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A Novel Method for Extracting and Recognizing Logos

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ABSTRACT

Nowadays, the high volume of archival documents has made it exigent to store documents in electronic databases. A text logo represents the ownership of the text, and different texts can be categorized by it; for this reason, different methods have been presented for extracting and recognizing logos. The methods presented earlier, suffer problems such as, error of logo detection and recognition and slow speed. The proposed method of this study is composed of three sections: In the first section, the exact position of the logo can be identified by the pyramidal tree structure and horizontal and vertical analysis, and in the second section, the logo can be extracted through the algorithm of the boundary extension of feature rectangles. In the third section, after normalizing the size of the logo and eliminating the skew angle, for feature extraction, we first blocked the region encompassing the logo, and then we extract a particular feature by the parameter of the center of gravity of connected component each block. Finally, we use the KNN classification for the recognition of the logo.

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1. INTRODUCTION

One of the needs of the world today, is the mechanization of document classification in order to save time. Logo is one of the most important elements in business and government documents by which one can recognize the organization to which the document belongs [1]. Correct recognition of Logos is dependent on an appropriate detection of it. Logo is usually a combination of text and graphics, which can influence the detection [2]. Among the other issues of logo detection is the variety of document layouts and the quality of scanned images [1, 3]. Researches on logo can be divided into two categories: logo detection [1, 4, 5, 6, 7], and logo recognition [8, 9, 10]. A method [5] has been presented for logo detection in grayscale images, which acts based on logo spatial density. In this way, it is assumed that the spatial density of the logo is more than other sections of the image. One of the weaknesses of this method is the erroneous detection of non-logos as logos. In [4], we have used the segmentation of hierarchical top-down decision tree classifier x-y to investigate the documents. After image segmentation, 16 features are extracted from each segment and using a decision tree classifier, non-logo is separated from logo. Since x-y tree algorithm does not always work well this method is not reliable. In [7], the two features of spatial compactness and color uniformity have been used for logo detection. First, the image size is reduced and the gap between text and graphic components of the logo are reduced by morphological operations. Then logo region is extracted by spatial and color density. This method is specific to color images. In [1], using the algorithm of boundary extension of feature rectangles, any connected shape is extracted from the text image. Then non-logo is separated from logo through the trained decision tree classifier. In this method, separated part logos cannot be extracted;

also, the speed of this method is very low. In [9], a new method has been proposed for measuring the similarity between shapes and extracting it for recognizing objects. In this method, the measurement of similarity is preceded by: (1) solving for correspondences between points on the two shapes; (2) using the correspondences to estimate an aligning transform. In order to solve the correspondence problem, we attach a descriptor, the shape context, to each point. The shape context at a reference point captures the distribution of the remaining points relative to it, thus offering a globally discriminative characterization. Corresponding points on two similar shapes will have similar shape contexts, enabling us to solve for correspondences as an optimal assignment problem. The dissimilarity between the two shapes is computed as a sum of matching errors between corresponding points. In [10], to develop a recognition method which is resistant to a variety of conditions such as scale variation, direction variation, broken curves, added noise, and occlusion, the modified line segment Hausdorff distance (MLHD) has been proposed. This method has the advantage of structural and spatial information to compute the dissimilarity between the two sets of line-segments. The proposed method has been applied to the line-segments of the logo and the results are shown. It is proposed in this paper that, firstly, to extract the logo out of text content, different levels of resolution are obtained with the help of the pyramidal tree structure; then by vertical and horizontal analysis, the document pages are recursively segmented in horizontal and vertical directions. After page segmentation, the algorithm of the boundary extension of feature rectangles was obtained on the segments and was applied to extract the logo. By doing so, many regions on which the algorithm should be applied to find the logo, will reduce, and as a result, the detection speed increases. Also in this method, due to the reduction of the original image resolution, the separated segments of the logo are connected together and the logo can be extracted integrally. In the second stage of this paper, to recognize the logo, we extract a few features from the logo obtained in the previous stage. For extracting feature, first we block the region including the logo, then using the center of gravity of the connected component of each block, we extract a specific feature from each block. Finally, we use the k nearest neighborhood classification, for the recognition of the logo. The structure of this paper is as follows: in 2 sections we introduce the proposed method. In section 3, the proposed algorithm for recognizing the logo extracted from section 2 is investigated, and in section 4, the practical results are analyzed, and finally in section 5, the conclusions are finalized.

2. THE PROPOSED METHOD FOR THE DETECTION OF LOGOS

The proposed procedure for detecting the logo is as follows. The procedure will be described below in the relevant sections.

Step 1: Recognizing and correcting the image skew angle. In this study, the algorithm of reference [11] is used to detect the skew angle θ.

