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Fast Logo Detection Based on Morphological Features in Document Images

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Abstract— **In this paper, a novel fast logo detection approach in document images is presented. Logos with separated parts usually can affect the logo detection process. To overcome this problem, some specifications of logos are considered. Our proposed method divided in three main sections. In the first section, a horizontal dilation operator is used to merge separated parts of logo in horizontal direction. In the second section, a simple decision classifier is applied for classifying logo and non-logo. In the final section, a modifying operation for detecting separated-part-logo, logo which has separated part, based on two specifications is used. These specifications include centroid coordinate and intersection of each logo's separated part bounding box. The proposed approach is evaluated on a public document image database and international logos. Experimental results show its performance in logo detection problem.**

Keywords— **Logo detection, horizontal dilation, spatial density, feature extraction, decision tree classifier.**

I. Introduction

Nowadays need for automatic document classification due to saving time is necessary. The detection of logo can be considered as a method for document image analysis and retrieval. Logos are also applicable for identifying of document source. Logos are 2D shapes that have various styles and usually they are combination of graphical parts, text parts and etc. Also, diverse layout and quality of document images can affect logo detection problem. In Fig. 1, some logos from University of Maryland logo database [1] are shown.

Former researches related to logos in document images divided into logo detection problems [2,4,5,6,7] and logo recognition problems [8,9,10,11,12,13]. Seiden et al. [2] used a top-down X-Y cut segmentation algorithm [3] to analyse a binary document. After using this segmentation algorithm, for each connected component that obtained, sixteen features are extracted and classification is done by a rule-based classifier. Because of diverse layout of document images, this cut segmentation algorithm is not reliable. Pham [4] presented an unconstrained logo detection method based on spatial density of foreground pixels within a given window. Based on his assumption, the spatial density that related to logo regions is greater than those of non-logo regions. Firstly, a document image binarized by global thresholding algorithm. Then the spatial density within each given window is computed and the region with the highest value considered as a logo region. The selection of window size is problem and can lead to incomplete logo detection. Zhu et al. [5] used a method that is a combination of logo detection and recognition in a unified framework based on multi-scaled strategy. After choosing an initial coarse scale for image resolution reduction to obtain connected component, the initial classification is performed on each connected component using trained fisher classifier. After that, additional classification will be performed on each logo candidate region by successive cascade classifiers. The gap between logo and non-logo parts is important so that small gap leads to merge logo and non-logo parts. Wang and Chen [6] proposed a logo detection method based on boundary extension of feature rectangle algorithm. This approach based on assumption that logos usually have background surrounding it and they are separated from other parts of a document image with white spaces. However this assumption is restricted due to large variance of logo design. Wang [7] presented a simple approach to detection and recognition logo in document images. A dynamic logo detection and recognition process is performed step-by-step. After initial detection of logo, recognition of detected logo will be done and the results of recognition will feedback to input using real time decision as a closed loop.

Detection of separated-part-logo usually is a challenge in logo detection problem. So in this paper, we proposed a method that improves the performance of logo detection in such challenges. Centroid coordinate in vertical direction and intersection of each logo's separated part bounding box are two major specifications that we use in this paper. The remainder of this paper is organized as fallow: In next section we introduce the proposed method. In section 3, experimental result is given. Finally, the summarized remarks are given in section 4.

II. Proposed Method

The block diagram of the proposed method for fast logo detection is shown in Fig. 2. In the following, we describe the details of each module of the block diagram.

Fig. 1. Some logos from University of Maryland logo database [1]

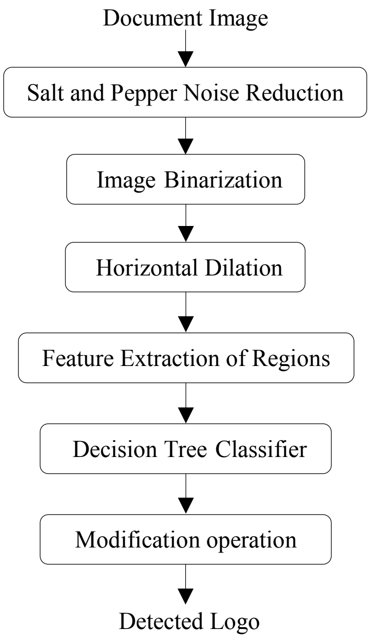


Fig. 2. The block diagram of the proposed method for fast logo detection.

