Automatic Logo Detection and Extraction using Singular Value Decomposition

Umesh D. Dixit, M. S. Shirdhonkar

Abstract—**Logo detection and extraction from a document image has found its importance in applications like logo based document image retrieval and logo based classification of documents. In this paper we propose a novel method for automatic logo detection and extraction from document image using mathematical tool Singular Value Decomposition (SVD). The method proposed is tested for publicly available realistic document image database Tobacco-800. We also compared the results of proposed method with current state of the art. Average logo detection rate achieved with proposed method is 89.52%.**

Index Terms—**Logo detection, Logo extraction, Singular Value Decomposition(SVD)**

I. INTRODUCTION

Rapid and tremendous growth of internet and advancement in technology demands a solution towards quick access of the document images stored. One of the solutions found in the past decade to increase the accessing speed of documents is indexing of documents based on the logo they contain. Most of the organizations, companies and enterprises are using logo as a graphic symbol for representing their ownership or authentication of documents since many decades. Depending on whether logos contain graphics, text and combination of both, they can be categorized as graphical logo, text logo or as a mixed logo. Fig. 1 shows sample of these three different categories of logos found in widely used realistic and complex Tobacco – 800 database [1].

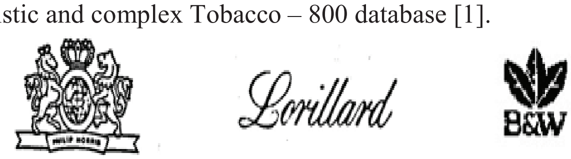

Fig. 1. Different types of Logos found in tobacco-800 database

Given an image of the document, detecting and separating out a logo becomes a highly important task during intelligent logo based document image retrieval and classification of documents based on the logo. Thus logo detection mainly helps in indexing of the document images and their by increases the ease of access to the documents stored in repository by the users. Therefore detection of a logo and separating it out from the document has drawn the attention of lot of researchers in the field of document image processing and document image analysis. Hence in this paper we are particularly addressing the issue of logo detection and providing an optimal solution for the same.

The main contribution of this paper is providing a novel solution for automatic detection of logo from image of the document and separating it out using algebraic mathematical tool singular value decomposition (SVD) [2]. The method we have proposed works without requiring any prior training or machine learning. We have tested our proposed method for all the three categories of logos as mentioned before. The idea behind the proposed method is that, a region containing high spatial density in the image of the document embeds a logo. Spatial density of the pixels can be computed in a variety of methods, however in our proposed method spatial density of document regions is computed by decomposing each small region by using SVD and then computing their energy. The region of the document that has highest energy compared to other regions is considered as the logo region in the document.

The remaining part of this paper is organized as follows: Section II briefly discusses about the related work carried out for detection and extraction of logo, section III describes the proposed methodology, section IV provides the results obtained using proposed method and finally section V concludes the paper.

II. RELATED WORK

In this section of the paper we briefly discuss about state of the art developed by different researchers. Seiden et. al [3] used the concept of connected components with sixteen region based features for segmenting document image into small blocks and then they applied rules based classification for detecting logo in their method. Pham [4] presented a method for logo detection which is based on an assumption that the spatial density of foreground pixels in a logo region will be more than that of non-logo regions in the document. In his method the document image is divided into a number of windows and for each fixed size window, spatial density is computed. Then the particular region that contains highest spatial density is treated as logo region of the document.

A method that uses multi-scale boosting strategy was proposed by Zhu and Doermann [5]. At coarse image scale they applied two-class Fisher classifier for each connected

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component and cascade of simple classifier at finer image scale to find out a logo from possible set of logo candidates.

A method based on discrete wavelet transform (DWT) was proposed by Shirdhonkar and Kokare [6], in which document image is divided into small windows with size approximately equal to size of the logo. The spatial density of each of these windows is computed by using the mean of the energy and standard deviation of the wavelet coefficients. Finally the window with sum of highest energy and standard deviation is considered as logo region of the document.

A frame work using spatial and structural features for logo detection and recognition was proposed by Hassanzadeh and Pourghassem [7]. They addressed the issue of detecting separated parts of logos in the document image. Morphological dilation operation is used for merging of separated parts of logos. Logo recognition is carried out using a new feature based on histogram of object occurrence. Nejad and Faez [8] introduced a method for logo extraction which makes use of horizontal and vertical analysis of pyramedial tree structure of the document for extraction of logo and a KNN classifier for recognition of a logo.

Morphological operation such as closing is used for detecting a logo from the simple document images in the method developed by Dixit and Shirdhonkar [9]. The method makes false logo detection sometimes, when a document is having more number of spatially densed components.

