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An algorithm to Recognize Number in Image: Based on Statistical Image Analysis

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Abstract

In many applications images consist of different types of objects. The object recognition is considered to be the largest challenge in image processing and computer vision. This work aims to recognize the numbers (as objects) in image. This paper introduces an algorithm for number recognition. The algorithm based on three major approaches that are: thresholding for converting gray level image into binary image, by using global threshold value, which obtained by iterative algorithm. The second approach is a median filter method for noise reduction that is considered to be good approach in case of salt and pepper noise. The third method is projection approach for dimensional reduction (image strip), this is done by calculate the sum of rows and columns of filtered image, and then determine the properties of each number. The algorithm has been applied to simulated data and gave good results, after then algorithm is applied to real data, and success results have been achieved in this case.

Keywords: Object recognition, Iterative Thresholding, Median Filter, Projection Approach, Image analysis.

1 Introduction

Image analysis has become more and more important field, and has a wider use in many areas. Image analysis satisfied many successful applications by using statistical concepts such as, Markov random models, statistical moments, conditional probability, and Bayesian approaches [6]. Image analysis is a process of image description with quantities measurement, where the input in this process is an image, while the output is quantities information. The definition of image processing is different from image analysis, where the techniques those are used to enhance pictures or any other images, such as space probes pictures, aircraft pictures, are called image processing. Image processing is applied in many fields, for example, graphic arts, film industry, documents processing, medical imaging, etc [11].

Pattern recognition is a process to detect one object or more from noisy image, after enhancing it. This process depends on determination number of objects in scene, location of each object, objects size, shapes, and spatial relation. There are two approaches of pattern recognition, decision-theoretic and structural, recognition the object by quantitative descriptors, such as length, area…etc leads to first approach, while the second approach depends on recognition object by qualitative descriptors [2]. The major classification of pattern recognition system (PRS) is:

Rule Based System, Classical Fuzzy System, Neural Networks System, Fuzzy Neural Networks System, and Bayesian System [5].

This work seeks to introduce an algorithm to recognize the number in the image. The objective will be to identify the number in the image automatically. To attain successive results of recognition process, the object shape should be determined. The algorithm is based on explore some characters for each number. These characters are used to recognize the numbers. The first step in the suggested algorithm is to segment the image into foreground (object) and background, the thresholding method will be applied in this step, and herein the iterative method is used.

The segmented image may contain on salt and pepper noise, and then the median filter method is proposed to remove this noise.

The projection method is the third stage in the algorithm; this method produces the horizontal and vertical profiles of image. These profiles will be used to extract some characteristics for each number to identify it.

Many authors and researchers introduce algorithms and apply them to detect numbers in image.

Ozbay and Ercelebi designed a simple algorithm for Automatic Vehicle Identification by Plate Recognition [10]. The algorithm depends on three major steps: extraction of plate region, segmentation of characters, and characters recognition.

They convert RGB (Red Green Blue) image into BW (Black White) image by using threshold, and used smearing algorithm to determine text area. Then, dilation is used for specifying the plate location. Segmentation is applied to separate plate character; they also applied the horizontal and vertical smearing to fined character regions. , next step is recognition the characters in each block by using template matching algorithm.

Maarif and Sardy introduced a system for plate number recognition [7]. The basic steps in their study are plate localization, and plate character recognition. In first they used mathematical morphology for plate localization, artificial neural network for plate character recognition.

Osorio *et al*. designed an artificial vision system used to recognize the Spanish cars license plate number [9]. They used soble to determine the boundaries of the plate. After this step they used threshold to convert multi colour image into binary image. Also they applied soften filter to count the number of white pixels in the image which are expected to give an idea about plate location. Finally character recognition has been done by techniques of data mining.

2 Method of analysis

2.1 Thresholding

In the field of digital image processing, some methods require dividing an image to regions represent the objects and the other represent the background. One of the most common methods is thresholding [2]. The basic concept of thresholding method is to classify a group of pixels that have values higher than threshold values as foreground with unique values equal to 1, and the other group of pixels that have values equal or lower than threshold values as background with unique values equal to 0 (or vice versa) [8]. In this paper threshold value will be selected by an iterative algorithm.

2.2 Median Filter

Median filter, which suggested by Tukey in 1974, is used to reduce the effect of noise. The basic idea of the median filter is sorting the intensity values of specified neighborhood (first order or high order) and replacing each pixel in this neighborhood by median of its neighbors, this process will be achieved for all pixels in the image [4]. Mean filter can be used, if the distribution of neighborhood is Gaussian distribution [3]. Sorting intensities values in increasing or decreasing order makes median approach too expensive to time as the resolution increases. After sufficient iterations of median process, the final result will produce more accurate version of input image [1].

