

## Indian Currency Classification using speeded up robust features

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**Abstract** — In this research paper we have used Speeded up robust features (surf) method for features extraction. Currency database has been used for experiments. For currency database preparation color scanner is used. In our experiments, we also use two new currency of denomination 500rs and 2000rs which came recently in circulation. The pre-processing like rotate and crop is applied on an input image. For classification, neural network classifier is used. The overall accuracy of the system is 99.8 %.

**Keywords-** Reserve Bank of India, Surf feature, Neural network, Confusion matrix, Assessment parameters

### I. INTRODUCTION

In public circulation, currency is any form of money. Hard money and soft money are two types of money. “Hard money” is called coin and “soft money” is called paper money. Governing body designated currency refers to money in a legal manner. Currency can refer to any object that has a value and can be exchanged for other objects. [1]

An Indian rupee is the official currency of the Republic of India. The RBI (Reserve Bank of India) controls an issuance of the currency. In India currency is managed by the Reserve Bank. On the basis of the Reserve Bank of India Act-1934, RBI derives its role in the management of currency. Reserve bank of India issues nine types of currency which is ₹1, ₹2, ₹5, ₹10, ₹20, ₹50, ₹100, ₹500 and ₹1000. These all currencies are in circulation. But ₹1 and ₹2 notes were discontinued in 1995. Also on November 8, 2016 Prime Minister Narendra Modi declared the withdrawal of ₹500 and ₹1,000 currency. On the same day, the RBI announced the issuance of new ₹500 and ₹2,000 currency. Currently, the RBI issues currency in values from ₹5 to ₹2,000. [2]

The new ₹2,000 currency has a portrait of Mahatma Gandhi, Ashoka Pillar Emblem on the front. It has magenta base color and portrait of Mars Orbiter Mission (MOM) on the back. The new ₹500 currency has an image of the Red Fort along with the Indian flag printed on the back and a stone gray base color. On the back of both the currency, Swachh Bharat Abhiyan logo is printed. [2]

As the part of the technological progression introduced to the banking sectors, financial institution and banking had started financial self-services. By using ATM counter and Coin - dispenser automated banking system is achieved where machines are used to handled currencies. In such situations, the machine will use the currency recognizer for the classification of the bank notes. [3]

### II. LITERATURE REVIEW

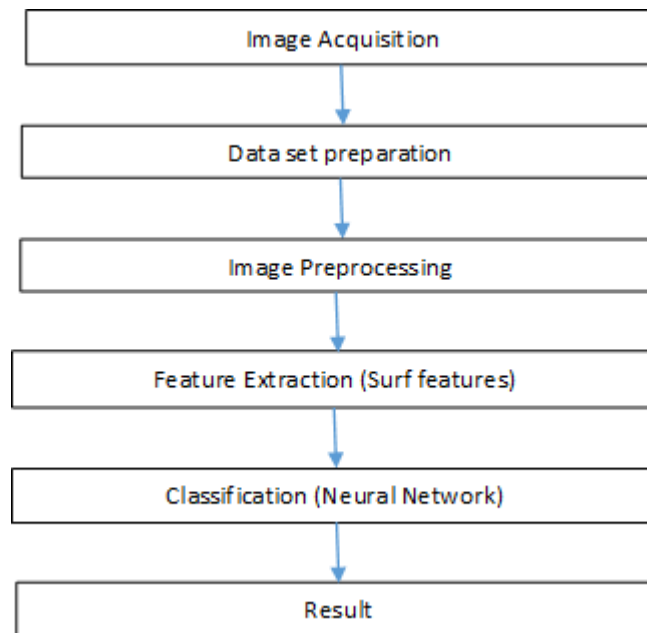
Vishnu R, Bini Omman [3] proposed a method where the system compares the features which are extracted from the given input note by computing the similarity measure between the features of the input note and the template image of the particular feature. Jaccard Similarity Indices is used for calculating similarity measured. Dr. Ajit Danti, Karthik Nayak [4] extract the shape feature, year and governor declaration from the note. For that, they use a grid-based method and divides the note into a number of blocks. Out of all blocks, they select only those block which contains shape feature, governor declaration and year respectively. From this block, they extract the features and then apply neural network for classification. Vishnu R, Bini Omman [5] used PCA (Principal Component Analysis) method and for data Validation WEKA Classifier is used. In this method to generate training model, extracted features in training set are loaded. Based on this training model classifier, decide the class of test feature. Model classification and generation are performed using WEKA. They have used Random Forest, Support Vector and Naive Bayes classification algorithms. Kedar Sawant, Chaitali More [6] proposed method where they extract four features from currency which are color information, aspect ratio, identification mark and latent image. For color feature extraction they used HSV color model, for Identification mark Fourier Descriptor is used, an aspect ratio is calculated by dividing the height of note with the length of the note. Finally, for classification Euclidean distance method is used. And then allocate the test sample to that class with the shortest Euclidean distance. Viranchi Patel, Udesang Jaliya, keyur Brahmabhatt [7] proposed a method in which they used a center feature of currency as a Region of interest (ROI). For segmentation, they used canny edge detector and for

classification they used NN pattern recognition tool, which gives 95.6% accuracy. Vishnu R, Bini Omman [8] proposed a method in which firstly histogram equalization is used to normalize the images. Then they extract five features (Shape, Center, RBI seal, Micro Letter, Latent image) from images of currency by using appropriate Region of Interest (ROI) mask. Once the features are extracted PCA (principal component analysis) is applied to each of these features. Finally, the distance between the weight vectors of the test image with a weight vector of each training images is calculated using Mahalanobis distance method. Then the class of test image is the class of training image for which the similarity is found to be high.

