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Indian Currency Recognition Based on ORB

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ABSTRACT: Financial exchange is an important part of day to day activities. But for the visually disabled/blind people it becomes somewhat difficult to identify denomination correctly. Hence it is necessary to develop a reliable currency recognition system that could be utilized as one of the part wherever money related transactions or an exchange is concerned. The system could be helpful for visually impaired person or person with some visual disabilities or may the person with eye defects. This paper will present a reliable technique of Indian currency recognition based on ORB. The accuracy of the system is 97.14%.

KEYWORDS: Currency recognition system, ORB (Oriented fast & Rotated Brief), visually impaired.

I. INTRODUCTION

Automatic machines have become an important part of our life. In the similar manner an automatic currency identifier is also the need of all financial institutions. It is important in every field where money related transactions are involved. Such systems could be of great help to visually impaired people. To identify any currency denomination is a difficult task for visually disabled person. Again it becomes more and more difficult when the notes get damaged during transportation or due to wear and tear.

Considering any paper currency note it shows many features which are encoded in it. That's why it becomes challenging for vision impaired person to identify the correct denomination of the note. Pattern recognition systems developed some techniques which are very helpful in the image matching. These technologies may helps to develop automatic recognition systems that allow the image matching in real time, thus such systems are found to be reliable to implement in the day to day life.

Paper is organized as: Section II gives a brief overview of state of art methods under literature survey. Methodology of the proposed system is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusions.

II. LITERATURE SURVEY

The existing currency recognition approaches in literature are based on different image processing techniques. Some of the techniques use the extrinsic properties of the currency or bill such as colour, size, etc whereas some of the techniques use intrinsic properties such as security features, watermark, etc. Some of the systems include hardware part to recognize the note.

Barani.S [1] presented currency identifier for visually disabled people. It is based on Indian denominations. A device is developed using IR sensors. Variations in the voltage can be sensed with the help of sensors. The processor converts the voltages from sensors into digital data. This digital data is compared with stored data of known bills. According to the match count the result gets generated. The operating voltage is about 5V DC. The accuracy of the system is 86%.

Mohammad M. Rahman *et.al.* [2] presented a method based on Oriented FAST and Rotated BRIEF (ORB). ORB is much faster than both SIFT (scale invariant feature transform) and SURF (speeded up robust Feature). In this method camera receives input image of the corresponding banknote. The bank notes are pre-processed to have all the notes of same size. The feature descriptors those are calculated and stored for further descriptor matching after that feature descriptors of query image are matched with feature descriptors of original image and with the help of these features denomination can be classified.

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Yanyan Qin, [4] *et.al.* Proposed an algorithm motivated by SIFT (Scale-Invariant Feature Transform). Initially, the scale spaces were built for the detection of stable extreme points, and then the detected stable extreme points were considered to be feature points which has scale invariance. Secondly, ORB descriptor was used to describe the feature points. This finally generated the binary descriptors with scale and rotation invariance. Hamming distance was used for point matching. Matching performance of the proposed algorithm was computed taking scale invariance into consideration. With the scale changes, feature points matching accuracy is found to be about 92.53%, with good computational speed than SIFT.

E. Rublee [8] *et.al.* proposed a very fast binary descriptor based on BRIEF, called ORB, which is rotation invariant and resistant to noise. It is demonstrated through experiments that ORB is faster than SIFT, while performing as well in many situations. The efficiency is tested on several real-world applications, including object detection and patch-tracking on a smart phone.

