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A Study on Diverse Recognition Techniques for Indian Currency Note

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Abstract

By expansion of modern banking services, automatic schemes for paper currency recognition are significant in many applications..Automated paper currency recognition system can be a very good utility in banking systems and other field of commerce. Since many years counterfeiting of paper currency challenges the financial system of every country in different sectors, India is also one of them. In this article, various methods for the recognition of paper currency is described. An efficient currency recognition system is vital for the automation in many sectors such as vending machine, rail way ticket counter, banking system, shopping mall, currency exchange service etc. A successful approach for currency recognition depends upon feature extraction of that currency image. In this survey, we empirically demonstrate the different techniques of Indian currency notes to recognition of currency notes.

Keywords: Image Processing, Binarisation, Heuristic Analysis, Morphology Filtering, Feature Extraction.

Introduction

Modernization of the financial system is a milestone in protecting the economic prosperity, and maintaining social harmony. There are approximately more than 150 currencies all over the world, each of them looking totally different. Automatic machines capable of recognizing banknotes are massively used in automatic dispensers of a number of different products, ranging from cigarettes to bus tickets, as well as in many automatic banking operations. By expansion of modern banking services, automatic schemes for paper currency recognition are significant in many applications. The requirements for an automatic banknote recognition system have offered many researchers to build up robust and dependable techniques. Speed and precision of processing are two vital factors in such systems. The technology of currency recognition aims to search and extract the visible and hidden marks on paper currency for efficient classification. The following figure shows the various features of paper Indian currency.
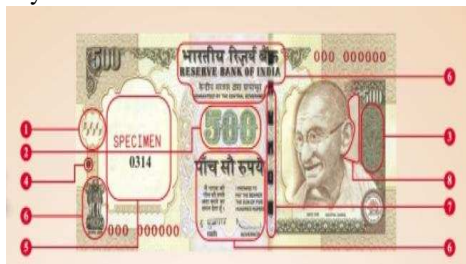
Figure1. Features of Indian currency note

The existing paper currency recognition methods, in the current literature, involve extraction of features for banknote classification. Paper currency recognition systems should be clever to recognize banknotes from each side and each direction. Since banknotes may be faulty during circulation, the designed system should have an important precision in detecting torn or worn banknotes. The simplest way is to make use of the visible features of the paper currency, for example, the size and color of the paper currency [1]. However, this kind of methods has great limitations as banknotes are getting worn and torn with the passing of time and they are even dirtier when holding by dirty hands or in dirt. If any banknote is dirty or it may be changed into any other color then the color content of banknote may change largely. Various authors have worked for paper currency recognition. Until now, there are many methods proposed for paper currency recognition.

For example, [7], used an invariant feature extraction for banknote classification which has performed very well when applied to banknote stores. Furthermore, [8], proposed a technique where characteristics of paper currencies include size, color and texture are used in recognition. In this technique, the Marcov Chain concept has been used to model texture of paper currencies as a random process. On

the other hand, [9], presented a currency recognition system using ensemble neural network (ENN). The individual neural networks in an ENN are skilled via negative correlation learning. Besides this, Takeda and Nishikage (2000), concentrated on enhancing neuro-recognition system to increase the number of recognition patterns using axis symmetrical mask and two image sensors. [10] presented a method using linear transform of grey image to diminish the influence of background image noises in order to give prominence to edge information of the image. [11] presented a currency recognition system using (ENN) and applied it to 7 different types of Taka (Bangladeshi currency)

Currency Recognition System- An Overview

The various processing steps[12] for analysis are pre-processing, binarization, morphological filtering, heuristic analysis and segmentation and feature extraction etc. The block diagram for this approach is shown in fig.2 given below:
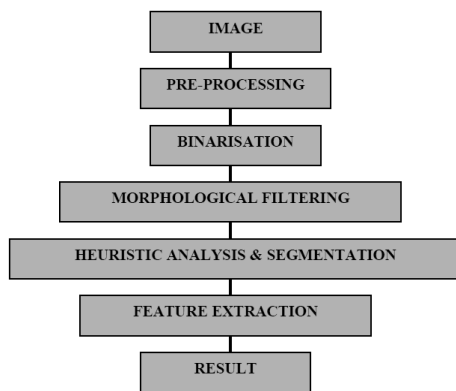
Figure 2: The Approach for Currency Recognition

Image Pre-processing

In order to feature extraction of paper currencies effectively, the currency images are collected with appropriate spatial resolutions and brightness resolution, where the spatial resolution describes how many pixels comprise a digital image or how many dots are in each inch of a digital image. The concept of the brightness resolution addresses how accurately the digital pixel's brightness can represent the intensity of the original image. After document scanning (see fig.2), a sequence of data pre-processing operations are normally applied to the images of the documents in order to put them in a suitable format ready for feature extraction[3].

Figure 3: Currency Images

Binarisation

Binarisation of images is to convert the given image into binary images by using the concept of thresholding. During the thresholding process, individual pixels in an image are marked as "object" pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as "background" pixels otherwise. This convention is known as threshold above. Variants include threshold below, which is opposite of threshold above; threshold inside, where a pixel is labelled "object" if its value is between two thresholds; and threshold outside, which is the opposite of threshold inside[4]. The thresholding is of two types:

- Global Thresholding
- Local Thresholding

Morphology Filtering

After image binarisation, the digits on the serial numbers of the banknotes often have some discontinuous particles, some further noise and some unexpected edges. To make the recognition task easier, we apply four morphological transformations to the binary images. Morphological transformations extract and alter the structure of particles in an image. We applied four binary processing functions erosion, dilation, opening and closing to remove noise.

