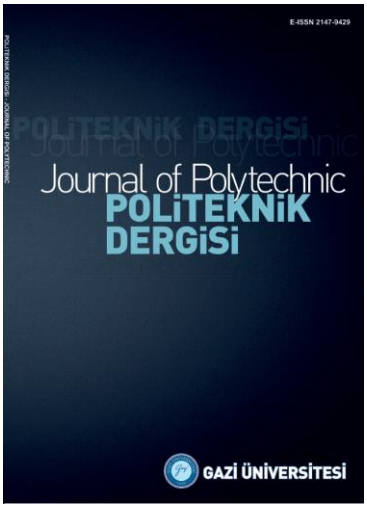

POLİTEKNİK DERGİSİ

JOURNAL of POLYTECHNIC

ISSN: 1302-0900 (PRINT), ISSN: 2147-9429 (ONLINE)
URL: http://dergipark.org.tr/politeknik

Effects of character recognition with Shell histogram method using plate characters

Plaka karakterleri kullanılarak shell histogram yöntemi ile karakter tanıma

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Bu makaleye şu şekilde atıfta bulunabilirsiniz(To cite to this article): Arslan Uzun R., İncetaş M. O. and Dikici S. "Effects of character recognition with shell histogram method using plate characters", ***Politeknik Dergisi***, 22(4): 1093-1099, (2019).

Erişim linki (To link to this article): http://dergipark.org.tr/politeknik/archive

DOI: **10.2339/politeknik.593633**

Effects of Character Recognition with Shell Histogram Method Using Plate Characters

Araştırma Makalesi / Research Article

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(Geliş/Received : 18.07.2018 ; Kabul/Accepted : 20.08.2018)

ABSTRACT

Character recognition is a study that has been used in various fields for many years. In character recognition, the aim is to identify the various texts, letters and symbols in the images as accurately and quickly as possible. In addition to the Optical Character Recognition (OCT) method, which is used as a very common method, there are many feature extraction methods in which character image features are compared. In this study, which is presented as another feature extraction method, the letters on the license plates are recognized. The characters were examined using the circular shape histogram technique and histograms were obtained from the sectors within the circular regions. Feature vectors for letter characters were created using character pixel densities in sectors. Feature vectors are analyzed linearly and an alternative quick character recognition method is presented. With the proposed method, the element numbers of the feature vectors are kept constant. In this way, both the processing speed is increased and the processing speed variations are minimized. The results show that the proposed method requires lesser parameters than the OCT method, but also has a significant success rate according to known feature extraction methods.

Keywords: Character recognition, feature extraction, shape histogram.

Plaka Karakterleri Kullanılarak Shell Histogram Yöntemi İle Karakter Tanıma

ÖZ

Karakter tanıma çalışmaları, uzun yıllardan beridir çeşitli alanlarda kullanılmaktadır. Karakter tanıma işleminde amaç görüntüler içerisindeki çeşitli yazı, harf ve simgelerin olabildiğince doğru ve hızlı bir şekilde tanımlanmasıdır. Çok yaygın bir yöntem olarak kullanılan Optik Karakter Tanıma (OKT) yönteminin yanı sıra karakter görüntü özelliklerinin karşılaştırıldığı birçok özellik çıkarım yöntemi de mevcuttur. Bir başka özellik çıkarım yöntemi olarak sunulan bu çalışmada araç plakalarındaki harflerin tanınması amaçlanmıştır. Karakterler dairesel şekil histogramı tekniği kullanılarak incelenmiş ve dairesel bölge içerisindeki sektörlerden histogramlar elde edilmiştir. Sektörlere ait histogramlar kullanılarak harf karakterlerine ait özellik vektörleri oluşturulmuştur. Özellik vektörleri doğrusal olarak analiz edilerek, alternatif bir hızlı karakter tanıma yöntemi sunulmuştur. Önerilen yöntem ile özellik vektörünün eleman sayısı sabit tutularak hem işlem hızının artırılması hem de işlem hızındaki değişkenliğin minimuma indirilmesi amaçlanmıştır. Elde edilen sonuçlar, önerilen yöntemin OKT yöntemine göre daha az işlem yükü gerektirmesinin yanı sıra bilinen özellik çıkarım yöntemlerine göre de kayda değer bir başarı oranına sahip olduğunu göstermektedir.