III. PROPOSED CURRENCY RECOGNITION SYSTEM

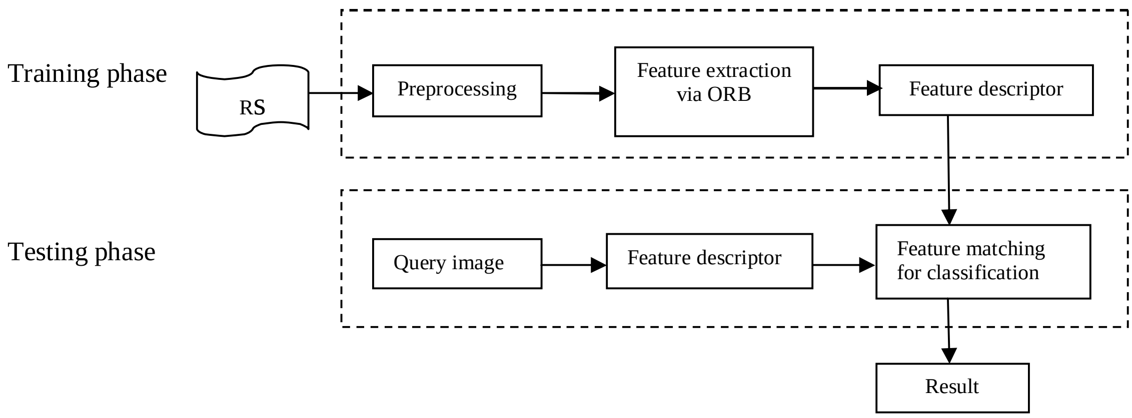

Fig. 1 Overview of currency recognition system

Fig.1 represents overview of currency recognition system. It has two phases for the recognition purpose which are as follows:

- **Training phase:**

This phase consists of the learning process in recognition. The training phase contains all pre-processing mechanism which extracts the information from the input image. It involves image resizing followed by image enhancement techniques gray scale conversion and histogram equalization. After that it goes for feature extraction via ORB where feature descriptors of that preprocessed image are calculated. This process is repeated for all samples of currency with different denominations.

Feature points detection initiates with fast corner selection. A candidate pixel is defined as fast corner when intensity of every point in a circular ring about candidate pixel is greater than or less than intensity of candidate pixel plus threshold.

After that a measure of corner orientation i.e. the intensity centroid is taken into consideration. For that purpose, the moments of a patch are calculated:

$$M_{p,q} = \sum_{(x,y)\in s} x^p y^q f(x,y)$$

Considering these moments, centroid can be found: $C = \left(\frac{M_{1,0}}{M_{0,0}}, \frac{M_{0,1}}{M_{0,0}} \right)$

A vector can be constructed from the corner's center O, to the centroid OC. The orientation of the patch is then given by:

$$\theta = arctan(M_{0,1} / M_{1,0})$$

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Once the orientation of the patch is calculated, it can be rotated to a canonical rotation and then descriptor can be computed, thus obtaining some rotation invariance. The rotation invariant descriptor of ORB is a bit string description of an image patch constructed from a set of binary intensity tests. Consider an image patch ***p*** of one feature point. A binary test τ is defined by:

$$\tau\,(p; x, y) = \begin{cases} 1, & p(x) < p\,(y) \\ 0, & p(x) \geq p(y) \end{cases}$$

where $p(x)$ is the intensity of ***p*** at a test point *x*. When *n* test point pairs are selected, the feature point descriptor with rotation invariance is defined as a vector of *n* binary tests:

$$fn(p) = \sum_{1 \leq i \leq n} 2^{i-1} \tau(p; x_i, y_i)$$

The above equation is used to describe the feature of *n* binary tests. Thus the descriptor generated with ORB is bit string.

- **Testing phase:**

This phase consists of updation of the process. The query image is taken and allowed for preprocessing and feature extraction. When feature extraction is completed for query image, the feature vectors obtained are compared with that of feature vectors of original image samples. Feature matching can be done by calculating hamming distance to find the best correspond.