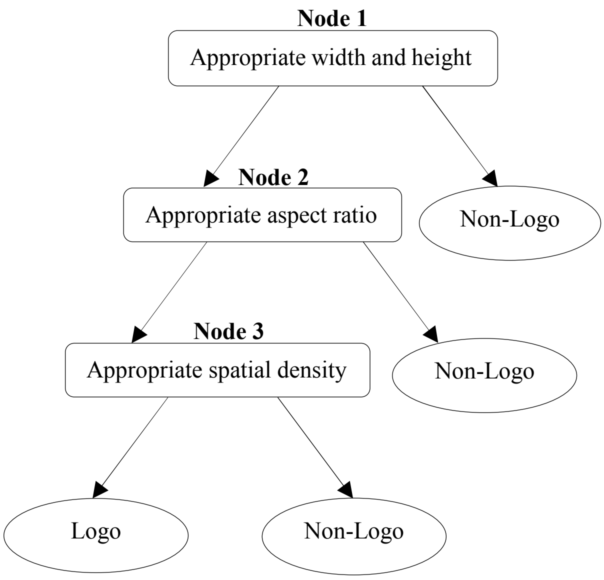


Fig. 3. Decision tree classifier with 3 nodes.

A. Salt and Pepper Noise Reduction

In this section, the salt and pepper noise in document images is reduced by median filtering. Note that the filter size is restricted due to diverse quality of document images. That is because it may remove any part of logo in degraded document images.

B. Image Binarization

A binarized image $g(x, y)$ is defined as:

$$g(x,y)=\begin{cases}1, & \text{if } f(x,y)>T \\ 0, & \text{if } f(x,y)\le T\end{cases} \quad (1)$$

Where $f(x, y)$ and T are the gray level of point (x, y) and threshold value respectively. Pixels labelled 0 correspond to objects, whereas pixels labelled 1 correspond to background.

C. Horizontal Dilation

Dilation is one of the basic operations in mathematical morphology. The dilation operation usually uses a structuring element for probing and expanding the shapes involved in the input image. With A and B as sets in Z^2 , the dilation of A by B , denoted $A \oplus B$, is defined as.

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \varnothing\} \quad (2)$$

This equation is based on obtaining the reflection of B about its origin and shifting the reflection by z .

D. Feature Extraction of Regions

The output of last section includes regions with value one. In previous works, size of the logo regions is used to classify logo and non-logo. As previously noted, in [2], the extracted features are related to segments which obtained by X-Y tree segmentation algorithm [3]. In [6], the extracted features are related to rectangle surrounding regions. As we know, every region has a bounding box that surrounds it. We use some properties of these bounding boxes as features. These features are appropriate width and height, and aspect ratio. Another feature that has key role in classifying logo and non-logo is spatial density [4] of each region in its bounding box. Note that we have to normalize the size of each bounding box to distinct number, before computing of spatial density. We remind the computation of spatial density of the foreground pixel around a given point $k \in w$ (w a window of size $m \times n$ which contains logo region) using the mountain function $M(p)$ as follow:

$$M(p)=\sum_{k\in w, p\neq k}\delta(k)\exp[-\alpha D(p,k)], \quad (3)$$

$$\delta(k)=\begin{cases}1, & f_k = foreground \\ 0, & f_k = background\end{cases} \quad (4)$$

$$D(p,k)=[x(p)-x(k)]^2+[y(p)-y(k)]^2. \quad (5)$$

Where, α is a positive constant (α=1), $D(p,k)$ is distance between p and the pixel located at k. $x(p)$ and $y(p)$ are the horizontal and vertical coordinates of p and $\delta(k)$ is a boolean function. After computing $M(p)$, we normalize it to a distinct number such as area of region's bounding box which is related to size feature.

E. Decision Tree Classifier

A simple decision tree for classifying logo and non-logo is shown in Fig. 3. This classifier includes 3 nodes which designed so that false accepts from logo candidate will be reduced. The first and second nodes related to size of the logo and third node related to the pixels density in the logo region. In some cases, signatures in the bottom of the document image are passed from the first and second nodes but will be rejected by the third node. This is preference of our proposed approach which causes to the better performance versus Wang's decision tree classifier [6]. Table 1 shows decision rules for each node in decision tree classifier.