Step 2: segmentation of document image I_0 into a set of images I_i (i = 0, 2, 3, ..., N) using hierarchical tree structure. The main document image is in the highest resolution, and document image I_N is in the lowest resolution.

Step 3: vertical analysis on the image I_i (i = 0, 1..., N), and horizontally segmentation it into smaller regions .

Step 4: horizontal analysis on the image (i = 0, 1..., N) I_i, and vertically segmentation it into smaller regions.

Step 5: Repetition of steps (3) and (4) until the image regions are segmentation into visual and textual homogeneous regions.

Step 6: Boundary extension of feature rectangles in the upper sections to extract the logo page.

Step 7: investigation of candidate logos by the decision tree classifier.

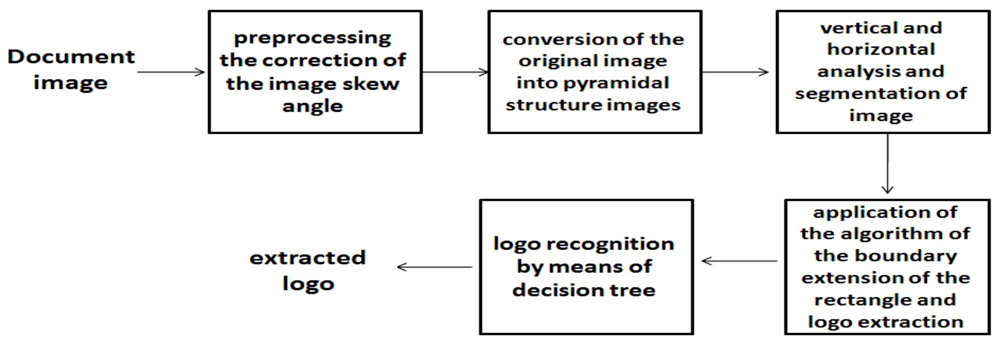

Figure 1. shows the overall procedure of the proposed method

2.1 Pyramidal tree structure

Pyramidal image structure is a simple and strong structure for displaying images in several different resolutions [12]. A pyramidal image is composed of a set of images whose resolution and size reduce in a pyramidal manner. Figure 2 shows the hierarchical tree structure; in this Figure the base of the pyramid is the original image with the highest resolution and its apex is the approximate image with the lowest resolution. To obtain the pyramidal sub-images of a binarized image, we use the diagram (3). To compute the image pyramid at i+1st level, first we separate the odd and even columns of the image I_i and segment them into two images of I_{i1} and I_{i2}, then we click OR the images I_{i1} and I_{i2}, and the image I_{i3} is obtained. In the next step, we separate the even and odd rows of the image I_{i3} and segment it into two images of I_{i4} and I_{i5}. The image I_{i6} is obtained by clicking OR the two images of I_{i4} and I_{i5}.

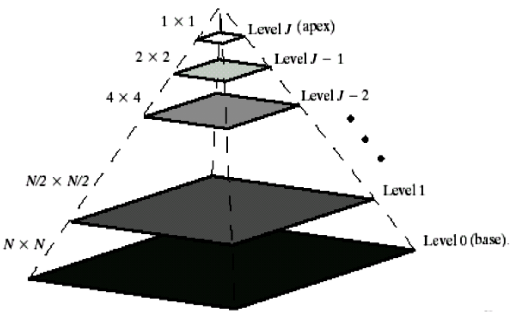

Figure 2. Pyramidal tree structure [12]

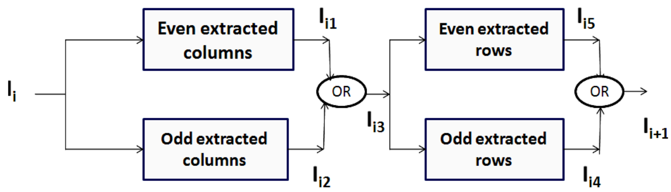

Figure 3.Diagram of the computation of sub-images of the pyramidal tree structure [12]

Figure (4) shows different levels of the pyramidal images for a document image with a logo using the diagram (2).

