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Paper Currency Identification using Image Processing and Radial Basis Function (Rbf)

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Abstract*: *"Currency", generally an accepted form of money, which is officially issued by the government and is circulated by the central bank of every country. It forms the basis for trade within or outside the country. Due to the presence of several countries in this world, there is a vast heterogeneity in currency. Various patterns, colors and images are integrated on paper currency by each country to retain the individuality and legality of their paper currencies. This results in difficulty for people in foreign exchange to recognize currencies from different countries. The aim is to help people solve this problem to remember every feature of the respective currencies.

Index Terms*: *Image processing, pattern recognition, Digital imaging, Radial Basis Function, Feature Extraction, Content-based image retrieval.

I. INTRODUCTION

There are many rapid advancement in digital camera technologies and availability in the digital or portable form that make it possible for the researchers to attain a large amount of studies in the field of digital image processing. It is a method or a technique, which is applied on the query image, provided by the user to extract meaningful or the required information from it or convert the query image into desired or required manipulated image. During the last one or two decades, number of applications and techniques come into existence such as object recognition, face recognition, hand written text recognition, fake signature recognition, motion detection, text extraction from a given image, etc. The present study is subjected to use the digital image processing technique along their implication in the recognition of the paper currency available from different countries. There are total 195 countries as of now and most of them uses different paper currencies. Due to this, there are approximately 164 official national currencies all over the world. For maintaining the individuality and originality every country print different features on their paper currency that make them look very different from each other. For instance the color, size of the paper, the patterns used on the paper, different images printed over them. The people who are employed to work with these paper currencies regularly such as in money exchanging department or the international banks are required to characterize each and every type of paper notes provided from different countries that requires a heavy duty. The officials are required to revise the denomination, symbols and other features of each currency repeatedly. This causes the wastage of useful time and causes difficulties in recognition, so they require an exact and efficient system or the software to help their work so that they can work with efficiency and convenience.

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II. PROPOSED MODEL

In this proposed system, a technique is use to engage characteristics or features of paper currencies that are used by the system to differentiate different currencies denominations from different countries. The important technique of this system is image analysis or image acquisition and image processing which are the part of intellectual and computer science. It also include a technique to separate out the damaged notes and auto reconstruct these images for increase in accuracy and efficiency of the system. This will help the user to identify even the damaged notes also.

Actually, the image is first converted into digital image and apply different standard image pre-processing techniques. Image analysis is a task that is easier than any other recognition or identification tasks such as biometric or reading the bar code.

In order to identify the currency to which the currency belongs, the system should contain the technique that include image pre-processing, segmentation, edge detection, pattern matching with Radial Basis Functions.

A. Process Background

The identification method used by the system is based on digital image processing techniques that are used to analyze, identify or process the image. This system includes the use of a query image or any image provided by the user to the system, which is then captured by the camera integrated with the system. The images can also be scanned by the user using the scanner and is provided to the system in the form of JPEG (Joint Photographic Experts Group) or PNG (Portable Network Graphics) format.

This system then uses much wider range of image processing tools or algorithm to convert the provided images (JPEG or PNG format) into a digital format and perform image pre-processing tasks that create the image in a format which is able to some operations on it, in order to get more intensified or enhanced image or to extract most useful information from it. With the aid of the algorithms, it is possible to apply techniques like RGB to Gray, noise elimination, segmentation, image binarization and pattern matching easily and efficiently. Fig 2.1 provides you with a small glance about the process background involved in this system.

B. Technical Background

The most important element of this technique is image analysis, image processing and Radial Basis Function (RBF), which are the part of the computer system and intellectual computer science. Image processing is a signal processing after pre-processing. Either the result or the output can be in the form of image or a group of characteristics or parameters related to the query image. Basically, the query image is processed as 2-Dimensional signal an applies some standard signal processing techniques with image processing technique involved. Image analysis is a task or a way through which the meaningful information from the query image is extracted mainly from converted digital images by means of digital image processing techniques. In order to identify the currency, the system must contain the techniques, which are discussed in the next section that include image pre-processing, segmentation, pattern matching etc.

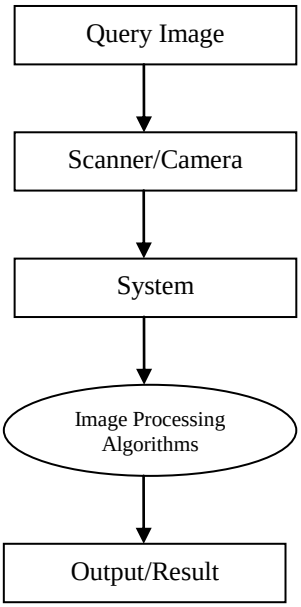


Fig. 2.1. Flowchart of Process Background.

III. Proposed Methodology

The first and foremost step of this method is to capture the query image using the camera or the scanner. This captured image is then stored in the system, which then analyses it and converts it into digital format and perform some operations on it to extract some important features. This system employed characteristics of paper that are used by the user for distinguishing different banknote denominations. As we know that, all the countries issue their official currencies with different characteristics. People may not pay attention to the exact details and characteristics of banknotes for their identification, rather they consider the general characteristics of banknotes such as the background color (the main color), the size of the banknote, and the textures (templates) that appeared on the banknotes. In this system, these characteristics are used in a decision (conclusion) tree to distinguish between different banknote denominations.