2.3 Projection Approach

Projection method is used for dimension reduction; it is a mathematical transformation which is used to map three dimensional plane (3D) into two dimensional plane (2D). The projection method is widely used in many scientific areas such as chemistry, physics, and medicine. Image reconstruction from Projection which is considered to be special class of image restoration, this is done by obtained two or higher dimension of object from one dimension project, as example, x-ray pictures which is used in medical imaging [12].

In this paper, projection method is suggested to obtain image stripe (one dimensional data) by calculation the sum of rows and columns of binary image.

3 The General Algorithm

The general algorithm, of number recognition, consists of some methods and steps which can be summarized as follows:

Firstly, the image is converted to binary and free-noise image, as much as possible, by the following steps.

1. Select global threshold by the iterative algorithm.
2. Apply the obtained threshold to segment the image into foreground (object) and background.
3. Use the median filter method to remove the noise in the thresholded image.

After the techniques of low-level image processing have been done, next step is number recognition or high- level image processing which is constructed as follow:

4. Find the vector H that consists of horizontal profile, and another vector V for vertical profile. This step is projection approach.

5. Remove the zeros values, and repeated values from the vectors H and V in step 4.

Now, the properties to recognize each number are in the following steps

6. If there are three elements in both vectors H^* and V^* the first value is equal to the third value in both vectors H^* and V^*, also the first value and the third value are greater than the second value in both vectors H^* and V^* then the number is zero.
7. If there exist one element only of vectors H^* and V^*, then the number is one.
8. If there are three elements in vector H^* and five elements in vector V^*. The first value and the third value are greater than the second value in vector H^*, also the first, the third, and the fifth values are greater than the second and the fourth values in vector V^*, this property is important to recognize the number two but it is not sufficient since the profiles of numbers two, five, and eight are similar, the algorithm will give misleading results. So, the algorithm suggests extra properties to distinguish the numbers two, five, and eight, these properties are:

   Store the first group of the vertical non-zeros values in matrix, that represents the binary image, in vector A this process will continuous until get on first zero in the image and store the last group of the vertical non-zeros values in matrix, that represents the binary image, in vector B if the length of vector A is greater than the length of vector B, then the number is two.

9. If the length of vector H^* is equal to two, and the length of vector V^* is equal to five, the second value is greater than the first value in the vector H^*, then the number is three.
10. If three elements are in both vectors H^* and V^*. The third value has the largest value in vector H^* and the middle value has the largest value in vector V^* then the number is four.
11. If there are three values in vector H^* and five values in vector V^*. The first value and the third value are greater than the second value in vector H^*, also the first, the third, and the fifth values are greater than the second and the fourth values in vector V^*, extra properties are:

    Store the first group of the vertical non-zeros values in matrix, that represents the binary image, in vector A this process will continuous until get on first zero in the image and store the last group of the vertical non-zeros values in matrix, that represents the binary image, in vector B if the length of vector A is less than the length of vector B, then the number is five.

12. If there are three values in vector H^* and five values in vector V^*. The first value has the largest value in vector H^* and the second value is greater than the fourth value in vector V^* of the same vector, then the number is six.
13. If the length of vectors H^* and V^* are equal to two, the second value is greater than the first value in both vectors H^* and V^* then the number is seven.
14. If there are three values in vector H^* and five values in vector V^*. The first value and the third value are greater than the second value in vector H^*, also the first, the third, and the fifth values are greater than the second and the fourth values in vector V^*, extra properties are:

    Store the first group of the vertical non-zeros values in matrix, that represents the binary image, in vector A this process will continuous until get on first zero in the image and store the last group of the vertical non-zeros values in matrix, that represents the binary image, in vector B if the length of vector A is equal to the length of vector B, then the number is eight.

15. If there are three values in vector H^* and five values in vector V^*. The third value has the largest value in the vector H^* the fourth value is greater than the second value in vector V^*, then the number is nine.

The above properties to recognize each number are summarized in Table 1, but before this it is necessary to explain some symbols.

N = number of rows, M = number of columns.

H^*: Vector contains values those resulted from horizontal profile, after excluding the zeros and repeated values. V^*: Vector contains values those resulted from vertical profile, after excluding the zeros and repeated values.

$h_i^* = i^{th}$ element of vector H^* , and $v_j^* = j^{th}$ element of vector V^*.

The vectors A and B contain additional steps to recognize the numbers two, five, and eight.