III. PROPOSED METHODOLOGY

We propose a novel method for logo detection and extraction from document image using a mathematical tool SVD. It is an algebraic transform that can be used in wide range of image processing applications.

Algorithm: Logo extraction using SVD

1. **Input:** Document image.
2. **Output:** Extracted logo from the document.
3. Read document image from database.
4. Find connected components and perform area based thresholding to get pool of possible logo candidates. Let A[1,2, .. N] represents pool of possible logo candidates.
5. Apply SVD to each possible logo candidate A_i and decompose into matrices U_i, S_i and V_i. Where U_i, V_i are unitary orthogonal matrices and S_i is diagonal matrix.
6. Calculate energy of each possible candidate A_i using equation (1)

   $$\mathbf{E_i = \frac{1}{M*N}\left\{\sum_{k=1}^{M}\sum_{l=1}^{N}[U_i(k,l) + S_i(k,l) + V_i(k,l)]\right\}} \quad \mathbf{(1)}$$

   Where E_i is energy of each possible logo candidate A_i, M and N are size of matrices U_i, S_i and V_i.
7. Detected logo = Candidate from the pool with Max. (E_i).
8. Extract detected logo from the document image.
9. End.

SVD allows splitting of the system into a set of linearly independent components, such that each of these components contributes their own energy. A square matrix will be singular only if one of its singular values is zero and number of non-zero singular values in the matrix is represent rank of that matrix. When we apply SVD to a matrix, it results into two unitary orthogonal matrices U, V and a diagonal matrix S.

Algorithm shows the steps used for logo extraction from document image using SVD. Following section describes the steps used in the algorithm in detail.

A. Preprocessing

Initially the document image is read and stored as a matrix of size M rows and N columns. Then the image read is converted into binary image consisting of pixels with intensity value 1 and 0. Intensity with value 0 indicates black pixels and 1 indicates white pixels. Usually document images suffer from dark horizontal and vertical lines due to duty noise of scanning devices. This type of noise is removed simply by replacing continuous string of 0s in either horizontal or vertical direction with value 1. After this a median filter is applied to remove impulse noise from the image.

B. Area based thresholding

In the next step we find the connected components of the document image and calculate area of each component. Then we consider only those connected components as possible logo candidates whose area is at least 25% of largest connected component in the document image. This results in area based thresholding and we get a pool of possible logo candidates. Figures

C. Singular Value Decomposition

Generally area containing logo will have more black pixels as compared to other regions of the document. To compute density of black pixels various techniques can be used. However in this paper we have used singular value decomposition to compute the density of black pixels.

Let A[1,2, .., N] represents an array of possible logo candidates obtained after area based thresholding. Now we apply SVD to each of these candidates A_i. This results decomposition of each A_i into corresponding matrices U_i[M,N], S_i[N,N] and V_i[N,N]. Where, U_i[M,N] is column orthogonal matrix of size M*N, S_i[N,N] is diagonal matrix of size N*N and V_i[M,N] is orthogonal matrix of size N*N satisfying following conditions.

a) $A = U*S*V^T$, Where 'A' is original matrix of size M*N, 'U' is an orthogonal matrix whose columns are Eigen vectors of AA^T and 'S' a diagonal matrix with elements $\sigma_1, \sigma_2, .., \sigma_n$; σ_i being singular values of A and also σ_i = Sqrt(Eigenvalue value of AA^T).
b) Similarly 'V' is also an orthogonal matrix in which it's columns represent eigen vectors of A^TA.

D. Logo detection and extraction

We compute energy E_i of each possible logo candidate A_i employing their decomposed matrices U_i, S_i and V_i using above mentioned equation (1).

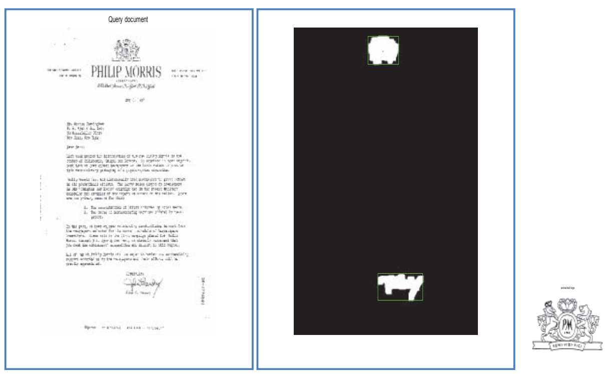
From the pool of possible logo candidates, we consider the candidate A_i whose energy E_i is maximum as a detected logo and then we extract this logo candidate from the pool.