Anahtar Kelimeler: Karakter tanıma, özellik çıkartımı, şekil histogramı.

1. INTRODUCTION

Character recognition is the process of converting characters in hand-written or images into computer environment, correctly. Character recognition that allows the characters in printed or digital media identified accurately and converted to editable text data, is used many different application areas such as, the recognition of the money or the checks in banking, the exaction of the texts to computers automatically in librarianship, automatic detection of the license plates of vehicles on the freeway etc [1, 2]. Character recognition is generally performed by two main methods. One is the Optical Character Recognition (OCR) method in which all character pixels are matched, while the other is the feature extraction method in which the attributes obtained from the pixel groups of the characters are used as distinctive.

At the OCR method forming the basis of character recognition studies, the closest letter/number is selected by matching the all pixels of the characters with the character pixels in the database [3]. In literature, it was shown that high performances have been achieved with the use of this method also named as template matching [4-8]. For instance, it was obtained 97.6% success rate with applying this method in a study on which high quality images were used [4]. Shapiro et al. [5] (2006) and Targian et al. [6] had achieved success rates of 98.2%

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and 97.18%, respectively, by utilizing OCR method to identify characters accurately. In this method, it can be obtained high success rate whereas lots number of operation necessitate because of the usage of whole pixel groups. Besides, in this method, database should be comprised from templates in which different character fonts can be matched. This causes lots of operation and data density in analyses. Therefore, It has been improved various feature extraction methods alternative to OCR.

The purpose of feature extraction methods is that character recognition can be done with less operation, by extracting feature vectors having specified number of element instead of matching of whole pixels. Common feature extraction methods include horizontal and/or vertical projection and sub-blocks techniques. In the horizontal and/or vertical projection techniques, the character region is scanned horizontally and vertically. The number of character pixels at the scanned direction is found with sum of the character pixels in this direction. Thus, the feature vector of the character is formed with the numbers of character pixels in each row or column. Kim and Chien [9] achieved a success of 85.5% in character recognition by using the vertical projection method. In the sub-blocks technique, the character zone is divided into small rectangular regions of certain dimensions and feature vectors are obtained with pixel densities in these regions. Amit et al. [10] created the feature vectors with pixel densities in the 5x5 rectangular areas of the character region and achieved a 94% character recognition success for 520 characters. The element numbers of feature vectors vary, depending on the dimensions of the characters and images at both the sub-block technique and the horizontal and/or vertical projection technique. For instance, in the horizontal and/or vertical projection techniques, element numbers of the feature vectors of characters will be different since the lengths and widths of the characters are different. In the sub-blocks technique, the sub-block dimensions are constant regardless of the image size. Therefore, element numbers of feature vectors of character will be different.

In this study, it is proposed a new feature extraction technique alternative to before mentioned techniques for systems where security is very important [11, 12]. The proposed technique takes advantage of the shape histogram generally used in image analysis [13]. To do this, the character zone is divided into 16 sectors by taking it into a circular grid. Then, character feature vectors is created with pixel densities in each sector. It was aimed to predict correctly by comparing the obtained feature vectors with all characters. The proposed technique enables to recognize characters by usage of less data.

2. MATERIAL and METHOD

2.1. Shape Histogram

In image processing, the histogram is defined as the statistical distribution of all gray levels of a digital image [14]. Shape histogram refers the gray level distributions of the pixels at the regions obtained by dividing the areas of objects in the image in various ways. In order to calculate, compare and define the geometric similarity of objects, one can use shape histogram from which the feature vectors are obtained by the image segmentation [15]. In this context, Tangelder et al. [16] analyzed the image in a circular manner and proposed 3 different models. These models shown in Figure 1, respectively, are shell model formed with concentric shells, sector model divided circular area into equal sectors by concentric lines, and spider web model obtained by combining these two models.