IV. EXPERIMENTAL RESULTS

Overall there are seven types of Indian currency denominations (from front and back) considered. Denominations considered are Rs.5, 10, 20, 50, 100, 500, 1000. The proposed ORB (Oriented fast and Rotated Brief) algorithm is implemented with the help of MATLAB. As per the proposed currency recognition system preprocessing is the primary step to be followed. Preprocessing initiates with image acquisition. Experimental results are shown as follows:

Fig.1- Resized input image of Rs.20

Above Fig.1 shows the resized input image. Since there are seven denominations considered, all of these notes differ in size. For ex. Rs.5 has the small size (117X63mm) as compared Rs. 10, 20, 50, etc, in the similar way Rs.1000 has the large size than all these notes. Due to this, image resizing is done. Image taken for the experiment is RGB image. Feature extraction with RGB image is somewhat difficult; therefore after image resizing the input RGB image is converted into gray scale image. The gray scale image carries intensity information, composed of many shades of gray from black as the weakest intensity to the white as the largest intensity. Even though for further image enhancement histogram equalization can be done.

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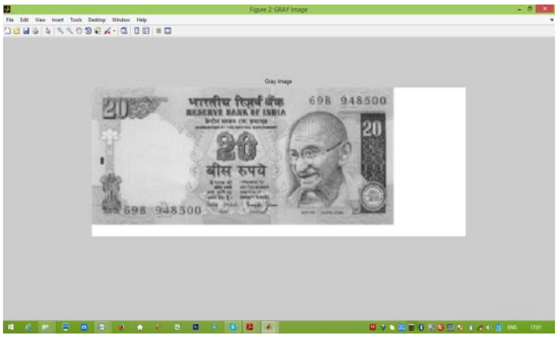

Fig.2- Gray scale conversion

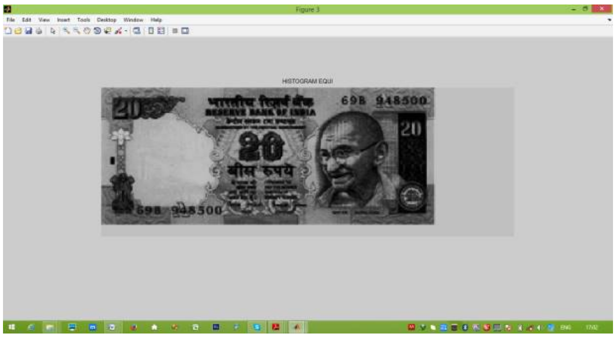

Fig.3- Histogram equalized image

Fig.3 shows histogram equalization. From Fig. 2 & Fig.3 it can be clearly seen that after histogram equalization the image becomes clearer than the gray scale image, as histogram equalization converts low contrast image into high contrast image. This image enhancement technique helps in the fast corner point location as:

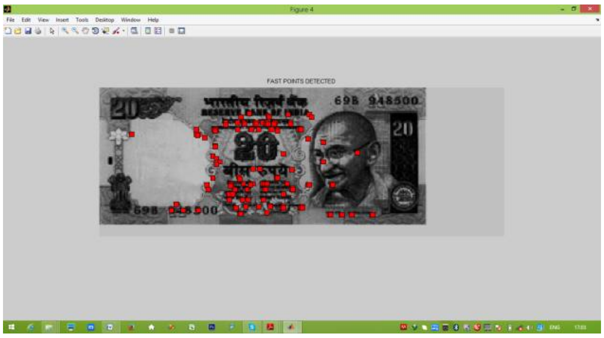

Fig.4- Fast points selection via FAST descriptor

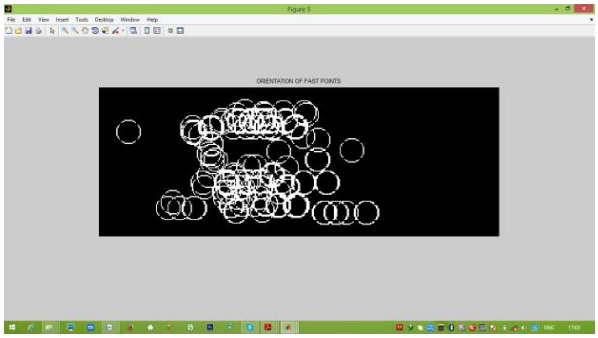

Fig.5- Orientations by intensity centroid

In fig.4 feature points are located in accordance with the fast corner selection. These fast points indicate the points of interest that helps in the image matching. In fig.5 orientations by intensity centroid are located about the fast corner points to determine the orientation of the fast points. The feature points generated are divided into small image patches and among those patches random points are selected and lines are drawn accordingly. If intensity of the start point is greater than intensity of the end point, then record ‘1’ , else record ‘0’. In this way a bit string is generated. The similar process can be repeated for query image and bit matching can be done with hamming distance. Fig.6 shows test points generated and corresponding lines generated from starting to end point.

