

Administrative Document Processing

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Computer Science

by

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CERTIFICATE

This is to certify that the dissertation entitled ‘**Administrative Document Processing**’ submitted by **Satish Chandra** to Indian Statistical Institute, Kolkata, in partial fulfillment for the award of the degree of **Master of Technology in Computer Science** is a bonafide record of work carried out by him under my supervision and guidance. The dissertation has fulfilled all the requirements as per the regulations of this institute and, in my opinion, has reached the standard needed for submission.

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Abstract

In this work we have developed a system which retrieve the document images from a collection of documents based on Logo, Seal or Signature. This work presents a two stage approach for retrieving the documents. In the first stage detection of Logo, Seal and Signature is done by extracting the non-text part from document and fed to Support Vector Machine (SVM) to detect whether it is Logo, Seal or Signature. Scale-Invariant Feature Transform (SIFT) descriptors and Spatial Pyramid matching are used for feature extraction. Second stage is recognition. Histogram of gradients is used for the recognition of logo and seal. For signature recognition, first the background blobs are extracted using character loops and water reservoir technique then Zernike moment feature is computed for each blobs and hierarchical clustering is used to generate the codebook. Using Generalized Hough Transform, we store some spatial features of signature blobs using the codebook which is used for the recognition of signature.

Contents

1	Introduction	7
1.1	Motivation	7
1.1.1	Application	8
1.2	Problem Statement	8
1.3	Organization of the dissertation	11
2	Related work	12
2.1	Work on Logo	12
2.2	Work on Seal	13
2.3	Work on Signature	13
3	Our Approach	15
3.1	Detection of Logo, Seal or Signature	15
3.1.1	Segmentation of text and non-text part	15
3.1.2	Feature extraction	20
3.1.3	Logo, Seal and signature detection procedure	20
3.2	Recognition of Logo Seal and Signature	21
3.2.1	Recognition of Logo and Seal	21
3.2.2	Recognition of Signature	23
4	Experimental Results	28
4.1	Dataset Used :	28
4.2	Results for Classification	28
4.3	Results for Recognition	29
4.3.1	Results for Logo Recognition	29
4.3.2	Results for Seal Recognition	30
4.3.3	Results for Signature Recognition	30

4.4	Error Analysis	33
4.4.1	Error in Detection	33
5	Conclusion and Future Work	35

List of Figures

1.1	Logo and Seal in the document	9
1.2	Signature in the document	9
1.3	Signature in the document	10
1.4	Signature in the document	10
3.1	Original image	16
3.2	Horizontal erosion (img_h)	17
3.3	Vertical erosion (img_v)	18
3.4	After taking AND of (img_h) and (img_v)	19
3.5	Seal detected in two parts	20
3.6	Signature detected in two parts	21
3.7	Original Seal image	22
3.8	Seal image after rotation	22
3.9	Examples of some background blobs	24
3.10	Flow chart of generation of Codebook	24
3.11	R-Table	25
3.12	Flow chart for Signature Recognition	27
4.1	Logo after scaling and rotation	29
4.2	Samples of Seal	30
4.3	Signature after scaling and rotation	31
4.4	Detected Logo and Seal in the document	32
4.5	Detected Signature in the document	32
4.6	Erroneous image due to over segmentation	33
4.7	Erroneous image due to false detection	34

List of Tables

4.1	Classification Result	29
4.2	Results for Logo recognition	29
4.3	Results for Seal recognition	30
4.4	Results for Signature Recognition	31

Chapter 1

Introduction

Various research has been performed on Content Based Image Retrieval (CBIR). CBIR is defined as retrieving the images which are visually similar, from a collection of images, based on a given query image. Content Based Document Image Retrieval is a type of CBIR in which retrieval of document images takes place based on some query image. Traditionally, Document Image Retrieval is performed based on the textual queries using Optical Character Recognition (OCR). The OCR technique may fail for the documents which are degraded due to noise, compression or poor typing. For these type of documents, Word Spotting Technique [17, 24] is used in which query word image is searched in the document images. Word spotting is an interesting alternative to OCR.

1.1 Motivation

There are many documents which contain the graphical information in addition to the textual information like documents contain diagrams, tables or images. Administrative documents contain graphical information such as Logo, Seal and Signature. Searching the documents based on these information allow the quick retrieval of documents. For the retrieval of documents using the graphical information we have to first detect these symbols in the document image and have to recognize the symbols. As the volume of documents is increasing, retrieval of documents based on graphical information (Logo, Seal and Signature) is a better alternative to use OCR technique to read the text and retrieve the documents.

1.1.1 Application

There are many applications of retrieving the document images based on graphical information. For example:

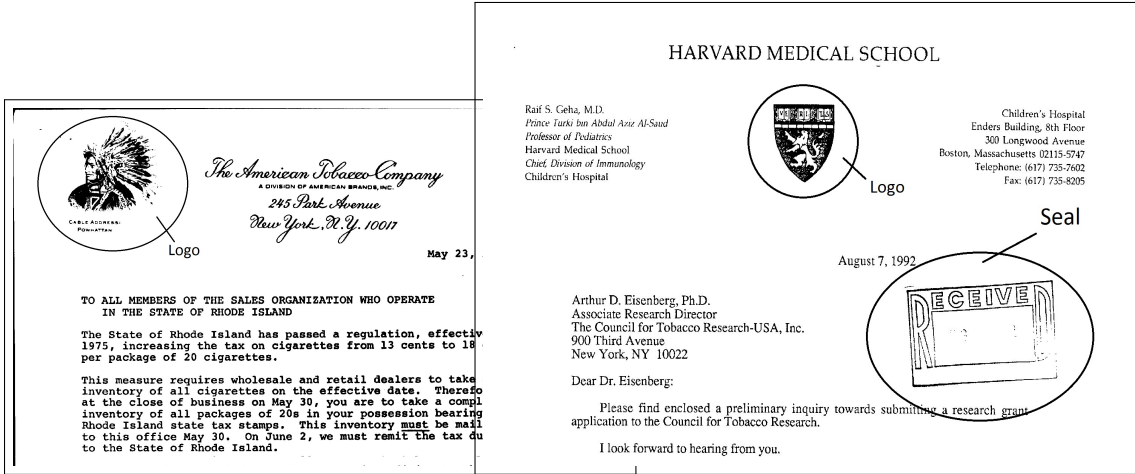
1. Organizations can use the approach of automatic distribution of incoming mails to their respective department based on the content of electronic documents. For automatic distribution they can use different graphical symbols present in the documents.
2. In the judicial system, one may retrieve the documents of the judgement given by a particular judge quickly, by using the image of signature.
3. Automatic document verification.

1.2 Problem Statement

Suppose many documents are given in the form of images and there is one query image that can be a Logo, Seal or Signature, then the task at hand is to retrieve all the image documents which contain the query image. The documents containing Logo, Seal or Signature are shown in the Figure 1.1, 1.2, 1.3 and 1.4.

There are many challenges involved in the detection and recognition of Logo, Seal and Signature, such as

- The position of the Logo, Seal or Signature may not be fixed in the document.
- It may be of different sizes in different document images.
- It may be rotated in the document.
- Due to free-flow nature of handwriting the signature may overlap/touch with other content information (text, line etc).
- Signature contains similar features as handwritten text. Hence, it is difficult to detect signature portion from such type of documents.



