The Graduate Institute of Science and Engineering

M.Sc. Thesis in Electrical and Computer Engineering

EVALUATION of WEB IMAGE SEARCH ENGINES

by

Rabia KARAPINAR

January 2015
Kayseri, Turkey

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Rabia KARAPINAR

A thesis submitted to

the Graduate Institute of Sciences and Engineering

of

Melikşah University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Electrical and Computer Engineering

January 2015
Kayseri, TURKEY

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_____

Jan 22, 2015 Assoc. Prof. Dr. Ahmet UYAR
Supervisor

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

_____

Jan 22, 2015 Prof. Dr. Murat UZAM
Head of Department

Examining Committee Members

Title and Name		Approved
Assoc. Prof. Dr. Ahmet UYAR	Jan 22, 2015	_____
Asst. Prof. Dr. Kadir A. PEKER	Jan 22, 2015	_____
Asst. Prof. Dr. Mehmet S. AKTAŞ	Jan 22, 2015	_____

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_____

Assoc. Prof. Dr. Ahmet UYAR
Substitute Director

January 2015.

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Rabia KARAPINAR

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January, 2015

Supervisor: Prof. Dr. Ahmet UYAR

ABSTRACT

There are many images on the public web and this number is increasing every day. People share many kinds of images. Retrieving relevant images among this huge image collection is a challenging task. Therefore, Image Search has become popular feature in many search engines, including Google, Bing and Yahoo. On the web, there are billions of web pages and images. Image search engines aim to retrieve relevant images for submitted queries by its users.

Images contain very valuable information. Sometimes, using this information is easier than going through many web pages. Main algorithms of document search engines are known pretty well. However, the algorithms of image search engines are less clear and they are not public. In addition, the strengths and weaknesses of image search engines are not studied much. In this thesis, we try to uncover some of the methods used by web image search engines and try to figure out some of their strengths and weaknesses. We evaluate various aspects of Google and Bing Image Search Engines.

A very important problem for image search engines is the relevancy of retrieved images for submitted queries. We investigate the precision of image search results for both popular and less popular entities. We also compare the precision values of document search and image search. In addition, we investigate whether these two image search engines employ any content based image retrieval methods. Moreover we investigate some of the reasons for image search engines to return irrelevant results.

We determined various kinds of query sets for different topics and submitted them to these two image search engines manually using their regular web interfaces. We also evaluated the returned results manually for relevancy.

Keywords: Image Search, Image Retrieval, Content based Image Retrieval, CBIR, Evaluation of Image Search.

EVALUATION of WEB IMAGE SEARCH ENGINES

Rabia KARAPINAR

Yüksek Lisans Tezi – Elektrik ve Bilgisayar Mühendisliği
Ocak 2015

Tez Yöneticisi: Prof. Dr. Ahmet UYAR

ÖZ

Günümüzde internetde bir çok resim var ve bu sayı her geçen gün hızla artıyor. Çok çeşitli resimleri internetde insanlar paylaşıyorlar. Yığın halini oluşturmuş bu resimleri uygun bir görsellikte sunmak önemli bir araştırma konusu olmuştur. Çoğu arama motoru için resim arama önemli bir özellik olmuştur. Bu özelliği kullanan bazı arama motorları; Google, Yahoo ve Bing... İnternetde milyonlarca web sayfası ve belki daha fazlasında resim var. Resim arama motorları kullanıcıların internetde resimlerin içeriklerine göre arama yapmalarına izin verir.

Resimler, içlerinde çok değerli bilgiler saklar. Tek tek dökümanlara gidip bilgi aramaktansa bazen resmin içindeki bilgilerden aranan konuya daha hızlı ulaşılabilinir. Döküman arama motorlarının çalışma yapıları, algoritmaları daha ayrıntılı olarak biliniyor. Bununla beraber, resim arama motorlarının çalışma şekli ve metotları umumî değil. Buna ilaveten, resim arama motorlarının dayanıklılığı veya zayıf noktaları çok araştırılmamış. Bu tezde, resim arama motorlarının bazı metotlarının çalışmasını keşfetmeye çalıştık ve onların güçlü ve zayıf yönlerini anlamaya çalıştık. Farklı yönlerden Google ve Bing resim arama motorlarını değerlendirdik.

Resim arama motorları için çok önemli problemlerden birisi; aranan sorgu için dönen resimlerin doğruluk oranlarıdır. Hem popular, hem de az popüler sorgular için resim arama sonuçlarının doğruluklarını inceledik. Aynı zamanda döküman arama ile resim aramalarının doğruluk değerlerini karşılaştırdık. Bunlara ek olarak, değerlendirdiğimiz iki resim arama motorları herhangi bir içerik analizi yapıp yapmadıklarını inceledik. Ayrıca resim arama motorlarının alakasız sonuçlar vermesinin bazı sebeplerini araştırdık.

Farklı konular için çeşitli sorgu kümeleri belirledik. Bunları her iki resim arama motorlarının regüler sayfalarına el ile girdik. Aynı zamanda, dönen sonuçların ilgililiğini el ile değerlendirdik.

Anahtar Kelimeler: Resim Arama, Resim verileri çekme, İçerik tabanlı resim arama, CBIR, Resim arama değerlendirmeleri.

DEDICATION

Dedicated to my family for their endless support and patience during the forming phase of this thesis.

ACKNOWLEDGEMENT

I would like to express my gratitude to my supervisor Prof. Dr. Ahmet UYAR whose stimulating suggestions and encouragement helped me during the course of research and writing of this thesis.

I also want to thank Melikşah University undergraduate students that participated in the survey.

I express my thanks and appreciation to my family for their understanding, motivation and patience.

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CHAPTER 1

INTRODUCTION

Effects of rapid growing on hardware, software technologies and internet speed, large collections of images are available on the web. Presenting desired image among huge collections on web becomes important study field. Image Search has become popular feature in many search engines, including Google, Yahoo, and Bing etc… Image search engines are that allow users to search the web for image content. Search results are presented as a ranked list by relevance to the given query and sometimes in a clustering way…

1.1 Objective of the Thesis

There are many images on public web and this number is increasing every day. People share many kinds of images. For example, "more than 250 billion photos have been uploaded to Facebook as of September 2013, and more than 350 million photos are uploaded every day on average" [1]. These images contain very valuable information. Users search for many types of images. Sometimes, it's easier searching information amoung images rather than going through many web pages.

Search engines play a fundamental role for information discovery and retrieval on the web. Among billions of web pages, they help users to locate the web pages that contain the desired information. Search engines enrich the user experience tremendously on the web.

Image search engines help us search through the billions of images on the web. Image search engines return a ranked list of related images for a given query. Some of the image search engines include Google Image Search, Bing Image Search, Yahoo Image Search, Yandex Image Search, TinEye, Ask Jeeves, Flickr Search, Facebook Search, etc. Image search engines accept two types of queries: natural language queries and image queries. In addition, while some image search engines crawl the public web for images, others use their own image collections. In this thesis, we focus on image search engines that crawl the public web for images and accept natural language queries.

Inner workings of image search engines and the methods they employ are not public and they are not very well known. In addition, the strengths and weaknesses of image search engines are not studied much. In this study, we try to uncover some of the methods image search engines use and figure out some of their strengths and weaknesses. This will give researches some insight for future directions and better evaluate the state of the art in image search.

General algorithms for text based document search on the web are well established. There are many well-known algorithms for crawling, indexing, and ranking web pages or evaluating queries [2, 3, 4]. However, image search is more challenging. Although there have been a lot of research for content based image retrieval [5, 6], it is still difficult to apply content based image search methods in the scale of web search. One of our purposes in this study is to investigate the extent of content based image search methods the current image search engines use.

Web image search engines have been using the texts on web pages to index images. They use the texts on web pages including; anchor text, image captions, file names, alternate text, surrounding text in web pages [7, 8, 9]. However, if this method is employed without any content analysis, it has many limitations. First of all, many objects or concepts that exist in images may not be mentioned in these texts. Usually images may contain so much information that even a person cannot describe all relevant information on it. Second, some of the keywords on those texts may not be related to the indexed images on that web page. In addition, many web pages contain more than one images and a lot of text. It is not easy to associate the correct text on a web page with correct images on that web page. These limitations may reduce the precision of returned images for a given query by returning irrelevant images. In addition, many related images may not be matched to the query and the search engine may provide poor recall. Therefore, the second aim of this study is to investigate the accuracy of returned images for queries. Studying the recall is much more difficult for web image search engines, since we don't have access to their indexes and the number of images on the web is very huge. So, we focus on precision instead.

We selected Google and Bing Image Search Engines for our study. They are general purpose image search engines supporting natural language queries and crawling the public web for images.

1.2 Research Questions:

We have determined the following research questions for this thesis:

1. Can image search engines return relevant results for queries? What are their precision values for returned images?
2. Do image search engines provide more accurate results for higher ranking images on the result list?
3. How does the precision values of document search results and image search results compare?
4. Do image search engines employ content analysis when performing the searches or do they solely rely on text search? Investigate whether image search engines recognize the texts on images and provide search based on those texts?
5. What are some of the reasons for search engines to return irrelevant images?
6. Do precision values of image search results for different types of searches differ? For example, whether precision values of image search results for people searches and plant searches differ.
7. How often do image search engines return the same images in result sets.

We investigate these research questions by determining a number of query sets and submitting them to both image search engines. We manually submit all queries and evaluate the relevancy of each returned image. We examine top 100 images for each query at three cutoff points: top 10, top 30 and top 100.

1.3 Outline of the Thesis

In the second chapter, we discuss related works about image search engines. Basic concepts of image search engines are discussed. Content based image retrieval and text based image retrieval are explained. An overview of current image search engines is provided.

In the third chapter, we explained the method we used in our investigation. We explain the method used to select the image search engines, to determine the query topics and to construct query sets.

In the fourth chapter, we provide people search results for popular and less popular persons. We examine the precision values. We also compare precision values of document searches and image searches. Some weaknesses of image search engines are discussed.

Chapter five focuses on searching for plant images. We examine and evaluate whether search engines can retrieve accurate image list for plant queries. Differences of plant image tests and people tests are discussed and compared.

In chapter six, we examined and evaluated whether search engines can retrieve accurate image lists for book cover. Book cover tests are represented. Test is represented about whether the searched engines use OCR or not.

In chapter seven, we examined and evaluated whether search engines can retrieve accurate image lists for firm logos. Firm logo tests are represented.

In chapter eight, we conclude the study by summarizing our tests and discussion of the future work.

CHAPTER 2

RELATED WORKS

2.1 Web Search Engines

Search engines are complex software systems that discover documents on the internet. When a set of keywords are submitted to them, they return a list of relevant documents on the Web.

A search engine operates in three stages: crawling, indexing, and searching. A crawler (or spider) traverses the web and downloads all relevant documents it can discover. It continually runs and looks for new web pages and checks for updates. The indexer then analyzes web page contents for indexing. It constructs inverted index files for keywords in web pages to provide speedy and scalable search services. All relevant content in web pages are indexed including the words from titles, page content, headings, meta tags, etc. The indexes can be constructed for single words, phrases or multiple words [10, 11, 12, 13].

When a user submits a query, the search engine examines the index files and retrieves the documents related to the query. Sometimes the resulting document set consists of millions or billions of web pages. Then, the search engine ranks the documents and returns the top documents that are highly relevant to the query and the most authoritative.

2.2 Image Search Engines

Image search engines are an important tool for finding images on the web. On the web, there are billions of web pages and images. Collecting and indexing images from the web is not easy. Image file sizes are usually bigger and it takes more space. Therefore, it is important to not save and process duplicate images. Furthermore, indexing images is much more difficult. It is not easy to determine all relevant keywords for an image. Even a person cannot determine all relevant keywords for an image. To overcome this difficulty, image search engines use the text in image file

names, image captions, alt texts, anchor text, hyperlinks, and other text surrounding images as keywords [12, 8, 9]. However, this approach has two problems. First, the text around an image may not be relevant to that image. In this case, irrelevant images may be returned for queries. Second, many of the concepts in images may be missed. Only a very small set of concepts from an image can be indexed. Other relevant concepts are missed and this image is not returned when those concepts are searched. The first problem may result in poor precision for image search engines. The second problem may result in poor recall.

To overcome the difficulties in text based image retrieval, researchers have been working on to develop content-based image retrieval (CBIR) methods. By examining the contents of images, they try to identify the relevant keywords for that image. They examine the colors, shapes, backgrounds, etc. However, it is still very difficult to determine all relevant entities and concepts in images.

While many image search engines accept text queries, there are also image search engines that accept image queries. There are two types of image search engines that accept image queries. One type of image search engine accepts the image query, then converts the submitted image to a text query by examining its content. Then it executes the search by using determined text query. Google Image search provides this feature. Another type of image search engine that supports image queries compares the submitted image to other images on its own database or web pages. It returns the images most visually similar to the submitted image. TinEye.com image search engine provides this search feature.

2.3 Web Image Search Engines

There are many image search engines on Internet. While some of them crawls the public, others use their own image databases. We call the image search engines that crawl the web for images and provide image search features as **web image search engines**.

Web image search engines use many types of data when providing image search functionality. They use the text on web pages to index the images. In addition, they use the graph structure of the web to determine authoritative web pages and images. Some

of the current examples of web image search engines are Google Image Search, Bing Image Search, Yahoo Image Search and Yandex Image Search.

There are many other image search engines that provide image search functionality on its own image databases. Facebook recently started to provide image search services on its own image database. Flickr is another website that provides image search among the images posted by its users. It is also possible to search for image on Instagram.

2.4 Current Image Search Engines

Some current image search engines are; Flickr, Instagram, Google, Bing, Facebook, TinEye, Yahoo…

Flickr is an image and video hosting website that was created by Ludicorp in 2004. Flickr offers online community for users. Users can share and embed personal photographs. The Verge reported in March 2013 that Flickr had a total of 87 million registered members and more than 3.5 million new images uploaded daily [14]. Flickr allows advance search. Exact phrase or exclude/include words or tags can be accepted. Image search can be filtered by providing parameters such as from my contacts, from everyone's uploads… While searching image, safety level, content type, media type, date can be chosen. Flickr supports organizing personal photos and creating group images. Flickr allows search by text only. There is no text complete feature on search bar.

While searching image, Flickr search engine uses description, tags, people name, taken date, user comments, person name who added as faves. However, when date and person are added together, Flickr could not retrieve any images. It seems it takes exact words. There are comments number, view number and fave number for each image. Probably, they are used for ranking of images. In the page for an image, connected albums & galleries are represented. Flickr doesn't crawl any images from web, it uses own image collection on the web.

Instagram is a mobile image and video hosting website that was created by Kevin Systrom and Mike Krieger in 2010. Users can share photo or video from mobile as online community. Instagram has users over 300 million as of December 2014 [15].

User can search for specific users or words. User can select from hashtags. Instagram allows search by text only. There is no text complete feature on search bar.

Instagram home page on the web, there is no searching facility. While searching image, Instagram search engine uses hashtags and user name. There is no comment searching. Instagram doesn't crawl any images from web, it uses own image collection on the web.

Facebook is online social service to share photo and video and to exchange messages. Facebook was created in 2004. Facebook had over 1.3 billion active users as of June 2014[16]. Search with multiple words are available. Facebook search doesn't allow exclude word or Boolean search. Facebook doesn't support search by image and voice. Facebook allows search by text only. There are available options while entering query on search bar. Facebook doesn't crawl any images from web, it uses own image collection on the web. Facebook uses search based on friends' profile or user content. Facebook uses graph search features. Thus, related friends are retrieved easily. Facebook match phrases as well as objects on the retrieved site.

Google Image Search Engine is search service to find images from web pages or other documents. Google Images is one part of Google, introduced in 2001. Google reported that the index reached over 10 billion images by 2010 [17]. Google Image Search is a plain web page. Search by text, search by image and search by voice are available. While writing queries on search bar, text complete options are available. Advanced search is supported. Google images supports Boolean operations like all words, exact phrase, any of words or none of words. Google images also supports searching by image size, colors, type of image, published region, file type and date range. Safesearch and usage rights options are available. There are three options for search by image; uploading image, dragging and dropping image, and searching with image URL. Google image doesn't give hit count number. Google image has feature of clustering visually similar images in result list.

While searching image for image query, Google image search engine converts query to text and then it search with the text query mostly. Google Images engine crawls and collects from web. For ranking, Some parameters are used. Google web graph is also used for ranking.

