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Banknotes detected using Image Processing Techniques

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Abstract - recently many researches have been performed made in the domain of banknote reader device. Such devices examine banknote worth and in some cases, have the ability to recognize and detect forgery. Important factors which play an important role in constructing this system are speed and accuracy; due to the rapid advancement and non-stop science and technology and so efficient algorithms, it can upgrade these factors. In this study, these algorithms will also be offered and will be implemented on the Iranian banknotes. In this paper, an automatic system is proposed. This system consists of two steps. First, the banknote image in input will be read by RGB color model. Then, applying image processing techniques, we get numerical model that is between 1 and 10. Second, the input banknote image is in black and white models. Then by applying some image processing techniques on the banknote image, the value of money will be determined.

Keywords - banknotes, histogram, OCR, PCA, neural network

I. INTRODUCTION

Human rapid approach is towards mechanization and manpower removal of the service work as much as possible and using this force in the development of scientific and research issues. This approach will lead to advances in science and technology.

Automated payment systems, including mechanized systems are considered more in recent years over the past and many activities in this regard is yielded.

One of the main parts in most automated payment systems is vision systems. One of the important science that is used in vision systems is science image processing. Image processing has flexibility and as a result it provides stronger algorithms in the field of creativity. Efficient algorithms (in automatic payment systems) have two factors of speed and the ability to tolerate noise. Banknote recognition system is a device that is able to recognize the value of banknotes intelligently and approve their forgery.

In the proposed system in this paper, attempt has been made to eliminate note noise as much as possible so that we can recognize the value of banknotes value more accurately and quickly.

In this study, an efficient algorithm for recognizing Iran's banknotes has been offered. Common Iranian currency includes: 100000 Rials, 500000 Rials, 20000 Rials, 10000 Rials, 5000 Rials, 2000 Rials and 1000 Rials. The main steps include pre-processed using image processing techniques.

Two different algorithms for the software is provided as following:

In the first method, the image of banknotes is taken by the camera in color using RGB model at first. In preprocessing, histogram normalization is applied on algorithm image resulting in increased image resolution. Then digitizing operationis used on the image using image processing techniques. It takes place by "correlation" techniques and a numerical pattern will be achieved in the end. Use this template to recognize the value of banknotes.

In the second algorithm, the image of the banknote is taken by the camera. Then it changes to a gray image. In the pre-processing stage, a series of image processing techniques will be applied to obtain a suitable model of input banknotes. Thus, by dividing the notes to certain parts, input banknote images will be turned to the images without noise. During this process, a large amount of image noise disappears as input data volume drastically reduced. Then, the patterns are divided into certain parts and banknote value will be determined and the numbers will be digitized and stored separately.

II. BACKGROUND

A . In the this method, the image is taken as an Iranian input banknotes and then the rotation angle of bank is gotten to balance the image. To be able to obtain rotation angle, two Points are taken into account and will make them in the shape of right triangle. utilize the relationship between triangle and its angles, we obtain the rotation angle of banknote. Then, using the Sobel filter, we do edge detection operations. By using the red Persian numbers, the Persian banknotes have been recognize by using specific features of banknotes, inversion of banknotes has been detected and corrected (using HSV) then by using processing techniques, the image of Persian numbers is emerged on banknotes. Then by using extracted numbers, special features of banknotes are determined to work with neural network and two neural networks are produced to detect and diagnose banknotes.[18]

B . PCA method is used to detect tissue of Image. The technique is for feature extraction and classification of images. This method reduces the data size and includes the main original data too.[19]

C . the color detection, banknote image is divided into regions, each of these sections has the same color or the color change is slow. The regional colors can be a well measure to determine the part of banknotes. Because the algorithm is a comparative algorithm, in the case of old banknotes which are pale, colors matching and their similarity will be determined. The median filter is used in the extraction stage. [19]

D . sofar, Iranian banknote identification can be done through using wavelet transform and neural network. This method uses wavelet transform to extract image features. The proposed method consists of two phases: In the first phase, a pre-process of the image is taken and its size is reduced and RGB image becomes gray. Extracted information can be used as inputs to the neural network.[19]