(a) Logo in Document

(b) Both Logo and Seal in the document

Figure 1.1: Logo and Seal in the document

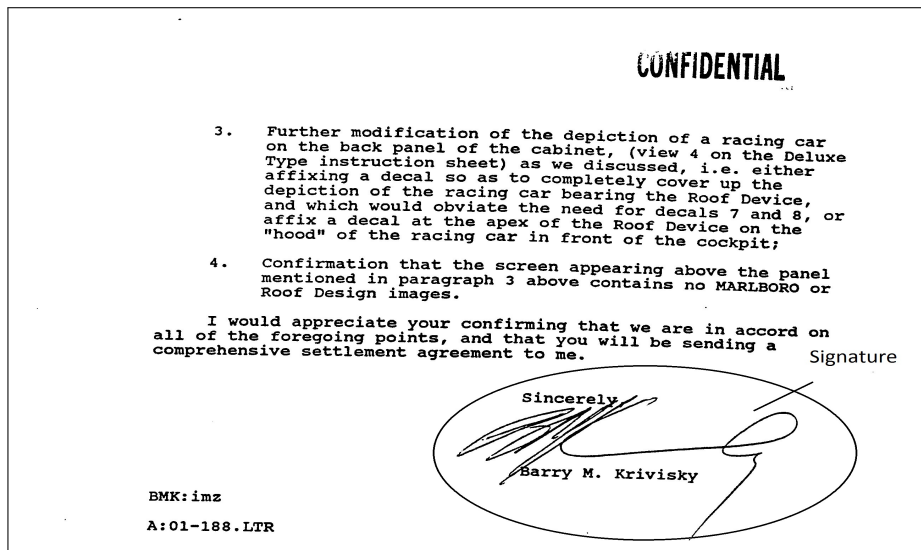


Figure 1.2: Signature in the document

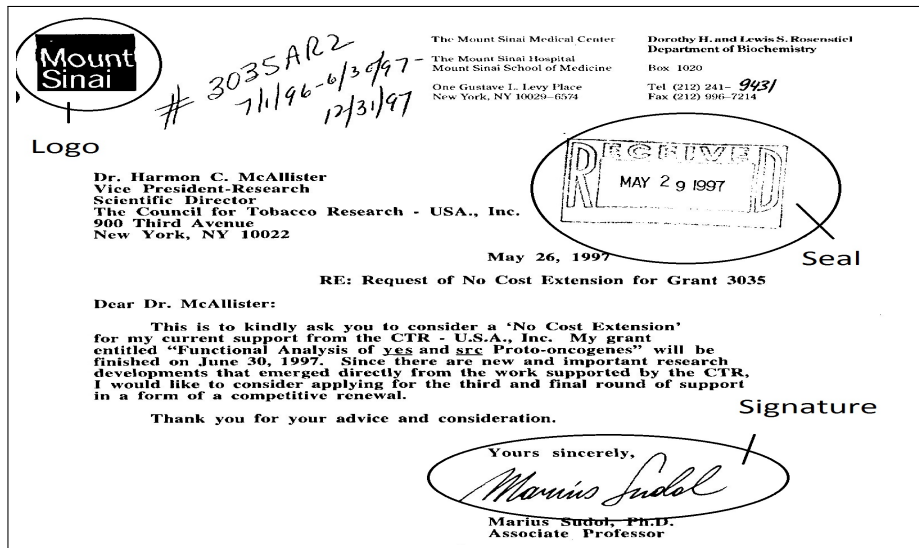


Figure 1.3: Signature in the document

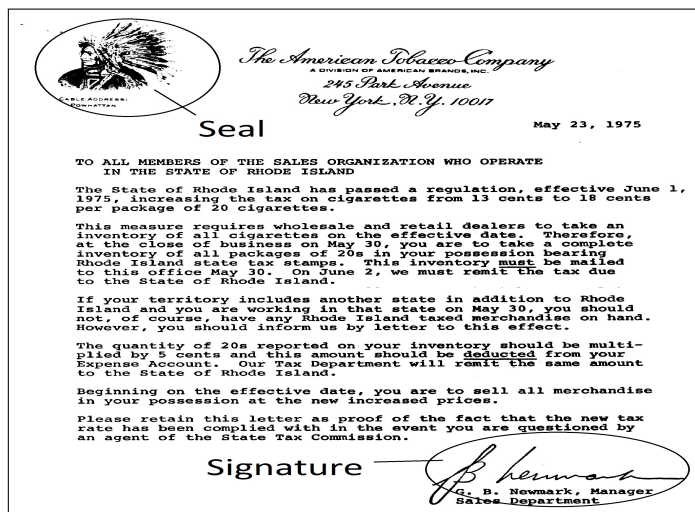


Figure 1.4: Signature in the document

1.3 Organization of the dissertation

The rest of the dissertation is organized as follows.

Chapter 2: A brief study of relevant research is presented here.

Chapter 3: In this chapter, we have described our approach for detection and recognition of Logo, Seal and Signature.

Chapter 4: In this chapter, we have shown the detailed experimental results and error analysis.

Chapter 5: Finally in this chapter, we have concluded the dissertation and given the future scope of work.

Chapter 2

Related work

In this chapter we discuss a brief review on the existing piece of work on Logo, Seal and Signature to know the current state of the art of this area.

2.1 Work on Logo

Various approaches for logo detection and recognition are presented in many papers. Logo detection methods find the location of logo, i.e., where the logo is present in the given document [30, 29]. A typical approach for detecting the logo in a document is to segment the document image based on connected component analysis and describes these component using features like size, density, aspect ratio, circulatory, domain knowledge (e.g. prior knowledge of position of the logo) [30, 29]. Then for separating the logo from other components, Decision tree or Fisher classifier is used. In logo recognition, there are various approaches that has been proposed using shape feature [16]. Lowther et.al. [16] presented a system for logo recognition. They have computed the feature using higher-order spectra and then nearest neighbor classifier is used for classification. But the shape extraction technique is not suitable for the recognition because it is sensitive to the noise and shape distortion. Doermann et.al. [7] extract the text and various shapes like circle, line and rectangle using many feature detector and using algebraic and differential invariants, they calculate shape descriptor for matching.

2.2 Work on Seal

There are some works that has been done for seal detection and recognition in document images. Zhu et al. [31] presented a seal detection technique based on the outer boundary shape of the seal e.g. circular, elliptical etc. A heuristic approach is proposed by Hu et al. [10] to find the best match between model and sample seal image. Correlation based block matching in polar coordinate system is presented in [5]. This method is based on rotation invariance feature. Matsuura et al. [21] uses discrete K-L expansion of Discrete Cosine Transform (DCT) to verify the seal image. A rotation invariance feature is proposed by converting the image in log-polar form and calculate the Fourier Series coefficient in [22]. For registration and classification of seal an attributed stroke graph obtained from skeleton of the seal is used in [12]. Gao et al. [9] used a verification method based on stroke edge matching combined with image difference analysis. W. Lee et al. [12] proposed a scheme based on attributed stroke graph matching for the automatic seal verification. In this work shape of the seal is allowed to be imperfect. Roy et al. [26] proposed a seal detection technique based on the text information present in the seal. The concept of Generalized Hough Transform is used to detect the seal.

2.3 Work on Signature

Segmentation and recognition of signature from document image is a challenging task. There are a few piece of work on signature segmentation. For detection and segmentation, a multi-scale saliency approach is proposed by Zhu et al [32]. In this work instead of considering the local feature they computed the structural saliency using a signature production model and then computed the dynamic curvature of 2D contour fragments over multiple scales. They used shape dissimilarity based on anisotropic scaling and registration residual error. In order to segment the signature in machine printed document, there are some techniques that has been proposed in the works [18, 2]. To segment the signature, a sliding window approach has been proposed by Madasu et al [18]. They used entropy to select the signature block. However, one drawback of this approach is that it assumes the location of signature apriori, hence it will not work in real life documents. A Speeded Up Robust Features (SURF) based approach for signature segmentation from document images is proposed by Ahmed et al. [2]. To retrieve the documents based on signature, Chalechale et al. [4] proposed a method based on connected component analysis and geometric

feature of labeled region. For the description on spatial distribution of pixel in the interested region an angular partitioning scheme was used. Srinivasan and Srihari [27] proposed a method on signature-based retrieval of scanned documents. They have used Conditional Random Fields (CRF) model to label the extracted segment as printed, signature or noise then Support Vector Machine(SVM) is used to remove the printed part and noise, overlapping the signature image. A global shape-based feature is computed for each image and normalized correlation similarity is used for the matching. Roy et al. [25] proposed a signature based document retrieval with cluttered background. They extracted the blobs from the documents and by using Zernike moment and K-means clustering they generated a codebook. Finally Generalized Hough Transform (GHT) is used to detect the query signature. Mandal et al. [19] presented signature segmentation and recognition technique. They extracted the signature block using word-wise component extraction and performed the classification using gradient based feature. They used SIFT Descriptor and SPM technique for the recognition of the signature.

Chapter 3

Our Approach

Our proposed work is divided into two parts. First, we need to detect the Logo, Seal or Signature in the document and then we recognize the extracted Logo, Seal or Signature, based on which we can retrieve the relevant documents accordingly.

3.1 Detection of Logo, Seal or Signature

The detection approach is divided into two parts: First part is the segmentation of non text parts from the the text part in the document using erosion and connected component analysis. Second part involves the classification of this extracted part into Logo, Seal and Signature.