A. Size

The size of the banknote is the first step in recognizing the banknote. The size characteristic becomes the important issue as the edges of banknotes become worn and torn because of circulation in the market. Due to this torn and worn, the size of the banknote may reduce or even is increased slightly. Therefore, the size characteristic in the decision tree are proposed as:

$$| \alpha - \alpha_0 | < \delta_\alpha \ \& \ | \beta - \beta_0 | < \delta_\beta \qquad (1)$$

Where a_0 and b_0 are size of the testing paper currency, and a and b are size of the query paper currency. In (1) δ_α and δ_β represent changes in the vertical and horizontal directions.

B. Color

Although the banks use various colors while printing the paper currency, people generally use one or more dominant color for differentiating between different paper currencies. For example the dominant colors in a five-hundred rupees banknote are green, yellow and brown. In this system, the digital image of the banknote is transformed to a gray scale image. Then the gray scale level from the image is reduced to get a meaningful judgment about the background color of the banknote. For this reason the banknote images are quantized to 52 level in gray scale and then the histogram of the image is computed to calculate the plentitude of different color in the banknote

C. Texture

In most of the countries, the size and the color spectrum of some banknotes are very close to each other. Moreover, these characteristics of banknotes from different countries may be too close to each other hence these characteristics may not be enough to easily distinguish between various paper banknotes. Consequently, the system consider template or the texture of the banknotes in addition to the renouncing characteristics. For recognizing the template, the concept known as Markov Chain is use for representing random phenomenon.

A random process {xt, t = 0, 1, 2 …} is known as Markov Chain if the possible value in state xn+1 depends on just the possible value in state xn, i.e.:

$$P(x_{n+1} = \beta | x_n = \alpha, x_{n-1} = \alpha_{n-1} \ldots x_0 = \alpha_0) = P(x_{n+1} = \beta | x_n = \alpha) \quad (2)$$

Although an image is identified by the value of its pixels at different locations, the way in which the adjacent pixels vary can also be used to differentiate different images.

D. Image Pre-processing

The system read not only JPEG (Joint Photographic Experts Group) format but others also. Therefore, after Scanning through scanner or camera, the image will have lots of white area surrounding the currency. Actually, this is useless part for recognition. In a way to make the system efficient, the white area part will be cut entirely. The main aim of image pre-processing is to repress undesired distortions or enhance some image features that are needed for further processing. As the image is either captured or scanned, so some noise will appear on the image. Image noises are the arbitrary variation of brightness in the images. In order to remove noises on the image, Gaussian blur is use. After removing the noise, some useless areas are cutoff. Sometimes, some black lines are appear on the edge of the original image that result in affecting the next operations.

E. Segmentation

After observation, it was found that each currency has one or more unique patterns. Therefore, these unique patterns are more important feature that can be used to distinguish different types of currencies. Segmentation is one of the most important part to process the image details. It split the image into different parts that have a strong correlation with objects.

F. Red-Green-Blue Model

This model is mostly used in computer as the basis of a color space in computer graphics. Color is a property of extensive importance too human visual perception. The computer hardware generally deliver or display color via RGB model. This model is totally based on primary colors Red, Green and Blue. Each color appears in its primary spectral components. The main purpose of RGB model is for the representation, sensing, and displays of images in electronic systems. The primary color of the image is used to check which currency is this and this is one of the important characters for identifying the currency.

G. Pattern Matching

After segmenting the pattern of the image, there is a need to recognize the pattern. To achieve this a process called correlation is used to measure the similarity between the images and segmented parts of image. Correlation is used to explore whether the object is present in the image or not. A template is used to search the object which is consists in the original image. If something matches between the template image and the original image, the correlation function will reach to its maximum value at the position of the object.

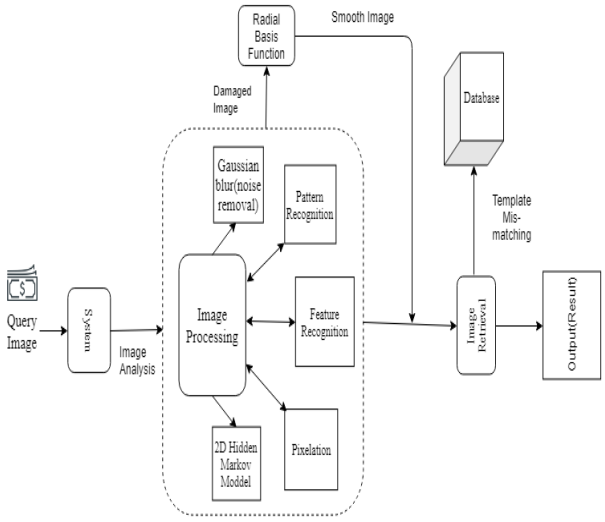
H. Edge Detection

The final step of image processing is to inspect the result. After performing the correlation, the process provides the coordinates of the subject in the original image. These coordinates are very helpful in edge detection mechanism. A way of detecting the edges is Sobel that computes the approximation of the gradient in the image. It is also used in computing the gradient of image brightness function approximation. Any point in the query image using this operator will have a corresponding gradient vector.

