Recognition of Indian Currency Note Based on HSV Parameters

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Abstract: *This paper presents the novel method for detection of the counterfeit Indian Paper Currency. The proposed approach works with all the types of denominations of Indian paper currency. The system relies on a specific feature of the Indian Bank Notes and relied feature is not possible to replicate for the counterfeit makers or producers. And there is no chance that they would be capable to imitate this feature even within a pretty long time. The recognition system is composed of two parts. The captured image is first preprocessed by reducing data size and extracting its features by using image processing toolbox in MATLAB. The feature extraction is finished by considering HSV (Hue Saturation Value). The second step is recognition, in which the core is neural network classifier. The success-rate of the counterfeit detection with properly captured image is 100%.*

Keywords: Detection, Feature Extraction, HSV pattern recognition.

1. Introduction

In recent years, along with the accelerative developments of world economics incorporation course, the start of Euro area, and the increase of Asia economics, frontier trade and personal intercourse of various countries are frequent increasingly. Travelling people always take many countries of paper currency. Probabilities that the paper currencies of various countries are probably interweaved together therefore rises increasingly. It is a challenge for conventional paper currency recognition systems. However, the focus of most of the conventional currency recognition systems and machines is on recognizing counterfeit currencies. It is not enough for practical businesses. The reason is that in most of banks, especially those internationalized banks, there are large quantities of cash belonging to many different countries need to be processed, and it is possible that all of them are real cashes. Hence it is necessary to develop the currency recognition systems and bank machines that can not only realize correct recognitions and classifications for known paper currencies, but also complete effective rejections for unknown paper currencies. Recognition can be done by any of the following methods.

1) The recognition of the serial numbers of the Indian paper currency such as 100, 500 or 1000 banknotes can be detected using various methods. But the drawback of this method is that we need to have the datasheet of serial numbers of available currency notes.
2) Optical character recognition has been a topic of interest since possibly the late 1940's. The earliest OCR machines were primitive mechanical devices with fairly high failure rates. Today there are many OCR devices in use based on different algorithms. All of the popular algorithms sport high accuracy and most high speed, but still many suffer from a fairly simple flaw: when they do make mistakes (and they all do), the mistakes are often very unnatural to the human point of view. That is, mistaking a "5" for an "S" is not too surprising because most people are willing to agree that these two characters are similar, but mistaking a "5" for an "M" is unexpected. Algorithms make such mistakes because they generally operate on a different set of features than humans for computational reasons.
3) Some features about how to detect a fake note by observing:
   - **Optical Variable Ink:** The colour of the numeral 500 appears green when the banknote is held flat but would change to blue when the banknote is held at an angle. The font size is also reduced.
   - **Latent Image:** When the note is head horizontally, the vertical band on the right shows an image of the number 500.
   - **Security Thread:** The note also has a three millimeter wide security thread with the inscriptions: one thousand, the word 'Bharat' in Hindi and RBI.
   - **Micro lettering:** The 'RBI' and the numeral, "500" - which can be viewed with the help of a magnifying glass - are between the Mahatma Gandhi portrait and the vertical band.
   - **Watermark:** When the note is held against the light, the picture of Gandhi and an electrolyte mark showing the number 500 appear in the white space. The best way to identify a note is the silver bromide thread that runs vertically through a currency note. Fake currency notes tend to have silver-coloured band painted in place of the silver thread. A real note has a prominent thread with raised 'RBI' markings made on it in English and Hindi. Also, in a real note, the colour of the thread shifts from green to blue when viewed from different angles.
4) Recognition considering the hue, saturation and intensity values. We are using this method as it has 100% accuracy rate and many more advantages. We have analyzed the properties of the HSV (Hue, Saturation and Value)color space with emphasis on the visual perception of the variation in Hue, Saturation and Intensity values of an

image pixel. The HSV color space is fundamentally different from the widely known RGB color space since it separates out the Intensity (luminance) from the color information (chromaticity). This Currency recognition system is divided into following parts:

1. Image acquisition.
2. Pre-Processing of currency image.
3. Feature Extraction.
4. Classification.
5. Display of Result

