VISUAL INFORMATION RETRIEVAL FROM HISTORICAL DOCUMENT IMAGES

by

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THESIS PRESENTED TO ÉCOLE DE TECHNOLOGIE SUPÉRIEURE
IN PARTIAL FULFILLMENT OF A MASTER’S DEGREE
WITH THESIS IN AUTOMATED MANUFACTURING ENGINEERING
M.A.Sc.

MONTREAL, AUGUST 10, 2018

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE
UNIVERSITÉ DU QUÉBEC

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ACKNOWLEDGEMENTS

I would like to take this opportunity to express my sincerest thanks to my supervisor Prof. Mohamed Cheriet for his permanent guidance, continuous support and encouragement during my master study.

I am also very grateful to Prof. Ratté, Prof. Duong, and Prof. Suen, my board of examiners, for giving me the honor of accepting to judge my thesis.

My thanks also go to all of my friends and lab mates at Synchromedia laboratory, especially, Atena, Hossein, Sadegh, Sherif, Ehsan, Anna, Athmane and Saida, who kindly supported me. I am also very grateful to Shahin for introducing me to the Synchromedia laboratory.

Without question, none of this would have been possible without my wonderful family. I owe my profound gratitude to my parents for their unconditional love and support throughout my life. And special thanks to my brother, Sasan, for always being there for me no matter what, where or when. I would also like to thank my fiance, Jeremie, for his enduring support and patience and more importantly for always encouraging me to strive for the best.

To my family

LA RECHERCHE D'INFORMATION VISUELLE À PARTIR D'IMAGES DE DOCUMENTS HISTORIQUES

Sara ZHALEHPOUR

RÉSUMÉ

Au cours des dernières décennies, la préservation et la publication de documents historiques en format numérique ont fait l'objet d'une attention considérable. Bien que les techniques modernes de numérisation aient pour la plupart résolu le problème de la protection et de l'accès à ces documents, la tâche de la recherche et de l'interprétation de l'information visuelle demeure un problème difficile. Cela est dû aux structures complexes et inhabituelles des documents historiques en plus de leur nature dégradée. Pour la recherche d'informations à partir de documents historiques, une approche appropriée est nécessaire pour caractériser le contenu du document de manière cohérente. Les documents imprimés contiennent non seulement des caractères de texte et leurs formats, mais également des éléments typographiques associés. Trouver et poursuivre les objets typographiques visuels existants qui façonnent le contenu des documents historiques nous aide à récupérer et à transmettre plus d'informations sur les différentes méthodes de représentation de ces documents. Ces éléments peuvent être des notes de bas de page qui font référence aux auteurs et démontrent la relation entre les manuscrits et les sources, ou des tableaux qui résument différentes sortes d'informations dans des formes géométriques. Cette recherche se concentre sur le problème de la détection des notes de bas de page et des tableaux dans les documents historiques et établit un cadre pour chacun des objectifs déterminés. Ces cadres doivent gérer efficacement des structures complexes de documents historiques et posséder en même temps le pouvoir de généralisation pour s'appliquer aux collections d'images de documents à grande échelle. Jusqu'à maintenant, la détection des notes de bas de page a rarement été abordée dans la littérature.

Par conséquent, notre première contribution est de présenter un nouveau cadre pour la classification des images de documents basée sur les notes de bas de page dans les documents historiques. L'idée de base derrière ce cadre est d'utiliser les caractéristiques visuelles les plus importantes d'une note de bas de page pour créer un vecteur de caractéristiques. Les trois caractéristiques visuelles les plus importantes d'une note de bas de page sont la taille réduite de la note par rapport au corps du texte, l'emplacement de la note au bas de la page et l'écart relativement plus important entre la note et le corps du texte comparé à l'espace de ligne standard. Trois méthodes sont proposées en fonction de chacune de ces observations. Nous définissons certaines règles à l'aide de ces observations pour créer notre vecteur de caractéristiques. Notre cadre pour la classification des images de documents basée sur les notes de bas de page dans les documents historiques est complété en alimentant par ces vecteurs caractéristiques un classificateur de machine à vecteurs de support (SVM). Le cadre proposé est appliqué à plus de 32 millions d'images du 18 $^{\text{ème}}$ siècle. Les résultats de l'évaluation prouvent l'efficacité, la puissance de généralisation et la robustesse de notre cadre présenté pour détecter les pages contenant une note de bas de page malgré leur mise en page et leur type de structure.

Les méthodes les plus récentes de détection de tableaux dans les documents utilisent principalement des documents de balisage (par exemple, pdf, HTML, etc.) et ne couvrent pas tous les types de tableaux dans un cadre. Cependant, pour les documents historiques, qui sont notre principale étude dans le cadre de cette thèse, nous avons seulement accès à l'image numérisée et devons traiter tous les types de tableaux en même temps. Le cadre proposé est basé sur l'hypothèse que les textes dans les tableaux se présentent de manière harmonique en colonnes. Ce fait suggère l'idée d'utiliser une méthode spectrale pour développer notre cadre. Nous proposons une approche basée sur l'utilisation de coefficients cepstraux de fréquence de Mel (MFCC) pour classer des images de document selon la présence ou non de tableaux dans la page. Les MFCC sont des procédures bien connues de reconnaissances automatiques de la parole. Ces méthodes mettent l'accent sur la fréquence basses du signal. Un classificateur SVM est utilisé comme dernière étape de notre framework pour détecter les pages contenant des tableaux. Nous testons le cadre introduit sur nos ensembles de données et les résultats confirment l'efficacité de la méthode proposée par rapport à la fois à une méthode reconnue et à notre ensemble de données de référence des documents imprimés du 18$^{\text{ème}}$ siècle.

Mots-clés: La recherche d'information visuelle, Document historique image, Classification des documents, Détection de note,Boîtes de délimitation, Projection horizontale, Détection de tableaux, Tableaux de lignes de régnant, Tableaux de lignes Non-régnant, MFCC, Machines à vecteurs de support.

VISUAL INFORMATION RETRIEVAL FROM HISTORICAL DOCUMENT IMAGES

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ABSTRACT

In the recent decades, preserving and publicizing historical documents in digital format has gotten considerable attention. Although modern digitizing techniques have mostly solved the problem of protecting and accessing these documents, the task of visual information retrieval and interpretation is still an arduous issue. This is due to historical documents' complex and unusual structures beside their degraded nature. For information retrieval from historical documents, an appropriate approach is required to characterize the document content in a coherent way. Printed documents contain not only text characters and their formattings but also some associated typographical elements. Finding and pursuing the existing visual typographical objects that shape the content of historical documents, helps us retrieve and convey more information about the various methods of representing these documents. These elements can be footnotes that connect the authority and demonstrate the relationship between manuscripts and sources, or tables that summarize different sort of information into geometric forms. This research focuses on the problem of detecting footnotes and tables in historical documents and establishes a framework for each of the driven objectives. These frameworks must efficiently handle complex structures of historical documents and at the same time possess the generalization power to be applied to large-scale document image collections.

To the best of our knowledge, up to this date, footnote detection has rarely been addressed in the literature. Therefore, our first goal is to present a novel framework for footnote-based document image classification in historical documents. The basic idea behind this framework is to utilize the most prominent visual features of a footnote to create a feature vector. The three most notable visual features of a footnote in a page are the smaller font size of the footnote respect to the body text, the footnote location at the bottom of the page and the relatively greater gap between the footnote and the body text compared to the standard line space. Three methods are proposed according to each of these observations. We define a set of rules using these observations to create our final feature vector. Our framework for footnote-based document image classification in the historical documents is completed by feeding these feature vectors to a support vector machine (SVM) classifier. The proposed framework is applied to more than 32 million images from 18$^{\text{th}}$ century. The evaluation results prove the efficiency, generalization power, and robustness of our presented framework for detecting page containing footnote despite their layout and structure type.

The state-of-the-art methods for table detection in documents mostly use markup documents (e.g., pdf, HTML, etc.) and do not cover all types of the tables within one framework. However, for historical documents, which are our main target for this thesis, we only have access to the scanned image and need to deal with all types of tables at the same time. The proposed framework is based on the hypothesis that texts in tables occur in a harmonic column-wise manner. This fact suggests the idea of using a spectral method for developing our framework.

We propose an approach based on using Mel frequency cepstral coefficients (MFCC) to classify document images according to the presence or not presence of tables on the page. MFCCs are well-known speech processing features, which emphasize lower frequency components rather than higher ones. An SVM classifier is used as the final step of our framework for detecting pages containing tables. We test the introduced framework on our datasets and the results confirm the efficiency of the proposed method in comparison to both a state-of-the-art method and our benchmark dataset from the 18th century printed documents.

Keywords: Visual information retrieval, Historical document image, Documents classification, Footnote detection, Bounding boxes, Horizontal projection, Table detection, Ruling line tables, Non-ruling line tables, MFCC, SVM.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATIONS

BBox	Bounding box based method
CNN	Convolutional neural network
CV	Cross validation
DBN	Deep belief network
DCT	Discrete Cosine transform
DIR	Document Image Retrieval
ECCO	Eighteenth Century Collections Online
FFT	Fast Fourier Transformsub
FN	Footnote
f_n	False negative
f_p	False positive
GenRef	Reference
HistAndGeo	History and Geography
HV	Horizontal/vertical
HVP	horizontal-vertical pooling
LitAndLang	Literature and Language
MFCCs	Mel frequency cepstral coefficients
MedSciTech	Medicine, Science, and Technology
MLP	Multi-layer perceptron

NFN	Not having a footnote
NRL-Ts	Non-ruling-line tables
NT	No-table
OCR	Optical character recognition
PCA	Principal component analysis
Proj	Projection based method
RelAndPhil	Religion and Philosophy
RF	Random forest
RL-Ts	Ruling-line tables
SSAndFineArt	Social Science and Fine Arts
SVM	Support vector machine
t_p	True positive

CHAPTER 1

INTRODUCTION

Even though the research in the field of document image retrieval has received a vast amount of attention over the last decades, it is still appealing but challenging; especially when we are dealing with a large collection of low-quality historical document images. Our goal in this work is to facilitate information retrieval from historical documents by finding the various typographic objects in them.

1.1 Motivation

Museums and libraries have substantial collections of historical documents. Various groups of people, from historians and scholars to human scientists, are interested in these documents and trying to study and understand different cultures and communities through these documents (Cheriet *et al.*, 2013). However, due to sensitivity and the valuable nature of these documents, only a small group of people are granted the access to these documents. Therefore, in recent years, historical document collections, which are appealing to the broader group of people, are digitized to be preserved while making them publicly accessible via digital media.

Information retrieval from historical documents is a hard task since the size of these collections is often extremely large. Also, their contents are generally unusual and unstructured beside the fact that degraded quality is also part of historical collections. Therefore, the document image retrieval (DIR) concept for historical documents has been developed (Marinai *et al.*, 2007). The objective of DIR systems is to retrieve visual information from document images by relying only on the document image features, either the text or the image. Applying DIR techniques to historical documents are now trendier than before due to a large number of digitized historical collections.

From a broader point of view, DIR approaches usually follow two main streams, either recognition based retrievals or recognition free retrievals. Generally, recognition based retrieval approaches transform the digital images into machine-encoded text using optical character recognition (OCR) tools (Chowdhury, 2010). The assumption for OCR systems is that their performance is perfect and the minimal errors are ineffective in the final results. However, this assumption is not always accurate especially in the case of noisy document images, documents with variable and unusual layouts, multilingual manuscripts, pages without any standard fonts, etc. These problems are particularly the concerns for the historical documents or early modern printed documents (Marinai *et al.*, 2007) and make the OCR based methods unfit for this type of documents. The other drawback of using OCR techniques for DIR especially for enormous collections of digitized documents is that they are expensive and tedious. Therefore, using them is misspending of the resources while at the end, we are still in need of human revision. Consequently, recognition free approaches come first for the retrieval purposes. They use images visual features without the need for character recognition techniques. Developing a new recognition free DIR system with a feature extraction process that can handle the challenging nature of historical documents is what motivated us for this research.

1.2 Problem statement

An invaluable and irreplaceable cultural heritages are spread over the libraries throughout the world. They hold crucial information about the people and communities and records of the cultures and periods they were living in it. Understanding the range of visual typographical practices for scientific notation after the development of modern printing can bring researchers from different fields of history of science, book history and document image analysis together to a better perception of "the page image" and its influence on shaping the history of scientific knowledge.

Modern knowledge has been formed using various typographical objects. These graphical objects are used to transfer information and state a truth, often to reduce the complexity and obscurity. Some of the important visual practices that have been used since previous centuries are as follow:

- **Footnotes:** They are used to prove the authorization and as an indication of the correspondence between the sources. Therefore, the need to reproduce the entire source content is omitted by only citing it as a footnote.

- **Tables:** They reproduce the inconsistent and different forms of information in the text, into a geometrical representation of the data.

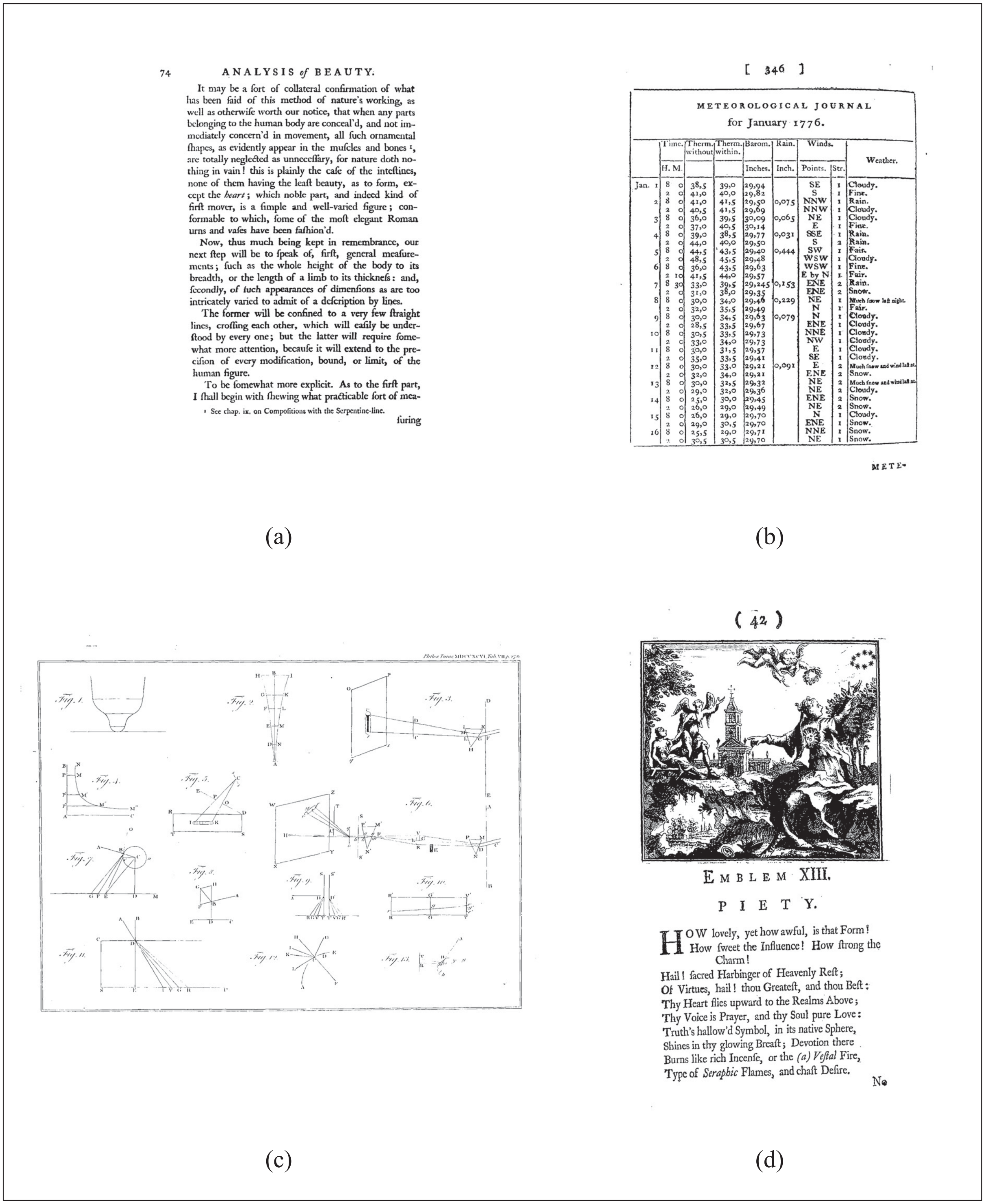
- **Diagrams:** They provide a tabloid representation of a rational process or natural phenomena to summarize it more symbolically. Using diagrams have become more prevalent during the Enlightenment period.

- **Figures:** They generate a graphic representation of the objects they intend to represent with marking lines and area of tones. In another word, a figure depicts the same object in a non-linguistic two-dimensional scheme.

Figure 1.1 shows examples of each of the aforementioned typographical practices in 18th century publications.

Historical documents beside their unusual structures and layouts usually suffer from different types of degradation they caught over the time. These documents acquire the degradation from various possible sources. These sources vary from chemical, biological and human-caused sources to the external sources that can be generated during document acquisition process such as tears, fold in papers, etc. Figure 1.2 demonstrates examples of these degradations that can complicate the DIR process. The complexities that the nature of historical document images forces upon the retrieval process make the DIR process a more challenging task compared to their associated modern types. Therefore, the main concern of the current study is exploring the different feature extraction and classification techniques, which are insensitive to the complex layout and degraded essence of historical document images.

To this end, our research is aimed to explore the solutions for the following research questions:



74 ANALYSIS *of* BEAUTY.

It may be a ſort of collateral confirmation of what has been ſaid of this method of nature's working, as well as otherwiſe worth our notice, that when any parts belonging to the human body are conceal'd, and not immediately concern'd in movement, all ſuch ornamental ſhapes, as evidently appear in the muſcles and bones [1], are totally neglected as unneceſſary, for nature doth nothing in vain! this is plainly the caſe of the inteſtines, none of them having the leaſt beauty, as to form, except the *heart*; which noble part, and indeed kind of firſt mover, is a ſimple and well-varied figure; conformable to which, ſome of the moſt elegant Roman urns and vaſes have been faſhion'd.

Now, thus much being kept in remembrance, our next ſtep will be to ſpeak of, firſt, general meaſurements; ſuch as the whole height of the body to its breadth, or the length of a limb to its thickneſs: and, ſecondly, of ſuch appearances of dimenſions as are too intricately varied to admit of a deſcription by lines.

The former will be confined to a very few ſtraight lines, croſſing each other, which will eaſily be underſtood by every one; but the latter will require ſomewhat more attention, becauſe it will extend to the preciſion of every modification, bound, or limit, of the human figure.

To be ſomewhat more explicit. As to the firſt part, I ſhall begin with ſhewing what practicable ſort of mea-

[1] See chap. ix. on Compoſitions with the Serpentine-line.

ſuring

(a)

[346]

METEOROLOGICAL JOURNAL
for January 1776.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
Jan. 1	8	0	38,5	39,0	29,94		SE	1	Cloudy.
	2	0	41,0	40,0	29,82		S	1	Fine.
2	8	0	41,0	41,5	29,50	0,075	NNW	1	Rain.
	2	0	40,5	41,5	29,69		NNW	1	Cloudy.
3	8	0	36,0	39,5	30,09	0,065	NE	1	Cloudy.
	2	0	37,0	40,5	30,14		E	1	Fine.
4	8	0	39,0	38,5	29,77	0,031	SSE	1	Rain.
	2	0	44,0	40,0	29,50		S	2	Rain.
5	8	0	44,5	43,5	29,40	0,444	SW	1	Fair.
	2	0	48,5	45,5	29,48		WSW	1	Cloudy.
6	8	0	36,0	43,5	29,63		WSW	1	Fine.
	2	10	41,5	44,0	29,57		E by N	1	Fair.
7	8	30	33,0	39,5	29,245	0,153	ENE	2	Rain.
	2	0	31,0	38,0	29,35		ENE	2	Snow.
8	8	0	30,0	34,0	29,46	0,229	NE	1	Much ſnow laſt night.
	2	0	32,0	35,5	29,49		N	1	Fair.
9	8	0	30,0	34,5	29,63	0,079	N	1	Cloudy.
	2	0	28,5	33,5	29,67		ENE	1	Cloudy.
10	8	0	30,5	33,5	29,73		NNE	1	Cloudy.
	2	0	33,0	34,0	29,73		NW	1	Cloudy.
11	8	0	30,0	31,5	29,57		E	1	Cloudy.
	2	0	35,0	33,5	29,41		SE	1	Cloudy.
12	8	0	30,0	33,0	29,21	0,091	E	2	Much ſnow and wind laſt nt.
	2	0	32,0	34,0	29,21		ENE	2	Snow.
13	8	0	30,0	32,5	29,32		NE	2	Much ſnow and wind laſt nt.
	2	0	29,0	32,0	29,36		NE	2	Cloudy.
14	8	0	25,0	30,0	29,45		ENE	2	Snow.
	2	0	26,0	29,0	29,49		NE	2	Snow.
15	8	0	26,0	29,0	29,70		N	1	Cloudy.
	2	0	29,0	30,5	29,70		ENE	1	Snow.
16	8	0	25,5	29,0	29,71		NNE	1	Snow.
	2	0	30,5	30,5	29,70		NE	1	Snow.

METE-

(b)

(c)

(42)

EMBLEM XIII.

PIETY.

HOW lovely, yet how awful, is that Form!
How ſweet the Influence! How ſtrong the Charm!
Hail! ſacred Harbinger of Heavenly Reſt;
Of Virtues, hail! thou Greateſt, and thou Beſt:
Thy Heart flies upward to the Realms Above;
Thy Voice is Prayer, and thy Soul pure Love:
Truth's hallow'd Symbol, in its native Sphere,
Shines in thy glowing Breaſt; Devotion there
Burns like rich Incenſe, or the *(a) Veſtal* Fire,
Type of *Seraphic* Flames, and chaſt Deſire.

No

(d)

Figure 1.1 Examples of different typographical practices in 18th century documents; pages containing: (a) a footnote, (b) a table, (c) a diagram and (d) a figure.

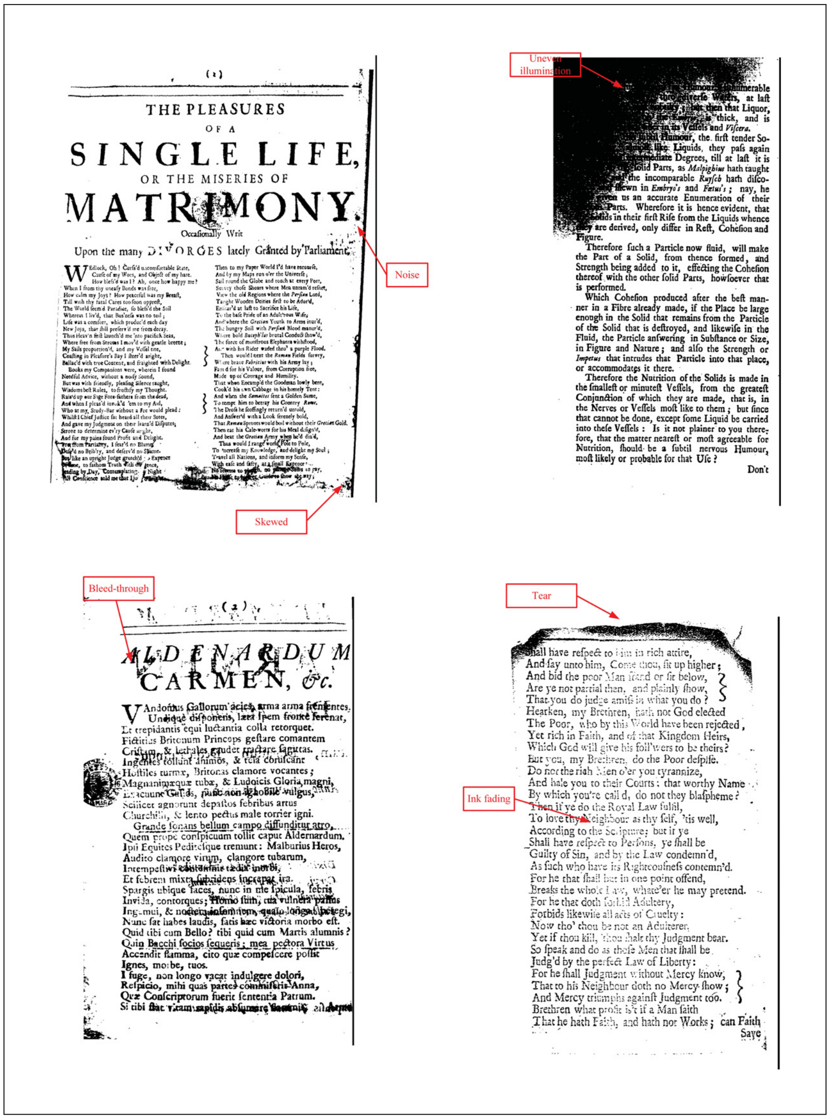


Figure 1.2 Examples of degradation types in historical printed documents.

- Is it possible to develop an effective and efficient algorithm to carry out the retrieval process?

- To what degree can we enhance the performance of the DIR system by introducing the powerful combination of feature extraction techniques and classifiers?

- Which feature extraction method or classification technique is insensitive to the variation of layout and structure style on degraded documents?

- What are the drawbacks of the system and the recommended solutions to overcome these drawbacks?

1.3 Objective of the thesis

The overall objective of this thesis is to design an advanced system for retrieval the typographical information from the documents and categorize them according to their types. This framework should be applicable to document images with variable structures, layouts, and artifacts. In this work, our focus is on the first two mentioned typographical objects: footnotes and tables. We formulate our two specific objectives around this main objective as below:

- **O1:** Footnotes are one of the essential elements during the Enlightenment period. However, there has not been any work regarding detecting footnote in these documents. Therefore, we aim to propose an automatic framework that can detect the appearance of a footnote on the page despite the layout and structure of the page.
- **O2:** Tables in historical documents vary significantly in structure and representation. Traditional state-of-the-art algorithms are not capable of handling these irregularities. Each of known table detection algorithms has their limitations, and none can provide the ideal performance. Hence, we try to propose an automatic method for detecting tables in historical document images despite the layout of the page and type of tables. Furthermore, this approach should be resistant to a variety of degradation and layouts of the document.

Thesis outline

This thesis is organized into five chapters. The introduction chapter introduced the general content of the thesis. It discussed the problem statement and the background of the information retrieval from document images. It also presented the main and specific objectives of this work. Chapter 2 is dedicated to the first specific objective. It describes the footnote and the detailed proposed methodology used to tackle the problem of footnote-based document image classification. Chapter 3 presents the definition of the table and our new approach for extracting their features and classifying them. Chapter 4 focuses on introducing the benchmark datasets used in this study and for each method it presents and explains the experimental results used to validate our proposed system. Finally, in the last chapter conclusion and research direction for future work are discussed.

CHAPTER 2

FOOTNOTE-BASED DOCUMENT CLASSIFICATION

Footnote detection is the concentration of this chapter. We first briefly go over the definition of footnote and the state-of-the-arts in this field. Then, we present our first framework for classifying historical documents based on their typographical object.

2.1 What is a footnote?

One of the defining and most significant features of the Enlightenment period is the growth of circulated printed materials. This growth rose another characteristic of this period, which are footnotes or in more general term indices. The appearance of footnote and cross-references is increased progressively as the number of printed document rose up approaching the end of 18th century. Therefore, detecting footnotes will be a crucial element in understanding and linking different scholars and books through the Enlightenment period.

Footnote is a text string appears at the bottom of the page in a document or book and provides clarification and evidence to the claims of an author (Grafton, 1999). A footnote points to a range of indexical forms, including in-text citations, headnotes, marginal notes, and appendices (Pasanek & Wellmon, 2015). Scholars have been using footnote generally for the following reasons:

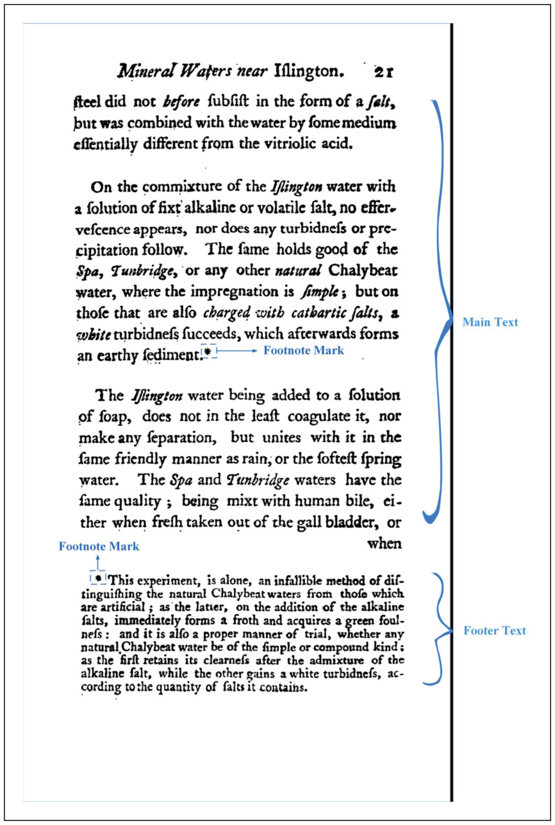
- To provide more information regarding an author's comments.
- To prove their claims have reliable sources and identify how they end up citing the mentioned source.
- To help the readers to trace back an author's claim to the place where it is originated, and the given source can be verified along further information.

Footnotes are critical for the scientific nature of the historical documents. They present both ideology and technical practices of the document by proofing authors have searched in appropriate archives and have found the necessary documents. Footnotes not only provide this evidence by doing the cross-referencing but also they connect and coordinate the ever-growing system of print (Pasanek & Wellmon, 2015). It is good to mention that in the 20th-century editions, the use of footnotes for citing has lost its traditional place and replaced by endnote at the end of the chapter or book.

In this work, with the help of human scientists, we define footnote as a typographical object that is distinct on the page, has been marked in the main text and referenced at the bottom of the page. Each of these conditions is important to distinguish between the positive and negative examples of the footnote. Figure 2.1 depicts how footnotes generally appear on the page in historical documents. However, even using this simple definition, because of a large variety of footnote patterns, fonts, styles and inconsistent structures in the 18th-century, distinguishing footnotes is still hard. Figure 2.2 and Figure 2.3 give some examples of pages containing footnote but different in font size style, layout, content and structure. This definition also prevents side footnotes and commentary notes at the bottom of the page from being considered as a footnote. Figure 2.4 gives examples of these two cases. Moreover, some cases deceptively seem to be a footnote but only a note or comment (see Figure 2.5). Along the diversity of footnote types, degraded and hard to capture document pages makes the problem of detecting footnotes even more challenging task. Figure 2.5 gives some examples of these types of image. Even by a brief comparison of these Figures, we can conclude that footnotes in the 18th-century are barely following a straightforward procedure and there is indeed a wide range of diverging forms of footnotes.

2.2 state-of-the-arts

There have been various works in the scope of information retrieval from historical document images. However, to the best of our knowledge, there are only two works published in the field of detecting footnotes from historical documents. Abuelwafa *et al.* (2017) proposed a method



Mineral Waters near Iſlington. 21

ſteel did not *before* ſubſiſt in the form of a *ſalt*, but was combined with the water by ſome medium eſſentially different from the vitriolic acid.

On the commixture of the *Iſlington* water with a ſolution of fixt alkaline or volatile ſalt, no effervefcence appears, nor does any turbidneſs or precipitation follow. The ſame holds good of the *Spa*, *Tunbridge*, or any other *natural* Chalybeat water, where the impregnation is *ſimple*; but on thoſe that are alſo *charged with cathartic ſalts*, a *white* turbidneſs ſucceeds, which afterwards forms an earthy ſediment.[*]

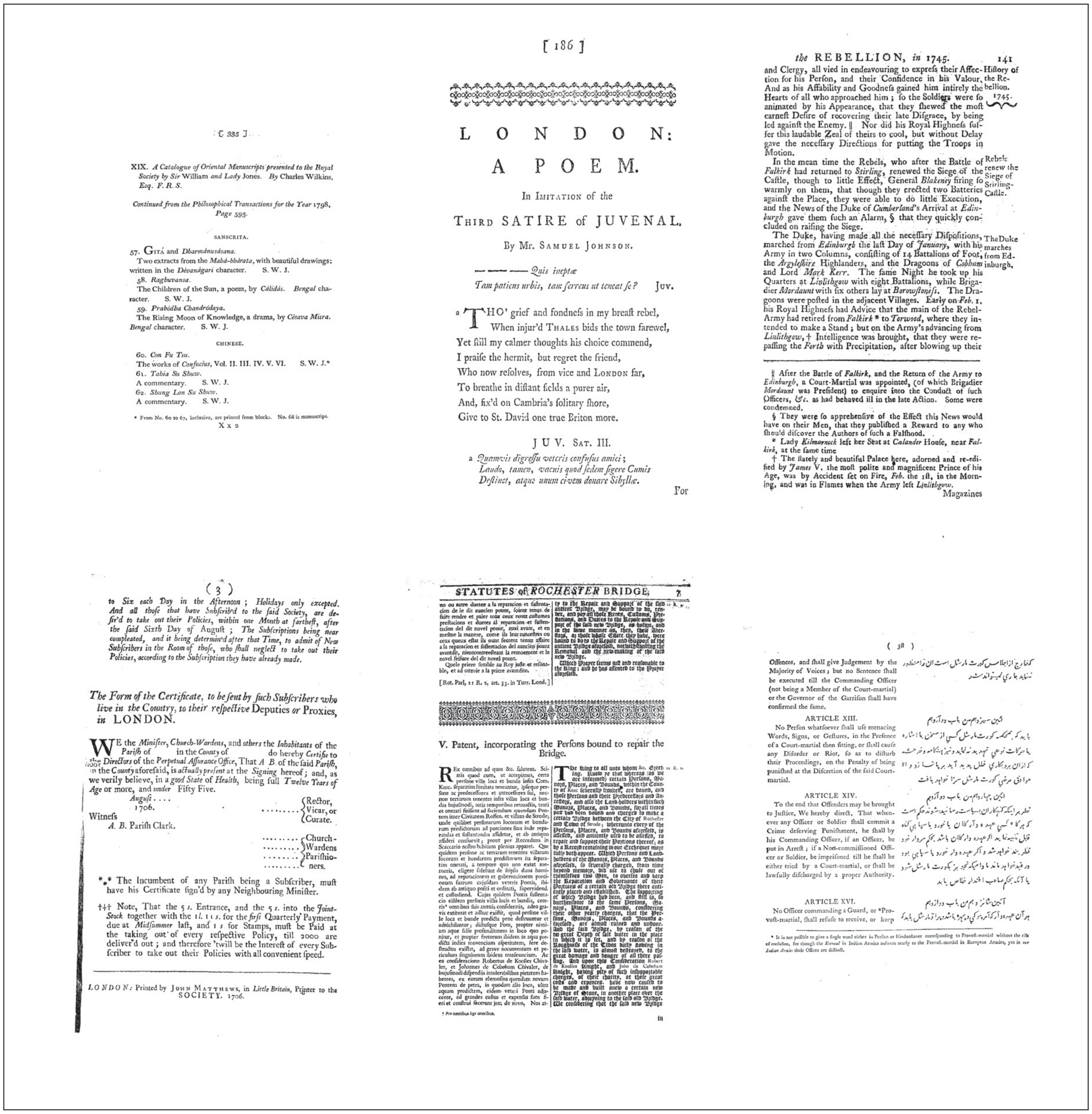
The *Iſlington* water being added to a ſolution of ſoap, does not in the leaſt coagulate it, nor make any ſeparation, but unites with it in the ſame friendly manner as rain, or the ſofteſt ſpring water. The *Spa* and *Tunbridge* waters have the ſame quality; being mixt with human bile, either when freſh taken out of the gall bladder, or

when

[*] This experiment, is alone, an infallible method of diſtinguiſhing the natural Chalybeat waters from thoſe which are artificial; as the latter, on the addition of the alkaline ſalts, immediately forms a froth and acquires a green foulneſs: and it is alſo a proper manner of trial, whether any natural Chalybeat water be of the ſimple or compound kind; as the firſt retains its clearneſs after the admixture of the alkaline ſalt, while the other gains a white turbidneſs, according to the quantity of ſalts it contains.

Figure 2.1 An example of a historical document page with a footnote.

based on a deep belief network (DBN). Their approach includes two phases, unsupervised pre-training and supervised fine-tuning. In this work, each image is represented by merging the two text lines from the top of the image and two from the bottom. The features are then extracted from these merged images in an unsupervised manner using a DBN model to initialize the parameters for a multi-layer perceptron (MLP). The MLP is later retrained and fine-tuned using the labeled document data. The main advantage of this method is that it can be beneficial in the case of sparsely labeled data specifically for historical documents with not enough labeled data. The second work is done by Mhiri *et al.* (2017) and uses a one-dimensional convolutional neural network (CNN) to tackle the problem of footnote detection. For this work, the document image is represented by merging the horizontal intensity histogram of the two top and three bottom text lines, which reduces the complexity of using CNN.



[335]

XIX. *A Catalogue of Oriental Manuscripts presented to the Royal Society by Sir* William *and Lady* Jones. *By* Charles Wilkins, *Esq. F. R. S.*

Continued from the Philosophical Transactions for the Year 1798, *Page* 593.

SANSCRITA.

57. Gitá and *Dharmánusásana.*

Two extracts from the *Mahá-bhárata*, with beautiful drawings; written in the *Dévanágari* character. S. W. J.

58. *Raghuvansa.*

The Children of the Sun, a poem, by *Cálidás*. *Bengal* character. S. W. J.

59. *Prabódha Chandródaya.*

The Rising Moon of Knowledge, a drama, by *Césava Misra*. *Bengal* character. S. W. J.

CHINESE.

60. *Con Fu Tsu.*

The works of *Confucius*, Vol. II. III. IV. V. VI. S. W. J.*

61. *Tahia Su Shuw.*

A commentary. S. W. J.

62. *Shung Lon Su Shuw.*

A commentary. S. W. J.

* From No. 60 to 67, inclusive, are printed from blocks. No. 68 is manuscript.

X x 2

[186]

LONDON:
A POEM.

In Imitation of the
Third SATIRE of JUVENAL.

By Mr. Samuel Johnson.

——— *Quis ineptæ*
Tam patiens urbis, tam ferreus ut teneat ſe? Juv.

[a] THO' grief and fondneſs in my breaſt rebel,
When injur'd Thales bids the town farewel,
Yet ſtill my calmer thoughts his choice commend,
I praiſe the hermit, but regret the friend,
Who now reſolves, from vice and London far,
To breathe in diſtant fields a purer air,
And, fix'd on Cambria's ſolitary ſhore,
Give to St. David one true Briton more.

JUV. Sat. III.

[a] *Quamvis digreſſu veteris confuſus amici;*
Laudo, tamen, vacuis quod ſedem figere Cumis
Deſtinet, atque unum civem donare Sibyllæ.

For

the REBELLION, *in* 1745. 141

and Clergy, all vied in endeavouring to expreſs their Affection for his Perſon, and their Confidence in his Valour. And as his Affability and Goodneſs gained him intirely the Hearts of all who approached him; ſo the Soldiers were ſo animated by his Appearance, that they ſhewed the moſt earneſt Deſire of recovering their late Diſgrace, by being led againſt the Enemy. ‖ Nor did his Royal Highneſs ſuffer this laudable Zeal of theirs to cool, but without Delay gave the neceſſary Directions for putting the Troops in Motion.

History of the Rebellion. 1745.

In the mean time the Rebels, who after the Battle of *Falkirk* had returned to *Stirling*, renewed the Siege of the Caſtle, though to little Effect, General *Blakeney* firing ſo warmly on them, that though they erected two Batteries againſt the Place, they were able to do little Execution, and the News of the Duke of *Cumberland*'s Arrival at *Edinburgh* gave them ſuch an Alarm, § that they quickly concluded on raiſing the Siege.

Rebels renew the Siege of Stirling-Caſtle.

The Duke, having made all the neceſſary Diſpoſitions, marched from *Edinburgh* the laſt Day of *January*, with his Army in two Columns, conſiſting of 14 Battalions of Foot, the *Argyleſhire* Highlanders, and the Dragoons of *Cobham* and Lord *Mark Kerr*. The ſame Night he took up his Quarters at *Linlithgow* with eight Battalions, while Brigadier *Mordaunt* with ſix others lay at *Borowſtoneſs*. The Dragoons were poſted in the adjacent Villages. Early on *Feb.* 1. his Royal Highneſs had Advice that the main of the Rebel-Army had retired from *Falkirk* * to *Torwood*, where they intended to make a Stand; but on the Army's advancing from *Linlithgow*, † Intelligence was brought, that they were repaſſing the *Forth* with Precipitation, after blowing up their

The Duke marches from Edinburgh.

‖ After the Battle of *Falkirk*, and the Return of the Army to *Edinburgh*, a Court-Martial was appointed, (of which Brigadier *Mordaunt* was Preſident) to enquire into the Conduct of ſuch Officers, *&c.* as had behaved ill in the late Action. Some were condemned.

§ They were ſo apprehenſive of the Effect this News would have on their Men, that they publiſhed a Reward to any who ſhould diſcover the Authors of ſuch a Falſhood.

* Lady *Kilmarnock* left her Seat at *Calander* Houſe, near *Falkirk*, at the ſame time

† The ſtately and beautiful Palace here, adorned and re-edified by *James* V. the moſt polite and magnificent Prince of his Age, was by Accident ſet on Fire, *Feb.* the 1ſt, in the Morning, and was in Flames when the Army left *Linlithgow*.

Magazines

(3)

to Six each Day in the Afternoon; Holidays only excepted. And all thoſe that have Subſcrib'd to the ſaid Society, are deſir'd to take out their Policies, within one Month at fartheſt, after the ſaid Sixth Day of Auguſt; *The Subſcriptions being near compleated, and it being determin'd after that Time, to admit of New Subſcribers in the Room of thoſe, who ſhall neglect to take out their Policies, according to the Subſcription they have already made.*

The Form of the Certificate, to be ſent by ſuch Subſcribers who live in the Country, to their reſpective Deputies *or* Proxies, *in* LONDON.

WE the *Miniſter*, *Church-Wardens*, and *others* the *Inhabitants* of the *Pariſh* of in the *County* of do hereby *Certifie* to the *Directors* of the *Perpetual Aſſurance Office*, That *A B.* of the ſaid *Pariſh*, in the *County* aforeſaid, is *actually preſent* at the *Signing* hereof; and, as we verily believe, in a *good State* of *Health*, being full *Twelve Years of Age* or more, and *under* Fifty Five.

Auguſt . . . .
1706.

. . . . Rector, Vicar, or Curate.

Witneſs
A. B. Pariſh Clark.

. . . . Church-
. . . . Wardens
. . . . Pariſhio-
. . . . ners.

*** The Incumbent of any Pariſh being a Subſcriber, muſt have his Certificate ſign'd by any Neighbouring Miniſter.

††† Note, That the 5 *s.* Entrance, and the 5 *s.* into the *Joint-Stock* together with the 1*l.* 11 *s.* for the *firſt* Quarterly Payment, due at *Midſummer* laſt, and 1 *s* for Stamps, muſt be Paid at the taking out of every reſpective Policy, till 2000 are deliver'd out; and therefore 'twill be the Intereſt of every Subſcriber to take out their Policies with all convenient ſpeed.

LONDON: Printed by John Matthews, in *Little Britain*, Printer to the SOCIETY. 1706.

STATUTES of *ROCHESTER* BRIDGE. 7

en ou autre duetee a la reparacion et ſuſtentacion de le dit auncien pount, ſoient tenuz de faire rendre et paier toux ceux rentz cuſtumes preſtacions et duetes al reparacion et ſuſtentacion del dit novel pount, auxi avant, et en meſme la manere, come ils leur aunceſtres ou ceux queux eſtat ils ount feurent tenuz affaire a la reparacion et ſuſtentacion del auncien pount avantdit, nientcontreeſteant la remoement et le novel feiſure del dit novel pount.

Quele priere ſemble au Roy juſte et reſonable, et ad ottroie a la priere avantdite.

[Rot. Parl, 21 R. 2. art. 33. in Turr. Lond.]

ty to the Repair and Support of the ſaid antient Bridge, may be bound to do, render, and pay all thoſe Rents, Cuſtoms, Preſtations, and Duties to the Repair and Support of the ſaid new Bridge, as before, and in the ſame manner as, they, their Anceſtors, or thoſe whoſe Eſtate they have, were bound to do to the Repair and Support of the antient Bridge aforeſaid, notwithſtanding the Removal and the new making of the ſaid new Bridge.

21 R. 2.

Which Prayer ſeems juſt and reaſonable to the King; and he has aſſented to the Prayer aforeſaid.

V. Patent, incorporating the Perſons bound to repair the Bridge.

REx omnibus ad quos &c. ſalutem. Sciatis quod cum, ut accepimus, certa perſone ville loca et bunde infra Com. Kanc. ſeparatim limitata teneantur, ipſeque perſone ac predeceſſores et anteceſſores ſui, necnon terrarum tenentes infra villas loca et bundas hujuſmodi, totis temporibus retroactis, tenti et onerati fuiſſent ad faciendum quendam Pontem inter Civitatem Roffen. et villam de Strode; unde quilibet perſonarum locorum et bundarum predictorum ad porciones ſuas inde reparandas et ſuſtentandas aſſidetur, et ab antiquo aſſideri conſuevit; prout per Recordum in Scaccario noſtro habitum plenius apparet. Que quidem perſone ac terrarum tenentes villarum locorum et bundarum predictorum ita ſeparatim onerati, a tempore quo non extat memoria, eligere ſolebant de ſeipſis duos homines, ad reparacionem et gubernacionem porcionum ſuarum cujuſdam veteris Pontis, ibidem ab antiquo poſiti et ordinati, ſupervidend. et cuſtodiend. Cujus quidem Pontis ſuſtentacio eiſdem perſonis villis locis et bundis, ceteris* omnibus ſuis annuis conſideratis, adeo gravis extiterat et adhuc exiſtit, quod perſone ville loca et bunde predicta pene deſtruuntur et adnichilantur; dictuſque Pons, propter nimiam aque ſalſe profunditatem in loco quo ponitur, et propter fretorum ibidem in aqua predicta indies movencium aſperitatem, fere deſtructus exiſtat, ad grave nocumentum et periculum ſingulorum ibidem tranſeuncium. Ac ea conſideracione Robertus de Knolles Chivaler, et Johannes de Cobeham Chivaler, de hujuſmodi diſpendiis intolerabilibus pietatem habentes, ex eorum elemoſina quendam novum Pontem de petra, in quodam alio loco, ultra aquam predictam, eidem veteri Ponti adjacente, ad grandes cuſtus et expenſas ſuos fieri et conſtrui fecerunt jam de novo, Nos at-

The King to all unto whom &c. Greeting. Know ye that whereas (as we are informed) certain Perſons, Manors, Places, and Bounds, within the County of Kent ſeverally limited, are bound, and thoſe Perſons and their Predeceſſors and Anceſtors, and alſo the Land-holders within ſuch Manors, Places, and Bounds, for all times paſt had been bound and charged to make a certain Bridge between the City of Rocheſter and Town of Strode; whereunto every of the Perſons, Places, and Bounds aforeſaid, is aſſeſſed, and antiently uſed to be aſſeſſed, to repair and ſupport their Portions thereof; as by a Record remaining in our Exchequer more fully doth appear. Which Perſons and Land-holders of the Manors, Places, and Bounds aforeſaid, ſo ſeverally charged, from time beyond memory, did uſe to chuſe out of themſelves two Men, to overſee and keep the Reparation and Governance of their Portions of a certain old Bridge there antiently placed and eſtabliſhed. The ſupporting of which Bridge had been, and ſtill is, ſo burthenſome to the ſame Perſons, Manors, Places, and Bounds, conſidering their other yearly charges, that the Perſons, Manors, Places, and Bounds aforeſaid, are almoſt ruined and undone. And the ſaid Bridge, by reaſon of the two great Depth of ſalt water in the place in which it is ſet, and by reaſon of the Roughneſs of the Tides daily flowing in the ſaid water, is almoſt deſtroyed, to the great damage and danger of all there paſſing. And upon this Conſideration Robert de Knolles Knight, and John de Cobeham Knight, having pity of ſuch inſupportable charges, of their charity, at their great coſts and expences, have now cauſed to be made and built anew a certain new Bridge of Stone, in another place over the ſaid water, adjoyning to the ſaid old Bridge. We conſidering that the ſaid new Bridge

21 R. 2.

* *Pro* omnibus *lege* oneribus.

in

(38)

Offences, and ſhall give Judgement by the Majority of Voices; but no Sentence ſhall be executed till the Commanding Officer (not being a Member of the Court-martial) or the Governor of the Garriſon ſhall have confirmed the ſame.

