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Survey on Paper Currency Recognition System

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Abstract

Paper currency recognition is an important active research area in pattern recognition. The recognition system mainly consists of few basic steps like image acquisition, its pre-processing, feature extraction and finally recognition of the currency. Normally scanner is used in order to acquire the image. Then these images are processed by using various pre-processing techniques and then different features of the images are extracted, by using neural network classifies the images. Applications on currency recognition includes foreign exchange, automatic selling of things and in banks. Recognition ability depends on the currency note characteristics of the particular country and extracted features.

Keywords: Currency recognition, Pre-processing, Feature extraction, Classifier, Neural network.

1. INTRODUCTION

Currency recognition is an image processing technology that is used to identify currency of various countries. Probabilities that the paper currencies of various countries are probably interweaved together therefore rises increasingly. Paper currency recognition systems should be able to recognize banknotes from each side and each direction. Since some notes are defaced during circulation, the design systems should be accurate in detecting worn or torn notes.

There are approximately 50 currencies all over the world with each of them looking totally different. For instance the size of the paper is different, the same as the color and pattern. The staffs who work for the money exchanging have to distinguish different types of currencies and that is not an easy job as they have to remember the symbol of each currency. This may cause some problems, so they need an efficient system to help their work.

2. STEPS FOR PAPER CURRENCY RECOGNITION

2.1. Image Acquisition

This can be broadly defined as the action of retrieving an image from some source, usually a hardware based source. Performing image acquisition is always the first step in the workflow sequence because, without an image no processing is possible. It 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 pre-processing.

2.2. Pre-Processing

The aim of image pre-processing is to suppress undesired distortions or enhance some image features that are important for further processing or analysis. It significantly improves the performance of the recognition system. It includes

2.2.1Image Adjusting

When we get the image from the scanner, the size of the image is so big. In order to reduce the calculation, we decrease the size of image. Image adjusting is done with the help of image interpolation. Interpolation is the technique that is used for certain tasks such as zooming, rotating, shrinking, and for geometric corrections.

2.2.2Image smoothening

When we use a scanner for image acquisition and perform image transfers, some noise will appear on the image. Removing noise is an important task in this image pre-processing, because this noise may affect segmentation and pattern matching. Convolution method is used for image smoothening. In this method the neighbor of the pixel is used to do some transforming, after that a new pixel is created. The neighbor of the pixel, consisting with some other pixels build up a matrix where the target pixel is located on the middle of the matrix. We also median filters.

3. FEATURE EXTRACTION

Feature extraction is the process of extracting certain features of our interest and presented for further processing. It is a important procedure considerably for currency recognition, which effects on design and performance of the classifier intensively[1]. There are mainly two types of features [1] as, Structural feature: It describes geometrical and topological characteristics of pattern by representing its global and local properties. Statistical Features: It describes characteristic measurements of the pattern It is a type of dimensionality reduction. Features are significant clues towards the

recognition of an object. There are many features of currency notes, here we consider features like color[6], texture, shape. In order to store these extracted features we must create a feature vector, n*1 array that encodes the n features of an image.

3.1. Texture Feature

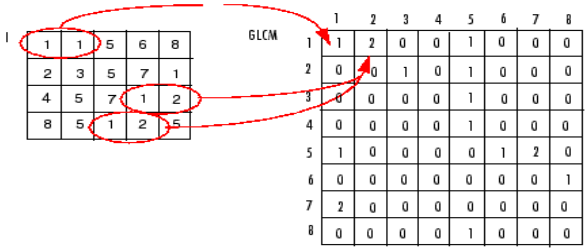
Texture is the visible feature of the paper currency.

3.1.1.Gray Level Co-occurrence Matrix

A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the grey-level spatial dependence matrix. Grey Level Co-occurrence Matrices (GLCM) are one of the earliest techniques used for image texture analysis. Texture analysis is the extraction of textural features from images .In image analysis, texture is defined as a function of the spatial variation in intensities of pixels. To create a GLCM, use the graycomatrix function.

glcm = graycomatrix(I)

It creates a gray-level co-occurrence matrix (GLCM) from image I. Graycomatrix creates the GLCM by calculating how often a pixel with gray-level value *i* occurs horizontally adjacent to a pixel with the value *j*.