2. Literature Survey

In [1] proposed a Euro banknote recognition system using two types of neural networks; a three-layered perception and a Radial Basis Function (RBF) network. In this paper, author has proposed a banknote recognition system composed of two parts; a classification part and a validation part. The classification part uses a three-layered perception and the validation part uses several RBF networks. While the three-layered perception is a well known method for pattern recognition and is also very effective for classifying banknotes, it makes boundaries only for classifying given training data and is unassured of rejecting unknown data. The RBF network has a data approximation property, which seems a proper tool for rejecting unknown data. It is able to configure the system employing only one RBF network.

In [2] the proposed system "SLCRec" comes up with a solution focusing on minimizing false rejection of notes. Sri Lankan currency notes undergo severe changes in image quality in usage. Hence a special linear transformation function is adapted to wipe out noise patterns from backgrounds without affecting the notes' characteristic images and re-appear images of interest. The transformation maps the original gray scale range into a smaller range of 0 to 125. Applying Edge detection after the transformation provided better robustness for noise and fair representation of edges for new and old damaged notes. A three layer back propagation neural network is presented with the number of edges detected in row order of the notes and classification is accepted in four classes of interest which are100, 500, 1000 and 2000 rupee notes.

Few authors [3] presented a currency recognition system using ensemble neural network (ENN). The individual neural networks (NNs) in an ENN are trained via negative correlation learning. The objective of using negative correlation learning (NCL) is to expertise the individuals on different parts or portion of input patterns in an ensemble. The image of different types note is converted in gray scale and compressed in the desired range. Each pixel of the compressed image is given as an input to the network. This system is able to recognize highly noisy or old image of TAKA. Ensemble network is very useful for the classification of different types of currencies. It reduces the chances of misclassification than a single network and ensemble network with independent training.

In [4] put forward a new image based technique for Birhani paper currency recognition based on two classifiers, the weighted Euclidean distance using suitable weights and the Neural Network. First of all color image of paper currency having quality approximately equal to 600 dpi is obtained through scanning process. In pre-processing step four different kinds of images are obtained from color image ,viz. the binary image; the gray scale image using Sobel mask; the gray scale image using Prewitt mask; and the gray scale image using Canny mask. Then features are extracted by calculating the sum of pixels of each of the four images. Also, the Euler number is calculated for each of the images then computed the correlation coefficient of input image after converting it to gray scale. After feature extraction paper currency classification is done by using two different methods called Weighted Euclidean Distance (WED) and Neural Networks using feed forward back propagation.

3. System Architecture

Our proposed system for currency reorganization is divided into different parts. The captured image is first preprocessed by reducing data dimensionalities and extracting its features by using image processing toolbox in MATLAB. According to the HSV (Hue, Saturation, Value) color space, the work of color feature extraction is finished. The second one is recognition, in which the core is neural network classifier. And finally the result of recognition will be displayed
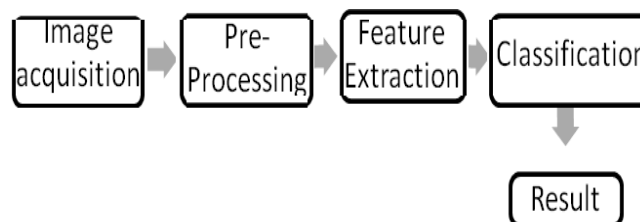

Figure 1: Block Diagram for currency recognition

1) **Image acquisition:** There are various ways to acquire image such as with the help of camera or scanner. Its main aim is that acquired image should retain all the features.
2) **Pre-Processing:** The image to be processed must be put in a format appropriate for digital computing. It includes transformation of image from one format into other. It also involves image adjusting, image smoothening, shrinking, rotating, zooming. Image smoothening also includes removal of noise using different filters.
3) **Feature Extraction:** It involves the extraction of different features that are present on the note. Feature extraction of Indian Paper currency can be done by analyzing its color, histogram hue saturation intensity/value (HSV) color space.
4) **Classification:** After getting features of currencies, it is essential to recognize the pattern of the currencies on the base of these features, which should be practiced by an effective recognition system called classifier. A Neural network based recognition scheme is used here for currency recognition. A multi-layered perceptron is a kind of feed forward neural networks which is well known tool for pattern recognition.
5) **Result:** After the classification of note its value (HSV) is compared which gives the result that the currency is counterfeit or genuine.

