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Multi - Feature based Logo Identification and Retrieval from Document Images

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Abstract: ***This paper presents an effective method for logo identification and retrieval from document images, utilizing multiple features. Initially, logos are identified and segmented using a segmentation algorithm, and the resulting segmented logo images are stored in a library. Subsequently, a combination of Local Binary Patterns (LBP), Histogram of Oriented Gradients (HOG), and Texture features is extracted to enable discrimination between logos of different categories. The cosine distance metric is then applied to measure the similarity between a query logo and candidate logos, and relevance is determined by generating distance ranks. Through experimentation, a threshold of 98% is selected, and logos that match appropriately are retrieved. The proposed method achieves impressive performance, with an average precision rate of 92%, an average recall rate of 93.20%, and an average F - measure of 91.00%.***

Keywords: Logo retrieval, Logo identification, Document image, Multi feature, Segmentation, Algorithm.

1. Introduction

As digital technologies continue to advance, the world is witnessing a shift towards automation and multilingualism. Digital solutions have facilitated easy storage, access, and retrieval of information within digital libraries and document repositories. The growing demand for paperless offices has led to significant research in document image analysis and information retrieval from documents. Automatic document processing systems rely on two primary content - based information retrieval methods: Optical Character Recognition (OCR) and Keyword spotting. Both of these methods play crucial roles in office automation, where OCR is widely used for information retrieval based on recognized text. However, OCR faces challenges when dealing with documents containing complex layouts, noise, graphical components, and skew, leading to limitations in information retrieval. Graphical components, such as logos, are essential sources of information and should be considered key elements in the retrieval process. Logos serve as graphical marks or emblems used by various entities to identify and promote instant recognition or authorization of documents.

The detection of logos in document images holds potential for robust document classification and categorization, as well as information retrieval based on logo identity. For instance, in scenarios where an invoice is received from a judicial organization and needs to be forwarded to the appropriate department, automatic logo detection can aid in categorizing the document based on its logo and directing it to the relevant authority. Previous research on logo detection, recognition, and matching has explored two approaches: segmentation - based and segmentation - free methods. However, segmentation of graphical components like logos poses challenges due to varying document structures, complex layouts, printing quality, and degradation over time, leading to inconclusive results in image segmentation. In this paper, we present a segmentation - free technique for logo identification in a given document image, eliminating the need for segmentation, training, and testing processes.

2. Contemporary Work

Several interesting algorithms for logo detection in document images have been reported in the literature. In [1], a scheme is presented where the document image is first binarized using global thresholding and divided into foreground and background pixels. Spatial density is then calculated within a fixed - size window under the assumption that the logo region exhibits higher density than the non - logo region. However, this approach becomes unreliable for documents with complex layouts, aging degradation, and variable ink quality, as global thresholding may not produce accurate results for spatial density calculation. In [2], a method for detecting and recognizing specifically separated logos is proposed. The input document undergoes binarization, salt and pepper noise removal, and horizontal morphological dilation to form binary object regions. Simple shape features such as height, width, aspect ratio, and spatial density of bounding boxes are extracted for feature representation. [3] employs an employee boosting strategy across multiple image scales, using a cascade of classifiers to classify logo vs. non - logo regions. [4] adopts a multiple scale approach for detection and extraction of logos, utilizing translation, scale, and rotation invariant shape descriptors with a neighborhood graph. In [5], hashing shape context descriptors are utilized, but it may fail with low - quality images due to the edge detection approach. [6] Introduces a counter - based logo detection scheme, involving binarization, counter detection, and segmentation. While providing interesting results, it is costly in terms of pre - processing and segmentation. [8] employs a bag - of - word model for logo detection, but it disregards spatial relationships, which are significant for image representation. [9] uses geometric shape invariants as features for logo matching and Bayesian model processing on connected components' signatures. [10] claims fast logo detection and recognition using shape descriptors and line profiles, performing logo verification through geometrical matching with an "anchor line" technique. [11] focuses on document categorization by logo spotting, presenting Bag of Words and Sliding window over BMS descriptors with normalized cross - correlation as two schemes. While these algorithms show encouraging results, they have limitations, including working on connected components, struggling with low - quality images, handling gaps between connected components and adhesion of logos with other parts, and computational expense in real - life document processing. In light of these challenges, we propose a segmentation - free and layout - independent approach that works well with noisy and complex documents. We utilize a sliding window approach with horizontal projection of the Radon transform and simple correlation to locate logo regions efficiently, aiming to address the need for a generalized logo detection system in real - life document transactions.

