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Indian Currency Recognition and Authentication using Image Processing and Machine Learning

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ABSTRACT: The features of the paper notes differ for various countries. Currency identification is one of the important applications of pattern recognition. We have proposed a system for the automation of banknote identification as well as authentication of new Indian banknotes printed after demonetization. Only paper currency will be considered. In this method, certain predefined areas of interest are identified, and then denomination in the form of numerical value is extracted using color and text on the note. Initially, it receives the frontside and backside image of banknotes as input and then cropped into specific predefined areas of interest. Then each picture is separated into three sections. Filtering is applied to each section. RGB image is obtained by combining Red, Green, and Blue channels and further HSV are taken from the RGB image. The proposed model is based on a feature extraction and cosine similarity classifier for recognizing test banknote. The recognition system indicates that the proposed approach is one of the most effective strategies for identifying currency patterns to read its face value and determine its authenticity for Indian currency notes.

Our system is able to accurately identify test currency.

KEYWORDS: Indian Currency Recognition, Feature Extraction, HSV, Cosine Similarity Classifier.

I. INTRODUCTION

The identification of banknotes depends on the attributes of banknotes of a country. As the banknotes have been used for a long period of time, they may be contaminated. There are many characteristics to recognize an authentic banknote. Although it may not be practically possible to accurately identify a counterfeit in a paper currency which only an intelligent machine can identify.

Modern automation systems in the real world require a system for currency recognition. It has various potential applications such as currency counting machines, money exchange machines, assisting blind persons, electronic banking, currency monitoring systems etc. The identification of currency is a very important feature for the visually impaired. They cannot differentiate between currencies correctly, so they can get cheated very easily. Therefore, there is an urgent need to design a system to recognize the value of currencies.

II. LITERATURE SURVEY

Vedasamhitha et al. Proposed framework for computerized banknote recognition using image processing. The proposed technique can be utilized for identifying the nation as well as the value of the given banknote. This strategy works by first distinguishing the origin nation of the banknote utilizing certain predefined parts, and then extracting the value using factors such as size, color, or text on the note [1].

The recognition of banknotes relies on the factors of banknotes of a particular nation. As the banknotes have been in use for a long period of time, they may be contaminated with noises. It is hard for a framework to identify old, torn, and noisy pictures of currency. Jesmin A. et al. proposed a system for in which each picture was separated into three sections and filtering was applied to each section. Finally, the red, the green, and the blue sections are recombined to get the RGB [2].

The requirement for a currency recognition framework is increasingly relevant because of the level of technology and machinery used to fake the currency. There are numerous characteristics to recognize a real banknote. Despite the fact that it may not be possible for a person to distinguish an authentic banknote to a fake. Many features



are included for solid protection against fake banknotes by Dincy M. et. al. for the paper currency which only an intelligent machine can identify [3].

In fourth reference paper by Ahmed Y et.al. , a mobile based banknote identification system for visually impaired using ORB is proposed. This method applied some image processing operations to remove the noise. Then, ROI is extracted by using the connected component Algorithm. The ORB is applied to obtain the binary descriptors that are stored in the database. Finally, matching the results with the descriptors in the database using hamming distance techniques [4] [5].

III.PROPOSED DESIGN

3.1CURRENCY RECOGNITION SYSTEM

Identifying distinguishable regions:

After the pre-processing steps have been completed, we can recognize which parts of the banknote are relatively distinguishable. This is done based on certain predefined regions. All the bank notes have certain regions with fixed coordinates which we crop out for classification of notes. We have chosen 5 features from each currency note that are highlighted below in the images. Grouping is done by finding out the values for pictorial features like hue and saturation for each feature and then those values are compared with the original images of notes. The values selected to differentiate the currency have been found after rigorous experimentation.