که خارج ازاجلاس کورت مارشل است ان را منظور
نه نماید جاری نمیتواند شد

ARTICLE XIII.

No Perſon whatſoever ſhall uſe menacing Words, Signs, or Geſtures, in the Preſence of a Court-martial then ſitting, or ſhall cauſe any Diſorder or Riot, ſo as to diſturb their Proceedings, on the Penalty of being puniſhed at the Diſcretion of the ſaid Court-martial.

ائین سیزدهم من باب دوازدهم

باید که بمحکمه کورت مارشل کسی از سخن یا اشاره
یا حرکات نوعی تهدید نه نماید و نیز هنگامه و خرخشه
که ازان بروبکاری خلل پدید آید برپا نسازد و الا
موافق مرضی کورت مارشل سزا خواهد یافت

ARTICLE XIV.

To the end that Offenders may be brought to Juſtice, We hereby direct, That whenever any Officer or Soldier ſhall commit a Crime deſerving Puniſhment, he ſhall by his Commanding Officer, if an Officer, be put in Arreſt; if a Non-commiſſioned Officer or Soldier, be impriſoned till he ſhall be either tried by a Court-martial, or ſhall be lawfully diſcharged by a proper Authority.

ائین چهاردهم من باب دوازدهم

نظر براینکه گنهکاران بسیاست رسانیده شوند حکم است
که هرگاه کسی عهده دار کلان یا خورد یا سپاهی گناه
قابل تنبیه نماید اگر عهده دار کلان باشد بحکم سردار خود
نظر بند خواهد شد و اگر عهده دار خورد یا سپاهی بود
در قید خواهد ماند تا وقتیکه تجویز بکورت مارشل شود
یا آنکه بحکم صاحب اقتدار خلاص یابد

ARTICLE XVI.

No Officer commanding a Guard, or *Provoſt-martial, ſhall refuſe to receive, or keep

آئین شانزدهم من باب دوازدهم

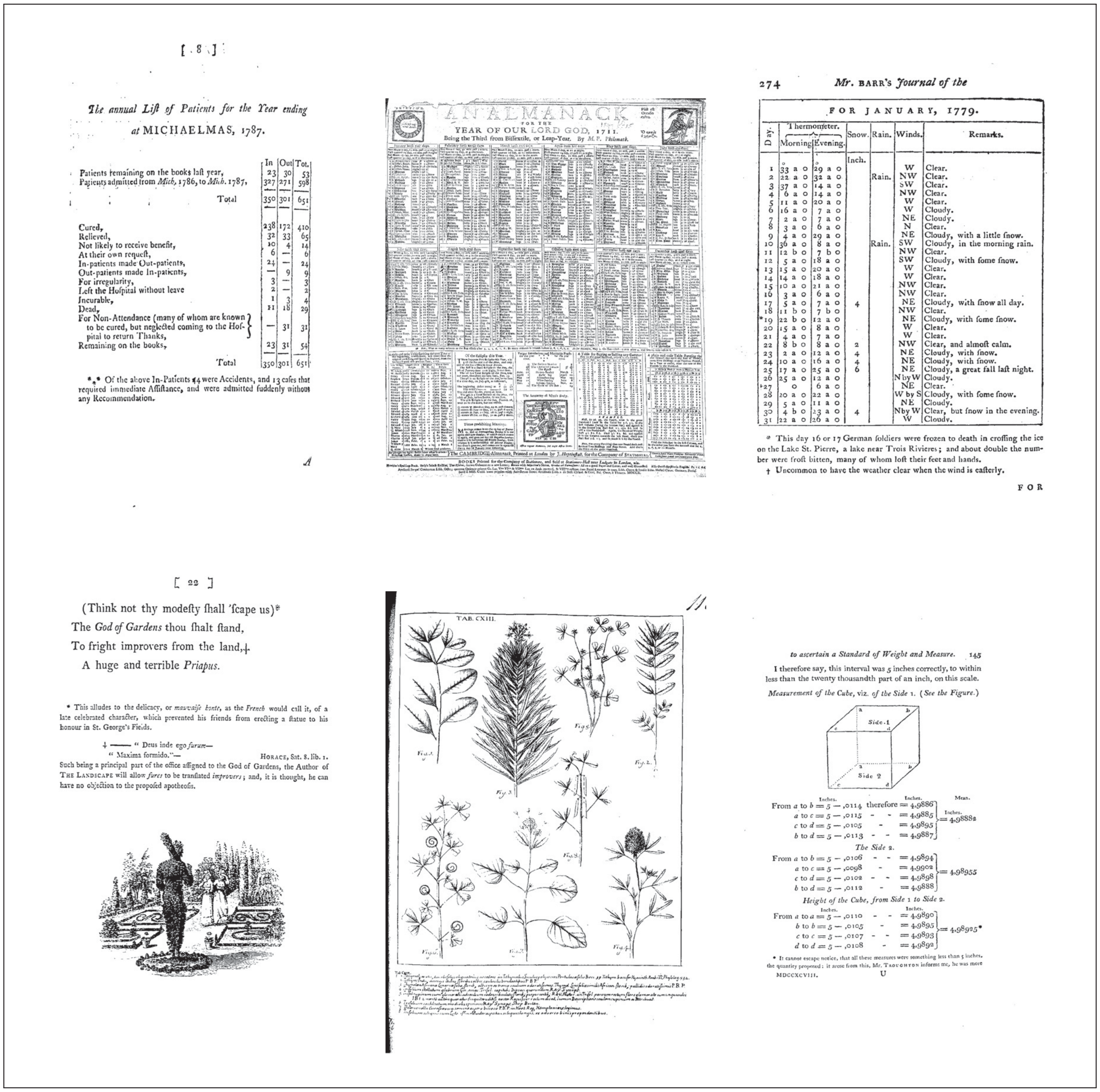
هر آن عهده دار که آمر چوکی و پهره باشد و پراوو مارشل باید که

* It is not poſſible to give a ſingle word either in Perſian or Hindooſtanee correſponding to Provoſt-martial without the riſk of confuſion, for though the *Kotwal* in Indian Armies anſwers nearly to the Provoſt-martial in European Armies, yet in *our Indian Armies* their Offices are diſtinct.

Figure 2.2 Examples of pages with different column numbers, font sizes and layouts containing footnote.

2.3 Footnote-based feature extraction

In this section, we describe our methodology to extract features related to the appearance of a footnote on the page. The fundamental idea behind this approach is to generate our hypothesis around the most remarkable visual features of footnotes. For this aim, three visual features



[8]

The annual Liſt of Patients for the Year ending at MICHAELMAS, 1787.

	In	Out	Tot.
Patients remaining on the books laſt year,	23	30	53
Patients admitted from *Mich*, 1786, to *Mich*. 1787,	327	271	598
Total	350	301	651
Cured,	238	172	410
Relieved,	32	33	65
Not likely to receive benefit,	10	4	14
At their own requeſt,	6	—	6
In-patients made Out-patients,	24	—	24
Out-patients made In-patients,	—	9	9
For irregularity,	3	—	3
Left the Hoſpital without leave	2	—	2
Incurable,	1	3	4
Dead,	11	18	29
For Non-Attendance (many of whom are known to be cured, but neglected coming to the Hoſpital to return Thanks,	—	31	31
Remaining on the books,	23	31	54
Total	350	301	651

‚ Of the above In-Patients 44 were Accidents, and 13 caſes that required immediate Aſſiſtance, and were admitted ſuddenly without any Recommendation.

A

AN ALMANACK FOR THE YEAR OF OUR LORD GOD, 1711. Being the Third from Biſſextile, or Leap-Year. By M.P. Philomath.

274 *Mr.* BARR's *Journal of the*

FOR JANUARY, 1779.

Day.	Thermometer.		Snow.	Rain.	Winds.	Remarks.
	Morning	Evening.				
	°	°	Inch.			
1	33 a o	29 a o			W	Clear.
2	22 a o	32 a o		Rain.	NW	Clear.
3	37 a o	14 a o			SW	Clear.
4	6 a o	14 a o			NW	Clear.
5	11 a o	20 a o			W	Clear.
6	16 a o	7 a o			W	Cloudy.
7	2 a o	7 a o			NE	Cloudy.
8	3 a o	6 a o			N	Clear.
9	4 a o	29 a o			NE	Cloudy, with a little ſnow.
10	36 a o	8 a o		Rain.	SW	Cloudy, in the morning rain.
11	12 b o	7 b o			NW	Clear.
12	5 a o	18 a o			SW	Cloudy, with ſome ſnow.
13	15 a o	20 a o			W	Clear.
14	14 a o	18 a o			W	Clear.
15	10 a o	21 a o			NW	Clear.
16	3 a o	6 a o			NW	Clear.
17	5 a o	7 a o	4		NE	Cloudy, with ſnow all day.
18	11 b o	7 b o			NW	Clear.
*19	22 b o	12 a o			NE	Cloudy, with ſome ſnow.
20	15 a o	8 a o			W	Clear.
21	4 a o	7 a o			W	Clear.
22	8 b o	8 a o	2		NW	Clear, and almoſt calm.
23	2 a o	12 a o	4		NE	Cloudy, with ſnow.
24	10 a o	16 a o	4		NE	Cloudy, with ſnow.
25	17 a o	25 a o	6		NE	Cloudy, a great fall laſt night.
26	25 a o	12 a o			N by W	Cloudy.
†27	o	6 a o			NE	Clear.
28	20 a o	22 a o			W by S	Cloudy, with ſome ſnow.
29	5 a o	11 a o			NE	Cloudy.
30	4 b o	23 a o	4		N by W	Clear, but ſnow in the evening.
31	22 a o	26 a o			W	Cloudy.

* This day 16 or 17 German ſoldiers were frozen to death in croſſing the ice on the Lake St. Pierre, a lake near Trois Rivieres; and about double the number were froſt bitten, many of whom loſt their feet and hands.

† Uncommon to have the weather clear when the wind is eaſterly.

FOR

[22]

(Think not thy modeſty ſhall 'ſcape us)*
The *God of Gardens* thou ſhalt ſtand,
To fright improvers from the land,‡
A huge and terrible *Priapus*.

* This alludes to the delicacy, or *mauvaiſe honte*, as the *French* would call it, of a late celebrated character, which prevented his friends from erecting a ſtatue to his honour in St. George's Fields.

‡ —— " Deus inde ego *furum*—
" Maxima formido."— HORACE, Sat. 8. lib. 1.
Such being a principal part of the office aſſigned to the God of Gardens, the Author of THE LANDSCAPE will allow *fures* to be tranſlated *improvers*; and, it is thought, he can have no objection to the propoſed apotheoſis.

TAB. CXIII.

to aſcertain a Standard of Weight and Measure. 145

I therefore ſay, this interval was 5 inches correctly, to within leſs than the twenty thouſandth part of an inch, on this ſcale.

Meaſurement of the Cube, viz. of the Side 1. (*See the Figure.*)

From a to $b = 5 - ,0114$ therefore $= 4,9886$
a to $c = 5 - ,0115$ - - $= 4,9885$
c to $d = 5 - ,0105$ - $= 4,9895$
b to $d = 5 - ,0113$ - - $= 4,9887$
Mean. Inches. $= 4,98882$

The Side 2.

From a to $b = 5 - ,0106$ - - $= 4,9894$
a to $c = 5 - ,0098$ - $= 4,9902$
c to $d = 5 - ,0102$ - - $= 4,9898$
b to $d = 5 - ,0112$ - $= 4,9888$
$= 4,98955$

Height of the Cube, from Side 1 *to Side* 2.

From a to $a = 5 - ,0110$ - - $= 4,9890$
b to $b = 5 - ,0105$ - $= 4,9895$
c to $c = 5 - ,0107$ - - $= 4,9893$
d to $d = 5 - ,0108$ - $= 4,9892$
$= 4,98925$*

* It cannot eſcape notice, that all theſe meaſures were ſomething leſs than 5 inches, the quantity propoſed: it aroſe from this, Mr. TROUGHTON informs me, he was more

MDCCXCVIII. U

Figure 2.3 Examples of footnotes appearing in the tabular and illustrative layouts.

are observed which are the smaller font size of the footnote respect to the body text, footnote location in the document page and the relatively greater gap between the footnote and the main text compared to the regular line space. The smaller font size is our strongest hypothesis and has been the case for over 85% of the almost 6000 images we observed. The last two visual features are the weaker ones but still necessary for forming an efficient footnote detection framework. To fulfill each of these observations, four methods are proposed based on the font

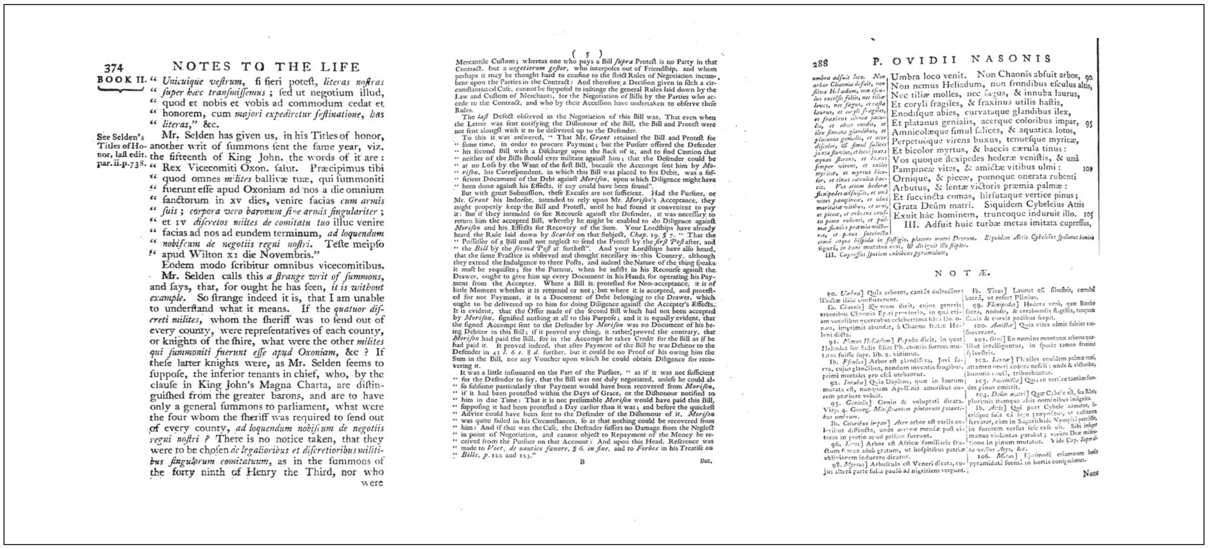


Figure 2.4 Examples of pages with side notes and commentary notes.

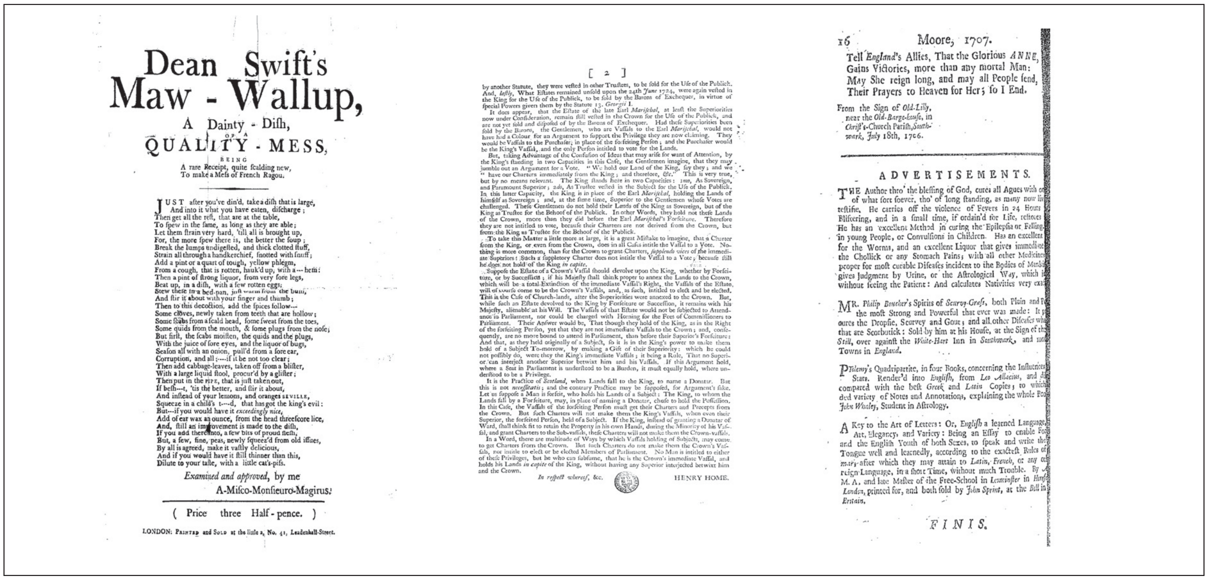
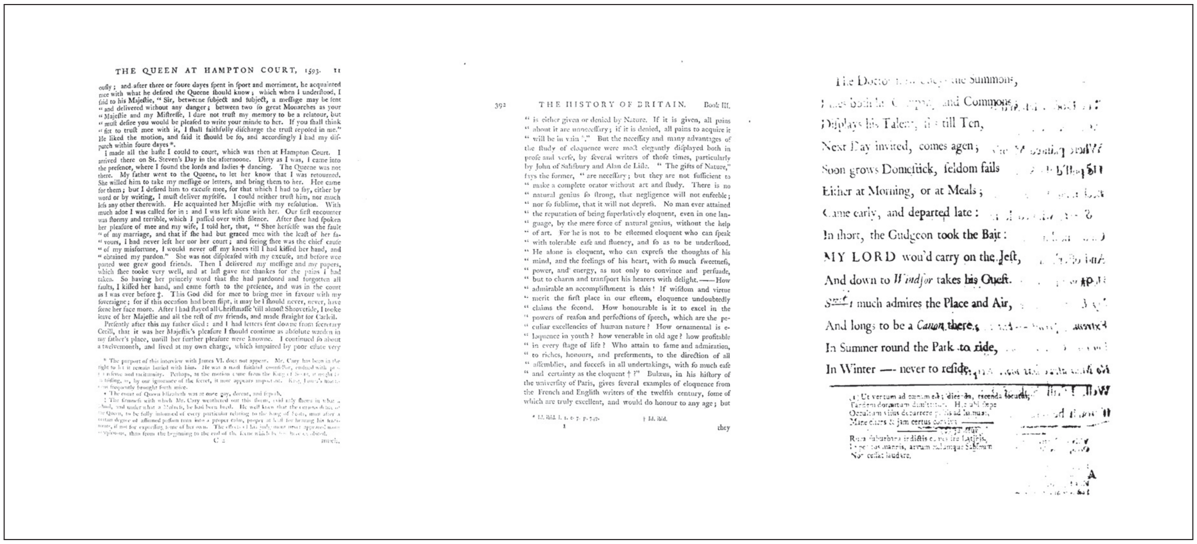


Figure 2.5 Examples of footnote-like pages.

size, the footnote location, and spacing between the body text and the footnote. Below. We briefly explain each of these methods along the preprocessing steps needed for each of them.



THE QUEEN AT HAMPTON COURT, 1593. 11

ouſly; and after three or foure dayes ſpent in ſport and merriment, he acquainted mee with what he deſired the Queene ſhould know; which when I underſtood, I ſaid to his Majeſtie, "Sir, betweene ſubject and ſubject, a meſſage may be ſent "and delivered without any danger; between two ſo great Monarches as your "Majeſtie and my Miſtreſſe, I dare not truſt my memory to be a relatour, but "muſt deſire you would be pleaſed to write your minde to her. If you ſhall think "fit to truſt mee with it, I ſhall faithfully diſcharge the truſt repoſed in me." He liked the motion, and ſaid it ſhould be ſo, and accordingly I had my diſpatch within foure dayes*.

I made all the haſte I could to court, which was then at Hampton Court. I arrived there on St. Steven's Day in the afternoone. Dirty as I was, I came into the preſence, where I found the lords and ladies † dancing. The Queene was not there. My father went to the Queene, to let her know that I was retourned. She willed him to take my meſſage or letters, and bring them to her. Hee came for them; but I deſired him to excuſe mee, for that which I had to ſay, either by word or by writing, I muſt deliver myſelfe. I could neither truſt him, nor much leſs any other therewith. He acquainted her Majeſtie with my reſolution. With much adoe I was called for in: and I was left alone with her. Our firſt encounter was ſtormy and terrible, which I paſſed over with ſilence. After ſhee had ſpoken her pleaſure of mee and my wife, I told her, that, "Shee herſelfe was the fault "of my marriage, and that if ſhe had but graced mee with the leaſt of her fa"vours, I had never left her nor her court; and ſeeing ſhee was the chief cauſe "of my misfortune, I would never off my knees till I had kiſſed her hand, and "obtained my pardon." She was not diſpleaſed with my excuſe, and before wee parted wee grew good friends. Then I delivered my meſſage and my papers, which ſhee tooke very well, and at laſt gave me thankes for the pains I had taken. So having her princely word that ſhe had pardoned and forgotten all faults, I kiſſed her hand, and came forth to the preſence, and was in the court as I was ever before ‡. This God did for mee to bring mee in favour with my ſoveraigne; for if this occaſion had been ſlipt, it may be I ſhould never, never, have ſeene her face more. After I had ſtayed all Chriſtmaſſe 'till almoſt Shrovetide, I tooke leave of her Majeſtie and all the reſt of my friends, and made ſtraight for Carleil.

Preſently after this my father died: and I had letters ſent downe from ſecretary Cecill, that it was her Majeſtie's pleaſure I ſhould continue as abſolute warden in my father's place, untill her further pleaſure were knowne. I continued ſo about a twelvemonth, and lived at my own charge, which impaired by poor eſtate very

* The purport of this interview with James VI. does not appear. Mr. Cary has been in the right to let it remain buried with him. He was a moſt faithful counſellor, endued with [illegible] reſerve and taciturnity. Perhaps, as the motion came from the King of Scots, it might [illegible] trifling, as, by our ignorance of the ſecret, it now appears important. King James's [illegible] frequently brought forth mice.

† The court of Queen Elizabeth was at once gay, decent, and ſuperb.

‡ The firmneſs with which Mr. Cary weathered out this ſtorm, evidently ſhews in what a ſchool, and under what a Miſtreſs, he had been bred. He well knew that the curious diſpoſition of the Queen, to be fully informed of every particular relating to the King of Scots, muſt after a certain degree of aſſumed paſſion turn into a proper calm, proper at leaſt for hearing his [illegible] if not for expelling ſome of her own. The effects of his judgment never appeared more [illegible] than from the beginning to the end of the ſcene which he [illegible] exhibited.

C 2 much,

392 THE HISTORY OF BRITAIN. Book III.

" is either given or denied by Nature. If it is given, all pains " about it are unneceſſary; if it is denied, all pains to acquire it " will be in vain *." But the neceſſity and many advantages of the ſtudy of eloquence were moſt elegantly diſplayed both in proſe and verſe, by ſeveral writers of thoſe times, particularly by John of Saliſbury and Alan de Liſle. "The gifts of Nature," ſays the former, "are neceſſary; but they are not ſufficient to " make a complete orator without art and ſtudy. There is no " natural genius ſo ſtrong, that negligence will not enfeeble; " nor ſo ſublime, that it will not depreſs. No man ever attained " the reputation of being ſuperlatively eloquent, even in one lan" guage, by the mere force of natural genius, without the help " of art. For he is not to be eſteemed eloquent who can ſpeak " with tolerable eaſe and fluency, and ſo as to be underſtood. " He alone is eloquent, who can expreſs the thoughts of his " mind, and the feelings of his heart, with ſo much ſweetneſs, " power, and energy, as not only to convince and perſuade, " but to charm and tranſport his hearers with delight.——How " admirable an accompliſhment is this! If wiſdom and virtue " merit the firſt place in our eſteem, eloquence undoubtedly " claims the ſecond. How honourable is it to excel in the " powers of reaſon and perfections of ſpeech, which are the pe" culiar excellencies of human nature? How ornamental is e" loquence in youth? how venerable in old age? how profitable " in every ſtage of life? Who attain to fame and admiration, " to riches, honours, and preferments, to the direction of all " aſſemblies, and ſucceſs in all undertakings, with ſo much eaſe " and certainty as the eloquent † ?" Bulæus, in his hiſtory of the univerſity of Paris, gives ſeveral examples of eloquence from the French and Engliſh writers of the twelfth century, ſome of which are truly excellent, and would do honour to any age; but

* Id. ibid. l. 1. c. 7. p. 747. † Id. ibid.

1 they

The Docto[illegible] the Summons,
[illegible] both in C[illegible] and Commons;
Diſplays his Talen[illegible] till Ten,
Next Day invited, comes agen;
Soon grows Domeſtick, ſeldom fails
Either at Morning, or at Meals;
Came early, and departed late:
In ſhort, the Gudgeon took the Bait:
MY LORD wou'd carry on the Jeſt,
And down to *Windſor* takes his Gueſt.
S[illegible]t much admires the Place and Air,
And longs to be a *Canon* there;
In Summer round the Park to ride,
In Winter — never to reſide.

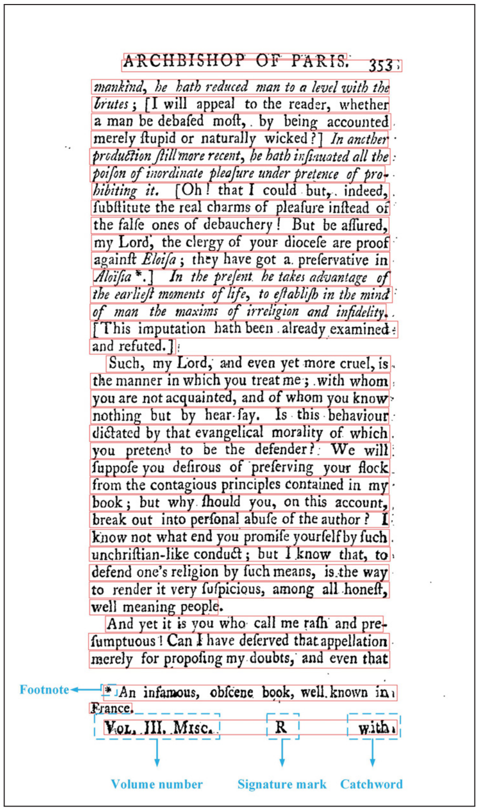
(1) Ut ventum ad cœnam eſt; dicenda, tacenda locutus,
Tandem dormitum dimittitur. Hic ubi ſæpe
Occultum viſus decurrere piſcis ad hamum,
Mane cliens & jam certus conviva
[illegible]
Rura ſuburbana indictis comes ire Latinis,
Im[illegible] mannis, arvum cœlumque Sabinum
Non ceſſat laudare.

Figure 2.6 Examples of images with degraded nature and faded footnote markers.

2.3.1 Preprocessing

Text line segmentation is the primary phase of our feature extraction methods and related to layout analysis. To do so, we used the method proposed by Santos *et al.* (2009). According to their method horizontal projection of binarized images are obtained. Following that there is a text line separation step based on finding the empty spaces between histogram peaks and applying a dynamically calculated threshold. This threshold is related to the average horizontal histogram values of the text lines. This step identifies the vertical location of each text line. We need a vertical histogram projection to find the horizontal position of the text lines. Applying a vertical projection also helps in avoiding false words. Finally, to optimize the segmentation results, we perform a text line selection. The result of this process is shown for an example image in Figure 2.7.

One of the common practices in 17th and 18th centuries were using signature marks and catchwords at the end of the page (Marcussen & Bergendorff, 2003). They both were used to help the bookbinder or printer to bind the pages and sections in right order for the press. Advancements in printing technology have overtaken these practices, and they are out of use nowadays. There is also the number of the volume at the bottom of the page. All of these practices can



ARCHBISHOP OF PARIS. 353

mankind, he hath reduced man to a level with the
brutes; [I will appeal to the reader, whether
a man be debaſed moſt, by being accounted
merely ſtupid or naturally wicked?] *In anether*
production ſtill more recent, he hath inſinuated all the
poiſon of inordinate pleaſure under pretence of pro-
hibiting it. [Oh! that I could but, indeed,
ſubſtitute the real charms of pleaſure inſtead of
the falſe ones of debauchery! But be aſſured,
my Lord, the clergy of your dioceſe are proof
againſt *Eloiſa*; they have got a preſervative in
Aloïſia *.] *In the preſent he takes advantage of*
the earlieſt moments of life, to eſtabliſh in the mind
of man the maxims of irreligion and infidelity.
[This imputation hath been already examined
and refuted.]

Such, my Lord, and even yet more cruel, is
the manner in which you treat me; with whom
you are not acquainted, and of whom you know
nothing but by hear-ſay. Is this behaviour
dictated by that evangelical morality of which
you pretend to be the defender? We will
ſuppoſe you deſirous of preſerving your flock
from the contagious principles contained in my
book; but why ſhould you, on this account,
break out into perſonal abuſe of the author? I
know not what end you promiſe yourſelf by ſuch
unchriſtian-like conduct; but I know that, to
defend one's religion by ſuch means, is the way
to render it very ſuſpicious, among all honeſt,
well meaning people.

And yet it is you who call me raſh and pre-
ſumptuous! Can I have deſerved that appellation
merely for propoſing my doubts, and even that

* An infamous, obſcene book, well known in
France.

VOL. III. MISC. R with

Figure 2.7 An image example with segmented text lines (red boxes) which contains a footnote along the volume number, the signature mark, and the catchword.

be a source of false detection based on our hypothesis. Specifically, they have the same font size as the main text while usually coming after a footnote. Figure 2.7 depicts an example of the image containing all aforementioned practices along footnote on the page. As it can be seen, not considering them in our algorithm can obscure the problem later. Therefore, before applying the page segmentation algorithm, we crop one-fourth of the page image from the right to avoid the problem of catchwords. To deal with the signature marks, the last text line started at the bottom midpoint of the page is eliminated from the process.

2.3.2 Font size based methods

We propose two methods based on font size namely the bounding box based method (BBox) and horizontal projection based method (Proj). These methods aim to find the approximate font size of each line on the page and then use that information to drag a set of rules for the appearance of the footnote on the page. Based on our primary hypotheses, we expect a drop in font size in the footnote line. However, this is an ideal scenario, and other typographical objects can cause this drop as well, e.g., title, figures, tables, etc. Hence, we need some additional rules to avoid false detection and to detect the footnote line accurately. Below we briefly explain each of these two methods.

2.3.2.1 Bounding box based method (BBox)

Our first method based on estimating the font size of each line is BBox method. In this method, we aim to find the bounding box around letters in the text line. We first apply contrast-limited adaptive histogram equalization (Zuiderveld, 1994) to each text line area, and then the smallest connected component regions are found using rectangular bounding boxes. After locating the bounding boxes, we try to approximate the font size of the lower case letters in each text line. To do so, first, for each text line, we find the bottom (base) line that all the letters are written on it. Then the most frequently repeating height of the bounding boxes above that line is taken as the font size estimated for that text line (see Figure 2.8).

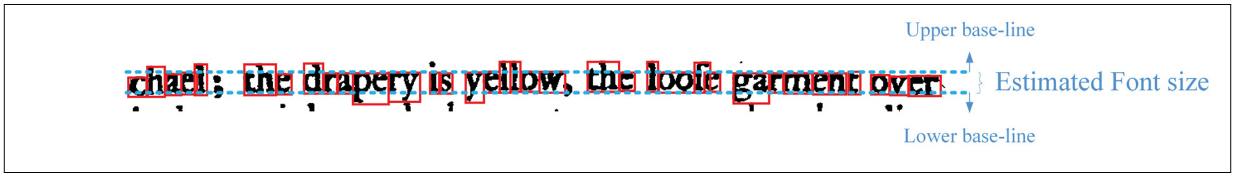


Figure 2.8 Font size estimation for the bounding box method.

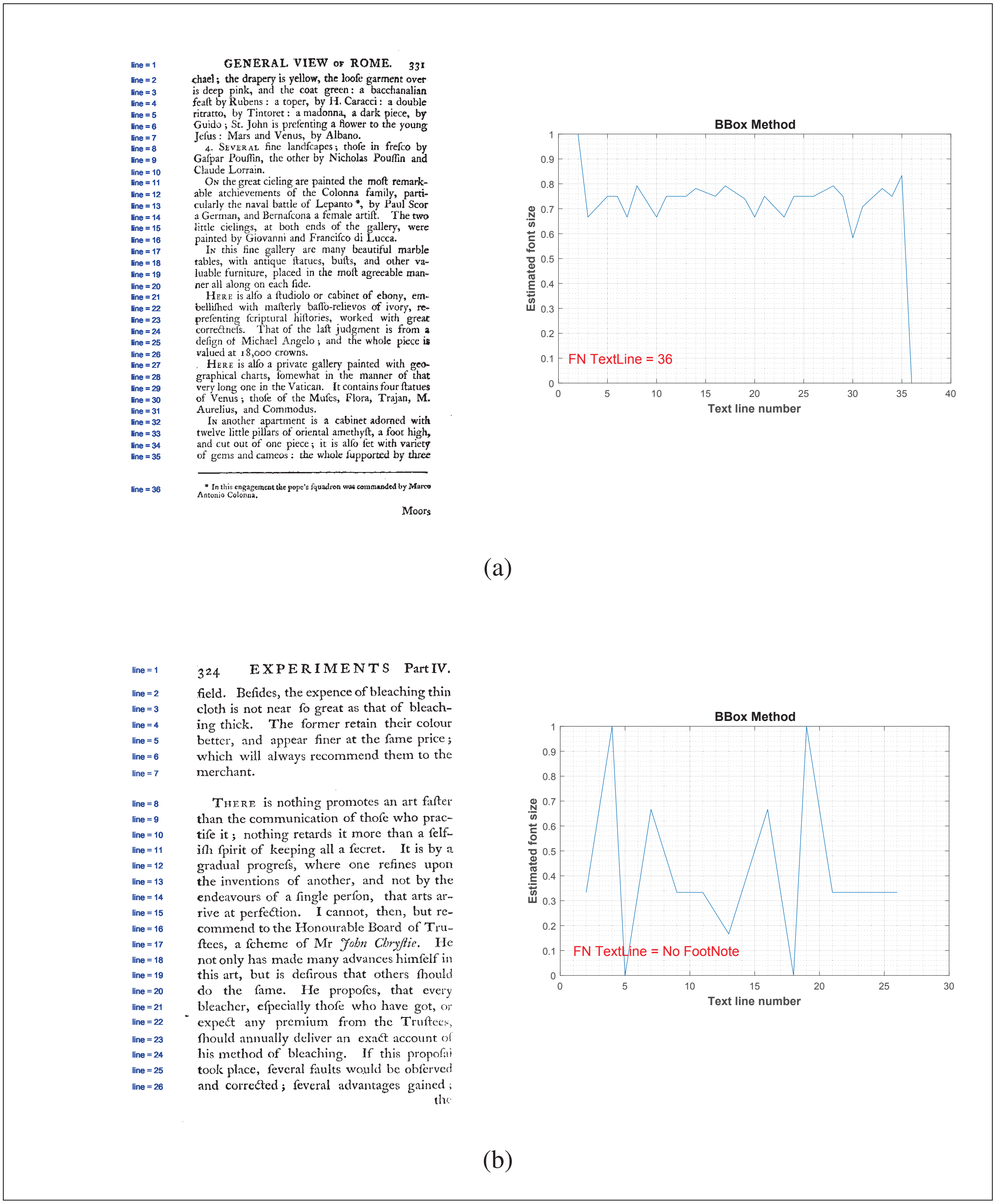
The font sizes are then normalized between zero and one to make the results generalizable for the other images. Small noises, lines, logos or even punctuation marks (such as dots, semicolons, etc.) can affect the font size estimation due to their unusual sizes. Therefore to avoid this problem a threshold has been used. Only the bounding boxes with the height between 50 and 200 pixels are kept. Moreover, the ones with the width over 150 pixels are eliminated. Figure 2.9 shows two examples of a page containing a footnote and without a footnote. It is evident from the figure that wherever a footnote appears, we can expect a drop in font size

(Figure 2.9 (a)) and when there is no footnote we would have some random oscillation in the graph of font size versus text lines (Figure 2.9 (b)).

After obtaining the normalize font size, to find a way to extract features from the font size information and associate it with the appearance of a footnote on the page, we define a set of rules according to observing about 100 images from each category. The basic rule for having footnote wrap around the drop of 0.55 between two consecutive lines rule. There exist some other rules for having footnote such as not having a footnote in first three lines of the page; condition of having at least three lines in a page; having only on a global drop, etc. The logical zero and one answers to these rules build a feature vector of size 18 for this method. The detailed descriptions of these features are presented in Table 2.1.

Table 2.1 List of the extracted features using BBox method.

Features	**Conditions**
F1	1 if there is no drop more than 0.55. Otherwise,0.
F2	1 if there are 1+ drops of more than 0.55 (Footnote line's condition). Otherwise,0.
F3	1 if the last two lines' heights are less than 0.1. Otherwise,0.
F4	1 if the last line's height is less than 0.1. Otherwise,0.
F5	1 if the last two lines' heights are less than 0.1 and there is a footnote. Otherwise,0.
F6	1 if the line before last line's height is less than 0.1. Otherwise,0.
F7	1 if the footnote is not in the 4th line. Otherwise,0.
F 8	1 if there are 2+ drops more than 0.55. Otherwise,0.
F9	1 if the footnote is not in the lines 4th, 5thand 6th. Otherwise,0.
F10	1 if there are 2+ drops less than 0.55 or footnote is not in the lines 4th, 5th and 6th. Otherwise,0.
F11	1 if there is a drop greater than 0.15. Otherwise,0.
F 12	1 if footnote line is in the line 6th or more. Otherwise,0.
F13	1 if the height of the footnote line is 0.55 greater than the line before the last line. Otherwise,0.
F14	1 if there is a drop of greater than 0.35 between the line before and after footnote line. Otherwise,0.
F15	1 if there is a line except the last line selected as the footnote line and there is a drop of greater than 0.35 between the line before and after it. Otherwise,0.
F16	1 if there is a difference less than 0.17 between the line before and after the footnote line. Otherwise,0.
F17	1 if there is a line except the last line selected as the footnote line and there is a difference less than 0.17 between the line before and after it. Otherwise,0.
F18	1 if it the page has more than three lines. Otherwise,0.



GENERAL VIEW OF ROME. 331

chael; the drapery is yellow, the looſe garment over is deep pink, and the coat green: a bacchanalian feaſt by Rubens: a toper, by H. Caracci: a double ritratto, by Tintoret: a madonna, a dark piece, by Guido; St. John is preſenting a flower to the young Jeſus: Mars and Venus, by Albano.

4. SEVERAL fine landſcapes; thoſe in freſco by Gaſpar Pouſſin, the other by Nicholas Pouſſin and Claude Lorrain.

ON the great cieling are painted the moſt remarkable atchievements of the Colonna family, particularly the naval battle of Lepanto *, by Paul Scor a German, and Bernaſcona a female artiſt. The two little cielings, at both ends of the gallery, were painted by Giovanni and Franciſco di Lucca.

IN this fine gallery are many beautiful marble tables, with antique ſtatues, buſts, and other valuable furniture, placed in the moſt agreeable manner all along on each ſide.

HERE is alſo a ſtudiolo or cabinet of ebony, embelliſhed with maſterly baſſo-relievos of ivory, repreſenting ſcriptural hiſtories, worked with great correctneſs. That of the laſt judgment is from a deſign of Michael Angelo; and the whole piece is valued at 18,000 crowns.

HERE is alſo a private gallery painted with geographical charts, ſomewhat in the manner of that very long one in the Vatican. It contains four ſtatues of Venus; thoſe of the Muſes, Flora, Trajan, M. Aurelius, and Commodus.

IN another apartment is a cabinet adorned with twelve little pillars of oriental amethyſt, a foot high, and cut out of one piece; it is alſo ſet with variety of gems and cameos: the whole ſupported by three

* In this engagement the pope's ſquadron was commanded by Marco Antonio Colonna.

Moors

(a)

324 EXPERIMENTS Part IV.

field. Beſides, the expence of bleaching thin cloth is not near ſo great as that of bleaching thick. The former retain their colour better, and appear finer at the ſame price; which will always recommend them to the merchant.

THERE is nothing promotes an art faſter than the communication of thoſe who practiſe it; nothing retards it more than a ſelfiſh ſpirit of keeping all a ſecret. It is by a gradual progreſs, where one refines upon the inventions of another, and not by the endeavours of a ſingle perſon, that arts arrive at perfection. I cannot, then, but recommend to the Honourable Board of Truſtees, a ſcheme of Mr *John Chryſtie*. He not only has made many advances himſelf in this art, but is deſirous that others ſhould do the ſame. He propoſes, that every bleacher, eſpecially thoſe who have got, or expect any premium from the Truſtees, ſhould annually deliver an exact account of his method of bleaching. If this propoſal took place, ſeveral faults would be obſerved and corrected; ſeveral advantages gained;

the

(b)

Figure 2.9 An example of font size changes using bounding box based method for a page (a) with a footnote (b) without a footnote.

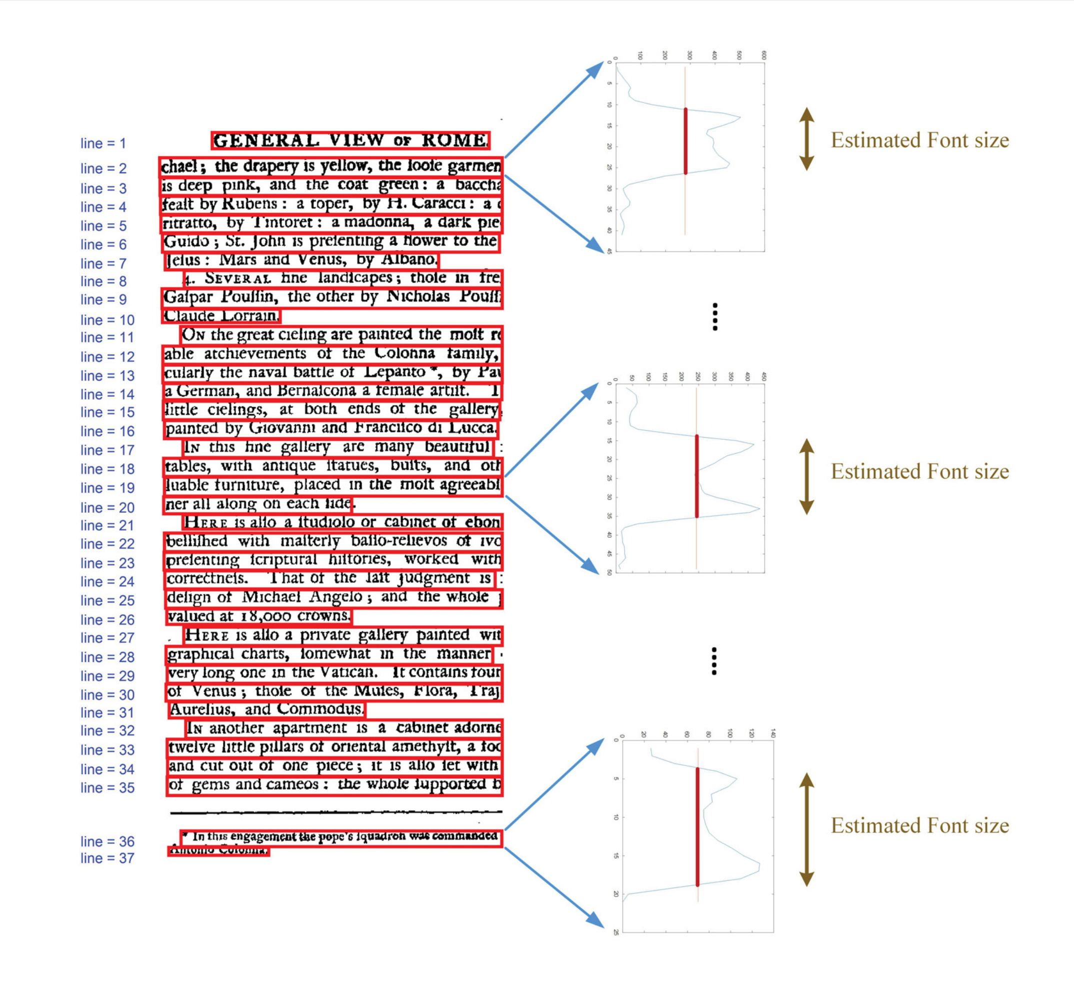
2.3.2.2 Horizontal projection based method (Proj)

This is the second method based on finding an approximate size of the font in each line. In this method, the approximate font sizes are determined using the intensity of horizontal projection in each text line. First, we find the outline bounding boxes of each text line and discard the outlines with a height of lower than 50 pixels and higher than 200 pixels. After applying Contrast-limited adaptive histogram equalization to each text line (Zuiderveld, 1994), we calculate the horizontal projection for each line. Next, the intersection points of a straight line equal to 0.55 of the difference between the maximum and minimum of the histogram and the histogram itself are located on each line. The value 0.55 is found empirically. The distance between the intersected points indicates our estimated font size for that line (see Figure 2.10). Finally, the font sizes are normalized between zero and one to make the comparison between other pages possible. As it is clear from Figure 2.11, it can be seen the Proj method also follows the same pattern as the BBox method. Wherever we have a footnote, we can expect a drop in the font sizes and random changes of the font size in the same range indicates not having a footnote in our pages (Figure 2.11 (a and b)).

Therefore, like the BBox method by observing 100 images from both classes of FN and NFN, we defined a set of rules and conditions for each category. The essential assumption for the appearance of a footnote is again a drop of 0.55 between two consecutive lines. There are also some sub-assumptions such as having at least three lines on the page; not accepting the lines except the last line as the footnote line unless there is a difference of 0.25 or more between the lines before and after it. The logical answers to these rules and conditions, which are given in Table 2.2, create our Proj feature vector of size 24.