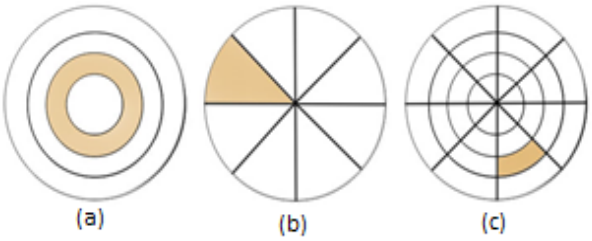

Figure 1. Circular shape histogram models **(a)** Shell model **(b)** Sector model **(c)** Spider web model

In the shell model, the center of the object is detected, then the object is separated into concentric shells beginning from the center, and the distribution of the pixels is generated based their distances from the center. In the sector model, object is divided into circular sectors by means of concentric lines at equal angles. In this model, feature vectors obtained by pixel distributions in each sector can be used to get pixel densities of the image at various directions. In the spider web model created by combining of both models (sector model and shell model), one can obtain the feature vectors that give information about the object in more detail. In this model, the object can be divided into different number of sectors and shells, and thereby, feature vectors in different structure can be obtained.

Figure 2 shows the shape histograms obtained by three models mentioned above for image containing a 'Z' character. When the pixel distributions of the object are examined in the shell model, especially in the shells 5, 6 and 7, it is clear that the pixel density is higher in middle shells. In the sector model, the separated regions are concentric and equal distance to the edges, and thus, it can be possible to determine direction on which pixels of the object are more intense. When the Z letter image is studied, it can be seen that pixel densities are high in sectors 6, 7, 15 and 16 whereas it is lower in sectors 4, 5, 12, and 13. This shows that Z letter has a rectangular shape, also is piled on top and bottom sides. Spider web model gives information about both the whole directions and the regions at different distances from the center of the object. Feature vectors can be created with the help of the shape histogram graphs obtained by using these models.

The feature is defined as a measurable function of each element's information [17]. Feature vectors are generated

by collecting in a series of the features of objects within the image, such as color, gray level distribution, edge information, and formal contents. These give quantitative information about images. Therefore, it is often used in studies such as character recognition [18], image matching, and similarity calculations [19]. In the literature, there are many studies that allow objects and their similarity to be identified by creating feature vectors with shape histogram [20-24].

2.2. Feature Extraction for Characters

The characters are different in shape and are separated from each other by these differences. In this study, Spider

In order to compose feature vectors, at first, characters should be detected in image and decomposed from each other. Therefore, color images converted to gray level are transformed to binary image and segmentation process is executed. In this study, Otsu method is used for binary transformation of image [25]. If pixel values in the image are greater than the threshold value T, their value are taken as 1 otherwise their value are 0, as given below:

$$G(x,y) = \begin{cases} G(x,y) = 0\,; & x < T \\ G(x,y) = 1\,; & x \geq T \end{cases} \quad (1)$$

Image should be segmented so that the characters in the image can be processed as different objects.

