

RECENT DEVELOPMENTS IN PAPER CURRENCY RECOGNITION SYSTEM

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Abstract

Currency denomination recognition is one the active research topics at present. And this wide interest is particularly due to the various potential applications it has. Monetary transaction is an integral part of our day to day activities. However, blind people particularly suffer in monetary transactions. They are not able to effectively distinguish between various denominations and are often deceived by other people. Also, a reliable currency recognition system could be used in any sector wherever monetary transaction is of concern. Thus, there is an ardent need to design a system that is helpful in recognition of paper currency notes correctly. Currency denomination detection is a vast area of research and significant progress had been achieved over the years. This paper presents an extensive survey of research on various developments in recent years in identification of currency denomination. A number of techniques applied by various researchers are discussed briefly in order to assess the state of art.

Keywords:- Currency recognition system, Artificial Neural Network.

1. INTRODUCTION

World Health Organization (WHO) approximates that there are 161 million visually impaired people around the world, about 2.6% of total population. Among these 124 million had low vision and 37 million are blind. Blind people face great difficulties in there day to day life monetary transaction. Also the present day financial self services have an ardent need of an automated currency recognition system. Automatic methods of banknotes recognition are required in many applications, such as automatic selling goods and vending machines, among others.

1.1. Methodology

In any currency recognition system the main steps are:

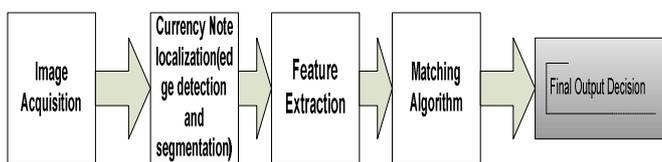


Fig1. General Flow diagram of a Currency Recognition System

- **Image Acquisition**-Image acquisition is the creation of digital images, typically from a physical scene. The image here is that of a currency note and is generally acquired

by using digital camera. The image is then stored for further processing.

- **Edge Detection**- It is a fundamental tool in image processing, particularly in the area of feature detection and extraction, which aims at identifying points in digital image at which the image brightness changes sharply. Here, the aim of edge detection is basically to localize the currency note that is the region of interest.
- **Image Segmentation**-This method sub divides the image into its constituent regions or objects. Segmentation algorithm for monochrome images generally are based on two properties
 - a) Discontinuity
 - b) Similarity
- **Feature Extraction**-It is a challenging work in digital image processing. In any currency recognition system, feature extraction is one of the most challenging tasks. Here, the aim is to analyze and identify the unique and distinguishing features of each denomination under various challenging conditions such as old notes, worn out notes, also under different illumination and background.

- **Matching Algorithm-** This step classifies or recognizes currency notes of different denomination based on the various unique features extracted.

1.2 Potential Applications

Recent years have seen an increased interest in currency recognition system worldwide. And this is because of the various potential applications it has. Few of them are mentioned below:

- **Assisting visually impaired people-** There is a strong need for assisting visually impaired people because one specific difficulty that a blind person would encounter is to know the value of the currency or bill he or she is holding [1]. Although these visually impaired people can distinguish between two different denominations using the different size of notes, but the size variation alone is not enough to flawlessly determine the currency note. In reality, the very little difference between the sizes of consecutive denominations makes them confused and unable to distinguish the currency notes from one another. The currency notes are provided with few special identification marks only for the blind people so that they may easily recognize the denomination correctly. Every currency note has its denomination engraved at the top right end which is sensitive to touch, but this mark fades away after the currency note goes in circulation for some time. This again creates a difficulty for the visually impaired people to correctly determine the denomination of the currency note [2].
- **Distinguishing original note from counterfeit currency-** Another important application is to distinguish original note from counterfeit currency so that it would be very helpful in encountering the counterfeit note that is flowing throughout Indian economy.
- **Automatic selling-goods-** The system must be very helpful for automatic selling goods. Vendors may sometimes get confuse when there is a huge crowd in a market. There is a possibility of being miscalculation on some of the goods. So the system will help vendors in keeping records of goods sold and the amount received.
- **Banking Applications-** The system should be very helpful in banking application such as counting of notes and its value during monetary transactions, detection of counterfeit notes, etc. Such a system will make the banking process a trustworthy and reliable process. As time is the important factor in today's world so such system will be helpful in saving time too.