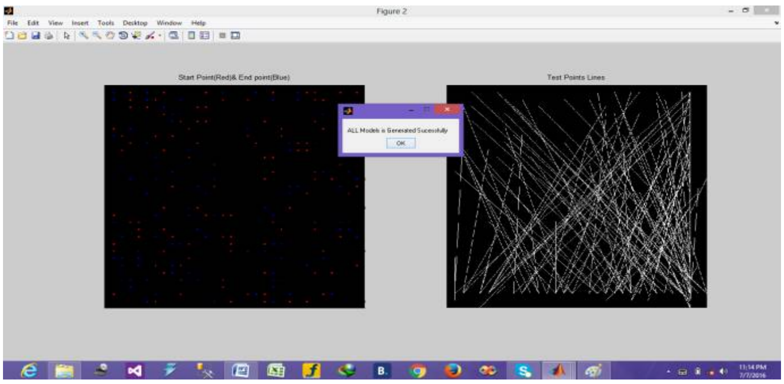

Fig.6-Selection of test points & lines via ORB

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Graphical user interface is used for the integration of whole algorithm. It involves implementation of whole system in terms of input, output, training and testing. Here the GUI is used to load an image and generate an output.

Fig.7-Graphical User Interface for Rs.20

Fig.7 represents graphical user interface consisting of input and output sections. The result displays denomination of the input image that helps to confirm about the note value, where as output section displays fast points location as well as orientations. The currency samples are tested for various conditions from which accuracy can be calculated.

Table 1- table showing correctly and incorrectly recognized samples for conditions as illumination changes, rotation and scale change.

Note value	***Number of test samples considered (For each note value)***	$\%Accuracy = \frac{No.of\ correctly\ recognized\ notes}{Total\ no.notes} x100$					
		Illumination changes		***Rotation***		***Scale change***	
		Correctly recognized	Incorrectly recognized	Correctly recognized	Incorrectly recognized	Correctly recognized	Incorrectly recognized
5 Back	15	15	00	15	00	15	00
5 Front	15	15	00	13	02	15	00
10 Back	15	15	00	15	00	15	00
10 Front	15	15	00	13	02	15	00
20 Back	15	14	01	14	01	15	00
20 Front	15	13	02	11	04	13	02
50 Back	15	15	00	14	01	15	00
50 Front	15	14	01	12	03	14	01
100 Back	15	14	01	14	01	13	02
100 Front	15	15	00	14	01	15	00
500 Back	15	14	01	14	01	14	01
500 Front	15	15	00	13	02	15	00
1000 Back	15	15	00	12	03	15	00
1000 Front	15	15	00	14	01	15	00
Total test samples	210	204	06	188	22	204	06
% Accuracy		97.14%		89.52%		97.14%	

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On the whole there are 15 samples considered for every denomination while testing. Note samples are considered from back side and front side. The above table represents correctly recognized as well as incorrectly recognized note samples with different conditions. These conditions include illumination changes, rotation and also change in scale. The accuracy can be calculated with the consideration of correctly recognized samples to the total number of samples.

V. CONCLUSIONS

Currency denomination recognition is much more difficult task for visually impaired people. Techniques till date are useful but are complex, some of them are costly and also time consuming. The technique of Indian currency recognition based on ORB is much faster so that it can be helpful to increase computational speed. Experimentally the currency samples are tested for various conditions as illumination change, rotation and scale changes. This technique is reliable and robust where money transactions are involved.

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