2.3.3 Space based features

This method is based on a weaker hypothesis, driven from the observation that the main body and the footnote section are separated from each other using a gap or space between them. As it can be seen from Figure 2.12 (a), we have a broader line spacing between the footnote line



GENERAL VIEW OF ROME.
chael; the drapery is yellow, the looſe garmen
is deep pink, and the coat green: a baccha
feaſt by Rubens: a toper, by H. Caracci: a
ritratto, by Tintoret: a madonna, a dark pie
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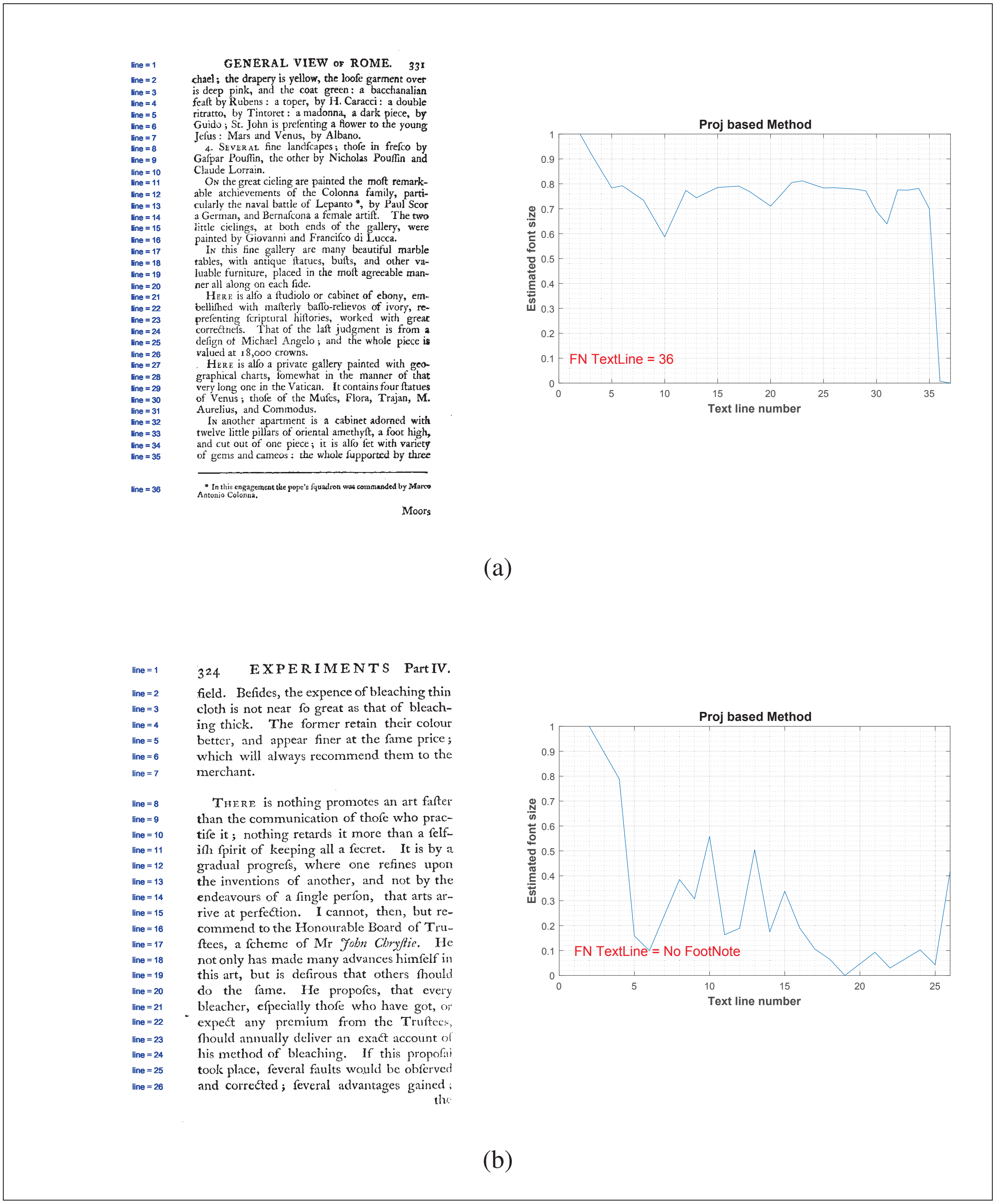
IN another apartment is a cabinet adorne
twelve little pillars of oriental amethyſt, a foo
and cut out of one piece; it is alſo ſet with
of gems and cameos: the whole ſupported b

* In this engagement the pope's ſquadron was commanded
Antonio Colonna.

Figure 2.10 The horizontal projection of intensity inside each text line box is determined and then it is intersected with a line equal to 0.55 of the difference between the maximum and minimum of the projection curve. This difference (Red bold lines on the projection graph) is selected as the approximated font size of the line.

and the main text. However, this gap could appear for other different reasons like the paragraph spacing or the space after titles or images (Figure 2.12 (b)). Therefore, we introduced some rules with the underlying assumption of having at least ten lines to proceed. After finding the outline box and the space between them, these spaces are normalized between zero and one for comparison purpose. We candidate the maximum line spacings which are 0.7 space above the average space. Next, divide the page into four sections and analyze if any maximum spacing appears at the three last one of them. We create the initial features based on space using this approach. Ultimately, by finding the approximate location of last/only maximum spacing on



GENERAL VIEW of ROME. 331

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324 EXPERIMENTS Part IV.

field. Beſides, the expence of bleaching thin cloth is not near ſo great as that of bleaching thick. The former retain their colour better, and appear finer at the ſame price; which will always recommend them to the merchant.

THERE is nothing promotes an art faſter than the communication of thoſe who practiſe it; nothing retards it more than a ſelfiſh ſpirit of keeping all a ſecret. It is by a gradual progreſs, where one refines upon the inventions of another, and not by the endeavours of a ſingle perſon, that arts arrive at perfection. I cannot, then, but recommend to the Honourable Board of Truſtees, a ſcheme of Mr *John Chryſtie*. He not only has made many advances himſelf in this art, but is deſirous that others ſhould do the ſame. He propoſes, that every bleacher, eſpecially thoſe who have got, or expect any premium from the Truſtees, ſhould annually deliver an exact account of his method of bleaching. If this propoſal took place, ſeveral faults would be obſerved and corrected; ſeveral advantages gained; the

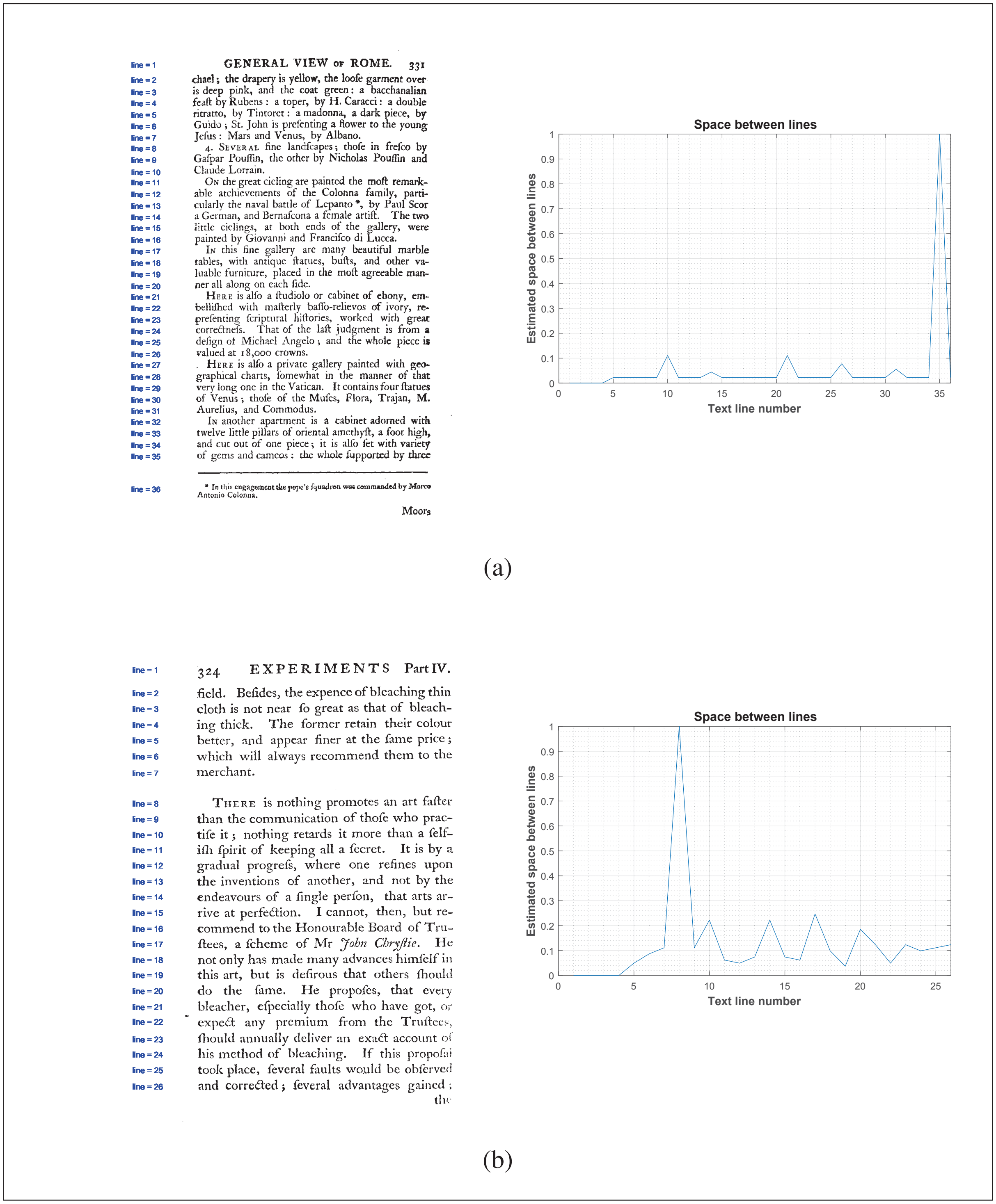
(b)

Figure 2.11 An example of font size change using horizontal projection based method for a page (a) with a footnote (b) without a footnote.

Table 2.2 List of the extracted features using Proj method.

Features	Conditions
F1	1 if there are more than three lines on the page. Otherwise, 0.
F2	1 if there is no possible footnote. Otherwise, 0.
F3	1 if there is more than one possible footnote (drops with the amount of 0.55 or more). Otherwise, 0.
F4	1 if footnote line is in the first three lines, or there are more than three possible footnotes. Otherwise, 0.
F5	1 if there are more than three possible footnotes, or there are lines shorter than 0.13 but not footnote lines. Otherwise, 0.
F6	1 if footnote line is in the first three lines, or there are lines shorter than 0.13 but not footnote lines. Otherwise, 0.
F7	1 if footnote line is in the first three lines. Otherwise, 0.
F 8	1 if there are more than three possible footnotes. Otherwise, 0.
F9	1 if there are lines shorter than 0.13 but not footnote lines. Otherwise, 0. Otherwise, 0.
F10	1 if footnote line is in the first three lines, or there are 3+ possible footnotes, or there are lines shorter than 0.13 but not footnote lines. Otherwise, 0.
F 11	1 if the last line or the line before has a height less than 0.1. Otherwise, 0.
F12	1 if the last line or the line before having the height less than 0.1 and there is a footnote Otherwise, 0.
F13	1 if the last line has a height less than 0.1. Otherwise, 0.
F14	1 if the line before the last line has a height less than 0.1. Otherwise, 0.
F15	1 if there still exists a footnote line. Otherwise, 0.
F16	1 if the height of the last line is less than 0.4. Otherwise, 0.
F17	1 if the last line has a height less than 0.1 and there exist a footnote line. Otherwise, 0.
F18	1 if the line before the last line has a height less than 0.1 and there exist a footnote line. Otherwise, 0.
F19	1 if the height of the last line is less than 0.4 and there is a footnote line. Also, the last line or the line before has a height less than 0.1. Otherwise, 0.
F20	1 if the greatest height drop is equal to or greater than 0.4, and there is at least a 0.25 drop between the line before and after footnote. Otherwise, 0.
F21	1 if there is at least a 0.25 drop between the line before and after footnote and footnote line's height is less than 0.4. Otherwise, 0.
F22	1 if the greatest height drop is equal to or greater than 0.4 and the height of the last line is less than 0.4. Otherwise, 0.
F23	1 if the height of the last line is less than 0.4, and the greatest height drop is equal to or greater than 0.4, and there is at least a 0.25 drop between the line before and after footnote. Otherwise, 0.
F24	1 if the height of footnote line is 0.4 below the highest height of the all other lines except the first 3 and last lines. Otherwise, 0.

the page, we complete the features based on the page line spacing. Features F1 to F8 in Table 2.3, represent the features according to this method.



GENERAL VIEW of ROME. 331

chael; the drapery is yellow, the looſe garment over is deep pink, and the coat green: a bacchanalian feaſt by Rubens: a toper, by H. Caracci: a double ritratto, by Tintoret: a madonna, a dark piece, by Guido; St. John is preſenting a flower to the young Jeſus: Mars and Venus, by Albano.

4. SEVERAL fine landſcapes; thoſe in freſco by Gaſpar Pouſſin, the other by Nicholas Pouſſin and Claude Lorrain.

ON the great cieling are painted the moſt remarkable atchievements of the Colonna family, particularly the naval battle of Lepanto *, by Paul Scor a German, and Bernaſcona a female artiſt. The two little cielings, at both ends of the gallery, were painted by Giovanni and Franciſco di Lucca.

IN this fine gallery are many beautiful marble tables, with antique ſtatues, buſts, and other valuable furniture, placed in the moſt agreeable manner all along on each ſide.

HERE is alſo a ſtudiolo or cabinet of ebony, embelliſhed with maſterly baſſo-relievos of ivory, repreſenting ſcriptural hiſtories, worked with great correctneſs. That of the laſt judgment is from a deſign of Michael Angelo; and the whole piece is valued at 18,000 crowns.

HERE is alſo a private gallery painted with geographical charts, ſomewhat in the manner of that very long one in the Vatican. It contains four ſtatues of Venus; thoſe of the Muſes, Flora, Trajan, M. Aurelius, and Commodus.

IN another apartment is a cabinet adorned with twelve little pillars of oriental amethyſt, a foot high, and cut out of one piece; it is alſo ſet with variety of gems and cameos: the whole ſupported by three

* In this engagement the pope's ſquadron was commanded by Marco Antonio Colonna.

Moors

(a)

324 EXPERIMENTS Part IV.

field. Beſides, the expence of bleaching thin cloth is not near ſo great as that of bleaching thick. The former retain their colour better, and appear finer at the ſame price; which will always recommend them to the merchant.

THERE is nothing promotes an art faſter than the communication of thoſe who practiſe it; nothing retards it more than a ſelfiſh ſpirit of keeping all a ſecret. It is by a gradual progreſs, where one refines upon the inventions of another, and not by the endeavours of a ſingle perſon, that arts arrive at perfection. I cannot, then, but recommend to the Honourable Board of Truſtees, a ſcheme of Mr *John Chryſtie*. He not only has made many advances himſelf in this art, but is deſirous that others ſhould do the ſame. He propoſes, that every bleacher, eſpecially thoſe who have got, or expect any premium from the Truſtees, ſhould annually deliver an exact account of his method of bleaching. If this propoſal took place, ſeveral faults would be obſerved and corrected; ſeveral advantages gained;

the

(b)

Figure 2.12 Example of showing the relationship between space and having a footnote: (a) footnote (b) no footnote.

2.3.4 Location based features

This method uses the location information achieved form BBox and Proj methods along the line spacing to extract more features for detecting footnote on the page. First, it tries to find the relative location of the footnote on the page by dividing the approximate detected line as the footnote to the total number of the text lines on the page. Later, having the location of the maximum space between the lines (last maximum space in the case of having more than one), we investigate if this point is anywhere around the detected footnote from BBox and Proj methods. For this purpose, we change the range of search from 0.02 to ± 0.14 by steps of ± 0.02. More details about features can be found in Table 2.3 (F9 to F30).

The combination of all these features generates the final feature set: 18 features form BBox method, 24 from Proj method and 30 from the spaced and location-based features, which sum up to total 72 features.

2.4 Classification

In recent years, support vector machines (SVMs) have been widely used for analyzing data and recognizing pattern (Hearst *et al.*, 1998). In this research, we use the SVM classifier to discriminate pages with a footnote from the one without a footnote. SVM implementation is done using LIBSVM toolbox (Chang & Lin, 2011) and the SVM has a degree two polynomial kernel function. Ten percent of the training set is used as the validation set to calculate the hyperparameters of SVM.

Table 2.3 List of the extracted features using space and location-based methods.

Features	**Conditions**
F1	1 if there are more than 10 lines on the page. Otherwise, 0.
F2	1 if there is a space peak in the 2nd 1/4th of the page & there are more than 10 lines on the page. Otherwise, 0.
F3	1 if there is a space peak in the 3^{rd} $1/4^{th}$ of the page & there are more than 10 lines on the page. Otherwise, 0.
F4	1 if there is a space peak in the 4^{th} $1/4^{th}$ of the page & there are more than 10 lines on the page. Otherwise, 0.
F5	1 if there is only one peak in whole the page & there are more than 10 lines on the page. Otherwise, 0.
F6	1 if there is more than one peak on the page& there are more than 10 lines on the page. Otherwise, 0.
F7 – F8	1 if there is a footnote(Using BBox and Proj methods) in the last $1/4^{th}$ of the page & there are more than 10 lines on the page. Otherwise, 0.
F9 – F10	1 if there is a footnote(Using BBox and Proj methods) on the page & there are more than ten lines on the page. Otherwise, 0.
F11 - F16	1 if for a page with more than 10 lines, peak location appears anywhere (according to a threshold from ±0.02 by 0.02 up to ±0.14) around the footnote located by Proj method in the last $1/4^{th}$ of the page. Otherwise, 0.
F17 - F22	1 if for a page with more than 10 lines, the last peak location on the page appears anywhere (according to a threshold from ±0.02 by 0.02 up to ±0.14) around the footnote located by the Proj method in the last $1/4^{th}$ of the page. Otherwise, 0.
F23 – F26	1 if for a page with more than 10 lines, peak location appears anywhere (according to a threshold from ±0.02 by 0.02 up to ±0.14) around the footnote located by the BBox method in the last $1/4^{th}$ of the page. Otherwise, 0.
F27 – F30	1 if for a page with more than 10 lines, the last peak location on the page appears anywhere (according to a threshold from ±0.02 by 0.02 up to ±0.14) around the footnote located by theBBox method in the last $1/4^{th}$ of the page. Otherwise, 0.

CHAPTER 3

TABLE-BASED DOCUMENT CLASSIFICATION

The content of this chapter introduces our second method for information retrieval from historical documents. Our focus is on tackling the problem of table-based document image classification. We start with an introduction to table definition and its different forms. Following that, we explain state-of-the-art methods for table detection in literature. Finally, we end this chapter by presenting our proposed algorithm for table-based document classification in historical documents.

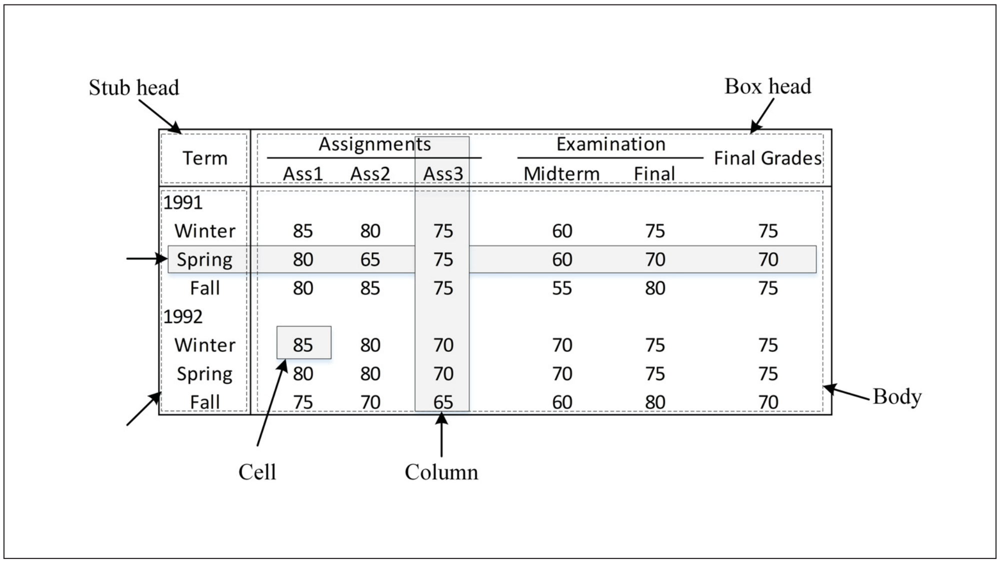
3.1 What is a table?

The growth of interest in the field of automatic historical document analysis by historians and human scientists brings up the need for systems that can retrieve and understand information from these documents. Generally, documents contain different textual and graphical contents (e.g., titles, symbols, footnotes, figures, tables, etc.). Tables are one of the most common objects that can be found in multiple classes of documents throughout the history from scientific journals and newspapers to forms and invoices. Tables are used to summarize the correlational data and present them in an ordered, meaningful and compact manner (Tran *et al.*, 2016).

3.1.1 Table characteristics

The most straightforward table types are regular matrices of cells with a row-column structure. Figure 3.1 shows a typical example of these kinds of table and its general terminology for different parts. However, tables not often follow such a simple structure, particularly the tables in printed documents from the Enlightenment period which are the core of our research. During this period, there was not any established style for tables, and printed documents were recently prevalent. Tables in these documents were more heterogeneous in structure, style, flexibility, notation and in one word their representation. This heterogeneity could reveal itself in the form of nesting cells, missing boundary lines, etc (Wang, 2016).

Tables can be interpreted from different perspectives: location, size, caption size and location, frames and separator lines, cell alignment and cell types. Below we explain some of these perspectives that can assist in clarifying the tables for our further steps of table retrieval in historical documents.



Term	Assignments			Examination		Final Grades
	Ass1	Ass2	Ass3	Midterm	Final	
1991						
Winter	85	80	75	60	75	75
Spring	80	65	75	60	70	70
Fall	80	85	75	55	80	75
1992						
Winter	85	80	70	70	75	75
Spring	80	80	70	70	75	75
Fall	75	70	65	60	80	70

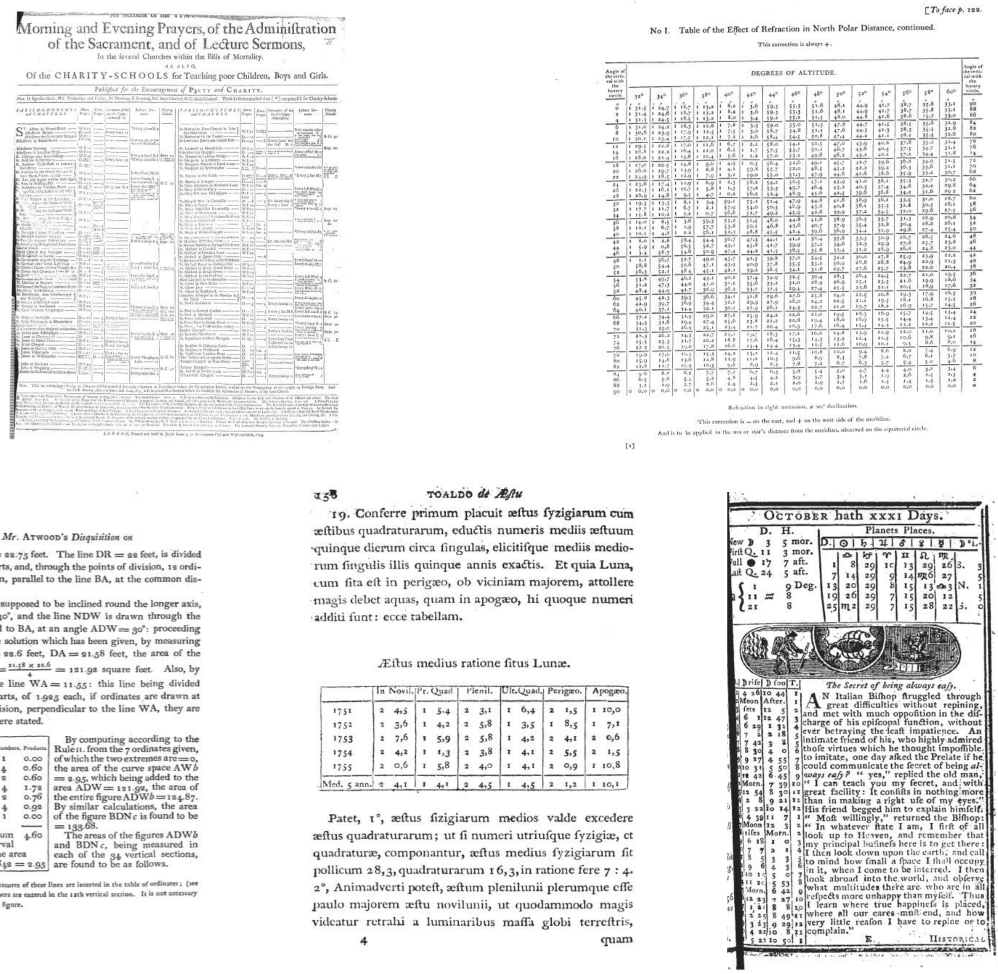
Figure 3.1 The terminology of a simple table structure (Wang, 2016).

3.1.1.1 Table size

Tables can be classified into two group of cross-column versus single-column tables or wide versus narrow tables. A cross-column table requires having a width wider than half of the document page and including at least one space between to columns of the document. All other tables are considered single-column. Figure 3.2 demonstrate some examples form 18th-century document pages from both of these categories.

3.1.1.2 Table caption location

Table captions and in general captions have an essential rule for understanding and interpretation of tables. According to the recent guidelines for captions, they should be above the



Morning and Evening Prayers, of the Adminiſtration of the Sacrament, and of Lecture Sermons,

In the ſeveral Churches within the Bills of Mortality.

AS ALSO,

Of the CHARITY-SCHOOLS for Teaching poor Children, Boys and Girls.

Publiſhed for the Encouragement of PIETY *and* CHARITY.

[To face p. 122.

No I. Table of the Effect of Refraction in North Polar Distance, continued.

This correction is always +.

Refraction in right ascension, × sec² declination.

This correction is — on the east, and + on the west side of the meridian.

And is to be applied to the sun or star's distance from the meridian, observed on the equatorial circle.

288 *Mr.* ATWOOD'S *Disquisition on*

water-section = 22.75 feet. The line DR = 22 feet, is divided into 11 equal parts, and, through the points of division, 12 ordinates* are drawn, parallel to the line BA, at the common distance of 2 feet.

The vessel is supposed to be inclined round the longer axis, at an angle of 30°, and the line NDW is drawn through the point D, inclined to BA, at an angle ADW = 30°: proceeding according to the solution which has been given, by measuring the line DW = 22.6 feet, DA = 21.58 feet, the area of the triangle ADW = $\frac{21.58 \times 22.6}{4}$ = 121.92 square feet. Also, by mensuration, the line WA = 11.55: this line being divided into six equal parts, of 1.925 each, if ordinates are drawn at the points of division, perpendicular to the line WA, they are found to be as here stated.

	Ordinates. Pts. of 1 Foot.	Numbers.	Products.
a	= 0.00	1	0.00
b	= 0.15	4	0.60
c	= 0.30	2	0.60
d	= 0.43	4	1.72
e	= 0.38	2	0.76
f	= 0.23	4	0.92
g	= 0.00	1	0.00
		Sum	4.60

$\frac{1}{3}$ common interval = .642; and the area AW*b* = 4.6 × .642 = 2.95

By computing according to the Rule 11. from the 7 ordinates given, of which the two extremes are = 0, the area of the curve space AW*b* = 2.95, which being added to the area ADW = 121.92, the area of the entire figure ADW*b* = 124.87. By similar calculations, the area of the figure BDN*c* is found to be = 133.68.

The areas of the figures ADW*b* and BDN*c*, being measured in each of the 34 vertical sections, are found to be as follows.

* The numerical measures of these lines are inserted in the table of ordinates; (see Appendix;) the numbers are entered in the 12th vertical section. It is not necessary to express them in the figure.

158 TOALDO *de Æſtu*

19. Conferre primum placuit æſtus ſyzigiarum cum æſtibus quadraturarum, eductis numeris mediis æſtuum quinque dierum circa ſingulas, elicitiſque mediis mediorum ſingulis illis quinque annis exactis. Et quia Luna, cum ſita eſt in perigæo, ob viciniam majorem, attollere magis debet aquas, quam in apogæo, hi quoque numeri additi ſunt: ecce tabellam.

Æſtus medius ratione ſitus Lunæ.

	In Novil.		Pr. Quad.		Plenil.		Ult. Quad.		Perigæo.		Apogæo.	
1751	2	4,5	1	5.4	2	3,1	1	6,4	2	1,5	1	10,0
1752	2	3,6	1	4,2	2	5,8	1	3,5	1	8,5	1	7,1
1753	2	7,6	1	5,9	2	5,8	1	4,2	2	4,1	2	0,6
1754	2	4,2	1	1,3	2	3,8	1	4,1	2	5,5	2	1,5
1755	2	0,6	1	5,8	2	4,0	1	4,1	2	0,9	1	10,8
Med. 5 ann.	2	4,1	1	4,1	2	4,5	1	4,5	2	1,2	1	10,1

Patet, 1°, æſtus ſizigiarum medios valde excedere æſtus quadraturarum; ut ſi numeri utriuſque ſyzigiæ, et quadraturæ, componantur, æſtus medius ſyzigiarum ſit pollicum 28,3, quadraturarum 16,3, in ratione fere 7 : 4. 2°, Animadverti poteſt, æſtum plenilunii plerumque eſſe paulo majorem æſtu novilunii, ut quodammodo magis videatur retrahi a luminaribus maſſa globi terreſtris,

4 quam

OCTOBER hath XXXI Days.

	D.	H.	
New ☽	3	5	mor.
First Q.	11	3	mor.
Full ●	17	7	aft.
Last Q.	24	5	aft.

{	1		9 Deg.
	11	♒	8
	21		8

Planets Places.

D.	☉	♄	♃	♂	♀	☿	☽'s L.	
	♎	♑	♈	♊	♌	♍		
1	8	29	10	13	29	26	S.	3
7	14	29	9	14	♍6	27		5
13	20	29	8	15	13	♎3	N.	1
19	26	29	7	15	20	12		5
25	♏2	29	7	15	28	22	S.	0

☽ riſe	☽ ſou	T.
4 26	10 44	1
Moon	After.	1
ſets	12 5	2
6 1	12 47	3
6 29	1 32	4
7 2	2 18	5
7 42	3 8	5
8 30	4 0	6
9 27	4 55	7
10 31	5 50	8
11 42	6 45	9
Morn.	7 39	10
12 54	8 30	11
2 8	9 21	12
3 22	10 14	12
4 39	11 7	1
Moon	12 3	2
riſes	Morn.	2
6 18	1 0	3
7 7	2 1	4
8 5	3 3	5
9 6	4 3	6
10 15	5 0	7
11 20	5 53	8
Morn.	6 42	9
12 23	7 27	10
1 2[illegible]	8 8	10
2 25	8 49	11
3 23	9 29	12
4 22	10 8	12
5 22	10 50	1

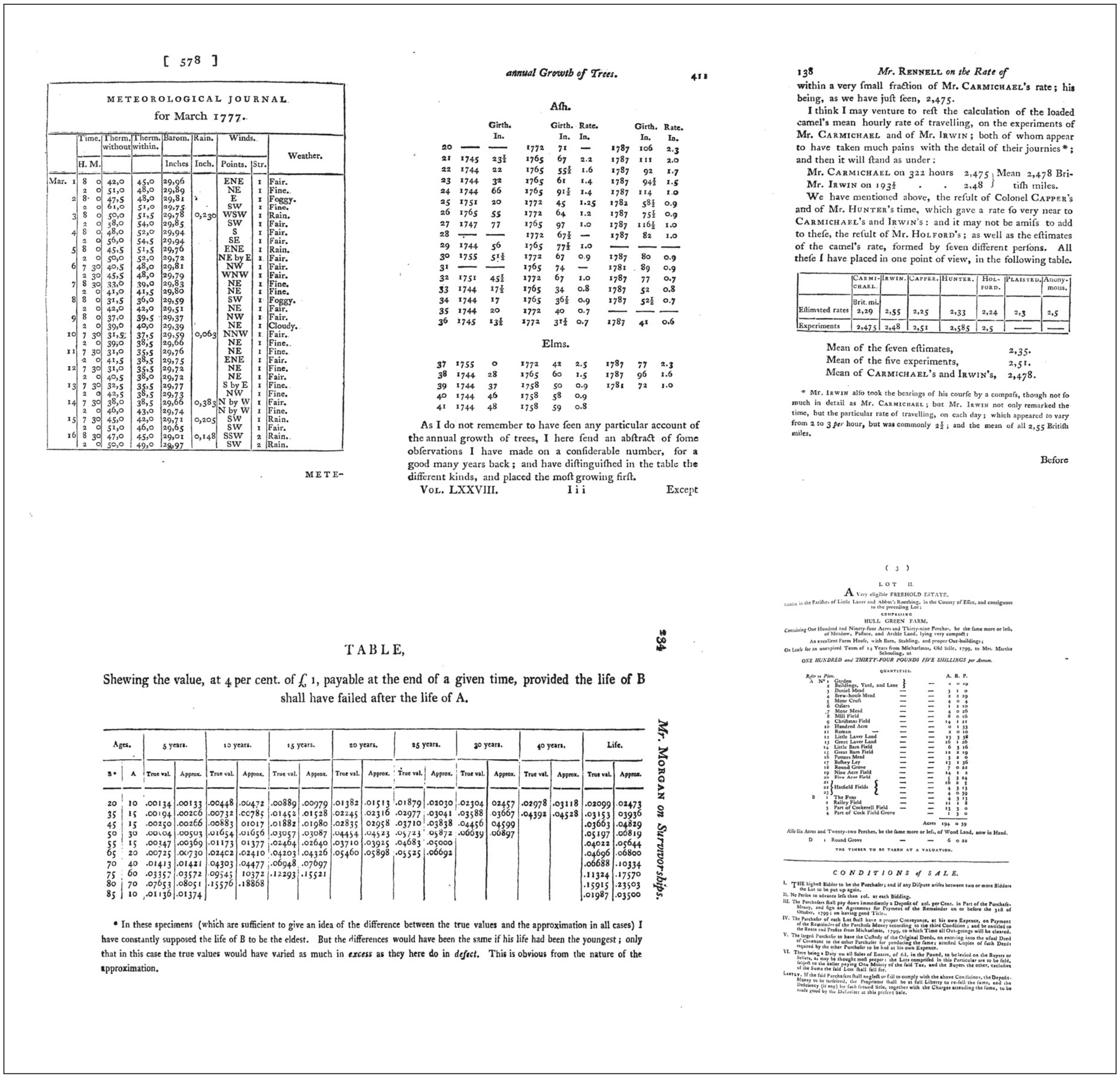
The Secret of being always eaſy.

AN Italian Biſhop ſtruggled through great difficulties without repining, and met with much oppoſition in the diſcharge of his epiſcopal function, without ever betraying the leaſt impatience. An intimate friend of his, who highly admired thoſe virtues which he thought impoſſible to imitate, one day aſked the Prelate if he could communicate the ſecret of being *always eaſy?* "yes," replied the old man, "I can teach you my ſecret, and with great facility: It conſiſts in nothing more than in making a right uſe of my eyes." His friend begged him to explain himſelf. "Moſt willingly," returned the Biſhop: "In whatever ſtate I am, I firſt of all look up to Heaven, and remember that my principal buſineſs here is to get there: I then look down upon the earth, and call to mind how ſmall a ſpace I ſhall occupy in it, when I come to be interred. I then look abroad into the world, and obſerve what multitudes there are who are in all reſpects more unhappy than myſelf. Thus I learn where true happineſs is placed, where all our cares muſt end, and how very little reaſon I have to repine or to complain."

E. HISTORICAL

Figure 3.2 Examples of document images with cross-columns and single-column table sizes.

table. They should not be too brief and not provide enough information or be extremely large. However, Enlightenment period captions do not obey these guidelines, and there exist several cases without any captions. Such inconsistent behaviors profoundly weaken the table detection algorithms based on the OCR. Figure 3.3 shows some examples of caption style and format in 18th-century document images.



[578]

METEOROLOGICAL JOURNAL for March 1777.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches	Inch.	Points.	Str.	
Mar. 1	8	0	42,0	45,0	29,96		ENE	1	Fair.
	2	0	51,0	48,0	29,89		NE	1	Fine.
2	8	0	47,5	48,0	29,81		E	1	Foggy.
	2	0	61,0	51,0	29,75		SW	1	Fine.
3	8	0	50,0	51,5	29,78	0,230	WSW	1	Rain.
	2	0	58,0	54,0	29,85		SW	1	Fair.
4	8	0	48,0	52,0	29,94		S	1	Fair.
	2	0	56,0	54,5	29,94		SE	1	Fair.
5	8	0	45,5	51,5	29,76		ENE	1	Rain.
	2	0	50,0	52,0	29,72		NE by E	1	Fair.
6	7	30	40,5	48,0	29,81		NW	1	Fair.
	2	30	45,5	48,0	29,79		WNW	1	Fair.
7	8	30	33,0	39,0	29,83		NE	1	Fine.
	2	0	41,0	41,5	29,80		NE	1	Fine.
8	8	0	31,5	36,0	29,59		SW	1	Foggy.
	2	0	42,0	42,0	29,51		NE	1	Fair.
9	8	0	37,0	39,5	29,37		NW	1	Fair.
	2	0	39,0	40,0	29,39		NE	1	Cloudy.
10	7	30	31,5	37,5	29,59	0,063	NNW	1	Fair.
	2	0	39,0	38,5	29,66		NE	1	Fine.
11	7	30	31,0	35,5	29,76		NE	1	Fine.
	2	0	41,5	38,5	29,75		ENE	1	Fair.
12	7	30	31,0	35,5	29,72		NE	1	Fine.
	2	0	40,5	38,0	29,72		NE	1	Fair.
13	7	30	32,5	35,5	29,77		S by E	1	Fine.
	2	0	42,5	38,5	29,73		NW	1	Fine.
14	7	30	38,0	38,5	29,66	0,383	N by W	1	Fair.
	2	0	46,0	43,0	29,74		N by W	1	Fine.
15	7	30	45,0	42,0	29,71	0,205	SW	1	Rain.
	2	0	51,0	46,0	29,65		SW	1	Fair.
16	8	30	47,0	45,0	29,01	0,148	SSW	2	Rain.
	2	0	50,0	49,0	29,97		SW	2	Rain.

METE-

annual Growth of Trees. 411

Aſh.

		Girth. In.		Girth. In.	Rate. In.		Girth. In.	Rate. In.
20	——	——	1772	71	—	1787	106	2.3
21	1745	23½	1765	67	2.2	1787	111	2.0
22	1744	22	1765	55½	1.6	1787	92	1.7
23	1744	32	1765	61	1.4	1787	94½	1.5
24	1744	66	1765	91½	1.4	1787	114	1.0
25	1751	20	1772	45	1.25	1782	58½	0.9
26	1765	55	1772	64	1.2	1787	75½	0.9
27	1747	77	1765	97	1.0	1787	116½	1.0
28	——	——	1772	67½	—	1787	82	1.0
29	1744	56	1765	77½	1.0	——	——	——
30	1755	51½	1772	67	0.9	1787	80	0.9
31	——	——	1765	74	—	1781	89	0.9
32	1751	45½	1772	67	1.0	1787	77	0.7
33	1744	17½	1765	34	0.8	1787	52	0.8
34	1744	17	1765	36½	0.9	1787	52½	0.7
35	1744	20	1772	40	0.7	——	——	——
36	1745	13½	1772	31½	0.7	1787	41	0.6

Elms.

37	1755	0	1772	42	2.5	1787	77	2.3
38	1744	28	1765	60	1.5	1787	96	1.6
39	1744	37	1758	50	0.9	1781	72	1.0
40	1744	46	1758	58	0.9			
41	1744	48	1758	59	0.8			

As I do not remember to have ſeen any particular account of the annual growth of trees, I here ſend an abſtract of ſome obſervations I have made on a conſiderable number, for a good many years back; and have diſtinguiſhed in the table the different kinds, and placed the moſt growing firſt.

Vol. LXXVIII. I i i Except

138 *Mr.* Rennell *on the Rate of*

within a very ſmall fraction of Mr. Carmichael's rate; his being, as we have juſt ſeen, 2,475.

I think I may venture to reſt the calculation of the loaded camel's mean hourly rate of travelling, on the experiments of Mr. Carmichael and of Mr. Irwin; both of whom appear to have taken much pains with the detail of their journies*; and then it will ſtand as under:

Mr. Carmichael on 322 hours 2,475 } Mean 2,478 Bri-
Mr. Irwin on 193½ . . 2,48 } tiſh miles.

We have mentioned above, the reſult of Colonel Capper's and of Mr. Hunter's time, which gave a rate ſo very near to Carmichael's and Irwin's: and it may not be amiſs to add to theſe, the reſult of Mr. Holford's; as well as the eſtimates of the camel's rate, formed by ſeven different perſons. All theſe I have placed in one point of view, in the following table.

	Carmichael.	Irwin.	Capper.	Hunter.	Holford.	Plaisted.	Anonymous.
Eſtimated rates	Brit. mi. 2,29	2,55	2,25	2,33	2,24	2,3	2,5
Experiments	2,475	2,48	2,51	2,585	2,5	——	——

Mean of the ſeven eſtimates,	2,35.
Mean of the five experiments,	2,51.
Mean of Carmichael's and Irwin's,	2,478.

* Mr. Irwin alſo took the bearings of his courſe by a compaſs, though not ſo much in detail as Mr. Carmichael; but Mr. Irwin not only remarked the time, but the particular rate of travelling, on each day; which appeared to vary from 2 to 3 *per* hour, but was commonly 2½; and the mean of all 2,55 Britiſh miles.

Before

(3)

LOT II.

A Very eligible FREEHOLD ESTATE,

Situate in the Pariſhes of Little Laver and Abbot's Roothing, in the County of Eſſex, and contiguous to the preceding Lot;

COMPRISING

HULL GREEN FARM,

Containing One Hundred and Ninety-four Acres and Thirty-nine Perches, be the ſame more or leſs, of Meadow, Paſture, and Arable Land, lying very compact;

An excellent Farm Houſe, with Barn, Stabling, and proper Out-buildings;

On Leaſe for an unexpired Term of 14 Years from Michaelmas, Old Stile, 1799, to Mrs. Martha Schooling, at

ONE HUNDRED and THIRTY-FOUR POUNDS FIVE SHILLINGS per Annum.

QUANTITIES.

Refer to Plan.			A.	R.	P.
A	N° 1 2	Garden Buildings, Yard, and Lane	2	0	29
	3	Daniel Mead	3	1	0
	4	Brew-houſe Mead	2	2	29
	5	Moor Croft	4	0	4
	6	Oziers	1	2	10
	7	Moor Mead	4	0	26
	8	Mill Field	8	0	16
	9	Chriſtmas Field	14	1	21
	10	Hundred Acre	0	1	33
	11	Roman	2	0	10
	12	Little Laver Land	13	3	38
	13	Great Laver Land	16	1	26
	14	Little Barn Field	6	3	16
	15	Great Barn Field	12	2	19
	16	Potters Mead	3	2	0
	17	Buſhey Ley	13	1	36
	18	Round Grove	7	0	22
	19	Nine Acre Field	14	1	2
	20	Five Acre Field	5	3	24
	21	Hatfield Fields	16	2	5
	22		4	3	13
	23		4	0	39
B	1	The Fens	4	3	13
	2	Railey Field	11	1	8
	3	Part of Cockerell Field	13	3	0
	4	Part of Cock Field Grove	1	3	0
		Acres	194	0	39

Alſo Six Acres and Twenty-two Perches, be the ſame more or leſs, of Wood Land, now in Hand.

D	1	Round Grove	6	0	22

THE TIMBER TO BE TAKEN AT A VALUATION.

CONDITIONS of SALE.

I. THE higheſt Bidder to be the Purchaſer; and if any Diſpute ariſes between two or more Bidders the Lot to be put up again.

II. No Perſon to advance leſs than 10l. at each Bidding.

III. The Purchaſers ſhall pay down immediately a Depoſit of 20l. per Cent. in Part of the Purchaſe-Money, and ſign an Agreement for Payment of the Remainder on or before the 31ſt of October, 1799; on having good Titles.

IV. The Purchaſer of each Lot ſhall have a proper Conveyance, at his own Expence, on Payment of the Remainder of the Purchaſe Money according to the third Condition; and be entitled to the Rents and Profits from Michaelmas, 1799, to which Time all Out-goings will be cleared.

V. The largeſt Purchaſer to have the Cuſtody of the Original Deeds, on entering into the uſual Deed of Covenant to the other Purchaſer for producing the ſame; atteſted Copies of ſuch Deeds required by the other Purchaſer to be had at his own Expence.

VI. There being a Duty on all Sales of Eſtates, of 6d. in the Pound, to be levied on the Buyers or Sellers, as may be thought moſt proper: the Lots compriſed in this Particular are to be ſold, ſubject to the Seller paying One Moiety of the ſaid Tax, and the Buyers the other, excluſive of the Sums the ſaid Lots ſhall ſell for.

Lastly. If the ſaid Purchaſers ſhall neglect or fail to comply with the above Conditions, the Depoſit-Money to be forfeited, the Proprietor ſhall be at full Liberty to re-ſell the ſame, and the Deficiency (if any) by ſuch ſecond Sale, together with the Charges attending the ſame, to be made good by the Defaulter at this preſent Sale.

284 *Mr.* Morgan *on Survivorſhips.*

TABLE,

Shewing the value, at 4 per cent. of £ 1, payable at the end of a given time, provided the life of B shall have failed after the life of A.

Ages.		5 years.		10 years.		15 years.		20 years.		25 years.		30 years.		40 years.		Life.	
B*	A	True val.	Approx.	True val.	Approx.	True val.	Approx.	True val.	Approx.	True val.	Approx.	True val.	Approx.	True val.	Approx.	True val.	Approx.
20	10	.00134	.00133	.00448	.00472	.00889	.00979	.01382	.01513	.01879	.02030	.02304	02457	.02978	.03118	.02099	.02473
35	15	.00194	.00206	.00732	.00785	.01452	.01528	.02245	.02316	.02977	.03041	.03588	03667	.04392	.04528	.03153	03936
45	15	.00250	.00266	.00883	01017	.01882	.01980	.02835	02958	.03710	.03838	.04456	04599			.03663	.04829
50	30	.00504	.00503	.01654	.01656	.03057	.03087	.04454	.04523	.05723	05872	.06639	.06897			.05197	.06819
55	15	.00347	.00369	.01173	01377	.02464	.02640	.03710	.03925	.04683	.05000					.04022	.05644
65	20	.00725	.00730	.02402	.02410	.04203	.04326	.05460	.05898	.05525	.06692					.04696	.06800
70	40	.01413	.01421	.04303	.04477	.06948	.07697									.06688	.10334
75	60	.03357	.03572	.09545	10372	.12293	.15521									.11324	.17570
80	70	.07653	.08051	.15576	.18868											.15915	.23503
85	10	.01136	.01374													.01987	.03500

* In these specimens (which are sufficient to give an idea of the difference between the true values and the approximation in all cases) I have constantly supposed the life of B to be the eldest. But the differences would have been the same if his life had been the youngest; only that in this case the true values would have varied as much in *excess* as they here do in *defect*. This is obvious from the nature of the approximation.

Figure 3.3 Examples of document images with different table captions.

3.1.1.3 Table frames and separator lines

Not all the tables in document images include frames and separator lines. In this sense, we can classify tables into two main classes according to their framing composition: ruling-line tables (RL-Ts) and non-ruling-line tables (NRL-Ts) (Tran *et al.*, 2016). Figure 3.4 illustrates this categorization in more detail.

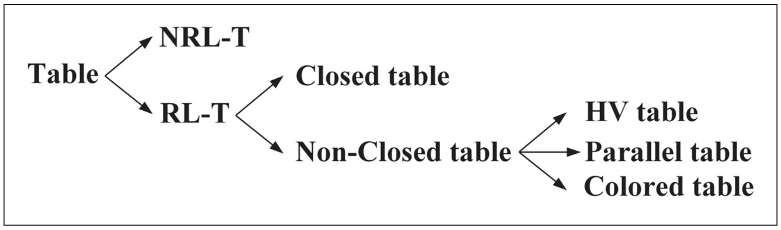


Figure 3.4 Table categorization (Tran *et al.*, 2016).