3.1.2. LBP operator: It is originally introduced by Ojala et al [7]. In LBP, the neighbourhood pixels are converted to binary code 0 or 1 by using the gray value of the centre pixel as threshold and further arranged to form as a ordered pattern. The feature extracted with LBP gives the relationship of the texture within local area. LBP code for pixel p is defined as

$$LBP(p) = \sum_{i=0}^{7} 2^i s(g_i - g_p)$$

Where

gp – Gray value of the centre pixel p.

gi – Gray value of the ith pixel, 8-neighbourhood of p

i – 0, 1 ...7.

s(t) = gi - gp, is the threshold function and given by

$$(t) = \begin{cases} 1, t \geq 0 \\ 0, else \end{cases}$$

From equation (1) we can say that LBP can produce 256 kinds of different outputs, orresponding to 256 kinds of different binary patterns. Junfang Guo, Yanyun Zhao[8] has proposed the improved method for texture analysis using LBP. They have segment the whole image into M * N blocks. In each block calculate the LBP value for every pixel, and make the histogram of the block, which is known as a block histogram. The block histogram is normalized by the number of pixels in the block.

3.1.3. Markov Chain Concept: As in many countries colour spectrum and size of some banknotes are very close to each other. For such a type of difficulties we are considering template of the banknotes. And to recognize these templates we are using Markov Chain Concept [9] to represent the random phenomenon. A random process {xk, k = 0, 1, 2....} is called Markov chain if the possibility value in state xn+1 depends on the possible value in state xn, given as below

$$P(x_{n+1} = \beta | x_n = \alpha, x_{n-1} = \alpha_{n-1}, \ldots x_0 = \alpha_0)$$
$$P(x_{n+1} = \beta | x_n = \alpha)$$

This possibility can be shown by Pij. The state space of a Markov chain can be shown in matrix as below

$$P = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix}$$

Where n, is the number of states in the chain. In discrete time Markov chain, the possibility value of different states in the matrix is computed as

$$P_{ij} = \frac{n_{ij}}{\sum_{k=1}^{n} n_{ik}}$$

Where nij, is the number of transitions from state i to state j. considering (5), matrix P can be multiplied by the denominator of (5). To obtain

$$P = \begin{bmatrix} N_{11} & N_{12} & \cdots & N_{1n} \\ N_{21} & N_{22} & \cdots & N_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ N_{n1} & N_{n2} & \cdots & N_{nn} \end{bmatrix}$$

This is matrix is used to differentiate between textures in different denominations [7].

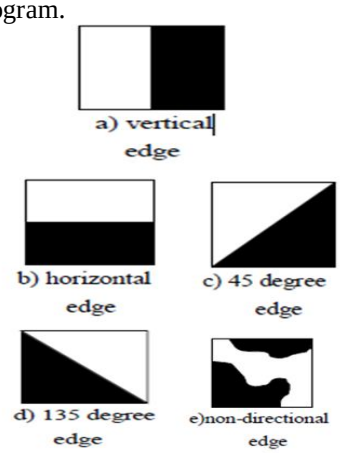
3.2. Color Feature

The primary image which is in RGB format, then convert to XYZ color space [2] that encompasses all color sensations that an average person can experience. And then it is converted to CIELUV color space, is especially useful for additive mixtures of lights, due to its linear addition properties. It is a non-linear color space, but the conversions are reversible. Then we have to find mean, color skewness and color variance for each channel of l ,u ,v.

3.3. Shape

Histogram is the most commonly used characteristic to represent the feature composition of an image. Edge in the image is considered as an important feature and extracted[5] to represent the content of the image. Five Edge types are defined in the Edge Histogram. They are four directional edges and one non directional edge. Four directional edges include vertical ,horizontal ,45 degrees and 130 degrees diagonal edges. These directional Edges are extracted from the image blocks. If the image block contains an arbitrary edge without any directionality, then it is classified as a non directional edge. Then Sobel mask is applied, max sobel gradient and index of the orientation are calculated. Canny's edge detection method is used to detect the edges. Multiply edge images with the

types of orientations detected by the Sobel masks in order to find histogram.



4. CLASSIFIER

After getting features of currencies, it is essential to recognize the pattern of the currencies on the base of these features, which should be practiced by an effective recognition system called classifier. The input of the classifier will be the test currency images and the output of the classifier will be the corresponding currency name.

A Neural network based recognition system is used in which the extracted features are fed into a multilayer perception, that is trained for recognition. A Neural network based recognition scheme is used for Bangladeshi banknotes [3]. The scheme can efficiently be implemented in cheap hardware which may be very useful in many places. The recognition system takes scanned images of banknotes which are scanned by low cost optoelectronic sensors and then fed into a multilayer perception, trained by back propagation algorithm, for recognition. Baiqing Sun [4] proposes a kind of currency recognition system, in which a three-layer feed forward neural network is used as a classifier, They proposed it in order to improve the performance of currency recognition system. The classifier here we used is feed-forward back propagation model which classifies effectively with high performance.

5. 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 [10].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 [11]. GMMRF model was used by researchers in image segmentation [12].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.

5.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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