3.1.1 Segmentation of text and non-text part

For a given document (say img), our text and non-text part separation approach is as follows:

1. First convert the given document image into binary image.
2. Take structuring element of size 1×5 and apply erosion on the document in horizontal direction, we get an image, say img_h as shown in Figure 3.2.
3. Using the same structuring element, erosion is applied on the document in vertical direction, we get an image, say img_v as shown in Figure 3.3.
4. We take the bitwise *AND* of these two images namely img_h and img_v and call it as img_{hv} , see Figure 3.4
5. Apply the connected component analysis on img_{hv} to extract the non text part.

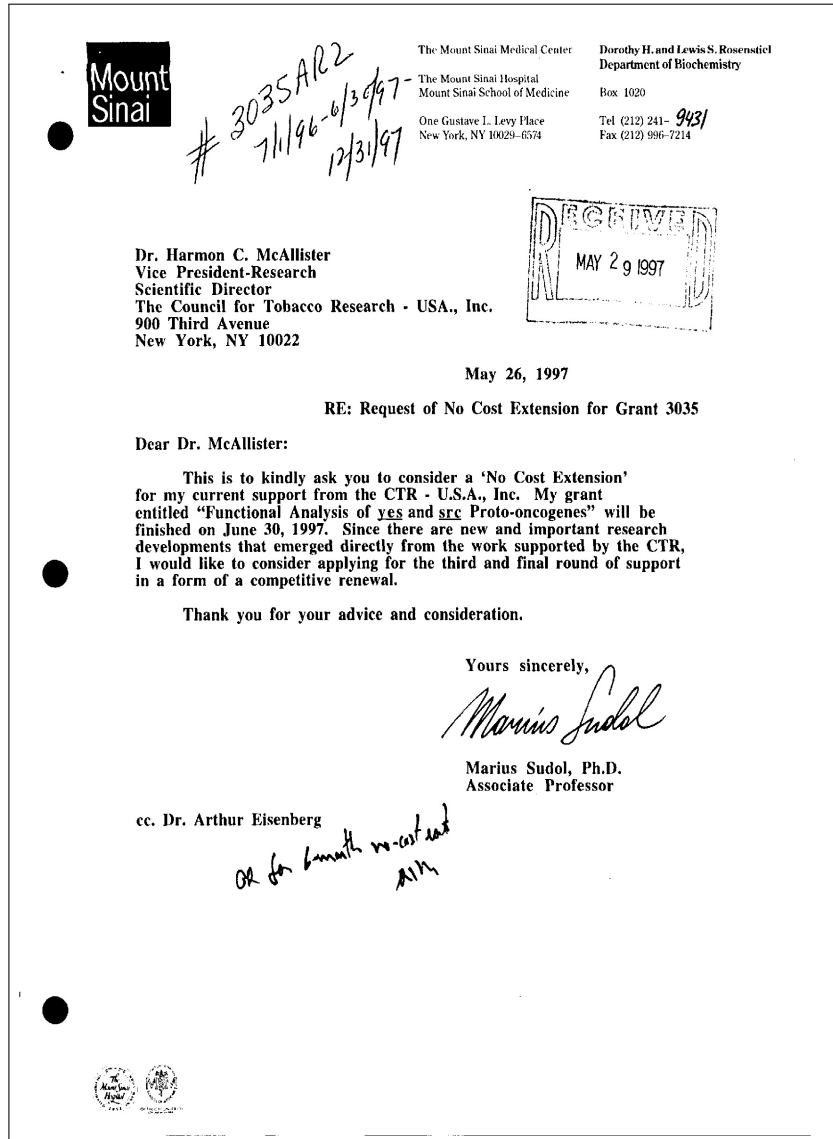


Figure 3.1: Original image

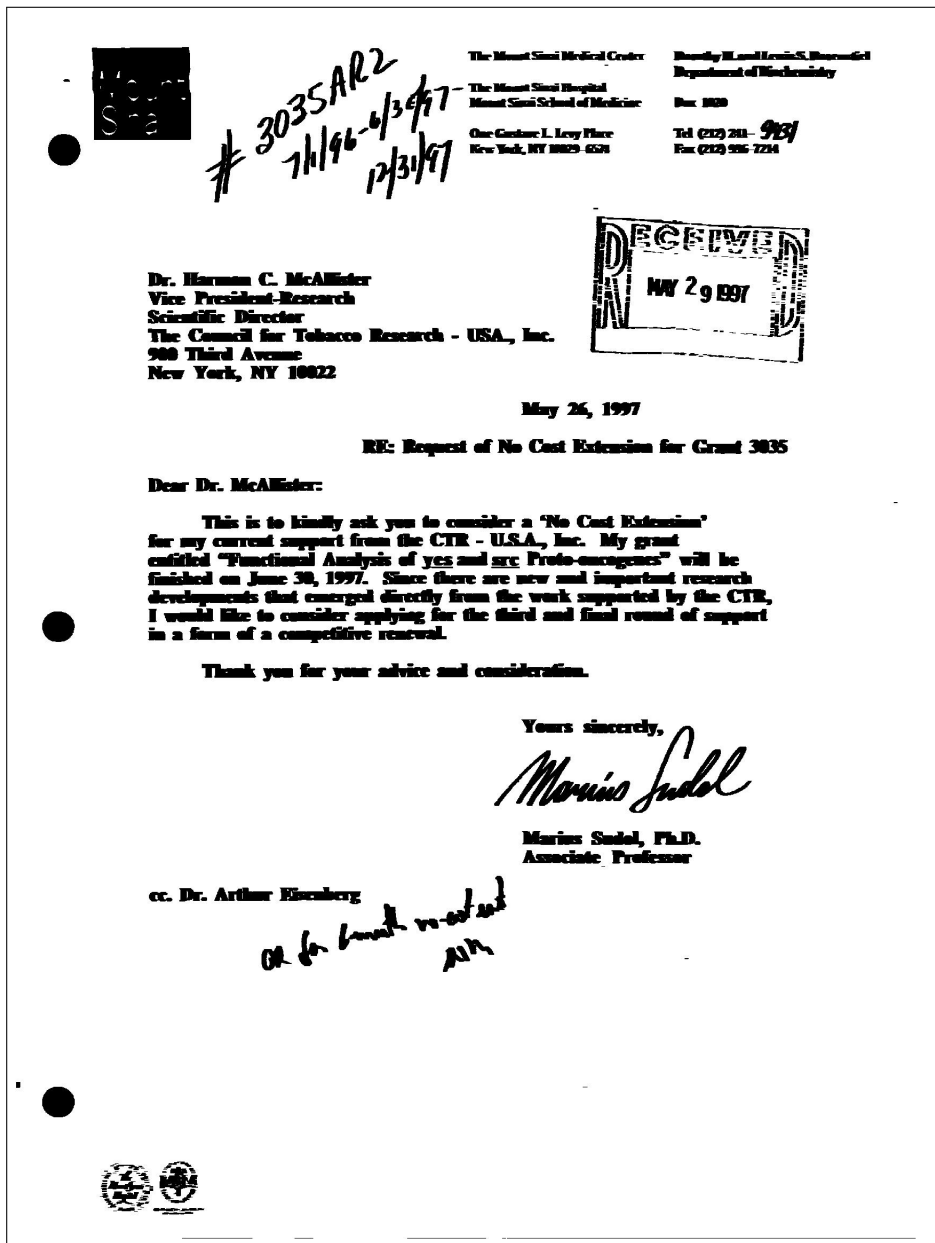


Figure 3.2: Horizontal erosion (img_h)