Bing image search engine is search service to find images from web pages or other documents. Bing was introduced by Microsoft CEO Steve Ballmer in 2009. Bing image search engine supports search by text. While writing queries on search bar, text complete options are available. Searching with one or more words, exclude words, exact phrase is supported. Bing image search supports searching by image size, color, type of image and date. Bing image search doesn't give hit count number. Bing image search engines crawls from web.

Yahoo image search engine is search service to find images from web pages or other documents. Yahoo supports only search by text. While writing queries on search bar, text complete options are available. Searching with one or more words is supported. Yahoo image search supports these features; search by any time or latest, search by size, search by any color or black & white, search by usage rights. Yahoo image search doesn't give hit count number. Yahoo image search engines crawls from web.

TinEye is a reverse image search engine. TinEye was created by Idée Inc. TinEye uses image identification rather than keywords or metadata. TinEye finds exact matches including those that have been cropped, color adjusted, edited, rotated or resized. Retrieval image list can be sort by 'best match', 'biggest image', 'most changed', and 'newest' or 'oldest' crawled image. TinEye searches on web pages. There are also option searching on own private collection or local hard drive as a paid service. Total image count is presented. TinEye supports search by image and URL.

In summarize some features of image search engines represent on **Table 1**. First column shows feature of image search engines. Following columns describe whether image search engine has mentioned features or not.

	Bing	Facebook	Flickr	Google	Instagram	TinEye	Yahoo
Search by Text	+	+	+	+	+	-	+
Search by Image	-	-	-	+	-	+	-
Search by voice	-	-	-	+	-	-	-
Query Complete	+	+	-	+	-	-	+
hit count	-	-	-	-	-	+	-
clustering results	-	-	-	+	-	-	-
Searching exact phrase	+	-	+	+	+	-	+
Any of words	+	+	+	+	+	-	+
None of words	+	-	+	+	-	-	+
Image size	+	-	-	+	-	-	+
color	+	-	-	+	-	-	+
Type of image	+	-	-	+	-	-	-
Date range	+	-	+	+	-	-	+
Search on web	+	-	-	+	-	+	+
Search on own database	-	+	+	-	+	+	+
Allow uploading Image	-	+	+	-	+	+	-

Table 1 Summary of the Image Search Engines Features.

2.5 Search Engine Evaluation Studies

There have been many studies investigating various aspects of popular commercial web search engines. A whole book [18] has been written to cover many aspects of search engine studies. However, we have not seen any work on literature to investigate any aspect of image search engines. This is the first work to investigate various aspects of web image search engines.

Search engine studies continue to be an important research track. A recent study [19] investigated the customization of search results for different geographical markets. Another study [20] investigated the effects of personalization in search engine results. Freshness of multiple commercial search engine databases is studied by [21]. Accuracy of hit count estimates of three search engines is studied by [22] .

Some of the early studies about web search engines investigated the coverage of them. [23] investigated web page coverage of then search engines. [24] investigated the coverage bias of search engines for commercial websites of different countries. [25] proposed a method for measuring the relative size and overlap of public Web search engines.

Although web image search engines are in existence for many years, no aspect of them is investigated by researchers. This study aims to investigate some of the main

features of them. Particularly the precisions of image search engines are investigated thoroughly for both popular and less popular entities. Because, it is a challenging task to provide highly accurate image results for a given query.

CHAPTER 3

The Method

3.1 Image Search Engine Selection

There are many image search engines on the web. Our aim is to select the ones that provide natural language query interfaces and crawl the web for images. They should also be popular and provide image search services to general web users. We conducted a small survey to find out the popular web image search engines people use. We prepared a questionnaire and asked 54 students at Melikşah University. 94% of students used Google image search engine. Secondly Bing and Yandex are used by 12-14% of students attending the survey. Therefore, we have chosen Google and Bing image search engines for evaluation.

3.2 Query Submission and Result Evaluation

We used text-based queries for evaluation of search engines. We submitted text queries to both image search engines by using their browser interfaces. We manually submitted each query to the search engines and saved the result page for evaluation. We retrieved 100 images for each query. One person evaluated the relevancy of each result image to the query. Each returned image is labeled as either relevant or irrelevant by using a binary judgment.

We examined the results in three cutoff points; top 10, top 30 and top 100 images. We determined the precision values for these three cutoff points for each query.

3.3 Selection of Query Topics

There are many types of images on the web. People search for various kinds of images about many things. To answer the research questions outlined, we need to select some set of queries. Before selecting the queries, we determined the topics for queries. When selecting the search topics, we considered many parameters. First of all, the

selected topics should be diverse. In addition, it should cover different types of images with various levels of difficulty for image search and content analysis. Moreover, the selected topics should be frequently used.

We determined four types of query topics:

A. **People:** People searches are very common on the web. In addition, it is very difficult to identify persons on images. Therefore, we selected person images as the one topic.
B. **Plants:** Plant searches are very difficult when performing content analysis. Plants are difficult to identify in pictures. It is very difficult for algorithms to identify them.
C. **Book covers:** Book cover pictures are one of the easiest pictures to recognize by content analysis. It has text on them and by using OCR methods, accurate identification of the text can be achieved.
D. **Firm logo:** Firm logos are usually simple and easily recognizable. There are also many logo pictures on the web.

3.4 Query Types

We determined two sets of queries for each query topic. Each set had 10 entries. One set included the queries for popular entities and the other set included the queries for less popular entities. By determining two types of queries, we aim to better evaluate the quality of image search results. Since we are focusing on precision, it would be easier for search engines to return relevant images for popular entities among many images on the web. However, it would be more difficult to return accurate results for less popular entities with fewer numbers of images on the web.

We have selected the popular entities by choosing the very well known entities of each topic. For example, for the topic of people, we selected “Barack Obama”, “Bill Gates”, “Steve Jobs”, etc. Our criteria for selecting the popular entities is that when we submit that query to Bing image search engine, the hit count for that query must be at least 1000. But, usually much more images are found for the selected entities.

Selection of less popular entities is more challenging. There are many less popular entities to choose from. In addition, we should make sure that the selected entity has some number of pictures on the web. Otherwise we cannot expect the search engines to return relevant results. Therefore, our criterion for less popular entities is that the hit

count for each entity must be between 100 to 500 in Bing image search engine. This makes sure that the selected entity has some images on the web but not a lot.

At the time of conducting this research, Google image search engine did not provide hit count values for image searches. Therefore we used Bing image search results. However, during this study around March 2014, Bing has also stopped providing hit count values for image searches. Therefore, we used hit count values from Yandex image search results for some queries.

3.5 Constructing Unambiguous Query Sets

When selecting entities, we make sure that the selected query for the entity is not ambiguous. Many queries may refer to multiple entities. For example, there may be many people sharing the same name. A plant name may also be used for other things. While "orange" is a plant name, the word "orange" also refers to a color, various companies with this name, a county in California, multiple restraunts around the world, etc. When evaluating the relevancy of resulting images, it is important that the used query refers to predominantly for a single entity.

We assume that a query refers to a single entity predominantly if Google web search returns at least 8 documents out of top 10 for that entity. After determining an initial entity set, we test each query on Google web search and count the number of relevant documents. We leave out the ones that do not return at least 8 relevant documents among top 10 results. In the end, we determined 10 popular and 10 less popular query sets for each topic. Overall, we constructed 80 queries for 80 different entities.

3.6 Entities and Queries

We construct the queries to target the requested entities. Usually the queries are composed of the entity names. However, we add extra words to clarify the intent of the search for some queries. The queries for person entities are the full names of the selected person. An example query is "Barack Obama". The queries for plant entities are English names of the plants. Some sample queries are "Tomato", "basil", and "Centaurea behen". The queries for book covers are constructed by adding the author name to the name of the book. An example query is "The Goldfinch by Donna Tartt".

The queries for firm logos are constructed by adding the word “logo” to the company name. For example, the query for the logo of Starbucks Coffee is “starbucks coffee logo”.

3.7 Determining Repetition of Images in Search Results

The same images may be posted on many websites. Consequently, the search engines may return the same image from different web sites to a given query. This should be avoided by the search engines. They should identify the same images even if they are retrieved from different sources. They should also identify the same images with different sizes.

We count the number of repeated images in the result set of a query. If two images are the same except their sizes or a slight change in brightness, we assume that they are the same image. If there are more changes, we assume that they are two different images.

3.8 Search Engine Settings

We have used the English web interfaces of both image search engines. We used the global .com websites of each search engines: www.google.com and www.bing.com. We have used the following settings for Google Image Search Engine:

Image Size: any size
Aspect Ratio: any aspect ratio
Colors in Image: any color
Type of Image: any type
Region: any region
SafeSearch: Show most relevant results
File Type: any format
Usage Rights: not filtered by license

We have used the following settings for Bing Image Search Engine:
Filter adult content from your search results: Moderate
Location: Kayseri
Display Language: English

Size: All

Color: All

Type: All

Layout: All

People: All

CHAPTER 4

SEARCHING FOR HUMAN IMAGES

Users search for information about a diverse set of topics on web search engines. Among them, searching for information about people makes up an important segment. Bing reports that [26] people searches are the most popular on the web and it makes up about 10 percent of all searches. Users search for celebrities, professionals, friends, etc. Therefore, it is very important for image search engines to find accurate images for people searches.

Although human beings have very advanced face recognition ability and correctly identify faces in many difficult conditions, this task is really difficult for computers. Face recognition has many parameters that make it harder for algorithmic identification of individual person images. All faces share the same main components but they differ in details. Various levels of illuminations in images, older and younger versions of faces, diverse set of backgrounds, varying angles of images, the distance of faces to the camera, all make it harder to correctly identify the human faces. Therefore, we investigate the image retrieval quality of image search results for person searches.

The questions we hope to answer in our research include the following:

1. Can these two image search engines provide useful results for people searches? What are the precision values for queries about popular and less popular persons? Do image search engines provide more accurate results for more popular people searches?
2. Do image search engines provide more accurate results for the higher ranking images on the result list?
3. How does the precision of document searches and image searches compare for less popular persons on the web?
4. What are the main reasons for search engines to return irrelevant images?
    a. Do image search engines work only with the texts on web pages? Do they perform any image content analysis?

b. When image search engines return an irrelevant image, can it be because of the incorrect identification of images on the target web page? While a relevant image exists on that page, is it returning an irrelevant image from that page?

We attend to analyze each of the questions in this chapter. We analyze each question by given the methods in chapter 3. Chapter four is analysis of the evaluation of search engines for human images as a whole. Outline of chapter four is as follows.

In the first section, we examine precision rates of popular person images. Google and Bing search engines retrieve lots of images about the popular persons. We examine first 100 images in three cutoff points; first 100, 30 and 10 images. We calculate the precision rates of each category. We also look for the repeated images among the retrieved images. Repetition of images reduces the quality of image retrieval.

In the second section, we investigate images for less popular persons. We select persons that have between 100 and 500 images on the web. Selected queries are searched on Google and Bing search engines. Similar to the popular person results, we examine the precision values at three cutoff points; first 100, 30 and 10 images.

In the third section, we compare the precision values of image search results and document search results for less famous 10 people. We submit the searched person names to Google and Bing document search engines. Relevancy results of the retrieved top 30 documents are compared to image results.

In the fourth section, we investigate the reasons for the lower precision values of image searches for less famous persons. We investigate existentency of searched query terms on web pages.

In the fifth section, we examine the web pages that contain irrelevant images among the top 100 results for two queries for less popular persons. We examine to see whether target pages contain any relevant images for the queries.

4.1.1 Popular Persons on Web

We would like to investigate whether image search engines can return relevant results for people that have many images on the web. We determined 10 famous people and tested whether they have many images on the web. We used the estimated hit count values on Bing Image Search Engine result page. Google image search engine does not return the estimated hit count for image searches. We require estimated hit counts to be at least 1000 for each query. For the set of persons on **Table 2**, the minimum hit count value is 40.500.

	QUERIES	Estimated Hit count on Bing
1	Steve Jobs	56200
2	Bill Gates	66700
3	John F. Kennedy	73100
4	Martin Luther King	58000
5	Nelson Mandela	58900
6	Muhammad Ali	45100
7	Elvis Presley	48900
8	Leonardo da Vinci	44100
9	Thomas Edison	40500
10	Atatürk	50500

Table 2 Estimated Hit counts for 10 famous persons on Bing Image Search

Table 3 shows the number of relevant images for the first 100 results in Google and Bing image search engines. Second column shows the person that we searched. Third and fourth columns show the number of relevant images for the searched person on Google and Bing respectively.

The results on this table show that these two image search engines can return highly relevant images. There are very few irrelevant images. The only exception is the query "Leonardo da Vinci". For this query, both search engines return around 30 images of the person Leonardo da Vinci. The irrelevant images for this query are usually the paintings by him. Some of those images are the paintings of other people by him and some others are the paintings of other objects by him.

If we exclude the query for "Leonardo da Vinci", the precision values are 99.3% for Google and 98.3% for Bing. Out of the 900 retrieved images from Google, there are

only 6 images that do not belong to the person searched in the query. Similarly, out of the 900 retrieved images from Bing, there are only 15 images that do not belong to the person searched in the query.

These results show that both image search engines can retrieve highly relevant images for people that have many images on the web. In addition, the results indicate that the query should be unambiguous for the high retrieval effectiveness. It seems that the query "Leonardo da Vinci" refers to both the person and his paintings. Since we are searching for the images of the person, precision value for the retrieved images is smaller compared to the other queries.

The irrelevant images are usually the images of other people. For example, for the query of "Steve Jobs" on Google, two irrelevant images belong to two other people. Similarly, for the query of "John F. Kennedy" on Bing, 10 irrelevant images belong to another person from Kennedy family.

Google precision values are a little more than Bing precision values. However, the difference is not significant.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Steve Jobs	98	100
2	Bill Gates	100	100
3	John F. Kennedy	100	90
4	Martin Luther King	100	99
5	Nelson Mandela	100	100
6	Muhammad Ali	99	97
7	Elvis Presley	100	100
8	Thomas Edison	100	99
9	Atatürk	97	100
10	Leonardo da Vinci	37	30
	Average Precision excluding Leonardo da Vinci	99.3%	98.3%

Table 3 Precision Values for famous people for the first 100 results

Table 4 shows the number of relevant images for the first 30 results in Google and Bing image search engines. **Table 5** shows the number of relevant images for the first 10 results in Google and Bing image search engines.

Both search engines return 100% relevant images for the first 10 results excluding the query "Leonardo da Vinci". Similarly, both search engines return 99.6% relevant images for the first 30 results excluding the query "Leonardo da Vinci". There is only one irrelevant image for the first 30 images for 9 queries in both search engines. These results show that both search engines can return very accurate results for the top returned images for famous people.

These results also indicate that the accuracy of returned images increases as the ranking of those results becomes closer to the top. Precision values for the top 10 images are highest, followed by the precision values for the top 30 images. Precision values for the top 100 images are the lowest as we expect.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Steve Jobs	30	30
2	Bill Gates	30	30
3	John F. Kennedy	30	30
4	Martin Luther King	30	30
5	Nelson Mandela	30	30
6	Muhammad Ali	30	29
7	Elvis Presley	30	30
8	Thomas Edison	30	30
9	Atatürk	29	30
10	Leonardo da Vinci	16	18
	Average Precision excluding Leonardo da Vinci	99.6%	99.6%

Table 4 Precision Values for famous people for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Steve Jobs	10	10
2	Bill Gates	10	10
3	John F. Kennedy	10	10
4	Martin Luther King	10	10
5	Nelson Mandela	10	10
6	Muhammad Ali	10	10
7	Elvis Presley	10	10
8	Thomas Edison	10	10
9	Atatürk	10	10
10	Leonardo da Vinci	7	4
	Average Precision excluding Leonardo da Vinci	100	100

Table 5 Precision Values for famous people for the first 10 results

Table 6 shows the repeated images for the first 100 images retrieved for each query. For the search query "Bill Gates" on Google, there are two different images repeated two times each (2x2). Similarly, for the query "John F. Kennedy" on Bing, there is one image repeated two times (1x2) and there is another image repeated three times (1x3).

Leonardo da Vinci results are excluded because of most of retrieval results are his paintings.

We have examined the repeated images and observed that usually they have some slight differences in brightness or size. We have not observed any exact replica in result set.