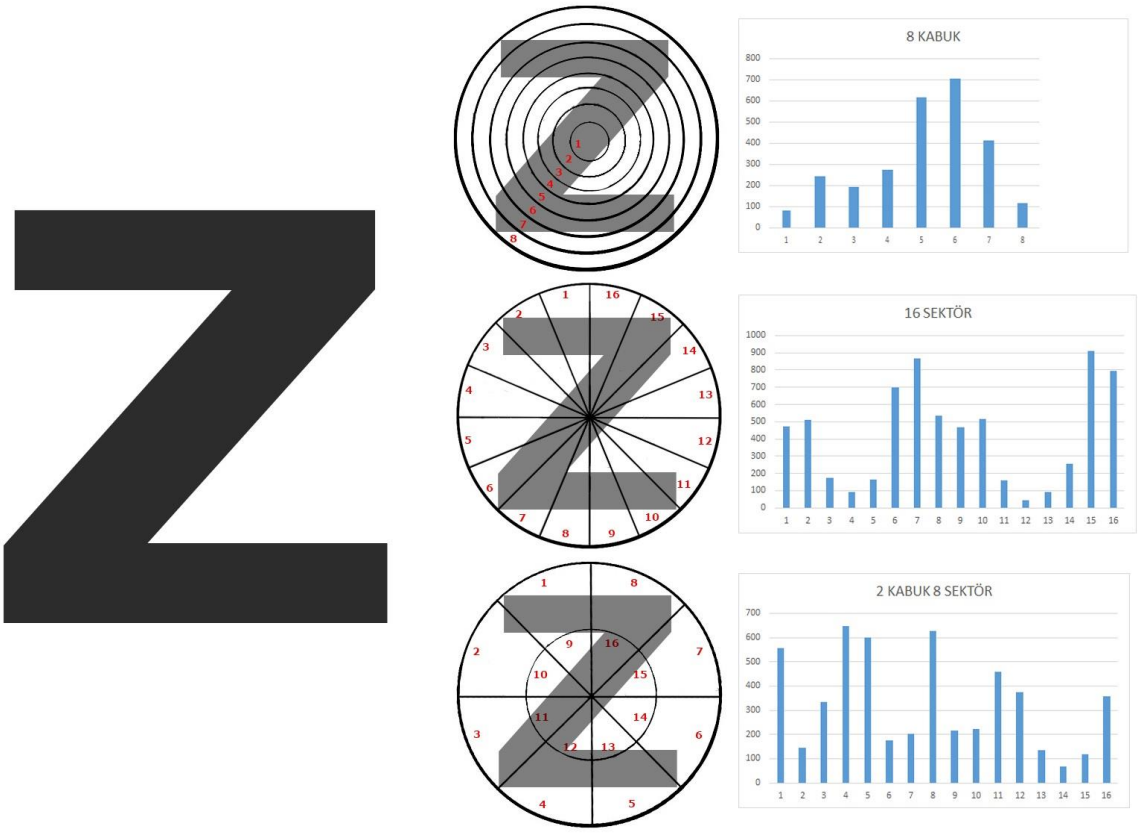

Figure 2. Shape histograms of a letter

Web model shown in Figure 1c is used in order to exhibit these character differences statistically. To introduce characters to the database, it is used 4 different font styles which are commonly preferred in license plates in Turkey (Figure 3). In this context, first, all characters are divided into sections by means of circular shape histogram for each font style. Then, a single feature vector is composed for each character by averaging of the feature vectors obtained from the character pixel densities in all sections.

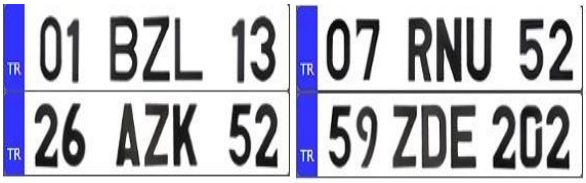

Figure 3. Commonly preferred license plates fonts in Turkey

Segmentation is generally the process of separating regions having different characteristics. In this study, the segmentation of the images converted to the binary format is performed by the usage of labeling method in decomposing of the characters. In the labeling method, the pixels of the binary image are enumerated by scanning vertically and horizontally. For each scanned pixel, the neighborhood with the previously labeled pixels is checked. Different groups of pixels without any neighboring relationship are given new label numbers, so that the non-connected shapes are separated. The transformation of an image to binary format, the segmentation and labelling of the inverted image is shown in Figure 4.