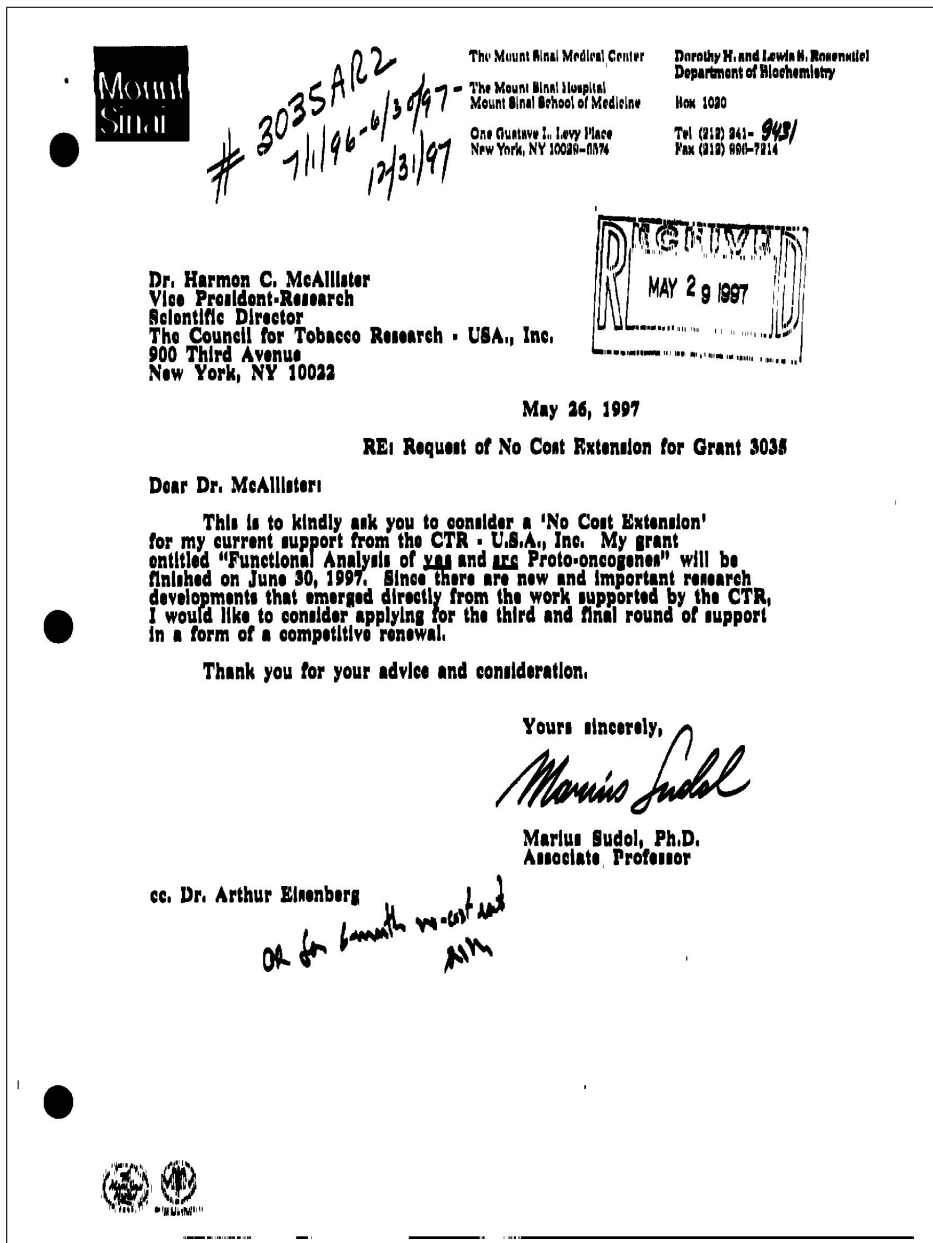


Figure 3.3: Vertical erosion (img_v)

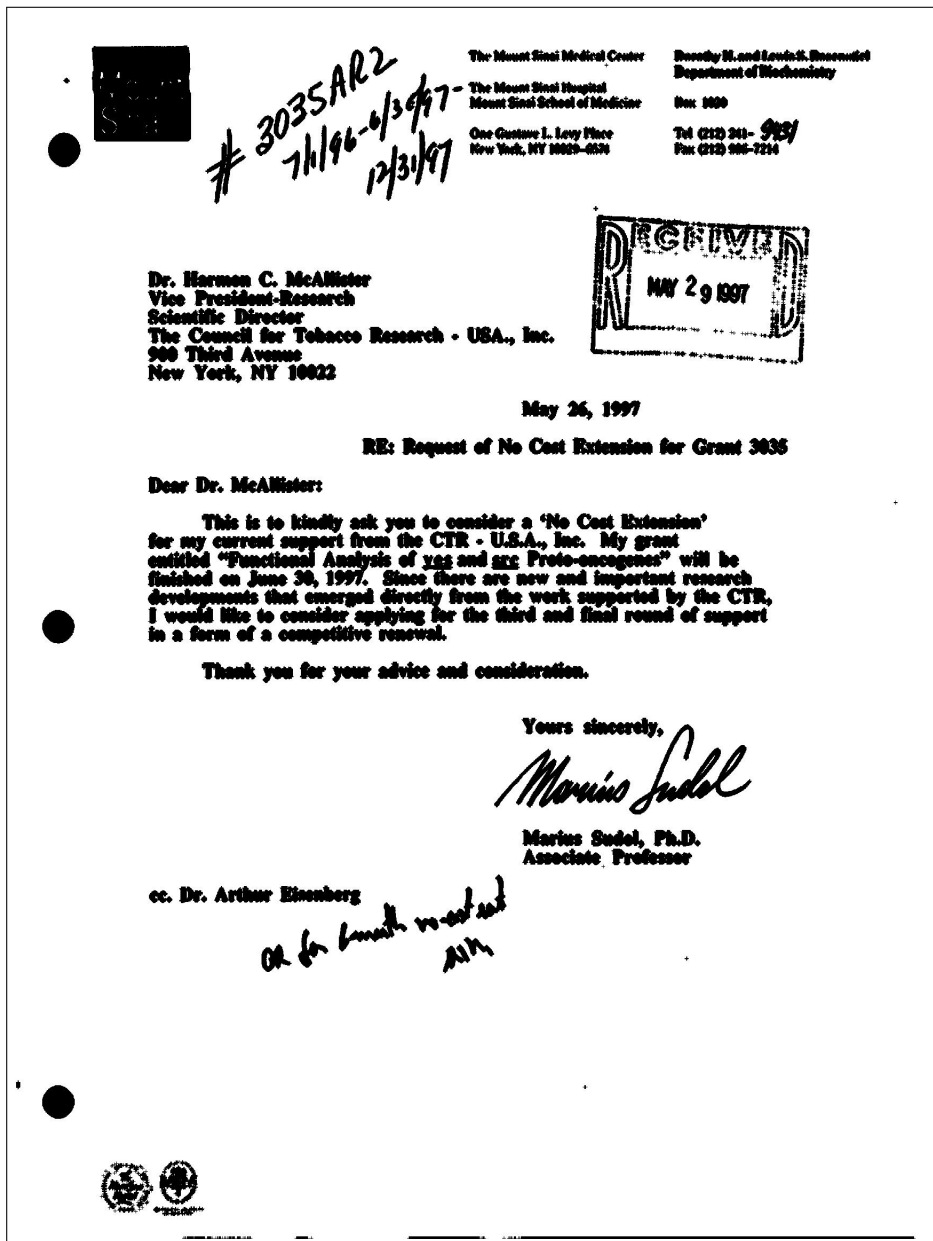


Figure 3.4: After taking AND of (img_h) and (img_v)

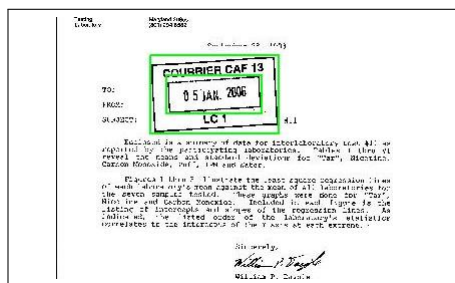
3.1.2 Feature extraction

First we need a model to classify the extracted non-text part into Logo, Seal or Signature. For that we took training set images of 3 classes Logo, Seal and Signature and extract the feature to train the model. For extracting the feature, image is divided into 16×16 patches. SIFT descriptors [15] of length 128 are calculated over a patch. Hence we have 256 SIFT descriptors for one image. For all the training images of the 3 classes in question, calculate the SIFT descriptors, and using K-means clustering generate the codebook. The length of the codebook is 256. Finally Spatial Pyramid Matching (SPM) [11] is used to generate the feature vectors. These feature vectors are fed to an SVM classifier and a model is built to classify the image into 3 classes Logo, Seal and Signature.

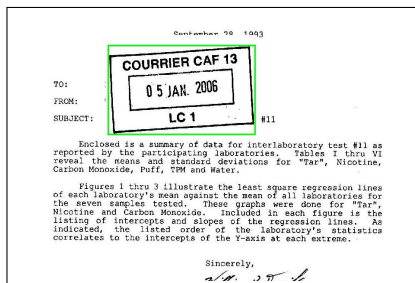
3.1.3 Logo, Seal and signature detection procedure

While extracting the connected component we fed it to the SVM based model to find whether the connected component is Logo, Seal or Signature, and bounding box information of that component is saved. Several scenarios may be encountered, which may include detecting a logo inside a logo, detecting a single signature into two or more signatures. In order to handle such erroneous cases, we have used bounding box information to merge them and find one complete image of logo, seal or signature. The procedure is as follows:

1. If one bounding box is inside other, consider the bigger one, see Figure 3.5.
2. If two bounding boxes are overlapping or the distance between them is less than some threshold, find the minimal rectangular convex hull covering all eight points of these two bounding box, see Figure 3.6.