3. Proposed Work

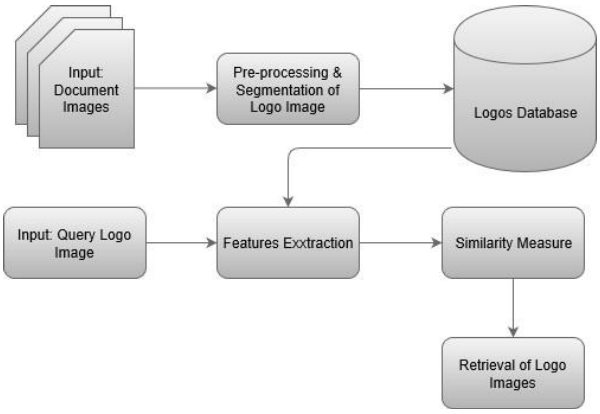
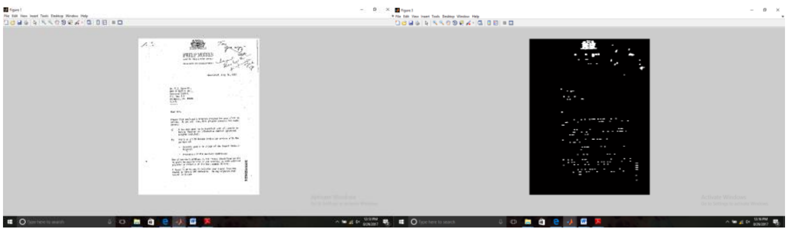


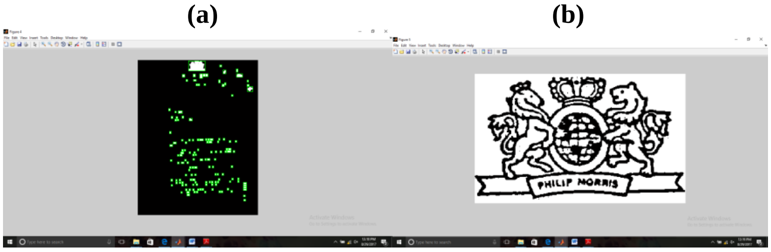
Figure 1: Block diagram of logo identification and retrieval.

3.1 Pre - processing and segmentation of logo

For binarizing the input document image, we adopted a straightforward grey - level threshold selection method as described in [12]. To further refine the document image and eliminate noise and small components, we applied Morphological Opening. Additionally, we employed horizontal and vertical dilation with a fixed length line structuring element (determined through experimentation) to ensure that each logo appears as a single connected component [13]. By applying the connected component rule, we successfully isolated each logo from the document, achieving 100% accuracy in logo segmentation for uncontaminated documents. Figure 2 illustrates the entire logo identification and extraction process from the document.



(a) (b)



(c) (d)

Figure 2: (a) Sample document image (b) Dilated document image (c) Connected component labeled document image (d) Segmented logo

3.2 Feature Extraction Techniques

Local binary pattern

Local binary pattern is well known and widely used features for several applications such as face recognition, identification of human fingerprints, problems of a pattern recognition and many more. This LBP techniques was introduces by Ojala [14]. This method helps to describe the texture of the image by considering the 3×3 window around a central pixel and converting the binary values of neighboring pixels into a decimal equivalent. The final results represent the central pixel of the method. The annotation LBPPR is used, where P refers to the total number of neighboring pixels, and R is the radius of the window. The LBPPR operator generates 2P different local binary patterns. In essence, LBP acquiring the local texture message within an image, making it valuable for several pattern recognition tasks. Figure 3 provides a visual representation of the LBP operator.