	QUERIES	Repeated images on Google	Repeated images on Bing
1	Steve Jobs	0	0
2	Bill Gates	2x2	0
3	John F. Kennedy	0	1x2 + 1x3
4	Martin Luther King	0	1x2
5	Nelson Mandela	1x2	3x2
6	Muhammad Ali	0	0
7	Elvis Presley	0	0
8	Thomas Edison	0	1x4 + 5x2
9	Atatürk	0	0
10	Leonardo da Vinci		

Table 6 Number of Repeated Images for famous people for the first 100 results

Image 1 Retrieved top 100 images for "**Steve Jobs**" by Google image Search.

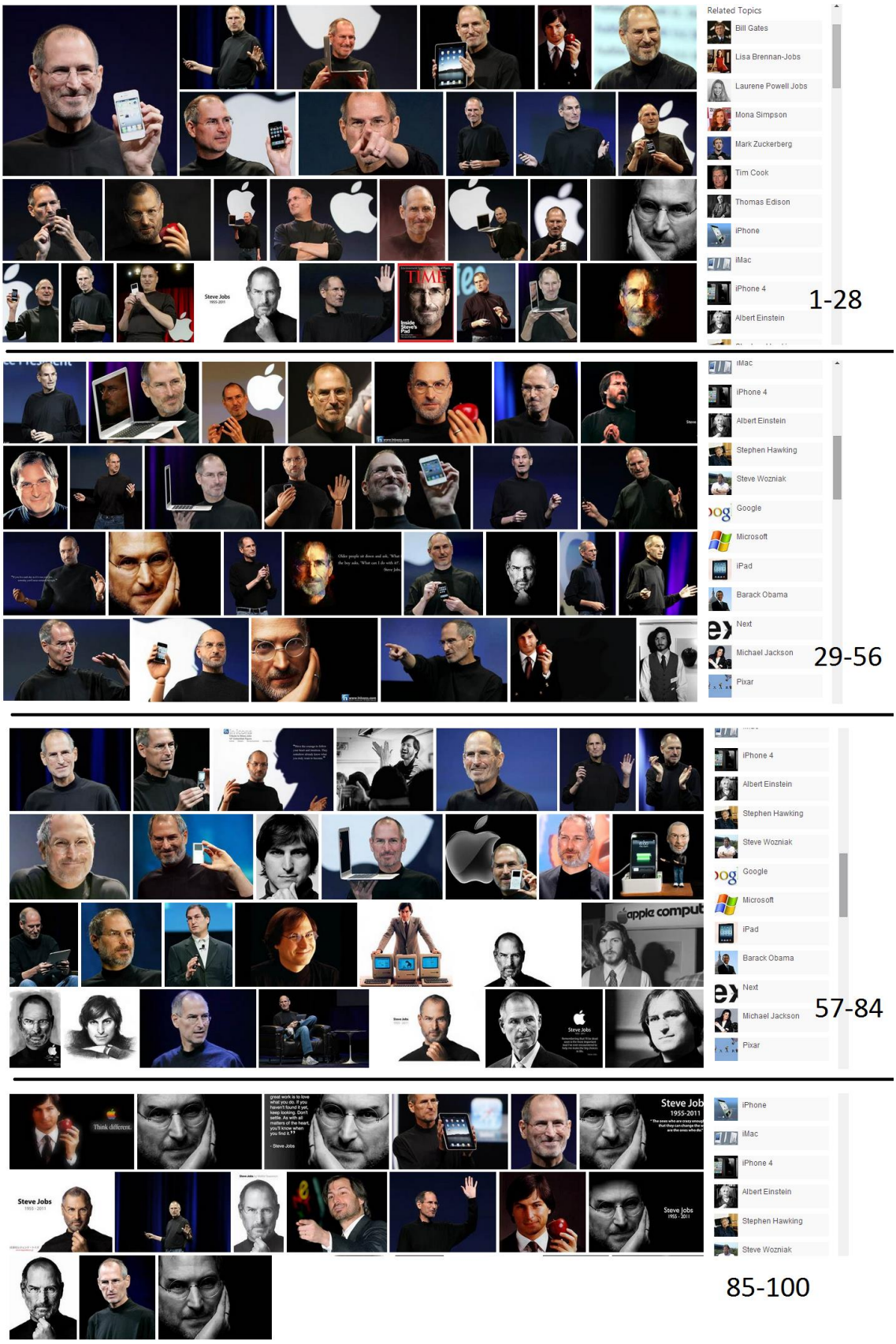

Image 2 Retrieved top 100 images for "**Steve Jobs**" by Bing image Search.

We recorded retrieved results in order not to lose images. **Image 1** shows retrieved top 100 images results for “Steve Jobs” by Google image search. We put line amoung each screenshot in order to count images easily. There are 2 images that irrelevant for “Steve Jobs”. Below images are 56th and 88th images. They are not belongs to “Steve Jobs”.

Image 3 Amoung Top 100 images, It’s 56th Image for Google

Image 4 Amoung Top 100 images, It’s 88th Image for Google

Image 2 shows retrieved top 100 images results for “Steve Jobs” by Bing image search. We put line among each screenshot in order to count images easily. There are no any irrelevant images for “Steve Jobs”.

4.1.2 Less Popular Persons on web

We would like to investigate whether image search engines can return relevant results for people that have few images on the web. We determined 10 people mostly academics from universities in Turkey. We tested whether they have few images on the web by using Bing image search engine. We used the estimated hit count values on result pages of Bing image search. We require estimated hit count values to be between 100 and 500 for each query. **Table 7** shows the person names and the estimated hit count values.

	QUERIES	Estimated Hit counts on Bing
1	Tankut Yalçınöz	285
2	Lemi Orhan Ergin	283
3	Nüket Yetiş	171 (on Yandex)
4	Ramazan Özey	431
5	Murat Uzam	161
6	Hasan Fevzi Batırel	140
7	A. Ercan Gegez	309
8	Şahamet Bülbül	112
9	Gülden Z. Omurtag	116
10	Mahir Günday	117

Table 7 Estimated Hit counts for 10 less famous persons on Bing Image Search

Table 8 shows the number of relevant images for the first 100 results at Google and Bing. On the average, the precision value for Google is 24.1% and the precision value for Bing is 18.9%. It seems that on the average only one image out of 5 is relevant.

There are many types of irrelevant images. Majority of irrelevant images belong to other people. However, there are other types of irrelevant images. Some irrelevant images are book covers that may or may not be related to these persons. Some irrelevant images are document or presentation images. There are also images of buildings, logos, plants, etc.

These results imply that Google and Bing image search engines not performing face detection or face recognition for people. They seem to return all kinds of images when searching for person names. It is highly likely that they return the results based on the text in web pages.

The lowest precision value for Google results is for the query "Murat Uzam". Only 8 images belonging to him is returned among the first 100 images. The lowest precision value for Bing results is for the query "Lemi Orhan Ergin". Only 3 images belonging to him is returned among the first 100 images.

These results imply that the precision values for image search can be really low at times. It can be less than 10%. This is highly unlikely for document searches in the web. Web search engines usually return much better results with higher precision values. Particularly, for the unambiguous queries that we used in these experiments. In the next

sub section, we compare precision values of image search results and documents search results.

Probably the reason for the low precision values may be the result of generating image search results by using texts in web pages. A string may appear in a web page and there may be multiple images on that page. It seems that the image search engines are having difficulties to determine the correct images in a web page.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Tankut Yalçınöz	35	40
2	Lemi Orhan Ergin	12	3
3	Nüket Yetiş	52	40
4	Ramazan Özey	19	14
5	Murat Uzam	6	4
6	Hasan Fevzi Batırel	38	23
7	A. Ercan Gegez	26	27
8	Şahamet Bülbül	15	12
9	Gülden Z. Omurtag	20	21
10	Mahir Günday	16	5
	Average Precision	24,2%	18.9%

Table 8 Precision Values for less famous people for the first 100 results

Table 9 shows the number of relevant images for the first 30 results in Google and Bing. **Table 10** shows the number of relevant images for the first 10 results in Google and Bing.

Similar to the precision results for famous people, image search engines return more relevant images on top results for less famous people. For Google, 71% of images belong to the persons that are searching for the first 10 results. For Bing, 48% of images belong to the persons that are searching for the first 10 results.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Tankut Yalçınöz	18	10
2	Lemi Orhan Ergin	7	3
3	Nüket Yetiş	24	15
4	Ramazan Özey	18	11
5	Murat Uzam	6	4
6	Hasan Fevzi Batırel	22	15
7	A. Ercan Gegez	14	15
8	Şahamet Bülbül	10	7
9	Gülden Z. Omurtag	15	13
10	Mahir Günday	10	3
	Average Precision	48%	32%

Table 9 Precision Values for less famous people for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Tankut Yalçınöz	7	5
2	Lemi Orhan Ergin	6	2
3	Nüket Yetiş	8	7
4	Ramazan Özey	9	4
5	Murat Uzam	6	2
6	Hasan Fevzi Batırel	9	9
7	A. Ercan Gegez	9	7
8	Şahamet Bülbül	6	3
9	Gülden Z. Omurtag	9	8
10	Mahir Günday	2	1
	Average Precision	71%	48%

Table 10 Precision Values for less famous people for the first 10 results

Image 5 Retrieved top 100 images for "**Tankut Yalçınöz**" by Google image Search.

Image 6 Retrieved top 100 images for "**Tankut Yalçınöz**" by Bing image Search.

Image 5 and **Image 6** represents retrieved top 100 images results for "Tankut Yalçınöz" by Google image search and by Bing image search respectively. There are 65 images that irrelevant for "Tankut Yalçınöz" for Google image search. There are 60 images that irrelevant for "Tankut Yalçınöz" for Bing image search. Some irrelevant images are shown below.

Image 7 Irrelevant images for “Tankut Yalçınöz” (4th-7th-9th-11th images on Google).

Image 8 Irrelevant images for “Tankut Yalçınöz” (5th-6th-7th-8th images on Google).

4.1.3 Comparision of Precisions of Document Searchs and Image Searches

In this section, we investigate the precision values of document search results for less famous 10 people. We would like to compare the precision values of image search results and document search results.

We submit the person names as queries to Google and Bing search engines using the regular web search engine interfaces. We examine the top 30 documents for each query and determine the relevancy of each result for the submitted query.

Table 11 shows the number of relevant documents among the first 30 documents in both Google and Bing. **Table 12** shows the number of relevant documents among the first 10 documents in both Google and Bing.

On the average, the precision of document searches for top 30 results is %93.7 for Google and %90.7 for Bing. On the average, the precision of document searches for top 10 results is %92 for Google and %93 for Bing. These results show that the precision of document searches are very high. On the other hand, the precision of image search results for top 30 results were %48 for Google and %32 for Bing.

These results clearly show that the precisions of image search results are much lower compared to the precisions of document searches for top 30 and top 10 results. It seems that finding the relevant images for queries is much harder compared to finding the relevant documents. The primary difficulty for this is that image search engines perform indirect searches for relevant images. Instead of analyzing the content of images and performing the searches on that information, they perform searches based on the texts surrounding the images.

Text based image search has two main problems. First, many terms around an image may not be related to the image. Second, many of the objects or concepts in an image may not be mentioned in the texts around the image. The first problem results in lower precision values for image search queries. Irrelevant texts around an image may be associated with that image. Therefore, images may be returned for irrelevant terms. The second problem results in lower recall values. Since many objects or concepts are not mentioned in texts around an image, when these unmentioned terms are searched, these relevant images are not retrieved.

Content analyses of images are difficult to perform and compute intensive. It is very difficult to correctly identify all objects and concepts in images. For example, face detection is rather easy but face identification is very difficult.

On the other hand, Image search engines have a very important advantage compared to the document search engines. Users may check many images and identify the relevant ones much faster compared to the document search results. Based on this observation, Image search engines provide many downsized images on results pages. While they return only top 10 results for document searches by default, they return hundreds of images when the user scrolls down the result page. It is expected that users can check many images and identify the relevant ones. This method also gives users the opportunity of finding the relevant images without going to the target web pages. The same thing is not true for document searches. Although a short description of target documents is provided in result pages, it is much more difficult to judge the relevancy of documents without visiting the actual web pages. Because of this, search engines may be willing to return image search results with low precision. In addition, this may give users a wider spectrum to choose targeted images.

	QUERIES	Relevant documents on Google	Relevant documents on Bing
1	Tankut Yalçınöz	26	29
2	Lemi Orhan Ergin	28	26
3	Nüket Yetiş	30	28
4	Ramazan Özey	29	26
5	Murat Uzam	28	29
6	Hasan Fevzi Batırel	30	28
7	A. Ercan Gegez	29	26
8	Şahamet Bülbül	25	25
9	Gülden Z. Omurtag	28	29
10	Mahir Günday	28	26
	Average Precision	93.7%	90.7%

Table 11 Precision Values of Document Searches for less famous people for the first 30 results

	QUERIES	Relevant documents on Google	Relevant documents on Bing
1	Tankut Yalçınöz	7	9
2	Lemi Orhan Ergin	9	10
3	Nüket Yetiş	10	9
4	Ramazan Özey	10	8
5	Murat Uzam	10	10
6	Hasan Fevzi Batırel	10	10
7	A. Ercan Gegez	9	10
8	Şahamet Bülbül	7	7
9	Gülden Z. Omurtag	10	10
10	Mahir Günday	10	10
	Average Precision	92%	93%

Table 12 Precision Values of Document Searches for less famous people for the first 10 results

4.1.4 Existence of Query Terms in Target Web Pages for Irrelevant Image Results

We determined the irrelevant images among the top 100 results for two queries for less popular persons. We downloaded and examined the content of web pages that contained those irrelevant images. First, we examined whether the target web pages contain the query words.

Table 13 shows the results of the tests for the existence of query words in target pages for Google results. First column shows the two queries that we examined. Second column shows the number of irrelevant images for these queries among the top 100 results. Third column shows the number of target web pages that include all the words in the queries. Fourth column shows the number of target web pages that include some of the query words. The fifth column shows the number of pages that does not contain any of the query words. There are only two pages that do not have any of the query words among 153 pages. Majority of other web pages contain all query words. Only 9 out of 153 web pages contain some of query words. Web search engines may return web pages that contain some of the terms in queries for document searches. The same thing may be true in this case.

Table 14 shows the results of the tests for the existence of query words in target pages for Bing results. In this case, there are more web pages that do not contain any of the query terms. 11 pages out of 157 web pages do not contain any of the query terms. We examined these web pages and it seems that majority of those pages are frequently updated web pages. Some of them are dynamic social media web pages.

These results strongly suggest that Google and Bing perform text based searches for images. In the case of Google, only two out of 153 pages do not contain any of the query words. For Bing, 11 out of 157 web pages do not contain any of the query words. Either those pages may have been updated since the last crawl or query words may exist in the anchors of the pointing links two those pages.

Query	Irrelevant Images	All words exists	Single word exists	No word exists	Page does not exist
Tankut Yalçınöz	65	54	9	1	1
Lemi Orhan Ergin	88	87	0	1	0

Table 13 Existence of query words on the target web page for irrelevant images for Google results

Query	Irrelevant Images	All words exists	Single word exists	No word exists	Page does not exist
Tankut Yalçınöz	60	56	1	2	1
Lemi Orhan Ergin	97	79	4	9	5

Table 14 Existence of query words on the target web page for irrelevant images for Bing results

4.1.5 Existence of Relevant Images in Target Web Pages for Irrelevant Image Results

In this section, we continue to examine the web pages that contain the irrelevant images among the top 100 results for two queries for less popular persons. We examine to see whether target pages contain any relevant images for the queries.

Table 15 shows the existence of relevant images on the target web pages for Google results. We examined the target web pages and determined whether they contain the images of persons we are searching. For the query "Tankut Yalçınöz", half of the target web pages contained the images of that person. For the query "Lemi Orhan Ergin", 75% of the target web pages contained the images of that person. In total for two queries, %57 of web pages contain relevant images.

Table 16 shows the existence of relevant images on the target web pages for Bing results. The results are similar to Google results. In this case, in total %46 of web pages contain a relevant image for the searched queries.

These results show that determining the relevant images in a web page for a query is a very important issue. When a web page has query words and multiple images, both Google and Bing have difficulty determining the correct relevant images. Around half of irrelevant images could have been avoided, if they have better algorithms to select among multiple images in web pages.