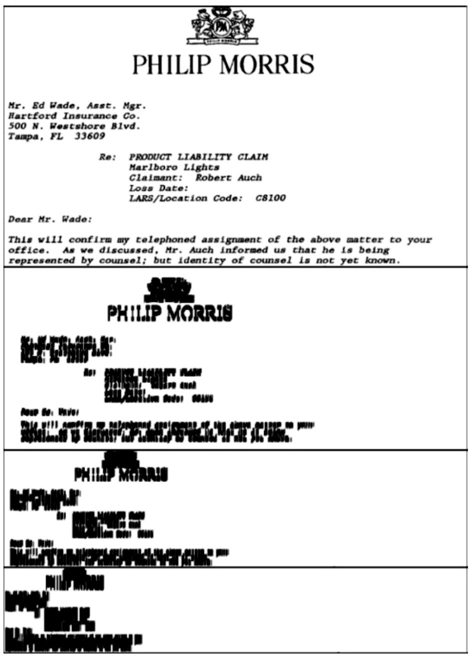

Figure 4. Images of pyramidal structure for a document page

2.2 Vertical Analysis

To carry out the operations of vertical analysis, we start from the images of the top of a pyramid; in case an image of a pyramid level lack horizontal grooves, the vertical analysis of the pyramid images is done in the lower levels of the pyramid. In the vertical analysis, the vertical projection of the regions of the pyramid image is obtained with coordinate (1). P_v (n) is the mean of the black points in a column. In this coordinate, $I_L(X,Y)$ is pyramid image at the L^{th} level, and W×H denotes the size of pyramid image at the L^{th} level.

$$P_v(n) = \frac{1}{H}\sum_{y=1}^{H}(I_L(\mathbf{n},\mathbf{y})) \quad 1 \le n \le W \tag{1}$$

Signal values of $P_v(n)$ are normalized between 0.0 and 1.0. The coordinate (2) shows the binarization relation of the one-dimensional signal $P_v(n)$. If the value of $P_v(n)$, which is the mean of the black points in a column, be less than 0.05, we ignore it, because it cannot represents the a section of the logo but it is the noise of the scanning. The threshold 0.05 has been obtained when carrying out experiments on different images.

$$t_1v\ (n) = \begin{cases} 1.0 & P_1v\ (n) \ge 0.05 \\ 0 & other\ wise \end{cases} \tag{2}$$

Binary signal analysis $T_v(m)$ is a good measure for page segmentation in horizontal direction. If the signal $T_v(m)$ be a fixed value with level 1, that is, it does not have an edge, the pyramid image at the L^{th} level cannot be segmented into several regions. If the binary signal $T_v(m)$ has one or more zero levels, the zero levels of the signal and the ascending and descending edges of the signal will determine the segmentation points of the region of the pyramid image in a horizontal direction.

2.3 - Horizontal Analysis

At this stage, the segmented regions of the vertical analysis are segmented in vertical direction by being horizontally analyzed. To expedite the process, the horizontal analysis on the regions is done recursively. For each segmented region in the pyramid images, at first, its horizontal projection is obtained using coordinate (3).

$$P_H(n) = \frac{1}{W}\sum_{x=1}^{W}(I_L(\mathbf{x},\mathbf{n})) \quad 1 \le n \le H \tag{3}$$

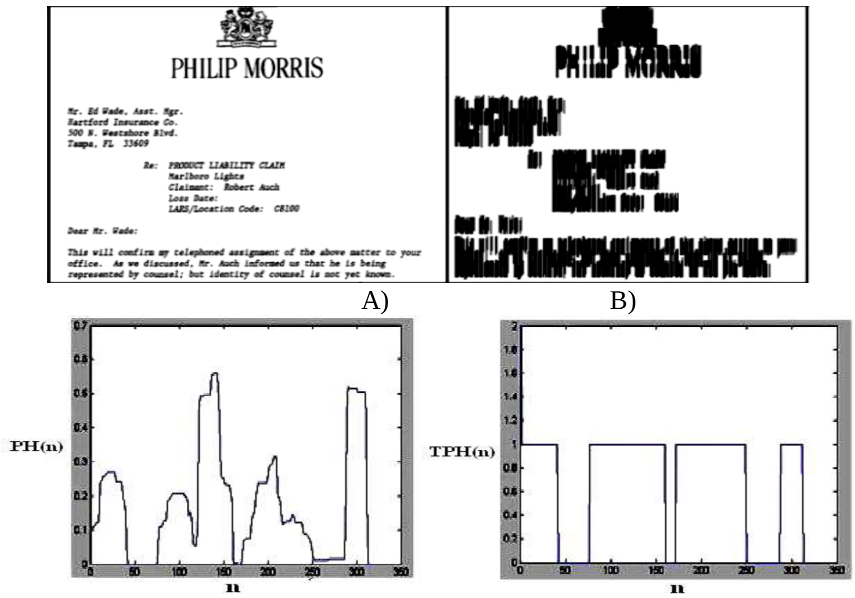

Figure 5. a) original image in the pyramid; b) image at the fourth level of pyramid; c) horizontal projection of image at the fourth level; D) horizontal binary projection of image at the fourth level