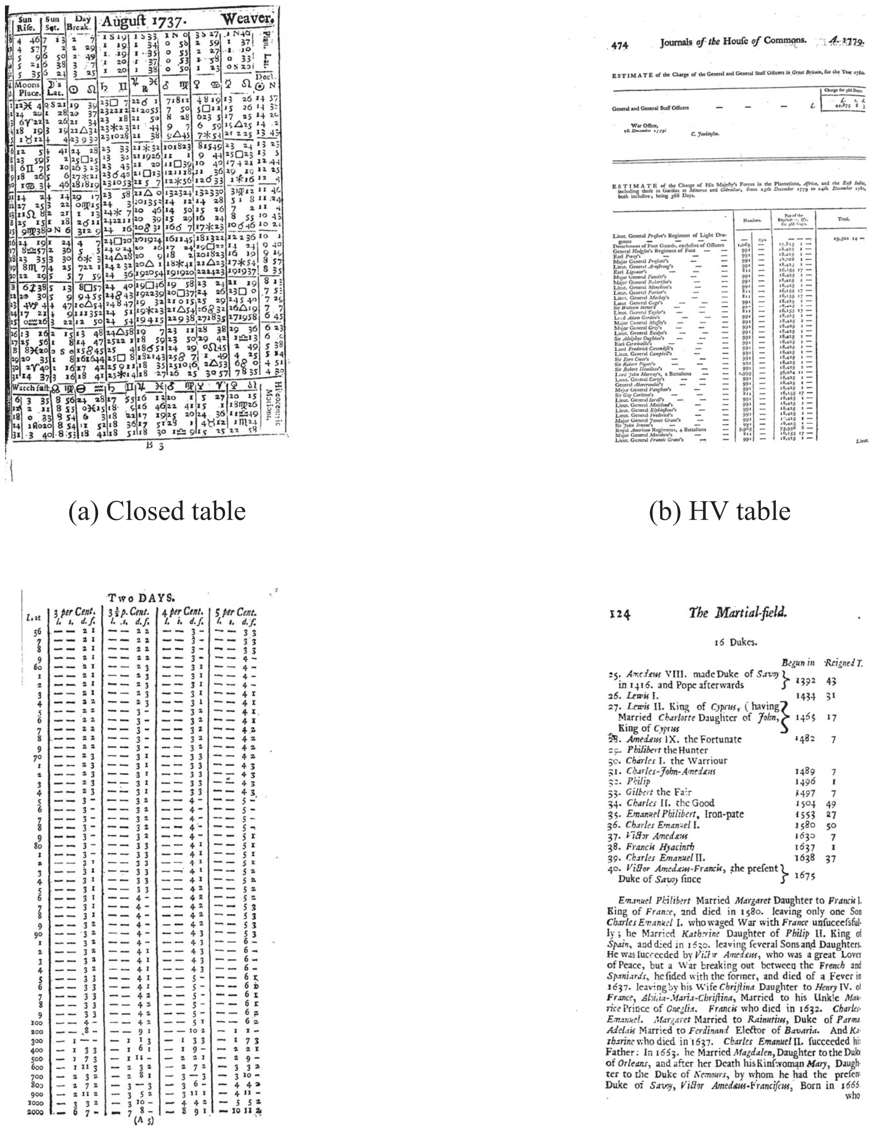
Ruling-line tables (RL-Ts)

RL-Ts are the most common type of tables. From outside an outer bounding box surrounds them and within they are divided by one or more ruling lines (i.e., vertical lines, horizontal lines or a mixture of both). These tables can be further split into two categories of closed tables and non-closed tables:

- **Closed table:** A table is called closed if a complete outer bounding box surrounds it as shown in Figure 3.5(a).
- **Non-closed tables:** This kind of table consists of at least one type of ruling line (either vertical or horizontal), and contrary to the closed tables the outer bounding box is not a complete rectangular. They can be further subdivided into three separate groups:
  - **Horizontal/vertical(HV) table:** The structure of this table has both vertical and horizontal ruling lines, see Figure 3.5 (b).
  - **Parallel table:** This table contains only horizontal ruling lines which are parallel, see Figure 3.5(c).
  - **Colored table:** A combination of colorful rectangular blocks creates this kind of tables. However, during the 18$^{\text{th}}$-century, colorful tables have rarely been used for press printing. Thus, we do not consider them in our study.

Non-ruling-line tables (NRL-Ts)

These tables do not contain any ruling-line or bounding box. They are mostly used in reports or letters (see Figure 3.5(d)).



(a) Closed table

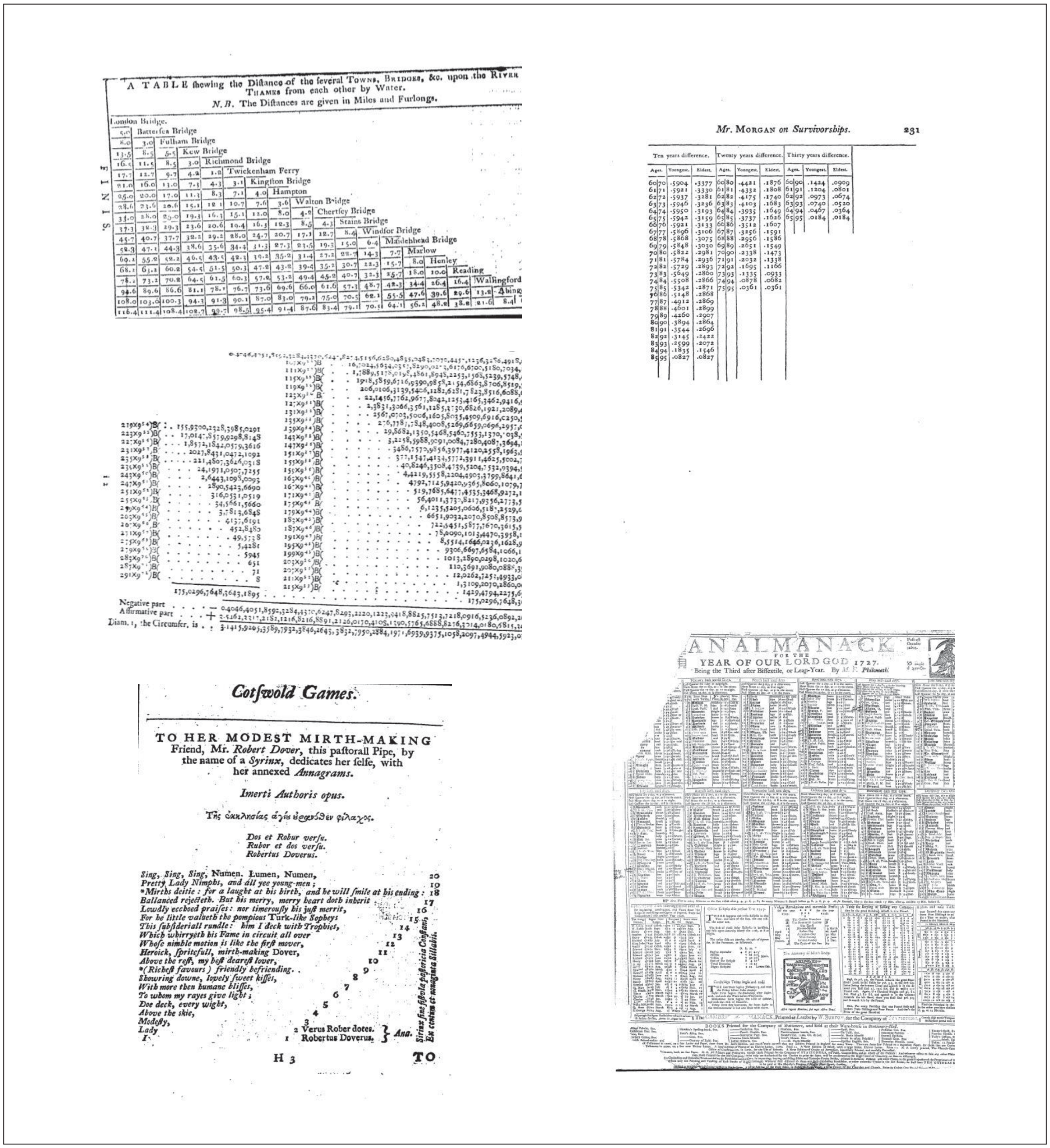
(b) HV table

(c) Parallel table

(d) Non-ruling line table

Figure 3.5 Example of table classes: (a-c) ruling line tables and (d) a non-ruling line table.

Nonetheless, always there can be tables that are not following the rules above in the same order. For instance, tables may contain nested/empty cell, figures/symbols or formula. Also, columns or rows may not be aligned. Figure 3.6 provides some examples of these irregular table structures.



A TABLE ſhewing the Diſtance of the ſeveral TOWNS, BRIDGES, &c. upon the RIVER THAMES from each other by Water.

N.B. The Diſtances are given in Miles and Furlongs.

London Bridge.																		
5.0	Batterſea Bridge																	
8.0	3.0	Fulham Bridge																
13.5	8.5	5.5	Kew Bridge															
16.5	11.5	8.5	3.0	Richmond Bridge														
17.7	12.7	9.7	4.2	1.2	Twickenham Ferry													
21.0	16.0	13.0	7.3	4.3	3.1	Kingſton Bridge												
25.0	20.0	17.0	11.3	8.3	7.1	4.0	Hampton											
28.6	23.6	20.6	15.1	12 1	10.7	7.6	3.6	Walton Bridge										
33.0	28.0	25.0	19.3	16.3	15.1	12.0	8.0	4.2	Chertſey Bridge									
37.3	32.3	29.3	23.6	20.6	19.4	16.3	12.3	8.5	4.3	Stains Bridge								
45.7	40.7	37.7	32.2	29.2	28.0	24.7	20.7	17.1	12.7	8.4	Windſor Bridge							
52.3	47.1	44.3	38.6	35.6	34.4	31.3	27.3	23.5	19.3	15.0	6.4	Maidenhead Bridge						
60.2	55.2	52.2	46.5	43.5	42.3	39.2	35.2	31.4	27.2	22.7	14.3	7.7	Marlow					
68.2	63.2	60.2	54.5	51.5	50.3	47.2	43.2	39.4	35.2	30.7	22.3	15.7	8.0	Henley				
78.2	73.2	70.2	64.5	61.5	60.3	57.2	53.2	49.4	45.2	40.7	32.3	25.7	18.0	10.0	Reading			
94.6	89.6	86.6	81.1	78.1	76.7	73.6	69.6	66.0	61.6	57.3	48.7	42.3	34.4	26.4	16.4	Wallingford		
108.0	103.0	100.3	94.3	91.3	90.1	87.0	83.0	79.2	75.0	70.5	62.1	55.5	47.6	39.6	29.6	13.2	Abing	
116.4	111.4	108.4	102.7	99.7	98.5	95.4	91.4	87.6	83.4	79.1	70.5	64.1	56.2	48.2	38.2	21.6	8.4	

Mr. MORGAN *on Survivorships.* 231

Ten years difference.				Twenty years difference.				Thirty years difference.			
Ages.		Youngest.	Eldest.	Ages.		Youngest.	Eldest.	Ages.		Youngest.	Eldest.
60	70	.5904	.3377	60	80	.4421	.1876	60	90	.1424	.0909
61	71	.5921	.3330	61	81	.4332	.1808	61	91	.1204	.0801
62	72	.5937	.3281	62	82	.4175	.1740	62	92	.0973	.0674
63	73	.5946	.3236	63	83	.4103	.1683	63	93	.0740	.0520
64	74	.5950	.3193	64	84	.3935	.1649	64	94	.0467	.0364
65	75	.5942	.3159	65	85	.3737	.1626	65	95	.0184	.0184
66	76	.5921	.3133	66	86	.3512	.1607				
67	77	.5896	.3106	67	87	.3256	.1591				
68	78	.5868	.3075	68	88	.2956	.1586				
69	79	.5848	.3030	69	89	.2651	.1549				
70	80	.5822	.2981	70	90	.2338	.1473				
71	81	.5784	.2936	71	91	.2032	.1338				
72	82	.5729	.2893	72	92	.1695	.1166				
73	83	.5649	.2860	73	93	.1335	.0933				
74	84	.5508	.2866	74	94	.0878	.0682				
75	85	.5342	.2871	75	95	.0361	.0361				
76	86	.5148	.2868								
77	87	.4912	.2869								
78	88	.4601	.2899								
79	89	.4260	.2907								
80	90	.3894	.2864								
81	91	.3544	.2696								
82	92	.3145	.2422								
83	93	.2599	.2072								
84	94	.1835	.1546								
85	95	.0827	.0827								

0.4046,4051,8592,3284,4370,6247,8214,5156,6280,4835,0483,7070,4457,1236,3256,4918,

		107×9^{26})B(	16,7024,5634,0367,8290,0273,6176,6700,5180,7034,
		111×9^{27})B(	1,7889,5178,0198,4861,8948,2253,1568,5239,5748,
		115×9^{28})B(	1918,5859,6716,9390,9858,2154,6863,8706,8529,
		119×9^{29})B(	206,0106,3139,5406,1282,6281,7823,8516,6088,
		123×9^{30})B(	22,1456,7762,9677,8042,1253,4165,3462,9416,
		127×9^{31})B(	2,3831,3066,3561,1285,3730,6826,1921,2089,
		131×9^{32})B(	2567,0705,5006,1605,8035,4509,6916,6250,
		135×9^{33})B(	276,7787,7848,4008,5269,6659,0696,2957,
219×9^{54})B(	155,9300,2328,3985,0291	139×9^{34})B(	29,8682,1350,5468,5460,7553,1370,7038,
223×9^{55})B(	17,0147,8579,9298,8148	143×9^{35})B(	3,2258,5988,9091,0084,7280,4087,3694,
227×9^{56})B(	1,8572,1842,0579,3616	147×9^{36})B(	3486,7570,9856,3977,4120,2558,1963,
231×9^{57})B(	2027,8431,0472,1092	151×9^{37})B(	377,1547,4134,5772,3911,4625,5002,
235×9^{58})B(	221,4807,3626,0318	155×9^{38})B(	40,8246,3508,4739,5204,7532,9394,
239×9^{59})B(	24,1971,0507,7255	159×9^{39})B(	4,4219,5558,2204,4905,3799,8641,
243×9^{60})B(	2,6443,1098,0093	163×9^{40})B(	4792,7125,9420,9365,8060,1079,
247×9^{61})B(	2890,5423,6690	167×9^{41})B(	519,7685,6477,4535,3468,9272,
251×9^{62})B(	316,0531,0519	171×9^{42})B(	56,4011,3737,8217,9356,2773,
255×9^{63})B(	34,5661,5660	175×9^{43})B(	6,1235,5205,0606,5187,2529,
259×9^{64})B(	3,7813,6848	179×9^{44})B(	6651,9032,2070,8508,8573,
263×9^{65})B(	4137,6191	183×9^{45})B(	722,5451,5877,7670,3615,
267×9^{66})B(	452,8480	187×9^{46})B(	78,6090,1013,4470,3958,
271×9^{67})B(	49,5738	191×9^{47})B(	8,5514,1646,0236,1628,
275×9^{68})B(	5,4281	195×9^{48})B(	9306,6697,6584,1066,
279×9^{69})B(	5945	199×9^{49})B(	1013,2890,0298,1020,
283×9^{70})B(	651	203×9^{50})B(	110,3691,9080,0888,
287×9^{71})B(	71	207×9^{51})B(	12,0262,7252,4933,
291×9^{72})B(	8	211×9^{52})B(	1,3109,2070,2860,
		215×9^{53})B(	1429,4794,2275,
	175,0296,7648,3643,1895		175,0296,7648,3

Negative part	−	0.4046,4051,8592,3284,4370,6247,8293,2220,1223,9418,8825,7513,7218,0916,5236,0892,
Affirmative part	+	3.5462,3317,2182,1216,8216,8891,2126,0170,4108,1390,5765,6888,8276,3014,0180,6815,
Diam. 1, the Circumfer. is		3.1415,9265,3589,7932,3846,2643,3832,7950,2884,1971,6939,9375,1058,2097,4944,5923,

Cotſwold Games.

TO HER MODEST MIRTH-MAKING Friend, Mr. *Robert Dover*, this paſtorall Pipe, by the name of a *Syrinx*, dedicates her ſelfe, with her annexed *Annagrams*.

Imerti Authoris opus.

Τῆς ἐκκλησίας ἁγίᾳ ϑεραπόθεν φίλαχος.

Dos et Robur verſu.
Rubor et dos verſu.
Robertus Doverus.

Sing, Sing, Sing, Numen. Lumen, Numen, 20
Pretty Lady Nimphs, and all yee young-men ; 19
**Mirths deitie : for a laught at his birth, and he will ſmile at his ending :* 18
Ballanced rejecteth. But his merry, merry heart doth inherit 17
Lowdly ecchoed praiſes : nor timerouſly his juſt merrit, 16
For he little valueth the pompious Turk*-like Sopheys* 15
This ſubſideriall rundle : him I deck with Trophies, 14
Which whirryeth his Fame in circuit all over 13
Whoſe nimble motion is like the firſt mover, 12
Heroick, ſpritefull, mirth-making Dover, 11
Above the reſt, my beſt deareſt lover, 10
**(Richeſt favours) friendly befriending.* 9
Showring downe, lovely ſweet kiſſes, 8
With more then humane bliſſes, 7
To whom my rayes give light ; 6
Doe deck, every wight, 5
Above the skie, 4
Modeſty, 3
Lady 2 Verus Rober dotes. } *Ana.*
I 1 Robertus Doverus. }

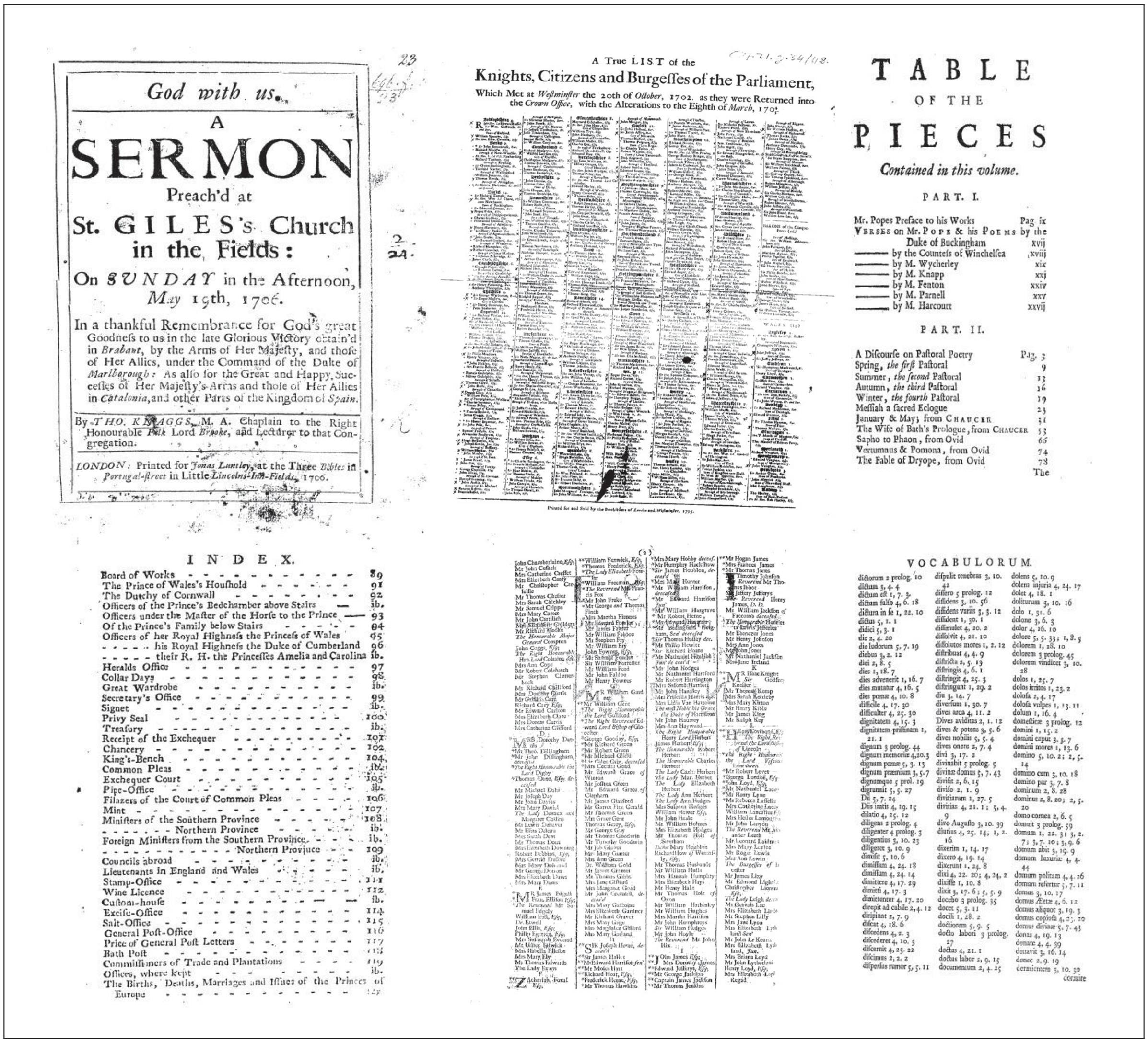
Sirinx ſine fiſtula paſtoricia Conſtans,
Ex centum et nonaginta Sillabis.

H 3 TO

AN ALMANACK FOR THE YEAR OF OUR LORD GOD 1727.
Being the Third after Biſſextile, or Leap-Year. By M. P. Philomath.

Figure 3.6 Examples of irregular tables.

Furthermore, several cases of false tables can appear in the documents. Index, content, lists and catalog pages are one of these false tables. They follow all the rules for being a table. However, they can not be considered as a table. Also, NRL-Ts can appear as multi-column document images. Moreover, there are title pages with external bounding box even ruling lines but not defined as a table. Figure 3.7 demonstrates some examples of these false tables.



God with us.

A SERMON Preach'd at St. GILES's Church in the Fields:

On *SUNDAY* in the Afternoon, *May* 19th, 1706.

In a thankful Remembrance for God's great Goodneſs to us in the late Glorious Victory obtain'd in *Brabant*, by the Arms of Her Majeſty, and thoſe of Her Allies, under the Command of the Duke of *Marlborough*: As alſo for the Great and Happy Succeſſes of Her Majeſty's Arms and thoſe of Her Allies in *Catalonia*, and other Parts of the Kingdom of *Spain*.

By *THO. KNAGGS*, M. A. Chaplain to the Right Honourable *Fulk* Lord *Brooke*, and Lecturer to that Congregation.

LONDON: Printed for *Jonas Luntley*, at the Three *Bibles* in *Portugal-ſtreet* in Little *Lincolns-Inn-Fields*, 1706.

A True LIST of the Knights, Citizens and Burgeſſes of the Parliament, Which Met at *Weſtminſter* the 20th of *October*, 1702. as they were Returned into the *Crown Office*, with the Alterations to the Eighth of *March*, 1705.

TABLE OF THE PIECES

Contained in this volume.

PART. I.

Mr. Popes Preface to his Works	Pag. ix
VERSES on Mr. POPE & his POEMS by the Duke of Buckingham	xvij
—— by the Counteſs of Winchelſea	xviij
—— by M. Wycherley	xix
—— by M. Knapp	xxj
—— by M. Fenton	xxiv
—— by M. Parnell	xxv
—— by M. Harcourt	xxvij

PART. II.

A Diſcourſe on Paſtoral Poetry	Pag. 3
Spring, *the firſt* Paſtoral	9
Summer, *the ſecond* Paſtoral	13
Autumn, *the third* Paſtoral	16
Winter, *the fourth* Paſtoral	19
Meſſiah a ſacred Eclogue	23
January & May; from CHAUCER	31
The Wife of Bath's Prologue, from CHAUCER	53
Sapho to Phaon, from Ovid	65
Vertumnus & Pomona, from Ovid	74
The Fable of Dryope, from Ovid	78

The

INDEX.

Board of Works	89
The Prince of Wales's Houſhold	91
The Dutchy of Cornwall	92
Officers of the Prince's Bedchamber above Stairs	ib.
Officers under the Maſter of the Horſe to the Prince	93
Of the Prince's Family below Stairs	94
Officers of her Royal Highneſs the Princeſs of Wales	95
- - - - - his Royal Highneſs the Duke of Cumberland	96
- - - - - their R. H. the Princeſſes Amelia and Carolina	ib.
Heralds Office	97
Collar Days	98
Great Wardrobe	ib.
Secretary's Office	99
Signet	ib.
Privy Seal	100
Treaſury	ib.
Receipt of the Exchequer	101
Chancery	102
King's-Bench	104
Common Pleas	ib.
Exchequer Court	105
Pipe-Office	ib.
Filazers of the Court of Common Pleas	106
Mint	107
Miniſters of the Southern Province	108
- - - - - - - Northern Province	ib.
Foreign Miniſters from the Southern Province	ib.
- - - - - - - - - - - Northern Province	109
Councils abroad	ib.
Lieutenants in England and Wales	ib.
Stamp-Office	111
Wine Licence	112
Cuſtom-houſe	ib.
Exciſe-Office	114
Salt-Office	115
General Poſt-Office	116
Price of General Poſt Letters	117
Bath Poſt	118
Commiſſioners of Trade and Plantations	119
Offices, where kept	ib.
The Births, Deaths, Marriages and Iſſues of the Princes of Europe	127

VOCABULORUM.

Figure 3.7 Examples of false tables.

3.1.2 Table definition in our study

In this study, we use two definitions for tables. We have a general and then a looser definition, which is a subset of the first one.

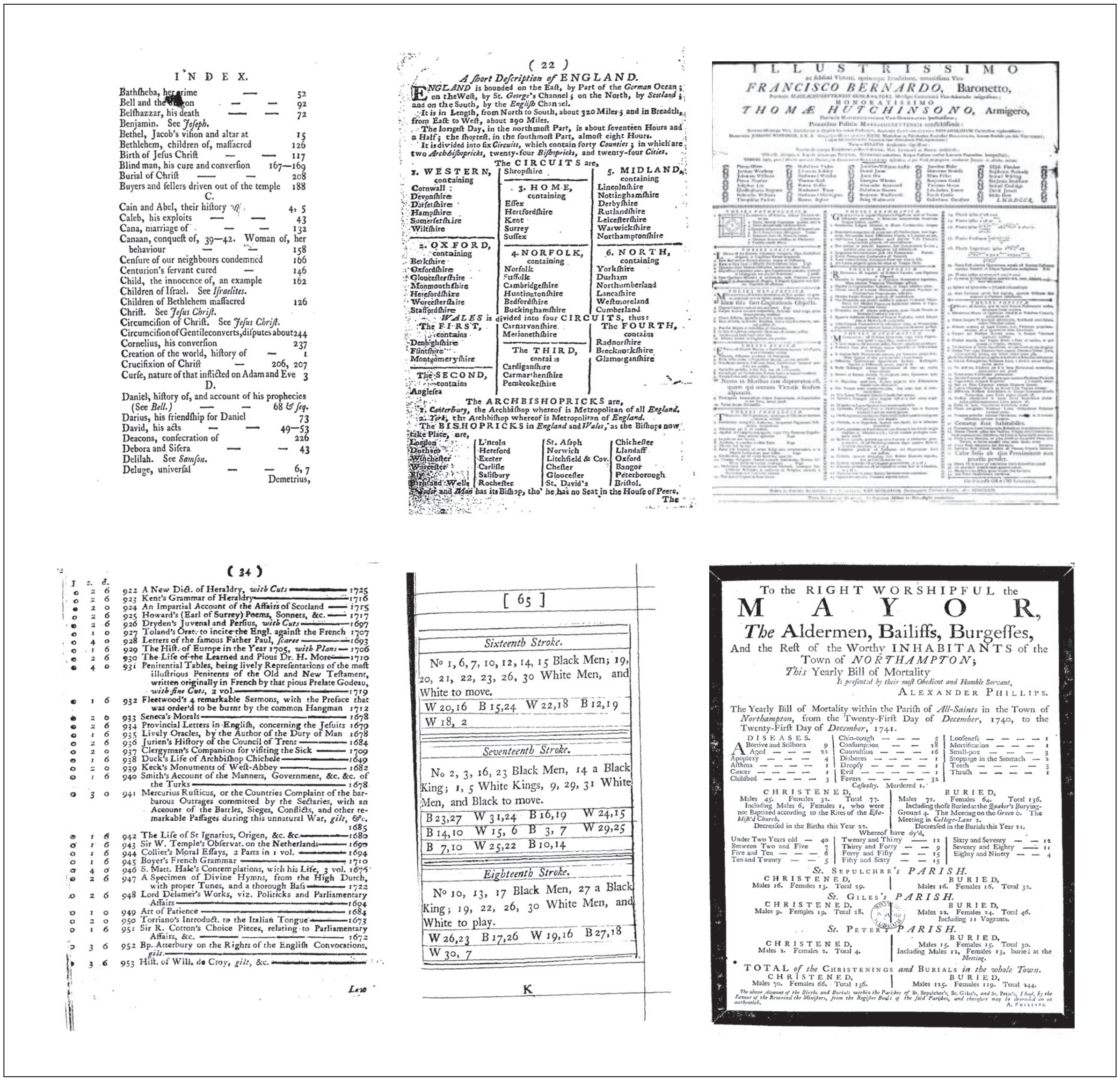
3.1.2.1 T2(General definition)

Any regular form of tables that consist of columns and rows, whether containing ruling lines or white space is categorized in this class. There should be no doubt in assigning the samples of this class as a table.

3.1.2.2 T1(Loose definition)

Any table with irregular layout compared to the standard format of the page is included in this category. The document pages belong to this category range from title, list, content, index, and catalog to multi-column pages or even pages having the mixture of these situations. They can firmly have tabular form especially multi-columns pages or title pages with bold ruling lines. They may also have no-table (NT) class appearance that hardly can resemble a table. Figure 3.8 provides some pages from class T1 with table-like appearance, while Figure 3.9 shows some examples with NT appearance.

According to these categories, we have a sequential decision tree. Starting with the T2 label, we first check if the table belongs to the T2 and if not check the T1 category. This labeling serves people in the field of human sciences. It helps to study the tables in the past centuries and monitor their evolving and changes in printed documents as well as their in-between connection. To do so, researchers not only need as many images containing table as they can but also they are interested in finding any relation and difference between the loose and general definition of tables. Moreover, they favor finding the T2 over the T1 class considering T2s are strictly the tables and will be most advantageous in the analyzing the historical table data.



I N D E X.

Bathſheba, her crime — 52
Bell and the [illegible]on — — 92
Belſhazzar, his death — — 72
Benjamin. See *Joſeph.*
Bethel, Jacob's viſion and altar at 15
Bethlehem, children of, maſſacred 126
Birth of Jeſus Chriſt — — 117
Blind man, his cure and converſion 167—169
Burial of Chriſt — — 208
Buyers and ſellers driven out of the temple 188
C.
Cain and Abel, their hiſtory 4, 5
Caleb, his exploits — — 43
Cana, marriage of — — 132
Canaan, conqueſt of, 39—42. Woman of, her behaviour — — 158
Cenſure of our neighbours condemned 166
Centurion's ſervant cured — 146
Child, the innocence of, an example 162
Children of Iſrael. See *Iſraelites.*
Children of Bethlehem maſſacred 126
Chriſt. See *Jeſus Chriſt.*
Circumciſion of Chriſt. See *Jeſus Chriſt.*
Circumciſion of Gentile converts, diſputes about 244
Cornelius, his converſion 237
Creation of the world, hiſtory of — 1
Crucifixion of Chriſt — 206, 207
Curſe, nature of that inflicted on Adam and Eve 3
D.
Daniel, hiſtory of, and account of his prophecies (See *Bell.*) — — 68 & *ſeq.*
Darius, his friendſhip for Daniel 73
David, his acts — — 49—53
Deacons, conſecration of 226
Debora and Siſera — — 43
Delilah. See *Samſon.*
Deluge, univerſal — — 6, 7
Demetrius,

(22)

A ſhort Deſcription of ENGLAND.

ENGLAND is bounded on the Eaſt, by Part of the *German* Ocean; on the Weſt, by St. *George*'s Channel; on the North, by *Scotland*; and on the South, by the *Engliſh* Channel.

It is in Length, from North to South, about 320 Miles; and in Breadth, from Eaſt to Weſt, about 290 Miles.

The longeſt Day, in the northmoſt Part, is about ſeventeen Hours and a Half; the ſhorteſt, in the ſouthmoſt Part, almoſt eight Hours.

It is divided into ſix *Circuits*, which contain forty *Counties*; in which are two *Archbiſhopricks*, twenty-four *Biſhopricks*, and twenty-four *Cities.*

The CIRCUITS are,

1. WESTERN, containing	Shropſhire	5. MIDLAND, containing
Cornwall	3. HOME, containing	Lincolnſhire
Devonſhire	Eſſex	Nottinghamſhire
Dorſetſhire	Hertfordſhire	Derbyſhire
Hampſhire	Kent	Rutlandſhire
Somerſetſhire	Surrey	Leiceſterſhire
Wiltſhire	Suſſex	Warwickſhire
		Northamptonſhire
2. OXFORD, containing	4. NORFOLK, containing	6. NORTH, containing
Berkſhire	Norfolk	Yorkſhire
Oxfordſhire	Suffolk	Durham
Glouceſterſhire	Cambridgeſhire	Northumberland
Monmouthſhire	Huntingtonſhire	Lancaſhire
Herefordſhire	Bedfordſhire	Weſtmoreland
Worceſterſhire	Buckinghamſhire	Cumberland
Staffordſhire		

WALES is divided into four CIRCUITS, thus:

The FIRST, contains	Carnarvonſhire	The FOURTH, contains
Denbighſhire	Merionethſhire	Radnorſhire
Flintſhire	The THIRD, contains	Brecknockſhire
Montgomeryſhire	Cardiganſhire	Glamorganſhire
The SECOND, contains	Carmarthenſhire	
Angleſea	Pembrokeſhire	

The ARCHBISHOPRICKS are,
1. *Canterbury*, the Archbiſhop whereof is Metropolitan of all *England.*
2. *York*, the Archbiſhop whereof is Metropolitan of *England.*

The BISHOPRICKS in *England* and *Wales*, as the Biſhops now take Place, are,

London	Lincoln	St. Aſaph	Chicheſter
Durham	Hereford	Norwich	Llandaff
Wincheſter	Exeter	Litchfield & Cov.	Oxford
Worceſter	Carliſle	Cheſter	Bangor
Ely	Saliſbury	Glouceſter	Peterborough
Bath and Wells	Rocheſter	St. David's	Briſtol.

Sodor and *Man* has its Biſhop, tho' he has no Seat in the Houſe of Peers.

The

I L L U S T R I S S I M O

[illegible]

FRANCISCO BERNARDO, Baronetto,

[illegible]

H O N O R A T I S S I M O

THOMÆ HUTCHINSONO, Armigero,

[illegible]

(34)

l.	s.	d.			
0	2	6	922	A New Dict. of Heraldry, *with Cuts*	1725
0	2	6	923	Kent's Grammar of Heraldry	1716
0	2	0	924	An Impartial Account of the Affairs of Scotland	1715
0	2	6	925	Howard's (Earl of Surrey) Poems, Sonnets, &c.	1717
0	2	6	926	Dryden's Juvenal and Perſius, *with Cuts*	1697
0	1	0	927	Toland's Orat. to incite the Engl. againſt the French	1707
0	4	0	928	Letters of the famous Father Paul, *ſcarce*	1693
0	1	6	929	The Hiſt. of Europe in the Year 1705, *with Plans*	1706
0	2	6	930	The Life of the Learned and Pious Dr. H. More	1710
0	4	0	931	Penitential Tables, being lively Repreſentations of the moſt illuſtrious Penitents of the Old and New Teſtament, written originally in French by that pious Prelate Godeau, *with fine Cuts,* 2 vol.	1719
0	1	6	932	Fleetwood's 4 remarkable Sermons, with the Preface that was order'd to be burnt by the common Hangman	1712
0	2	0	933	Seneca's Morals	1678
0	2	6	934	Provincial Letters in Engliſh, concerning the Jeſuits	1679
0	1	6	935	Lively Oracles, by the Author of the Duty of Man	1678
0	2	6	936	Jurien's Hiſtory of the Council of Trent	1684
0	2	0	937	Clergyman's Companion for viſiting the Sick	1709
0	1	6	938	Duck's Life of Archbiſhop Chichele	1649
0	2	0	939	Keck's Monuments of Weſt-Abbey	1682
0	1	6	940	Smith's Account of the Manners, Government, &c. &c. of the Turks	1678
0	3	0	941	Mercurius Ruſticus, or the Countries Complaint of the barbarous Outrages committed by the Sectaries, with an Account of the Battles, Sieges, Conflicts, and other remarkable Paſſages during this unnatural War, *gilt,* &c.	1685
0	1	6	942	The Life of St Ignatius, Origen, &c. &c.	1680
0	1	6	943	Sir W. Temple's Obſervat. on the Netherlands	1690
0	1	6	944	Collier's Moral Eſſays, 2 Parts in 1 vol.	1694
0	1	6	945	Boyer's French Grammar	1710
0	4	0	946	S. Matt. Hale's Contemplations, with his Life, 3 vol.	1676
0	2	6	947	A Specimen of Divine Hymns, from the High Dutch, with proper Tunes, and a thorough Baſs	1722
0	2	6	948	Lord Delamer's Works, viz. Politicks and Parliamentary Affairs	1694
0	1	0	949	Art of Patience	1684
0	2	0	950	Torriano's Introduct. to the Italian Tongue	1673
0	1	6	951	Sir R. Cotton's Choice Pieces, relating to Parliamentary Affairs, &c.	1672
0	3	6	952	Bp. Atterbury on the Rights of the Engliſh Convocations, *gilt.*	
0	3	6	953	Hiſt. of Will. de Croy, *gilt,* &c.	

Law

[65]

Sixteenth Stroke.

No 1, 6, 7, 10, 12, 14, 15 Black Men; 19, 20, 21, 22, 23, 26, 30 White Men, and White to move.

W 20,16 B 15,24 W 22,18 B 12,19
W 18, 2

Seventeenth Stroke.

No 2, 3, 16, 23 Black Men, 14 a Black King; 1, 5 White Kings, 9, 29, 31 White Men, and Black to move.

B 23,27 W 31,24 B 16,19 W 24,15
B 14,10 W 15, 6 B 3, 7 W 29,25
B 7,10 W 25,22 B 10,14

Eighteenth Stroke.

No 10, 13, 17 Black Men, 27 a Black King; 19, 22, 26, 30 White Men, and White to play.

W 26,23 B 17,26 W 19,16 B 27,18
W 30, 7

K

To the RIGHT WORSHIPFUL the
M A Y O R,
The Aldermen, Bailiffs, Burgeſſes,
And the Reſt of the Worthy INHABITANTS of the
Town of *NORTHAMPTON*;
This Yearly Bill of Mortality
Is preſented by their moſt Obedient and Humble Servant,
ALEXANDER PHILLIPS.

The Yearly Bill of Mortality within the Pariſh of *All-Saints* in the Town of *Northampton*, from the Twenty-Firſt Day of *December*, 1740, to the Twenty-Firſt Day of *December*, 1741.

DISEASES.					
ABortive and Stilborn	9	Chin-cough	5	Looſeneſs	1
Aged	22	Conſumption	28	Mortification	1
Apoplexy	4	Convulſion	16	Small-pox	3
Aſthma	1	Diabetes	1	Stoppage in the Stomach	2
Cancer	1	Dropſy	1	Teeth	3
Childbed	3	Evil	1	Thruſh	1
		Fevers	32		

Caſualty. Murdered 1.

CHRISTENED,	BURIED,
Males 45. Females 32. Total 77. Including Males 6, Females 1, who were not Baptized according to the Rites of the *Eſtabliſh'd Church.* Decreaſed in the Births this Year 22.	Males 72. Females 64. Total 136. Including thoſe Buried at the *Quaker*'s Burying-Ground 4. The Meeting on the *Green* 0. The Meeting in *College-Lane* 2. Decreaſed in the Burials this Year 21.

Whereof have dy'd,

Under Two Years old	40	Twenty and Thirty	12	Sixty and Seventy	12
Between Two and Five	7	Thirty and Forty	9	Seventy and Eighty	11
Five and Ten	6	Forty and Fifty	15	Eighty and Ninety	4
Ten and Twenty	5	Fifty and Sixty	15		

St. SEPULCHRE's *PARISH.*

CHRISTENED,	BURIED,
Males 16. Females 13. Total 29.	Males 16. Females 16. Total 32.

St. GILES's *PARISH.*

CHRISTENED,	BURIED,
Males 9. Females 19. Total 28.	Males 22. Females 24. Total 46. Including 11 Vagrants.

St. PETER's *PARISH.*

CHRISTENED,	BURIED,
Males 2. Females 2. Total 4.	Males 15. Females 15. Total 30. Including Males 12, Females 13, buried at the *Meeting.*

TOTAL *of the* CHRISTENINGS *and* BURIALS *in the whole Town.*

CHRISTENED,	BURIED,
Males 70. Females 66. Total 136.	Males 125. Females 119. Total 244.

The above Account of the Births and Burials within the Pariſhes of St. Sepulchre's, St. Giles's, *and* St. Peter's, *I had, by the Favour of the Reverend the Miniſters, from the Regiſter Books of the ſaid Pariſhes, and therefore may be depended on as authentick.*

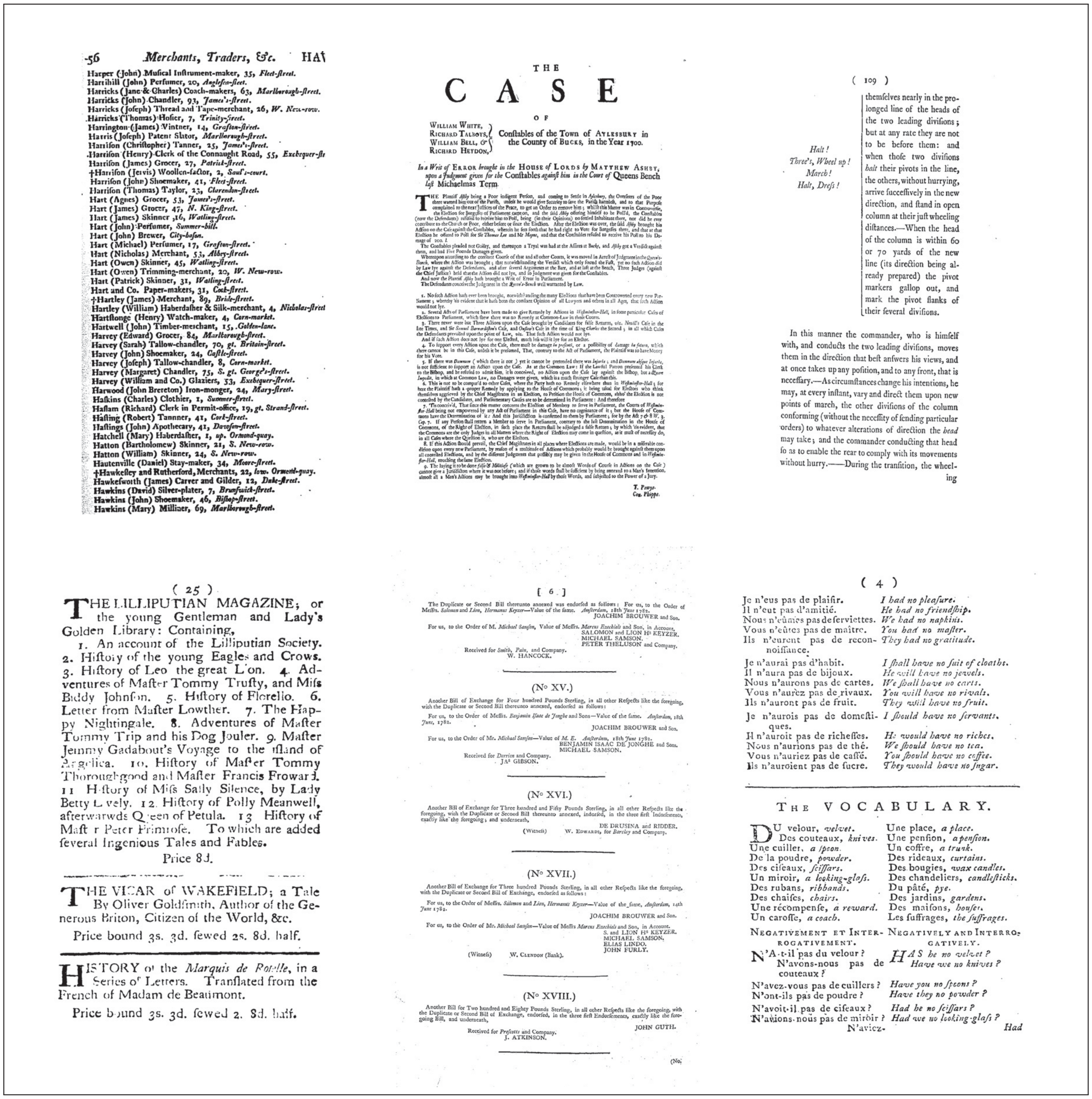
A. PHILLIPS.

BRITISH MUSEUM

Figure 3.8 Some table-like examples of the images belong to class T1.

3.2 state-of-the-art

In the past two decades, various approaches have been proposed to detect tables in documents with different formats and styles. However, finding tables in scanned documents requires a more advanced process than pure text or markup documents (e.g., pdf, HTML, etc.) because less info about their contents is available. Therefore, scanned documents need to be converted from pixel representation to more abstract representations. Along these problems, there is also



-56 *Merchants, Traders, &c.* HAV

Harper (John) Muſical Inſtrument-maker, 35, *Fleet-ſtreet.*
Hartihill (John) Perfumer, 20, *Angleſea-ſtreet.*
Harricks (Jane & Charles) Coach-makers, 63, *Marlborough-ſtreet.*
Harricks (John) Chandler, 93, *James's-ſtreet.*
Harricks (Joſeph) Thread and Tape-merchant, 26, *W. New-row.*
Harricks (Thomas) Hoſier, 7, *Trinity-ſtreet.*
Harrington (James) Vintner, 14, *Grafton-ſtreet.*
Harris (Joſeph) Patent Slator, *Marlborough-ſtreet.*
Harriſon (Chriſtopher) Tanner, 25, *James's-ſtreet.*
Harriſon (Henry) Clerk of the Connaught Road, 55, *Exchequer-ſt*
Harriſon (James) Grocer, 27, *Patrick-ſtreet.*
†Harriſon (Jervis) Woollen-factor, 2, *Saul's-court.*
Harriſon (John) Shoemaker, 41, *Fleet-ſtreet.*
Harriſon (Thomas) Taylor, 23, *Clarendon-ſtreet.*
Hart (Agnes) Grocer, 53, *James's-ſtreet.*
Hart (James) Grocer, 47, *N. King-ſtreet.*
Hart (James) Skinner ,16, *Watling-ſtreet.*
Hart (John) Perfumer, *Summer-hill.*
Hart (John) Brewer, *City-baſon.*
Hart (Michael) Perfumer, 17, *Grafton-ſtreet.*
Hart (Nicholas) Merchant, 53, *Abbey-ſtreet.*
Hart (Owen) Skinner, 45, *Watling-ſtreet.*
Hart (Owen) Trimming-merchant, 20, *W. New-row.*
Hart (Patrick) Skinner, 31, *Watling-ſtreet.*
Hart and Co. Paper-makers, 31, *Cook-ſtreet.*
†Hartley (James) Merchant, 89, *Bride-ſtreet.*
Hartley (William) Haberdaſher & Silk-merchant, 4, *Nicholas-ſtreet*
Hartſtonge (Henry) Watch-maker, 4, *Corn-market.*
Hartwell (John) Timber-merchant, 15, *Golden-lane.*
Harvey (Edward) Grocer, 84, *Marlborough-ſtreet.*
Harvey (Sarah) Tallow-chandler, 70, *gt. Britain-ſtreet.*
Harvey (John) Shoemaker, 24, *Caſtle-ſtreet.*
Harvey (Joſeph) Tallow-chandler, 8, *Corn-market.*
Harvey (Margaret) Chandler, 75, *S. gt. George's-ſtreet.*
Harvey (William and Co.) Glaziers, 53, *Exchequer-ſtreet.*
Harwood (John Brereton) Iron-monger, 24, *Mary-ſtreet.*
Haſkins (Charles) Clothier, 1, *Summer-ſtreet.*
Haſlam (Richard) Clerk in Permit-office, 19, *gt. Strand-ſtreet.*
Haſting (Robert) Tannner, 41, *Cork-ſtreet.*
Haſtings (John) Apothecary, 41, *Dawſon-ſtreet.*
Hatchell (Mary) Haberdaſher, 1, *up. Ormond-quay.*
Hatton (Bartholomew) Skinner, 21, *S. New-row.*
Hatton (William) Skinner, 24, *S. New-row.*
Hautenville (Daniel) Stay-maker, 34, *Moore-ſtreet.*
†Hawkeſley and Rutherford, Merchants, 22, *low. Ormond-quay.*
Hawkeſworth (James) Carver and Gilder, 12, *Duke-ſtreet.*
Hawkins (David) Silver-plater, 7, *Brunſwick-ſtreet.*
Hawkins (John) Shoemaker, 46, *Biſhop-ſtreet.*
Hawkins (Mary) Milliner, 69, *Marlborough-ſtreet.*

THE

CASE

OF

WILLIAM WHITE,
RICHARD TALBOYS,
WILLIAM BELL, &
RICHARD HEYDON,
Conſtables of the Town of AYLESBURY in the County of BUCKS, in the Year 1700.