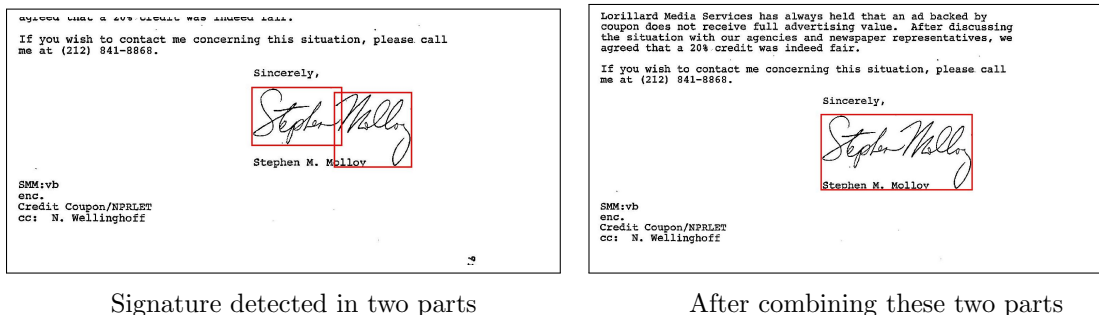


Seal detected in two parts



After combining these two parts

Figure 3.5: Seal detected in two parts



Signature detected in two parts

After combining these two parts

Figure 3.6: Signature detected in two parts

3.2 Recognition of Logo Seal and Signature

For recognition of Logo, Seal and Signature, we have the template images for each of the three that contain the different classes of Logo, Seal and Signature respectively. We already know the query image i.e. Logo or Seal or Signature. Accordingly, the recognition method as given below is applied.

First of all the two images which are supposed to be matched, might vary in size and they might be oriented in different directions. In order to take care of these cases, the second image is rotated and scaled to bring it in direct correspondence with the first image. For the rotation and scaling, we are using a feature based technique based on Computer Vision System toolbox [20]. It uses SURFFeatures and GeometricTransformEstimator to calculate the rotation angle and scaling factor of second image, then it transform the second image based on angle and scale. It is shown in Figure 3.7 and Figure 3.8 in the next page.

The method which we have used for recognition of Logo and Seal do not work properly for Signature recognition. This may be possible because there are less information present in Signature image than Logo or seal. Hence we have two approaches, one is for the recognition of Logo and Seal and the other for the recognition of Signature. The approaches are discussed as follows:

3.2.1 Recognition of Logo and Seal

Feature Extraction : For extracting the feature for Logo and Seal recognition, we used Histogram of Gradient (HOG) [6]. The algorithm for feature extraction for a given image is as follows:

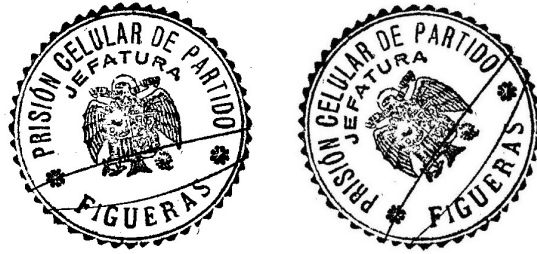


Figure 3.7: Original Seal image



Figure 3.8: Seal image after rotation

1. The gradient is calculated in the x-direction and y-direction.
2. The gradient magnitude and gradient direction are calculated at each pixel.
3. The image is divided into 25×25 patch with 50% overlap i.e. total $24 \times 24 = 576$ blocks. Each patch consists of 2×2 cells of size $(r/25 * c/25)$ where r and c is number of rows and column in the image.
4. For each block, quantize the gradient direction into 9 bins considering an interval of 20 degree [10 30 50 70 90 110 130 150 170]
5. Increment the particular bin vote as follows
 - I Suppose $\theta \leq 10$ or $\theta \geq 170$ then increment the (bin_{10}) or (bin_{170}) with magnitude at that point respectively.
 - II Suppose $\theta = 48$ then it is between bin center 30 and 50. Then increment the value of bin by

$$\text{newValue}(bin_{30}) = \text{oldValue}(bin_{30}) + \text{magnitude at that pixel} * (50-48)/20$$

$$\text{newValue}(bin_{50}) = \text{oldValue}(bin_{50}) + \text{magnitude at that pixel} * (48-30)/20$$
 we noted that this weighting scheme is useful for better distinction.
6. Concatenate the histograms from all the blocks and form one vector. This vector of size l where $l = \text{number of block} * 9$, will be the final feature vector for one image.

Matching : For a given query image, find the feature vector, say $V1$, using the above method. For each template image, we find the feature vector, say $V2$, using the above method. Find the Euclidean distance between $V1$ and $V2$. The template image which gave us the minimum value of the Euclidean distance is declared to be the matched image.

3.2.2 Recognition of Signature

Our signature recognition procedure has two steps

- Background blob extraction and clustering.
- Signature recognition using GHT.

Background Blobs Extraction and clustering : Most of the existing work uses foreground information for recognition. Here we are using background information for our purpose. We took a collection of signature images.

I **Background Blobs Extraction** - By using character loops and water reservoir concept, the background blobs are extracted.

Character Loop Extraction : For each connected component in a signature, character loops are extracted.

Water Reservoir Extraction : Water reservoir illustrates the cavity region of a component. Principle of Water Reservoir [23] is as follows:- If water is poured from a side of component, the region of the background of the component where the water gets stored is called as reservoir. We consider water reservoir region as the blobs.

Top Reservoir : Reservoirs obtained after pouring the water from top side of the component are called top reservoirs.

Bottom Reservoir : Bottom reservoir will be same as top reservoir when water is poured from top after rotating the component by 180° .

Left Reservoir : Reservoir obtained by pouring the water from left side of the component are the left reservoirs. Left reservoir will be same as top reservoir when water is poured from top after rotating the component by 90° clockwise.

Right Reservoir : These reservoirs are obtained by pouring the water from right side of the component are the right reservoir. Right reservoir will be same as top reservoir when water is poured from top after rotating the component by 90° anticlockwise.

Examples of some background blobs extracted using character loops and water reservoir technique is given in the Figure 3.9



Figure 3.9: Examples of some background blobs

II **Clustering of Extracted Blobs** - After extracting the background blobs, we do a clustering of the blobs and generate the codebook. For generating the codebook, we calculate Zernike moment feature from the background blobs [14] and apply hierarchical clustering. We divide the feature into 30 clusters and for each cluster, we take the median of the feature present in that cluster and consider the selected median as the cluster center. These cluster centers together constitute the codebook. Flow chart for the codebook generation is given in Figure 3.10.

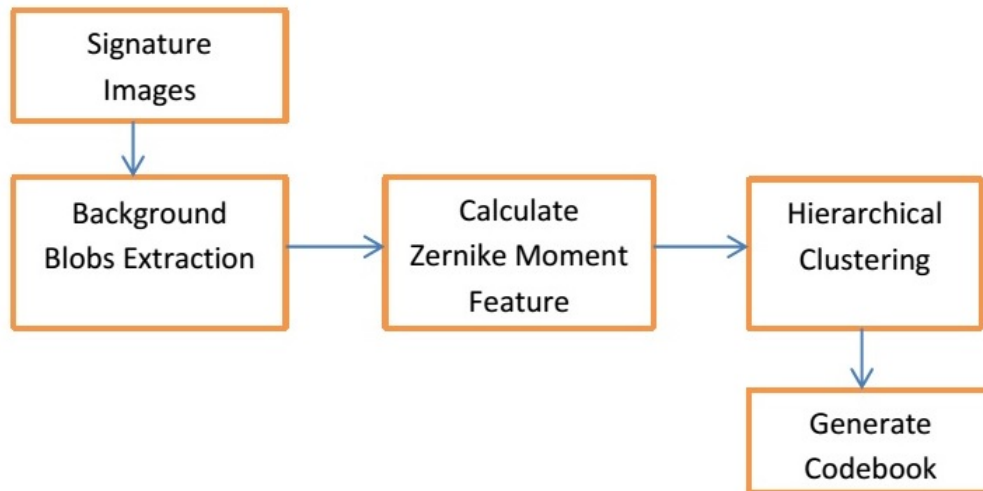


Figure 3.10: Flow chart of generation of Codebook

Signature Recognition using GHT : We use Generalized Hough Transform [3] for image matching. Different steps of this procedure is as follows. Also flow chart for the signature recognition is given in Figure 3.12.