Histogram of Oriented Gradient

N. Dalal and B. Triggs introduces a method Called HOG (Histogram of Oriented Gradient) for recognition of human in the year 2005 [14]. The primary aim of this method is to find the local appearance and shape of the object, which represent effectively characterized by the distribution of local intensity gradients or edge directions, without the need for precise knowledge of particular gradient or edge locations. In this techniques the cells are formed by dividing the image window into small spatial areas, afterward using these cells constructing 1 - D histogram of gradient directions of the small spatial areas of the image or edge locations for each cell's pixels. In [15], authors was represented its application for the sketch based image retrieval and human detection. Further in [17] these features also represented for handwritten word spotting based on segmentation free approach, they divided document images into equally - sized cells and represented them using 31 - dimensional HOG histograms, while queries were characterized similarly with cells of the same pixel size. Then the image area scores were calculated using the convolution method with respect to that area of the image. Further using a dot product operation the similarity of the cells are measured using the HOG descriptors [16]. In our proposed technique, we extracted 81 features using HOG to achieve an increased retrieval rate.

Textural filters

The proposed method includes extracting texture filters on each word image, which provide robust information about local pixel strength variation in the image [18]. The extracted filters include entropy, which quantifies randomness in the input image; entropy filters, computing local entropy of a grayscale image; range filters, calculating local image range; and standard deviation filters, determining local image standard deviation. These filters produce output images of the same size as the input image, allowing computation of their mean and standard deviation.

Morphological feature

The image preprocessing technique using morphological filters involves non - linear processes based on the shape or morphology of an image. These operations rely solely on the relative sequence of pixel values, making them ideal for binary images. For a single word image, we extracted 20 morphological features, including erosion in four directions (0, 90, 180, and - 45 degrees), opening, top, and bottom hat transformations in vertical and horizontal directions, and the background to foreground ratio computed after hole filling. The structuring element used in these operations was based on the average height of characters in the word [19].

4. Similarity Measure

Cosine similarity: The similarity between query logo and candidate logo image is computed using cosine distance [20] [21]. It is a measure of similarity between two vectors of an inner product space that measures the cosine of the angle between them.

5. Experiment

5.1 Dataset

To show the performance of presented method we use the Tobacco - 800 database [22], [23], [24], which is used widely for document image analysis tasks.

5.2 Result and Discussion

In this section, we present the results of logo identification and retrieval from document images, and assess the efficiency of our proposed method using the Tobacco - 800 dataset, as explained in Section 5.1. To evaluate the performance of our methods, we employ precision, recall, and F - measure. The results are summarized in Table - 1, Table - 2, and Table - 3, showcasing the performance of the proposed algorithms with the cosine distance metric. These comprehensive experimental findings demonstrate the potential of our approach in effectively retrieving the desired logos from the Tobacco - 800 dataset. For the experiment, we selected ten query logos from the database, including text logos, graphical logos, and combinations of both. After a careful analysis of the performance evaluation parameters, such as Precision (PR) and F - measure (FM), for various combinations of local binary pattern with morphological features, histogram of oriented gradient with morphological filters, and texture filters with morphological filters, we found that the texture filters with morphological filters consistently maintained superior performance in terms of PR and FM. Precision and recall curves of the proposed methods are illustrated in Figure 5, Figure 6, and Figure 7, depicting the performance of the proposed method using the following evaluation metrics.

$$Precision = \frac{RetrievedWords \cap Releventwords}{RetrievedWords}$$

$$Recall = \frac{RetrievedWords \cap ReleventWords}{ReleventWords}$$

$$F - Measure = \frac{2 * RetrievedWords * ReleventWords}{RetrievedWords + ReleventWords}$$

Table 1: Retrieval results based on local binary pattern with morphological filters