In a Writ of ERROR *brought in the* HOUSE *of* LORDS *by* MATTHEW ASHBY, *upon a Judgment given for the* Conſtables *againſt him in the Court of* Queens Bench *laſt* Michaelmas Term.

THE Plantiff *Aſhby* being a Poor indigent Perſon, and coming to Settle in *Ayleſbury*, the Overſeers of the Poor there warned him out of the Pariſh, unleſs he would give Security to ſave the Pariſh harmleſs, and to that Purpoſe complained to the next Juſtices of the Peace, to get an Order to remove him; whilſt this Matter was in Controverſie, the Election for Burgeſſes of Parliament came on, and the ſaid *Aſhby* offering himſelf to be Poll'd, the Conſtables (now the Defendants) refuſed to receive him to Poll, being (in their Opinions) no ſettled Inhabitant there, nor did he ever contribute to the Church or Poor, either before or ſince the Election. After the Election was over, the ſaid *Aſhby* brought his Action on the Caſe againſt the Conſtables, wherein he ſets forth that he had right to Vote for Burgeſſes there, and that at that Election he offered to Poll for Sir *Thomas Lee* and Mr *Mayne*, and that the Conſtables refuſed to receive his Poll to his Damage of 200 *l*.

The Conſtables pleaded not Guilty, and thereupon a Tryal was had at the Aſſizes at *Bucks*, and *Aſhby* got a Verdict againſt them, and had Five Pounds Damages given.

Whereupon according to the conſtant Courſe of that and all other Courts, it was moved in Arreſt of Judgment in the *Queen's-Bench*, where the Action was brought; that notwithſtanding the Verdict which only found the Fact, yet no ſuch Action did by Law lye againſt the Defendants, and after ſeveral Arguments at the Barr, and at laſt at the Bench, Three Judges (againſt the Chief Juſtice) held that the Action did not lye, and ſo Judgment was given for the Conſtables.

And now the Plantiff *Aſhby* hath brought a Writ of Error in Parliament.

The Defendants conceive the Judgment in the *Queen's-Bench* well warranted by Law.

1. No ſuch Action hath ever been brought, notwithſtanding the many Elections that have been Controverted every new Parliament; whereby 'tis evident that it hath been the conſtant Opinion of all Lawyers and others in all Ages, that ſuch Action would not lye.

2. Several Acts of Parliament have been made to give Remedy by Actions in *Weſtminſter-Hall*, in ſome particular Caſes of Elections to Parliament, which ſhew there was no Remedy at Common-Law in thoſe Courts.

3. There never were but Three Actions upon the Caſe brought by Candidates for falſe Returns, *viz.* *Nevill's* Caſe in the late Times, and Sir *Samuel Barnardiſton's* Caſe, and *Onſlow's* Caſe in the time of King *Charles* the Second; in all which Caſes the Defendants prevailed upon the point of Law, *viz.* That ſuch Action would not lye.

And if ſuch Action does not lye for one Elected, much leſs will it lye for an Elector.

4. To ſupport every Action upon the Caſe, there muſt be damage *in præſenti*, or a poſſibility of damage *in futuro*, which there cannot be in this Caſe, unleſs it be preſumed, That, contrary to the Act of Parliament, the Plaintiff was to have Money for his Vote.

5. If there was *Damnum* (which there is not) yet it cannot be pretended there was *Injuria*; and *Damnum abſque Injuria*, is not ſufficient to ſupport an Action upon the Caſe. As at the Common Law: If the Lawful Patron preſented his Clerk to the Biſhop, and he refuſed to admit him, it is conceived, no Action upon the Caſe lay againſt the Biſhop, but a *Quare Impedit*, in which at Common Law, no Damages were given, which is a much ſtronger Caſe than this.

6. This is not to be compar'd to other Caſes, where the Party hath no Remedy elſewhere than in *Weſtminſter-Hall*; for here the Plaintiff hath a proper Remedy by applying to the Houſe of Commons; it being uſual for Electors who think themſelves aggrieved by the Chief Magiſtrates in an Election, to Petition the Houſe of Commons, altho' the Election is not conteſted by the Candidates, and Parliamentary Cauſes are to be determined in Parliament: And therefore

7. 'Tis conceiv'd, That ſince this matter concerns the Election of Members to ſerve in Parliament, the Courts of *Weſtminſter-Hall* being not empowered by any Act of Parliament in this Caſe, have no cognizance of it; but the Houſe of Commons have the Determination of it: And this Juriſdiction is confirmed to them by Parliament; for by the Act 7 & 8 *W.* 3. *Cap.* 7. If any Perſon ſhall return a Member to ſerve in Parliament, contrary to the laſt Determination in the Houſe of Commons, of the Right of Election, in ſuch place the Return ſhall be adjudged a falſe Return; by which 'tis evident, that the Commons are the only Judges in all Matters where the Right of Election may come in queſtion, as it muſt of neceſſity do, in all Caſes where the Queſtion is, who are the Electors.

8. If this Action ſhould prevail, the Chief Magiſtrates in all places where Elections are made, would be in a miſerable condition upon every new Parliament, by reaſon of a multitude of Actions which probably would be brought againſt them upon all conteſted Elections, and by the different Judgments that poſſibly may be given in the Houſe of Commons and in *Weſtminſter-Hall*, touching the ſame Election.

9. The laying it to be done *falſo & Malitioſe* (which are grown to be almoſt Words of Courſe in Actions on the Caſe) cannot give a Juriſdiction where it was not before; and if thoſe words ſhall be ſufficient by being annexed to a Man's Intention, almoſt all a Man's Actions may be brought into *Weſtminſter-Hall* by thoſe Words, and ſubjected to the Power of a Jury.

T. Powys.
Cog. Phipps.

(109)

Halt!
Three's, Wheel up!
March!
Halt, Dreſs!

themſelves nearly in the prolonged line of the heads of the two leading diviſions; but at any rate they are not to be before them: and when thoſe two diviſions *halt* their pivots in the line, the others, without hurrying, arrive ſucceſſively in the new direction, and ſtand in open column at their juſt wheeling diſtances.—When the head of the column is within 60 or 70 yards of the new line (its direction being already prepared) the pivot markers gallop out, and mark the pivot flanks of their ſeveral diviſions.

In this manner the commander, who is himſelf with, and conducts the two leading diviſions, moves them in the direction that beſt anſwers his views, and at once takes up any poſition, and to any front, that is neceſſary.—As circumſtances change his intentions, he may, at every inſtant, vary and direct them upon new points of march, the other diviſions of the column conforming (without the neceſſity of ſending particular orders) to whatever alterations of direction the *head* may take; and the commander conducting that head ſo as to enable the rear to comply with its movements without hurry.——During the tranſition, the wheel-

ing

(25)

THE LILLIPUTIAN MAGAZINE; or the young Gentleman and Lady's Golden Library: Containing,

1. An account of the Lilliputian Society. 2. Hiſtory of the young Eagles and Crows. 3. Hiſtory of Leo the great Lion. 4. Adventures of Maſter Tommy Truſty, and Miſs Biddy Johnſon. 5. Hiſtory of Florello. 6. Letter from Maſter Lowther. 7. The Happy Nightingale. 8. Adventures of Maſter Tommy Trip and his Dog Jouler. 9. Maſter Jemmy Gadabout's Voyage to the iſland of Angelica. 10. Hiſtory of Maſter Tommy Thoroughgood and Maſter Francis Froward. 11 Hiſtory of Miſs Sally Silence, by Lady Betty Lovely. 12. Hiſtory of Polly Meanwell, afterwarwds Queen of Petula. 13 Hiſtory of Maſter Peter Primroſe. To which are added ſeveral Ingenious Tales and Fables.

Price 8d.

THE VICAR of WAKEFIELD; a Tale By Oliver Goldſmith, Author of the Generous Briton, Citizen of the World, &c.

Price bound 3s. 3d. ſewed 2s. 8d. half.

HISTORY of the *Marquis de Roſelle*, in a Series of Letters. Tranſlated from the French of Madam de Beaumont.

Price bound 3s. 3d. ſewed 2. 8d. half.

[6]

The Duplicate or Second Bill thereunto annexed was endorſed as follows: For us, to the Order of Meſſrs. *Salomon* and *Lion*, *Hermanus Keyzer*—Value of the ſame. *Amſterdam*, 18th *June* 1782.

JOACHIM BROUWER and Son.

For us, to the Order of M. *Michael Samſon*, Value of Meſſrs. *Marcus Ezechiels* and Son, in Account.

SALOMON and LION Hs KEYZER.
MICHAEL SAMSON.
PETER THELUSON and Company.

Received for *Smith*, *Pain*, and Company.
W. HANCOCK.

(No XV.)

Another Bill of Exchange for Four hundred Pounds Sterling, in all other Reſpects like the foregoing, with the Duplicate or Second Bill thereunto annexed, endorſed as follows:

For us, to the Order of Meſſrs. *Benjamin Iſaac de Jonghe* and Sons—Value of the ſame. *Amſterdam*, 18th *June*, 1782.

JOACHIM BROUWER and Son.

For us, to the Order of Mr. *Michael Samſon*—Value of *M. E.* *Amſterdam*, 18th *June* 1782.

BENJAMIN ISAAC DE JONGHE and Sons.
MICHAEL SAMSON.

Received for *Derrien* and Company.
JAs GIBSON.

(No XVI.)

Another Bill of Exchange for Three hundred and Fifty Pounds Sterling, in all other Reſpects like the foregoing, with the Duplicate or Second Bill thereunto annexed, indorſed, in the three firſt Indorſements, exactly like the foregoing; and underneath,

DE DRUSINA and RIDDER.
(Witneſs) W. EDWARDS, for *Barclay* and Company.

(No XVII.)

Another Bill of Exchange for Three hundred Pounds Sterling, in all other Reſpects like the foregoing, with the Duplicate or Second Bill of Exchange, endorſed as follows:

For us, to the Order of Meſſrs. *Salomon* and *Lion*, *Hermanus Keyzer*—Value of the ſame, *Amſterdam*, 14th *June* 1782.

JOACHIM BROUWER and Son.

For us, to the Order of Mr. *Michael Samſon*—Value of Meſſrs *Marcus Ezechiels* and Son, in Account.

S. and LION Hs KEYZER.
MICHAEL SAMSON.
ELIAS LINDO.
JOHN FURLY.

(Witneſs) W. CLENDON (Bank).

(No XVIII.)

Another Bill for Two hundred and Eighty Pounds Sterling, in all other Reſpects like the foregoing, with the Duplicate or Second Bill of Exchange, endorſed, in the three firſt Endorſements, exactly like the foregoing Bill, and underneath,

JOHN GUTH.

Received for *Preſcotts* and Company.
J. ATKINSON.

(No.

(4)

Je n'eus pas de plaiſir.	*I had no pleaſure.*
Il n'eut pas d'amitié.	*He had no friendſhip.*
Nous n'eûmes pas de ſerviettes.	*We had no napkins.*
Vous n'eûtes pas de maître.	*You had no maſter.*
Ils n'eurent pas de reconnoiſſance.	*They had no gratitude.*
Je n'aurai pas d'habit.	*I ſhall have no ſuit of cloaths.*
Il n'aura pas de bijoux.	*He will have no jewels.*
Nous n'aurons pas de cartes.	*We ſhall have no carts.*
Vous n'aurèz pas de rivaux.	*You will have no rivals.*
Ils n'auront pas de fruit.	*They will have no fruit.*
Je n'aurois pas de domeſtiques.	*I ſhould have no ſervants.*
Il n'auroit pas de richeſſes.	*He would have no riches.*
Nous n'aurions pas de thé.	*We ſhould have no tea.*
Vous n'auriez pas de caffé.	*You ſhould have no coffee.*
Ils n'auroient pas de ſucre.	*They would have no ſugar.*

THE VOCABULARY.

DU velour, *velvet.*
Des couteaux, *knives.*
Une cuiller, *a ſpoon.*
De la poudre, *powder.*
Des ciſeaux, *ſciſſars.*
Un miroir, *a looking-glaſs.*
Des rubans, *ribbands.*
Des chaiſes, *chairs.*
Une récompenſe, *a reward.*
Un caroſſe, *a coach.*

Une place, *a place.*
Une penſion, *a penſion.*
Un coffre, *a trunk.*
Des rideaux, *curtains.*
Des bougies, *wax candles.*
Des chandeliers, *candleſticks.*
Du pâté, *pye.*
Des jardins, *gardens.*
Des maiſons, *houſes.*
Les ſuffrages, *the ſuffrages.*

NEGATIVEMENT ET INTERROGATIVEMENT.	NEGATIVELY AND INTERROGATIVELY.
N'A-t-il pas du velour?	*HAS he no velvet?*
N'avons-nous pas de couteaux?	*Have we no knives?*
N'avez-vous pas de cuillers?	*Have you no ſpoons?*
N'ont-ils pas de poudre?	*Have they no powder?*
N'avoit-il pas de ciſeaux?	*Had he no ſciſſars?*
N'avions-nous pas de miroir?	*Had we no looking-glaſs?*
N'aviez-	Had

Figure 3.9 Some non-tabular examples of the images belong to class T1.

the fact that document images are obtained through scanning and digitizing process and subject to several errors such as noise and skewness (Long, 2010).

Table detection algorithms commonly follow two main strategies: [1] non-text analysis by manipulating the pixels directly and finding the table template in the image pixels, and [2] text analysis by using OCR tools to retrieve the ASCII text from the document images (Long, 2010). Many issues are associating with the OCR-based approaches. The main problem is the fact that these tools are not entirely reliable and any error in this stage can significantly affect the table processing stage. Also, these tools are not able to completely transform some typographical information such as font or symbols back to the text, which causes information loss. Even though modern OCR systems have targeted the tables in their process, but still they are biased to specific forms and formats of the table and collapse in the case of irregular and unfamiliar tabular structures like what we commonly encounter in historical documents. Therefore, OCR tools are not often considered as a successful method when it targets tables in scanned document images.

One of the earliest works on table detection in scanned documents belongs to Laurentini & Viada (1992). They find the horizontal and vertical ruling lines using the run-length analysis as the first indication of the appearance of a table in machine-printed documents. Then, they execute several tests to see if a group of character-sized connected components is tightly fixed within the located table cells. Hu *et al.* (1999) proposed an approach for detecting tables from single column document images. Their method is based on the assumption that page can be easily segmented to text lines and from there, table detection is only a matter of determining the start and end of ruling lines by utilizing some quality functions. However, this method is only limited to the single column images with simple layouts.

The method introduced by Wangt *et al.* (2001), detects the potential table lines using the gap between consecutive words. Holding this information, they group the vertically adjacent lines along the horizontally adjacent words and form the table cell candidates. Finally, the candidates are refined according to a statistical approach by finding a consistency score. This approach assumes that the document page can have only one of these three page layouts: single-column, double-columns and mixed-column. The system is trained using this information as prior knowledge for table detection. The main disadvantage of this technique is its limitation to those page layouts. Cesarini *et al.* (2002) presented a method for finding parallel lines using MXY tree-based hierarchical representation. The parallel lines information aids to candidate tables by locating the perpendicular lines or white spaces in between the parallel lines. However, their prosed method is only applicable to the HV type of tables.

The approach used by Gatos *et al.* (2005) searches for the horizontal and vertical ruling lines on the page and finds their points of intersection. These points are further used to reconstruct the table by connecting the intersection line pairs. Their stated method has the problem of not covering the NRL tables. Lin *et al.* (2006) introduced a robust system for table detection from online ink notes. The first step of their method is extracting the fundamental elements of the table structure, i.e., ruling lines, table bounding boxes and drawing strokes candidates. Then by normalizing the table skeleton, the logical structure of the table and its cell content are achieved. Finally, taking advantage of the similarity between the detection process and decision tree, tables are found. Being limited to the RL-Ts is the main drawback of this method. Mandal *et al.* (2006) introduced an algorithm to detect tables with homogeneous bodies. This approach is built on the assumption that in the presence of a table and its columns, the gap between fields should be larger than the one between words. The disadvantage of this method even though it works independently from the ruling lines is that it only works for single column pages.

Shigarov *et al.* (2009) presented a method for table detection using a bottom-up segmentation of the document page. This approach first groups the text blocks and then segmented them into lines and from there extract bounding boxes of each text element in the lines. Finally, some qualitative rules are applied to detect the table candidates. The main drawback of this method is its sensitivity to full page tables and mixing them with multi-column pages. Shafait & Smith (2010) developed a method for detecting tables in multi-column documents. Their method first finds the page column candidates. Based on their assumption tables should be among this candidates. Therefore, defining some conditions to differ them from columns they determine the tables.

Chen & Lopresti (2011) proposed a method for detecting tables in noisy handwritten documents. This method starts with locating and eliminating the clutters on the page borders then proceed by a bottom-up approach to divide the page into small tiles. Then by feeding the

Gradient-Structural-Concavity (GSC) features to an SVM classifier, text vs. non-text tiles are found. Then they adopt the Hu *et al.* (1999) method to detect the tables. This method is covering all types of tables. However, still sensitive to the space noise and tabular shape structures since the style of handwritten documents is messier compared to the printed ones.

Kumar *et al.* (2012) presented a method for detecting the appearance of a table on the page. They applied statistics of codeword histogram to represent the spatial relationship of the patches. The code words histogram is obtained by partitioning the image up to a particular point, horizontally and vertically. Dhiran & Sharma (2013) proposed a method for detecting every type of the tables in document images. Their approach is based on finding the projection profiles and the Hugh line detection technique. The drawback of this method is its dependency on layout analysis. The system proposed by Kasar *et al.* (2013) employs a run length approach for detecting the vertical and horizontal lines in the document pages and through that, finds the column and row line separators. Finally, 26 low-level features are defined by applying the junction points of vertical and horizontal lines and fed to an SVM classifier to detect their class as table or not. The disadvantage of this method is that it requires tables having at least one kind of ruling lines.

Ghanmi & Belaid (2014) developed a system for table detection from handwritten chemistry documents using a conditional random fields (CRF) model. The proposed method uses the CRF model to label the segmented lines of the document. They exploit features related to the neighboring lines as well. One of the main flaws of this method is again its dependency on the line segmentation. Jahan & Ragel (2014) introduced an approach that detects and extracts both RL-Ts and NRL-Ts from document images. Their algorithm uses local thresholds for word space and the line height as the fundamental elements of identifying tables. However, it is not always working correctly in the case of irregular spacing on the page. Tian *et al.* (2014) proposed a method to detect table frame lines in low-quality images. The skew corrected images are passed through a run length smoothing algorithm to discard the text lines and preserve the horizontal or vertical lines longer than a specified threshold. Then the table frames are detected using the Hough transform. This approach is only working for RL-Ts.

Seo *et al.* (2015) presented a method that locates the candidate for the cell corners and labels these junctions according to their connectivity. To detect intersections, multiple curve detection algorithms are used, and the results are then labeled into 12 labels. This labeling forms a cost function revealing the pairwise relationships. The obtained cost function is minimized adopting a belief propagation algorithm. Their method can handle multiple tables on one page. Like most other methods, this approach is also limited to the RL-Ts.

Tran *et al.* (2015) proposed method for locating tables starts by merging the neighbor objects in the image after binarizing. Using the connected components, the bounding boxes of these merged objects are found. Then a region of interest (ROI) is extracted using the information of the table frame contacting object bounding boxes' horizontal and vertical lines. If the text objects in the ROI arranged vertically and horizontally, the selected ROI is a table. Tran *et al.* (2016) developed a technique for table detection using random rotation bounding boxes in printed, scanned documents. It first classifies the page to text and non-text regions using a multi-level homogeneous structure algorithm. Later, having the non-text elements and the text-lines extracted by the random rotation bounding box algorithm, RL-Ts are detected. Also, NRL-Ts are found via identifying the homogeneous regions of the text lines.

Gilani *et al.* (2017) used a deep learning based method to solve the problem of detecting tables in the image. Their approach first transforms the image from binary to a form of RGB image using three transform functions. Then this image is fed to a fine-tuned CNN model where it gives the feature map. This output feature map is then transferred to a region proposal network to get the table candidate regions which are the input for a fully connected detection network along their primary feature map to classify the image as table and non-table.

Summing up the state-of-the-art in table detection from document images, it can be seen the limitations each suffer, dealing with the variety of tables. Some methods, just dependent on the existence of the ruling lines in the tables and not capable of handling NRL-Ts or some can only handle one-column documents. One reason for these limitations can be the fact that most of the previous works were dealing with table recognition to extract the table location and structure of the tables thus some assumptions have been made to simplify the problem. Above all, some of the previous methods can only handle a specific class of document with a neat and clear layout and collapse in the case of degraded and old documents with unknown layouts. Therefore, there is a demand for a robust table detection algorithm that can manage all types of tables in complex heterogeneous documents. In this thesis, we limit our focus only on detecting if there is a table on the page or not. This approach aid not only to spot the appearance of a table which later can lead to locating it as well (i.e., using any of the existing methods) but also can help to describe the layout and structure of the tables.

3.3 Proposed methodology

As mentioned in the previous section there is a great need for a robust system that can detect tables despite their types. Here, we proposed a practical approach for classifying documents with challenging layout and compositions to two class of "table" and "not table." We build our hypothesis on the fact that the fundamental feature of a table is its harmonic column-wise scheme. Dealing with any harmonic pattern leads us to frequency concept. We expect that tables should have lower frequency compared to the text characters in each line since they are repeating less frequent than any possible columns of a table. Therefore, applying spectral methods should help in differentiating tables from other parts of the page. Mel frequency cepstral coefficients (MFCCs) are one of the most popular frequency-related features in the speech recognition (Huang *et al.*, 2001). They are generated through cepstral analysis and wrapped according to the Mel scale. The signature characteristic of MFCCs features is providing good discrimination of the lower frequency components against higher frequency components. This behavior makes them a good candidate for table detection purpose. For the best of our knowledge, using MFCCs for the image processing purposes have been only narrowed down to some works about the identification of satellite images, leukemia cells, palm and face and gesture recognition (Talal & El-Sayed, 2009; Biswas, 2009; Taleb & Atiya, 2017).

Our proposed method for tackling the problem of table detection in the historical documents converts images to a one-dimensional signal and then extract the MFCC-based features from these vectors. These features are then modified and will be fed to a classifier to decide on the presence of the table on the page document.

3.3.1 MFCCs-based features

MFCCs extraction process is the same as one for voice recognition. However, this algorithm only accepts vectors as input. Thus, we have to transform our images into one-dimensional signals then make them go through the MFCC algorithm.

Before transforming the images into vectors, first, we will have a scaling step. This step is necessary for our algorithm since all images have different dimensions and resolutions. Therefore, for this research, we empirically decided to use the combination of information from two scales to conserve as much data as possible in resizing steps. These two scales are 700x450 pixels and 500x350 pixels. Transforming the resized images into vectors is done by horizontally concatenating the content of each row in the images. Figure 3.10 depicts the process we follow for extracting MFCC features from each image. Below we will describe each of these steps in more details.

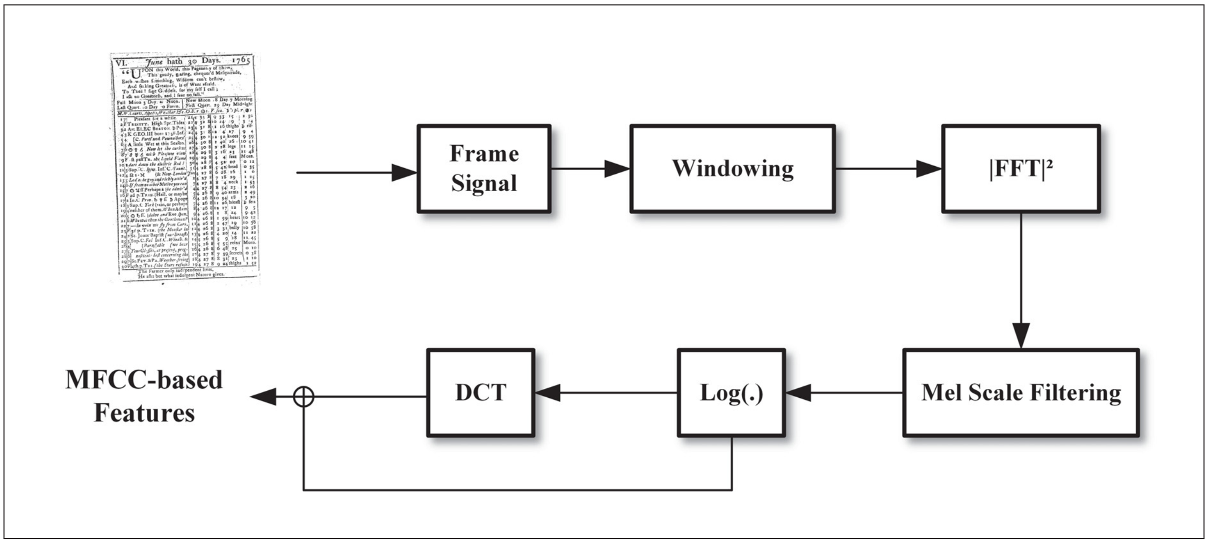


Figure 3.10 MFCC_based feature extraction process.

3.3.1.1 Frame the signal

MFCC features are spectral features and require stationary signals to achieve a reliable spectral analysis. Generally, a short length period of a signal can be considered as statistically stable. These short length trains of samples are called a frame. However, deciding on the right length of these frames is a crucial task due to the tradeoff between time and frequency resolution. Selecting frame size short leads to not having enough samples for calculating the power spectrum and on the other hand choosing this length long will result in not having samples with stationary behavior and too many changes throughout the frame.

We divide our image vectors into successive overlapping frames with the length of *N* samples (here pixels), and *O* pixels overlap for avoiding the loss of data in transition between frames. The frame overlap is generally 25% to 70% of its original length. The values of *N* and *O* for this study are selected *N* = 100 and *N*= 60 pixels. Figure 3.11 shows the process of framing for this work.

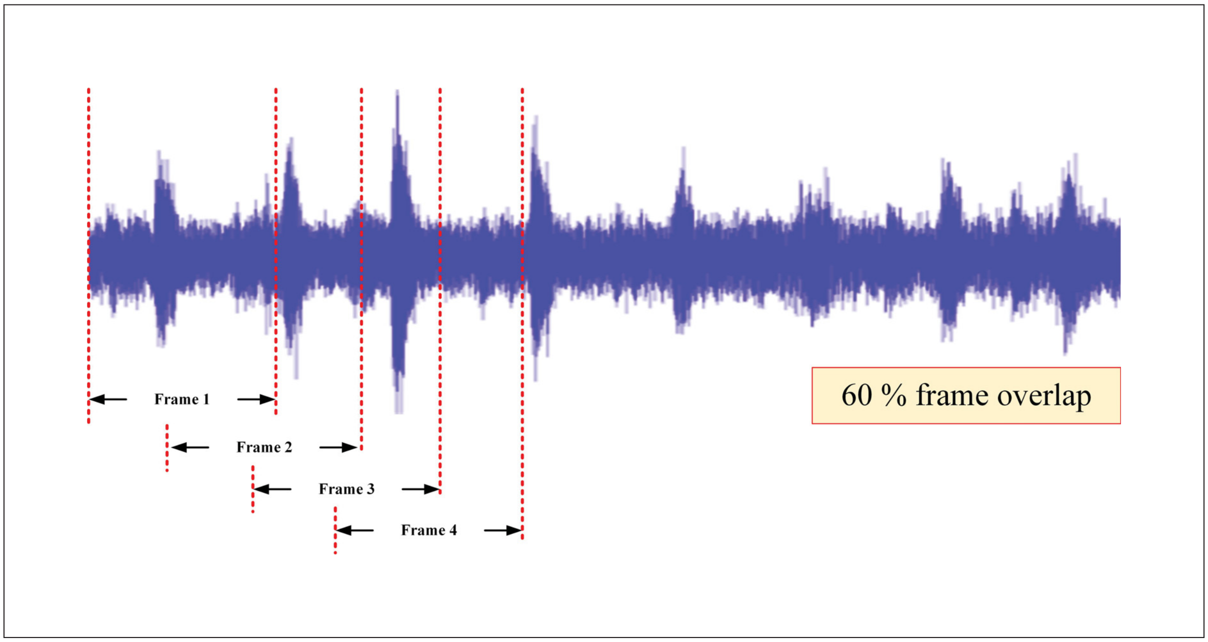


Figure 3.11 Dividing the signal into short overlapping frames.

3.3.1.2 Windowing

After framing the signal, each frame is multiplied point-wise by a window function. This step is equivalent to a convolution process between Fourier transforms of the frames and the chosen window in the frequency domain. Windowing is a necessary step to decrease the disruptions at the two ends of the frame and helps to enhance the continuity between the neighbor frames. Convolution used in windowing smooths the signal by reducing the side lobes and distribute the frequency to the surrounding bins. This makes the frame signal suitable for spectral analysis by reducing the artificial spectral disruptions in each frame. Desired window function should have a narrow main lope with low side lopes. Hamming window is one of the most popular windows uses for this purpose (see Figure 3.12). The following formula represents the hamming window:

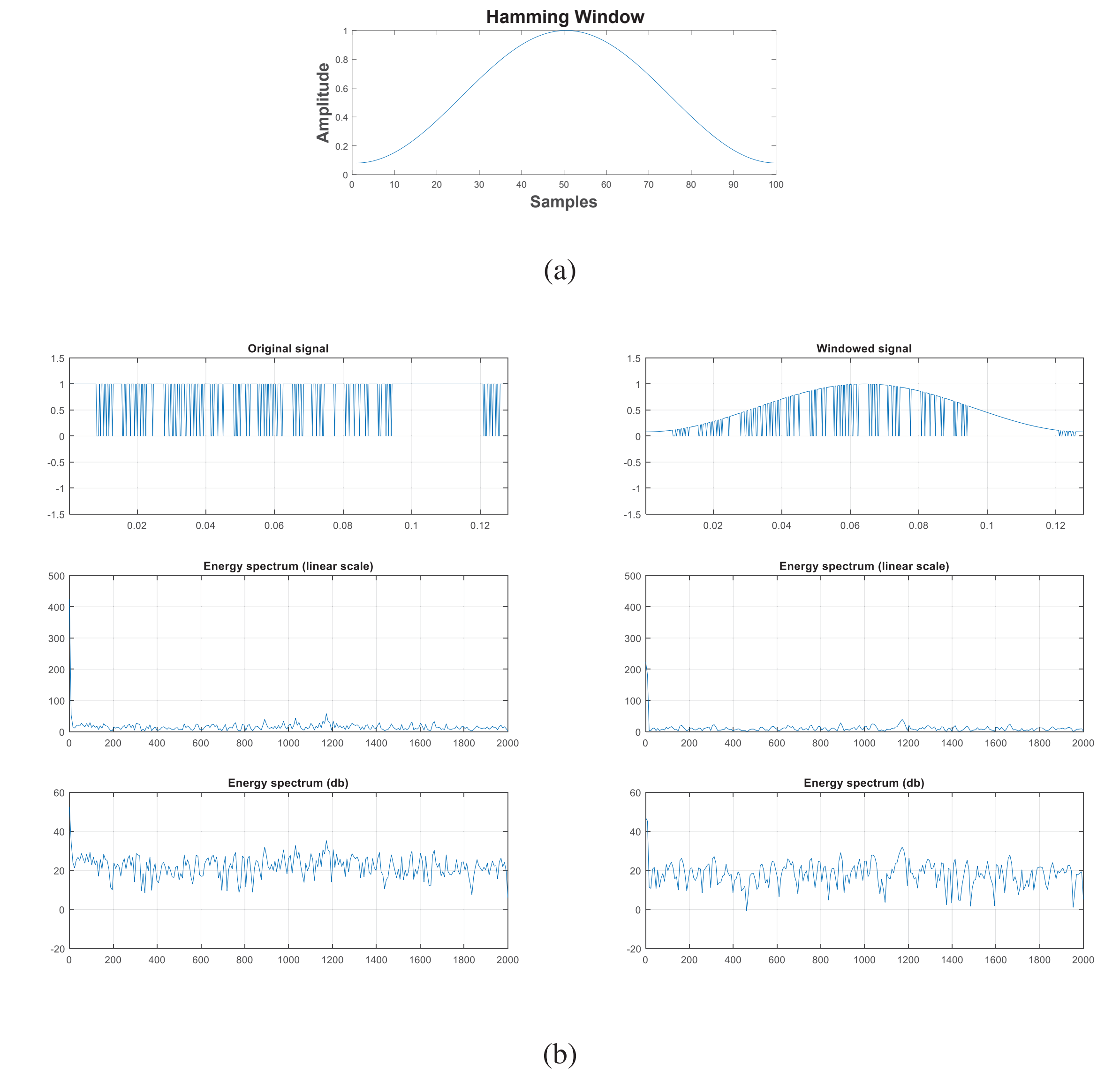
$$w(n) = 0.54 - 0.46cos(\frac{2\pi n}{N-1}),\ 0 \leq n \leq N-1. \tag{3.1}$$

where N is the length of window.

3.3.1.3 Fast Fourier transform (FFT)

The windowed signal is now transformed to the frequency domain using the FFT to calculate the estimation of the periodogram for the power spectrums. FFT is a fast processing algorithm and generally uses in various fast algorithms to compute the Discrete Fourier Transform (DFT) of the signal. To make the process of computing FFT faster and less complicated each frame is divided into small DFTs. DFT provides a mapping between time sequences and a discrete set of frequency domain samples. The periodogram estimate of the power spectrum $s_i(n)$ is given below:

$$P_i(k) = \frac{1}{N}|\sum_{n=1}^{N} s_i(n)h_i(n)e^{-j2\pi kn/N}|^2,\ 0 \leq k \leq K-1. \tag{3.2}$$



(a)

(b)

Figure 3.12 The effect of applying the Hamming window to the time and frequency domains: (a) Hamming window (b) The energy spectrums in both linear and decibel scales applied on the original signal (left column) and windowed signal (right column).

where $s_i(n)$ is the i^{th} framed signal with $1 \leq n \leq N$, $h(n)$ is the window function with sample length of N, and K is the length of FFT. For this study, a 512-point FFT is computed and the first 275 coefficients are stored for the next step. These values are common among the researchers in this field.

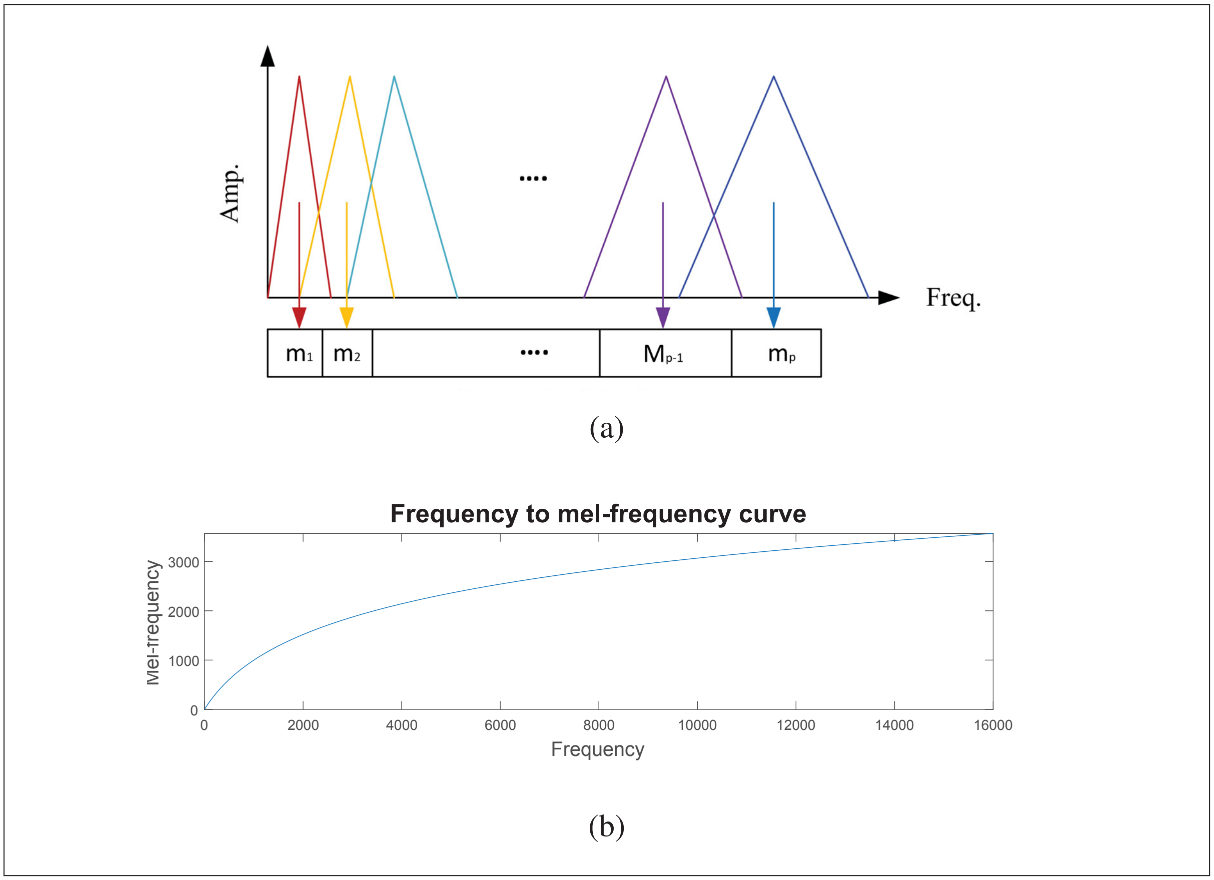
3.3.1.4 Mel filter banks

The source of the harmonics in the frequency response is the repeating fundamental periods in the frame. However, here we are more interested in the envelope of this response. We extract these envelope-like features by applying the triangular bandpass filters to smooth the magnitude spectrum. The triangular overlapping windows called Mel filter banks are used to map the power spectrums to the Mel scale. The Mel scale carries the information for space and wideness of each filter. The first filter starts from 0 Hz, and after the first filter bank, the widths of next filter banks enlarge logarithmically. Figure 3.13 (a) shows these filter banks and how they become wider as the frequency increases. A simple way of interpreting them is to view them as logarithmic filters with overlap in the frequency domain. In the following approximate formula, a subjective frequency, m, is measured on Mel scale using the actual frequency, f in Hz:

$$m_f = 2595 \log_{10}(\frac{f}{700} + 1). \tag{3.3}$$

Figure 3.13 (b) illustrates the relationship between frequency and Mel domains, where the curve shows linear behavior from zero to 1000 Hz and after that point, it follows a logarithmic form.

A set of filter banks are applied to the power spectrum calculated in the previous step. The standard number of filter banks used for MFCCs is between 20 to 40 filter banks. Each filter bank is a vector of size 275, mostly zero except in its bandpass. For calculating the filter banks energies, this vector is multiplied by the power spectrum of the targeted frame, and the result is summed up. The aggregated value indicates the amount of energy in that filter bank. For this thesis, we calculate these energies in the range of 64 Hz to 2000 Hz using 23 Mel filter banks, which results in having 15 coefficients for each frame.



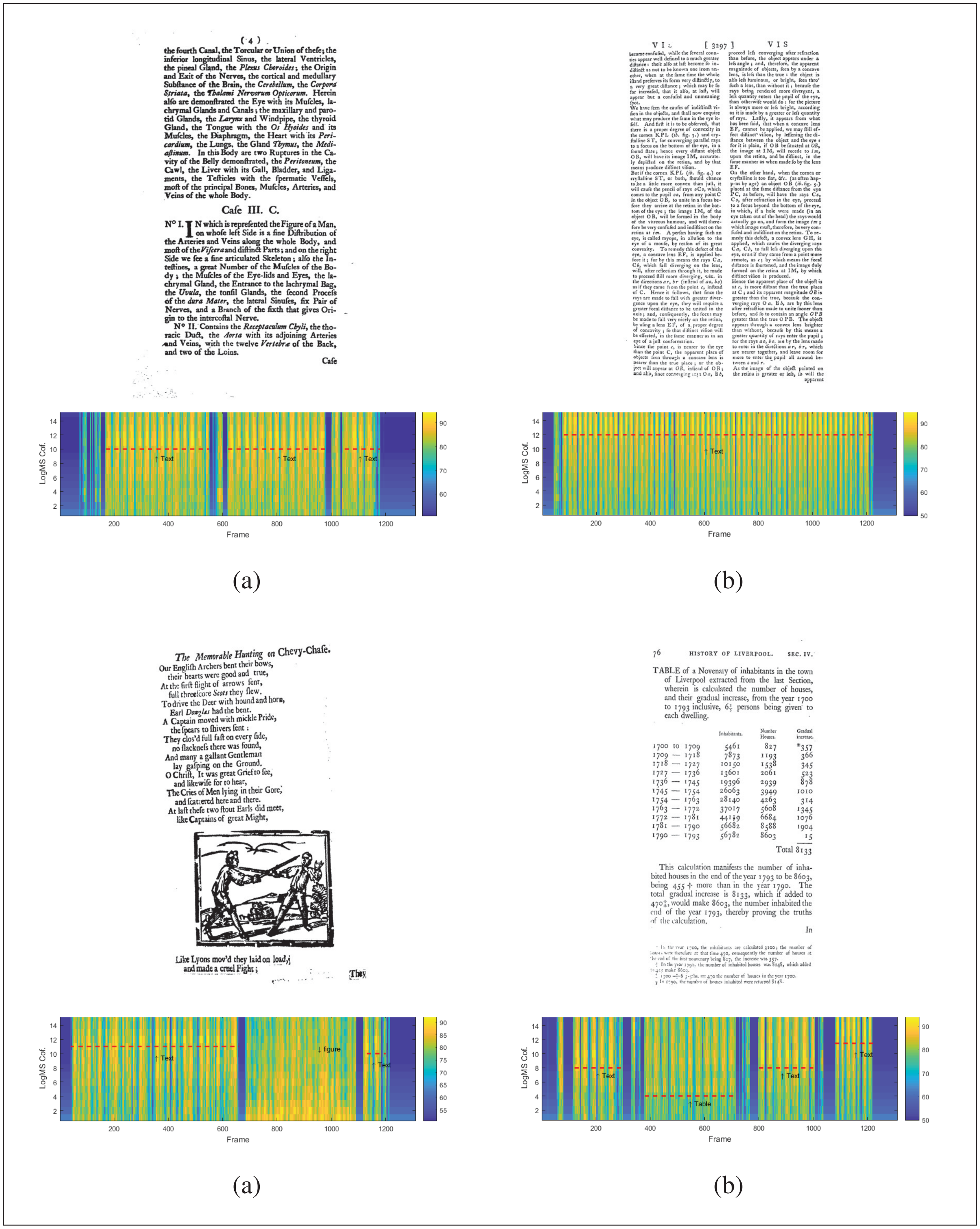
(a)

(b)

Figure 3.13 (a) Mel filter banks. (b) The plot of Mel frequency scale versus hertz.

3.3.1.5 Logarithm

The next step after calculating the energy coefficients is taking their logarithm. Logarithm function converts a multiplication into an addition, which here it serves to allow the cepstral mean subtraction for channel normalization. In another word, it helps the frequency estimates to be less sensitive to the slight power variations. What we obtain by applying the logarithm is the spectro-temporal representation of the signal, and it is called logarithmically scaled Mel-spectrogram (LogMS). Figure 3.14 illustrates the behavior of LogMS in the presence of different structural layout. It also shows how MFCC-based features can be used to characterize the document page specifically tables.



(4)

the fourth Canal, the Torcular or Union of theſe; the inferior longitudinal Sinus, the lateral Ventricles, the pineal Gland, the *Plexus Choroides*; the Origin and Exit of the Nerves, the cortical and medullary Subſtance of the Brain, the *Cerebellum*, the *Corpora Striata*, the *Thalami Nervorum Opticorum*. Herein alſo are demonſtrated the Eye with its Muſcles, lachrymal Glands and Canals; the maxillary and parotid Glands, the *Larynx* and Windpipe, the thyroid Gland, the Tongue with the *Os Hyoides* and its Muſcles, the Diaphragm, the Heart with its *Pericardium*, the Lungs, the Gland *Thymus*, the *Mediaſtinum*. In this Body are two Ruptures in the Cavity of the Belly demonſtrated, the *Peritoneum*, the Cawl, the Liver with its Gall, Bladder, and Ligaments, the Teſticles with the ſpermatic Veſſels, moſt of the principal Bones, Muſcles, Arteries, and Veins of the whole Body.

Caſe III. C.

N° I. IN which is repreſented the Figure of a Man, on whoſe left Side is a fine Diſtribution of the Arteries and Veins along the whole Body, and moſt of the *Viſcera* and diſtinct Parts; and on the right Side we ſee a fine articulated Skeleton; alſo the Inteſtines, a great Number of the Muſcles of the Body; the Muſcles of the Eye-lids and Eyes, the lachrymal Gland, the Entrance to the lachrymal Bag, the *Uvula*, the tonſil Glands, the ſecond Proceſs of the *dura Mater*, the lateral Sinuſes, ſix Pair of Nerves, and a Branch of the ſixth that gives Origin to the intercoſtal Nerve.

N° II. Contains the *Receptaculum Chyli*, the thoracic Duct, the *Aorta* with its adjoining Arteries and Veins, with the twelve *Vertebræ* of the Back, and two of the Loins.

Caſe

VI [3297] VIS

become confuſed, while the ſeveral counties appear well defined to a much greater diſtance: theſe alſo at laſt become ſo indiſtinct as not to be known one from another, when at the ſame time the whole iſland preſerves its form very diſtinctly, to a very great diſtance; which may be ſo far increaſed, that it alſo, at laſt, will appear but a confuſed and unmeaning ſpot.

We have ſeen the cauſes of indiſtinct viſion in the objects, and ſhall now enquire what may produce the ſame in the eye itſelf. And firſt it is to be obſerved, that there is a proper degree of convexity in the cornea KPL (*ib.* fig. 3.) and cryſtalline ST, for converging parallel rays to a focus on the bottom of the eye, in a ſound ſtate; hence every diſtant object OB, will have its image IM, accurately depicted on the retina, and by that means produce diſtinct viſion.