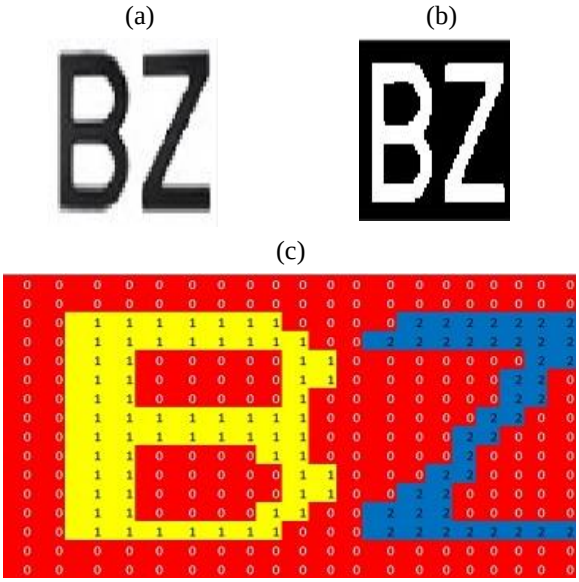

Figure 4. (a) Binary image **(b)** Inversed binary image **(c)** Labelling and segmentation of the characters

In the study, 16 element circular shape histogram is used to obtain the feature vector for each character separated by labeling. While the histogram is being created, the central position of each character is determined, the distance of the character pixel farthest from this position is calculated and the diameter of the circular shape is identified. Thus, all of the character pixels are ensured to be in the circle. Then; an inner circle with a half diameter of the outer circle and inner cross sections dividing these circles into 16 sections by horizontal, vertical and diagonal are constituted. The pixels within the sections of the circular shape histogram have been used to compose 16-elements feature vectors of the characters. Figure 5 illustrates examples of the separation of various characters into sectors.

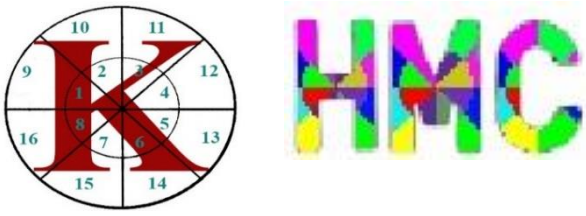

Figure 5. Analyses of the characters by using shape histogram

By separating each character into 16 sections and calculating the Sector Character Pixel Count (SCNP) ratio as the total Sectoral Pixel Count (NSP), the 16-element feature vectors are created (consumed) for all characters in 4 different font styles. By taking the average of the 16-element feature with vectors created in the four different font style for the each character with Equation 2, a single feature vector (C_i) have been created for each character.

$$C_i[j] = \frac{1}{4}\sum_{n=1}^{4}\frac{SCNP_j}{NSP_j} \quad (2)$$

where j is the section of the circular shape histogram, C_i is 16-elemet feature vector of the each character and n indicates 4 different font style. Calculated C value is average of the feature vectors of each characters in the 4 different font style. Thus, a more general feature vector has been composed by the use of several different fonts instead of a single font for all characters. Figure 6 shows how the fifth element of the 16-element feature vector of the A character has been obtained by this method. The fifth element of the feature vector defined to database for the A character has been identified by taking average of pixel densities in the 5th sector of each font using Equation 3:

$$C_A[5] = \frac{1}{4}\sum_{n=1}^{4}\frac{SKPS_A}{SPS_A}\frac{1+0{,}986+0{,}885+0{,}866}{4} = 0{,}934 \quad (3)$$

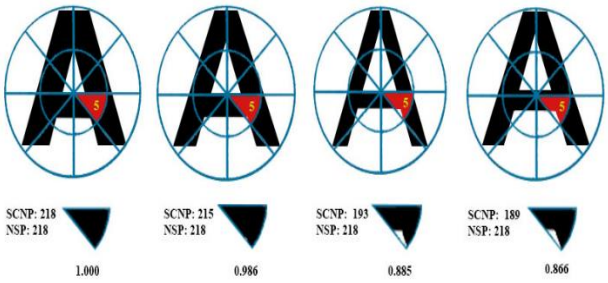

Figure 6. Calculation of pixel densities in one sector of shape histogram for 4 different font style of *A* character

The feature vectors obtained by the proposed this method are different for each letter. This is shown in Figure 7 by giving the distributions of the pixel densities of the letters A, E, G and T for each sector.