In this coordinate, I_L (X, Y) of the pyramid image is at the L^{th} level, and W×H denotes the size of pyramid image at the L^{th} level. Signal values of $P_v(n)$ are normalized between 0.0 and 1.0. In the second stage, by applying a fixed threshold (a value of 0.01 obtained experimentally by carrying out experiments on different images), the signal $P_v(n)$ is converted to a signal at the level of 0.0 or 1.0 or a binary. The coordinate (4) shows the relation converting the signal into binary mode.

$$tP_H(n) = \begin{cases} 1.0 & P_H(n) \geq 0.01 \\ 0 & otherwise \end{cases} \tag{4}$$

The threshold value is different in the vertical and horizontal analysis because the English and Persian writing is written horizontally and there are horizontally left spaces between the lines. If the threshold value of horizontal analysis is more than 0.01, the points which are scanned as noise within the left spaces when the image is scanned, are segmented like the writings.

Figure 5 shows the horizontal analysis on a document image including a logo. As can be seen Figure 5, the signal $P_H(n)$ in the fourth level of the pyramid has five zero levels, and this image has been segmented into five horizontal regions. Figure 6 shows the signal $P_H(n)$ for a document image including a logo.

In the third stage, to obtain the signal $tP_H(n)$, we examine the ascending and descending edges of the above binary signals. The horizontal analysis is done in the following modes on a region.

Mode 1: If the signal $tP_H(n)$ is related to a uniform region, that is, it has no edge (the tP_H (n) value be 0 or 1 for all Ns), in this case, if the signal tP_H (n) be related to the images of the top levels of pyramid, the horizontal analysis is done recursively on the corresponding region in the pyramid image at lower levels.

Mode 2: The region is not homogeneous in this mode (i.e. the signal $tP_H(n)$ has both zero points and points of 1) and this region should be separated into two or three other regions. Separation algorithm is applied recursively. Separation process continues until the signal $tP_H(n)$ related to the segmented regions become symmetrical or its value become uniform (1). Figure 7, shows the segmentation of the English text image into text regions and logo.

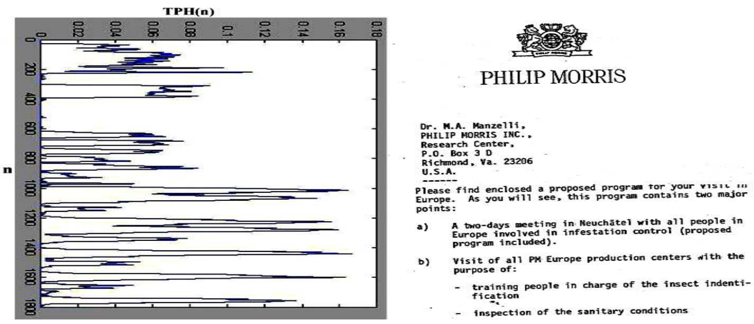

Figure 6. Horizontal analysis

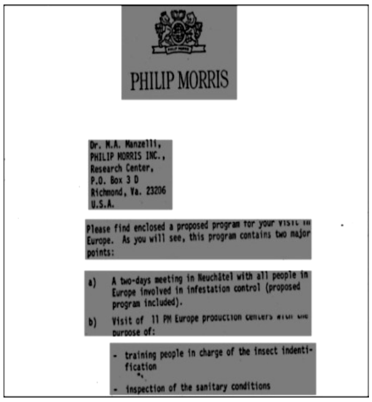

Figure 7. The segmentation of the English text image into text regions and logo

2.4 Boundary extension of feature rectangles for finding logos

Since the position of the logo is usually at the top of the page, we investigate fifth of the upper sections of pages [1]. After separately finding the candidate regions of the logo, the algorithm shown in Figure (8), is used for precise extraction of the logo. The general process of the algorithm of the boundary extension of feature rectangles is that, first, through a top-down sweep of the image, a 3×3 rectangle is formed around the first background (black) pixel that is found. This rectangle is called the feature rectangle [1], and according to the definition, it is the smallest box that encompasses the candidate logo, and its four corners include background (white) pixels and it has the lowest region. This rectangle is enlarged by extending the boundary region of the logo candidate so as to encompass the entire region. One of the advantages of this method for extracting the logo is that this method is independent of the logo shape. In the proposed method, instead of an entire sweep, the mentioned algorithm is applied only on the regions obtained from of stage 2-3. Thereupon, the application speed of algorithm goes up fast. On the other hand, the segments obtained in section 2-3, on which the algorithm is applied, are interconnected segments; therefore, separate logos are also extractable in this method.

