships. Support vector machines (SVMs) are a set of related supervised learning methods that analyze data and recognize patterns, used for classification and regression analysis. The original SVM algorithm was invented by Vladimir Vapnik .Vapnik. The standard SVM takes a set of input data and predicts, for each given input, which of two possible classes the input is a member of, which makes the SVM a non-probabilistic binary linear classifier.

4. FAKE CURRENCY RECOGNITION

Fake currency recognition is done after the currency denomination is recognized. The three different authenticating features proposed by this paper consist of security thread, RBI microprint and serial numbers detection. The security thread is a security feature of many banknotes to protect against counterfeiting. It consists of a thin ribbon that is threaded through the paper notes. Usually, the ribbon runs vertically, and is woven into the paper. It has characters engraved on it.

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. However when held up to the light the thread will always appear as a solid line. Features can be built into the thread material e.g. it is a difficult feature to counterfeit but some counterfeiters have been known to print a thin grey line or a thin line of varnish in the area of the thread. Security threads can also be used as an anti-counterfeiting device in passports. The figure of security thread after cropping is shown in fig 6.

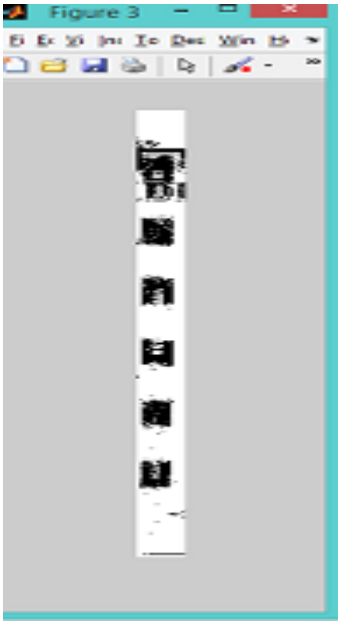

Fig 6: Security thread

The RBI microprint is present on currency notes. This can be found by cropping the required area and then zooming it to recognize whether the note is valid or not. The zoomed part is displayed. This feature appears between the vertical band and Mahatma Gandhi portrait. It contains the word 'RBI' in Rs.5 and Rs.10 note. The notes of Rs.20 and above contain the denominational value of the notes in microletters.

Fig 7 (a): Currency image with microprint

Fig 7(b): Zoomed Microprint

The Serial number detection is most important part of fake currency detection. The rightmost corner of the image is required part which is cropped. The segmentation is done on a particular threshold. Threshold value will binarize the image. Only the relevant part of the cropped image is stored as objects. The labelling of image is done to separate the objects. The objects of serial number are marked with specific label. So labelling helps to differentiate objects. Each labelled object is compared with the saved or already existing template to know whether that object is character or not. If characters match then they are stored in document. This

document is compared with the database containing fake serial numbers. If the match is found the note is considered fake [3].

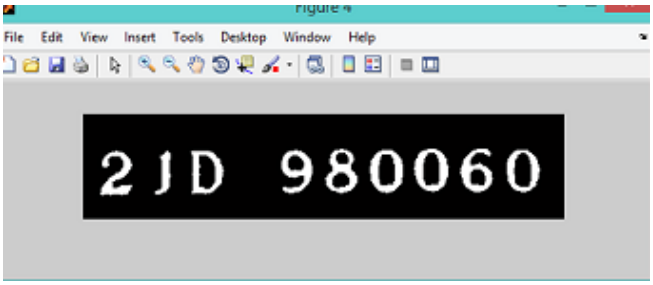

Fig 8: The cropped and thresholded part of the 10 rupee note without noise.

5. ACKNOWLEDGMENT

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6. CONCLUSION

In this paper, an efficient approach is proposed to extract the features of Indian currency notes and recognize it. The paper also contains the fake currency detection and authentication. Our future work will be concentrated on extraction of features from various currency notes belonging to different countries as well as recognition and classification. Our future scope will be conversion of currency denomination.

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