F. Modifying Operation

In this section, we want to modify our logo detection method based on knowledge that most separated-part-logos usually have one or both of these following specifications:

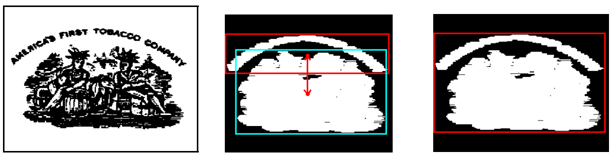
1) The centroid coordinate of each separated-part-logo bounding box in vertical direction is equal.

2) The intersection of each separated-part-logo bounding box is unequal to null.

Note that the gap between each logo part must be less than a given threshold. We define modifying rules based on above specifications as follow:

If one or both of above specifications are satisfied, merging operation will be done.

The procedure of our method is as follows: After classifying logo and non-logo in its own classes by decision tree classifier, modifying operation will be done to reduce false rejection from logo candidate based on defined rules. Fig. 4 and 5, illustrate how our method works.



(a) (b) (c)

Fig. 4. (a) Main logo. (b) Both of specification satisfied. (c) Merging process.

Fig. 5. Merging operation will be done based on first specification.

Fig. 6. Some logos which detected successfully by the proposed method.

III. Experimental Results

We tested our proposed method on tobacoo-800 dataset [14] which is composed of 1290 document images. There are 416 document images that involve logo. We used 120 documents which include logo as the training set and remaining documents used as testing. We evaluate the performance of our proposed method based on Zhu's evaluation methodology [5]. According to this approach, logo detection process is successful "*if and only if the detected region contains more than 75% pixels of a groundtruthed logo and less than 125% of the area of that groundtruthed logo*''. We define two criteria for performance evaluations as follows:

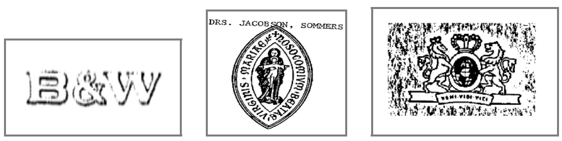
$$\text{Accuracy} = \frac{\text{\# of corrected detected logos}}{\text{\# of logos in groundtruth}} \quad (6)$$

$$\text{Precision} = \frac{\text{\# of corrected detected logos}}{\text{\# of detected logos}} \quad (7)$$

In the first step, we have to choose suitable value for structuring element in horizontal dilation. After several experiments we found that if document image's width equal to w, by choosing $w/100$ value as structuring element size in horizontal dilation, it will be led to best result. In the second step, we compute decision tree classifier values in each node. As mentioned earlier, we used 120 documents which contain logos for training decision tree classifier to classify logo and non-logo so that false accepts from logo candidate kept low. In Fig. 6, some logos have shown which successfully detected by proposed method. Fig. 7(a) shows incomplete logo which rejected by decision tree classifier. Fig. 7(b) shows logo adhesion with text part led to unsuccessful detection. Fig. 7(c) shows unsuccessful logo detection due to much noise around logo region.

TABLE I
Decision Tree Classifier Rules in Each Node

Node #	Feature	Range
1	$\frac{\text{Bounding box width}}{\text{Image width}}$	[0.04, 0.39]
	$\frac{\text{Bounding box height}}{\text{Image height}}$	[0.032, 0.23]
2	Aspect ratio	[0.39, 4.95]
3	Spatial density	[3.8, 31]



(a) (b) (c)

Fig. 7. Unsuccessful logo detection. (a) incomplete logo, (b) logo adhesion with other document parts, (c) much noise surrounding logo region.

The obtained accuracy and precision values of our proposed method are 86.9% and 95.6% respectively. Table 2 shows a comparison between our proposed method, Wang's unified framework method [7] and Wang's feature rectangle method [6].

TABLE II
PERFORMANCE COMPARISON BETWEEN DIFFERENT METHODS

Method	Accuracy	Precision
Proposed method	86.9%	95.6%
Wang's unified framework [7]	84.2%	94.7%
Wang's feature rectangle [6]	80.4%	93.3%

IV. CONCLUSIONS

In this paper we proposed a novel and fast method for logo detection in document images. After reading the document image, preprocessing step performed by median filter so that the quality of logo regions kept well. After that, the binarization process was done by global thresholding. Then we used horizontal dilation to merged separated parts of logo in horizontal direction as connected component. Next step involves Classifying logo and non-logo using decision tree classifier with three nodes based on appropriate width and height, aspect ratio and spatial density of bounding box surrounding logo. The final step in our method is modifying operation that modifies decision tree classifier to merge regions of separated-part-logo based on defined specifications. Experimental results show that our proposed method is faster and has more performance compared with other methods.

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