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Efficiency of Currency Recognition System using SURF Features

Saurabh Sengupta
Dept. of CSE, B.C.E.T, Durgapur, West Bengal, India.

Sayan Chakraborty
Dept of CSE, B.C.E.T, Durgapur, West Bengal, India.

Abstract— Paper currency plays a vital role in almost all domains requiring financial transactions. Paper currencies are of different for different nations and form the backbone of international trade and commerce and thus require proper and efficient management. Currency recognition has been always of great interest to researchers. The primary objective of this work is mainly focused on automatic detection different paper currencies on the basis of their respective nationalities to ensure proper management of economic resources. Furthermore studies about the detection process under unfavorable conditions have also been included. This robustness study constitutes the secondary objective.

Index Terms — currency recognition; SURF features, noise reduction.

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1. INTRODUCTION

In recent times there are around 180 different paper currencies in existence which are being continuously being used and exchanged at international level with the growth of international trade and commerce through foreign banks, currency exchange centers and so on. Paper currency still persists as a widely accepted form of transaction although there are a number of alternatives present in today's world. The wide acceptance of paper currency as a prime mode of financial transactions is due to the facts that it provides privacy, security, longevity, to name a few. Improper and inefficient use of currencies lead to wastage or loss of economic resources which may ultimately weaken trade relations at international level, so in order to deal with such a situation, proper and efficient management of different currencies is necessary.

Testing of all notes manually in transactions is a very time consuming process and there also is a strong chance of tearing while handling of the notes. Thus it becomes very important to introduce automatic methods of banknote recognition. When designing such a system, it is important that the person designing it must focus in extracting sufficient prominent characteristics from the images of the paper currencies in order to make the system more accurate and robust. The purpose behind currency recognition is to categorize the currency images in an efficient manner. In this paper, currencies are recognized from the images using a very effective and robust feature extraction technique called Speed Up Robust Features (SURF). The SURF technique is used to extract more effectively the local image features of the image. One important thing to note here about SURF is that the features which are extracted using this technique are both scale and rotation invariant, thus making the extraction process more robust and accurate.

In the past too, a number of studies were done in this field of currency recognition, but almost all of these studies were restricted to certain standard norms based on the environmental conditions. For example, in earlier proposed systems, the entire note must be visible without any part cut out from view and the note must be without any sort of wrinkles for the system to work efficiently and give near to accurate results.

Here, an effort has been made to develop an automated system which is capable of detecting three types of paper currencies (INR, USD, EUR) and categorize them according to their respective nationalities. Apart from appropriate detection of Indian paper currencies, US dollars and Euro, the system also returns an appropriate message for paper currencies it is not meant to detect or objects which are not paper currencies at all. Further more tests have been carried out taking paper currencies with varying orientations, contrast and noise levels to calculate the robustness and efficiency of the system.

2. RELATED WORKS

In [1], the authors have come up with a Euro banknote recognition system which uses two types of neural networks; a three-layered perception and a Radial Basis Function network. The system consists of two parts- classification (which uses

three-layered perception) and validation (which uses RBF network). In [2], the authors have come up with a proposed system for currency recognition which focuses on minimizing the false rejection of notes. The system works for Sri Lankan currency notes where a linear transformation function was applied to remove noise patterns from backgrounds without affecting the notes' characteristic images. After the transformation, edge detection technique is applied the number of edges which are detected in row order are presented to a three-layered back propagation neural network. In another study [3] a fairly different approach is observed in this regard. Here actually the recognition process is done for the Chinese currency banknotes. The approach used basically recognizes digits for the serial numbers on the banknotes. Recently, a study was carried out to apply recognition techniques for Bangladeshi paper currency [4]. In the proposed system, the authors used Negative Correlation Learning (NCL) for training the ensemble network. Votes were carried out among the individual networks of the neural network and based on these; the final decision of the network was taken. In another technique for paper currency recognition [5], three characteristics of paper currency which include size, color and texture were used for the recognition process. By using image histogram, an abundance of different colors in a paper currency were computed and compared with the paper currency under reference using an improved algorithm called block-LBP algorithm. In a new technique [6], currency recognition for Japanese and US currencies was performed with added emphasis on recognition ability and transaction speed. In this paper, comparison is done between two data sets- time series data and Fourier series spectra. Presently a number of techniques have been proposed for the recognition of paper currencies. Most of these methodologies use feed-forward neural network [7] [8]. In another such paper [9], the use of Ensemble Neural Network (ENN) is found to be used for the recognition process, which is a learning paradigm and here a finite number of neural networks are trained for the same task. Another similar paper [10] makes use of negative correlation learning, which is used to diversify the individual networks. Another paper in this field of currency recognition [11] focuses on feature extraction using Discrete Wavelet Transform (DWT) and using this, an approximate coefficient matrix of the image is derived. Extracted features are used to classify the currency note using Probabilistic Neural Network [12].