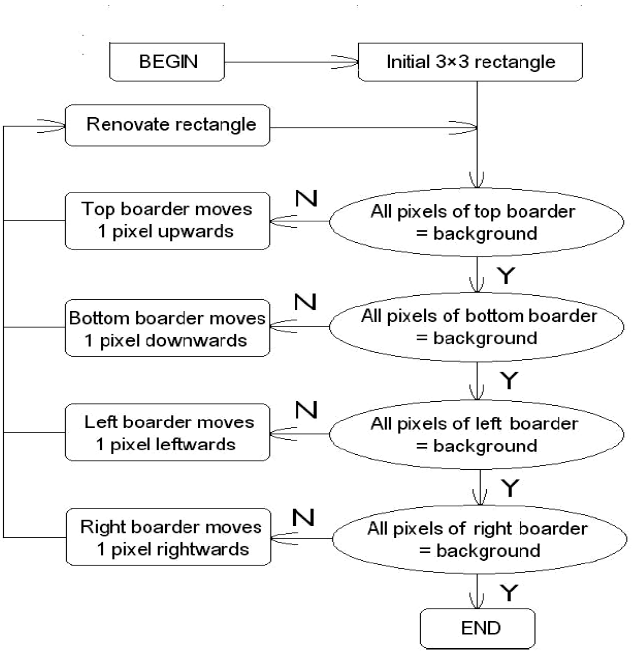

Figure 8. Process of boundary extension of feature rectangle [1]

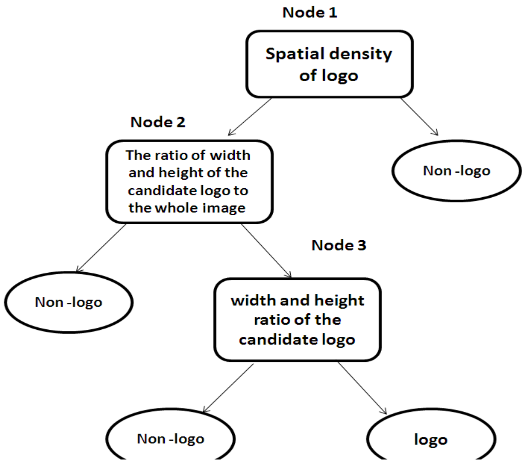

Figure 9. Classification of decision tree classifier for selecting the logo regions

2.4.1 Discovering the selected logo

After doing the algorithm of the previous stage, a number of candidate logos are obtained among which the main logo should be extracted. Decision tree classifier is used for this procedure. This tree is trained according to a series of logo attributes such as: logo position, the ratio of size, length, and width of the logo to the width of the entire image, and also the spatial density of the logo. Decision tree classifier is trained by a set of training logos. Table 1 shows the features from set of the training logos. Figure 9 shows a simple decision tree classifier which is used among candidate logos for logo recognition.

3. AN APPROACH FOR RECOGNIZING THE LOGOS

Figure 10 shows the various stages of logo recognition in the proposed method. In this method, after extracting the logo boundary and normalizing the logo image, the bonding box of the logo region is divided into blocks with equal size [16]. Finally, for extracting features for each logo, the center of gravity of the connected component of each block is computed. Finally, with the help of the k nearest neighborhood classification, the logo corresponding to the experimented logo is extracted.

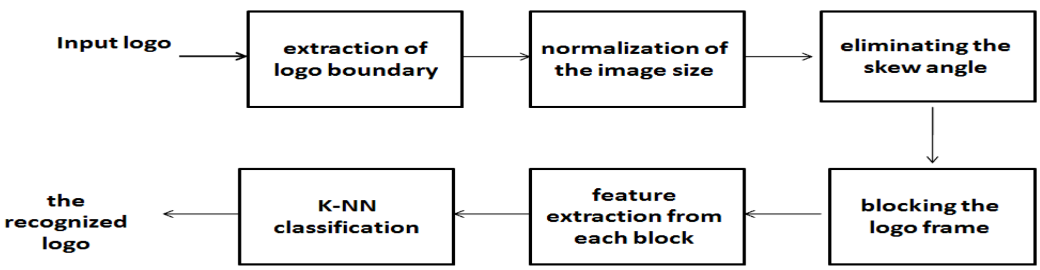

Figure 10. The general procedure of the proposed method

3.1. Extracting the boundary

At this stage, we extract the boundary of the logo. The output of this stage shows the spatial position of the boundary pixels of the logo. Logo boundary pixels coordinates are defined as follows:

$$P_1(x_1,y_1),\ P_2(x_2,y_2),\dots\ P_n(x_n,y_n) \qquad (5)$$

In which P_i is the neighboring pixel of P_{i+1} and we have $1 \le i \le n$:

$$|\, x_i - x_{i+1} \,| \le 1\ , \qquad |\, y_i - y_{i+1} \,| \le 1 \qquad (6)$$

And these two relations will never be simultaneously zero. Figure 11 shows the result of logo boundary extraction:

Figure 11. Extraction of the boundary of sample logo

Figure 12. The major axis of logo

Figure 13. The normalization of the size of a logo in relation to the major axis

3.2. Logo image normalization

Normalization is considered one of the basic parts in recognizing objects in images. The main purpose of normalization is to obviate the sensitivity of logo recognition to transference, rotation and resizing of it. It is obvious that in the proposed method, the sensitivity of logo recognition to transference has been obviated due to the use of the bonding box. Normalization in the proposed method includes the following two sections:

3.2.1. Normalizing the size of the logo

Usually, the procedure of such normalization is the extraction of a specific feature of an object and normalizing it in relation to a certain number. In the proposed method for normalizing the size, the major axis of logo [1] is considered as a special feature, and after the computation, it is normalized in relation to a certain number. The major axis of the logo mentioned above is a line-segment connecting the two points on the logo boundary, which have the most Euclidean distance.

If $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$ be the spatial positions of logo boundary pixels, the major axis of logo denotes LMA and is defined as follows:

$$LMA = \max\left[\,(p_i - p_j)^T\ (p_i - p_j)\,\right]^{0.5} \qquad (7)$$

in which P_i of the i^{th} pixel is obtained through the coordinate (x_i,y_i) and P_j of the j^{th} pixel through the coordinate (x_j,y_j), and $1 \le I, j \le n$ and $i \ne j$. Certainly the major axis of logo obtained from the above coordinate is not always unique, but is considered as a useful descriptor. The main reason for using the major axis of logo is that by resizing the logo, the position of the major axis will not vary and only its size will vary. Figure 12 shows the major axis of logo, and Figure 13 shows the result of normalization.

3.2.2. Normalizing the direction of logo

In the second stage, we proceed with the normalization of logo direction. At first, a few direct lines are selected on the logo boundary, and these lines are called reference lines [13]. Then, the position of each reference line should be made zero in relation to the horizontal axis. As a result, we will have a different view of the logo per reference line. Obviously, the more the number of reference lines is, the larger will be the database size and the volume of computations, but the possibility of logo recognition will also be more. Figure 14 shows some samples of the logo view per its reference line.

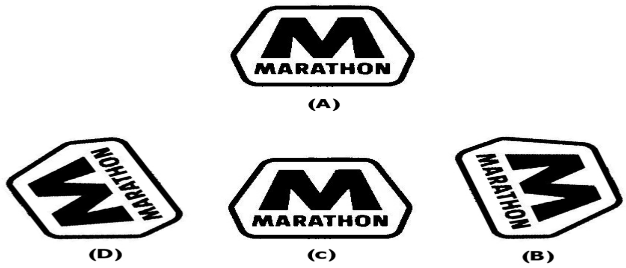

Figure 14. (a) The main logo. (b) - (c) some samples of different reference logo view per different reference lines.

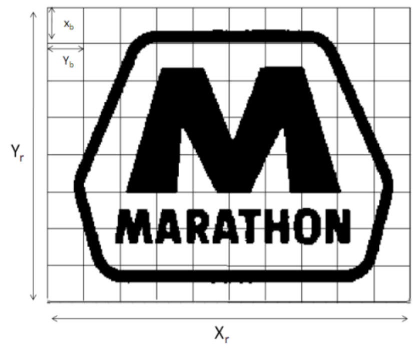

Figure 15. Blocking of the bonding box of the logo region

3-3. Feature extraction

The main idea of the proposed method for logo recognition is stated in this section including the following steps:

3.3.1. Blocking bonding box of the logo region

In this stage, we block the bonding box of the logo region. Choosing the block size is a fundamental parameter in this method. For example, if the block size is considered too small, an error will occur in the noisy images, and if the block size is considered too large, the frequency graph of logos will not make much difference. After different experiments, the result was that if the block size is proportional to the size of the bonding box of the logo region, the recognition will be most efficient. The ratio coefficient between block size and the bonding box of the logo region is called α. If we show the length and width of the bonding box of the logo region by x_r and y_r, respectively, and the block length and width with x_b and y_b, respectively, the relationship between block size and the size of the bonding box of the logo region is defined as follows:

$$x_b=\alpha \times x_r$$
$$y_b=\alpha \times y_r \qquad (8)$$

According to experiments, the best α value is 0.16 [16].