I **Generate R-Table** - For a given query signature, we first extract the blobs. Using the extracted blobs, we create the R-Table.

R-Table :- R-Table is a kind of data-structure just like adjacency list in the graph. It is the array of list.

The R-Table contains the distance (d_i) and angle (a_i) discussed in the next page, indexed by the representative codebook blob label (Z_i). The Representative codebook blob label is the particular index of the codebook for which the distance of zernike moment of extracted blob is minimum.

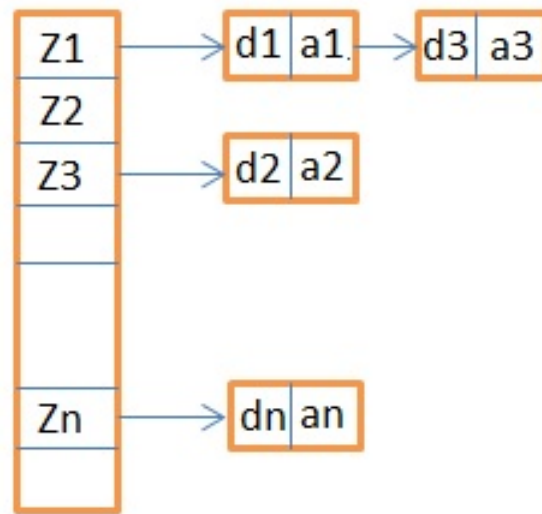


Figure 3.11: R-Table

Distance (d_i): Euclidean distance between the CG of signature image and CG of i^{th} blob.

Angle (a_i): Angle between positive x-axis and line joining the CG of blob and CG of signature image.

II **Find SURF Feature** - For each template image with which the query signature is going to be matched, we extract the SURF feature from the query image and template image and find the number of matched keypoints between these two images. If the number of matched keypoints is greater than a threshold (Th), we go for the next step i.e. to calculate the vote to find the matching score, otherwise ignore the template image.

- III *Calculate vote to find matching score* - For each template signature image, we extract the background blobs and find the zernike feature from these blobs and label the blobs using codebook based on zernike feature. For every blob, we can calculate the location of signature reference point using information saved in R-Table and cast a vote in the respective position in a matrix of the image size. After that we consider a 10*10 window and traverse the whole matrix and find the location where we get the maximum sum in this window and consider this sum as similarity between these two images.
- IV *Find matched signature* - For a given query, calculate the similarity from all the template images and the template image which shows the maximum similarity is declared to be the matched signature.

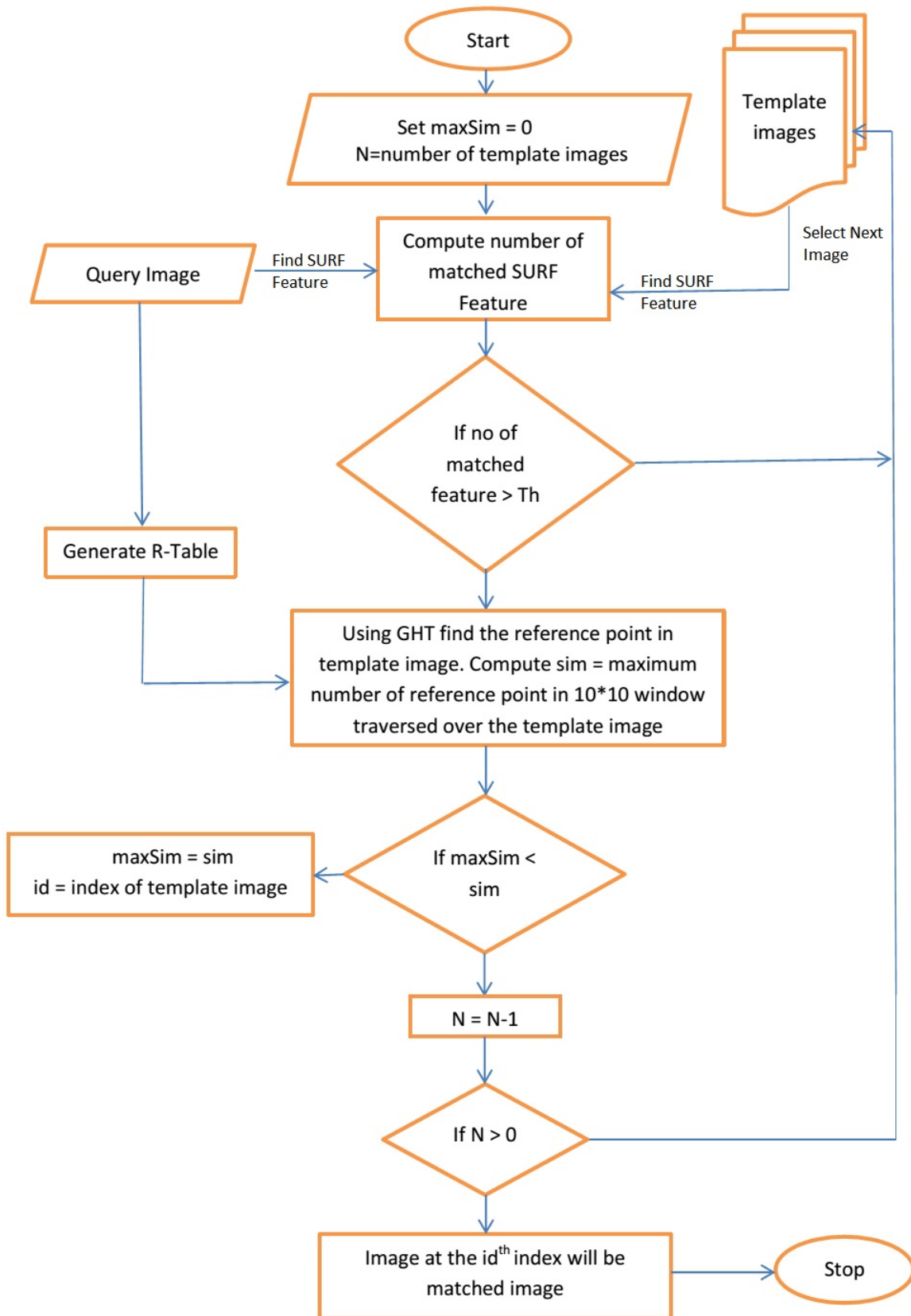


Figure 3.12: Flow chart for Signature Recognition

Chapter 4

Experimental Results

4.1 Dataset Used :

For training the SVM model we used Logo-UMD dataset [28] , for Logo, and SIG-Dataset [8] for Signature data. We have data for Seal from 19 classes.

Data for document images is taken from Tobacco800 Dataset [1, 13]. Tobacco-800 Data set contains the document images containing Logo, Seal or Signature. Tobacco800, composed of 1290 document images, is a realistic database for document image analysis research as these documents were collected and scanned using a wide variety of equipment over time. Resolutions of documents in Tobacco800 vary significantly from 150 to 300 DPI and the dimensions of images range from 1200 by 1600 to 2500 by 3200 pixels *.

4.2 Results for Classification

For classifying the Logo, Seal and Signature, we have trained the model using three classes. For training, we have taken 200 logo images, 227 seal images and 200 signature images.

For testing the model we have taken 22 logo, 20 seal and 22 signature images. These testing samples are not included while training the model. The results are shown in Table 4.1

*<http://www.umiacs.umd.edu/~zhugy/tobacco800.html>

Table 4.1: Classification Result

Data	Number of training samples	Number of testing samples	classified correctly	Accuracy	Average Accuracy
Logo	200	22	22	100%	95.31%
Seal	227	20	18	90%	
Signature	200	22	21	95.45%	

4.3 Results for Recognition

4.3.1 Results for Logo Recognition

We have 20 classes of logo which we are calling template images. As we do not have more than one sample from one class in Logo-Dataset, we have generated these 42 samples for testing by doing some rotation and scaling from the images contained in the 20 classes. One original image and its rotated and scaled sample is given in the Figure 4.1 below.