2. RELATED WORK

A numerous researchers and scientist have made several contributions towards development or designing of system for currency denomination recognition. In this paper we present an overview of such recent developments. Most of the work done in recent years have been successful in achieving 90% or more of accuracy and are mostly confined to one or two dimensions of currency recognition viz. color, texture and so on. The purpose of our paper is to study the techniques and methods implemented and applied by previous researchers and scholars. Unlike previous reviews, this paper concentrates on very recent developments, particularly in the field of currency recognition. This paper will also be focusing primarily on currency detection system including various steps involved in it like image acquisition, feature extraction and classification system using various algorithm.

2.1 Image Acquisition:

Image acquisition is the creation of digital image, typically from a physical scene. The co-ordinates of the pixels of the digital image in 2D form is given by 1st and 2nd index of an array and the 3rd index stores the RGB intensities for each co-ordinate. Each element of array then stores an unsigned 8-bit integer [2]. Once the images are obtained, they were further processed using programs to extract whatever information is desired.

2.2 Image Pre-Processing:

The aim of image pre-processing [3] is to suppress undesired distortions or enhance some image features that are important for further processing or analysis. It includes

- **Image adjusting** -When an image is obtained from a digital camera, the size of the image is too big. In order to reduce the calculation, the size of the image should be reduced. Image adjusting is done with the help of image interpolation.
- **Image smoothening-** While performing image transfers, some noise may appear on the image. Removing the noise is an important step when image processing is being performed. However noise may affect segmentation and pattern matching. Mask values can be used to determine the degree of smoothening and to reduce noise. Higher is the size of mask, more is the smoothening.

2.3 Edge Detection

Edge detection is a fundamental tool in image processing, particularly in the area of feature detection and extraction, which aims at identifying points in digital image at which the image brightness changes sharply [4]. Edge detection reflects sharp intensity changes in colors of the image [5]. It identifies object boundaries of an image. These algorithms include *Sobel*, *Prewitt*, *Roberts*, and *Canny*. The *Canny* method is more

powerful because it can detect true weak edges, it has low error rate, and edge points are well localized and gives only one response to a single edge [6]. So at first, the image should be converted to a binary image and then edge detection must be performed on that image using *Canny* edge detection technique to detect strong and weak edges.

A Sri Lankan currency recognition system developed by D.A.K.S. Gunaratna, N.D. Kodikara and H.L. Premaratne did not consider actual pixel range but mainly focused on edge detection and unwanted patterns and noise removal using linear transformation [5].

2.4 Boundary Subtraction

In order to detect and recognize the note, it is preferred to remove irrelevant background first. After binarization, black pixels touching the boundary of the image were regarded as background, since the note had a white background that separated itself from the backgrounds. The image obtained from the camera may not be directly used for localization and requires enhancement. Next, generally background subtraction followed by RGB to gray conversion was done [2]. This was done because to localize a note, one must know whether a pixel is present in an image or not. After boundary subtraction, some noise may still exist. Usage of Breadth-First-Search (BFS) from the image center [7] removed the noise and so as the mask value.

2.5 Feature Extraction:

Feature extraction is a challenging work in digital image processing. The feature extraction includes the extraction of features of serial numbers of currency notes. During this process, the dimensionality of data was reduced [4]. Feature extraction or selection was a pivotal procedure considerably for currency recognition, which effects on design and performance of the classifier intensively. If the differences of selected features were assumed to be too large, a classifier with good recognition performance could have been easily constructed. It was 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 [8]. Those features were extremely important both in recognition and authentication of notes. Basically, at first instance, people may not pay attention to the details and exact characteristics of banknotes for their recognition, rather they consider the common characteristics of banknotes such as the size, the background color (the basic color), and texture present on the banknotes [9].