### III. PROPOSED METHODOLOGY

#### A. PROPOSED DIAGRAM

The overview of the Indian currency classification system is shown in figure 1,



*Figure 1. Proposed diagram*

#### B. IMAGE ACQUISITION

Images are acquired using a color scanner. When scanning set appropriate resolution. Following figure 2 shows sample scan image of 20rs.



*Figure 2. Sample scan image*

### C. DATA SET PREPARATION

We scan 90 images of each denomination say 5rs, 10rs, 20rs, 50rs, 100rs, 500rs, and 2000rs. So total we have 540 images in the dataset.

### D. IMAGE PREPROCESSING

#### ROTATE AND CROP

Images are scanned in A4 size boundary but we are interested only in the currency part, so first rotate images to 90 degree and then crop the images by setting the dimensions.

### E. FEATURE EXTRACTION USING SURF (SPEEDED UP ROBUST FEATURES)

It is a local feature detector and descriptor. It is useful in recognition of the object, image classification, image registration, or in a reconstruction of 3D images. Interest point detection, local neighborhood description and matching are three main parts of this algorithm. Our interest is to detect interest point. [9]

#### INTEREST POINT DETECTION

It detects feature points by using determinant of the Hessian matrix. But before that first we need to convert the input image into an integral image which referred as summed area table.

#### INTEGRAL IMAGE

An Integral image is an algorithm and a data structure for efficiently and quickly generating the sum of values (pixel values) in a rectangular subset of a grid. [10]

At any point  $(x, y)$ , the value in the summed area table is just the sum of all the pixels above and to the left of  $(x, y)$ , including value of  $(x, y)$ . [10] Summed Area Table at  $(x, y)$  is simply calculated by [11]:

$$S(x, y) = i(x, y) + s(x-1, y) + s(x, y-1) - s(x-1, y-1) \quad (1)$$

Once the integral image has been computed, it takes three additions to calculate the sum of the intensities over any upright, rectangular area.

#### HESSIAN MATRIX

Given a point  $x = (x, y)$  in an image  $I$ , the Hessian matrix  $H(x, \sigma)$  in  $x$  at scale is defined as follows [12],

$$H(x, \sigma) = \begin{bmatrix} L_{xx}(x, \sigma) & L_{xy}(x, \sigma) \\ L_{xy}(x, \sigma) & L_{yy}(x, \sigma) \end{bmatrix} \quad (2)$$

Where,  $L_{xx}(x, \sigma)$  is the convolution of the Gaussian second order derivative.

### F. CLASSIFICATION

For classification neural network is used. For that firstly, input feature vector is created which is extracted using surf method. Input feature vector consists 128 size surf feature per image. For classification this input vector is given to neural network. There are three layers in neural network namely input layer, hidden layer and output layer. Input layer is nothing but the feature vector. Hidden layer consists a number of hidden neurons and output layer is a class label.

## IV. EXPERIMENTAL RESULTS

The proposed system is tested for seven currency class (5rs, 10rs, 20rs, 50rs, 100rs, 500rs and 2000rs) and 90 images from each class hence total 630 images is used for classification. Figure shows confusion matrix.