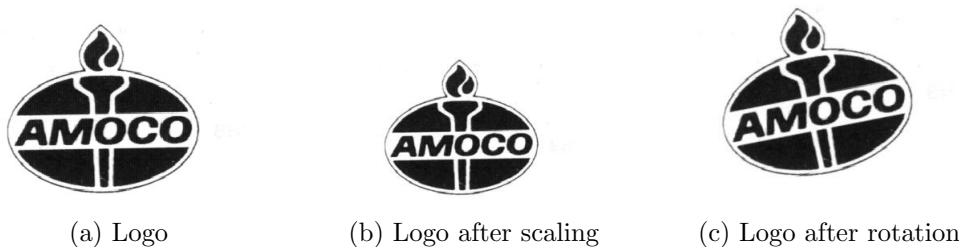


Figure 4.1: Logo after scaling and rotation

Logo recognition results are shown in Table 4.2. From the table it can be seen that accuracy of logo recognition procedure is 92.68%

Table 4.2: Results for Logo recognition

Data	Number of classes	Number of test samples	Accuracy
Logo	20	42	92.86%

4.3.2 Results for Seal Recognition

We have 19 classes of seal and we have taken 50 seal sample images to recognize. These 50 samples belong to one of these 19 classes but these might be rotated, scaled or noisy. Some sample images of Seal is given in the Figure 4.2.

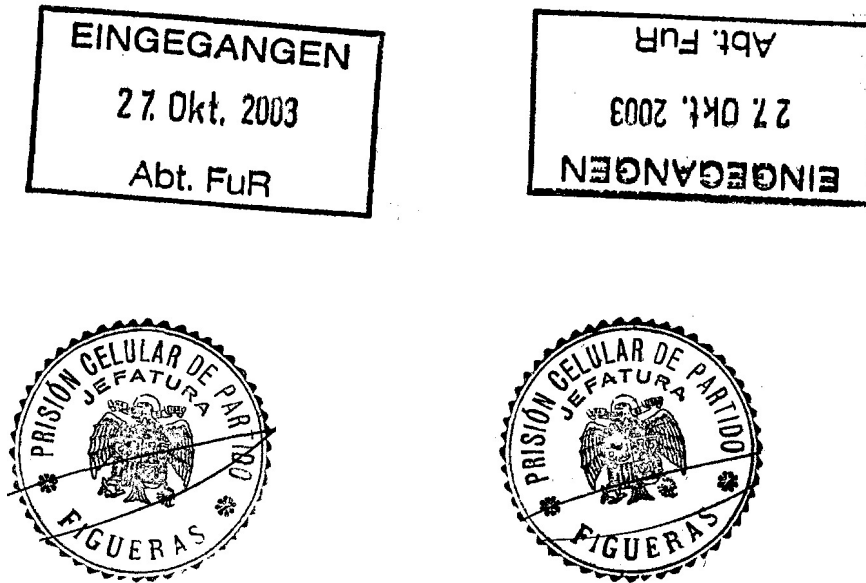


Figure 4.2: Samples of Seal

Seal recognition results are shown in Table 4.3.

Table 4.3: Results for Seal recognition

Data	Number of classes	Number of test samples	Accuracy
Seal	19	50	96.00%

4.3.3 Results for Signature Recognition

We have 18 classes of signature which we are calling template images. We have taken 36 signatures as test sample to recognize and these 36 samples are generated by doing some rotation and scaling of the template images. Examples of different signature including rotated and scaled are shown in Figure 4.3

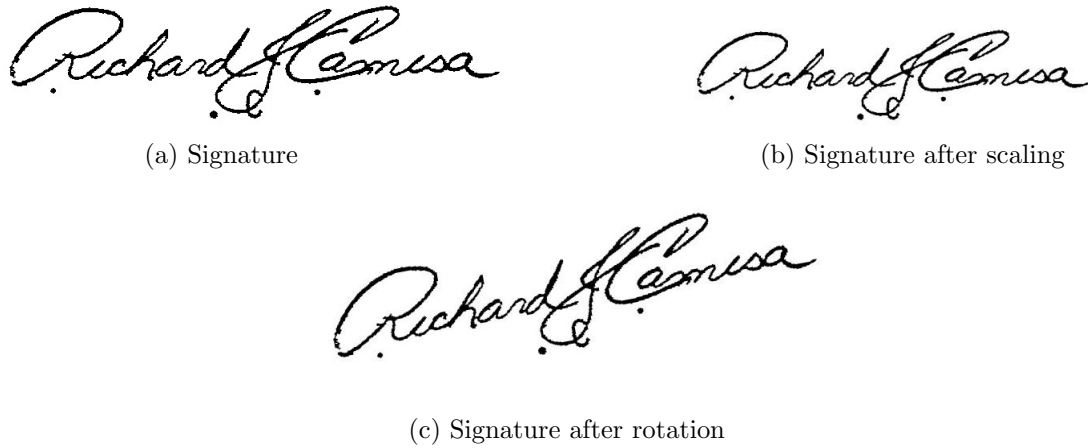
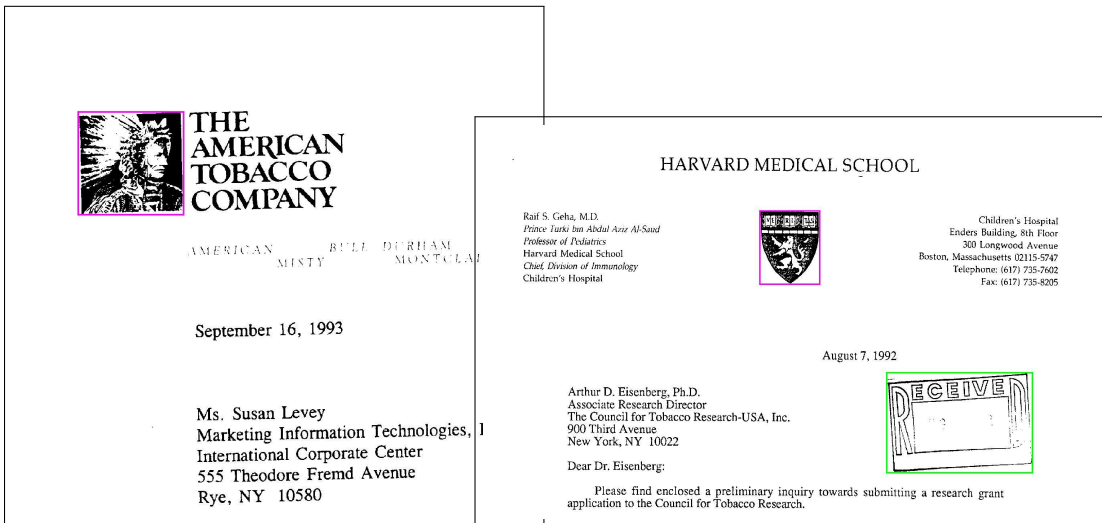


Figure 4.3: Signature after scaling and rotation

Signature recognition results are shown in Table 4.4

Table 4.4: Results for Signature Recognition

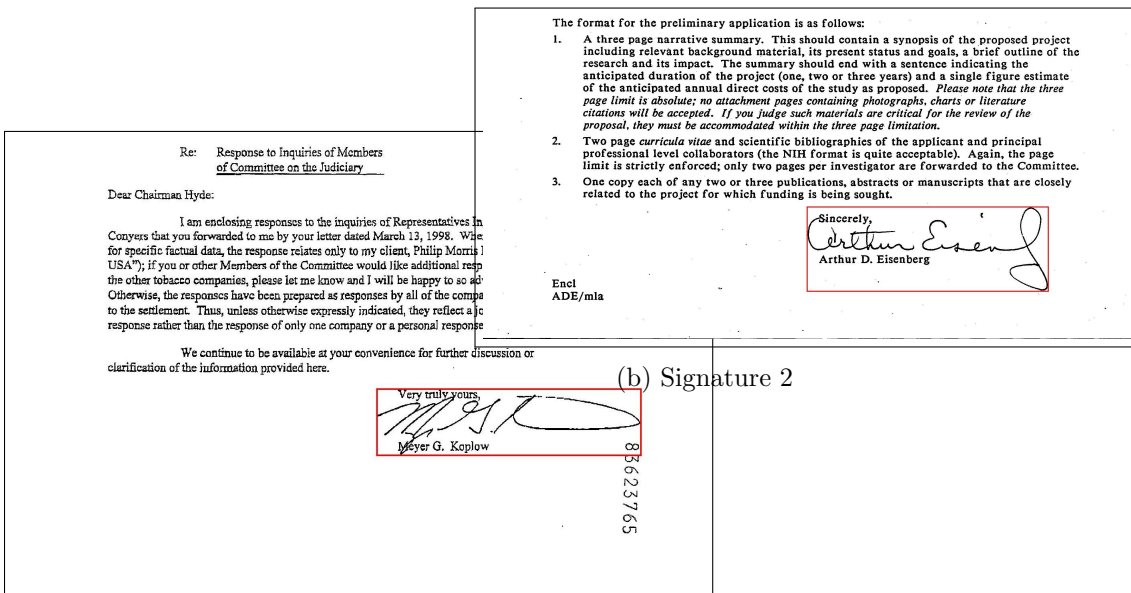
Data	Number of classes	Number of test samples	Accuracy
Signature	18	36	91.67%