2.6 Evaluation Algorithm

Over the years, various algorithms have been proposed by various researchers for reliable currency recognition. After getting features of currencies, it is essential to recognize the pattern of the currencies on the basis of these features, which should be practiced by an effective recognition system called classifier. One of the most common classification techniques that

had been used recently is Artificial Neural Network. A Neural network based recognition scheme was used for currency recognition in [9,10,11,12]. The Neural Network consisted of three layers that are input layers, hidden layers and output layers. In this method, the image acquired at first was RGB image and then it was being converted into gray scale. Edge detection of the whole gray scale image was then performed. After detecting edges, the four characteristics of the paper currency was cropped and segmented. After segmentation, the characteristics of the paper currency were extracted. The characteristics of test image are compared with the original pre-stored image in the system. If it matches then the currency is genuine otherwise counterfeit. Then they found the hue and saturation for input image and evaluated the neural network for those values. If the hue and saturation thresholds from the neural network were less than the current image threshold, then the current image was considered genuine else the image was declared as a counterfeit one. Similar work was done in [13] where the authors had used image histogram based on which plenitude of different colors in a paper currency was calculated and compared with the one in the reference paper currency. They also used Markov chain concept to model texture of the paper currencies as a random process and finally used ensemble neural network (ENN) with negative correlation for classification. In [14,15] the author proposed another neural network based currency classification system using Negatively correlated Ensemble Neural Network. The Ensemble Network had better performance for recognition than single network. Another paper proposed by Vipin Kumar Jain and Dr. Ritu Vijay [16] developed an image processing technique to extract paper currency denomination. The extracted ROI was used with Pattern Recognition and Neural Networks matching technique. The Pattern Recognition and Neural Networks matcher technique was used to match or find currency value or denomination of paper. In another Neural Network based classification [9], the authors proposed a currency recognition system using neural network that uses histogram based feature extraction and multilayer Perceptron model for classification. In [17] three layers feed-forward Back-propagation Neural Network (BPN) was used for classification of currency note. They proposed a technique which was simple and comparatively less time consuming which made it suitable for real-time applications.

Also in [8], the authors proposed a system which made intensive Heuristic analysis of serial number characteristics across the note and suggested a particular trend in terms of values of Hue and saturation, contrast and brightness. They concluded that contrast and brightness are dependent on extrinsic factors of sensor, and Hue and saturation are more likely dependent on consistent pattern design of the note.

Several works have been done based on color component analysis of Currency notes. In [2] Hanish Aggarwal and Padam Kumar presented a paper for Indian currency recognition on the basis of color. They suggested that currency notes have at least one color which is more prominent and that had been utilized by

them in recognition. In [18] the authors made a money detector system which was used to detect the bank note using a system of Light Dependent Resistor (LDR) sensors and Light Emitting Diode (LED) lights which are programmed to sense the color patterns of the bank notes. Texture information of currency note had also been used by various researchers to classify different denominations. In [19] the authors introduced a recognition method for Mexican banknotes by using artificial vision. They converted the image into gray-scale and then texture is extracted and applied to Wiener Filter in order to reduce the dirt from mistreated banknotes. Histogram matching techniques was utilized by authors in [20].

3. DISCUSSION

Despite an intense research in this field, many issues related to currency recognition system still remain unanswered and provides researchers a vast field to explore in future, especially in certain areas. Based on our study we found that Artificial Neural Network based currency classification is one of the most frequently used methods. Various types of neural network such as Feed Forward, network, Back Propagation Neural Network, Ensemble Neural Network. Also RBF network was utilized by some researchers as it possesses a proper data approximation property, which seems a good tool for rejecting unknown data [21]. There are various models developed by the researchers to recognize the paper currencies. Among them is Markov Chain concept is employed by many researchers as a random process to model the texture of paper currencies [14]. GMMRF model was used by researchers in image segmentation [22]. RGB Color based classification had also been used by many authors to classify currency notes based on the fact that in each note, only one of these color component is uniquely prominent. However some other authors considered classification based on analysis of color histogram, hue, saturation and intensity value by [13]. They suggested that advantage of HSV color space is that it is closer to human conceptual understanding of colors and has the ability to separate chromatic and achromatic components. Although a number of currency detection techniques had been developed till date yet the development of a robust background model adaptive to changes in varying environments is still a challenge.

CONCLUSIONS

New sophisticated tools and advancement in the technology demonstrates that the visually impaired problems can be challenged in today's world. It is good to see many researchers and scholars rapidly advancing their achievements into more intelligent practical applications. Keeping in mind the agony of visually impaired persons and old people with reduced vision power, who often could not recognize the correct denominations, a general processing framework for recognition of Currency banknote recognition is presented as an overview of recent developments in this field. The frame work of the existing methods is described and the focus is on image acquisition,

image localization, feature extraction, template matching and validating the output. We hope this survey provides a base for researchers interested in currency recognition system.

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