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4. Color Spaces

Images delivered by contemporary digital cameras capture the human perception of primary colors in a combination of tri stimulus, namely, red (B), green (G) and blue (B) into electrical signals. Subsequent electronic processing of these color signals can take a number of different representation formats denoted as color spaces. Each format or space has its own advantages whether it is suitable for graphic display devices or transmission through radio television (TV) channels. In the context of processing, the choice of color space may have a paramount influence on the performance of procedures such as segmentation. The characteristics of several popular color spaces are briefly reviewed in the following. Here, it is assumed that a primary image is available from cameras in the RGB format and other spaces are obtained through appropriate transform operations. Imaging applications often require conversion between data classes and image types which is fulfilled by MATLAB. Image Processing Toolbox provides a variety of utilities for conversion between data classes, including single- and double precision floating-point and signed or unsigned 8,16, and 32- bit integers. The toolbox includes algorithms for conversion between image types, including binary, gray scale, indexed color, and true color. Specifically for color images, the toolbox supports a variety of color spaces such as YIQ, HSV, YUV, HSI and YCrCb high dynamic range images.

1) YIQ: This space is used to encode color information in American TV systems. The Y signal represents the illumination intensity while I and Q (in-phase and quadrature phase) jointly describe the hue and saturation. The YIQ space is obtained from RGB through a linear transform. Here the RGB signals are each bounded within [0, 1]. The YIQ partially reduces the correlation of RGB components.

2) YUV: The YUV color space is similar to the YIQ space except that it is used in European TV transmissions. The U and V components convey the color information. It is also able to reduce the inter-dependencies of the RGB components. This color space is obtained from simple and efficient transformation. The reduction in computation complexity may be useful in applications where real-time performance is critical.

3) HIS: The HSI color space is a commonly used color space in image processing. Color information is given by the hue (H).Saturation (S) reflects the color purity and the brightness is denoted by intensity (I). The hue signal is related to human color perception.

4) YCbCr: The YCbCr color space is used in digital video. Color information is given by three components: Luminanace(Y), Cb and Cr are used for color information storage for two color difference.

5) HSV: The HSV color space is similar to the HSI space where the value (V) component is given by an alternative transformation as the maximum of the RGB components.

5. Feature Extraction

Feature extraction of images is challenging work in digital image processing. The feature extraction of Indian currency notes involves the extraction of features of Indian currency. During the feature extraction process the dimensionality of data is reduced. This is almost always necessary, due to the technical limits in memory and computation time. Extracting too many features will not only increase the cost but also sometimes lower the system performance in terms of execution time. Therefore, we have to choose only the critical features that are easy to extract but difficult to imitate. After resizing process, the image is converted from RGB color space to HSV color space. Feature extraction of Indian Paper currency can be done by analyzing its:

1) Color Histogram
2) Hue
3) Saturation
4) Intensity/Value

HSV color space is widely used in computer graphics, visualization in scientific computing and other fields. In this space, hue is used to distinguish colors, saturation is the percentage of white light added to a pure color and value refers to the perceived light intensity. The advantage of HSV color space is that it is closer to human conceptual understanding of colors and has the ability to separate chromatic and achromatic components. HSV stands for *hue*, *saturation*, and *value*. In each cylinder, the angle around the central vertical axis corresponds to "hue", the distance from the axis corresponds to "saturation", and the distance along the axis corresponds to "lightness", "value" or "brightness". HSV is simple transformations of device-dependent RGB models, hence the physical colors they define depend on the colors of the red, green, and blue primaries of the device or of the particular RGB space, and on the gamma correction used to represent the amounts of those primaries. Each unique RGB device therefore has unique HSV space to accompany it, and numerical HSV values describe a different color for each basis RGB space.