IV. RESULTS AND DISCUSSION

The proposed method in this paper is tested for documents from our own database created and as well as publicly available realistic data base Tobacco-800. Tobacco-800 is a public subset of the IIT CDIP, has 42 million pages of documents obtained from UCSF [1] and released by Tobacco companies under the master settlement agreement. Fig. 2 shows sample result with original image of the document, pool of possible logo candidates and extracted logo using the proposed method.

Logo detection rate is used as a parameter for evaluation of the proposed method. Logo detection rate is computed using equation (2)

$$\text{Logo detection rate} = \frac{\text{No. of Logos that are correctly detected}}{\text{Total number of Documents}} \quad (2)$$



(a) (b) (c)

(a) Input Document image
(b) Pool of possible logo candidates
(c) Extracted logo

Fig. 2. Sample result

As performance of logo detection also depends on logo type, we have evaluated and analyzed the method for documents containing different type of logos. Results of the proposed method is compared with the earlier method used in [6]. Table I shows the comparison of logo detection rate for different category of logos with the proposed method and earlier method used in [6]. In Table I we have shown logo type, number of documents containing that particular logo and detection rate obtained using both the methods. By using earlier method an average logo detection rate of 56.81% is achieved, whereas with the proposed method achieved average logo detection rate is 89.52% for same set of documents under testing. Fig. 3 shows graph of comparison of results obtained with proposed method and earlier method [6]. The X-axis of the graph depicts category of logos and Y-axis shows logo detection rate obtained for individual category of logos. Fig. 4 shows comparison of average logo detection rates with both of the methods. The results shown in the graph reveals that the performance of the proposed method is much better compared with earlier method used in [6].

TABLE I
COMPARISON OF LOGO DETECTION RATE

Sl. No.	Logo type	Number of Documents	Detection Rate (%)	
			Earlier method [6]	Proposed method
1	PHILIP MORRIS	54	90	94
2	THE AMERICAN TOBACCO COMPANY	65	70.7	96.9
3	Lorillard	54	77.7	98
4	m	10	30	80
5	B&W	42	38	64
6		23	85.7	91
7	B&W	31	13	96.7
8		6	100	100
9		10	40	90
10		13	23	84.6
Average detection rate			**56.81**	**89.52**

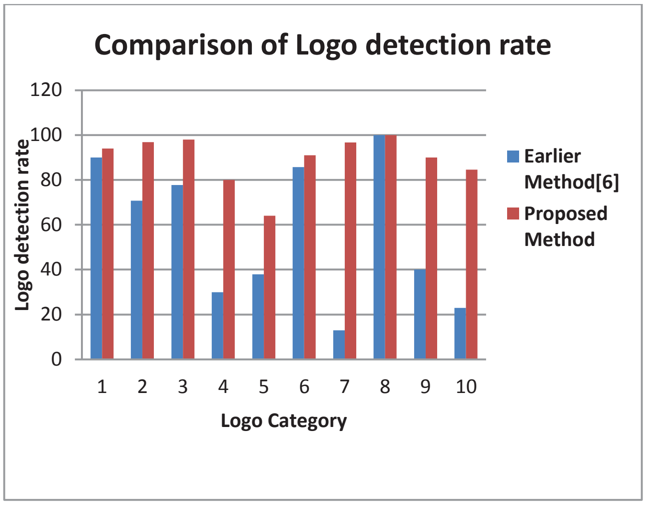


Fig. 3. Comparison of logo detection rate

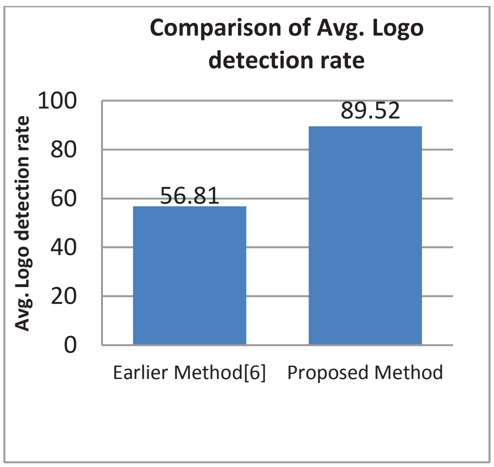


Fig. 4. Comparison of average logo detection rate

V. CONCLUSION

In this paper, we proposed a novel method for detecting and extracting logo automatically from document image using algebraic mathematical tool SVD. The proposed method is implemented, tested and analyzed for documents of our own database as well as publicly available realistic complex database Tobacco–800 using matlab software on Intel core i5 with 8GB (RAM) system. Testing has been carried out for different category of logos and we have achieved an average logo detection rate of 89.52% with the method presented.

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