Heuristic analysis and Segmentation

Sometimes there are redundant elements, which do not correspond to proper characters. These elements are not reliably separable by traditional OCR methods, although they vary in size as well as in contrast, brightness or hue. Since the feature extraction methods do not consider these properties, there is a need to use additional heuristic analyses to filter non-character elements. The analysis expects all elements to have similar properties. Elements with considerably different properties are treated as invalid and excluded from the recognition process. The analysis deals with statistics of brightness and contrast of segmented characters.

Feature Extraction

Feature extraction or selection is a pivotal procedure considerably for currency recognition, which effects on design and performance of the classifier intensively. If the differences of selected features are so large, it can easily construct a

classifier with good recognition performance. It is difficult to get it with the contrary situation. The essential task of feature extraction and selection is how to find the correspondingly effective features out of many pending features [6].
 Feature types are categorized as follows:

- *Structural features:* It describes geometrical and topological characteristics of a pattern by representing its global and local properties.

- *Statistical features:* Statistical features are derived from the statistical distribution of pixels and describe the characteristic measurements of the pattern.

- *Global transformation:* Global transformation technique transforms the pixel representation to a more compact form. This reduces the dimensionality of the feature vector and provides feature invariants to global deformation like translation, dilation and rotation.

Paper Currency Recognition Technique Using Neural Network

A. Euro banknote recognition system using a three layer perceptron and RBF networks[13]:- proposed an Euro banknote recognition system using two types of neural networks; a three-layered perceptron 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 perceptron and the validation part uses several RBF networks. While the three-layered perceptron 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 configurate the system employing only one RBF network. One-phased RBF network method has two problems. First, defining feature extraction areas in image data is quite complicated. Second, the calculation cost is in proportion to $O(mn^2)$,where m is the number of kernels for each class and n is the number of given classes. So the author has designed two-phased method for solving these problems. The feature extraction area can be simply defined for each class. In addition, the calculation cost of the validation part is independent of the number of given classes.

B. ANN Based Currency Recognition System using Compressed Gray Scale and Application for Sri Lankan Currency Notes-SLCRec [14]:- 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 are 100, 500, 1000 and 2000 rupee notes.

Currency Recognition task has been categorized into two components. The first step involves getting characteristic features of Sri Lankan currency images extracted that vary from each denomination. The second step requires using these characteristic features in an intelligent system for recognition.

C. A Paper Currency Recognition System Using Negatively Correlated Neural Network Ensemble [15]:- 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. To prove the efficiency of proposed ENN method author has compared it with the other methods like Hidden Markov Model (HMM), radial basis function (RBF) and Feature Extraction method called SLCRec.

. D. Bahraini Paper Currency Recognition [16]:- 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

Reference	Neural Network Method	Currency Used	Remarks	Accuracy
Masato Aoba[13]	Radius Basis Function	Euro	Three layer perception for classification and RBF for validation.	100%
D. A. K. S. Gunaratna et al.[14]	Three layer back propagation	Sri Lankan Currency Notes	Canny algorithm for edge detection and Three layer back propagation neural network for currency classification.	100%
Kalyan Kumar Debnath et al[15]	Negatively Correlated Neural Network Ensemble	TAKA (Bangladeshi currency)	ensemble neural network classifier and trained via negative correlation learning	100%
Ebtesam Althafiri et al.[16]	multilayer perceptron	Bahrain Paper Currency	two classifiers, the weighted Euclidean distance using suitable weights and the Neural Network	85.1%

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. The minimum distance classification method by taking the Weighted Euclidean Distance shows 96.4% accuracy rate while the Neural Network with feed forward back propagation classification technique provides almost 85.1% average of accuracy

for the best case. Therefore, author concluded that the Weighted Euclidean Distance approach is better than the Neural Network.
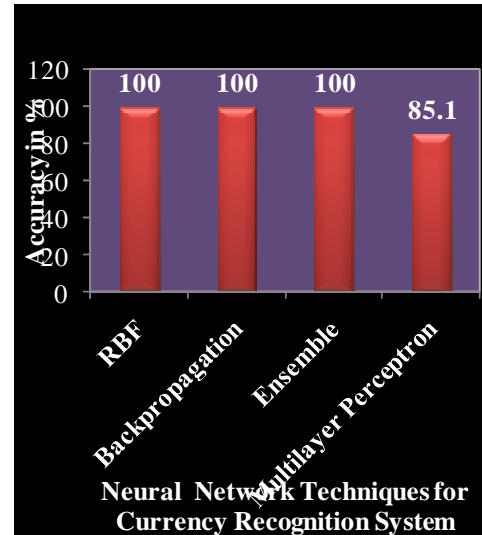

Figure 4: Accuracy Comparison of Various Neural Network Techniques used for Currency Recognition System

Conclusion

Automated paper currency recognition system can be a very good utility in banking systems and other field of commerce. Automatic currency note recognition invariably depends on the currency note characteristics of a particular country and the extraction of features directly affects the recognition ability. We have presented a comprehensive overview of techniques for the recognizing currency using neural network techniques. Nonetheless, we have surveyed and classified a significant fraction of the proposed approaches, taking into consideration the techniques they utilize, methodology they propose and the currency they have been applied to and the accuracy of recognition. In our opinion, this survey has shown that a significant number of neural network techniques exist for the problem of currency recognition, but It has also shown that the researchers have worked on currency of different countries like Taka, Euro etc. We believe that the field will be significantly enriched if methods from these sources is incorporated into efficient recognition of Indian currency with the features mentioned in our study.

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