HSV is an intuitive color space, and a user-oriented color system. H (hue) shows among the perceived colors, such as red, orange, yellow, green, cyan, blue and magenta .V (value) describes the brightness of a color and S (saturation) represents how much the number of white lights mixed with a hue. As the value of V component was increased, the corresponding color would become increasingly brighter. To reduce the dimensionality of color features and the effect of luminance, the V component can be removed.
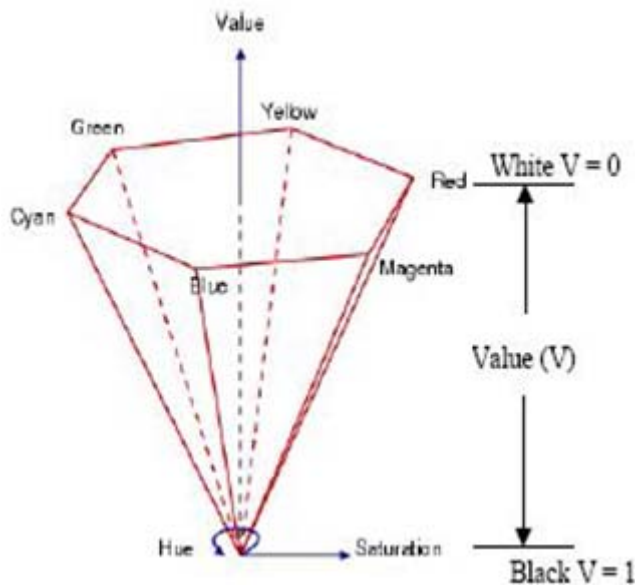
Figure 2: HSV Color Cylinder

The transformation to HSV can be achieved by the following equations:

Conversion of colors from RGB to HSI Conversion

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360 - \theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2 + (R-B)(G-B)]^{1/2}} \right\}$$

Conversion of colors from HSI to RGB-
For RG sector :

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

$$0° \le H < 120°$$

$$B = I(1-S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$G = 3I - (R+B)$$

For GB sector:

$$120° \le H < 240°$$

$$H = H - 120°$$

$$R = I(1-S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$B = 3I - (R+G)$$

For BR sector:

$$240° \le H < 360°$$

$$H = H - 240°$$

$$G = I(1-S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$R = 3I - (G+B)$$

In feature extraction, by using the above calculations, we can convert the RGB color format into HSV and vice verca. The primary image is in RGB format, then after resizing it is converted to HSV colour space. Advantage of HSV colour space is that it is closer to human conceptual understanding of colours and has ability to separate chromatic and achromatic components. Feature extraction of a colour image can be done by analyzing its colour histogram, hue, saturation, intensity (or value) In HSV (Hue, Saturation, Value) space hue distinguishes colour, Saturation is the percentage of white light added to a pure colour and value represents perceived light intensity.

6. Evaluation Algorithm

The algorithm is one of the techniques for which the objective is to find minimum squared error. This algorithm uses an iterative algorithm that minimizes squared error. This procedure consists of following steps as follows.

1) Read neural network
2) Find Histogram of input image and compare it with histogram of saved images.
3) If the difference in threshold is greater than a specified value then the image is genuine else it is counterfeit.
4) Find the hue and saturation for input image and evaluate the neural network for these values.
5) If the hue and saturation thresholds from the neural network are less than the current image threshold then the current image is genuine else he image is counterfeit.
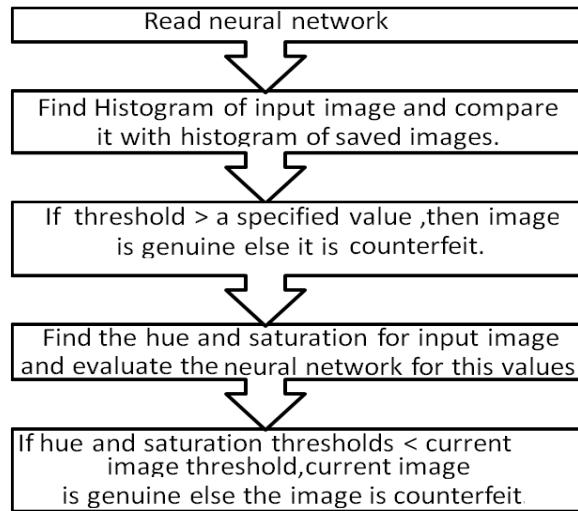
Figure 3. Evaluation Algorithm

This algorithm is very simple method and is very easy to implement. Success rate of this algorithm depends on the testing parameter as well as its training parameter. This paper proposes method to determine mean squared error.