Table 1: Summary of general algorithm steps

	Properties of rows	**Properties of columns**	**The classification**
1	$h_1^* = h_3^*$, $h_1^*, h_3^* > h_2^*$	$v_1^* = v_3^*$, $v_1^*, v_3^* > v_2^*$	The number is zero
2	One element in vector H^* is h_1^*	One element in vector V^* is v_1^*	The number is one
3	$h_1^* = h_3^*$ $h_1^*, h_3^* > h_2^*$	Length(A)> Length(B) $v_1^*, v_3^*, v_5^* > v_2^*, v_4^*$	The number is two
4	$h_2^* > h_1^*$	$v_1^* = v_3^* = v_5^*$ $v_2^* = v_4^*$	The number is three
5	$h_3^* > h_1^*, h_2^*$	$v_2^* > v_1^*, v_3^*$	The number is four
6	$h_1^* = h_3^*$ $h_1^*, h_3^* > h_2^*$	Length(A) < Length(B) $v_1^*, v_3^*, v_5^* > v_2^*, v_4^*$	The number is five
7	$h_1^* > h_2^*, h_3^*$	$v_1^* = v_3^* = v_5^*$ $v_2^* > v_4^*$	The number is six
8	$h_2^* > h_1^*$	$v_2^* > v_1^*$	The number is seven
9	$h_1^* = h_3^*$ $h_1^*, h_3^* > h_2^*$	Length(A) = Length(B) $v_1^*, v_3^*, v_5^* > v_2^*, v_4^*$	The number is eight
10	$h_3^* > h_1^*, h_2^*$	$v_1^* = v_3^* = v_5^*$ $v_2 < v_4$	The number is nine

4 Applications

4.1 Simulated data

Number three has been generated to demonstrate the suggested algorithm. An image, with number three as object. The resolution of this image is 200 $\times$200 pixels. The values of pixels those represent the object are equal to one.

The Gaussian noise, with mean 0 and standard deviation 0.2, has been added to the image and the resulted image is shown in Figure 1(a).

The threshold value that obtained from iterative algorithm is 0.493. Then filtered image is obtained by median filter approach.

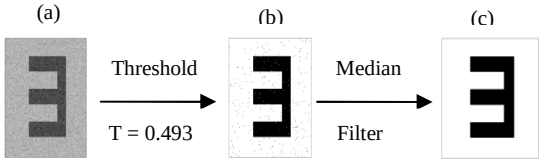

Figure 1: (a) Noisy image, (b) Thresholded image, (c) Filtered image.

Projection method is plotted in Figure 2.

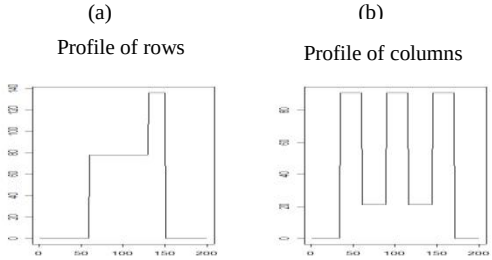

Figure 2: Projection: (a) Horizontal profile, (b) Vertical profile.

The profile of rows is shown two groups of non-zero data, while the profile of columns, has five groups of non-zero data. The two profiles are summarized to: H^* = (78,136), and V^* = (91,21,91,21,91).

Since the length of vector H^* is equal to two, and the length of vector V^* is five, also the second value in the vector H^* has the largest value $h_2^* > h_1^*$. The property 4 in the Table 1, then the number in the image is detected as number three, (step 9 in the general algorithm).

4.2 Real data

The good achievement in the applications to simulated data has been obtained, gives to the algorithm validation to apply to real data. This paper presents example for applying the algorithm to real data. Real image data, in this example, has been taken from the website:

http:// www.pongsaversshot.html.

last update: 24/8/2009, and it is shown in Figure 3, represents the numbers which are one,seven, two, and eight. The image resolution is 193$\times$ 368.

Figure 3: Real data image.

The next step is to segment the image into object (foreground) and background. To do so, iterative threshold is used for image. The threshold value for this image is 64.615 this value is used to segment image into binary image, as shown in Figure 4.

Figure 4: Segment image for real data image.

Visually the image is seemed to be free of noise, but some edges of numbers two and seven are lost this will cause a problem in recognition them, since those edges represent important information for recognition algorithm. So median filter will be used to solve this problem. The data will be passed through the median filter as next step in the algorithm; the filtered image is illustrated in Figure5.

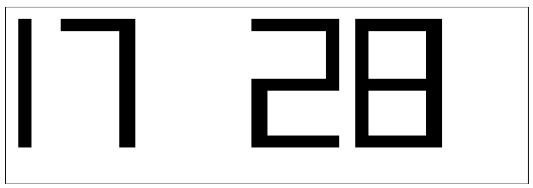

Figure 5: Filtered image using median filter.