Query	Irrelevant Images	Image Exist on target page	
		Yes	No
Tankut Yalçınöz	65	32	33
Lemi Orhan Ergin	88	66	22

Table 15 existence of relevant images on the target web pages for Google results

Query	Irrelevant Images	Image Exist on target page	
		Yes	No
Tankut Yalçınöz	60	44	16
Lemi Orhan Ergin	97	29	68

Table 16 existence of relevant images on the target web pages for Bing results

4.1.6 Conclusion

In this chapter, we examined and evaluated whether Google and Bing image search engines can retrieve accurate image lists for human queries. We provide the answers of each research question below.

1. Can these two image search engines provide useful results for people searches? What are the precision values for queries about popular and less popular persons? Do image search engines provide more accurate results for more popular people searches?

Table 17 shows the precision rates for popular and less popular human image searches. Precision rates are excellent for popular person searches. Among the first 100 retrieved images, usually there are only one or two irrelevant images. This shows that image search engines can satisfy the user information needs with very high accuracy for popular person searches. We should point out that we omitted the results for "Leonardo da Vinci" since his paintings and his own images are provided in result pages.

Precision values for less popular person queries are much lower. Around %20 of images belongs to the searched person. This shows that the image search engines need to improve their algorithms significantly. When there are less documents and images about a person, they have much difficulty to correctly retrieve the relevant images.

	Top 100	Top 30	Top 10
Popular person searches at Google	99,3	99,6	100
Popular person searches at Bing	98,3	99,6	100
Less popular person searches at Google	24,2	48	71
Less popular person searches at Bing	18,9	32	48

Table 17 Precision percentages of human image searches

2. Do image search engines provide more accurate results for the higher ranking images on the result list?

The results on **Table 17** show that the top ranking images have much better precision values. The results are particularly significant in less popular person searches. While the precision rate of top 10 results in Google for less popular persons is 71%, it is 24.2% for top 100 results. Bing results also have a big difference between the precisions of top 10 and top 100 results. This is a positive result for search engines since it is much more important to deliver correct results among the top ranking images.

3. How does the precision of document searches and image searches compare for less popular persons on the web?

Precision rates of less popular person searches are so low according to **Table 17**. We examined the reasons for it and compared it to the precision values of document searches. We used 10 less popular person queries for document searches. **Table 18** shows the average precision values for top 10 and top 30 documents. Precision values are much higher compared to the image search results.

Document Results	Top 30	Top 10
Google	93,7	92
Bing	90,7	93

Table 18 Average precision rates of 10 less popular people on document searches

It seems that finding the relevant images for queries is much harder compared to finding the relevant documents. The primary difficulty for this is that image search engines perform indirect searches for relevant images. Instead of analyzing the content of images and performing the searches on that information, they perform searches based on the texts surrounding the images.

4. What are the main reasons for search engines to return irrelevant images?
    a. Do image search engines work only with the texts on web pages? Do they perform any image content analysis?
    b. When image search engines return an irrelevant image, can it be because of the incorrect identification of images on the target web page? While a relevant image exists on that page, is it returning an irrelevant image from that page?

We downloaded and examined the content of web pages that contained irrelevant images. With very high percentages, searched query texts exist on target web pages. **Table 19** shows that web pages have query words although image is irrelevant. These results strongly suggest that Google and Bing perform text based searches for images.

	Google		Bing	
Query	Tankut Yalçınöz	Lemi Orhan Ergin	Tankut Yalçınöz	Lemi Orhan Ergin
Irrelavant Images	65	88	60	97
Query words exist in target web page	63	87	57	83
	96,92%	98,86%	95%	85,57%

Table 19 Existence of query terms in target pages for irrelevant images.

We examined the content of web pages that has irrelevant image results. **Table 20** shows the percentages of web pages that have relevant images for the query but an irrelevant image from that web page is returned. When a web page has query words and multiple images, both Google and Bing have difficulty deterimining the correct relevant images. Around half of irrelevant images could have been avoided, if they have better algorithms to select among multiple images in web pages.

	Google	Bing
Tankut Yalçınöz	49,23%	73,33%
Lemi Orhan Ergin	75%	29,90%

Table 20 Rate of image exists on target page.

CHAPTER 5

SEARCHING FOR PLANT IMAGES

5.1 Plants

We want to confirm people test results with plant tests. Image retrieval for plants is a difficult problem also. Plant images resemble each other and it is difficult to find distinguishing features. Particularly the plants from the same family resemble each other and it is difficult to distinguish them. Sometimes, there are more than a hundred plant species from one family. We examine whether plant tests will provide similar results with people tests.

In this chapter, we hope to answer following research questions:

1. Can these two image search engines provide useful results for plant searches? What are the precision values for queries about common and less common plants? Do image search engines provide more accurate results for more common plant searches?
2. Do image search engines provide more accurate results for the higher ranking images on the result list?
3. Are the results of plant tests same with people test? Compare the results?

We attend to analyze each of the questions in this chapter. We analyze each question by given the methods in chapter 3. In this way, we hope to strengthen ideas in chapter five. Outline of chapter five is as following.

In the first section, we examine precision rates of common plant images. Google and Bing search engines retrieve lots of images about the searched entities. We examine the results in three cutoff points; top 100, top 30 and top 10 images. We look precision rates for each category.

In the second section, we investigate images for less common plants. We select plants that have between 100 and 600 images on the web. Selected queries are searched

on Google and Bing search engines. Similar to the popular plant results, we examine the precision values at three cutoff points; first 100, 30 and 10 images.

In the third section, we investigate the reasons for the higher precision values of image searches for less common plants according to precision values of less popular person.

5.1.1 Popular Plants on Web

We would like to investigate whether image search engines can return relevant results for plant images on the web. Detecting plant images by analyzing the content of images is very difficult. Therefore, we would like to examine the results of image search engines for plant image searches.

We determined 10 widespread plant names and tested whether they have many images on the web. When determining plant names, we made sure that the selected plant names are not ambiguous and they are primarily used for the searched plant. This is to make sure that the relevancy assessments of returned results are accurate. For example, we have not selected the name “daisy” as a query, because there is a famous cartoon character with the same name. When we search for the query “daisy”, the search engines may return plant images and the cartoon character images. Therefore, it would be difficult to assess the relevancy of returned results.

We use a simple method to determine whether a query is unambigous. We perform a text search on Google and require that at least 8 of the top 10 results belong to the searched plant. Otherwise, we conclude that the query is not unambiguous. We do not select that query in our tests. All the selected queries in this section are unambiguous. At least 8 of the top 10 returned documents on Google search are related to those plants.

We used the estimated hit count values on Bing Image Search Engine result page or Yandex Image Search Engine result page. Google image search engine does not return the estimated hit count for image searches. Bing Image Search Engine removed hit count numbers from the result pages after March 2014, so Yandex Image Search

Page is used for hit counts. We require estimated hit counts to be at least 1000 for each query. For the set of plants on **Table 21**, the minimum hit count value is 14.000.

	QUERIES	Estimated Hit counts	
1	Orchid	300000	Yandex
2	Watermelon	199000	Yandex
3	Garlic	60300	Bing
4	Scallion	14000	Yandex
5	Rosemary	60600	Yandex
6	Peas	301000	Yandex
7	Cinnamon	83100	Bing
8	Basil	55300	Bing
9	Cloves	72500	Bing
10	Grapefruit	80000	Yandex

Table 21 Estimated Hit counts for 10 popular plant on Bing Image Search or Yandex Image Search.

Table 22 shows the number of relevant images about plants for the first 100 results in Google and Bing image search engines. Second column shows the plants that we searched. Third and fourth columns show the number of relevant images for the searched plants on Google and Bing respectively.

The results on this table show that these two image search engines can return highly relevant images for plants that have many images on the web. There are very few irrelevant images. The precision values are 98.8% for Google and 97.3% for Bing. Out of the 1000 retrieved images from Google, there are only 12 images that do not belong to the plants searched in the query. Similarly, out of the 1000 retrieved images from Bing, there are only 27 images that do not belong to the plants searched in the query.

The irrelevant images are not far from searched query. For example, for the query of "Watermelon" on Google, two irrelevant images belong to watermelon shoes and jelly sugar with red color. Similarly, for the query of "Garlic" on Bing, 1 irrelevant image belongs to another plant. On the other hand, there are 15 irrelavant images for query of "Scallion" on Bing. These images belong to completely different images. For example; knife, map, etc. For "Cinnamon" query, both of the engines found one snake with colour of cinnamon.

Google precision values are a little more than Bing precision values. However, the difference is not significant.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Orchid	99	100
2	Watermelon	98	99
3	Garlic	100	99
4	Scallion	100	85
5	Rosemary	99	99
6	Peas	98	96
7	Cinnamon	99	99
8	Basil	100	100
9	Cloves	95	96
10	Grapefruit	100	100
	Average Precision	98,8%	97,3%

Table 22 Precision Values for popular plant for the first 100 results

Table 23 shows the number of relevant images for the first 30 results in Google and Bing image search engines **Table 24** shows the number of relevant images for the first 10 results in Google and Bing image search engines.

Both search engines return 100% relevant images for the first 10 results. Google search engine returns 100% relevant images for the first 30 results. Bing search engine returns 99% relevant images for the first 30 results. There is only one irrelevant image for the first 30 images for Bing search engines. These results show that both search engines can return very accurate results for the top returned images for popular plants.

These results also indicate that the accuracy of returned images increases as the ranking of those results becomes closer to the top. Precision values for the top 10 images are highest, followed by the precision values for the top 30 images. Precision values for the top 100 images are the lowest as we expect.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Orchid	30	30
2	Watermelon	30	30
3	Garlic	30	30
4	Scallion	30	28
5	Rosemary	30	30
6	Peas	30	29
7	Cinnamon	30	30
8	Basil	30	30
9	Cloves	30	30
10	Grapefruit	30	30
	Average Precision	100%	99%

Table 23 Precision Values for popular plants for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Orchid	10	10
2	Watermelon	10	10
3	Garlic	10	10
4	Scallion	10	10
5	Rosemary	10	10
6	Peas	10	10
7	Cinnamon	10	10
8	Basil	10	10
9	Cloves	10	10
10	Grapefruit	10	10
	Average Precision	100%	100%

Table 24 Precision Values for popular plants for the first 10 results

Image 9 Retrieved top 100 images for "**Orchid**" by Google image Search.

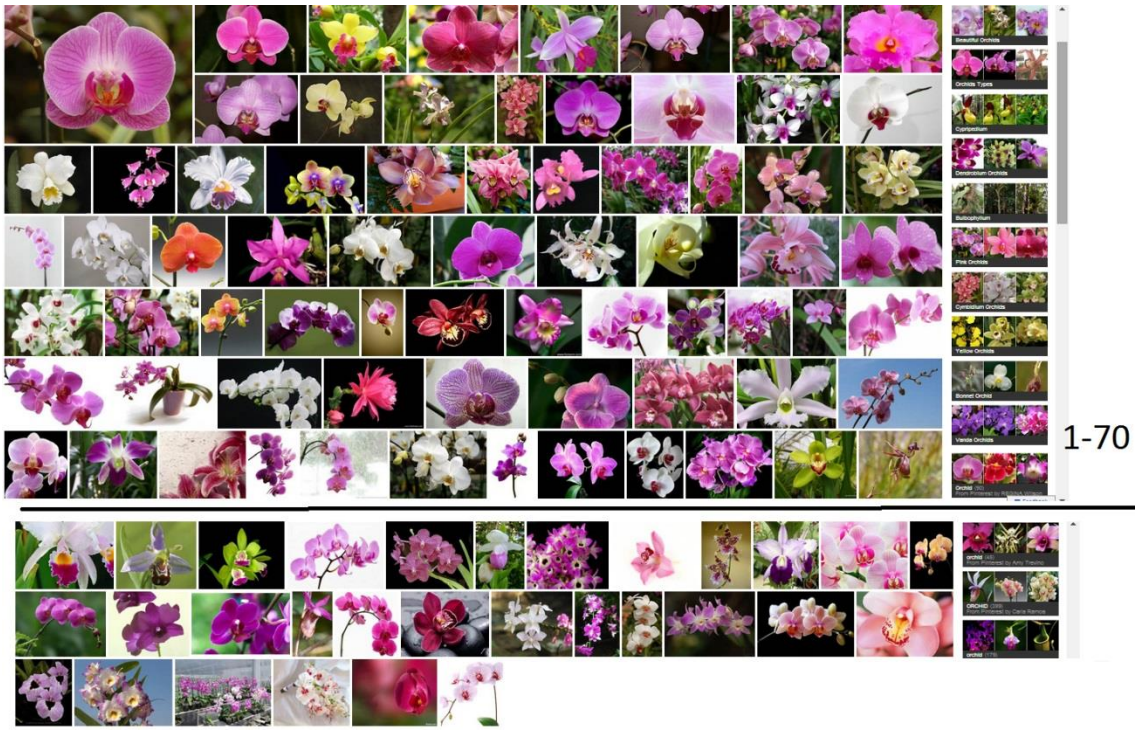

Image 10 Retrieved top 100 images for "**Orchid**" by Bing image Search.

Image 9 and **Image 10** show retrieved top 100 images results for "Orchid" by Google image search and by Bing image search respectively. On Bing, all images are

relevant. There are 1 irrelevant images for “Orchid” on Google image search results. The irrelevant image is below:

Image 11 An Irrelevant Image for “Orchid” on Google Image Search Result.

5.1.2 Less Popular Plants on Web

We would like to investigate whether image search engines can return relevant results for plants that have few images on the web. We determined 10 unambigous plant names as queries. We tested whether they have few images on the web by using Bing image search engine. We used the estimated hit count values on the result pages of Bing image search. We require estimated hit count values to be between 100 and 600 for each query. Table 25 shows the plant names and the estimated hit count values.

	QUERIES	Estimated Hit counts
1	Centaurea behen	221
2	DIGITALIS LANATA EHRH.	358
3	CETRARIA İSLANDICA L. ACH.	220
4	Corynanthe yohimbe	573
5	Hedeoma pulegioides	464
6	Centaurea tchihatcheffii	318
7	LAUROCERASUS OFFICINALIS ROEM.	106
8	Cirsium acarna	165
9	Heracleum platytaenium	137
10	LABURNUM ANAGYROIDES MEDIC.	136

Table 25 Estimated Hit counts for 10 less popular plant on Bing Image Search

Table 26 shows the number of relevant images for the first 100 results in Google and Bing. On the average, the precision value for Google is 69% and the precision value for Bing is 63.7%.

There are many types of irrelevant images. Some of irrelevant images belong to images of other kinds of plants. Some irrelevant images belong to images of statistical information from books and presentations. Other irrelevant images may belong to insects, maps, articles, drugs, people, etc.

These results imply that Google and Bing image search engines not performing content analysis for plant searches. They do not try to detect plants and recognize them. It is highly likely that they return the results based on the texts in web pages.

The lowest precision value for Google and Bing results is for the query "Centraurea Behen". Only 36 images are relevant for Google results. Only 19 images are relevant for Bing results. This plant seems to be the least unambiguous query among our list. There are many other plants sharing the same first name "Centraurea".

In summary, around 65% of returned images are relevant to the searched plants. This value is much higher compared to the less popular results of people queries. For less popular people searches, around 20% of returned images were relevant. We investigate the reason for this difference in the next sub section. Our observation is that the web pages that contain person information have on the average more images and more diverse images. On the other hand, the web pages that contain plant information have less images and they are less diverse. Because of this, search engines may determine the relevant images on web pages with higher precision values.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Centaurea behen	36	19
2	DIGITALIS LANATA EHRH.	76	88
3	CETRARIA İSLANDICA L. ACH.	91	92
4	Corynanthe yohimbe	63	76
5	Hedeoma pulegioides	69	68
6	Centaurea tchihatcheffii	81	75
7	LAUROCERASUS OFFICINALIS ROEM.	81	99
8	Cirsium acarna	54	19
9	Heracleum platytaenium	51	41
10	LABURNUM ANAGYROIDES MEDIC.	87	60
	Average Precision	68,9%	63,7%

Table 26 Precision Values for less popular plant for the first 100 results

Table 27 shows the number of relevant images for the first 30 results in Google and Bing. **Table 28** shows the number of relevant images for the first 10 results in Google and Bing.