7. Experimental Results

MATLAB image processing tools were used to implement system. In figure, graph shows minimization of error at the time of training, testing as well as validation. The mean squared error is approximately 106 mse.
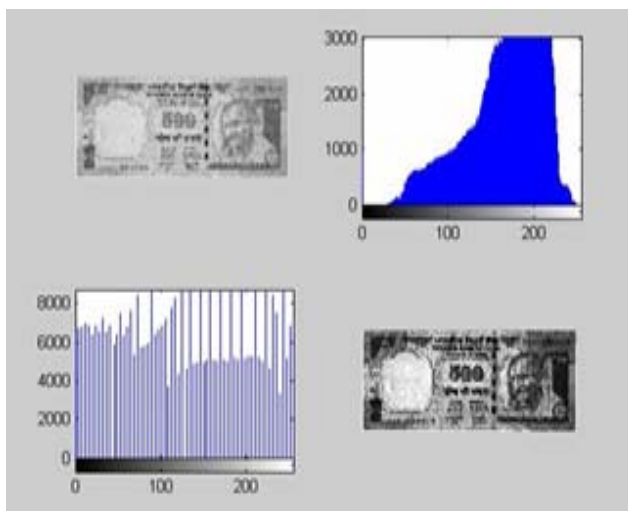
Figure 4: Color Histogram of An Image
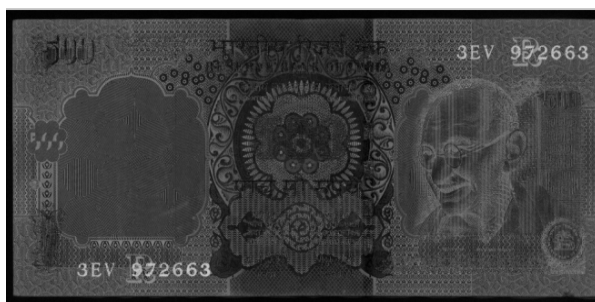
Figure 5: Saturation

Figure 6: Intensity

Figure 7: Hue
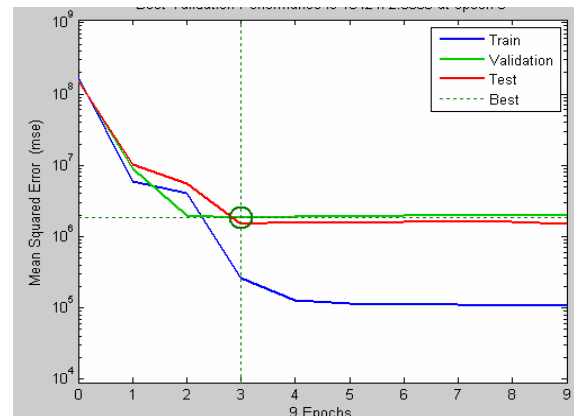
Figure 8: Performance of Currency Recognizer

8. Conclusion

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 technology of currency recognition aims to search and extract the visible and hidden marks on paper currency for efficient classification. We have proposed currency recognition system for verifying Indian paper currency. The system has a good performance for both accepting valid banknotes and rejecting invalid data.

In this paper, we have applied Fitting tool of Neural Network for the purpose of paper currency verification and recognition. After extracting crucial features from Indian banknotes by using Image processing, we have experimented on our Neural Network classifier and achieved very good performance. Furthermore, the proposed classifier has very good generalization ability and needs low computing power. Hence it is very suitable for implementing an automatic verifier for paper currency.

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