E . Alternatively, new detection algorithm of banknotes number is based on support vector machine. In this method, extracting serial number have been used to check the authenticity of banknotes. In another way, serial number is read by applying masking techniques and neural network and in other ways also the location of serial number is specified and by knowing the number location, the banknote number is extracted. [19]

F . Another method of banknote detection is edge detection. The edges of the banknotes images is diagnosed in this method and the image is divided into horizontal bands and then in each bar the number of points on the edge of pictures is counted and this data is applied to a Perceptron Neural Network.[19]

G . Diagnosing banknotes rupture by removing banknotes image from the reference image and calculating the size of the remaining part of the difference, the amount of rupture can be determined. Through drawing histogram, diagnosis can be done. [19]

H . After changing RGB to gray picture, image noises will be eliminated by filters and in case of tilt, its image is recorded by calculating the angle and rotating the image in the opposite direction. In order to do this, first, we remove additional parts of the picture with additional edges then we calculate the amount of rupture by removing the banknotes image from the reference image and calculating the size of the remaining part but in studies it was observed that due to the erosion of notes, the main difference between two pictures is calculated more than its real rapture. Simply by counting pixels on the banknotes image you can specify the amount of tears. By examining the appearance of Iranian banknotes it becomes clear that all banknotes except 5000 and 10000 have the most pixels on the left quarters. However, 5 and 10 thousand Rial banknotes have this feature on their right quadrant. We can have two sections of up and down serials. Taking the ratio between the two images we can estimate the percentage of similarity between the two series. [19]

III. PROPOSED BY METHOD

A . Pictures Database

With the development of electronic devices entering in the country's banking system, it was assumed that the role of banknotes in transactions Would be reduced but with all electronic amenities such as internet banking and bank cards and credit cards bank has retained its special status. ATMs, banknote staking devices, banknotes authenticity detection devices and banknote detection devices for the blind and etc. are produced for the simplicity of working with banknotes. This article has been provided a way to recognize the value of banknotes.

For this purpose, the Iranian banknotes are placed on a fixed plate camera and took shots from behind and front the banknotes using 14.2 MEGA PIXELS. Keep in mind that for the first time there should be unfolded and new banknotes.

For the other time, we took picture from dirty and torn banknotes.

To run this program we have used 2015 MATLAB software.

B . Picture Load

After editing, save the images in a folder and then we run the load command. Note that the image is in color and must be converted to gray images. Gray spectrum is composed of white and black color which is 256 in total. Fig. 1 shows the implementation of this order (the picture of behind and front of common Iranian banknotes).

Fig. 1 calling the Iranian currency banknotes

C . Removing banknote noises

To remove the possible noise on images due to camera shaking when taking pictures with the camera or photo taking, we consider a suitable mask and rotate it on banknotes. By reducing the image size or neighbor pixels and then by increasing image size or neighbor pixels we can make a balance in the picture. These operations are for interior side of the picture.

For exterior side of picture, by increasing the image size or neighbor pixels and then by reducing image size or neighbor pixels we can make a balance in the picture.

D . Histogram

The histogram is a graph shows the image content and light status. This graph is based on the frequency of an image pixel values. For example, in an image with gray background, the horizontal axis of the histogram has the range from 0 to 255 and the vertical axis is the representative of the number of occurrences of each of these numbers in the picture. all banknote histograms are plotted. None of the banknote histograms are the same, even the histogram of back and front of a banknote is different. It makes our work more difficult.

In Fig. 2, show banknote histograms based on their load in order.