Fig. 3.1.a: Frontside of Rs 2000 banknote



Fig. 3.1.b: Backside of Rs 2000 banknote

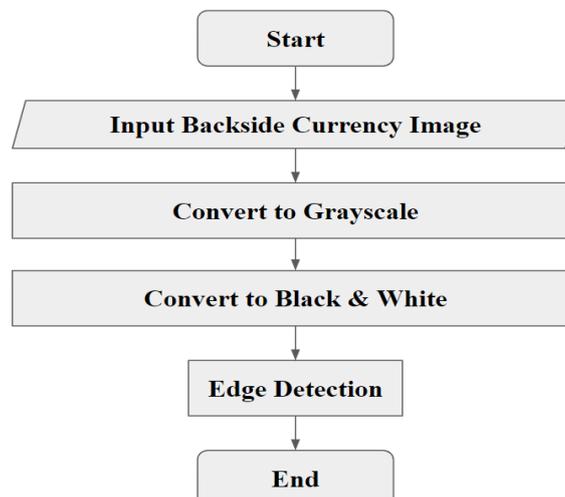


Fig. 3.1.c: Value Detection Flowchart

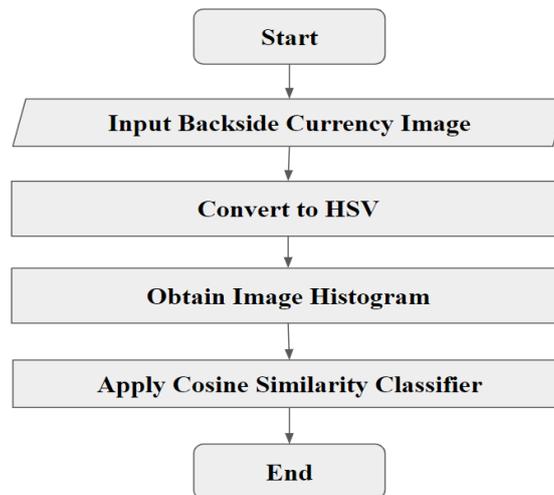


Fig. 3.1.d: Currency Authentication Flowchart

3.2 METHODOLOGY

1) RGB Splitting:

RGB Color Model: - Basic Color Model

The basic color model consists of rgb and alpha. Which makes it a rgba model.

Red-R, Green-G, Blue-B, Alpha-A(Transparency of image).

The pixel is 32 bit.

R-G-B 8bits each and Alpha-8 bits.

2) Color Blur:

Image blurring is applied to remove noise from the image.

It makes the images smooth for processing.

Image Blurring is of two types one is grayscale blurring and other is color blurring.

We use windowing technique to blur an image.

Window can be of 3*3, 5*5 etc.

3) RGB TO HSV Conversion:

HSV Color Model: More Stable Color Model and very good for detecting natural colors.

hu -Hue (Denotes the original color)

st-Saturation--(Concentration of color and mixture of white color)

val-Value/Luminous --Brightness

- Divide r, g, b by 255
- Calculate max_val, min_val, difference
- Hue calculation :
 - if max_val and min_val equal 0, then hu = 0
 - if max_val equal r, then compute $hu = (60*((g - b)/difference)+360)\% 360$
 - if max_val equal g then compute $hu = (60*((b - r)/difference)+120)\% 360$
 - if max_val equal b then compute $hu = (60*((r - g)/difference)+240)\% 360$
- Saturation computation :
 - if max_val = 0, then s = 0
 - if max_val does not equal 0 then compute $st = (diff/max_val)*100$
- Value computation :
 - val = max_val*100

3.3 IMPLEMENTATION

3.3.A: Currency Value Detection

The picture of the currency should initially be pre-processed to expel any unnecessary noise. This is done by applying ade-noising filter and some fundamental pre-processing steps. The picture is then changed to a binary image using

adaptive thresholding. Even if there are some background patterns, those will be removed by de-noising followed by changing to a binary picture. The picture is also resized for simpler calculations.

1. *Image Resizing*

Resized image with the standard size (800x160) is used in this system. The figure below shows the resized image.



Fig. 3.3.a: Resized Images

2. *Cropping image*

When an image is obtained from a camera, the size of the image is too large. So as to reduce the figuring, the picture size should be decreased. The smaller the picture is, the quicker the extraction.



Fig. 3.3.b: Cropped Image

3. *Binarization*

In order to make the image texture feature for image binarization processing, the gray image is needed to convert the binary image. Figure below shows binarization of images.

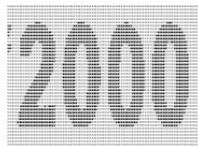


Fig. 3.3.c. Binarization

4. *Noise Removing*

The image acquired by the scanner, there are many kinds of noise. Noise removal is a crucial step in image processing. These noises are removed using a median filter. The figure below shows the image after removing noise.

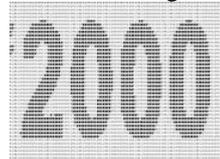


Fig. 3.3.d.Noise Removed Image

5. *Applying OCR*

Optical Character Recognition (OCR) is the electronic change of pictures into machine encoded text from an image in this case it is a currency note. We are using OCR to extract the value of a note to determine its value.

3.3.B: Currency Authentication

The steps for pre-processing of the image of the front side of the banknote is done and then the two important steps are carried out that are listed below.