Similar to the precision results for famous people, image search engines return more relevant images on top results for less known plant. For both of Google and Bing, 98% of images belong to the plants that are searching for the first 10 results.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Centaurea behen	21	17
2	DIGITALIS LANATA EHRH.	26	29
3	CETRARIA İSLANDICA L. ACH.	30	30
4	Corynanthe yohimbe	28	29
5	Hedeoma pulegioides	28	24
6	Centaurea tchihatcheffii	30	28
7	LAUROCERASUS OFFICINALIS ROEM.	25	30
8	Cirsium acarna	19	16
9	Heracleum platytaenium	28	30
10	LABURNUM ANAGYROIDES MEDIC.	27	29
	Average Precision	87,33%	87,33%

Table 27 Precision Values for less popular plant for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Centaurea behen	10	10
2	DIGITALIS LANATA EHRH.	10	10
3	CETRARIA İSLANDICA L. ACH.	10	10
4	Corynanthe yohimbe	10	10
5	Hedeoma pulegioides	10	9
6	Centaurea tchihatcheffii	10	10
7	LAUROCERASUS OFFICINALIS ROEM.	10	10
8	Cirsium acarna	8	9
9	Heracleum platytaenium	10	10
10	LABURNUM ANAGYROIDES MEDIC.	10	10
	Average Precision	98%	98%

Table 28 Precision Values for less popular plant for the first 10 results

Image 12 Retrieved top 100 images for "**Centaurea behen**" by Google image Search.

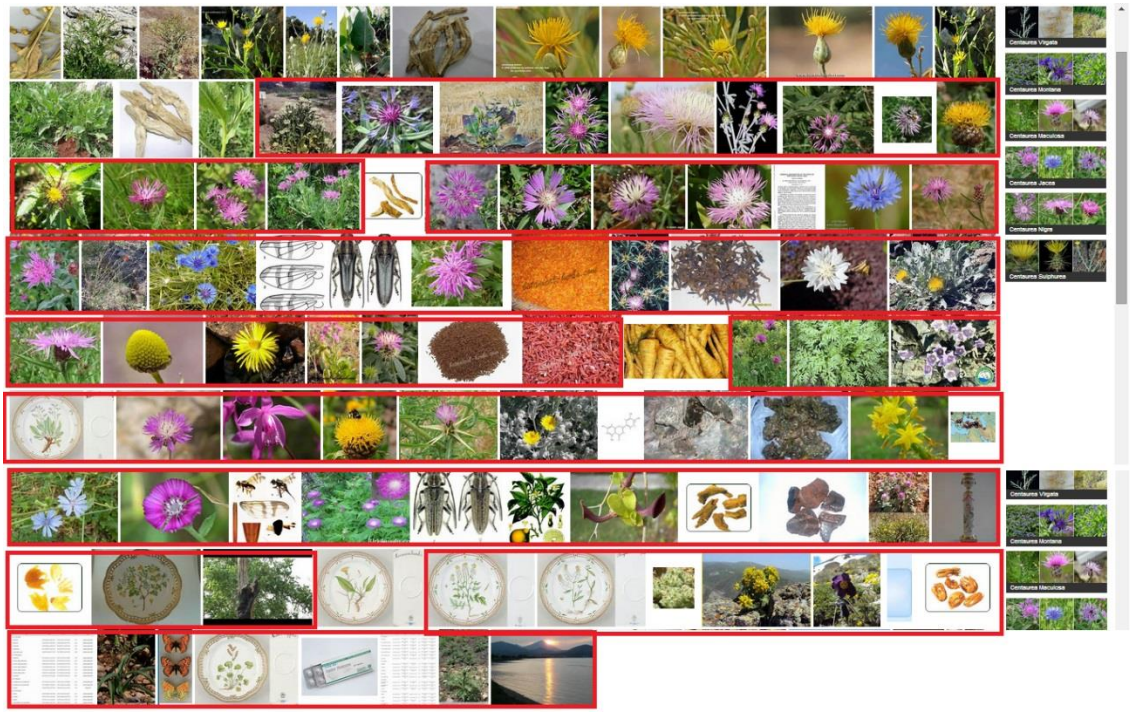

Image 13 Retrieved top 100 images for "**Centaurea behen**" by Bing image Search.

Image 12 and **Image 13** represents retrieved top 100 images results for "Centaurea behen" by Google image search and by Bing image search respectively.

5.1.3 Investigating the Difference between Less Popular Person and Less Popular Plant Searches

Precision values for less popular plant searches are much higher compared to the precision values for less popular person searches. **Table 29** and **Table 30** provides the summary of precision values for less popular person and plant searches on Google and Bing. To understand the difference between these two types of searches, we examine the target web pages. We count the number of images on target web pages and determine the number of relevant images. We try to understand that whether there are significant differences between these two types of web pages.

Google	Top 100 Results	Top 30 Results	Top 10 Results
People	24.2%	48%	71%
Plant	68.9%	87.33%	98%

Table 29 Less popular people and plant precision values for Google

Bing	Top 100 Results	Top 30 Results	Top 10 Results
People	18.9%	32%	48%
Plant	63.7%	87.33%	98%

Table 30 Less popular people and plant precision values for Bing

We selected 5 queries from each query set. We retrieved top 10 images for these queries and examined the contents of web pages that contain these images. **Table 31** shows Google results for 5 less popular person queries. The first column shows the queries as person names. The second column shows the number of web pages that have %100 relevant images. If all images on a web page are relevant to the query, we count this web page as %100 relevant. Search engine may return any one of those images and it will be relevant to the query. Search engines can not make a mistake when selecting the relevant images from the target web page. Out of 50 web pages for less popular persons, 17 web pages contain %100 relevant images on Google.

The third column shows the number of web pages that have %50 to %100 relevant images to the query. The forth columns shows the number of web pages that have up to %50 relevant images to the query. The fifth column shows the number of web pages that does not have any relevant images to the query. All images are irrelevant. The last column shows the number of web pages that we could not retrieved.

Table 32, **Table 33** and **Table 34** are similar to **Table 31**. They have the same types of columns. **Table 32** has the results for less popular plants on Google. **Table 33** has the results for less popular persons on Bing. **Table 34** has the results for less popular plants on Bing.

We have summarized the less popular person query results and less popular plant query results at **Table 35**. This table shows that in general the web pages that have plant images have more relevant images. The web pages that have person images have less relevant images. Out of 98 web pages for less popular person queries, only 28 of them have all relevant images. On the other hand, out of 94 web pages for less popular plant queries, 68 of them have all relevant images. Similarly, out of 98 web pages for less popular person queries, 23 of them have none relevant images. However, out of 94 web pages for less popular plant queries, only 3 of them have none relevant images.

These results explain the difference between the precision values of less popular person searches and less popular plant searches. These two types of web pages have

very different properties. The web page that have plant images are mostly informational web pages. They contain information about plants. They also have some pictures. Most of the information and pictures belong to the plants. However, the web pages that have person names comprise a diverse set. Those web pages may be news articles, blog entries, etc. These kinds of web pages have information and pictures about many people and many types of entities.

These results also show that image search engines have a lot of difficulty when detecting the relevant images in a web page for a given query. This is an important problem.

Google	100%	(100%-50%]	(50%-0%)	0%	Page not retrieved
Tankut Yalçınöz	2	0	5	2	1
Lemi Orhan Ergin	2	1	7	0	0
Nüket Yetiş	5	1	2	2	0
Ramazan Özey	7	0	3	0	0
Murat Uzam	1	0	6	3	0
Total result	17	2	23	7	1

Table 31 Percantages of relevant images to total images on target pages for less popular person queries on Google

Google	100%	(100%-50%]	(50%-0%)	0%	Page not retrieved
Centaurea behen	7	0	1	0	2
DIGITALIS LANATA EHRH.	2	3	4	0	1
CETRARIA İSLANDICA L. ACH.	5	1	3	1	0
Corynanthe yohimbe	6	1	2	1	0
Hedeoma pulegioides	9	0	1	0	0
Total result	29	5	11	2	3

Table 32 Percantage ratio for right image to total image on target page

BING	100%	(100%-50%]	(50%-0%)	0%	Page not retrieved
Tankut Yalçınöz	2	1	5	2	0
Lemi Orhan Ergin	1	0	6	3	0
Nüket Yetiş	4	4	1	0	1
Ramazan Özey	3	0	1	6	0
Murat Uzam	1	0	4	5	0
Total result	11	5	17	16	1

Table 33 Percantage ratio for right image to total image on target page

BING	100%	(100%-50%]	(50%-0%)	0%	Page not retrieved
Centaurea behen	10	0	0	0	0
DIGITALIS LANATA EHRH.	9	0	1	0	0
CETRARIA İSLANDICA L. ACH.	7	1	1	0	1
Corynanthe yohimbe	6	2	0	0	2
Hedeoma pulegioides	7	0	2	1	0
Total result	39	3	4	1	3

Table 34 Percantage ratio for right image to total image on target page

Query types	100%	(100%-50%]	(50%-0%)	0%	Total
Less popular person	28	7	40	23	98
Less popular plants	68	8	15	3	94

Table 35 Comparison of relevant images on target pages for less popular persons and less popular plants

5.1.4 Conclusion

In this chapter, we examined and evaluated whether Google and Bing image search engines can retrieve accurate image lists for plant queries. We provide the answers of each research question below.

1. Can these two image search engines provide useful results for plant searches? What are the precision values for queries about common and less common plants? Do image search engines provide more accurate results for more common plant searches?

Table 36 shows summary of the precision rates for popular and less popular plant image searches. Precision rates are excellent for popular plant searches. Among the first 100 retrieved images, usually there are a few irrelevant images. This shows that image search engines can satisfy the user information needs with very high accuracy for popular plant searches.

Precision values for less popular plant queries are lower than popular plant queries. Around 65% of images belong to the searched plant. This still shows that the image search engines need to improve their algorithms. There are big differences between the precision values of less popular person results and less popular plant

results. The precision values for less popular plant results are much higher around 65% compared to the precision values for less popular people results that is around 20%.

	Top 100	Top 30	Top 10
Popular plant searches at Google	98,8	100	100
Popular plant searches at Bing	97,3	99	100
Less popular plant searches at Google	68,9	87,3	98
Less popular plant searches at Bing	63,7	87,3	98

Table 36 Precision percentages of plant image searches

2. Do image search engines provide more accurate results for the higher ranking images on the result list?

The results on **Table 36** show that the top ranking images have much better precision value. The results are clearer in less popular person searches. While the precision rate of top 10 results in Google for less popular persons is 98%, it is 68.9% for top 100 results. Bing results also have almost same difference between the precisions of top 10 and top 100 results. This is a positive result for search engines since it is much more important to deliver correct results among the top ranking images.

3. Are the results of plant tests the same with people test? Compare the results?

Precision values for less popular plant searches are much higher compared to the precision values for less popular person searches. **Table 29** and **Table 30** provides the summary of precision values for less popular person and plant searches on Google and Bing. To understand the difference between these two types of searches, we examine the target web pages. We count the number of images on target web pages and determine the number of relevant images. We try to understand that whether there are significant differences between these two types of web pages.

We have summarized the less popular person query results and less popular plant query results at **Table 35**. This table shows that in general the web pages that have plant images have more relevant images. The web pages that have person images have less relevant images. These results explain the difference between the precision values of less popular person searches and less popular plant searches. These two types of web pages have very different properties. The web page that have plant images are mostly informational web pages. They contain information about these plants. They also have

some pictures. Most of the information and pictures belong to these plants. However, the web pages that have person names comprise a diverse set. Those web pages may be news articles, blog entries, etc. These kinds of web pages have information and pictures about many people and many types of entities.

These results also show that image search engines have a lot of difficulty when detecting the relevant images in a web page for a given query. This is an important problem.

CHAPTER 6

SEARCHING FOR BOOK COVER IMAGES

6.1 Searching For Book Cover Images

Book covers have both text and images. Usually the text on book covers has the most important information about it. The name of the book and the author of it are printed as text. Therefore, an image search engine providing some content analysis such as optical character recognition (OCR) can easily search the book cover images and provide highly accurate results. Therefore, in this chapter, we first investigate the precision values for book cover searches. The results will show that whether these two image search engines are employing OCR in images as a way of content analysis.

We assume that the easiest and most accurate content analysis method is OCR for images. If search engines are not employing OCR, we can assume that they would not employ other more complex and less accurate content analysis methods.

In this chapter, we hope to answer following research questions:

1. Can these two image search engines provide useful results for book cover searches? What are the precision values for queries about common and less common book cover? Do image search engines provide more accurate results for popular book cover searches?
2. How does the precision results of book cover searches compare to the precision values of people and plant searches?
3. Do these search engines employ OCR for book cover searches?

We attend to analyze each of the questions in this chapter. We analyze each question by given the methods in chapter 3. In this way, we hope to strengthen ideas in chapter six. Outline of chapter six is as following.

In the first section, we examine precision rates of popular book cover images. Google and Bing search engines retrieve lots of images about the searched entities. We

examine the results in three cutoff points; top 100, top 30 and top 10 images. We look precision rates for each category.

In the second section, we investigate images for less popular book cover images. We select book covers that have between 100 and 500 images on the web. Selected queries are searched on Google and Bing search engines. Similar to the popular book cover results, we examine the precision values at three cutoff points; first 100, 30 and 10 images.

In that way, precision rate of popular book cover and less popular book cover is searched.

6.1.1 Popular Book Covers on Web

We would like to investigate whether image search engines can return relevant results for book covers that have many images on the web. We determined 10 best seller books and tested whether they have many images on the web. The selected set of books are shown on **Table 37** with the estimated hit count values. Hit count values are retrieved from Bing but the ones mentioned as Yandex on the last column are retrieved from Yandex Image search.

	QUERIES	Estimated Hit counts	
1	The Goldfinch by Donna Tartt	10900	
2	Humans of New York by Brandon Stanton	8520	
3	Sycamore Row by John Grisham	6300	
4	Doctor Sleep by Stephen King	25300	
5	Memoirs of a Secretary at War by Robert M Gates	25300	
6	The Book Thief Paperback by Markus Zusak	11000	
7	Time to kill by John Grisham	3000	Yandex
8	A Fighting Chance by Elizabeth Warren	2000	Yandex
9	Don't Make Me Think by Steve Krug	1000	Yandex
10	The Yellow Birds by Kevin Powers	8000	Yandex

Table 37 Estimated Hit counts for 10 popular book covers on Bing Image Search or Yandex Image Search

Table 38 shows the number of relevant images for the first 100 results in Google and Bing image search engines. Second column shows the book cover name that we

searched. Third and fourth columns show the number of relevant images for the searched book cover on Google and Bing respectively.

The results on this table show that these two image search engines can return poorly relevant images. There are very few relevant images. Especially second query is too low. For this query, both search engines return around fewer than 5%. The irrelevant images for this query are usually the images from people on New York.

If we exclude the query for “Humans of New York by Brandon Stanton”, the precision values are 44.3% for Google and 69% for Bing. If we include, the precision values are 40.1% for Google, 62.5% for Bing.

It is surprising that the precision results show that both image search engines can retrieve poorly relevant images for book cover searches. Precision values are much lower compared to the precision values of people and plant searches. This suggests that probably these two image search engines are not employing OCR analysis on images. Otherwise, we would expect to get highly relevant images. Another explanation for the lower precision values might be the fact that the hit count values for book cover queries are much smaller. If there are much fewer images related to these queries, the search engines may return less relevant results compared to the people and plant searches.

In the query, author name and book name is searched. Therefore, if the resulting image has the author name or the author image and also the book name, we accept it as a relevant image. For this reason, sometimes we accept images from posters, TV scenes, etc. The irrelevant images are usually the images of book’s author or images of author’s another books. Other irrelevant images are about; other peoples’ photo showing some book or message, car images, paintings, people from New York, a part of book or drawings from that book, film scenes from the searched book et.

The second query may be interpreted as ambiguous. However, we performed the ambiguity test on Google document search and seen that all top 10 results are related to this book.

Bing precision values are a little more than Google precision values. There are similar images in Bing.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	The Goldfinch by Donna Tartt	36	69
2	Humans of New York by Brandon Stanton	2	4
3	Sycamore Row by John Grisham	56	85
4	Doctor Sleep by Stephen King	54	83
5	Memoirs of a Secretary at War by Robert M Gates	40	45
6	The Book Thief Paperback by Markus Zusak	60	92
7	Time to kill by John Grisham	57	81
8	A Fighting Chance by Elizabeth Warren	20	23
9	Don't Make Me Think by Steve Krug	36	70
10	The Yellow Birds by Kevin Powers	40	73
	Average Precision	40,1%	62,5%

Table 38 Precision Values for popular book cover searches for the first 100 results

Table 39 shows the number of relevant images for the first 30 results in Google and Bing image search engines. **Table 40** shows the number of relevant images for the first 10 results in Google and Bing image search engines.