But if the cornea KPL (*ib.* fig. 4.) or cryſtalline ST, or both, ſhould chance to be a little more convex than juſt, it will cauſe the pencil of rays *o*C*o*, which comes to the pupil *oo*, from any point C in the object OB, to unite in a focus before they arrive at the retina in the bottom of the eye; the image IM, of the object OB, will be formed in the body of the vitreous humour, and will therefore be very confuſed and indiſtinct on the retina at *im*. A perſon having ſuch an eye, is called myops, in alluſion to the eye of a mouſe, by reaſon of its great convexity. To remedy this defect of the eye, a concave lens EF, is applied before it; for by this means the rays C*a*, C*b*, which fall diverging on the lens, will, after reflection through it, be made to proceed ſtill more diverging, *viz.* in the directions *ar*, *br* (inſtead of *ao*, *bo*) as if they came from the point *c*, inſtead of C. Hence it follows, that ſince the rays are made to fall with greater divergence upon the eye, they will require a greater focal diſtance to be united in the axis; and, conſequently, the focus may be made to fall very nicely on the retina, by uſing a lens EF, of a proper degree of concavity; ſo that diſtinct viſion will be effected, in the ſame manner as in an eye of a juſt conformation.

Since the point *c*, is nearer to the eye than the point C, the apparent place of objects ſeen through a concave lens is nearer than the true place; or the object will appear at *OB*, inſtead of OB; and alſo, ſince converging rays O*a*, B*b*, proceed leſs converging after refraction than before, the object appears under a leſs angle; and, therefore, the apparent magnitude of objects, ſeen by a concave lens, is leſs than the true: the object is alſo leſs luminous, or bright, ſeen thro' ſuch a lens, than without it; becauſe the rays being rendered more divergent, a leſs quantity enters the pupil of the eye, than otherwiſe would do: for the picture is always more or leſs bright, according as it is made by a greater or leſs quantity of rays. Laſtly, it appears from what has been ſaid, that when a concave lens EF, cannot be applied, we may ſtill effect diſtinct viſion, by leſſening the diſtance between the object and the eye: for it is plain, if OB be ſituated at *OB*, the image at IM, will recede to *im*, upon the retina, and be diſtinct, in the ſame manner as when made ſo by the lens EF.

On the other hand, when the cornea or cryſtalline is too flat, &c. (as often happens by age) an object OB (*ib.* fig. 5.) placed at the ſame diſtance from the eye PC, as before, will have the rays C*o*, C*o*, after refraction in the eye, proceed to a focus beyond the bottom of the eye, in which, if a hole were made (in an eye taken out of the head) the rays would actually go on, and form the image *im*; which image muſt, therefore, be very confuſed and indiſtinct on the retina. To remedy this defect, a convex lens GH, is applied, which cauſes the diverging rays C*a*, C*b*, to fall leſs diverging upon the eye, or as if they came from a point more remote, as *c*; by which means the focal diſtance is ſhortened, and the image duly formed on the retina at IM, by which diſtinct viſion is produced.

Hence the apparent place of the object is at *c*, is more diſtant than the true place at C; and its apparent magnitude *OB* is greater than the true, becauſe the converging rays O*a*, B*b*, are by this lens after refraction made to unite ſooner than before, and ſo to contain an angle *OPB* greater than the true OPB. The object appears through a convex lens brighter than without, becauſe by this means a greater quantity of rays enter the pupil; for the rays *ao*, *bo*, are by the lens made to enter in the directions *ar*, *br*, which are nearer together, and leave room for more to enter the pupil all around between *o* and *r*.

As the image of the object painted on the retina is greater or leſs, ſo will the apparent

The Memorable Hunting on Chevy-Chaſe.

Our Engliſh Archers bent their bows,
their hearts were good and true,
At the firſt flight of arrows ſent,
full threeſcore *Scots* they ſlew.
To drive the Deer with hound and horn,
Earl *Dowglas* had the bent.
A Captain moved with mickle Pride,
the ſpears to ſhivers ſent:
They clos'd full faſt on every ſide,
no ſlackneſs there was found,
And many a gallant Gentleman
lay gaſping on the Ground.
O Chriſt, It was great Grief to ſee,
and likewiſe for to hear,
The Cries of Men lying in their Gore,
and ſcattered here and there.
At laſt theſe two ſtout Earls did meet,
like Captains of great Might,

Like Lyons mov'd they laid on load,
and made a cruel Fight;

They

76 HISTORY OF LIVERPOOL. SEC. IV.

TABLE of a Novenary of inhabitants in the town of Liverpool extracted from the last Section, wherein is calculated the number of houses, and their gradual increase, from the year 1700 to 1793 inclusive, 6⅗ persons being given to each dwelling.

	Inhabitants.	Number Houses.	Gradual increase.
1700 to 1709	5461	827	*357
1709 — 1718	7873	1193	366
1718 — 1727	10150	1538	345
1727 — 1736	13601	2061	523
1736 — 1745	19396	2939	878
1745 — 1754	26063	3949	1010
1754 — 1763	28140	4263	314
1763 — 1772	37017	5608	1345
1772 — 1781	44119	6684	1076
1781 — 1790	56682	8588	1904
1790 — 1793	56782	8603	15
			Total 8133

This calculation manifests the number of inhabited houses in the end of the year 1793 to be 8603, being 455 † more than in the year 1790. The total gradual increase is 8133, which if added to 470‡, would make 8603, the number inhabited the end of the year 1793, thereby proving the truths of the calculation.

In

* In the year 1700, the inhabitants are calculated 3100; the number of houses were therefore at that time 470, consequently the number of houses at the end of the first nouvenary being 827, the increase was 357.

† In the year 1790, the number of inhabited houses was 8148, which added to 455 make 8603.

‡ 3100 ÷ 6 3-5ths. = 470 the number of houses in the year 1700.

§ In 1790, the number of houses inhabited were returned 8148.

(a)

(b)

(a)

(b)

Figure 3.14 Examples of LogMS behavior in the presence of different structural layouts: (a) one-column structure, (b) two-columns structure, (c) figure and text structure and (d) table and text structure. Layout regions are marked with an arrow and dashed red lines show the maximum energy in that region.

In documents containing plain text lines, energy concentration is maximum around higher frequency levels or coefficients. The smaller space between characters and words results in faster changes in the frequency domain and consequently higher coefficient level. Therefore, when the font size becomes smaller and as the result character distributions in their associated location become denser, we expect the frequency of the relevant lines rises to higher levels. We can visualize this relationship between the coefficient number and the energy concentration in Figure 3.14 (a and b). The image with two-column structure compared to the one-column one has higher coefficient level since it has smaller and more compressed characters. Besides, it can be seen that for texts with the same layout, the maximum energy of the frames are all almost at the same level. However, when we have a figure on the page, unlike text lines, there is no specific pattern in the pixel appearance for that figure. Therefore, the energy content mostly concentrates near the zero frequencies with no particular pattern. Nevertheless, if the figure has a table-like visual appearance, it can be mixed with tables. Figure 3.14 (c) shows an example of an image containing both text and figure. Finally, for tables same as texts, the appearance of columns follows a frequentative pattern. However, columns have more gap in between compare to text characters. This fact leads to having lower frequency components for tables. Figure 3.12 (d) depicts an example where tables appear along text on the page. As it is clear from the figure table, contain lower frequency level compared to the text lines. Figure 3.12 (d) also shows a page document which includes different font sizes. it can be seen that smaller font sizes (footnotes here) have slightly higher coefficient level compared to the standard font size of the page and energy level of both are higher than the table energy content.

3.3.1.6 Discrete cosine transform (DCT)

Finally, for MFCCs extraction, we transform back the logarithm of Mel spectrums to the time domain. This process aids to decorrelate the filter bank energy correlations because of their overlaps. In this work, DCT preferred over the inverse DFT since log power spectrum is real and symmetric. DCT produces more information with fewer coefficients, and its output coefficients will be real-valued and highly uncorrelated which makes both storage and further processing easier. The MFCCs are computed using the following formula:

$$c_i(m) = |\sum_{l=1}^{L}(logS_i(l))cos[m(l-\frac{1}{2})\frac{\pi}{M}]|,\ m = 0,1,...,M-1. \tag{3.4}$$

Where M and L indicate the number of MFCCs and number of filter banks, respectively. Moreover, $S_i(l)$ represents each filter banks energy.

Higher frequencies represent faster changes in the energies. Therefore, selecting them can lead to performance degradation by bringing in noisy information. Generally, only 12 to 20 DCT coefficients are chosen for the further processing. Also, the first coefficient shows the mean value of the frames and thus excluded.

The MFCCs are representing the power spectral envelops of each frame. Consequently signal can miss some local dynamic information, i.e., trajectories of MFCCs over the time. Therefore, the first and second derivative coefficients are calculated to add temporal information. First derivatives also are known as delta or differential coefficients are obtained using the regressive formula for all ms, as below:

$$d_i[m] = \frac{\sum_{j=1}^{2}(c_{i-j}[m]-c_{i+j}[m])}{2\sum_{j=1}^{2}(j^2)}. \tag{3.5}$$

Second derivatives also known as delta-delta or acceleration coefficients are computed by applying the delta to delta coefficients.

For this thesis, nine MFCCs including its delta and delta-delta coefficients (in total 27 coefficients) and 15 LogMSs are calculated to create 42 MFCC-based features for each frame of the image. Then some statistical functions are applied to reduce the dimension of feature vectors. These statistical functions are maximum, minimum, maximum position, minimum position, range, mean, variance, median, mode, entropy, kurtosis, and skewness. The distribution of each coefficient for frames suggest using some fitting techniques. Here, we apply a symmetric generalized Gaussian distribution (GGD) and an asymmetric generalized Gaussian distribution (AGGD) fitting. From the given MFCC-based coefficients the shape, variance and entropy information are extracted using a GGD fitting. Also, shape, mean, right and left variances, skewness and kurtosis and entropy are extracted in four orientations (horizontal, vertical, main diagonal and secondary diagonal) using an AGGD fitting. Finally, we will have a feature vector of size 1516 for each image. Considering that we have done the experiments on two scales this amount becomes double (3032 features).

Finally, we apply principal component analysis (PCA) to reduce the number of variables and redundancy in our feature vector while keeping as much variance as possible. With a threshold cumulative contribution ratio of 98%, PCA resizes the size of our feature vector to 561.

3.3.2 Classification

SVM and random forest (RF) classifiers are used for table detection in this research. SVM implementation is done using LIBSVM toolbox Chang & Lin (2011) and the SVM has a degree three polynomial kernel function. We implement RF using 1000 trees, and the number of attributes selected for each tree is equal to the square root of the number of features. Ten percent of the training set is used as the validation set to optimize the parameters.

CHAPTER 4

PERFORMANCE EVALUATION OF THE RESULTS

Below, we first give a brief description of the performance measurements used for both of our specific objectives to find tables and footnotes. Next, for each of these objectives, we first describe the employed datasets. Then, present and compare their performance by applying the proposed frameworks using different experimental set-ups on these datasets.

4.1 Performance metrics

In order to evaluate any system, we need to measure some performance metrics. For visual information retrieval purpose, precision and recall are two widely used measurements (Hedjam, 2013). One observes the performance from correctly spotted samples view and the other from the incorrectly spotted ones.

Recall or sensitivity is the ratio of correctly retrieved samples (true positive) to the all relevant samples. In another word, it indicates how many of page with footnotes/tables are correctly selected from the whole pages that contain footnotes/tables in the test set.

$$Recall = \frac{t_p}{t_p + f_n} \tag{4.1}$$

where t_p is true positive and f_n is false negative which is equal to the total number of non-spotted samples.

Precision or positive predictive value is the fraction of retrieved samples that are relevant to the query. In another word, it is the probability of that the retrieved sample belongs to its target image or in our case, how many of page with footnotes/tables are correctly selected from the detected pages as pages containing footnotes/tables.

$$Precision = \frac{t_p}{t_p + f_p} \tag{4.2}$$

where false positive (f_p) is the total number of misrecognized samples.

Finally, F_measure or balanced F_score is a measure that combines recall and precision and finds the harmonic mean of these to metrics.

$$F_{measure} = 2.\frac{Precision.Recall}{Precision + Recall} \tag{4.3}$$

4.2 Footnote-based document image classification

The proposed footnote-based document image classification approach is evaluated using our dataset and different experimental set-ups. These experiments show the performance, robustness and generalization power of our proposed framework. Below, we describe the dataset and the used experimental set-ups.

4.2.1 Dataset

One of the significant challenges in footnote-based document images classification is the lack of research in this field and consequently, lack of available datasets for experimental evaluation. Therefore, a dataset of labeled documents was generated for conducting our experiments and creating a common benchmarking mechanism for future assessments.

The generated dataset is part of "The Visibility of Knowledge" [1] project and its images are drawn from the digitized collection of eighteenth-century Collections Online (ECCO)[2]. ECCO is an online archive for historical documents printed between the course of 1,701 and 1,800

[1] https://txtlab.org/2016/09/the-visibility-of-knowledge/

[2] https://www.gale.com/primary-sources/eighteenth-century-collections-online

in Britain. It contains over 32 million manuscript pages from more than 155,000 volumes and eight subjects. These images are distributed over two subsets:

- **ECCO part I (ECCO_I):** Contains almost 150,000 manuscripts and about 26,000,000 pages.
- **ECCO part II (ECCO_II):** Contains almost 50,000 manuscripts and about 6,000,000 pages.

Figure 4.1 gives more insights into the distributions of the ECCO dataset over the time and subject. it can be seen that the pages are randomly distributed over the time, and also as expected by reaching the end of 18^{th}-century, there are more published printed volumes and pages. The subjects of ECCO are "Religion and Philosophy" (RelAndPhil), "Literature and Language" (LitAndLang), "History and Geography" (HistAndGeo), "Social Science and Fine Arts" (SSAndFineArt), "Medicine, Science, and Technology" (MedSciTech), "Law" and "Reference" (GenRef). From Figure 4.1, it is clear that high portions of the volumes or pages available in this dataset belong to the three categories of RelAndPhil, LitAndLang and SSAndFineArt.

For creating our ground truth, around 27,500 images from ECCO_I database have been randomly selected to keep the homogeneous distribution of the ECCO. These images are then labeled according to having a footnote (FN) or not having a footnote (NFN) in five subsets. Labeling is done using human sciences experts at McGill University. The final dataset contains 20,966 images labeled as NFN and 6,292 images labeled as FN. Figure 4.2 gives more information about each subset and their content. We will use these labeled subsets to create our train and test sets.

4.2.2 Results and discussion

We conducted two sets of experiments before our final evaluation of more than 32 million unlabeled data. Figure 4.3 gives more details about each experiment set-ups and their training

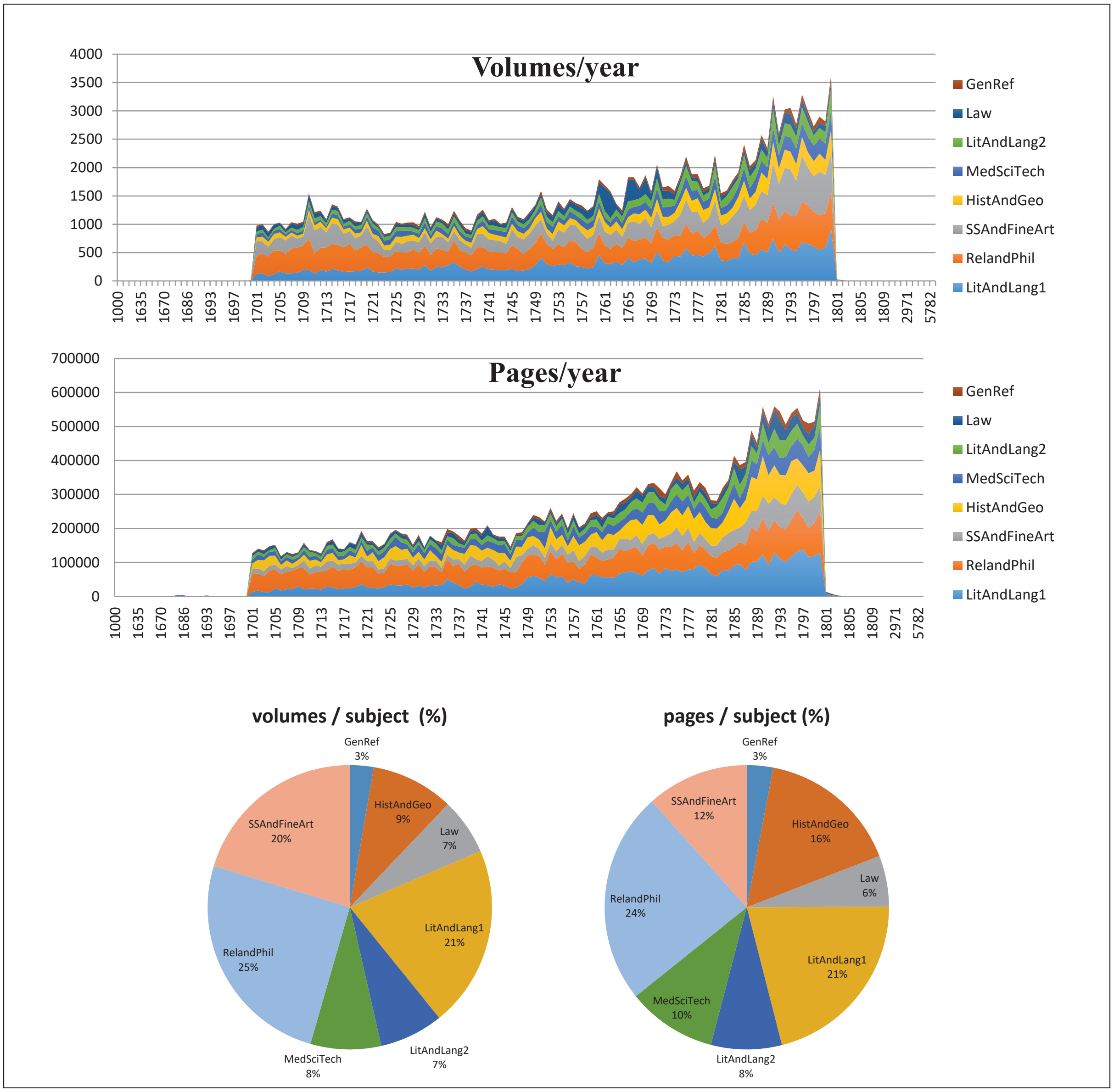


Figure 4.1 ECCO dataset distributions over time and subjects.

and test sets distributions. Below, we explain each of these experiments and discuss their results in more details.

4.2.2.1 First Experiment

This experiment was done using Trainset_0 as our main dataset and adopting two protocols. The first protocol uses a 10-fold cross-validation (CV) set-up where the all samples are ran-

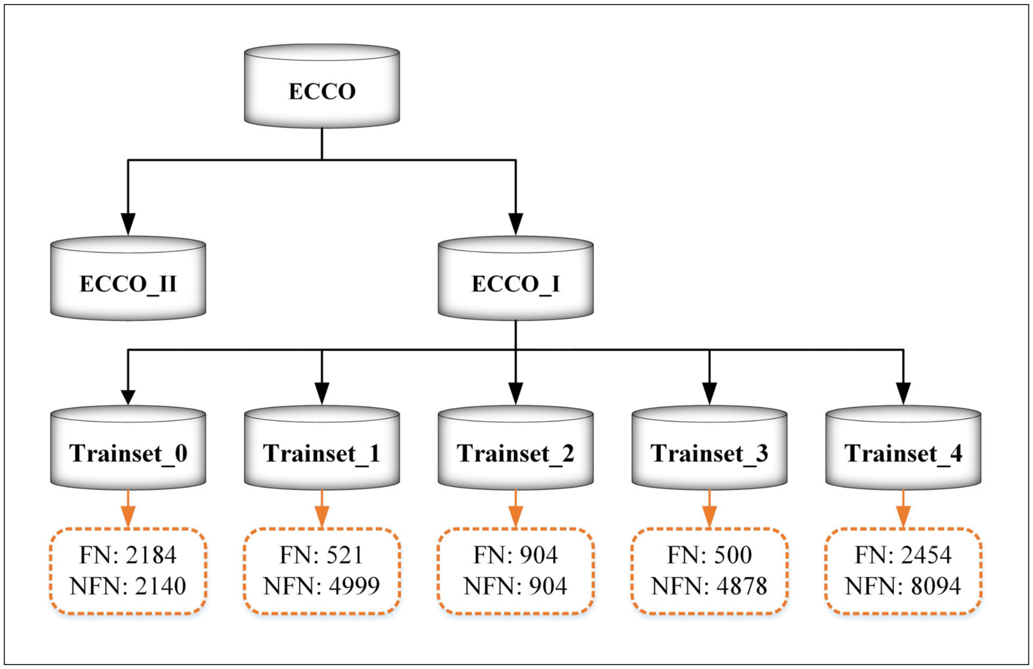


Figure 4.2 The information of the labeled dataset along its subsets. The numbers in the dashed orange boxes represent the number of images from each class of FN and NFN for each subset.

domly divided into 10-folds. In each testing cycle, one fold is assigned to the test set and the rest of the folds to the training set. The average result of repeating this process for each fold gives the final performance. One fold of the training set was used as the validation set whenever we needed to find the parameters. The results using 10-fold CV are reported using an SVM classifier in Table 4.1. The table is split into four sections. The first three ones show the results for each of font size and spaced based methods and the last row gives the results after fusing all the features to get the final 72 features.

The spaced based method clearly outperforms the BBox and Proj methods. However, spaced based method uses the footnote line estimation information from the BBox and Proj methods. Therefore, it can not be claimed that the spaced-based method is entirely independent of the two other methods. From the last row, it is evident that the combination of features reduces the precision value at the price of increasing the recall value. However, this fusion improves the overall performance of the system since it increases the discrimination power of the features.

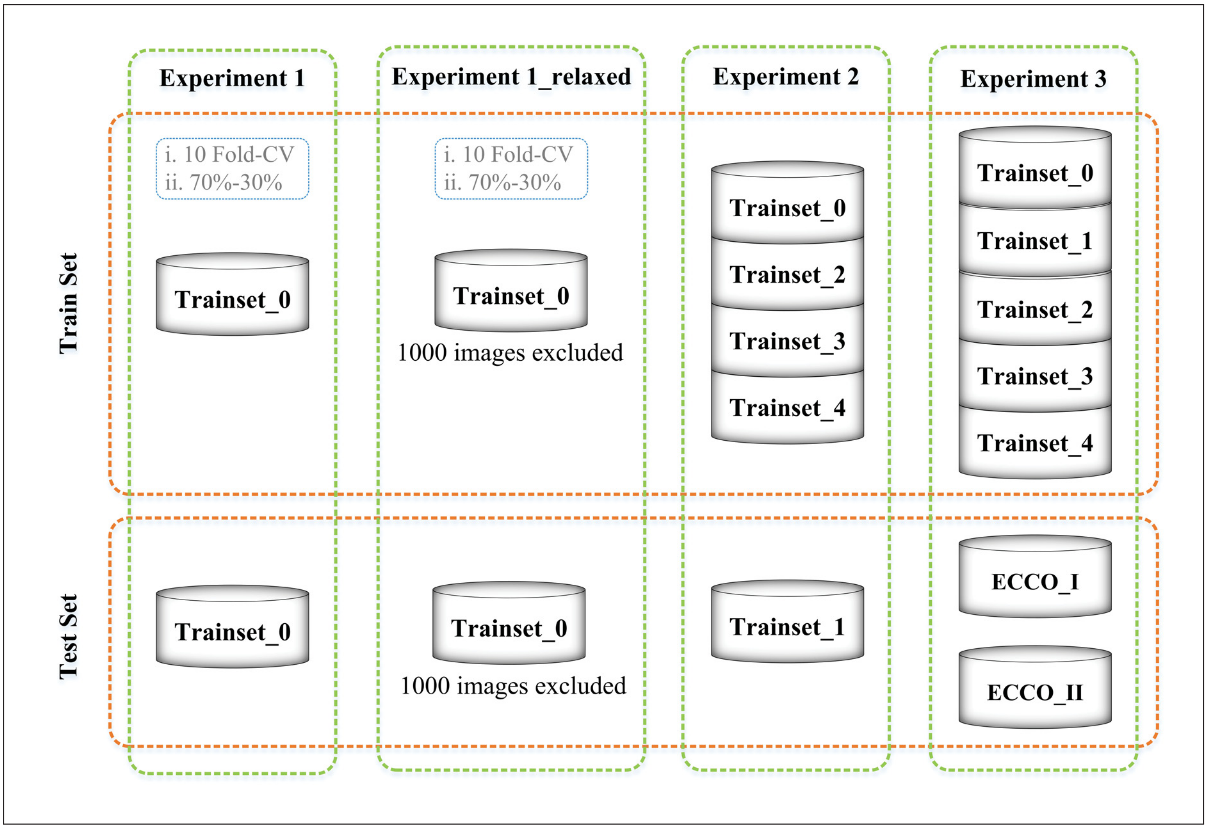
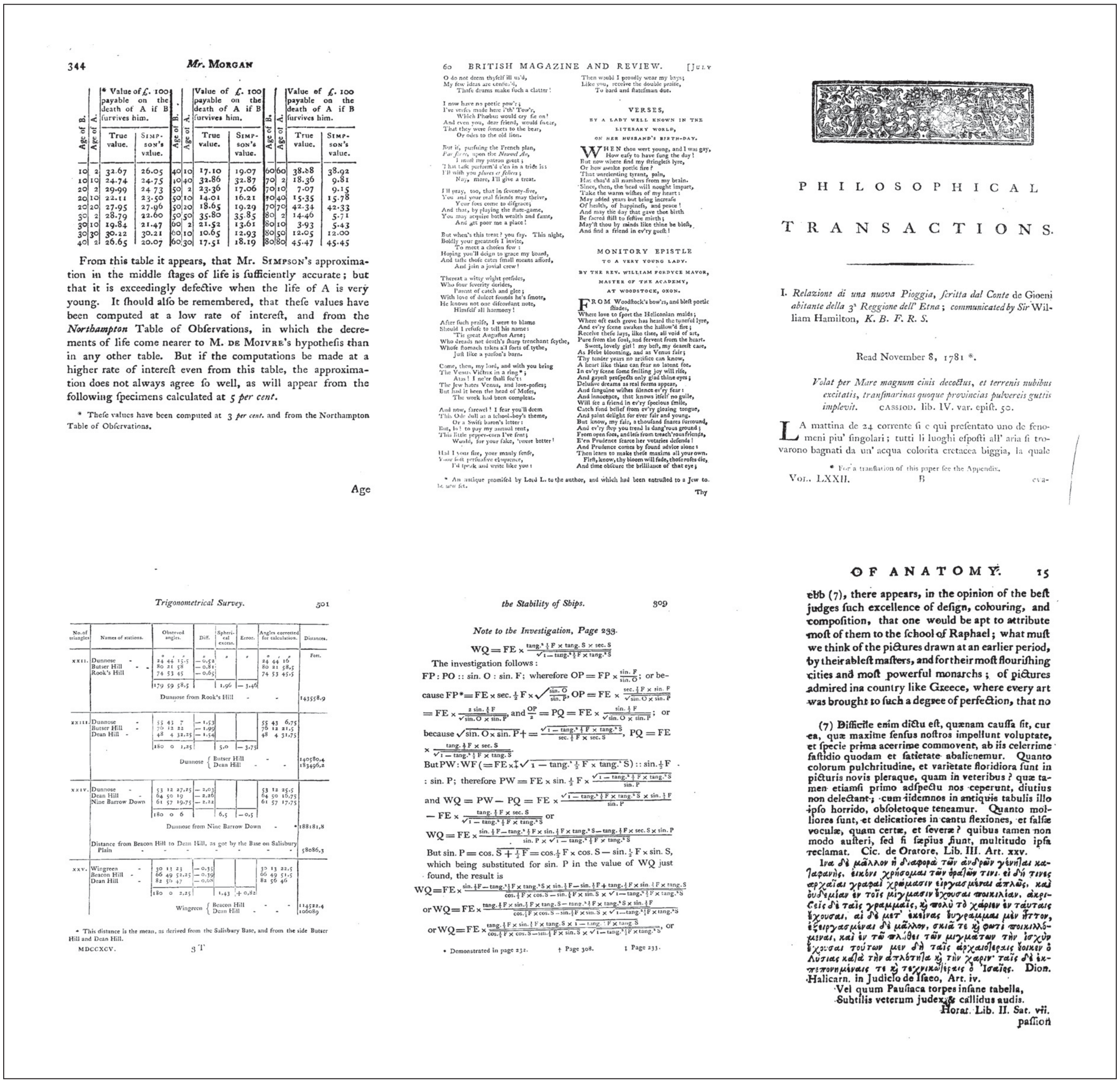


Figure 4.3 Experimental set-ups for each experiment.

One of our observations from the Table 4.1 is that the in all the cases the value of precision is higher than recall. This can be interpreted as the existence of some images that catching footnote in them is difficult. Checking these false negatives makes it clear that in most of the cases the misclassification is due to the complex and irregular layout of the page which makes finding text lines and consequently footnotes harder. These hard to catch footnotes can be in images containing two columns, figures, tables, formulas, Greek letters, etc. (See Figure 4.4). In order to see our method's performance in the absence of these types of images, we relaxed our data set by excluding 1000 images with complex layouts and repeat the experiments. The result of this step is given in Table 4.2. It can be seen that the value of both recall and precision have been increased however the best improvement belongs to the recall value since we have eliminated the complex images. Therefore, we can conclude that the lower precision of the full Trainset_0 is mostly due to the complex layout of the historical documents rather than the weakness of the method itself.



344 *Mr.* MORGAN

Age of B.	Age of A.	* Value of £. 100 payable on the death of A if B ſurvives him. True value.	Simpson's value.	Age of B.	Age of A.	Value of £. 100 payable on the death of A if B ſurvives him. True value.	Simpson's value.	Age of B.	Age of A.	Value of £. 100 payable on the death of A if B ſurvives him. True value.	Simpson's value.
10	2	32.67	26.05	40	10	17.10	19.07	60	60	38.88	38.92
10	10	24.74	24.75	40	40	32.86	32.87	70	2	18.36	9.81
20	2	29.99	24 73	50	2	23.36	17.06	70	10	7.07	9.15
20	10	22.11	23.50	50	10	14.01	16.21	70	40	15.35	15.78
20	20	27.95	27.96	50	20	18.65	19.29	70	70	42.34	42.33
30	2	28.79	22.60	50	50	35.80	35.85	80	2	14.46	5.71
30	10	19.84	21.47	60	2	21.52	13.61	80	10	3.93	5.43
30	30	30.22	30.21	60	10	10.65	12.93	80	50	12.05	12.00
40	2	26.65	20.07	60	30	17.51	18.19	80	80	45.47	45.45

From this table it appears, that Mr. SIMPSON's approximation in the middle ſtages of life is ſufficiently accurate; but that it is exceedingly defective when the life of A is very young. It ſhould alſo be remembered, that theſe values have been computed at a low rate of intereſt, and from the *Northampton* Table of Obſervations, in which the decrements of life come nearer to M. DE MOIVRE's hypotheſis than in any other table. But if the computations be made at a higher rate of intereſt even from this table, the approximation does not always agree ſo well, as will appear from the following ſpecimens calculated at 5 *per cent.*

[*] Theſe values have been computed at 3 *per cent.* and from the Northampton Table of Obſervations.

Age

60 BRITISH MAGAZINE AND REVIEW. [JULY

O do not deem thyſelf ill us'd,
My few ideas are confus'd,
Thoſe drums make ſuch a clatter!

I now have no poetic pow'r;
I've verſes made here i'th' Tow'r,
Which Phœbus would cry fie on!
And even you, dear friend, would ſwear,
That they were ſonnets to the bear,
Or odes to the old lion.

But if, purſuing the French plan,
Par force, upon the *Nouvel An*,
I muſt my patron greet;
That taſk perform'd e'en in a trice is:
I'll wiſh you *plures et felices*;
Nay, more, I'll give a treat.

I'll pray, too, that in ſeventy-five,
You and your real friends may thrive,
Your foes come to diſgrace;
And that, by playing the ſtate-game,
You may acquire both wealth and fame,
And get poor me a place!

But when's this treat? you ſay. This night,
Boldly your greatneſs I invite,
To meet a choſen few:
Hoping you'll deign to grace my board,
And taſte thoſe cates ſmall means afford,
And join a jovial crew!

Thereat a witty wight preſides,
Who four ſeverity derides,
Parent of catch and glee;
With love of dulcet ſounds he's ſmote,
He knows not one diſcordant note,
Himſelf all harmony!

After ſuch praiſe, I were to blame
Should I refuſe to tell his name:
'Tis great Auguſtus Arne;
Who dreads not death's ſharp trenchant ſcythe,
Whoſe ſtomach takes all ſorts of tythe,
Juſt like a parſon's barn.

Come, then, my lord, and with you bring
The Venus Victrix in a ring[*];
Alas! I ne'er ſhall ſee't:
The Jew hates Venus, and love-poſies;
But had it been the head of Moſes,
The work had been compleat.

And now, farewel! I fear you'll deem
This Ode dull as a ſchool-boy's theme,
Or a Swiſs baron's letter:
But, lo! to pay my annual rent,
This little pepper-corn I've ſent;
Would, for your ſake, 'twere better!

Had I your fire, your manly ſenſe,
Your ſoft perſuaſive eloquence,
I'd ſpeak and write like you:
Then would I proudly wear my bays;
Like you, receive the double praiſe,
To bard and ſtateſman due.

VERSES,

BY A LADY WELL KNOWN IN THE LITERARY WORLD,

ON HER HUSBAND'S BIRTH-DAY.

WHEN thou wert young, and I was gay,
How eaſy to have ſung the day!
But now where find my ſtringleſs lyre,
Or how awake poetic fire?
That unrelenting tyrant, pain,
Has chas'd all numbers from my brain.
Since, then, the head will nought impart,
Take the warm wiſhes of my heart:
May added years but bring increaſe
Of health, of happineſs, and peace!
And may the day that gave thee birth
Be ſacred ſtill to feſtive mirth;
May'ſt thou by minds like thine be bleſt,
And find a friend in ev'ry gueſt!

MONITORY EPISTLE

TO A VERY YOUNG LADY.

BY THE REV. WILLIAM FORDYCE MAVOR,

MASTER OF THE ACADEMY,

AT WOODSTOCK, OXON.

FROM Woodſtock's bow'rs, and bleſt poetic ſhades,
Where love to ſport the Heliconian maids;
Where oft each grove has heard the tuneful lyre,
And ev'ry ſcene awakes the hallow'd fire;
Receive theſe lays, like thee, all void of art,
Pure from the ſoul, and fervent from the heart.
Sweet, lovely girl! my beſt, my deareſt care,
As Hebe blooming, and as Venus fair;
Thy tender years no artifice can know,
A heart like thine can fear no latent foe.
In ev'ry ſcene ſome ſmiling joy will riſe,
And gayeſt proſpects only glad thine eyes;
Deluſive dreams as real forms appear,
And ſanguine wiſhes ſilence ev'ry fear:
And innocence, that knows itſelf no guile,
Will ſee a friend in ev'ry ſpecious ſmile,
Catch fond belief from ev'ry glozing tongue,
And paint delight for ever fair and young.
But know, my fair, a thouſand ſnares ſurround,
And ev'ry ſtep you tread is dang'rous ground;
From open foes, and leſs from treach'rous friends,
E'en Prudence ſcarce her votaries defends!
And Prudence comes by ſound advice alone:
Then learn to make theſe maxims all your own.
Firſt, know, thy bloom will fade, thoſe roſes die,
And time obſcure the brilliance of that eye;

[*] An antique promiſed by Lord L. to the author, and which had been entruſted to a Jew to be new ſet.

Thy

PHILOSOPHICAL

TRANSACTIONS.

I. *Relazione di una nuova Pioggia, ſcritta dal Conte* de Gioeni *abitante della* 3ª *Reggione dell' Etna*; *communicated by Sir* William Hamilton, *K. B. F. R. S.*

Read November 8, 1781[*].

Volat per Mare magnum cinis decoctus, et terrenis nubibus excitatis, tranſmarinas quoque provincias pulvereis guttis implevit. CASSIOD. lib. IV. var. epiſt. 50.

LA mattina de 24 corrente ſi e qui preſentato uno de fenomeni piu' ſingolari; tutti li luoghi eſpoſti all' aria ſi trovarono bagnati da un' acqua colorita cretacea biggia, la quale

[*] For a tranſlation of this paper ſee the Appendix.

VOL. LXXII. B eva-

Trigonometrical Survey. 501

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXII.	Dunnose -	24 44 15,5	− 0,52			24 44 16	
	Butser Hill - -	80 21 58	− 0,81			80 21 58,5	
	Rook's Hill	74 53 45	− 0,65			74 53 45,5	
		179 59 58,5		1,96	− 3,46		
	Dunnose from Rook's Hill - -						143558,9
XXIII.	Dunnose -	55 43 7	− 1,53			55 43 6,75	
	Butser Hill -	76 12 22	− 1,99			76 12 21,5	
	Dean Hill -	48 4 32,25	− 1,54			48 4 31,75	
		180 0 1,25		5,0	− 3,75		
	Dunnose { Butser Hill -						140580,4
	Dunnose { Dean Hill - -						183496,2
XXIV.	Dunnose -	53 12 27,25	− 2,03			53 12 25,5	
	Dean Hill -	64 50 19	− 2,26			64 50 16,75	
	Nine Barrow Down	61 57 19,75	− 2,22			61 57 17,75	
		180 0 6		6,5	− 0,5		
	Dunnose from Nine Barrow Down - *						188181,8
	Distance from Beacon Hill to Dean Hill, as got by the Base on Salisbury Plain - - - - - - -						58086,3
XXV.	Wingreen -	30 13 23	− 0,35			30 13 22,5	
	Beacon Hill -	66 49 52,25	− 0,39			66 49 51,5	
	Dean Hill -	82 56 47	− 0,68			82 56 46	
		180 0 2,25		1,43	+ 0,82		
	Wingreen { Beacon Hill - - -						114522,4
	Wingreen { Dean Hill - -						106089

[*] This distance is the mean, as derived from the Salisbury Base, and from the side Butser Hill and Dean Hill.

MDCCXCV. 3 T

the Stability of Ships. 309

Note to the Investigation, Page 233.

$$WQ = FE \times \frac{\text{tang.}^2\tfrac{1}{2}F \times \text{tang.}\,S \times \text{sec.}\,S}{\sqrt{1 - \text{tang.}^2\tfrac{1}{2}F \times \text{tang.}^2 S}}$$

The investigation follows:

$FP : PO :: \text{sin.}\,O : \text{sin.}\,F$; wherefore $OP = FP \times \frac{\text{sin.}\,F}{\text{sin.}\,O}$; or because $FP^{*} = FE \times \text{sec.}\,\tfrac{1}{2}F \times \sqrt{\frac{\text{sin.}\,O}{\text{sin.}\,P}}$, $OP = FE \times \frac{\text{sec.}\,\frac{1}{2}F \times \text{sin.}\,F}{\sqrt{\text{sin.}\,O \times \text{sin.}\,P}} = FE \times \frac{2\,\text{sin.}\,\frac{1}{2}F}{\sqrt{\text{sin.}\,O \times \text{sin.}\,P}}$, and $\frac{OP}{2} = PQ = FE \times \frac{\text{sin.}\,\frac{1}{2}F}{\sqrt{\text{sin.}\,O \times \text{sin.}\,P}}$; or because $\sqrt{\text{sin.}\,O \times \text{sin.}\,P}\,\dagger = \frac{\sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}{\text{sec.}\,\frac{1}{2}F \times \text{sec.}\,S}$, $PQ = FE \times \frac{\text{tang.}\,\frac{1}{2}F \times \text{sec.}\,S}{\sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}\,S}}$.

But $PW : WF \left(= FE \times \ddagger \sqrt{1 - \text{tang.}^2\tfrac{1}{2}F \times \text{tang.}^2 S}\right) :: \text{sin.}\,\tfrac{1}{2}F : \text{sin.}\,P$; therefore $PW = FE \times \text{sin.}\,\tfrac{1}{2}F \times \frac{\sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}{\text{sin.}\,P}$

and $WQ = PW - PQ = FE \times \frac{\sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S} \times \text{sin.}\,\frac{1}{2}F}{\text{sin.}\,P} - FE \times \frac{\text{tang.}\,\frac{1}{2}F \times \text{sec.}\,S}{\sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}$ or

$$WQ = FE \times \frac{\text{sin.}\,\frac{1}{2}F - \text{tang.}^2\frac{1}{2}F \times \text{sin.}\,\frac{1}{2}F \times \text{tang.}^2 S - \text{tang.}\,\frac{1}{2}F \times \text{sec.}\,S \times \text{sin.}\,P}{\text{sin.}\,P \times \sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}$$

But $\text{sin.}\,P = \text{cos.}\,\overline{S + \tfrac{1}{2}F} = \text{cos.}\,\tfrac{1}{2}F \times \text{cos.}\,S - \text{sin.}\,\tfrac{1}{2}F \times \text{sin.}\,S$, which being substituted for sin. P in the value of WQ just found, the result is

$$WQ = FE \times \frac{\text{sin.}\,\frac{1}{2}F - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S \times \text{sin.}\,\frac{1}{2}F - \text{sin.}\,\frac{1}{2}F + \text{tang.}\,\frac{1}{2}F \times \text{sin.}\,\frac{1}{2}F \times \text{tang.}\,S}{\text{cos.}\,\frac{1}{2}F \times \text{cos.}\,S - \text{sin.}\,\frac{1}{2}F \times \text{sin.}\,S \times \sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}$$

$$\text{or } WQ = FE \times \frac{\text{tang.}\,\frac{1}{2}F \times \text{sin.}\,\frac{1}{2}F \times \text{tang.}\,S - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S \times \text{sin.}\,\frac{1}{2}F}{\text{cos.}\,\frac{1}{2}F \times \text{cos.}\,S - \text{sin.}\,\frac{1}{2}F \times \text{sin.}\,S \times \sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}$$

$$\text{or } WQ = FE \times \frac{\text{tang.}\,\frac{1}{2}F \times \text{sin.}\,\frac{1}{2}F \times \text{tang.}\,S \times \overline{1 - \text{tang.}\,\frac{1}{2}F \times \text{tang.}\,S}}{\text{cos.}\,\frac{1}{2}F \times \text{cos.}\,S - \text{sin.}\,\frac{1}{2}F \times \text{sin.}\,S \times \sqrt{1 - \text{tang.}^2\frac{1}{2}F \times \text{tang.}^2 S}}, \text{ or}$$

[*] Demonstrated in page 232. [†] Page 308. [‡] Page 233.

OF ANATOMY. 15

ebb (7), there appears, in the opinion of the beſt judges ſuch excellence of deſign, colouring, and compoſition, that one would be apt to attribute moſt of them to the ſchool of Raphael; what muſt we think of the pictures drawn at an earlier period, by their ableſt maſters, and for their moſt flouriſhing cities and moſt powerful monarchs; of pictures admired in a country like Greece, where every art was brought to ſuch a degree of perfection, that no

(7) Difficile enim dictu eſt, quænam cauſſa ſit, cur ea, quæ maxime ſenſus noſtros impellunt voluptate, et ſpecie prima acerrime commovent, ab iis celerrime faſtidio quodam et ſatietate abalienemur. Quanto colorum pulchritudine, et varietate floridiora ſunt in picturis novis pleraque, quam in veteribus? quæ tamen etiamſi primo adſpectu nos ceperunt, diutius non delectant; cum iidem nos in antiquis tabulis illo ipſo horrido, obſoletoque teneamur. Quanto molliores ſunt, et delicatiores in cantu flexiones, et falſæ voculæ, quam certæ, et ſeveræ? quibus tamen non modo auſteri, ſed ſi ſæpius fiunt, multitudo ipſa reclamat. Cic. de Oratore, Lib. III. Art. xxv.

Ινα δὲ μᾶλλον ἡ διαφορὰ τῶν ἀνδρῶν γένηται καταφανής, εἰκόνι χρήσομαι τῶν ὁρατῶν τινι. εἰ δή τινες ἀρχαῖαι γραφαὶ χρώμασιν εἰργασμέναι ἁπλῶς, καὶ οὐδεμίαν ἐν τοῖς μίγμασιν ἔχουσαι ποικιλίαν, ἀκριβεῖς δὲ ταῖς γραμμαῖς, καὶ πολὺ τὸ χάριεν ἐν ταύταις ἔχουσαι, αἱ δὲ μετ' ἐκείνας εὔγραμμοι μὲν ἧττον, ἐξειργασμέναι δὲ μᾶλλον, σκιᾷ τε καὶ φωτὶ ποικιλλόμεναι, καὶ ἐν τῷ πλήθει τῶν μιγμάτων τὴν ἰσχὺν ἔχουσαι τούτων μὲν δὴ ταῖς ἀρχαιοτέραις ἔοικεν ὁ Λυσίας κατὰ τὴν ἁπλότητα καὶ τὴν χάριν· ταῖς δὲ ἐκπεπονημέναις τε καὶ τεχνικωτέραις ὁ Ἰσαῖος. Dion. Halicarn. in Judicio de Iſaeo, Art. iv.

Vel quum Pauſiaca torpes inſane tabella,
Subtilis veterum judex & callidus audis.
Horat. Lib. II. Sat. vii.

paſſion

Figure 4.4 Examples of images containing footnotes with a complex layout (e.g., two columns, figures, tables, formulas, Greek letters), which are hard to catch.

The second protocol used the 30%-70% set-up for dividing the dataset to the test and training sets. This scheme was done to make the comparison with other benchmark methods (Abuelwafa *et al.*, 2017; Mhiri *et al.*, 2017) possible. These benchmark methods, as described in the

Table 4.1 Experimental results using SVM and 10-fold CV set-up for the first experiment. Values are in percent and the bold numbers represent the best results.

Methods	Precision	Recall	F_measure
Single methods results:			
BBox	79.38	70.21	75.62
Proj	86.62	70.82	77.93
Space	**87.54**	74.77	80.66
Feature level fusion results:			
BBox+ Proj+ Space	83.33	**81.31**	**82.31**

Table 4.2 Experimental results using SVM and 10-fold CV set-up on the relaxed dataset for the first experiment. Values are in percent and the bold numbers represent the best results.

Methods	Precision	Recall	F_measure
Single methods results:			
BBox	85.07	77.45	81.08
Proj	90.35	79.00	84.30
Space	**91.07**	84.25	87.52
Feature level fusion results:			
BBox+ Proj+ Space	90.24	**86.21**	**88.17**

state-of-the-art section for footnotes (Chapter 2.2), both use deep learning based methods with minimum image processing approaches or any hand design features. Table 4.3 shows the results using the complete images of Trainset_0, using our proposed approach and the benchmark methods. Our proposed method has the highest precision among all other methods and competitive value of recall. Overall, our approach has the similar F_measure with the other proposed method. Also for relaxing the dataset case, it boosts the recall in favor of our proposed method while keeping the precision still high (See Table 4.4). Our method outperforms the others in the absence of any complex layout. Figure 4.5 illustrates this performance enhancement more clear.

Table 4.3 The first experiment results over 30%-70% set-up and their comparison with the state-of-the-art methods. Values are in percent, and the bold numbers represent the best results.

Methods	Precision	Recall	F_measure
Our proposed method	**83.89**	82.64	**83.26**
Method of Mhiri *et al.* (2017)	83.26	82.37	82.81
Method of Abuelwafa *et al.* (2017)	79.12	**85.71**	82.28

Table 4.4 The first experiment results over 30%-70% set-up on the relaxed dataset and their comparison with the state-of-the-art methods. Values are in percent, and the bold numbers represent the best results.