Query Logo	Precision	Recall	F-measure
1	90.00	100.00	94.73
2	94.33	92.59	93.45
3	83.33	100.00	91.81
4	100.00	100.00	100.00
5	100.00	100.00	100.00
6	87.50	100.00	92.25
7	100.00	100.00	100.00
8	100.00	100.00	100.00
9	80.00	88.80	83.90
10	75.00	100.00	85.71
Average	**91.01**	**96.14**	**94.10**

Table 2: Retrieval results based on histogram of oriented gradient with morphological filters

Query Logo	Precision	Recall	F-measure
1	88.80	80.00	84.20
2	95.00	92.59	93.77
3	90.00	75.00	81.81
4	100.00	100.00	100.00
5	100.00	100.00	100.00
6	100.00	87.50	92.59
7	100.00	100.00	100.00
8	75.00	100.00	85.71
9	75.00	100.00	85.71
10	75.00	100.00	85.71
Average	**89.88**	**93.45**	**90.95**

Table 3: Retrieval results based on texture filters with morphological filters

Query Logo	Precision	Recall	F-measure
1	90.00	100.00	94.73
2	96.22	94.44	95.32
3	91.66	100.00	95.64
4	100.00	100.00	100.00
5	100.00	100.00	100.00
6	100.00	100.00	100.00
7	100.00	100.00	100.00
8	100.00	100.00	100.00
9	90.00	100.00	94.73
10	75.00	100.00	85.71
Average	94.28	98.00	96.60

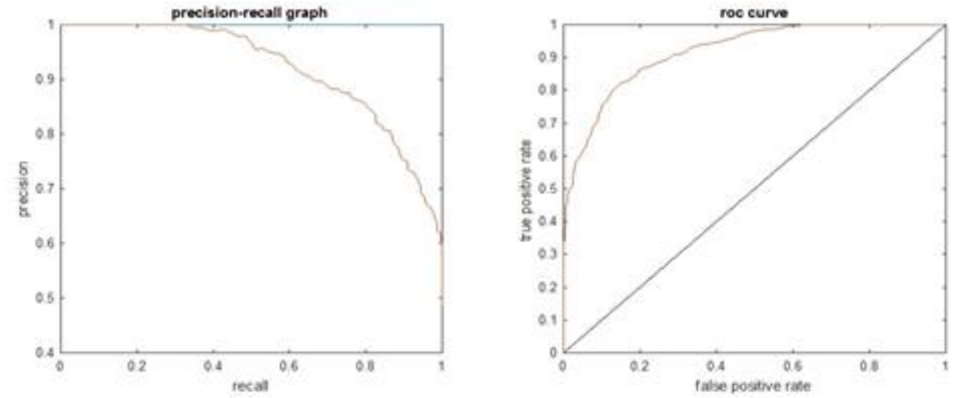


Figure 5: Precision - recall and ROC curve of LBP with morphological features.

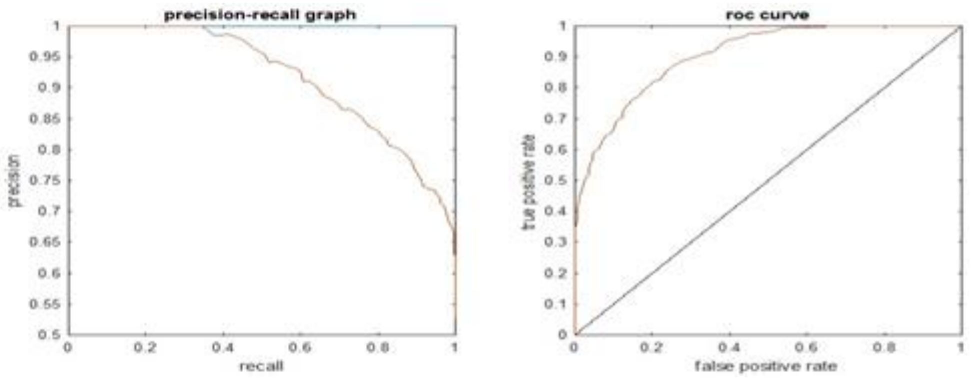


Figure 6: Precision - recall and ROC curve of HOG with morphological features.