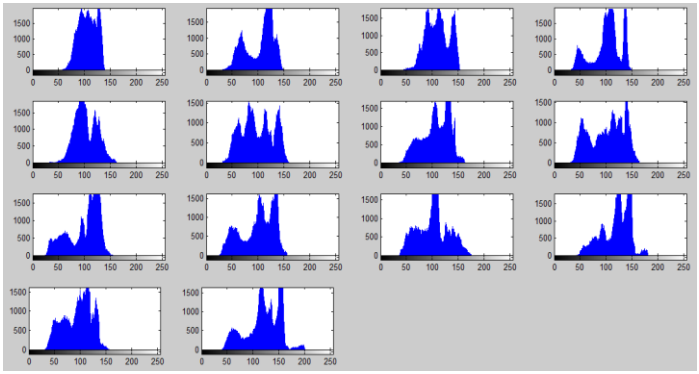

Fig. 2 draw a histogram behind the banknotes

In another test a few old and dirty banknotes with the same value are taken into consideration. The histogram diagrams are not the same, they are different. Fig. 3 shows this fact.

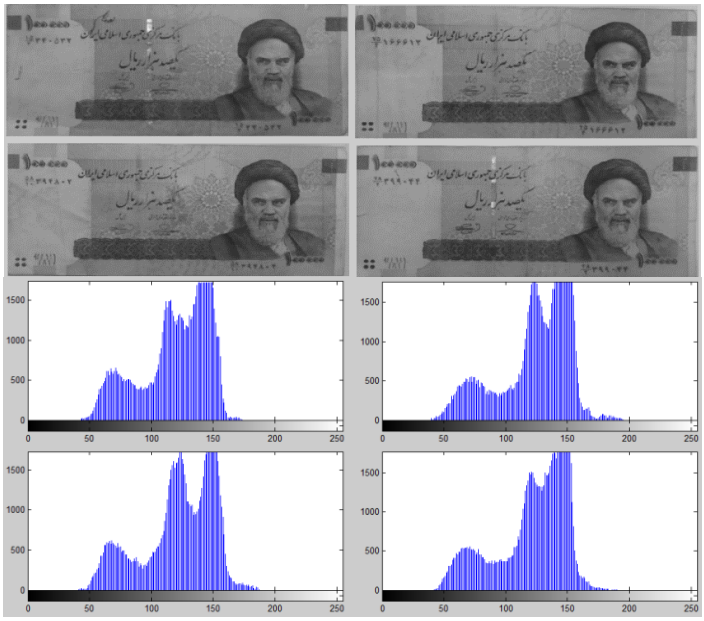

Fig. 3 draw a histogram few torn and dirty banknotes of equal value

E . Banknote Size

It can be seen that all Iranian banknotes have different size. For convenience, we consider all of the banknotes as the same size. The considered size for this program is [200 500].

F . Extraction of Banknote Value

As you see in Fig. 1, Iranian banknote values are in Persian side, at the top, on the left and underneath, on the right. First, find the center of banknotes and then by getting the matrix of values, we remove the values of banknotes.

To get the number on the banknotes, we use Sobel edge detection. In this way the desired results for the elimination of noise is not reached so we use another way. We introduce other algorithm in next part.

Fig. 4 picking the top left of banknotes

Fig. 5 picking the bottom right banknotes

G . RGB Photos

We work on the back of banknote in this algorithm. For example 5000 Rial banknotes.

A RGB photo with m*n*3 pattern is composed of color pixels in which each pixel is formed by three layers of red, green and blue everywhere. According to the class numbers in the image, RGB image layers have a range of numeric values.

Here after loading and saving notes, images R, G and B are separated.