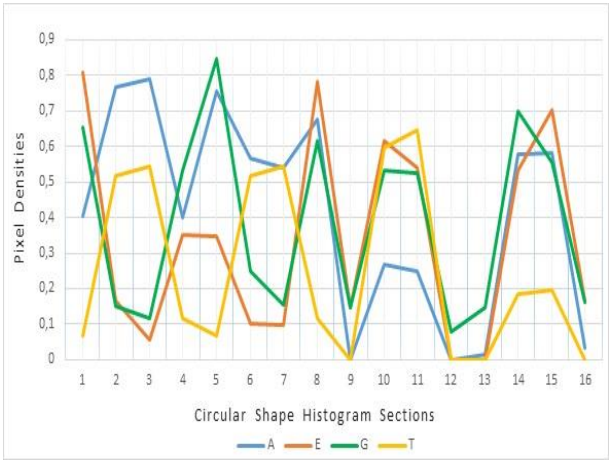

Figure 7. The feature vector graphs of *A*, *E*, *G*, and *T* characters

3. EXPERIMENTAL RESULTS

In the study, first, a database has been created from the 16-element feature vectors of the characters which are

used broadly in license lates in Turkish Republic by using circular shape histogram. The feature vectors have been composed from the average of the vectors in different font style for each letter. When recognizing a randomly selected character, a 16-element feature vector (R) has been extracted by usage of a circular shape histogram for that character. The obtained R vector has been compared linearly with each C_i vector in the database. The absolute differences between each element of R and $C_i$vectors have been summed and the error amount (E_i) has been calculated. The character candidate is determined from the minimum error rate inside the calculated E_i values for each 23 character as follows;

$$E_i = min(\sum_{k=1}^{16}(|R[k] - C_i[k]|)) \quad (4)$$

personnel computer with an Intel® Core™ CPU at 2.93 GHz and 3 GB of RAM.

The success of the proposed method was examined for 65 license plate images involved two or three letters. The results of the recognition process, which have been analyzed for total 166 characters comprised at least of 7 from each character, are shown in Table 2. A success rate of 95.2% has been obtained by estimating 158 inside 166 characters accurately. Also, it has been observed that 8 characters could not be detected correctly and therefore the false detection rate is below 5%.