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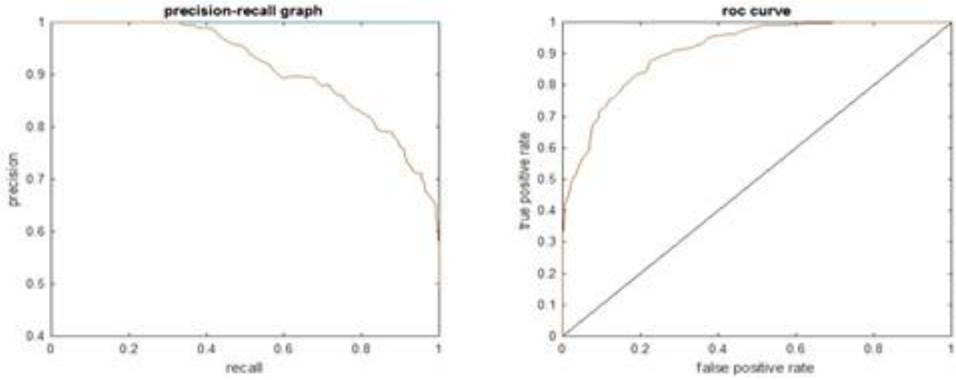


Figure 7: Precision - recall and ROC curve of textural filters with morphological features.

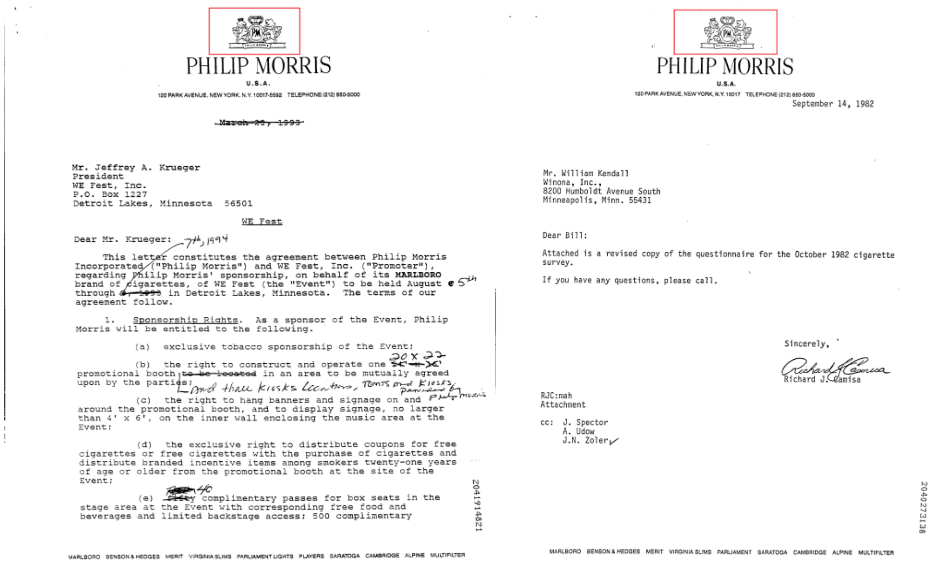
6. Comparative Analysis

The comparative analysis is made with [49] [50] [51] [52] [53] [54] [55] [56] and they have worked on dataset tobacco - 800 for automatic logo detection and document classification and reported the Precision as 73.5 with shape context distance. But, our algorithm showed a remarkable average precision as 87.00 against the same dataset with the cosine distance metric. The detailed analysis is reported in Table 4.