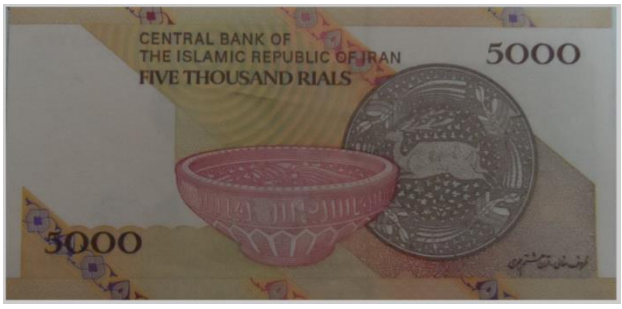

Fig. 6 5000 rial banknotes image

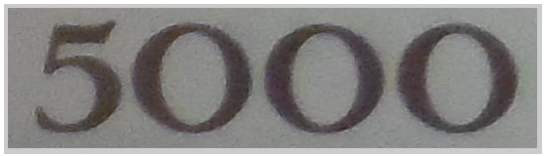

Fig. 7 separate the value of banknotes

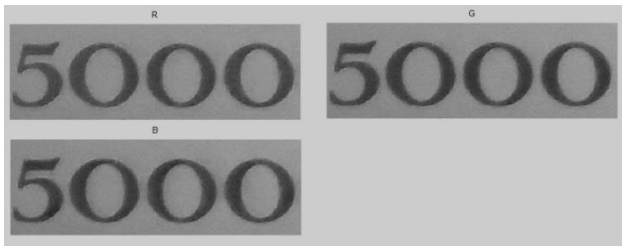

Fig. 8 images R, G and B

Then we turn acquired images to binary images. Fig. 9 shows this issue.

Then, noise will be destroyed around and outside images and then we get supplementary photo and use median filter to remove noise.

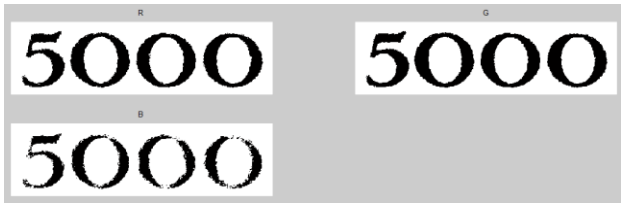

Fig. 9 convert images R, G and B in binary images

Fig. 10 pictures obtained after median filter

H . Extraction of Connected Components

We use this algorithm when we extract photo pixels with peculiarities which are connected to each other. Here we make a neighborhood of 8^{th}. We find interconnected components for obtained images so that numeric value in the new photo which belongs to an interconnected component is similar. For the first component and second component, 1 and 2 are considered respectively and so on. For photo R and for each interconnected component in R, we obtain the number of dots in the photo R. And if the amount of the total number of points is more than the corresponding interlocking G and B, this component is considered as noise and removed in the R photo. We repeat this procedure for photos G and B thus the meaningless parts are eliminated.

First "Bwlabel" command is used to calculate the connected components of 8-part photos. Then "find" function is used to provide sub-indexes for all rows and columns of pixels.

The noise in the photo is taken in this way.

The photos of R, G and B become OR together. The following photo shows the photo without noise.

Fig. 11 Noise

I . OCR

At this point we separate numbers. That's why we have used Latin part of the banknotes because OCR is not used for Persian part. Therefore, for the numbers from 0 to 9, a set of data is determined. However, we do "correlation" order of comparison. We

consider a fixed signal in convolution and then we upside down the signal or filter and then we shift. We act in correlation as convolution but we do not invert filter or signal.

The final result of this algorithm is as follows.

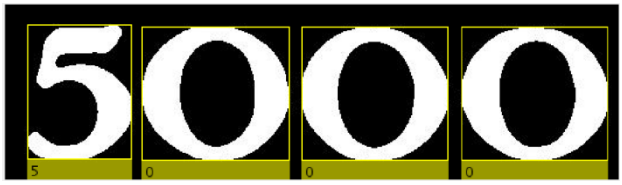

Fig. 12 The final results of the first algorithm

IV. THE SECOND ALGORITHM FOR DETERMINING THE VALUE OF BANKNOTES

A . Early Stages

We worked on the Persian banknotes in this algorithm. First we load the photo, then we change the photo into gray photo and then we use "binary" command automatically. Then we use edge detection order to remove the noise on the banknotes.