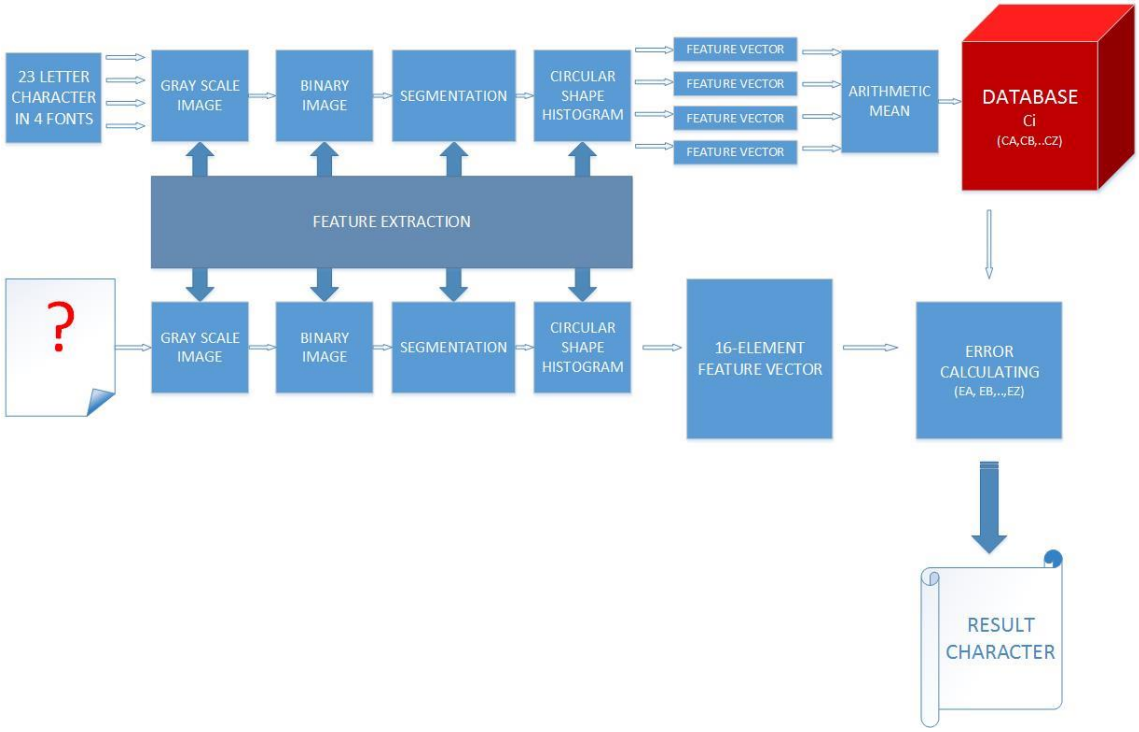

Figure 8. Flowchart of the proposed method

Table 1 shows the error rates that are calculated for some candidate characters (*A*, *E*, *G*, and *T*) taken from different images. The estimated character is ascertained from the character which has the minimum E value. According to the results obtained with the proposed method; *A*, *E* and *T* characters have been estimated correctly, whereas *G* character that has been matched by the character *O* has been misspecified.

Flow diagram of the proposed method for character recognition is given in Figure 8. As seen in the flowchart, a circular shape histogram is used to create the feature vectors of the characters as well as for character recognition processing. To our knowledge, there is no study that is similar to the proposed method in the literature. Matlab R2013a (Matrix Laboratory) is used as the development platform for experiments of the proposed method. These experiments are conducted on a

Table 1. The calculated E values for four different character

i				
A	**0,815253**	3,82751	4,377604	3,458174
B	3,440212	2,105279	2,621582	5,727891
C	4,70705	1,981152	2,116309	4,507834
D	3,930709	1,370409	1,485297	5,144262
E	3,278642	**0,652764**	2,555	4,97158
F	3,845415	1,309094	2,86	4,765772
G	3,416427	1,74672	1,789975	5,139554
H	3,815965	2,471358	2,075146	5,767321

I	3,635459	5,278517	5,250398	1,098084
J	5,186898	3,435349	2,540187	4,861983
K	2,342303	3,520305	4,658852	2,819902
L	4,764721	2,470569	3,108852	5,253819
M	3,269051	4,329381	3,925233	4,389095
N	2,499087	3,437076	3,241693	4,639747
O	4,139176	1,708374	**0,990495**	5,093284
P	4,203337	2,069217	3,07204	5,29141
R	3,455557	2,300471	3,258419	4,500661
S	3,415852	2,24729	2,222329	4,464415
T	3,959938	4,923956	5,222651	**0,722896**
U	3,837007	1,841372	1,304278	5,36427
V	3,136176	4,05602	4,221265	2,907217
Y	2,806354	4,823425	4,855131	1,488691
Z	3,779771	3,50065	3,805722	2,64004

Table 2. Examined character number and success rate

	Number	**Rate**
Total Character	166	%100
Correctly Recognized Character	158	%95.2
Incorrectly Recognized Character	8	%4.8

4. CONCLUSION

Character recognition process have long been applied in many areas. In addition to OCR method developed for character recognition, new techniques used feature vectors have been proposed in recent years. In this study, a feature extraction method has been presented which increases the speed of analysis by using less number of elements. The number of elements of the feature vectors consumed by this method is kept constant regardless of the image dimensions and characters sizes. It is also one of the most important features of the proposed technique that the calculations are based on a simple absolute difference and average process. Nowadays, character recognition systems are mostly used in real time for the security of traffic systems with mobile devices. For this reason, speed factor plays an important role in character recognition techniques using optimization and artificial intelligence systems [26-28]. In the future, it is planned to carry out studies to ensure that the proposed system is applied to real time systems with higher success rates while maintaining high speed performance.

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