Table 4: Comparative analysis

Methods	Dataset	Precision (%)	Accuracy (%)
Ref - [25] - 2007	Tobacco - 800	87.00	-
Ref - [26] - 2009	Tobacco - 800	82.6	78.5
Ref - [27] - 2009	Tobacco - 800	93.3	80.4
Ref - [28] - 2010	Tobacco - 800	94.7	84.2
Ref - [29] - 2011	Tobacco - 800	92.98	90.5
Ref - [30] - 2012	Tobacco - 800	87.00	-
Ref - [31] - 2013	Tobacco - 800	75.25	91.50
Ref - [32] - 2014	Tobacco - 800	91.15	88.78
Proposed LBP +Morphology filters	Tobacco - 800	**91.01**	**94.04**
Proposed HOG +Morphology filters	Tobacco - 800	**89.88**	**92.25**
Proposed Texture features+ Morphology filters	Tobacco - 800	**94.28**	**98.14**

Figure 8: Query logo



PHILIP MORRIS
U.S.A.
120 PARK AVENUE, NEW YORK, N.Y. 10017-5592 TELEPHONE (212) 880-5000

~~March 29, 1993~~

Mr. Jeffrey A. Krueger
President
WE Fest, Inc.
P.O. Box 1227
Detroit Lakes, Minnesota 56501

WE Fest

Dear Mr. Krueger: 7th, 1994

This letter constitutes the agreement between Philip Morris Incorporated ("Philip Morris") and WE Fest, Inc. ("Promoter"), regarding Philip Morris' sponsorship, on behalf of its **MARLBORO** brand of cigarettes, of WE Fest (the "Event") to be held August 5th through ~~, 1993~~ in Detroit Lakes, Minnesota. The terms of our agreement follow.

1. Sponsorship Rights. As a sponsor of the Event, Philip Morris will be entitled to the following.

(a) exclusive tobacco sponsorship of the Event;

(b) the right to construct and operate one 20 x 22 promotional booth ~~to be located~~ in an area to be mutually agreed upon by the parties; And three kiosks locations, Tents and kiosks provided by Philip Morris

(c) the right to hang banners and signage on and around the promotional booth, and to display signage, no larger than 4' x 6', on the inner wall enclosing the music area at the Event;

(d) the exclusive right to distribute coupons for free cigarettes or free cigarettes with the purchase of cigarettes and distribute branded incentive items among smokers twenty-one years of age or older from the promotional booth at the site of the Event;

(e) ~~Fifty~~ 40 complimentary passes for box seats in the stage area at the Event with corresponding free food and beverages and limited backstage access; 500 complimentary

2041914821

MARLBORO BENSON & HEDGES MERIT VIRGINIA SLIMS PARLIAMENT LIGHTS PLAYERS SARATOGA CAMBRIDGE ALPINE MULTIFILTER

PHILIP MORRIS
U.S.A.
120 PARK AVENUE, NEW YORK, N.Y. 10017 TELEPHONE (212) 880-5000

September 14, 1982

Mr. William Kendall
Winona, Inc.,
8200 Humboldt Avenue South
Minneapolis, Minn. 55431

Dear Bill:

Attached is a revised copy of the questionnaire for the October 1982 cigarette survey.

If you have any questions, please call.

Sincerely,

Richard J. Camisa

RJC:mah
Attachment

cc: J. Spector
A. Udow
J.N. Zoler

2040273138

MARLBORO BENSON & HEDGES MERIT VIRGINIA SLIMS PARLIAMENT SARATOGA CAMBRIDGE ALPINE MULTIFILTER

Figure 9: Retrieved document images with respect to query logo

Figure 10: Detected Logos

7. Conclusion

In the mission for finding the good retrieval technique, both logo and its corresponding document image from the database implemented through machine learning algorithms such as local binary pattern, textural filters, and HOG features with combination of morphological features are employed to determine which of these traditional methods is outperforming. Experimental results exhibited that textural filters with morphological features give prominent retrieval results compared to other methods. The proposed method has shown the high performance accuracy as a precision rate at 94.28% and recall rate at 98.00 and F - measure rate at 96.60% for the textural filters with morphological features. Hence, the proposed algorithm is efficient with respect to accuracy and time complexity. Figure - 8, Figure - 9, and Figure - 10 represents the example of query logo, detected document image and retrieved logo from the document image database respectively.

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