Google search engine returns around 60% relevant images for the first 30 results and Bing search engines returns around %70 relevant images for the first 30 results. These results are remarkable different from people and plant results. For best seller books, we were expecting high result like people or plants. We were also expecting examining content of books easier than people and plants. Therefore, we expect higher results for books than for people and plants.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	The Goldfinch by Donna Tartt	16	26
2	Humans of New York by Brandon Stanton	2	2
3	Sycamore Row by John Grisham	25	30
4	Doctor Sleep by Stephen King	26	27
5	Memoirs of a Secretary at War by Robert M Gates	18	20
6	The Book Thief Paperback by Markus Zusak	24	30
7	Time to kill by John Grisham	29	30
8	A Fighting Chance by Elizabeth Warren	12	10
9	Don't Make Me Think by Steve Krug	11	29
10	The Yellow Birds by Kevin Powers	15	26
	Average Precision	59,3%	76,7%

Table 39 Precision Values for popular book cover for the first 30 results

These results also indicate that the accuracy of returned images increases as the ranking of those results becomes closer to the top. Precision values for the top 10 images are highest, followed by the precision values for the top 30 images. Precision values for the top 100 images are the lowest as we expect.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	The Goldfinch by Donna Tartt	9	9
2	Humans of New York by Brandon Stanton	2	1
3	Sycamore Row by John Grisham	10	10
4	Doctor Sleep by Stephen King	9	10
5	Memoirs of a Secretary at War by Robert M Gates	7	7
6	The Book Thief Paperback by Markus Zusak	10	10
7	Time to kill by John Grisham	10	10
8	A Fighting Chance by Elizabeth Warren	4	6
9	Don't Make Me Think by Steve Krug	4	10
10	The Yellow Birds by Kevin Powers	7	9
	Average Precision	72%	82%

Table 40 Precision Values for popular book cover for the first 10 results

Image 14 Retrieved top 100 images for "**The Goldfinch by Donna Tartt**" by Google image Search.

Image 15 Retrieved top 100 images for "**The Goldfinch by Donna Tartt**" by Bing image Search.

Some irrelevant images from Google image search engine are;

Image 16 An Irrelevant Image for "**The Goldfinch by Donna Tartt**" by Google image Search.

Image 17 Two Irrelevant Image for "**The Goldfinch by Donna Tartt**" by Google image Search.

Some irrelevant images from Bing image search engine are;

Image 18 Some Irrelevant Image for "**The Goldfinch by Donna Tartt**" by Bing image Search.

6.1.2 Less Popular Book Covers on Web

We would like to investigate whether image search engines can return relevant results for books that have fewer images on the web. We determined 10 unambiguous book names as queries. We tested whether they have few images on the web by using Bing and Yandex image search engine. Bing gave up hit count after March 2014, so Yandex is used to collect hit counts. We require estimated hit count values to be between 100 and 500 for each query. **Table 41** shows the book names and the estimated hit count values.

	QUERIES	Estimated Hit counts	
1	İstemenin Esrarı Muhammed Bozdağ	370	
2	Things That Matter by Charles Krauthammer	357	
3	The Gifts of Imperfection: Let Go of Who You Think You're Supposed to Be and Embrace Who You Are Paperback by Brene Brown	417	
4	One Man Show by Seza Bali	373	Yandex
5	C++ For Dummies by Stephen R. Davis	403	Yandex
6	Flora and the Flamingo by Molly İdle	153	Yandex
7	Thirteen Reasons Why by Asher, Jay	302	Yandex
8	Counting by 7s by Sloan, Holly Goldberg	161	Yandex
9	Flood of Lies by James Cobb Jr.	433	Yandex
10	Knuffle Bunny by Mo Willems	142	Yandex

Table 41 Estimated Hit counts for 10 less popular book cover on Bing Image Search or Yandex Image Search

Table 42 shows the number of relevant images for the first 100 results in Google and Bing. On the average, the precision value for Google is 28.9% and the precision value for Bing is 36.9%.

There are many types of irrelevant images. Some of the irrelevant images are: pictures of the author, images of some plants, images of author's other books, images

of some other books, images of some other people, images from the inside of the book, the images of the main character on the book cover, etc.

These results imply that Google and Bing image search engines not performing content analysis for book searches. They don't perform OCR on book cover images. It is highly likely that they return the results based on the texts in web pages.

The lowest precision value for Google results is for the query "Flood of Lies by James Cobb Jr.". Only 7 images are relevant for Google results. The lowest precision value for Bing results is for the query "One Man Show by Seza Bali". Bing cannot retrieve any image about this book.

In summary, around 30% of returned images are relevant to the searched books. This value is too low for easy content analysis for books.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	İstemenin Esrarı Muhammed Bozdağ	27	12
2	Things That Matter by Charles Krauthammer	91	62
3	The Gifts of Imperfection: Let Go of Who You Think You're Supposed to Be and Embrace Who You Are Paperback by Brene Brown	14	51
4	One Man Show by Seza Bali	4	0
5	C++ For Dummies by Stephen R. Davis	24	8
6	Flora and the Flamingo by Molly İdle	24	44
7	Thirteen Reasons Why by Asher, Jay	47	75
8	Counting by 7s by Sloan, Holly Goldberg	25	59
9	Flood of Lies by James Cobb Jr.	7	13
10	Knuffle Bunny by Mo Willems	26	45
	Average Precision	28,9%	36,9%

Table 42 Precision values for less popular book covers for the first 100 results

Table 43 shows the number of relevant images for the first 30 results in Google and Bing. **Table 44** shows the number of relevant images for the first 10 results in Google and Bing.

Image search engines return more relevant images on top results for books have fewer images on the web. For first 30 results, relevant images are around 50%. For first 10 results, relevant images are around 65%.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	İstemenin Esrarı Muhammed Bozdağ	17	9
2	Things That Matter by Charles Krauthammer	24	25
3	The Gifts of Imperfection: Let Go of Who You Think You're Supposed to Be and Embrace Who You Are Paperback by Brene Brown	10	30
4	One Man Show by Seza Bali	3	0
5	C++ For Dummies by Stephen R. Davis	21	7
6	Flora and the Flamingo by Molly İdle	6	18
7	Thirteen Reasons Why by Asher, Jay	18	27
8	Counting by 7s by Sloan, Holly Goldberg	13	25
9	Flood of Lies by James Cobb Jr.	6	13
10	Knuffle Bunny by Mo Willems	8	13
	Average Precision	42%	55,7%

Table 43 Precision Values for less popular book cover for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	İstemenin Esrarı Muhammed Bozdağ	10	6
2	Things That Matter by Charles Krauthammer	10	9
3	The Gifts of Imperfection: Let Go of Who You Think You're Supposed to Be and Embrace Who You Are Paperback by Brene Brown	7	10
4	One Man Show by Seza Bali	2	0
5	C++ For Dummies by Stephen R. Davis	9	2
6	Flora and the Flamingo by Molly İdle	2	6
7	Thirteen Reasons Why by Asher, Jay	7	9
8	Counting by 7s by Sloan, Holly Goldberg	7	9
9	Flood of Lies by James Cobb Jr.	5	10
10	Knuffle Bunny by Mo Willems	4	5
	Average Precision	63%	66%

Table 44 Precision Values for less popular book cover for the first 10 results

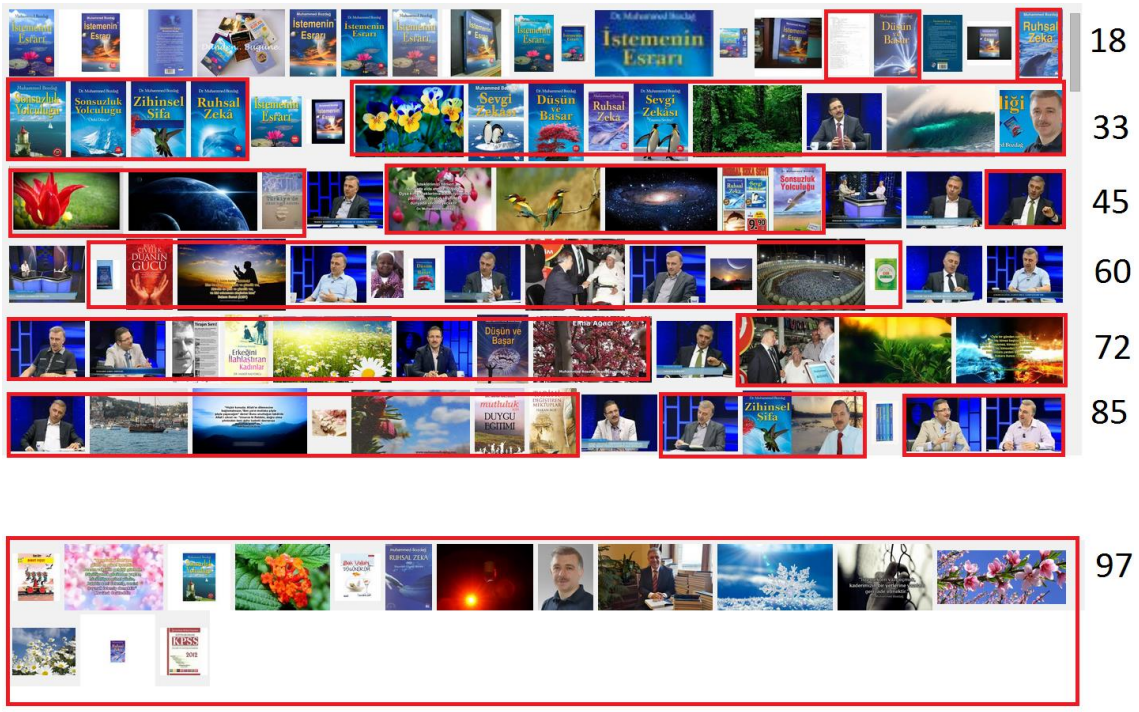

Image 19 Retrieved top 100 images for "**İstemenin Esrarı Muhammed Bozdağ**" by Google image Search.

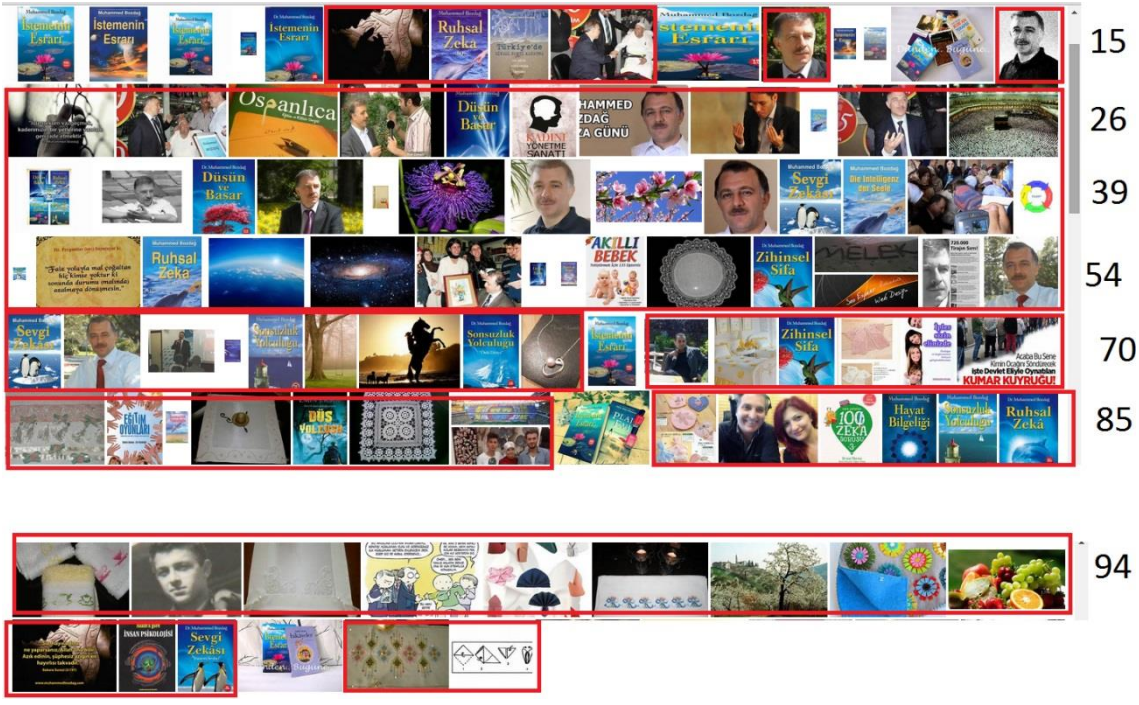

Image 20 Retrieved top 100 images for "**İstemenin Esrarı Muhammed Bozdağ**" by Bing image Search.

Some irrelevant images from Google image search are;

Image 21 Irrelevant images for "**İstemenin Esrarı Muhammed Bozdağ**" on Google Image Search.

Some irrelevant images from Bing image search are;

Image 22 Irrelevant images for "**İstemenin Esrarı Muhammed Bozdağ**" on Bing Image Search.

6.2 Is OCR Used?

The results on this chapter strongly suggest that these two image search engines do not use OCR on images. However, we conducted another experiment on this section to make sure that whether they perform OCR or not.

We selected some images with text on them. We made sure that the text on images does not appear in the web page. They only appear in the image. Then we searched the text as the query on both search engines. We examined the resulting images.

For example, there is an image at the web page http://www.istanbul.gov.tr/Default.aspx?pid=399 with the text "türkiye cumhuriyeti ilelebet payidar kalacaktır k. atatürk t.c. istanbul valiliği". We submit this text as the query to these two image search engines. We check the results to see whether the original image is returned.

Image 23 the text on image is queried on search engines.

Table 45 shows that the number of images search engines retrieved. First column shows the query number. Second column represents search queries. The searched queries are the same with the text on images. The third column shows the URL of the web pages that contains the image. Fourth column shows the total number of images returned by Google Image Search. The fifth column shows the total number of images returned by Bing Image Search. The last column shows the type of images.

Whole ten queries are searched on Google & Bing search engines. Neither Google nor Bing cannot retrieve any of the searched image.

	Query	URL	Google	Bing	Image type
1	türkiye cumhuriyeti ilelebet payidar kalacaktır k. atatürk t.c. istanbul valiliği	http://www.istanbul.gov.tr/Default.aspx?pid=399	978	3	Image
2	Nankör diye haykırmış, Saatler her geçen an'a, meğer arkadaş değilmiş akreple yelkovan..	http://siirsevenlere.blogcu.com/sessiz-gemi/4628417	87	5	Image
3	İnce bir sızı dizlerimde Yokuşlarda halsizim… Bir çocuk ağlar içimde susturamam! Boncuk boncuk buzyaşlarım… Dökülür yanaklarımdan ayak uçlarıma… tutamam!	http://birgo.mynet.com/teardrop_2008/yazi/sessiz-gemi...	1	2	Image
4	Sometimes, you read a book and it fills you with this weird evangelical zeal, and you become convinced that the shattered world will never be put back together unless and until all living humans read the book. John Green The Fault in Our Stars	http://www.thesilverpen.com/inspired-living-celebrating-life/inspirational-books-women-children/bookworm-the-fault-in-our-stars-by-john-green/	856	352	Image
5	$L000917: inc dword ptr [EBP-4] mov EAX,dword ptr [EBP-4]	https://hplusplus.wordpress.com/tag/the-h-sorting-library/	0	35	Image

6	Animation by Paco Zeng Start Take Card out Correct Position	http://www.ee.ryerson.ca/~courses/coe428/sorting/insertionsort.html	345	0	Image
7	LECTURER, AND RESEARCHER AT THAMAR UNIVERSITY eng\ Mohammed HUSSEIN MOHAMMEDHBI@GMAIL.COM	http://www.slideshare.net/MohammedHussein8/quick-sort-merge-sort-heap-sort	0	0	Image in Slide
8	ilgiyi üzerine, tozları içine çeken teknoloji: Yeni Arçelik Tornado	http://www.arcelik.com.tr/kucuk-ev-aletleri.html	54	0	Image
9	Arçelik Gurme çay makinesi, Filter Sense özel demleme teknolojisi ve kişiye özel lezzet seçimleri ile çayınız hep ilk içtiğiniz tazelikte.	http://www.arcelik.com.tr/kucuk-ev-aletleri.html	45	2	Image
10	C. Dilara Kınalı 8 yaşında. İstanbul'da yaşıyor. Öğrenci. Büyümek istiyorum Ben küçük bir çocuğum ne kötü ama ben büyümek istiyorum Büyüt beni ana	http://galeri.uludagsozluk.com/g/%C5%9Fiir-yazmak/	61	0	Image

Table 45 Text on image are searched on search engines.