3. METHODOLOGY

In this so designed system the process of feature extraction is one of the most important aspects which play an important role during the recognition process. Feature vectors of each paper currency image [13, 14, 15] are detected and extracted using SURF (speed up robust features detector) detector. The matrix of feature vectors obtained from the images [16, 17, 18] to be detected are compared with the feature matrices of each and every image in the system dataset and the matrix for which the maximum rows are matched is taken into account and the nationality of that paper currency image [19, 20] is assigned to the image being detected . Further to ensure robustness of the system a threshold value as low as twenty is taken. If the maximum number of matched rows for an image is found to be less than the threshold value the image is regarded as a false image or in other words an image that is not meant to be recognized by the system.

A. SURF detector

SURF (speed up robust features) interest point detector and descriptor creates a copy of the image of same size with Pyramidal Gaussian or Laplacian Pyramid shape with a reduced bandwidth, thereby imparting a blurring effect more, specifically known as scale space which further ensures that the so detected points of interest are scale invariant. SURF decrypting are quite capable and efficient while recognizing objects such as faces, 3-dimensional objects and extracting points of interest from the images it acts upon.

4. PROPOSED METHOD

A series of consecutive steps Starting form image acquisition to detection and categorization have been followed to fulfill the entire detection procedure. A brief description about the steps followed is as follows:-.

detect the currency images
  for i=1:n no. of images
    pre-process acquired images
    detect edges of the images
      extract features using SURF detector from the images
      apply feature matching technique on the images with the previous pre-processed images
    generate the result
  end **for**

Figure 1 presents a graphical representation of the entire detection procedure.

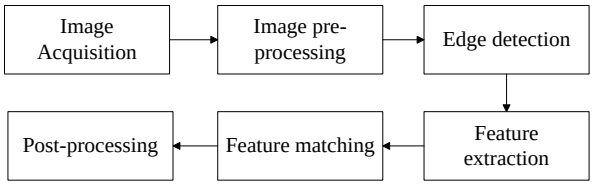

Figure 1 Block diagram of the proposed method

A detailed overview of the steps followed for successful completion of the entire procedure is as follows:-

Figure 2 Sample currency images

A. *Image acquisition*

Images to be detected are acquired in an automatic manner. Figure 2 shows few samples of the currency images that were processed using proposed framework.

B. *Image pre-processing*

Images acquired undergo pre-processing one by one. This involves two important procedures:-

i. Grayscale conversion: Images are converted to grayscale since it is easier to calculate a single luminance value rather than calculating all three luminance values of conventional RGB (red, green, blue) components of the images.

ii. Resizing Images: Images are converted to smaller fixed dimensions (300x134) to outweigh any sort of errors arising due to dimensional inequalities.

C. *Edge detection*

Edge Detection of the pre-processed images is carried out wherein edges are applied at points of sharply varying contrasts. Canny operator has been used for edge detection which apart from the conventional detection of edges, applies a low-pass filter and sobel filter reducing noise if included in the image thereby increasing robustness and saving us from using an additional filter at the same time.

D. *Feature extraction*

Feature extraction using SURF interest point descriptors is carried out for images and the feature matrix so obtained is compared with the feature matrices of each and every image in the system dataset which also undergoes similar steps of pre-processing and edge detection before being compared.

E. *Feature matching and result generation*

After comparing the feature matrices, the image in the system dataset for which maximum rows are matched is considered and further undergoes a procedure where the value of the rows matched is checked against a threshold value according to which determination of irrelevant images is carried out. If the image is found out to be relevant then the nationality of the image in the system dataset is assigned to the image undergoing the detection process.

5. RESULTS AND DISCUSSION

On an overall basis the system works quite fine for different paper currencies and returns appropriate results for images of good or normal quality. Furthermore efficient detection of irrelevant images makes it much less prone to errors which may arise due addition of images of irrelevant paper currencies or images which are not paper currencies at all.

In order to test robustness of the system or in order to find out maximum level of tolerance of the system towards decreasing image quality of paper currencies , tests have been carried out for images of decreasing contrast values , increasing noise levels and varying orientations (angle of rotation) and corresponding observations are recorded .

Decreasing contrast values results in a darker image. The efficiencies of the system for reducing contrast are shown in Table 1. Furthermore Figure 3 represents the changing robustness of the system in a much more vivid manner. It is observed that at the system is capable of about 76.08 % efficient detection up to reduced contrast levels of 55% for each and every image tested.