3.3.2. The extraction of feature in each block and display of its diagram for comparison

In the second stage, the vector of the feature required for classification is extracted. The method of feature extraction is as follows: by the algorithm of boundary extension of feature rectangles (reviewed in 2-5) we obtain the connected components of each block. Then, from among the connected components we choose the connected component which has the highest region density. Finally, the center of gravity of the largest connected component is considered as a block feature for each block. Figure 15 shows the blocking of the bonding box of the logo region.

3.3.2.1. Algorithm of the boundary extension of feature rectangles for obtaining the connected component for each block

The general procedure of the algorithm of the boundary extension of feature rectangles was investigated in section 2-5. One of the advantages of this method for the extraction is that this method is independent of the shape of the connected component. The algorithm of the boundary extension of feature rectangles is shown in Figure (7). After that the connected components of each block was obtained by the algorithm of the boundary extension of feature rectangles, we choose that connected component of the block which has the highest region density for obtaining its center of gravity. It means that, at first, using the following formula for each connected component, the region density of is computed, and then the connected component of each block is selected which has the highest region density.

$$f_{ij} = \frac{\sum_{i=m}^{m+k}\sum_{j=l}^{l+k} p(i\,,j)}{x_b \times y_b} \tag{9}$$

In this formula, f_{ij} is the region density of the j^{th} component of the i^{th} block of the logo, and x_b and y_b are the block length and width, respectively. P (i, j) is the pixel value at the position of i and j, which has two zero values (for foreground pixels) and a 1 value (for background pixels). In this respect, since the noise of the scanned image has a low region density, it is not considered for logo recognition and is excluded.

Now from each block a connected component is selected whose center of gravity should be computed. The center of gravity of each block is considered as a feature of that block. In other words, the center of gravity for each block logo is unique. The center of gravity for each block can be obtained from the following formula in which x and y are the center of gravity of each block:

$$A = \sum_{i=1}^{n}\sum_{j=1}^{m} B[i,j] \qquad \bar{x} = \sum_{i=1}^{n}\sum_{j=1}^{m} iB[i,j]/A \qquad \bar{y} = \sum_{i=1}^{n}\sum_{j=1}^{m} jB[i,j]/A \tag{10}$$

Finally, after obtaining the vector of logo feature, we use the KNN classification for classifying and recognizing logos. Below, the diagram of feature obtained from Figure 11 is displayed.

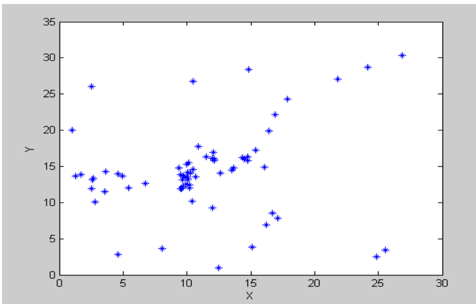

Figure 16. Diagram of feature of Figure (15)

4. RESULTS

4.1. Results of the logo detection

For implementing the proposed method, we used the database Tobacoo 800 [14]. This database is composed of 1290 scanned images, 416 of which have logos. From among these images, 116 images were selected for training and 300 images for experiment. Based on the definition of the method [1], logo detection will be successful when it includes 75 % of pixel of the basic logo and more than 125% of pixels of basic logos. For evaluating the proposed method, we use the two criteria of accuracy and precision stated in [1] as follows:

$$\mathbf{accuracy} = \frac{\textit{the number of accurately detected logos}}{\textbf{the total number of detected logos}} \tag{11}$$

$$\mathbf{precision} = \frac{\textit{the number of accurately detected logos}}{\textbf{the total number of detected logos}} \tag{12}$$

Figure 17. A few samples of the logos correctly detected by this method, which the method [1] was not able to detect

First, the decision tree classifier is trained by 116 logos. Then the main decision tree classifier is extracted from among the candidate. Figure 17 shows the number of logos which are detected by this method properly. It should be noted that method [1] is not able to detect them due to the fact that the sections of the logo are separated. But the proposed method is able to extract the entire logo uniformly because it connects together the separate sections of the logo.

Table 2 shows the comparison of the proposed method (implemented with MATLAB software) and the method [1]. The proposed method with a detection precision of 96/2% is more accurate than the method [1].