Methods	Precision	Recall	F_measure
Our proposed method	**89.91**	**87.44**	**88.66**
Method of Mhiri *et al.* (2017)	89.35	77.97	83.27
Method of Abuelwafa *et al.* (2017)	82.57	87.26	84.85

4.2.2.2 Second experiment

This experiment was done using over 27,000 labeled images. Trainset_1 as the test set and combination of Trainset_0, Trainset_2, Trainset_3 and Trainset_4 as the training set. This

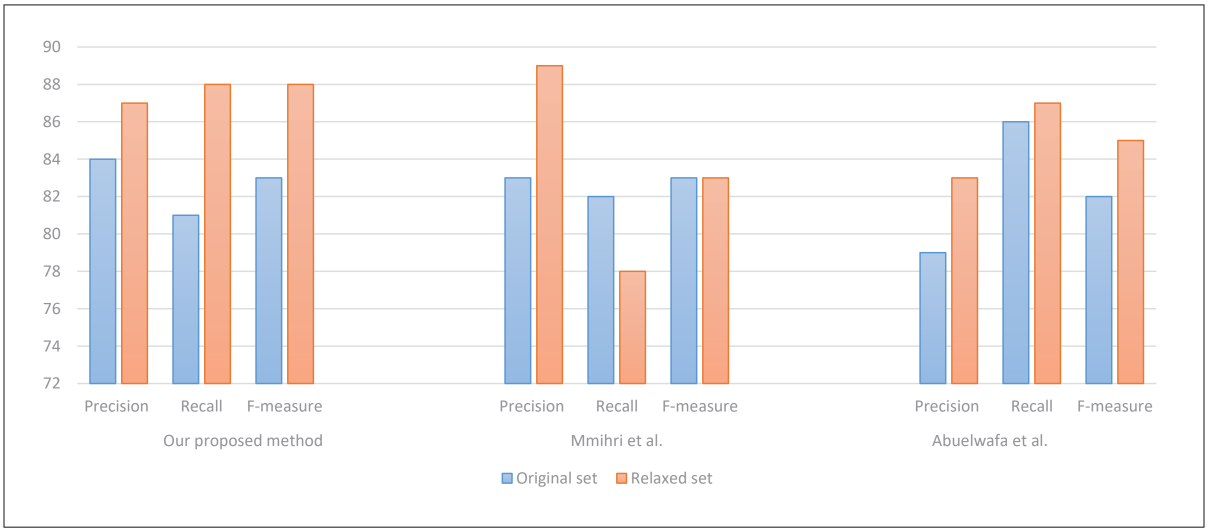


Figure 4.5 Result comparison for each method before and after relaxation. Values are in percent.

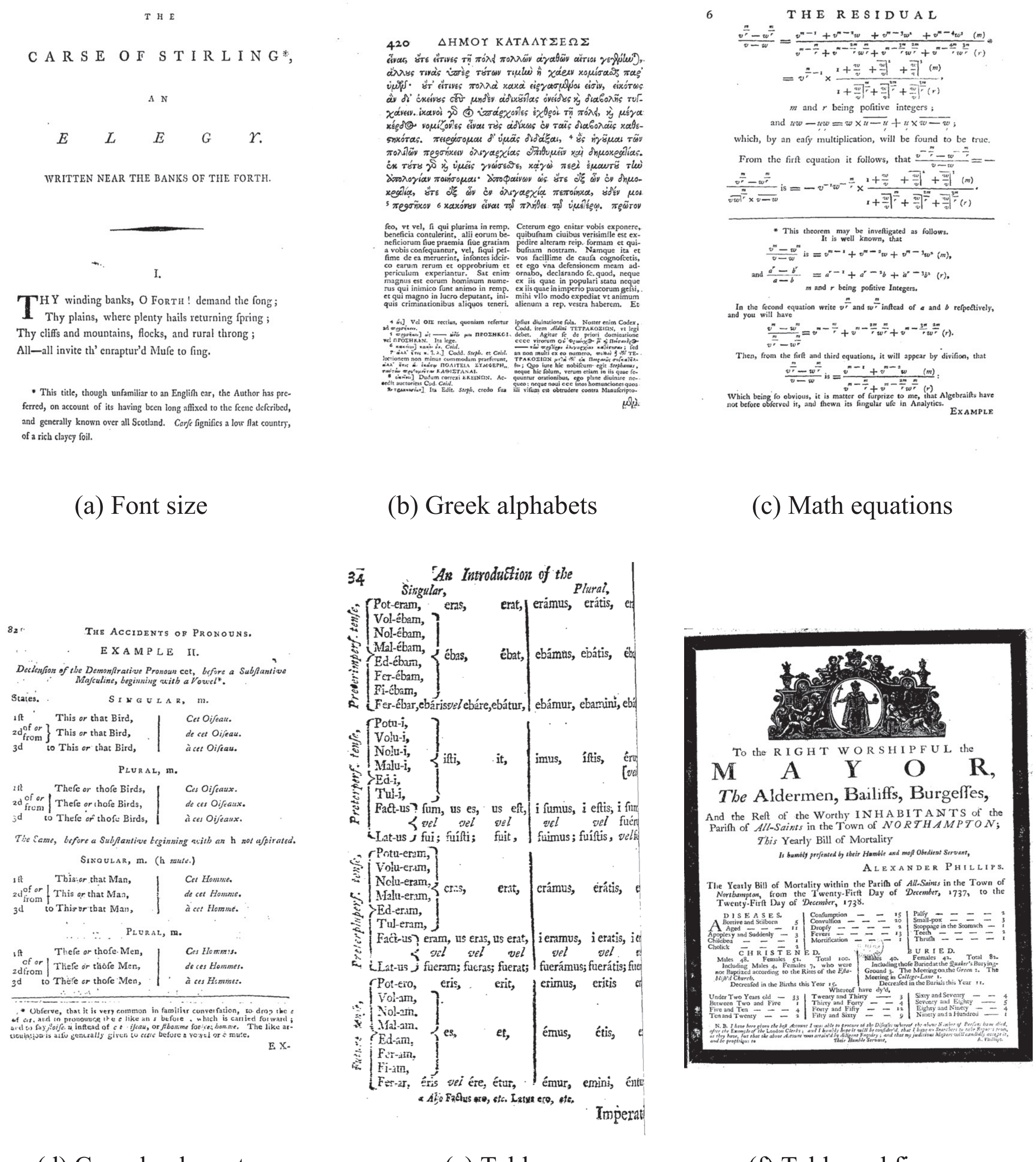
creates a training set of size 22,035 (FN: 6,071 images, NFN: 15,965 images) and a test set of size 5,520 (FN: 521 images, NFN: 4,999 images). The results of this experiment utilizing this dataset along two other benchmark methods are given in Table 4.5. We need to mention that updated versions of the benchmark methods are used to report their results. Our proposed method among others has the highest recall. This means that it is more capable than the other two deep learning-based methods in detecting a high portion of pages containing footnote. Also, even though our approach has lower precision value, it still has the best performance when we consider the F_measure value. Therefore, it has a better trade-off between the recall and precision values with respect to the others.

An overall look at the false positives and false negatives of our proposed method can give us good feedback regarding the strengths and limitations of our approach. While our method is capable of handling complex layout and structures, there are still some footnoted pages which are missed in our classification step. This kind of errors usually happens because our method is bind to its first step by layout analysis to extract lines. Therefore, even though precise measurement have been taken into account in the process, the appearance of some unusual structure can affect the results negatively. For example, having alternative font size changes on the page; or the occurrence of table and figure and a page containing a formula, Greek or Persian alphabets, all can be the source of an error. Besides, images that are highly degraded can cause errors. Moreover, since our hypothesis is built on the smaller font size of the footnote, the occurrence of smaller font size like notes and annotation at the bottom of the page can be mistakenly considered as a footnote. Figure 4.6 and Figure 4.7 show respectively examples of false negative images and false positive images using the proposed method.

Table 4.5 Experimental result for the second experiment. Values are in percent and the bold numbers represent the best results.

Methods	Precision	Recall	F_measure
Our proposed method	66.9	**59.8**	**63.15**
Method of Mhiri *et al.* (2017) *	**88.21**	47.4	61.66
Method of Abuelwafa *et al.* (2017)*	72.26	40.49	51.89

*The reported results are based on an updated version of proposed methods.



(a) Font size

(b) Greek alphabets

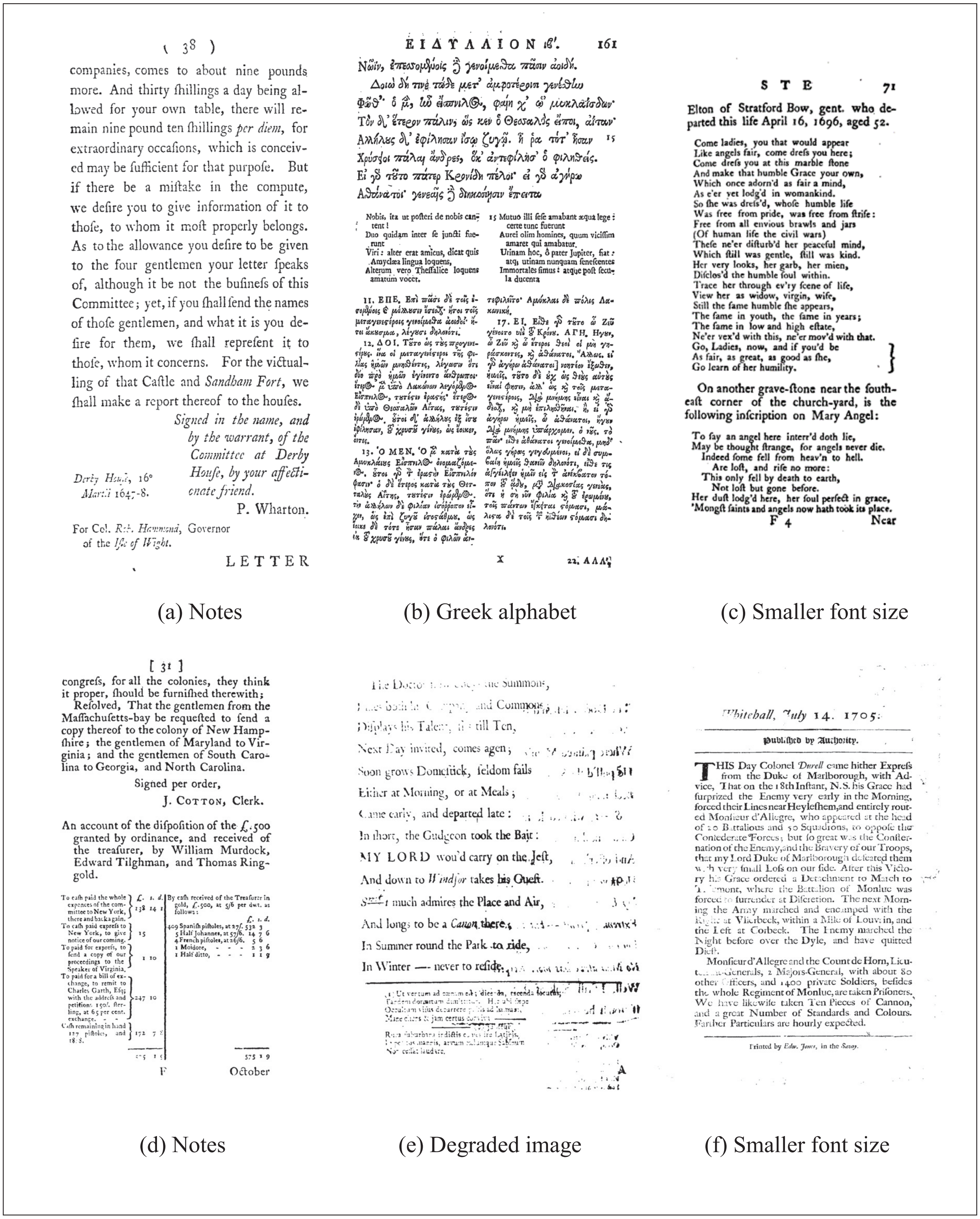
(c) Math equations

(d) Complex layout

(e) Table

(f) Table and figure

Figure 4.6 Examples of false negative images for the second experiment.



(38)

companies, comes to about nine pounds more. And thirty ſhillings a day being allowed for your own table, there will remain nine pound ten ſhillings *per diem*, for extraordinary occaſions, which is conceived may be ſufficient for that purpoſe. But if there be a miſtake in the compute, we deſire you to give information of it to thoſe, to whom it moſt properly belongs. As to the allowance you deſire to be given to the four gentlemen your letter ſpeaks of, although it be not the buſineſs of this Committee; yet, if you ſhall ſend the names of thoſe gentlemen, and what it is you deſire for them, we ſhall repreſent it to thoſe, whom it concerns. For the victualling of that Caſtle and *Sandham Fort*, we ſhall make a report thereof to the houſes.

Signed in the name, and by the warrant, of the Committee at Derby Houſe, by your affectionate friend.

P. Wharton.

Derby Houſe, 16°
Martii 1647-8.

For Col. *Rob. Hammond*, Governor
of the *Iſle of Wight*.

LETTER

(a) Notes

ΕΙΔΥΛΛΙΟΝ ιβ'. 161

Νῶϊν, ἐπεσσομένοις γὰρ γενοίμεθα πᾶσιν ἀοιδή.
Δοιώ δή τινε τώδε μετ' ἀμφοτέροισι γενέσθην
Φῶθ'· ὁ μὲν, ὡς εἴσπνιλος, φαίη χ' ὡ μυκλαΐσδων·
Τὸν δ' ἕτερον πάλιν, ὡς κεν ὁ Θεσσαλὸς εἴποι, ἀΐταν·
Ἀλλήλους δ' ἐφίλησαν ἴσῳ ζυγῷ. ἦ ῥα τότ' ἦσαν 15
Χρύσειοι πάλαι ἄνδρες, ὅτ' ἀντεφίλησ' ὁ φιληθείς.
Εἰ γὰρ τοῦτο πάτερ Κρονίδη πέλοι· εἰ γὰρ ἀγήρω
Ἀθάνατοι· γενεαῖς δὲ διηκοσίῃσιν ἔπειτα

Nobis, ita ut poſteri de nobis cantent!
Duo quidam inter ſe juncti fuerunt
Viri: alter erat amicus, dicat quis Amyclæa lingua loquens,
Alterum vero Theſſalice loquens amatum vocet.

15 Mutuo illi ſeſe amabant æqua lege: certe tunc fuerunt
Aurei olim homines, quum viciſſim amaret qui amabatur.
Urinam hoc, ô pater Jupiter, fiat: atq; utinam nunquam ſeneſcentes
Immortales ſimus: atque poſt ſecula ducenta

11. ΕΠΕ. Ἐπὶ πᾶσι δὲ τοῖς ἐσσομένοις καὶ μέλλουσιν ἔσεσθαι· ἤτοι τοῖς μεταγενεστέροις γενοίμεθα ἀοιδοί· ἤτοι ἄκουσμα, λέγουσι δηλονότι.

12. ΔΟΙ. Τοῦτο ὡς τοὺς προγενεστέρους. ἵνα οἱ μεταγενέστεροι τῆς φιλίας ἡμῶν μνησθέντες, λέγωσιν ὅτι δύο πρὸ ἡμῶν ἐγένοντο ἄνθρωποι· ἕτερος μὲν ὑπὸ Λακώνων λεγόμενος Εἴσπνιλος, τουτέστιν ἐραστής· ἕτερος δὲ ὑπὸ Θεσσαλῶν Αἴτας, τουτέστιν ἐρώμενος. οὗτοι δ' ἀλλήλους ἐξ ἴσου ἐφίλησαν, τοῦ χρυσοῦ γένους, ὡς ἔοικεν, ὄντες.

13. Ὁ ΜΕΝ. Ὁ μὲν κατὰ τοὺς Ἀμυκλαίους Εἴσπνιλος ὀνομαζόμενος. οὗτοι γὰρ τὸν ἐραστὴν Εἴσπνιλον φασιν· ὁ δὲ ἕτερος κατὰ τοὺς Θετταλοὺς Αἴτης, τουτέστιν ἐρώμενος. τὴν ἀλλήλων δὲ φιλίαν ἰσόρροπον εἶχον, ὡς ἐπὶ ζυγοῦ ἰσοστάθμου. ὡς ἔοικε δὲ τότε ἦσαν πάλαι ἄνδρες ἐκ τοῦ χρυσοῦ γένους, ὅτε ὁ φιλῶν ἀντεφιλεῖτο· Ἀμύκλαι δὲ πόλις Λακωνική.

17. ΕΙ. Εἴθε γὰρ τοῦτο ὦ Ζεῦ γένοιτο υἱὲ τοῦ Κρόνου. ΑΓΗ. Ἤγουν, ὦ Ζεῦ καὶ ὦ ἕτεροι θεοὶ οἱ μὴ γηράσκοντες, καὶ ἀθάνατοι. Ἄλλως. εἰ γὰρ ἀγήρω ἀθάνατοι] νοητέον ἔξωθεν, ἡμεῖς. τοῦτο δὲ οὐχ ὡς θεοὺς αὐτοὺς εἶναί φησιν, ἀλλ' ὡς καὶ τοῖς μεταγενεστέροις, διὰ μνήμης εἶναι καὶ ᾄδεσθαι, καὶ μὴ ἐπιλησθῆναι. ἢ, εἰ γὰρ ἀγήρω ἡμεῖς, ὦ ἀθάνατοι, ἤγουν διὰ μνήμης ὑπάρχομεν. ὁ νοῦς. τὸ πᾶν· εἴθε ἀθάνατοι γενοίμεθα, μηδ' ὅλως γήρως γευσάμενοι, εἰ δὲ συμβαίη ἡμεῖς θανεῖν δηλονότι, εἴθε τις ἀγγείλειεν ἡμῖν εἰς τὸν ἀνέκβατον τόπον τοῦ ᾅδου, μετὰ διακοσίας γενεὰς, ὅτι ἡ σὴ νῦν φιλία καὶ τοῦ ἐρωμένου, τοῖς πάντων ἔγκειται στόμασι, μάλιστα δὲ τοῖς τῶν ἠϊθέων στόμασι δηλονότι.

X 22. ΑΛΛ'

(b) Greek alphabet

S T E 71

Elton of Stratford Bow, gent. who departed this life April 16, 1696, aged 52.

Come ladies, you that would appear
Like angels fair, come dreſs you here;
Come dreſs you at this marble ſtone
And make that humble Grace your own,
Which once adorn'd as fair a mind,
As e'er yet lodg'd in womankind.
So ſhe was dreſs'd, whoſe humble life
Was free from pride, was free from ſtrife:
Free from all envious brawls and jars
(Of human life the civil wars)
Theſe ne'er diſturb'd her peaceful mind,
Which ſtill was gentle, ſtill was kind.
Her very looks, her garb, her mien,
Diſclos'd the humble ſoul within.
Trace her through ev'ry ſcene of life,
View her as widow, virgin, wife,
Still the ſame humble ſhe appears,
The ſame in youth, the ſame in years;
The ſame in low and high eſtate,
Ne'er vex'd with this, ne'er mov'd with that.
Go, Ladies, now, and if you'd be }
As fair, as great, as good as ſhe, }
Go learn of her humility. }

On another grave-ſtone near the ſouth-eaſt corner of the church-yard, is the following inſcription on Mary Angel:

To ſay an angel here interr'd doth lie,
May be thought ſtrange, for angels never die.
  Indeed ſome fell from heav'n to hell.
    Are loſt, and riſe no more:
  This only fell by death to earth,
    Not loſt but gone before.
Her duſt lodg'd here, her ſoul perfect in grace,
'Mongſt ſaints and angels now hath took its place.

F 4 Near

(c) Smaller font size

[31]

congreſs, for all the colonies, they think it proper, ſhould be furniſhed therewith;

Reſolved, That the gentlemen from the Maſſachuſetts-bay be requeſted to ſend a copy thereof to the colony of New Hampſhire; the gentlemen of Maryland to Virginia; and the gentlemen of South Carolina to Georgia, and North Carolina.

Signed per order,

J. Cotton, Clerk.

An account of the diſpoſition of the £.500 granted by ordinance, and received of the treaſurer, by William Murdock, Edward Tilghman, and Thomas Ringgold.

	£.	s.	d.
To caſh paid the whole expences of the committee to New York, there and back again.	138	14	1
To caſh paid expreſs to New York, to give notice of our coming.	15		
To paid for expreſs, to ſend a copy of our proceedings to the Speaker of Virginia.	1	10	
To paid for a bill of exchange, to remit to Charles Garth, Eſq; with the addreſs and petition: 150*l.* ſterling, at 65 per cent. exchange. - -	247	10	
Caſh remaining in hand 127 piſtoles, and 18: 8.	172	7	8
	575	1	9

By caſh received of the Treaſurer in gold, £.500, at 5/6 per dwt. as follows:

	£.	s.	d.
409 Spaniſh piſtoles, at 27*ſ*.	532	3	
5 Half Johannes, at 57/6.	14	7	6
4 French piſtoles, at 26/6.	5	6	
1 Moidore, - - -	2	3	6
1 Half ditto, - - -	1	1	9
	575	1	9

F October

(d) Notes

The Doctor [illegible] the Summons,
[illegible] both in C[illegible] and Commons,
Diſplays his Talent, [illegible] till Ten,
Next Day invited, comes agen;
Soon grows Domeſtick, ſeldom fails
Either at Morning, or at Meals;
Came early, and departed late:
In ſhort, the Gudgeon took the Bait:
MY LORD wou'd carry on the Jeſt,
And down to *Windſor* takes his Gueſt.
S——t much admires the Place and Air,
And longs to be a *Canon* there.
In Summer round the Park to ride,
In Winter —- never to reſide.

(1) Ut ventum ad cœnam eſt; dicenda, tacenda locutus,
Tandem dormitum dimittitur. Hic ubi ſæpe
Occultum viſus decurrere piſcis ad hamum,
Mane cliens & jam certus conviva ———
——— [illegible]
Rura ſuburbana indictis comes ire Latinis,
Impoſitus mannis, arvum cœlumque Sabinum
Non ceſſat laudare.

A

(e) Degraded image

Whitehall, July 14. 1705.

Publiſhed by Authority.

THIS Day Colonel *Durell* came hither Expreſs from the Duke of Marlborough, with Advice, That on the 18th Inſtant, N.S. his Grace had ſurprized the Enemy very early in the Morning, forced their Lines near Heyleſhem, and entirely routed Monſieur d'Allegre, who appeared at the head of 20 Battalious and 50 Squadrons, to oppoſe the Confederate Forces; but ſo great was the Conſternation of the Enemy, and the Bravery of our Troops, that my Lord Duke of Marlborough defeated them with very ſmall Loſs on our ſide. After this Victory his Grace ordered a Detachment to March to Tirlemont, where the Battalion of Monluc was forced to ſurrender at Diſcretion. The next Morning the Army marched and encamped with the Right at Vlierbeck, within a Mile of Louvain, and the Left at Corbeck. The Enemy marched the Night before over the Dyle, and have quitted Dieſt.

Monſieur d'Allegre and the Count de Horn, Lieutenant-Generals, 2 Majors-General, with about 80 other Officers, and 1400 private Soldiers, beſides the whole Regiment of Monluc, are taken Priſoners. We have likewiſe taken Ten Pieces of Cannon, and a great Number of Standards and Colours. Farther Particulars are hourly expected.

Printed by *Edw. Jones*, in the *Savoy*.

(f) Smaller font size

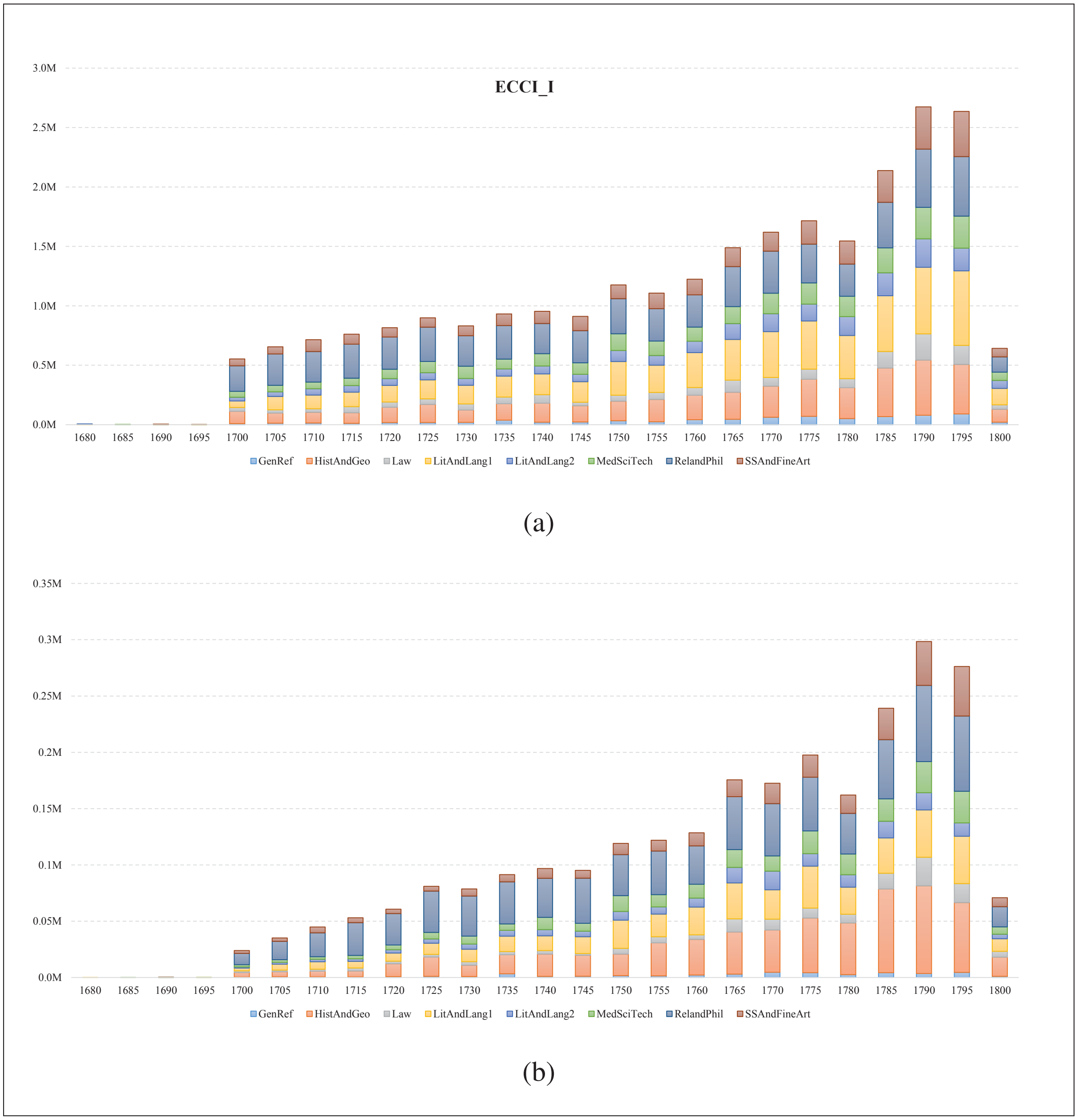
Figure 4.7 Examples of false positive images for the second experiment.

4.2.3 The third experiment

We showed the generalization power of our method by applying it to remaining images of the ECCO_I and the entire ECCO_II images (approximately 32 million images). This experiment was done using all available labeled data (27,588 images) as the training set and both ECCO_I and ECCO_II separately as the test sets. Applying the proposed method to the full ECCO dataset has led us to detect 2,551,827 and 587,928 images containing footnote for ECCO_I and ECCO_II, respectively. Figure 4.8 and Figure 4.9 give more information about the number and distribution of the detected images containing footnote throughout the years and subjects. From these two figures and comparing the distribution charts of the full data and footnoted data, it can be seen that the distribution of page with footnotes are very consistent with their complete datasets over the time and subjects. This can be interpreted as our proposed method has not missed footnotes in any subject or period during the detection process.

We expect that our method is capable of detecting footnote images with relatively high precision in both datasets. However, evaluating the performance in this scenario is a troublesome challenge since labeling over 32 million images will be a tedious and costly task. Therefore, we narrowed down our evaluation to only detect the precision of our method on sample sets of the ECCO_I and ECCO_II. For this mean, we sampled 1,500 images from the images detected as the footnote in each of ECCO_I and ECCO_II and labeled them. The final performance was estimated using the precision of detection over these 3,000 images.

Table 4.6 shows the precision results on the proposed method in comparison with state-of-the-art methods. Our method has the higher precision on the sample set compared to the deep learning based approaches. This proves that our approach was capable of keeping up with its performance even with a large increase in the amount of data. One reason that can justify the deep learning based methods lower performance is the fact that their techniques either partially use the image information on the bottom and top of the images, or their histogram, which both are clearly not enough for deciding on the presence of footnotes in a million scale. Also, maybe the training data is not capable of generalizing the whole ECCO set, and when the



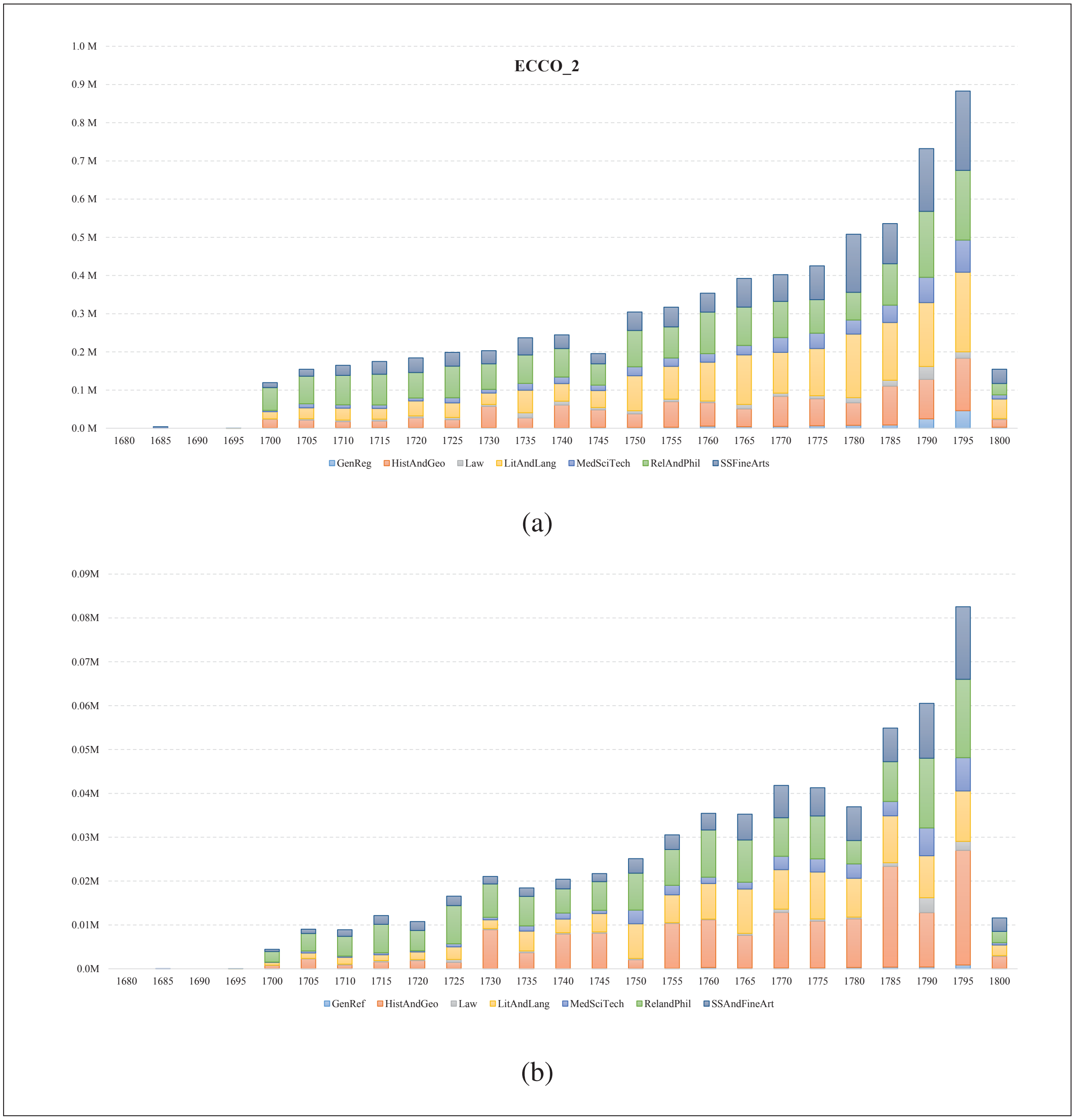
(a)

(b)

Figure 4.8 The histogram charts for the distribution of the images over the time in ECCO_I dataset: (a) all pages (b) detected pages with footnotes.

learning model encounters a new image that has not seen its similar ones before, it collapses. Thus, adding more training data may help in the improvement of the results.

From the result evaluation of these two sampled subsets, it can be seen that our method has been mostly successful in detecting the pages containing footnotes. However, there are some



(a)

(b)

Figure 4.9 The histogram charts for the distribution of the images over the time in ECCO_II dataset: (a) all pages (b) detected pages with footnotes.

common errors. One happens when the pages contain annotation or notes. Another source of common mistakes is when everything indicates the existence of the footnote even the font size, but there is no marker. Differentiating between these notes or annotation and the footnote is hard to even human eyes.

Table 4.6 Precision comparison of ECCO_I and ECCO_II.

Dataset	Our proposed method	Method of Abuelwafa *et al.* (2017)*	Method of Mhiri *et al.* (2017)*
ECCO_I	**91.13**	75.73	26.33
ECCO_II	**91.40**	76.00	25.20

*The reported results are based on an updated version of proposed methods.

4.3 Table-based document image classification

Our proposed algorithm for table detection in historical document images was evaluated on two datasets. Different experiments were also conducted to test the performance and robustness of our method.

4.3.1 Datasets

We used two datasets for evaluating our proposed method, a dataset of handwritten and printed Arabic documents and a dataset containing printed documents from 18th-century.

The purpose of using the first dataset was validating our method against the work done by Kumar *et al.* (2012). There is a lack of publicly available datasets with a fair number of images, which makes the comparison with other benchmarks harder. Their dataset contains 618 Arabic document images, where 216 images belong to a collection of hand-drawn and printed document pages with a table and 402 images are from mixed form document pages. Figure 4.10 and Figure 4.11 illustrate some examples from two classes of this dataset.

Most available datasets are designed to detect the region of the table and localize it. They usually contain less than 200 tabular images, which are defiantly not enough for training purposes. More importantly, they generally only target a specific type of tables and not cover both NRL-Ts and RL-Ts. To overcome this shortcoming, we generated a dataset called Dataset_v01 using the images available in ECCO collection of 18th-century printed images. This dataset is built from two subsets. The first subset and the second one are both randomly selected from the combination of ECCO_I and ECCO_II to keep the similar distributions as ECCO_I and

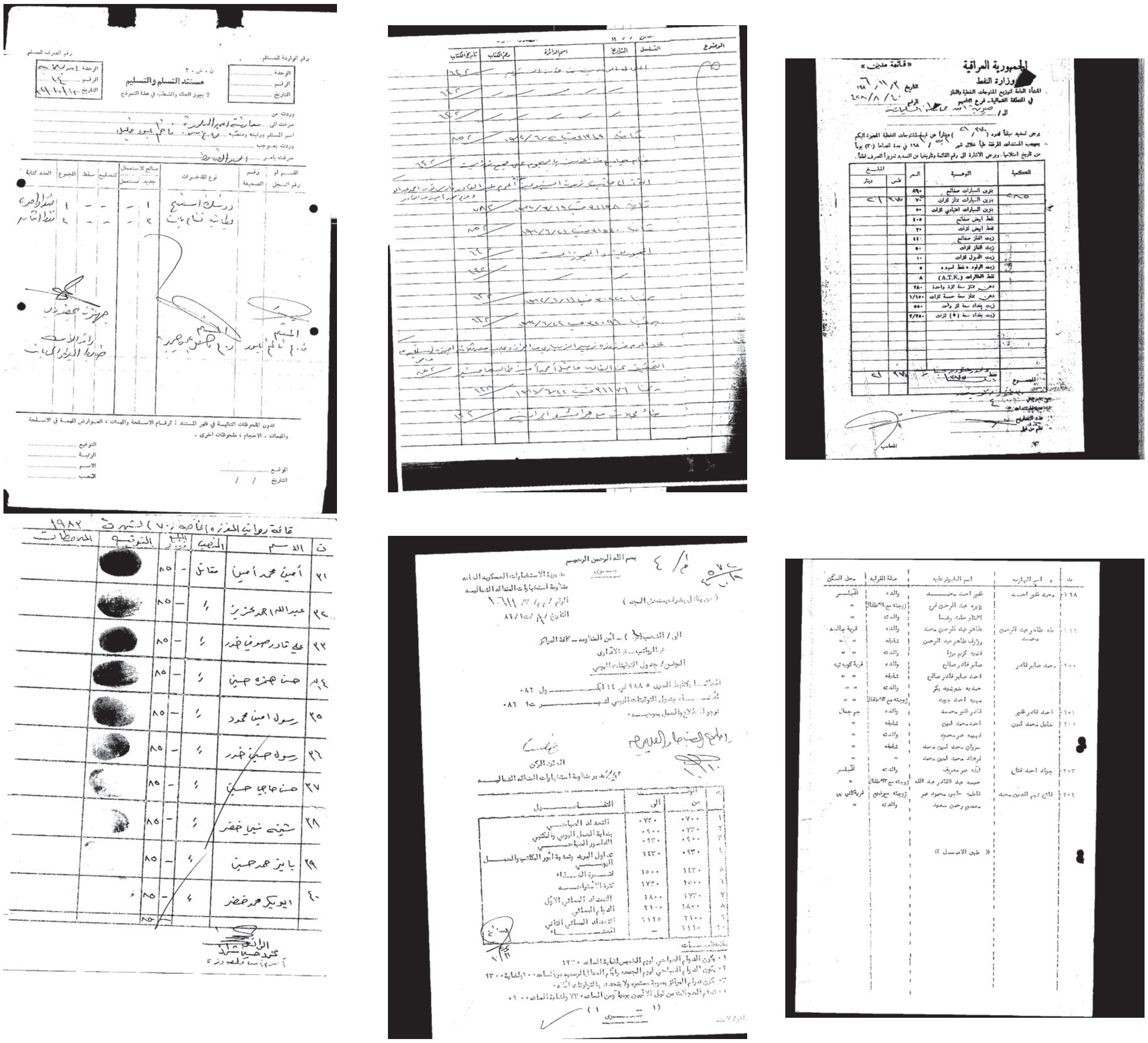


Figure 4.10 Examples of hand-drawn and printed document pages with a table from the dataset of Kumar *et al.* (2012).

ECCO_II over the time and subjects (see Figure 4.12). These images are then labeled according to not having a table (NT) or having the general (T2) and loose (T1) definition of tables. These two subsets are called Dataset_v0 and Dataset_v1, where the former has 6,406 images, and the later has 6,728 images. Figure 4.13 gives more insight into the content of each dataset.

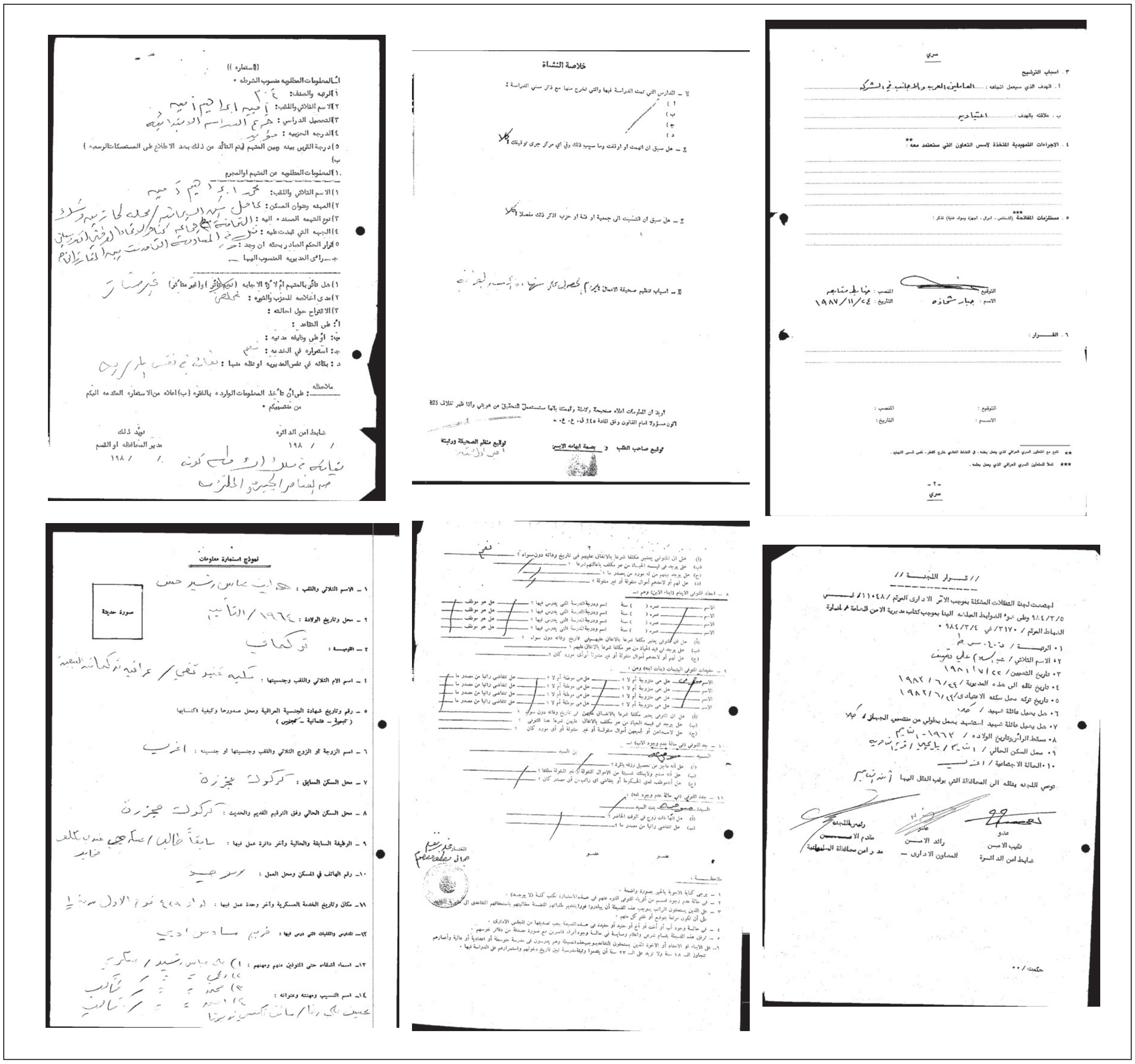


Figure 4.11 Examples of mixed form document pages from the dataset of Kumar *et al.* (2012).

4.3.2 Results and discussion

The proposed table-based document classification approach was evaluated using the aforementioned datasets and different experimental set-ups. These experiments show the performance and generalization power of our proposed framework. Below, we briefly describe each experiment and discuss regarding their results.

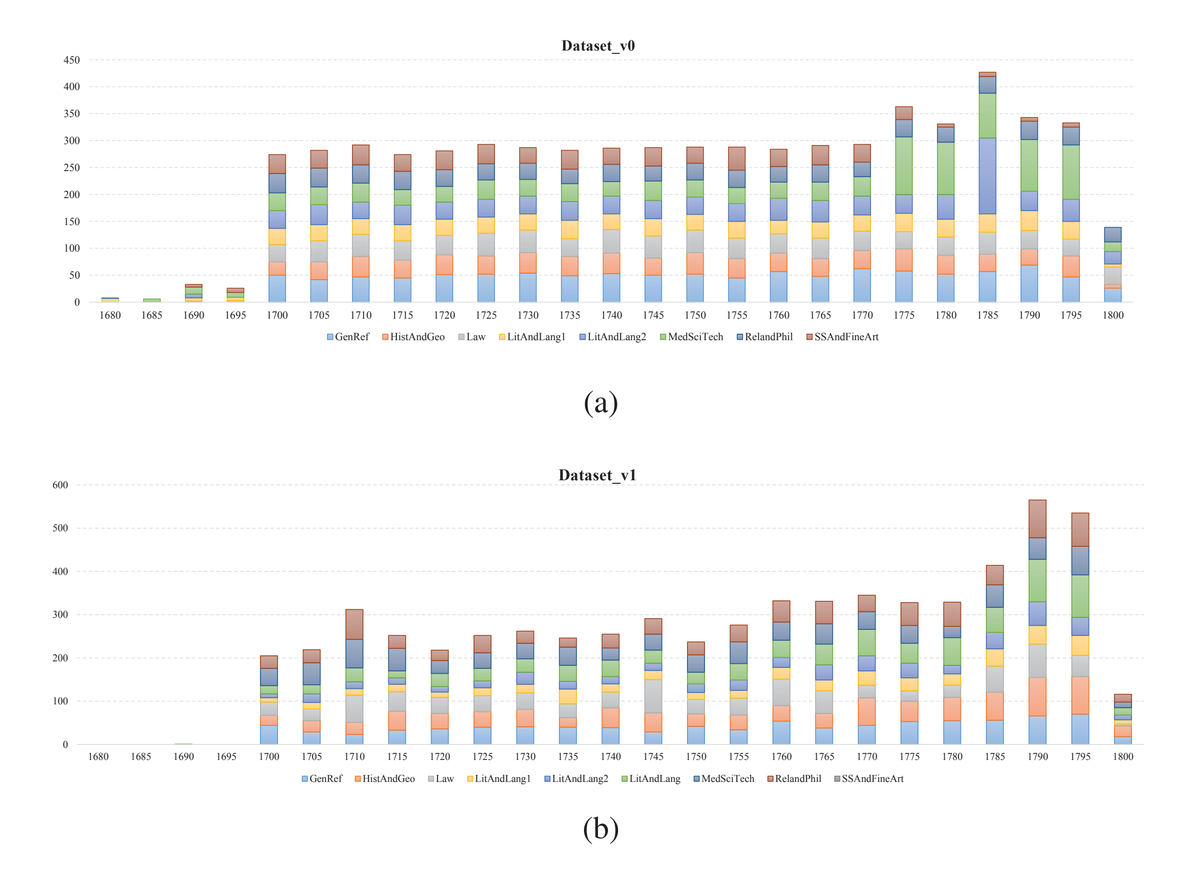
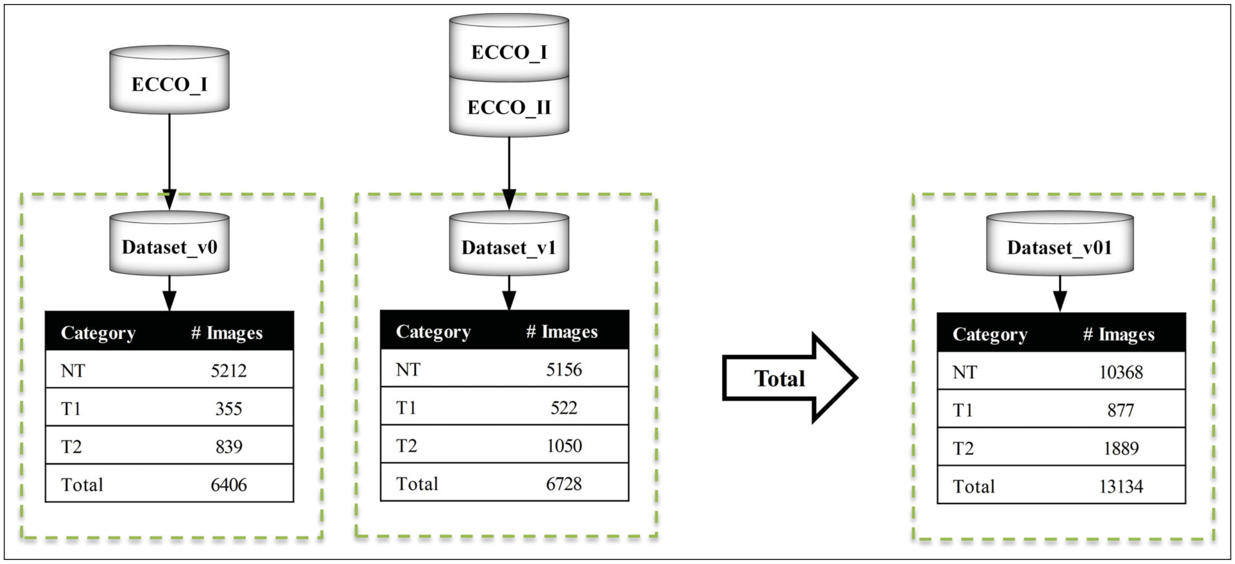


Figure 4.12 The histogram charts for the distributions of the images over the time at in (a) Dataset_v0 (b) Dataset_v1.