3.3.B.a: Feature Extraction from image:

There are various features of an image like homogeneity, contrast, energy, correlation, entropy, angular secondary momentum, hue, saturation, etc. To reduce the computational complexity, only some of these features were selected. In this paper we are working on HSV color model that is we extracted hue and saturation values of cropped images to reduce the computation. HSV color models remap the RGB essential colors into dimensions that are easy to grasp. Hue specifies the angle of the color on the RGB color circle. A 0° hue results in red, 120° results in green, and 240° results in blue. Saturation regulates the color usage. A color with 0% saturation yields grayscale while a color with 100% saturation is the purest. The brightness of the color is controlled by its value. A color with 100% brightness has no black color in it while a color with 0% brightness is pure black color. HSV value is calculated for each pixel for further comparison with the original image.

3.3.B.b: Cosine Similarity Classifier:

Cosine Similarity is a proportion of comparability between two non-zero vectors of an internal item space. Scientifically, it gauges the cosine of the point between two vectors that are projected in a multi-dimensional space. Considering the three dimensions as Hue, Saturation and Value we can plot the vectors of trained image and test image and then normalize the value for all the pixels and then comparing this normalized value with threshold we can confirm whether the test currency is fake or not.

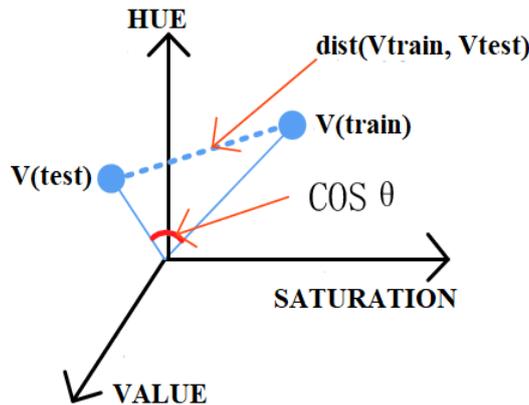


Fig. 3.3.B.a: Cosine Similarity Graph

$$similarity(A,B) = \frac{A \cdot B}{\|A\| \times \|B\|} = \frac{\sum_{i=1}^n A_i \times B_i}{\sqrt{\sum_{i=1}^n A_i^2} \times \sqrt{\sum_{i=1}^n B_i^2}}$$

where, A implies test Vector and B implies train Vector or vice versa. If, similarity(A,B) is 1 then it implies that both the images are totally similar and if it is 0 then it implies that both the images are not at all similar and comparing the value of similarity(A,B) with the threshold will confirm whether the currency is fake or not.

IV. RESULTS

The android application was tested with the help of nearly 80 Indian currency notes. In comparison to the number of notes that were tested, the success is around 87%, the number of notes that the android application recognized and authenticated was 69. The parameters that were used to authenticate and recognize the notes are given below. The photos of the notes that were used to test were taken according to the guidelines which have been provided in the application itself.

Currency notes of various denominations present in the Indian Currency were used (present in the table).The parameters used to compare notes are Color based Authentication, Note Value and National Symbol (values present in table). The values that we have used have been obtained from verified currency notes checked by the authentication system in the bank. The notes are compared with the model examples using the cosine Distance measure equation. If the notes after being tested can't pass the set parameters then they are recognized as fake.



Denomination	No. of samples	Correctly Identified	Accuracy (%)
100	25	22	88
200	15	13	86
500	15	14	90
2000	25	21	84

Table 1:-System Accuracy

Parameter	Value
Threshold Color Based Authentication	1000000
Threshold Note Value Authentication	25000
Threshold National Symbol Authentication	20000

Table 2:- Parameters and Values

V.CONCLUSION

In this paper, the authentication and recognition of Indian bank notes is portrayed by applying machine learning and image processing techniques. Basically five features are extracted including numeral value from frontside and backside, national emblem, left and right bleed lines from the image of currency. The currency denomination is extracted from the backside image using Optical Character Recognition(OCR) and pictorial features like Hue, Saturation Value (HSV) are extracted for authentication of the currency, and then Cosine Similarity Classifier is applied for identification by considering a specific threshold value and determine its authenticity. This methodology works for Indian denominations 100, 500 and 2000. The method is easy and simple for implementation. As the actual computation is carried on the server, this application works well even on low end android smartphones. The decision making is done within a second. The system implemented is a low cost system. By increasing the number of testing samples we can increase the accuracy of the application and lower value denomination will also be added in the future.

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