In confusion matrix,

Green square shows -correct responses

Red square shows -incorrect responses

Blue square shows -overall accuracies

Gray square shows- Per class accuracy

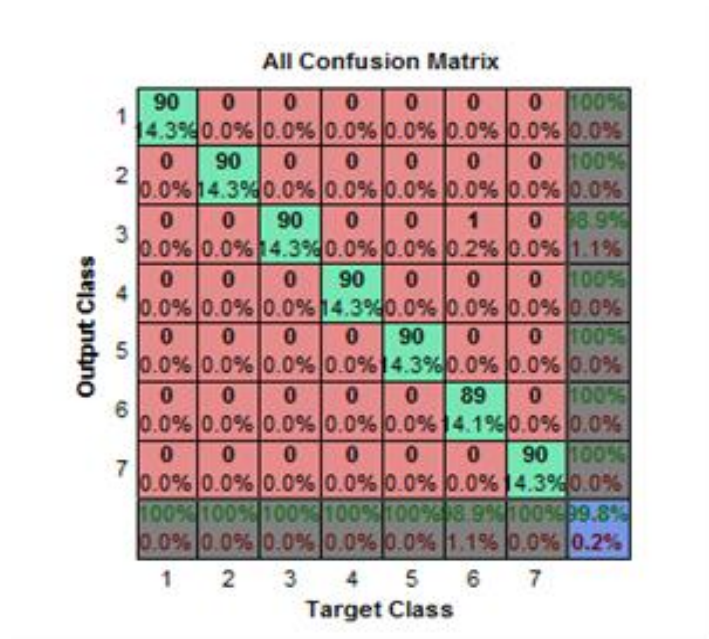


Figure 3. Confusion Matrix

#### A. NEURAL NETWORK ASSESSMENT PARAMETERS

##### TRUE POSITIVE CLASSIFICATION RATE PER CLASS

To find out true positive classification rate per class divide correctly classified image per class by total images per class.

$$\text{True positive classification rate per class} = \frac{\text{correctly classified image per class}}{\text{total images per class}} \quad (3)$$

Example

For Class 6(500 rs)

$$\text{True positive classification rate} = \frac{89}{90} = 0.9888$$

##### FALSE POSITIVE CLASSIFICATION RATE PER CLASS

To find out false positive classification rate per class divide number of image per class which is incorrectly positive by a total number of negative images per class.

$$\text{False positive classification rate per class} = \frac{\text{incorrectly positive per class}}{\text{total negative images per class}} \quad (4)$$

Example

For Class 3(20 rs)

$$\text{False positive classification rate} = \frac{1}{540} = 0.00185$$

**Table 1.Result**

| Currency     | Total images | Correctly classified | Incorrectly classified | TP classification Rate (%) | FP classification Rate (%) |
|--------------|--------------|----------------------|------------------------|----------------------------|----------------------------|
| 5            | 90           | 90                   | 0                      | 100                        | 0                          |
| 10           | 90           | 90                   | 0                      | 100                        | 0                          |
| 20           | 90           | 90                   | 0                      | 100                        | 0.185                      |
| 50           | 90           | 90                   | 0                      | 100                        | 0                          |
| 100          | 90           | 90                   | 0                      | 100                        | 0                          |
| 500          | 90           | 89                   | 1                      | 98.88                      | 0                          |
| 2000         | 90           | 90                   | 0                      | 100                        | 0                          |
| <b>Total</b> | <b>630</b>   | <b>629</b>           | <b>1</b>               | <b>99.84</b>               | <b>0.158</b>               |

## PRECISION

Precision is a measure of exactness means what percentage of tuples labeled as positive are actually positive. [13]

$$\text{Precision} = \frac{A}{A + B} \quad (5)$$

Where A=True positive tuples  
 B=False positive tuples

Example

For class 1(5rs)

$$\text{Precision} = \frac{90}{90 + 0} = 1$$

## RECALL

Recall is a measure of completeness means what percentage of positive tuples are labeled as positive. Recall is also known as sensitivity. [13]

$$\text{Recall} = \frac{A}{A + C} \quad (6)$$

Where A=True positive tuples  
 C=False negative tuples

Example

For class 2(10rs)

$$\text{Recall} = \frac{90}{90 + 0} = 1$$

## SPECIFICITY

It is a true negative rate measure negative tuples that are correctly labeled as a negative

$$\text{Specificity} = \frac{D}{D + B} \quad (7)$$

Where D=True negative tuples  
 B=False positive tuples

Example

For class 3(20rs)

$$\text{Specificity} = \frac{539}{539 + 1} = \frac{539}{540} = 0.9981$$

## F SCORE

It is an alternative way to use precision and recall to combine them into a single measure. It is also known as F measure and  $F_1$  score. [13]

$$F \text{ score} = \frac{2 * P * R}{P + R} \quad (8)$$

Where P=Precision  
 R=Recall

Example  
 For class 6(500 rs)

$$F \text{ score} = \frac{2 * 1 * 0.9888}{1 + 0.9888} = \frac{1.9776}{1.9888} = 0.9943$$

**Table 2. Assessment parameters**

| Currency class | Precision (%) | Recall/Sensitivity (%) | Specificity (%) | F score (%) |
|----------------|---------------|------------------------|-----------------|-------------|
| 1(5 rs)        | 100           | 100                    | 100             | 100         |
| 2(10 rs)       | 100           | 100                    | 100             | 100         |
| 3(20 rs)       | 98.90         | 100                    | 99.81           | 99.44       |
| 4(50 rs)       | 100           | 100                    | 100             | 100         |
| 5(100 rs)      | 100           | 100                    | 100             | 100         |
| 6(500 rs)      | 100           | 98.88                  | 100             | 99.43       |
| 7(2000rs)      | 100           | 100                    | 100             | 100         |

## V. CONCLUSION

The Indian currency classification system based on digital image processing takes the input image which is currency image taken from the dataset. In dataset total 630 images of seven currency class including two new currency (500rs and 2000rs). System use SURF method for feature extraction. For currency classification, neural network classifier is used. The accuracy of this currency classification system is 99.8 %.

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