(a) Logo

(b) Logo and Seal

Figure 4.4: Detected Logo and Seal in the document



(a) Signature 1

(b) Signature 2

Figure 4.5: Detected Signature in the document

4.4 Error Analysis

4.4.1 Error in Detection

Part of signature is not detected : We are extracting non-text part using connected component analysis after doing the erosion in the document. Due to this connected component analysis we may extract a signature into two or more parts. If any part of the signature does not get detected then we may not be able to get the complete signature. This shows in the following Figure 4.6:

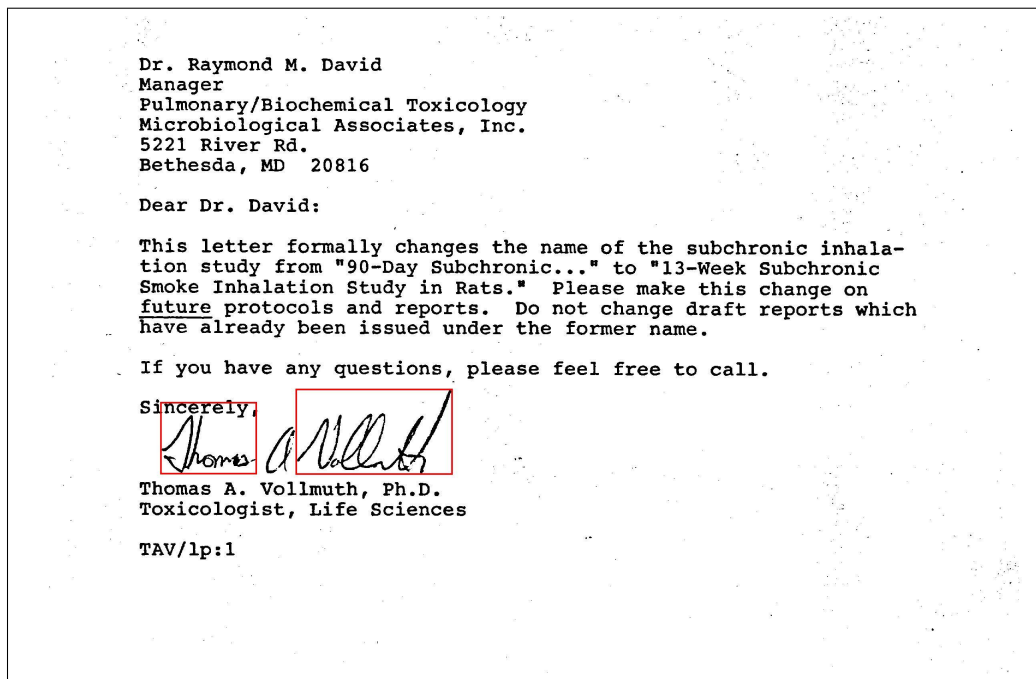


Figure 4.6: Erroneous image due to over segmentation

False Signature Detection : There may be false signature detection for hand-writing text or printed cursive writing if present in the documents. Figure 4.7 is an example of such errors.

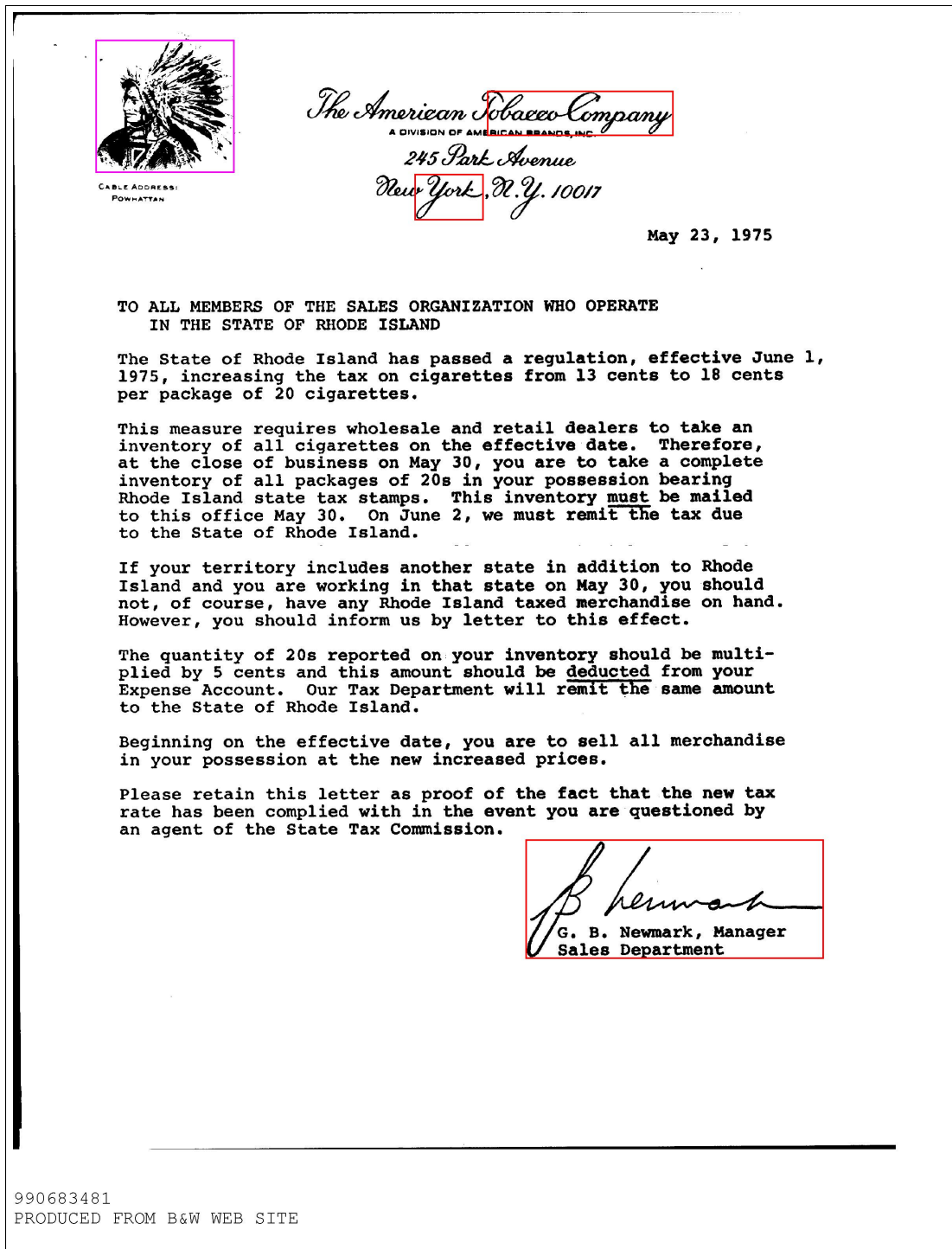


Figure 4.7: Erroneous image due to false detection

Chapter 5

Conclusion and Future Work

This dissertation deals with administrative document analysis problem. Here we have developed a system to retrieve the administrative document image from a collection of documents based on the Logo, Seal or Signature. In this work, we have done it in two stages : In first stage we detect the Logo, Seal or Signature in the document by extracting the non-text part from the document and fed to a model for classification based on SIFT descriptor and SPM technique to classify into Logo, Seal or Signature. Then extract the bounding box of the Logo, Seal and Signature.

In second stage we have done the recognition of Logo, Seal or Signature. For the recognition of Logo and Seal, we have used Histogram of Orientation (HOG) technique and for recognition of Signature, we have used background information of signature. To generate the codebook we are using Zernike moment and hierarchical clustering. Next Generalized Hough Transform is used to recognize the signature using the codebook.

Our main contribution in this dissertation is that we are not doing any training for recognition part. So, we do not need many sample images for Logo, Seal or Signature. We are extracting the feature in such a way that the direct matching can be done and for that we need only one sample for each class.

For extracting the non-text part, we are doing a morphological operation and connected component analysis. Instead of that, if we use some other method to extract non-text part it might improve the results. In future, we can improve this part and also we can train the system with variety of noise.

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