6.3 Conclusion

In this chapter, we examined and evaluated whether Google and Bing image search engines can retrieve accurate image lists for book cover. We provide the answers of each research question below.

1. Can these two image search engines provide useful results for book cover searches? What are the precision values for queries about common and less common book cover? Do image search engines provide more accurate results for popular book cover searches?

Table 46 shows summary of the precision rates for popular and less popular book cover image searches. Precision rates are poor for less and popular book cover images according to people and plant images. However, book cover is supposed to be found easier, according to people and plant. Among the first 100 retrieved images, around 45% of images are relevant for popular book cover at Google and 69% of images are

relevant at Bing. Less popular precision rate is lower. This evidences show that content-based image retrieval isn't used as retrieving image.

	Top 100	Top 30	Top 10
Popular book cover searches at Google	44,3	59,3	72
Popular book cover searches at Bing	69	76,7	82
Less popular book cover searches at Google	28,9	42	63
Less popular book cover searches at Bing	36,9	55,7	66

Table 46 Precision percentages of book cover image searches

2. How does the precision results of book cover searches compare to the precision values of people and plant searches?

Table 47 shows summary of the comparison of precision percentages of popular book cover with percentages of popular person and plant searches. Popular person and plant identification results are more consistent than popular book cover result. Whereas, book cover search is thought easier than person and plant searches.

Search queries about popular book cover contain book name and author name. Therefore we would expect to get highly relevant images. Retrieved some irrelevant images are from posters, TV scenes, author's another book, other peoples' photo showing some book etc… Web page contains text about searched query. Returning irrelevant images about popular book cover are probably evidence these two image search engines are not employing OCR analysis on images. However, popular person or popular plant identifications are difficult. There is lots of information about search popular person or plant queries in related page as text. Retrieved results are fine. This supports the idea that search engines are not employing OCR analysis on images. Another explanation for the lower precision values might be the fact that the hit count values for book cover queries are much smaller. If there are much fewer images related to these queries, the search engines may return less relevant results compared to the people and plant searches.

	Google			Bing		
	Top 100	Top 30	Top 10	Top 100	Top 30	Top 10
Popular book cover searches	44,3	59,3	72	69	76,7	82
Popular person searches	99,3	99,6	100	98,3	99,6	100
Popular plant searches	98,8	100	100	97,3	99	100

Table 47 Comparison of precision percentages of popular book cover with percentages of popular person and plant searches.

Table 48 shows summary of the comparison of precision percentages of less popular book cover with percentages of less popular person and plant searches. Less popular book cover search results are low for Google and Bing. There is a slight difference between Google and Bing but it is not significantly important.

Less popular person result search supports the less popular book cover search result. Less popular plant searches results are disagree with book cover and person search results. We examine reason of this result in paragraph 5.1.3. Web pages that contain person or plant images have very different properties. The web page that have plant images are mostly informational web pages. They contain information about plants. They also have some pictures. Most of the information and pictures belong to the plants. However, the web pages that have person names comprise a diverse set. Those web pages may be news articles, blog entries, etc. These kinds of web pages have information and pictures about many people and many types of entities.

These results also show that image search engines have a lot of difficulty when detecting the relevant images in a web page for a given query. This is an important problem. Therefore, less popular plant searches results are separated from other results.

	Google			Bing		
	Top 100	Top 30	Top 10	Top 100	Top 30	Top 10
Less popular book cover searches	28,9	42	63	36,9	55,7	66
Less popular person searches	24,2	48	71	18,9	32	48
Less popular plant searches	68,9	87,3	98	63,7	87,3	98

Table 48 Comparison of precision percentages of less popular book cover with percentages of less popular person and plant searches.

3. Do these search engines employ OCR for book cover searches?

The results on this chapter strongly suggest that these two image search engines do not use OCR on images. We make sure that whether the both search engines perform OCR or not. We select some images with text on them but web pages don't contain the text. **Table 45** represents 10 queries are searched on Google & Bing. Search queries appear on images but not on web page as text. Search engine cannot retrieve target images for 10 queries. This result strongly supports the idea that both search engines don't use OCR.

CHAPTER 7

SEARCHINGFOR FIRM LOGO IMAGES

Firm logo images are another easily searchable entities like book covers. Firm logos may contain text and some drawing. Firm logo pictures should be identifiable easily if search engines are performing some content analysis. We investigate the precision values for queries for firm logo images and compare the results to other entity results.

In this section, we hope to answer the following research questions:

1 Can these two image search engines provide useful results for firm logo searches? What are the precision values for queries about popular and less popular firm logos? Do image search engines provide more accurate results for popular firm logos searches?
2 How does the precision results of firm logo searches compare to the precision values of other results for people, plants and book cover searches?

7.1 Popular Firm Logo on Web

We would like to investigate whether image search engines can return relevant results for Firm logos that have many images on the web. We determined 10 famous firm logos and tested whether they have many images on the web. We used the estimated hit count values on Bing Image Search Engine result page. The queries and the estimated hit count values are shown on **Table 49**.

	QUERIES	Estimated Hit counts
1	Volkswagen logo	44600
2	Kızılay logo	6170
3	oracle logo	29500
4	bjk logo	12200
5	apple logo	50300
6	microsoft logo	48600
7	adidas logo	47600
8	twitter logo	57500
9	ülker logo	6400
10	koç holding logo	2510

Table 49 Estimated Hit counts for 10 popular firm logos on Bing Image Search

Table 50 shows the number of relevant images for the first 100 results in Google and Bing image search engines. Second column shows the firm logo name that we searched. Third and fourth columns show the number of relevant images for the searched firm logo on Google and Bing respectively.

The results on this table show that these two image search engines can return highly relevant images. However, it is less than we expected. Relevant images are around 85%. Both search engines retrieved low precision values for "koç holding logo" and "ülker logo". Bing also returned low precision values for "kızılay logo". All these queries have much smaller estimated hit count values compared to other queries. It seems that the number of images that exist on the web belonging to the searched entity affects the precision values significantly. Moreover, the irrelevant results for the query "koç holding logo" have images of other logos this company has. So, if there are similar entities to the searched entity that negatively affects the precision of returned results.

If we exclude the queries for "koç holding logo", "ülker logo" and "kızılay logo", the precision values are 92.3% for Google and 94.1% for Bing. These results are not as good as people and plant results but they are much better than the book cover results. We can say that these search engines provide highly accurate results for popular logo searches.

In the query, word of "logo" is added each query. Therefore I only accept searched logos. Low result is because of firm other products logos usually. For example, I'm searching Microsoft logo but office logos are confronted.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Volkswagen logo	99	100
2	Kızılay logo	96	46
3	oracle logo	84	94
4	bjk logo	85	79
5	apple logo	97	100
6	microsoft logo	90	90
7	adidas logo	100	100
8	twitter logo	91	96
9	ülker logo	70	68
10	koç holding logo	49	39
	Average Precision	86,1%	81,2%

Table 50 Precision Values for popular firm logo for the first 100 results

Table 51 shows the number of relevant images for the first 30 results in Google and Bing image search engines **Table 52** shows the number of relevant images for the first 10 results in Google and Bing image search engines.

Google search engine returns around 94.3% relevant images for the first 30 results and Bing search engines returns around 91.3% relevant images for the first 30 results.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Volkswagen logo	30	30
2	Kızılay logo	28	26
3	oracle logo	28	28
4	bjk logo	28	28
5	apple logo	29	30
6	microsoft logo	29	26
7	adidas logo	30	30
8	twitter logo	30	30
9	ülker logo	28	23
10	koç holding logo	23	23
	Average Precision	94,3%	91,3%

Table 51 Precision Values for popular firm logo for the first 30 results

These results also indicate that the accuracy of returned images increases as the ranking of those results becomes closer to the top. Precision values for the top 10 images are highest, followed by the precision values for the top 30 images. Precision values for the top 100 images are the lowest as we expect.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	Volkswagen logo	10	10
2	Kızılay logo	10	10
3	oracle logo	10	10
4	bjk logo	8	9
5	apple logo	10	10
6	microsoft logo	10	9
7	adidas logo	10	10
8	twitter logo	10	10
9	ülker logo	9	9
10	koç holding logo	10	10
	Average Precision	97%	97%

Table 52 Precision Values for popular firm logo for the first 10 results

Image 24 Retrieved top 100 images for "**Volkswagen logo**" by Google image Search.

Image 25 Retrieved top 100 images for "**Volkswagen logo**" by Bing image Search.

Bing image search engine has no any irrelevant image. Google image search engine has one irrelevant image. It is;

Image 26 An Irrelevant Image for "**Volkswagen logo**" by Google image Search.

7.2 Less Popular Firm Logo on Web

We would like to investigate whether image search engines can return relevant results for firm logos that have few images on the web. We determined 10 unambiguous firm logo names as queries. **Table 53** shows the firm name logos and the estimated hit count values.

	QUERIES	Estimated Hit counts	
1	sefamerve logo	220	Bing
2	boydak holding logo	414	Bing
3	çokonat logo	243	Bing
4	alpella logo	451	Bing
5	çokokrem logo	329	Bing
6	melikşah üniversitesi logo	363	Bing
7	vakko logo	220	Bing
8	sinangil logo	234	Bing
9	Sinbo logo	471	Yandex
10	gübretaş logo	225	Bing

Table 53 Estimated Hit counts for 10 less popular firm logo on Bing Image Search or Yandex Image Search.

Table 54 shows the number of relevant images for the first 100 results in Google and Bing. On the average, the precision value for Google is 51.2% and the precision value for Bing is 17%. The lowest precision value for Google results is for the query "sefamerve logo". Only 15 images are relevant for Google results. The lowest precision value for Bing results is for the query "boydak holding logo". Only 7 images are relevant for Bing results.

There are many types of irrelevant images. Some of irrelevant images belong to products of firm logo mostly, other logos, some photos meeting or private photos etc…

	QUERIES	Relevant images on Google	Relevant images on Bing
1	sefamerve logo	15	10
2	boydak holding logo	55	7
3	çokonat logo	26	9
4	alpella logo	57	32
5	çokokrem logo	57	23
6	melikşah üniversitesi logo	27	13
7	vakko logo	93	23
8	sinangil logo	66	12
9	Sinbo logo	84	27
10	gübretaş logo	32	14
	Average Precision	51,2%	17%

Table 54 Precision Values for less popular firm logo for the first 100 results

Table 55 shows the number of relevant images for the first 30 results in Google and Bing. **Table 56** shows the number of relevant images for the first 10 results in Google and Bing.

Image search engines return more relevant images on top results for logos have fewer images on the web. For first 30 results, relevant images are 66.3% for Google, 40.7% for Bing. For first 10 results, relevant images are around 82% for Google, 66% for Bing.

	QUERIES	Relevant images on Google	Relevant images on Bing
1	sefamerve logo	11	7
2	boydak holding logo	16	6
3	çokonat logo	19	8
4	alpella logo	24	21
5	çokokrem logo	20	17
6	melikşah üniversitesi logo	14	12
7	vakko logo	29	12
8	sinangil logo	22	11
9	Sinbo logo	22	16
10	gübretaş logo	22	12
	Average Precision	66,3%	40,7%

Table 55 Precision Values for less popular firm logo for the first 30 results

	QUERIES	Relevant images on Google	Relevant images on Bing
1	sefamerve logo	6	4
2	boydak holding logo	10	3
3	çokonat logo	2	4
4	alpella logo	10	9
5	çokokrem logo	8	9
6	melikşah üniversitesi logo	8	5
7	vakko logo	10	8
8	sinangil logo	9	6
9	Sinbo logo	10	10
10	gübretaş logo	9	8
	Average Precision	82%	66%

Table 56 Precision Values for less popular firm logo for the first 10 results

Image 27 Retrieved top 100 images for "**sefamerve logo**" by Google image Search.

Image 28 Retrieved top 100 images for "**sefamerve logo**" by Bing image Search.

Some irrelevant images from Google image search are;

Image 29 Irrelevant images for "**sefamerve logo**" on Google Image Search.

Some irrelevant images from Bing image search are;

Image 30 Irrelevant images for "**sefamerve logo**" on Bing Image Search.

7.3 Conclusion

In this chapter, we examined and evaluated whether Google and Bing image search engines can retrieve accurate image lists for firm logos. We provide the answers of each research question below.

1 Can these two image search engines provide useful results for firm logo searches? What are the precision values for queries about popular and less popular firm logos? Do image search engines provide more accurate results for popular firm logos searches?

We supported results of book cover with results of firm logo. **Table 57** shows summary of the precision rates for popular and less popular firm logo image searches. Precision rates are better for popular firm logo searches than book cover searches. Among the first 100 retrieved images, around 90% of images belong to the searched for popular firm logo. Precision rates of less popular firm logo searches are lower.

	Top 100	Top 30	Top 10
Popular firm logo searches at **Google**	90,2	94,3	97
Popular firm logo searches at **Bing**	85,9	91,3	97
Less popular firm logo searches at **Google**	51,2	66,3	82
Less popular firm logo searches at **Bing**	17	40,7	66

Table 57 Precision percentages of firm logo image searches

2 How does the precision results of firm logo searches compare to the precision values of other results for people, plants and book cover searches?

Table 58 represents precision percentages of popular firm logo results with popular people, plant, and book cover results for Google & Bing search engines. First column represents popular search queries. Second, third and fourth columns show precision percentages of popular search queries results for Google. Fifth, sixth and seventh columns show precision percentages of popular search queries results for Bing. Second and fifth columns show about precision percentages of first 100 results in search engines. Third and sixth columns show about precision percentages of first 30 results in search engines. Fourth and seventh columns show about precision percentages of first 10 results in search engines.

Popular person, plant and firm logo search results are similar. They all provide very good precision values above %90. Only the book cover results are much lower.

	Google			Bing		
	Top 100	Top 30	Top 10	Top 100	Top 30	Top 10
Popular firm logo searches	90,2	94,3	97	85,9	91,3	97
Popular book cover searches	44,3	59,3	72	69	76,7	82
Popular person searches	99,3	99,6	100	98,3	99,6	100
Popular plant searches	98,8	100	100	97,3	99	100

Table 58 Precision percentages of popular firm logo results with popular people, plant, and book cover results for Google & Bing search engines.

Table 59 represents precision percentages of less popular firm logo results with less popular people, plant, and book cover results for Google & Bing search engines. First column represents popular search queries. Second, third and fourth columns show precision percentages of less popular search queries results for Google. Fifth, sixth and seventh columns show precision percentages of less popular search queries results for Bing. Second and fifth columns show about precision percentages of first 100 results in search engines. Third and sixth columns show about precision percentages of first 30 results in search engines. Fourth and seventh columns show about precision percentages of first 10 results in search engines.

Less popular entity searches provide much lower precision values. The highest precision values among less popular entity searches belong to plant searches. The main reason for it is the type of web pages that contain plant images. Those web pages have

fewer images and less diverse. Therefore, it is easier for image search engines to determine relevant images in those web pages.

	Google			Bing		
	Top 100	Top 30	Top 10	Top 100	Top 30	Top 10
Less popular firm logo searches	51,2	66,3	82	17	40,7	66
Less popular book cover searches	28,9	42	63	36,9	55,7	66
Less popular person searches	24,2	48	71	18,9	32	48
Less popular plant searches	68,9	87,3	98	63,7	87,3	98

Table 59 Precision percentages of less popular firm logo results with less popular people, plant, and book cover results for Google & Bing search engines.

CHAPTER 8

CONCLUSION

In this chapter, we summarized our finding for all the evaluations about web image search engines.

8.1 Conclusion

We provide the answers of each research question below.

1. Can image search engines return relevant results for queries? What are their precision values for returned images?

We determined four types of query topics: people, plants, book covers, and firm logos. For each query topics, one set included the queries for popular entities and the other set included the queries for less popular entities. Each set consists of 10 entries.

Table 60 represents precision percentages of top 100 images about people, plants, book covers and firm logos results for Google & Bing search engines. First column is for search subject. Second and third column is for precision percentages results of top 100 images on Google and Bing respectively.