4.3.2.1 Experiments on the first dataset

To compare our method with the proposed approach of Kumar *et al.* (2012), we used a 5-fold CV set-up by randomly dividing their dataset to five folds and used one fold as the test set and the rest as the training set in each round. In any case, we needed a validation set to predict the parameters; we used one fold of the training set. The proposed method by Kumar *et al.* (2012) uses a 6,300-dimensional feature vector called horizontal-vertical pooling (HVP). They tested the accuracy of their system using two classifiers; SVM and RF. Using the same classifiers, we compared our method and the results are given in Table 4.7. These results are the accuracy values since Kumar *et al.* (2012) reported their results only using this metric. A brief look at the table makes it clear that our method outperforms their method by applying any of the



Category	# Images
NT	5212
T1	355
T2	839
Total	6406

Category	# Images
NT	5156
T1	522
T2	1050
Total	6728

Category	# Images
NT	10368
T1	877
T2	1889
Total	13134

Figure 4.13 The information on the labeled table dataset (Dataset_v01).

classifiers and with a fewer number of features (557 features for our proposed approach). It is good to mention that the high amount of accuracies (above 98%) is partially related to the nature of this dataset that only contains either forms or tables. This makes the discriminating of the classes easier for the classifiers. However, this does not undermine the value of this dataset especially that the tables are from both categories of NRL-Ts and RL-Ts.

Table 4.7 Experimental results using the first dataset and 5-fold CV along its comparison with the proposed method by Kumar *et al.* (2012). Values are in percent, and the bold numbers represent the best results.

	HVP SVM	MFCC based SVM	HVP RF	MFCC based RF
Table	93.2	94.4	97.4	**97.84**
Forms	97.6	98.43	98.9	**99.67**

4.3.2.2 Experiments on the second dataset

As mentioned in chapter 3.1.2, T1 tables or the loose definition tables are a subset of the T2 or general tables. In order to evaluate our table detection approach and in the meantime to study which category these loose tables belong; no tables or general tables, we conducted the experiments using two schemes:

1. **Combining T1 and T2 and classify them against NT (NTvsT1T2):** This scheme considers T2 and its subset T1 as tables. We expect a lower performance in the experiments using this manner since the T1 class is visually the less similar class to T2, and even though it is a subset of T2 differentiating T1 and T2 is a complicated process.
2. **Combining T1 and NT and classify them against T2 (NTT1vsT2):** This step considers the loose definition as an NT class. However, due to the non-tabular appearance of some of the T1 class members, the performance is expected to be higher.

We performed each of these schemes on Dataset_v0, Dataset_v1 and the combination of these two (Dataset_v01) using a 5-fold cross validation set-up. As before, one fold of the training set was assigned as the validation set to find the parameters of the classifier. Table 4.8 , Table 4.9 and Table 4.10 show the classification results for each dataset using these schemes. Our concern is more about the recall and precision values of either T1 or T1T2 classes depending on the used scheme.

The classification results confirm our prediction that mixing T1 with NT (NTT1vsT2) improves the table detection process compared to mixing T1 with T2 (NTvsT1T2). This improvement happens mostly on Dataset_v0 rather than Dataset_v1. One reason can be some mislabeled images in the T1 class of Dataset_v1. From the classification results, we can also observe that in all cases we have precision above 83%, which indicates two points. First, the ability of our approach to detect tables with high precision and second the generalization power of our method. This value for the Dataset_v01, with over 13,000 images is 86% and considering the complex layout of our document images; it is an impressive amount. However, the dissimilar and heterogeneous layout of the T1 class makes finding all tabular images from T1 especially in the scheme of NTvsT1T2 challenging, and reduce the recall value to 63%. For Dataset_v01 and the NTvsT1T2 scheme this value is 66% and by changing the scheme to NTT1vsT2 recall increases to 71.80%.

Figure 4.14 and Figure4.15 illustrate some of the true positive examples of our algorithm for each of these scenarios. From the figure, it can be seen that the results are from a wide range of either RL-Ts or NRL-Ts, which proves the effectiveness of our method considering the complexity of these images.

Table 4.8 Classification results using two schemes of NTvsT1T2 and NTT1vsT2 over Dataset_v0. Values are in percent.

	NTvsT1T2		NTT1vsT2	
	NT	T1T2	NTT1	T2
Recall	96.81	71.30	98.48	76.51
Precision	93.66	83.61	96.54	88.33

Table 4.9 Classification results using two schemes of NTvsT1T2 and NTT1vsT2 over Dataset_v1. Values are in percent.

	NTvsT1T2		NTT1vsT2	
	NT	T1T2	NTT1	T2
Recall	96.62	63.25	97.90	66.14
Precision	89.98	84.56	94.28	84.69

Table 4.10 Classification results using two schemes of NTvsT1T2 and NTT1vsT2 over Dataset_v01. Values are in percent.

	NTvsT1T2		NTT1vsT2	
	NT	T1T2	NTT1	T2
Recall	96.72	66.09	98.11	71.80
Precision	91.47	84.29	95.24	86.32

The error analysis on the results using the proposed method rise two points. The first point is the complexity of the dataset we are dealing with here. Indices and contents along lists and catalogs are some of the contents of this dataset. These images are intuitively or even visually similar to the tables, however, in the best case scenario, they are categorized as T1, and we prefer not detecting them. There is also the problem of figures with tabular appearance. These figures with tabular content are really hard to detect especially for our algorithm which only

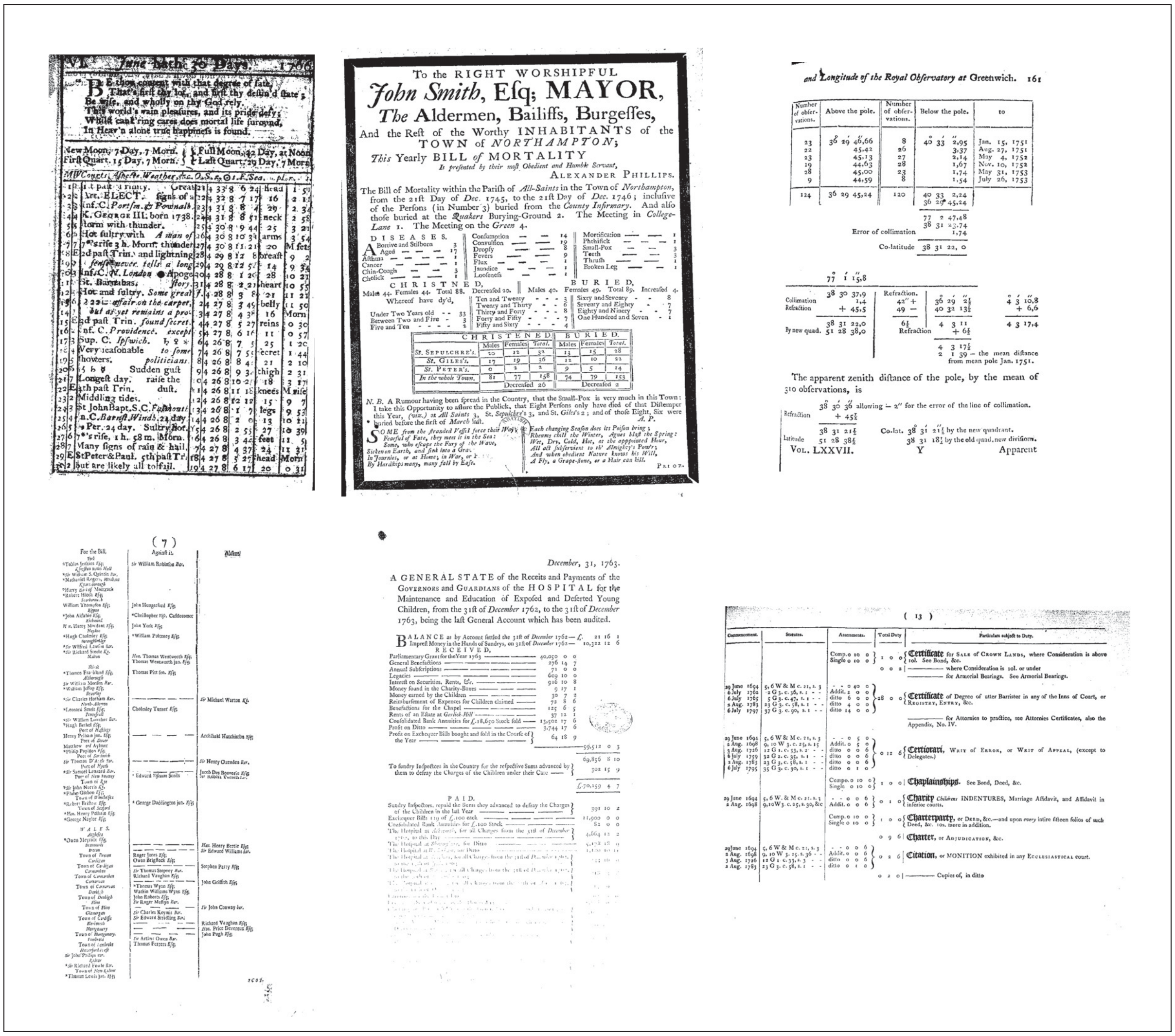
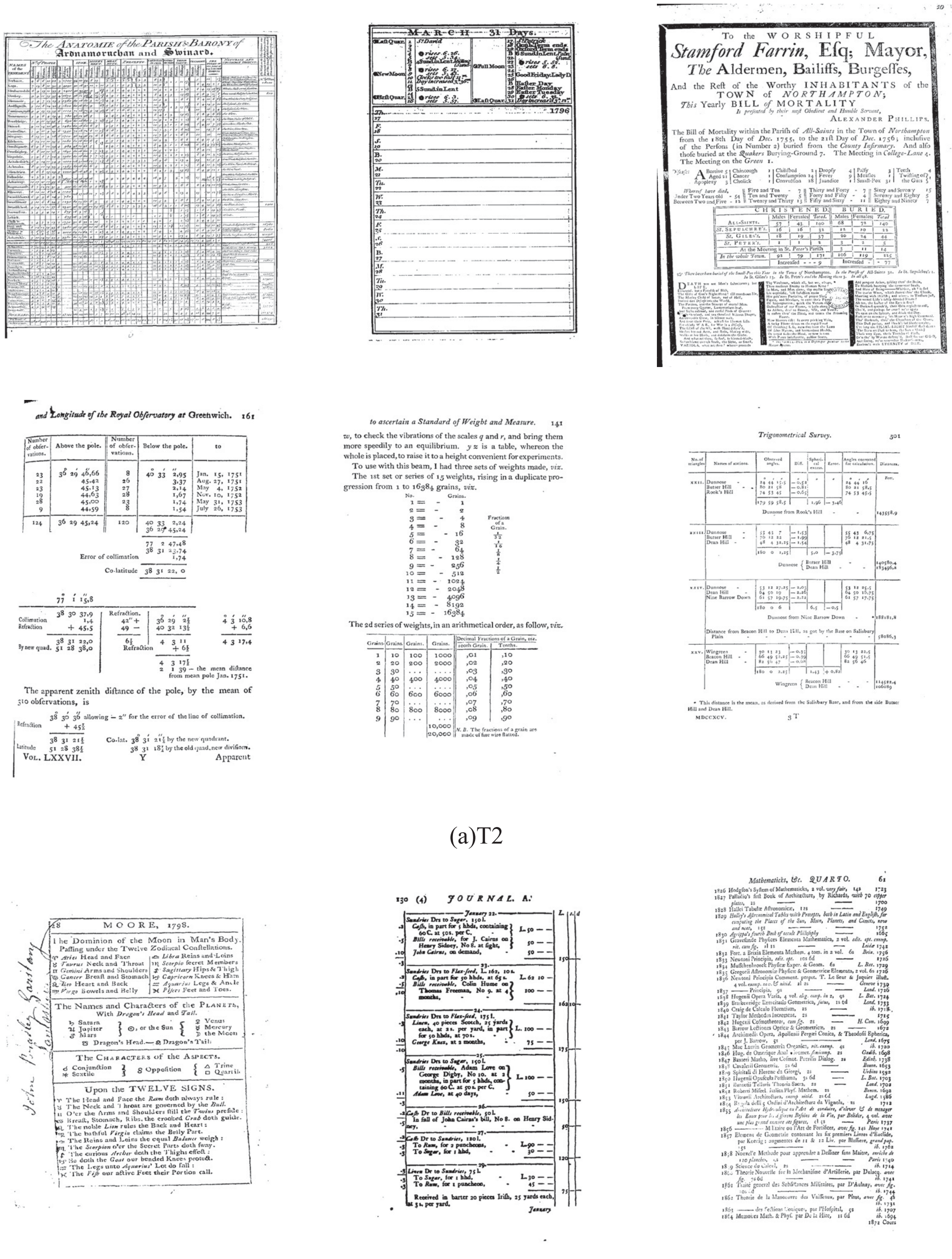


Figure 4.14 True positives for NTT1vsT2 Scheme.

depends on the frequency. Therefore, they are usually labeled as false positives. The other difficult to discriminate group is the multi-column pages. As the number of the columns rise, differentiating them and the tables become harder. The reverse scenario is also possible when the tables are mixed up with multi-column images resulting in having false negatives. The second point is related to some limitations of our method. In the presence of relatively high salt and pepper noise or in general term noises, our system can fail. It is the same for when the page contains large noisy white space. The weakness in the presence of noise is one of the limitations of MFCC-based methods. Moreover, the first step of the resizing images to fix numbers can

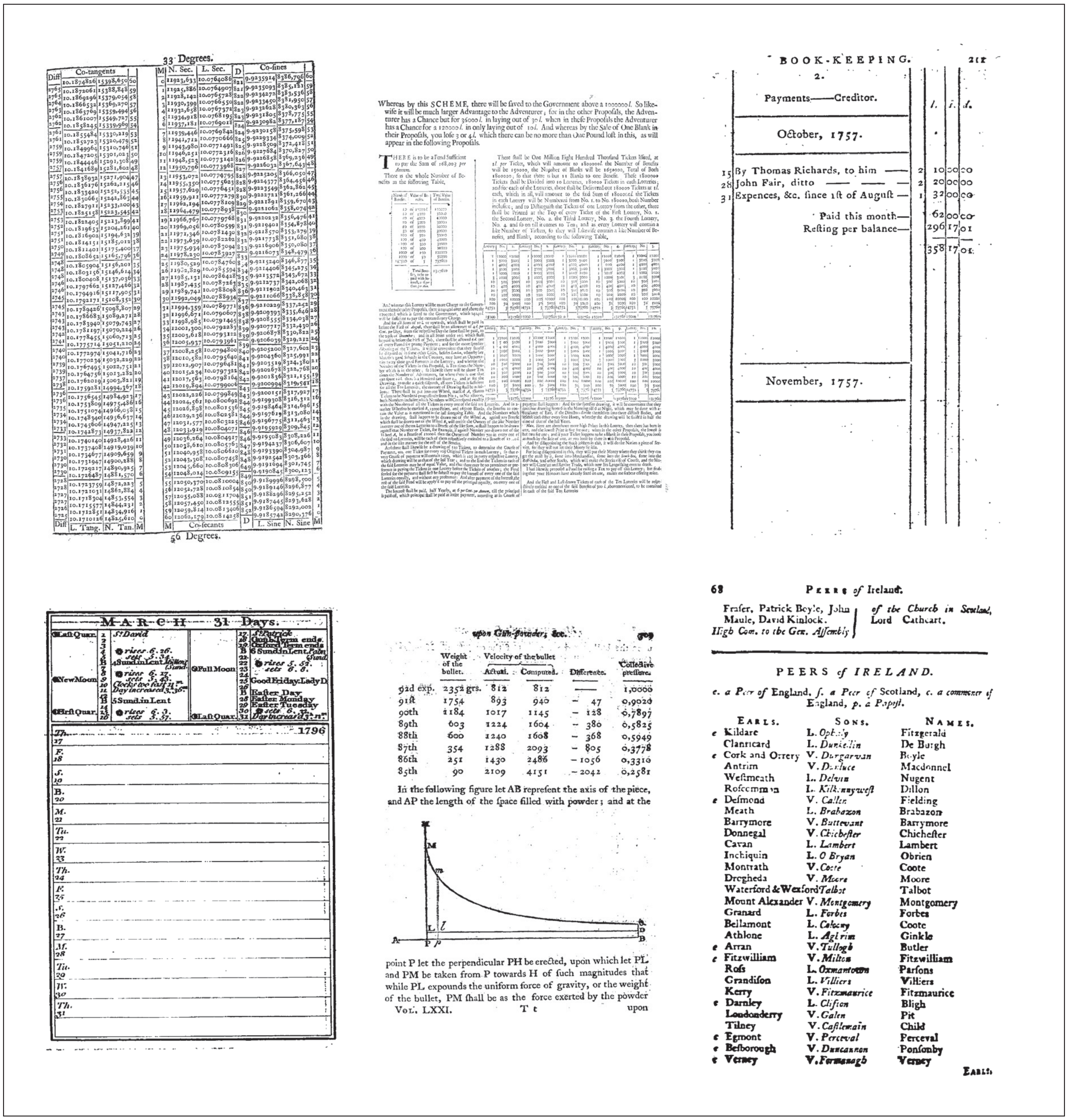


(a)T2

(b)T1

Figure 4.15 True positives for NTvsT1T2 Scheme from class (a) T2 and (b) T1.

cause problems in the further steps, like when images have a high resolution and making them smaller will result in losing useful information or when we have landscape images and resizing them to portrait orientation can be the beginning of errors. Having misdetections on a page with only texts rarely occurs unless when we encounter large fonts with enormous gaps between each character. Figure 4.16 to Figure 4.19 provide some examples of false negatives and false positives for the total dataset_v01 on each of our schemes.



33 Degrees.

56 Degrees.

BOOK-KEEPING. 211

2.

Payments——Creditor.

October, 1757.

		l.	s.	d.
15	By Thomas Richards, to him ——	2	10	00
28	John Fair, ditto —— ——	2	20	00
31	Expences, &c. since 1st of Auguſt —	1	32	00
	Paid this month—		62	00
	Reſting per balance—		296	17	01
			358	17	01

November, 1757.

MARCH 31 Days.

1796

upon Gun-powder, &c.

	Weight of the bullet.	Velocity of the bullet Actual.	Computed.	Difference.	Collective preſſure.
92d exp.	2352 grs.	812	812	——	1,0000
91ſt	1754	893	940	— 47	0,9020
90th	1184	1017	1145	— 128	0,7897
89th	603	1224	1604	— 380	0,5825
88th	600	1240	1608	— 368	0,5949
87th	354	1288	2093	— 805	0,3778
86th	251	1430	2486	— 1056	0,3316
85th	90	2109	4151	— 2042	0,2581

In the following figure let AB repreſent the axis of the piece, and AP the length of the ſpace filled with powder; and at the

point P let the perpendicular PH be erected, upon which let PL and PM be taken from P towards H of ſuch magnitudes that while PL expounds the uniform force of gravity, or the weight of the bullet, PM ſhall be as the force exerted by the powder

VOL. LXXI. T t upon

68 PEERS of Ireland.

Fraſer, Patrick Boyle, John Maule, David Kinlock. High Com. to the Gen. Aſſembly | of the Church in Scotland, Lord Cathcart.

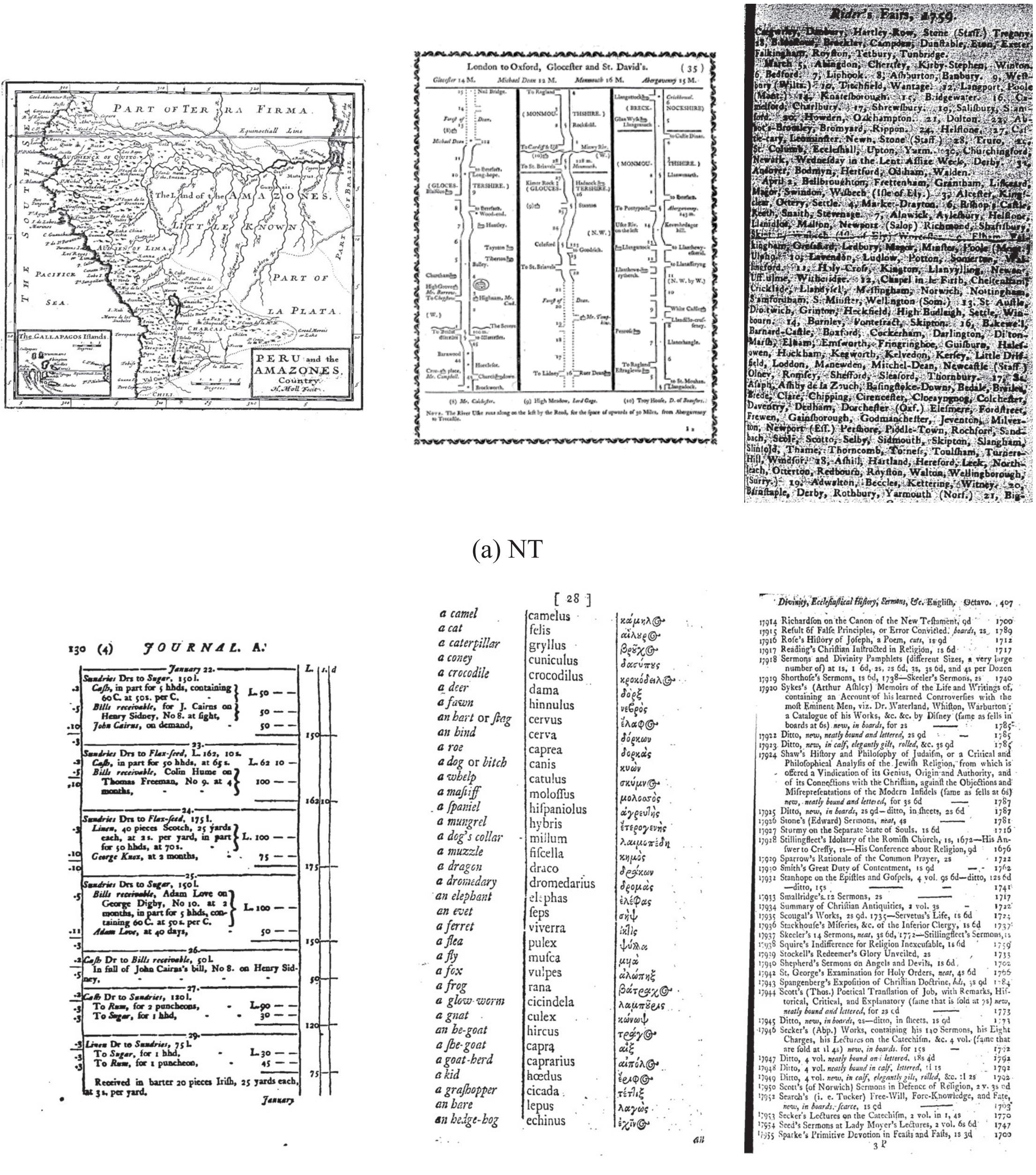
PEERS of IRELAND.

e. a Peer of England. ſ. a Peer of Scotland, c. a commoner of England, p. a Papiſt.

EARLS.	SONS.	NAMES.
e Kildare	L. Ophaly	Fitzgerald
Clanricard	L. Dunkelin	De Burgh
e Cork and Orrery	V. Dungarvan	Boyle
Antrim	V. Dunluce	Macdonnel
Weſtmeath	L. Delvin	Nugent
Roſcommon	L. Kilkenywest	Dillon
e Deſmond	V. Callen	Fielding
Meath	L. Brabazon	Brabazon
Barrymore	V. Buttevant	Barrymore
Donnegal	V. Chicheſter	Chicheſter
Cavan	L. Lambert	Lambert
Inchiquin	L. O Bryan	Obrien
Montrath	V. Coote	Coote
Drogheda	V. Moore	Moore
Waterford & Wexford	Talbot	Talbot
Mount Alexander	V. Montgomery	Montgomery
Granard	L. Forbes	Forbes
Bellamont	L. Coloony	Coote
Athlone	L. Aghrim	Ginkle
e Arran	V. Tullogh	Butler
e Fitzwilliam	V. Milton	Fitzwilliam
Roſs	L. Oxmantown	Parſons
Grandiſon	L. Villiers	Villiers
Kerry	V. Fitzmaurice	Fitzmaurice
e Darnley	L. Clifton	Bligh
Londonderry	V. Galen	Pit
Tilney	V. Caſtlemain	Child
e Egmont	V. Perceval	Perceval
e Beſborough	V. Duncannon	Ponſonby
e Verney	V. Fermanagh	Verney

EARLS

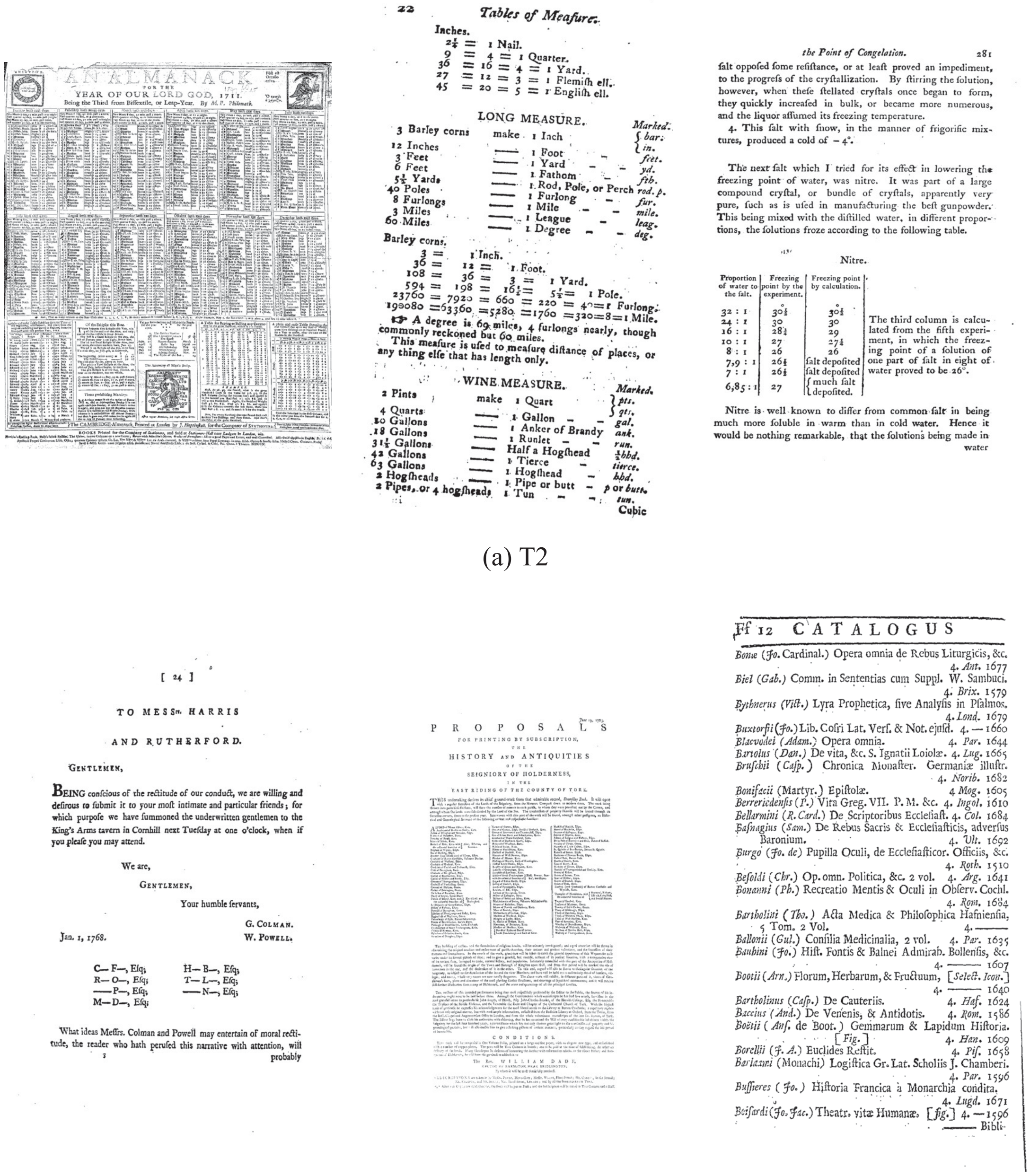
Figure 4.16 False Negatives NTT1vsT2 Scheme.



(a) NT

(b) T1

Figure 4.17 False Positives NTT1vsT2 Scheme from class (a) NT and (b) T1.



AN ALMANACK FOR THE YEAR OF OUR LORD GOD, 1711.
Being the Third from Biſſextile, or Leap-Year. By *M. P. Philomath.*

[illegible]

22 *Tables of Meaſure.*

Inches.

2¼ =	1 Nail.			
9 =	4 =	1 Quarter.		
36 =	16 =	4 =	1 Yard.	
27 =	12 =	3 =	1 Flemiſh ell.	
45 =	20 =	5 =	1 Engliſh ell.	

LONG MEASURE.

			Marked.
3 Barley corns	make	1 Inch	*bar.*
12 Inches	——	1 Foot –	*in.*
3 Feet	——	1 Yard – –	*feet.*
6 Feet	——	1 Fathom –	*yd.*
5½ Yards	——	1 Rod, Pole, or Perch	*fth.*
40 Poles	——	1 Furlong –	*rod. p.*
8 Furlongs	——	1 Mile – –	*fur.*
3 Miles	——	1 League –	*mile.*
60 Miles	——	1 Degree – –	*leag.*
			deg.

Barley corns.

3 =	1 Inch.					
36 =	12 =	1 Foot.				
108 =	36 =	3 =	1 Yard.			
594 =	198 =	16½=	5½=	1 Pole.		
23760 =	7920 =	660 =	220 =	40=	1 Furlong.	
190080 =	63360 =	5280 =	1760 =	320=	8=	1 Mile.

☞ A degree is 69 miles, 4 furlongs nearly, though commonly reckoned but 60 miles.

This meaſure is uſed to meaſure diſtance of places, or any thing elſe that has length only.

WINE MEASURE.

			Marked.
2 Pints	make	1 Quart	*pts.*
4 Quarts	——	1 Gallon – –	*qts.*
10 Gallons	——	1 Anker of Brandy	*gal.*
18 Gallons	——	1 Runlet – –	*ank.*
31½ Gallons	——	Half a Hogſhead	*run.*
42 Gallons	——	1 Tierce –	*½hhd.*
63 Gallons	——	1 Hogſhead –	*tierce.*
2 Hogſheads	——	1 Pipe or butt –	*hhd.*
2 Pipes, or 4 hogſheads		1 Tun – –	*p or butt.*
			tun.

Cubic

the Point of Congelation. 281

ſalt oppoſed ſome reſiſtance, or at leaſt proved an impediment, to the progreſs of the cryſtallization. By ſtirring the ſolution, however, when theſe ſtellated cryſtals once began to form, they quickly increaſed in bulk, or became more numerous, and the liquor aſſumed its freezing temperature.

4. This ſalt with ſnow, in the manner of frigorific mixtures, produced a cold of – 4°.

The next ſalt which I tried for its effect in lowering the freezing point of water, was nitre. It was part of a large compound cryſtal, or bundle of cryſtals, apparently very pure, ſuch as is uſed in manufacturing the beſt gunpowder. This being mixed with the diſtilled water, in different proportions, the ſolutions froze according to the following table.

Nitre.

Proportion of water to the ſalt.	Freezing point by the experiment.	Freezing point by calculation.
32 : 1	30½°	30½°
24 : 1	30	30
16 : 1	28¾	29
10 : 1	27	27¼
8 : 1	26	26
7,9 : 1	26½	ſalt depoſited
7 : 1	26½	ſalt depoſited
6,85 : 1	27	much ſalt depoſited.

The third column is calculated from the fifth experiment, in which the freezing point of a ſolution of one part of ſalt in eight of water proved to be 26°.

Nitre is well known to differ from common ſalt in being much more ſoluble in warm than in cold water. Hence it would be nothing remarkable, that the ſolutions being made in water

(a) T2

[24]

TO MESS^RS. HARRIS AND RUTHERFORD.

GENTLEMEN,

BEING conſcious of the rectitude of our conduct, we are willing and deſirous to ſubmit it to your moſt intimate and particular friends; for which purpoſe we have ſummoned the underwritten gentlemen to the King's Arms tavern in Cornhill next Tueſday at one o'clock, when if you pleaſe you may attend.

We are,
GENTLEMEN,
Your humble ſervants,
G. COLMAN.
Jan. 1, 1768. W. POWELL.

C— F—, Eſq; H— B—, Eſq;
R— O—, Eſq; T— L—, Eſq;
—— P—, Eſq; —— N—, Eſq;
M— D—, Eſq;

What ideas Meſſrs. Colman and Powell may entertain of moral rectitude, the reader who hath peruſed this narrative with attention, will probably

June 19, 1783.

PROPOSALS FOR PRINTING BY SUBSCRIPTION, THE HISTORY AND ANTIQUITIES OF THE SEIGNIORY OF HOLDERNESS, IN THE EAST RIDING OF THE COUNTY OF YORK.

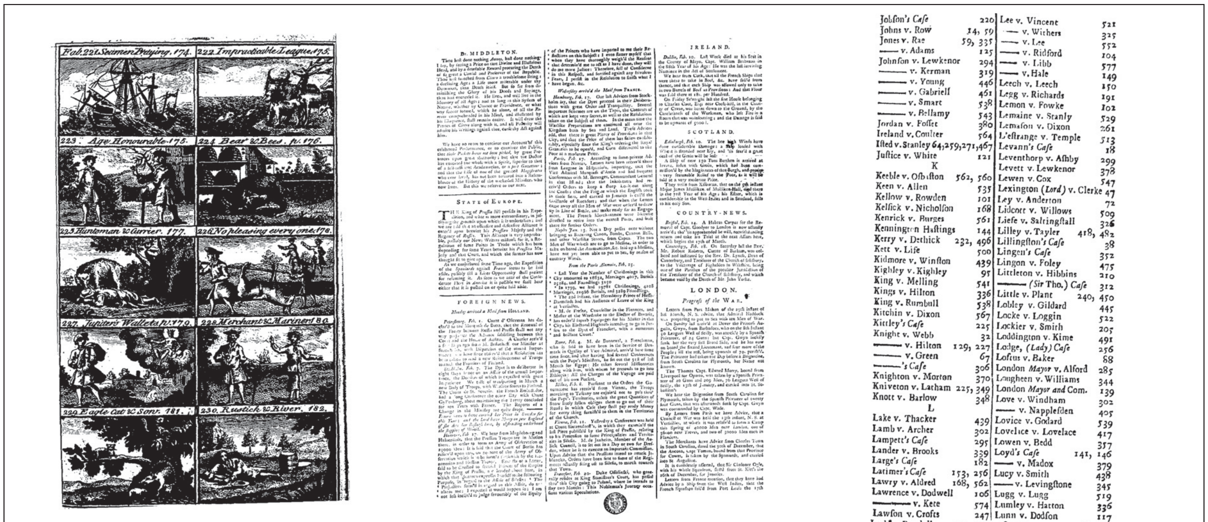
THIS undertaking derives its chief ground-work from that admirable record, *Doomſday Book.* [illegible]

Ff 12 CATALOGUS

Bonæ (*Jo.* Cardinal.) Opera omnia de Rebus Liturgicis, &c. 4. *Ant.* 1677
Biel (*Gab.*) Comm. in Sententias cum Suppl. W. Sambuci. 4. *Brix.* 1579
Bythnerus (*Vict.*) Lyra Prophetica, ſive Analyſis in Pſalmos. 4. *Lond.* 1679
Buxtorfii (*Jo.*) Lib. Coſri Lat. Verſ. & Not. ejuſd. 4. — 1660
Blacvodei (*Adam.*) Opera omnia. 4. *Par.* 1644
Bartolus (*Dan.*) De vita, &c. S. Ignatii Loiolæ. 4. *Lug.* 1665
Bruſchii (*Caſp.*) Chronica Monaſter. Germaniæ illuſtr. 4. *Norib.* 1682
Bonifacii (Martyr.) Epiſtolæ. 4 *Mog.* 1605
Berreriedenſis (*P.*) Vita Greg. VII. P. M. &c. 4. *Ingol.* 1610
Bellarmini (*R. Card.*) De Scriptoribus Eccleſiaſt. 4. *Col.* 1684
Baſnagius (*Sam.*) De Rebus Sacris & Eccleſiaſticis, adverſus Baronium. 4. *Ult.* 1692
Burgo (*Jo. de*) Pupilla Oculi, de Eccleſiaſticor. Officiis, &c. 4. *Roth.* 1510
Beſoldi (*Chr.*) Op. omn. Politica, &c. 2 vol. 4. *Arg.* 1641
Bonanni (*Ph.*) Recreatio Mentis & Oculi in Obſerv. Cochl. 4. *Rom.* 1684
Bartholini (*Tho.*) Acta Medica & Philoſophica Hafnienſia, 5 Tom. 2 Vol. 4. ——
Ballonii (*Gul.*) Conſilia Medicinalia, 2 vol. 4. *Par.* 1635
Bauhini (*Jo.*) Hiſt. Fontis & Balnei Admirab. Bollenſis, &c. 4. —— 1607
Bootii (*Arn.*) Florum, Herbarum, & Fructuum, [*Select. Icon.*] 4. —— 1640
Bartholinus (*Caſp.*) De Cauteriis. 4. *Haf.* 1624
Baccius (*And.*) De Venenis, & Antidotis. 4. *Rom.* 1586
Boëtii (*Anſ.* de Boot.) Gemmarum & Lapidum Hiſtoria. [*Fig.*] 4. *Han.* 1609
Borellii (*J. A.*) Euclides Reſtit. 4. *Piſ.* 1658
Barlaami (Monachi) Logiſtica Gr. Lat. Scholiis J. Chamberi. 4. *Par.* 1596
Buſſieres (*Jo.*) Hiſtoria Francica à Monarchia condita. 4. *Lugd.* 1671
Boiſardi (*Jo. Jac.*) Theatr. vitæ Humanæ. [*fig.*] 4. —1596
—— Bibli-

(b) T1

Figure 4.18 False Negatives NTvsT1T2 Scheme from class (a) T2 and (b) T1.


Feb.221 Seamen Praying. 174.
222 Impracticable League 175.
223. Age Honourable 175.
224 Bear & Bees. p. 176.
225 Huntsman & Currier. 177.
226 No pleasing every one 178.
227. Jupiter's Wallets p. 179.
228 Merchant & Mariner 180.
229 Eagle Cat & Sow. 181.
230. Rustick & River. 182.
D. MIDDLETON.
STATE of EUROPE.
FOREIGN NEWS.
IRELAND.
SCOTLAND.
COUNTRY-NEWS.
LONDON.
Rider's Fairs, 1759.
An Excellent BALLAD of
The Noble Marquis and Patient GRISSEL.
To the Tune of, The Bride's Good Morrow.

Jobſon's *Caſe*	220	Lee v. Vincent	521
Johns v. Row	14, 59	—— v. Withers	325
Jones v. Rae	59, 335	—— v. Lee	552
—— v. Adams	125	—— v. Ridford	104
Johnſon v. Lewkenor	294	—— v. Libb	577
—— v. Kerman	319	—— v. Hale	149
—— v. Young	446	Leech v. Leech	150
—— v. Gabriell	461	Legg v. Richards	191
—— v. Smart	538	Lemon v. Fowke	102
—— v. Bellamy	543	Lemaine v. Stanly	529
Jordan v. Foſſet	380	Lemaſon v. Dixon	261
Ireland v. Coulter	564	L'eſtrange v. Temple	513
Iſted v. Stanley	64, 259, 271, 467	Levann's *Caſe*	18
Juſtice v. White	121	Leventhorp v. Aſhby	299
K		Levett v. Lewkenor	378
Keeble v. Oſbiſton	562, 560	Lewen v. Cox	547
Keen v. Allen	535	Lexington (*Lord*) v. Clerke	47
Kellow v. Rowden	101	Ley v. Anderton	72
Kelſick v. Nicholſon	168	Lidcott v. Willows	509
Kenrick v. Burges	561	Liefe v. Saltingſtall	326
Kennington Haſtings	144	Lilley v. Tayler	418, 482
Kerry v. Dethick	232, 496	Lillingſton's *Caſe*	38
Kett v. Life	500	Lingen's *Caſe*	352
Kidmore v. Winſton	439	Lingon v. Foley	475
Kighley v. Kighley	95	Littleton v. Hibbins	210
King v. Melling	541	—— (*Sir* Tho.) *Caſe*	312
Kings v. Hilton	336	Little v. Plant	240, 450
King v. Rumbull	538	Lobley v. Gildard	445
Kitchin v. Dixon	567	Locke v. Loggin	522
Kittley's *Caſe*	225	Lockier v. Smith	205
Knight v. Webb	32	Loddington v. Kime	491
—— v. Hilton	129, 227	Lodge, (*Lady*) *Caſe*	256
—— v. Green	67	Loftus v. Baker	88
——'s *Caſe*	306	London *Mayor* v. Alford	285
Knighton v. Morton	370	Lougheen v. Williams	344
Kniveton v. Latham	225, 349	London *Mayor and* Com.	139
Knott v. Barlow	348	Love v. Windham	302
L		—— v. Napplesden	405
Lake v. Thacker	439	Lovice v. Godard	539
Lamb v. Archer	302	Lovelice v. Lovelace	417
Lampett's *Caſe*	295	Lowen v. Bedd	357
Lander v. Brooks	339	Loyd's *Caſe*	141, 146
Large's *Caſe*	182	—— v. Madox	379
Latimer's *Caſe*	153, 256	Lucy v. Smith	438
Lawry v. Aldred	168, 562	—— v. Levingſtone	345
Lawrence v. Dodwell	106	Lugg v. Lugg	519
—— v. Kete	574	Lumley v. Hatton	336
Lawſon v. Crofts	247	Lunn v. Dodſon	117
Leak v. Randall	105, 431	Q q 2	Lutch's

DISTINCTIONS.

15.	*Gratulatory and Propitiatory.*	93
16.	*Ordinary and Extraordinary.*	96
	Common and Special.	ibid.
	Common and Eminent.	ibid.
	Common and Emphatical.	ibid.
	Particular and Univerſal.	97
	Common and Singular.	ibid.
	Simple and Complex.	98
17.	*Nominal and Real.*	100
	Inſtrumental and Real.	101
	Metonymical and Real.	102
	Verbal and Real.	106
	Commemorative and Real.	111

ERRATA.

P. 11. line 14. read *intrinſick.*
P. 73. line 4. read *at.*
P. 75. in Notes, line 7. read νυχθέντ☉ ϰ῀ ῥεύσαντ☉
P. 75. in Notes, line 8. read σωτηρίαν.
P. 79. in Notes, line 2. read *Recurre.*
P. 84. in Notes, line 4. read *voce.*
P. 101. in Notes, line 5. read *ſit.*

Reverend

Figure 4.19 False Positives NTvsT1T2 Scheme.

CONCLUSION AND RECOMMENDATIONS

In this thesis, we have addressed two arising challenges in the field of information retrieval from historical documents. We presented a novel framework to detect footnotes in document pages and tested its efficiency over 32 million images. We also developed a new algorithm for detecting tables in documents using an MFCCs-based method and demonstrated its capability to be applied to a broad variability of tables.

In chapter 2, we developed a method to detect footnotes in historical documents. We used the three most salient features of a footnote in a page; smaller font size compared to the main body; footnote location on the page; and the considerable gap between the footnote and body text of the page. Acknowledging these three visual features, we created our final feature vector ready to be fed to an SVM classifier. Our experiments in a large-scale image dataset (almost 32 million) confirmed both the effectiveness and generalization power of the proposed method.

An entirely novel framework for detecting the existence of tables in historical document images is introduced in Chapter 3. This Chapter presented a new application of MFCCs from speech recognition field for table detection. The significant characteristic of the MFCCs is their capability to provide good discrimination of lower frequency components of a signal compared to its higher frequency components. The fact that the occurrence of text characters in tables follow a column-wise harmonic behavior, which has lower frequency compared to the text characters of the page, motivated us to use MFCC-based features for table detection. These MFCC-based features have been classified using SVM and RF classifiers. Experimental results using two sets of dataset proved the effectiveness of this algorithm.

Limitations and recommendations

The research works presented in this thesis addressed the initial attempts to solve several challenges in the field of information retrieval from historical documents. However, there is still more room for improvement. Below we summarize the potential paths to continue this research work.

One of the significant limitations of the work for footnote detection is its dependency to the layout analysis which can collapse in case of some complex layouts. Therefore, investing in finding an efficient and more robust layout analysis method definitely would have a great impact on the performance. Also expanding our features beyond the font size, location and space can provide more flexibility for our method. Moreover, exploring some classification techniques other than SVM such as deep learning methods, with the current rate of their popularity, can lead us to achieve better results.

Our proposed method for table detection can be improved further in several ways. Applying image enhancement techniques at the preprocessing step can deal with degraded and noisy images, which are extremely common in the historical documents. It is also a reasonable idea to expand our method beyond the spectral features and explorer temporal aspects of tables as well. Considering more scales reduce the possible information lost in the process of resizing. Another direction can be skipping the statistical function and fitting in order to reduce the dimensionality of MFCCs and LogMS features. As an alternative, directly feed MFCCs and LogMS matrices as an input to a system capable of handling matrices as an input features of each image, like deep neural networks. Finally, upgrading our algorithm in a way that can locate the tables after the detection processes can further promote our approach to its best version.

Summary of contributions

Below, we briefly highlight the major contributions of this thesis.

- A robust and promising approach for footnote-based document image classification in historical manuscripts.
- An efficient method for table-based document image classification in historical manuscripts.

Publications in peer reviewed journals

1. Zhalehpour, Sara, Ehsan Arabnejad, and Mohamed Cheriet. "Visual information retrieval from historical document images." Submitted to Journal of Cultural Heritage.

Publications in peer reviewed international conferences

1. Zhalehpour, Sara, Andrew Piper, Chad Wellmon, and Mohamed Cheriet. "Footnote-based document image classification." In International Conference Image Analysis and Recognition, pp. 634-642. Springer, Cham, 2017.
2. Zhalehpour, Sara, Andrew Piper, Chad Wellmon, and Mohamed Cheriet. "Table-based Document Classification in Historical Document Images" International Conference on Pattern Recognition and Artificial Intelligence, 2018.
3. Abuelwafa, Sherif, Mohamed Mhiri, Rachid Hedjam, Sara Zhalehpour, Andrew Piper, Chad Wellmon, and Mohamed Cheriet. "Feature learning for footnote-based document image classification." In International Conference Image Analysis and Recognition, pp. 643-650. Springer, Cham, 2017.

Awards

École de Technologie Supérieure (ÉTS), Internal Scholarship (2018).

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