Table 1. The decision rules for each decision tree classifier nodes

Value limit	feature	Node number
[0.69,0.83]	Spatial density	Node n^o 1
[0.030,0.29]	rectangle width / document image width	Node n^o 2
[0.025,0.18]	rectangle height / document image height	
[0.28,0.85]	The ratio of length to width in rectangle	Node n^o 3

Table 2. Comparison of performance in the proposed method and in the method [1]

Detection accuracy	Detection precision	Method
85%	96.2%	Proposed method
81.1%	94.2%	Method [1]

Table 3. Comparison of the application speed of the proposed method and that of the method [1]

Processing time (ms)	Method
3800	Proposed method
7200	Method[1]

Table 4. Comparison of logo detection rate of the proposed method and that of the method [9]

Test logo type	Number of Test logo	Detection rate of the proposed method	Detection rate of the method [9]
Main logo	40	100%	100%
Strip corrupted logo	40	95%	93%
Partially occluded logo	40	92.5%	89%

As was said, unlike [1], in the proposed method, instead of sweeping the whole image – which is time-consuming, the aforementioned algorithm is applied only on the regions obtained from stages 2-3, which helps speed up the application of the algorithm. This issue is observable in Table 3.

4.1.1. Error Analysis

The proposed algorithm does not work well in images with noise; this issue to the fact that the rectangle considers the noises around the logo as a part of the logo. Figure 18 shows some samples of logos which have failed to be extracted due to excessive noise.

Figure 18. Logos which have failed to be extracted due to excessive noise

4.2. Results of logo recognition

To evaluate the proposed algorithm for logo recognition, we have used the University of Maryland dataset [15]. In total, five experiments have been conducted to evaluate this database as follows:

1) The experiment included 40 logo images without any variation in the size and rotation of images in comparison with the images of the main model. The proposed method accurately identified all the 40 logos and a detection rate of 100%was obtained.
2) This experiment included 40 logo images which were corrupted by salt and pepper noise at the rate of 0.09 and a black tape is broken. Recognition rate was obtained as 95%.
3) This experiment includes 40 logo images in which a part of the logos is gone. Recognition rate obtained is 92.5 %. The results in the experiments 2, 1 and 3 are shown in Table 4.

It can be seen at the end that regarding the strip corrupted logos and the logos with partial occlusion, our proposed method worked better than the method [9].

Figure (19) shows the diagrams of the logo features before and after the application of noise, which suggests that the applied salt and pepper noise (at the rate of 0.09) in the proposed method has little impact on the diagram of feature, and this method of logo recognition suffers fewer errors.

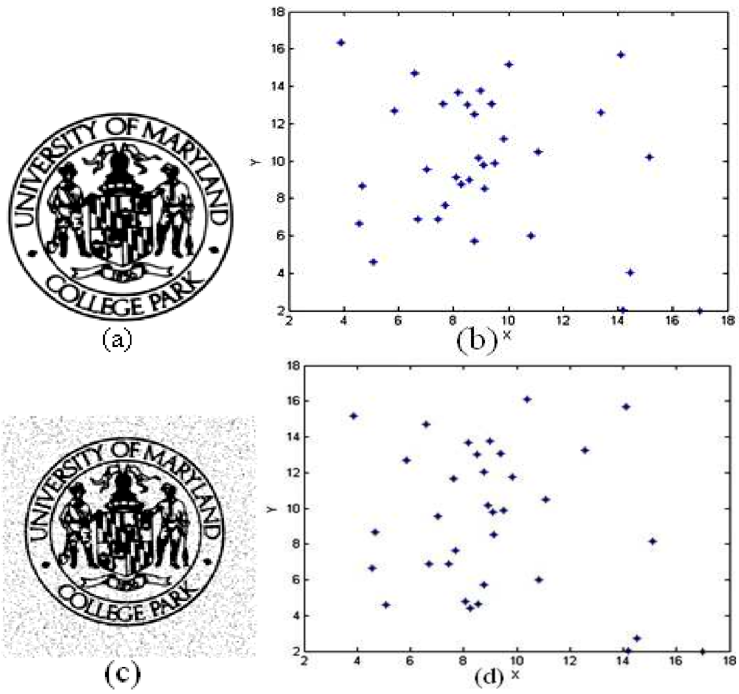

Figure 19. a -logo without noise .b– diagram of features; a logo without noise ,c - the logo after the application of the salt and pepper noise at the rate of 0.09. D – diagram of features; the logo after the application of the salt and pepper noise at the rate of 0.09

5. CONCLUSION

In this paper, a new method has been presented for detection and recognition of logos, in which, to segment the page for logo recognition according to the vertical and horizontal analysis in a recursive manner, we segmented document pages in horizontal and vertical directions using pyramidal tree images. Then, by extending the boundary of rectangles, the candidate logos are found, and using a trained decision tree classifier, the desired logo is extracted. Also for logo recognition, first we normalize the size of the logo, and then the skew angles of the logo disappear. For feature extraction, first, we block the region encompassing the logo, and then we extract a specific feature through the parameter of the center of gravity of the connected component. Finally, we use the KNN classification for classifying the logo. This method provides better accuracy than previous methods. And the logo detection rate is higher in this method compared with that of the other methods.

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