Since the algorithm is designed to detect one number in image, so it is necessary to divide the image into four sub-images. Figure 6 shows this step which is needed to apply the algorithm.

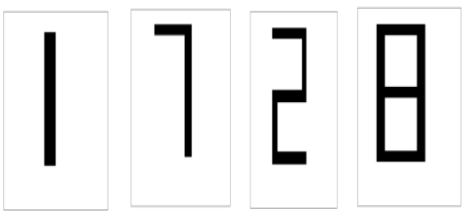

Figure 6: Sub-images of the filtered image.

Projection method is implemented to the binary data. This method will yield horizontal and vertical profiles, which are plotted in Figure 7.

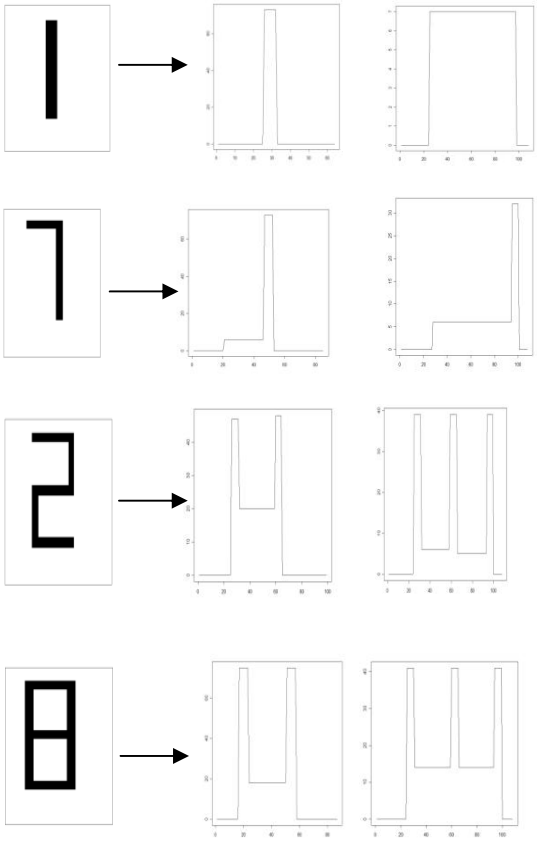

Figure 7: sub-image; Middle panel: horizontal profile for each sub-image; Right panel: vertical profile of each sub-image.

The horizontal and vertical profiles, for each number, have been summarized into the following vectors:

Object	Horizontal profile H^*	Vertical profile V^*
Number 1	(73)	(7)
Number 7	(6, 32)	(6, 73)
Number 2	(47, 20, 48)	(39, 6, 39, 5, 39)
Number 8	(75, 18, 75)	(41, 14, 41, 14, 41)

For one element only in both vectors H^* and V^*, the algorithm is recognized the first object in this image as number one.

Since the length of vectors H^* and V^* are equal and the second value is greater than the first value of vectors H^* and V^*, $h_2^* > h_1^*$ and $v_2^* > v_1^*$, then the second object is recognized also which is seven.

There are three values in vector H^* and five values in vector V^*. The first value and the third value are greater than the second value in vector H^*, $(h_1^* \& h_3^*) > h_2^*$ also the first, the third, and the fifth values are greater than the second and the fourth

values in the vector V^*, $(v_1^* \& v_3^* \& v_5^*) > (v_2^* \& v_4^*)$. According to extra steps in the general algorithm, the length of vector A is 69, and the length of vector B is 34, since length (A) > length (B), the algorithm will detect the number in this image as number two.

Both vectors A and B have the same length of 132, and then the number is detected as number eight.

5 Conclusions

This paper proposed an algorithm to detect the numbers in an image the proposed algorithm is based on a combination of some methods, such as threshold approach, median filter method, and projection method.

The iterative threshold method was adopted to segment image into object and background. The median filter method is applied to remove isolated pixels. The projection method has been used for dimensions reduction. The properties, which characterize each number, have been created to recognize the number.

Due to similarity in properties of some numbers such as two, five, and eight, the algorithm suggested to add extra properties is more able to distinguish these numbers.

The design of algorithm was independent of size and position of the object.

The suggested algorithm which is applied to simulated images (numbers from zero to nine) has achieved its goal in detecting numbers. The algorithm is then applied to real data.

The algorithm is designed to recognize single number, in future the algorithm can be extended to use in case of multi numbers in image, by adding some steps, also the algorithm maybe adjusted to recognize any type of numbers. Letters recognition can be done by using number recognition algorithm, which presented in this paper if properties of each letter can be created.

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