Table 1: Efficiency of the system upon contrast reduction

Contrast reduction (%)	Efficiency (%)
40	100
45	95.65
50	91.30
55	76.08
60	50

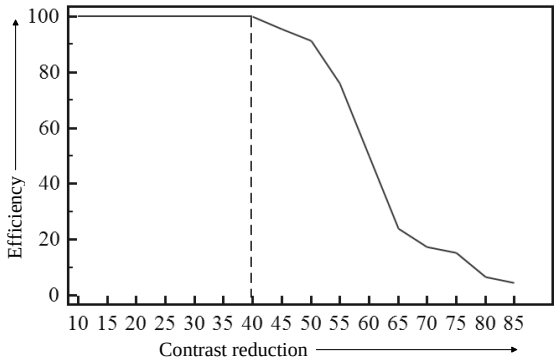

Figure 3. Change of efficiency upon contrast reduction

Introducing noise (“salt and pepper noise”) in an image decreases the quality of the image texture .Here tests have been carried out for images with increasing levels of noise and their corresponding efficiencies are recorded. Table 2 and Figure 4 represent tabular and graphical representations of robustness of the system towards images [21, 22, 23] with different levels of noise. It is observed that the system works

quite well up to noise level of 0.2 without using an additional noise filter [24].

Table 2: Efficiency of the system as a result of different noise levels

Noise level	Efficiency (%)
0.050	100
0.075	100
0.100	95.65
0.125	89.13
0.150	80.43
0.175	73.91
0.200	67.39

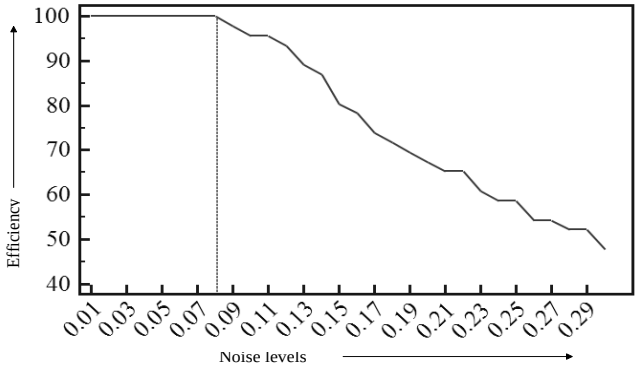

Figure 4. Change of efficiency upon noise level change

After carrying out tests for varying contrast and noise levels a final robustness test on changing orientation of images have been carried out where images to be detected were rotated in an anticlockwise fashion. Table 3 and Figure 5 represent tabular and graphical representations of the observations recorded. It is seen that the system gives quite a good efficiency of approximately 70% up to 9 degrees of rotation.

Table 3: Efficiency of the system upon rotation

Degree of anti-clockwise rotation (in degrees)	Efficiency (%)
2	100
4	100
6	95.65
8	76.08
10	63.04
12	23.91
14	10.86

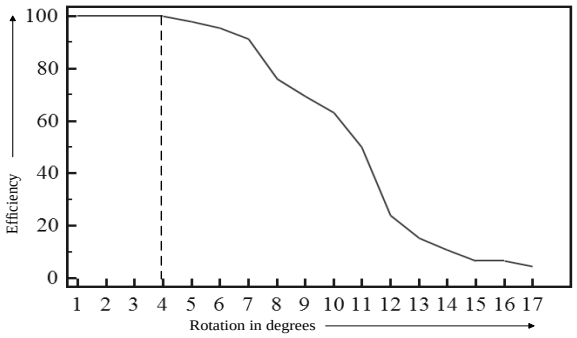

Figure 5. Change of efficiency upon degree of rotation

After carrying out robustness tests for the system under all the above unfavourable conditions and observing the respective tables and graphs so obtained, it can be concluded that the system is quite tolerant towards increasingly unfavourable conditions up to a considerable extent and is capable for imparting approximately 70% efficient performance for reducing contrast values up to 55%, increasing noise level up to the limit of 0.2 and changing degrees of rotation(anticlockwise) up to 9% , thus the system can be regarded as quite satisfactory as far as robustness is concerned.

6. CONCLUSIONS

The main motivation with coming up with the idea of this paper and its further development into the proposed system was to come up with a framework for fast, easy and accurate recognition of paper currency notes of different nationalities and in addition to that, making a detailed study of the different conditions up to which the system gives near to accurate results. After going through the entire review of the system so developed it can be concluded that the system being automatic reduces errors which may arise due to unskilled manual labor and performs efficient detection under normal conditions for images of good quality. Furthermore it is also observed that the system is capable of quite efficient detections for images of changing orientations and degraded qualities with noise and reduced contrast level up to a considerable limit making it much more robust under unfavorable conditions.

Since the system is capable of determining the nationalities of different currencies in an efficient and robust manner it can be used in automatic currency exchange centers and foreign banks handling international customers. The pros of SURF which include scale-invariant and rotation-invariant feature extraction strategies from images are effective in their own way to handle the rotation of images, changes in scale of the image and any sort of change in the illumination. Apart from this the system can be integrated with fake currency detectors to develop a robust genuine paper currency detector which may be of great importance to national security of respective nations. Thus based on the performance of the system, it can be said that the system has good recognition ability and it

needs very less computing power. Therefore it becomes very suitable for implementing such a system from its virtual state into the real world in the near future.

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