Popular person & plant searches results are very well for top 100 images on both search engines. Popular firm logo searches results are acceptable but book cover results are too low compared with others. Values for less popular searches are low generally except less popular firm logo searches for Google and less popular plant searches precision value results for both search engines.

	Top 100	
	Google	Bing
Popular person searches	99,3	98,3
Popular plant searches	98,8	97,3
Popular book cover searches	44,3	69
Popular firm logo searches	90,2	85,9
Less popular person searches	24,2	18,9
Less popular plant searches	68,9	63,7
Less popular book cover searches	28,9	36,9
Less popular firm logo searches	51,2	17

Table 60 Precision percentages of top 100 images about people, plants, book covers, and firm logos results for Google & Bing search engines.

2. Do image search engines provide more accurate results for higher ranking images on the result list?

Table 61 represent precision percentages results in three cut-off points as top 10, 30, and 100 for people, plants, book covers and firm logos. Precision values are increasing from bottom to top for each section. It shows top results give better precision values. Image search engines provide more accurate results for higher ranking images on the result list.

	Google			Bing		
	Top 100	Top 30	Top 10	Top 100	Top 30	Top 10
Popular person searches	99,3	99,6	100	98,3	99,6	100
Popular plant searches	98,8	100	100	97,3	99	100
Popular book cover searches	44,3	59,3	72	69	76,7	82
Popular firm logo searches	90,2	94,3	97	85,9	91,3	97
Less popular person searches	24,2	48	71	18,9	32	48
Less popular plant searches	68,9	87,3	98	63,7	87,3	98
Less popular book cover searches	28,9	42	63	36,9	55,7	66
Less popular firm logo searches	51,2	66,3	82	17	40,7	66

Table 61 Precision percentages of images about people, plants, book covers, and firm logos results in three cut-off points as top 100, 30, and 10 for Google & Bing search engines.

Figure 1 and **Figure 2** represent graphically precision values of Google and Bing for top 100, top 30 and top 10. Precision values are increasing from bottom to top for each search.

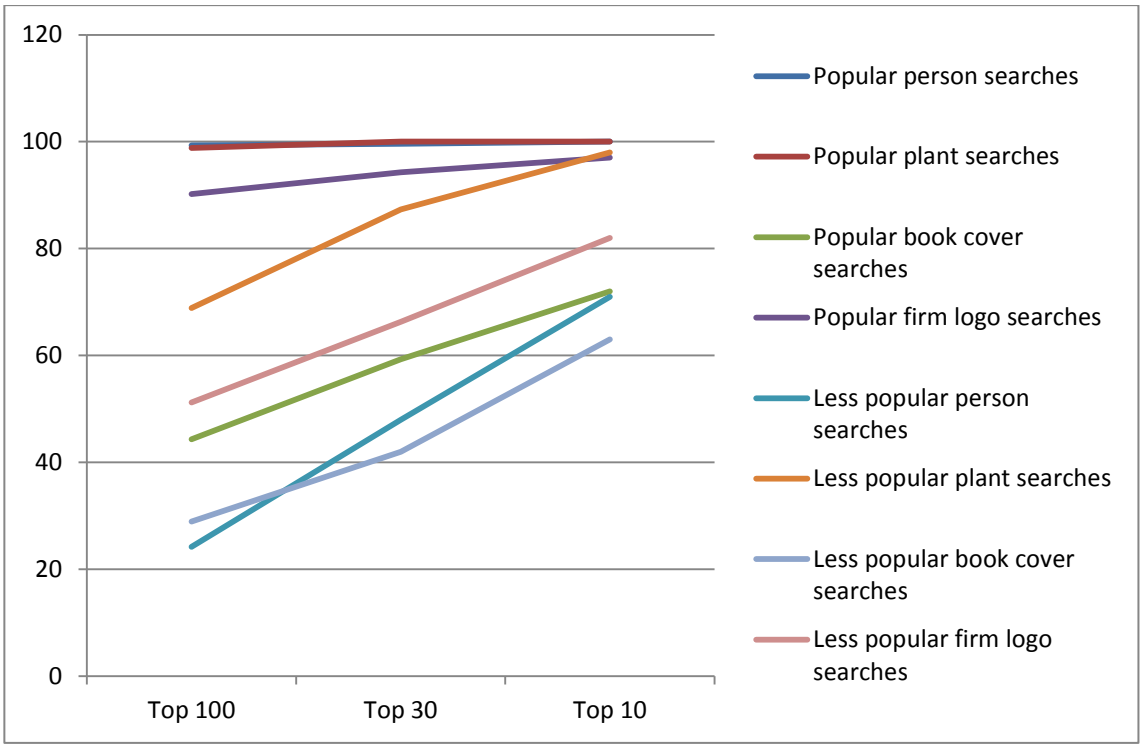

Figure 1 Precision percentages of images about people, plants, book covers, and firm logos results in three cut-off points as top 100, 30, and 10 for Google search engines.

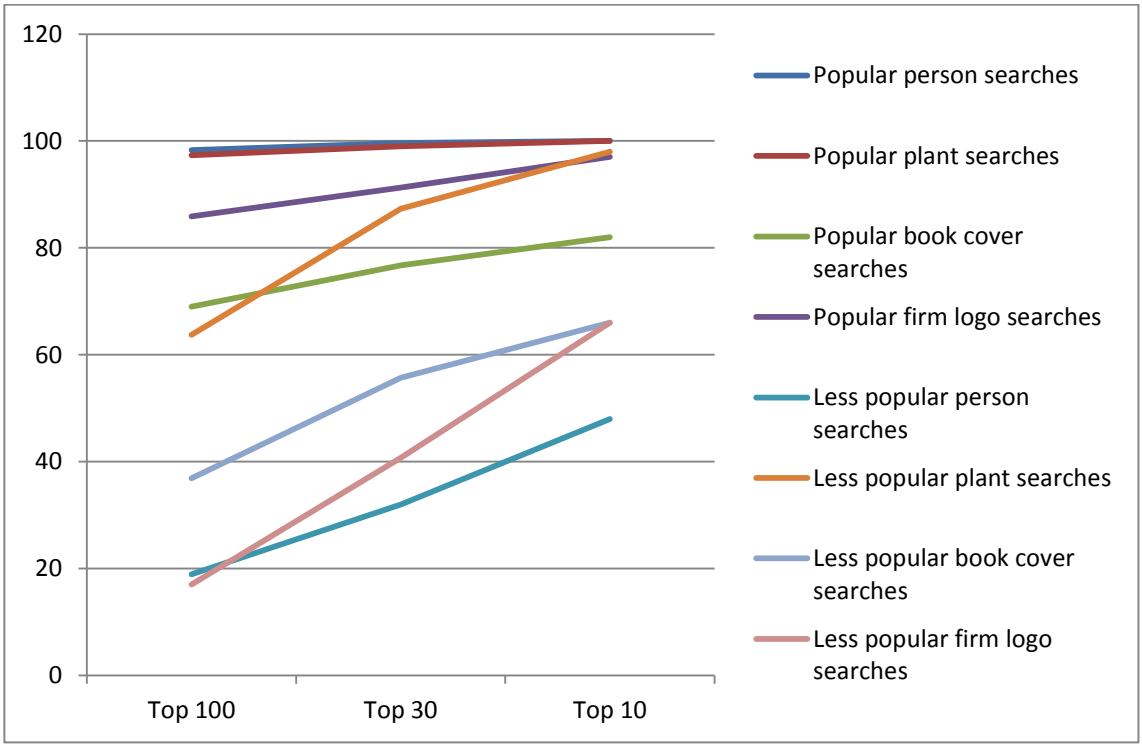

Figure 2 Precision percentages of images about people, plants, book covers, and firm logos results in three cut-off points as top 100, 30, and 10 for Bing search engines.

3. How does the precision values of document search results and image search results compare?

We found low precision values for less famous people on image search results. We examined documents results for less famous people. We used less famous 10 people as queries, in order to compare the precision values of image search results and document search results. We submitted the person names as queries to search engines using the regular web search engine interfaces. We examined the top 30 documents for each query and determined the relevancy of each result for the submitted query.

Table 62 represents average precision values of document searches and image searches for less famous people for the first 30 and 10 results.

	Document Results		Image Search Results	
	Top 30	Top 10	Top 30	Top 10
Google	93,7	92	48	71
Bing	90,7	93	32	48

Table 62 Average Precision Values of Document Searches and Image Searches for less famous people for the first 30 and 10 results.

Figure 3 and **Figure 4** represent results graphically. Document results are higher than image search results.

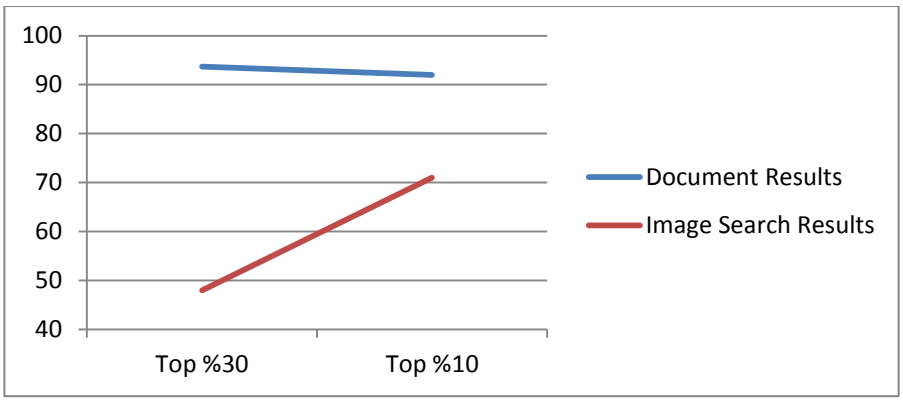

Figure 3 Average Precision Values of Document Searches and Image Searches for less famous people for the first 30 and 10 results for Google Image Search.

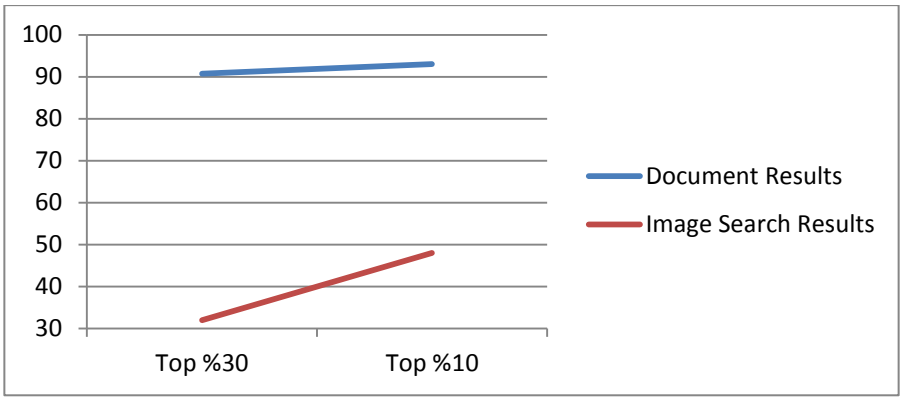

Figure 4 Average Precision Values of Document Searches and Image Searches for less famous people for the first 30 and 10 results for Bing Image Search.

These results clearly show that the precisions of image search results are much lower compared to the precisions of document searches for top 30 and top 10 results. It seems that finding the relevant images for queries is much harder compared to finding the relevant documents. The primary difficulty for this is that image search engines perform indirect searches for relevant images. Instead of analyzing the content of images and performing the searches on that information, they perform searches based on the texts surrounding the images.

Text based image search has two main problems. First, many terms around an image may not be related to the image. Second, many of the objects or concepts in an image may not be mentioned in the texts around the image. The first problem results in lower precision values for image search queries. Irrelevant texts around an image may be associated with that image. Therefore, images may be returned for irrelevant terms. The second problem results in lower recall values. Since many objects or concepts are not mentioned in texts around an image, when these unmentioned terms are searched, these relevant images are not retrieved.

Content analyses of images are difficult to perform and compute intensive. It is very difficult to correctly identify all objects and concepts in images. For example, face detection is rather easy but face identification is very difficult.

On the other hand, Image search engines have a very important advantage compared to the document search engines. Users may check many images and identify the relevant ones much faster compared to the document search results. Based on this observation, Image search engines provide many downsized images on results pages.

While they return only top 10 results for document searches by default, they return hundreds of images when the user scrolls down the result page. It is expected that users can check many images and identify the relevant ones. This method also gives users the opportunity of finding the relevant images without going to the target web pages. The same thing is not true for document searches. Although a short description of target documents is provided in result pages, it is much more difficult to judge the relevancy of documents without visiting the actual web pages. Because of this, search engines may be willing to return image search results with low precision. In addition, this may give users a wider spectrum to choose targeted images.

4. Do image search engines employ content analysis when performing the searches or do they solely rely on text search? Investigate whether image search engines recognize the texts on images and provide search based on those texts?

Popular person and plant identification results are more consistent than popular book cover result. Whereas, book cover search is thought easier than person and plant searches. However, book cover contains text on it. Detecting text on image is easier to mentioned searches. To answer this question, we selected some images with text on them. We made sure that the text on images does not appear in the web page. They only appear in the image. Then we searched the text as the query on both search engines. We searched 10 images, but we could not reach images on Google & Bing image search engines. The results strongly suggest that these two image search engines do not use OCR on images.

5. What are some of the reasons for search engines to return irrelevant images?

Search engines returned lots of irrelevant image for less popular person. We examine that search engines work only with the texts on web pages. Do engines perform any image content analysis? We downloaded and examined the content of web pages that contained irrelevant images. With very high percentages, searched query texts exist on target web pages. **Table 19** shows that web pages have query words although image is irrelevant. These results strongly suggest that Google and Bing perform text based searches for images.

When image search engines return an irrelevant image, can it be because of the incorrect identification of images on the target web page? While a relevant image exists

on that page, is it returning an irrelevant image from that page? We examined the content of web pages that has irrelevant image results. **Table 20** shows the percentages of web pages that have relevant images for the query but an irrelevant image from that web page is returned. When a web page has query words and multiple images, both Google and Bing have difficulty deterimining the correct relevant images. Around half of irrelevant images could have been avoided, if they have better algorithms to select among multiple images in web pages.

6. Do precision values of image search results for different types of searches differ? For example, whether precision values of image search results for people searches and plant searches differ.

We have summarized the less popular person query results and less popular plant query results at **Table 35**. This table shows that in general the web pages that have plant images have more relevant images. The web pages that have person images have less relevant images. These results explain the difference between the precision values of less popular person searches and less popular plant searches. These two types of web pages have very different properties. The web page that have plant images are mostly informational web pages. They contain information about these plants. They also have some pictures. Most of the information and pictures belong to these plants. However, the web pages that have person names comprise a diverse set. Those web pages may be news articles, blog entries, etc. These kinds of web pages have information and pictures about many people and many types of entities.

These results show that search results are differed according to type of page. Search engines should pay attention detecting the relevant images in a web page for different type of queries.

7. How often do image search engines return the same images in result sets?

We examined top 100 images for 9 popular people, if there is any replica in search engine result set in 4.1.1. While we examine for repeated images, we accept images with slight differences in brightness or size. There are 3 images with repeated one more times among Google's 900 images. There are 10 images with repeated one more times, 1 image with third times, 1 image with fourth times among Bing's 900 images. We have not observed any replica in result sets.

8.2 Future Work

Researchers are developing image search engine algorithm approachs. Although search engines works with desired reults, there is still lots of thing to be develop about image search. It could be further developed in some ways:

Optical character recognition (OCR) is the mechanical conversion of images of typewritten or printed text into machine-encoded text. In 6.2, we found out that Google and Bing don't use OCR. In the future work, investigation about usage of OCR will cause to increase precision of search engines results.

Secondly, in 4.1.5, we examine the web pages that contain the irrelevant images among the top 100 results for two queries for less popular persons. We examine to see whether target pages contain any relevant images for the queries. We reached the results of high percentages about the target web pages contain a relevant image for the searched queries. However, retrieved images were irrelevant. These results show that determining the relevant images in a web page for a query is a very important issue. When a web page has query words and multiple images, both Google and Bing have difficulty determining the correct relevant images. Search engines should develop their algorithms about selecting correct images. Around half of irrelevant images could have been avoided, if they have better algorithms to select among multiple images in web pages.

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