Fig. 13 50000 rial banknotes calls

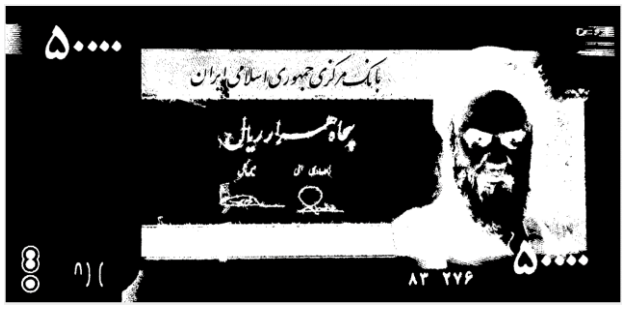

Fig. 14 Figure obtained after binary operations and splitter

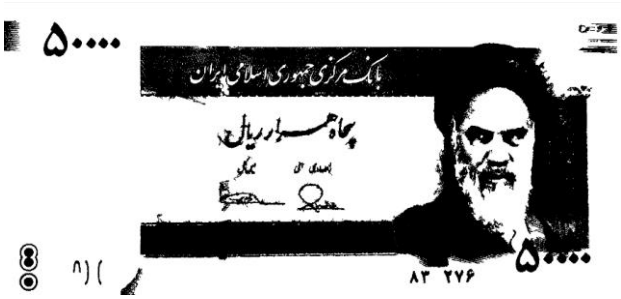

Fig. 15 negative the previous picture

B . Extraction of Interconnected Components

After performing the steps above, we obtain a binary photo of interconnected components. Each episode is a continuous component. We should obtain information about each component. Then we draw a rectangular box with the desired position. In fig 16, a rectangular box drawn around each interconnected component.

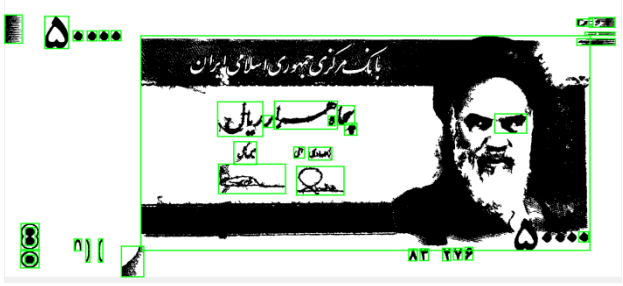

Fig. 16 dragging a rectangular box around each connected component

C . Finding the Value of Banknotes

In this stage, we obtain photo size and find the number corresponds to the value of banknotes and with interlocking element method, we draw rectangular box around the number one.

Fig. 17 Find the value of banknotes

D . Separation of Banknote Value

At this point we display the number as a digit. Keep in mind that the number must be saved and displayed at every step.

The final result of this algorithm is as follows.

Fig. 18 Final second algorithm

V. THE RESULTS OF THE PROPOSED METHODS

According to numerous applications of banknote readers in every society, which accelerate and make welfare more in the life of society, designing such devices is chosen as the project.

In other countries, for example, the device is used in the subway to receive and pay banknotes. To design the device, we must recognize the value of paper currency at first.

Before recognizing the value, the photo processing is done which is carried out in two ways.

In the first method, we take a banknote photo in RGB color model at first. Histogram normalization algorithm is applied on the photo in preprocessing resulting in increased resolution. Then digitizing operation is performed on the image using image processing techniques. It is carried out using correlation techniques and a numerical model is obtained finally. We use this template to recognize the banknote value.

In the second method, the photo of banknote is taken by camera. Then it is changed into a gray picture. In the pre-processing stage, a series of photo processing techniques is applied to obtain a suitable model of input banknotes. Thus, by dividing the banknotes into certain parts, the input banknotes is turned into without-noise photo. During this process a large amount of photo noise is disappeared and input data size is decreased dramatically. Then, the patterns are divided into certain parts and estimate the banknote value and digitize numbers in order and store them separately.

During this process we managed to eliminate some of the photo noise of input banknotes. It should be noted that the proposed algorithm is very flexible and by working on it much more noise can be removed from the input photo.

VI. CONCLUSION

In the proposed method, we have taken the photo of input Persian banknotes and then we have displayed the banknote values in number by removing existing noise and using photo processing techniques.

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