Sobel operators are of two types, one detect the X-axis direction and other detects the Y-axis direction.

I. Block Diagram

Fig 3.2. Architecture Diagram of Paper Currency Identification.



The Fig. 3.2 shows the architecture of currency identification system that describes the whole process from taking the input of query image to the output as the text in this system. As soon as the user take the image of the currency paper or scans it the system will analyze it. During this analysis process, the captured image is converted into digital image. On this digital image, different image pre-processing techniques are applied to make this digital image smooth and noise free. This enables the system to apply image-processing algorithms easily and efficiently also the patterns and features can be extracted easily on more smooth images. If during the image pre-processing period, the system found any damages or less information then the Radial Basis Function processes the image. This function helps the system to complete the damaged or lost information on the currency. After all the image-processing algorithms are executed then the template of original image is mis-matched with the image-processed image for recognizing the currency. This process of template mis-matching is performed with the help of the database present with the original information of the original paper currencies. The after process in-group is known as image retrieval.

When all the algorithms and processes are completed then the result or output will be presented in the form of text.

IV. RECONSTRUCTION OF DAMAGED IMAGES

Damages and incomplete images are one of the most interesting problems that occurs while processing the image. One solution for solving this problem is to collect information as much as possible from the original image as the quality and efficiency of the result depends on it. The Radial Basis Function is based on the quiver implicit functions principle and can be used for implantation of scattered data.

The RBF method is used to implant a smooth function given by n points. The function is defined as:

$$f(x) = \sum_{i=1}^{n} \lambda_i \phi(||x - c_i||) + P(x) \quad (3)$$

This function can more briefly be understood by the algorithm for reconstruction of incorrect pixels for a part of the given query image. The function selects the correct pixels from the image. RBF uses these pixels as an input for this method. After getting the input, the radial basis function is computed and the value of the incorrected pixels are computed. The radial basis function differs from instance to instance as several pixels might be missing. If in an image too many incorrect pixels values are found, then the incorrect pixels are not corrected and the algorithm continues. These incorrect pixels are corrected in the next repetition.

The second alteration reconstruct the wrong pixels in the algorithm called scan-line algorithm and the direction of repairing is changed. For an assessment of altered image with two-sided scan-line method, less number of repetitions are required. The reconstructed images are better than any other is.

V. RESULTS AND DISCUSSION

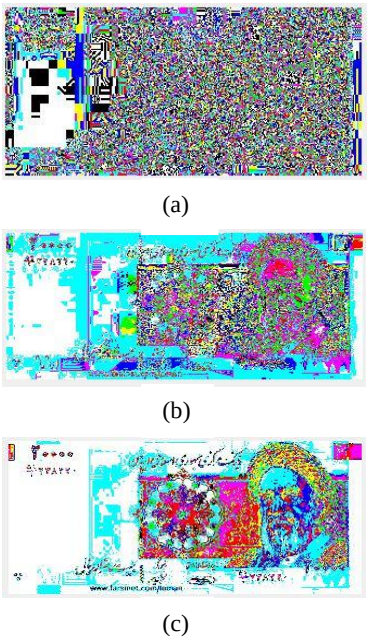
In this proposed model, several currencies were used for the identification process. The outputs consist of different image processing states for the three different currencies. The Fig. 5.1 shows the different stages of image processing to identify the US Dollar that is identified successfully. Fig. 5.2 shows the image identification of the France Euro with different preprocessing techniques. In fig. 5.3, Australian Dollar is identified successfully. In addition, some preprocessing techniques are shown that are performed during this process of identification.

Fig 5.1 US Dollar Identification.

Fig 5.2 France Euro Identification.

Fig 5.3 Australian Dollar Identification

The Fig 5.4 shows the evaluation of wrong image by the use of scan -line method. In addition, for this evaluation method, less number of iteration are required that can be seen as images are usually better as well.



(a)

(b)

(c)

Fig 5.4 The Iranian Rial image with 90% incorrect pixels (a), intermediate step of algorithm (b), and the result of scan-line algorithm (c)

VI. CONCLUSION AND FUTURE SCOPE

In this paper, we proposed a Currency identifying system using image processing method for users to recognize the currency to which country it belongs to efficiently and accurately. The system is eligible to recognize mostly all the currency available in the world. Various image processing and pre-processing techniques or algorithms are used to make the result more precise and logical. This includes the use of mean value of brightness of RGB model and also segmented the pattern from the currency and perform template matching to check the currency. A technique called Radial basis function is also applied for the recognition of damaged currencies. From the results we can conclude that this system is better than any other existing system as most of the currencies are identified easily.

In addition to the currency recognition system, this system can also be used for someone who is visually impaired, if the result in the form of text is changed to voice

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