Web Image Search Engine Evaluation

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Abstract: *Image search engine is a specialized search engine for retrieving images. It is rapidly growing with the growth in digital images on the web. The essential role of image search engine is to retrieve image results that are relevant to the users and provide them more reliable and comfortable services. The main challenge for image search engine is to retrieve images with content matching much more than text matching. This paper investigates the performance of three image search engines. The paper is realized in two phases. In the first phase, three image search engines, namely, Google, Yahoo and Ask, are selected. Then, twenty queries are determined from two researches. Each query is run on each image search engine separately and first twenty images retrieved are classified as being relevant or non-relevant. Afterwards, precision ratios are calculated at various cut-off points. In the second phase, image features, namely, color and shape are determined. Some of the images retrieved from first phase are analyzed according to their features. The results of first phase indicated that Google has the best overall retrieval effectiveness with 95% precision ratio, followed by Yahoo with 91%, and Ask at the last with 83.7%. Furthermore, the results from second phase showed that two images with similar color histograms can possess different content. As well as for shape feature, the number of edges is not efficient to identify relevant images.*

Keywords: *Search Engine (SE); Content-Based Image Retrieval (CBIR); Image Features.*

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1. Introduction

World Wide Web plays an essential role in human life. A large amount of information is available on the web, so search engines play an important role in allowing users search the contents online using textual queries [15]. Information retrieval systems have a critical role in fully utilizing information available on the internet. Most web search engines are built based on traditional information retrieval technologies, which essentially focus on text-based information retrieval. As digital technologies enhance and the spread of multimedia information, images become increasingly important for users to visualize things and concepts [28, 9].

With the rapid growth in digital images and increase of users searching images on the web, it's important to understand the image requested by users and design feasible solutions to deal with the large variety of needs and uses on a large scale [21].

Despite the popularity of digital images and its rapid increase on the internet, there is little attention that has been paid on image retrieval systems for web use [3] .This makes the task of image retrieval on the web more complicated [18]. The type of search engine specialized on finding images, pictures and animations is called Image Search Engine or Image Search [20].

The main objective of ISE is to retrieve image results that are relevant to the requested query and diverse enough to cover differences of semantic or visual concepts. The relevant images in traditional search engines found by matching the text query with image metadata (i.e. anchor text, surrounded text). Many top ranked images may be irrelevant to the query when the text information is limited and can be inaccurate. Also, there is no reliable way to actively promote the variation of the results without analyzing content of the images [15]. So there is a need to improve image search results and make the retrieval more efficient and accurate.

The image content has essential role in retrieval process; there are many visual features that are used to describe content of images (colour, shape, and texture). The user queries need to be interpreted correctly in image search engine, so we need to develop an approach that helps the user to reach his search goals faster and more comfortably.

The objective of this paper is to present an approach that improves information retrieval in image search engines. This paper evaluates the performance and competence of several ISEs by calculating the recall and precision to measure the effectiveness of ISEs related to images retrieval and compare them.

For the images that are retrieved from ISEs, we need to analyze their features. So we used MATLAB program to analyze the common image features and evaluate the ISEs according to these features. This will identify the searchable image's features and then analyze the impact of these features on the retrieval.

2. Related Work

The number of stored images on the internet is increasing due to an increase in affordable digital recording devices, such as digital camera and scanners. So the task of image retrieval as the internet grows

becomes more complicated [6]. According to [18], the growth of web image search engines has enabled users to search images on the web. Because of the poor performance of current search technologies, users still need to spend much time in navigating to find images of their interest through a large number of result pages. As described in [26], image retrieval has been one of the most active research fields. Various studies, such as [23, 5, 2], are carried to evaluate ISEs and to improve their effectiveness.

Initially the study of [23] provided an understanding of current technologies in image searching on the internet, and pointed to future areas of enhancement for multimedia applications. They developed a systematic set of image queries to evaluate the performance and competence of the ISEs. These queries are human oriented related to retrieval contents which are humanly meaningful as contrary to machine-oriented features such as shapes, colour and texture. The results of their study showed that current technology is only able to deliver an average precision of around 42% and an average recall of around 12%. While the best performers are capable of producing over 70% for precision and around 27% for recall.

In [5, 2], investigation were carried about the information retrieval performance and effectiveness of three image search engines namely, Google, Yahoo and Ask. As described in [5], 12 queries are determined from various topics and classified as one-word, two-word and three-word query groups. Where in [2], 35 queries are set and classified as various topics. Authors concluded that the image search engines to which the lowest and the best precision ratios belong, keep changing for every topic. The results also indicated that Google has the best overall retrieval effectiveness in topics "Automotive manufacturers", Broadcast Media", "Pharmaceutical and Media Product" and "Movies" and was followed by Ask in topic "Travel Destination and accommodations".

Several studies such as [11, 12], were done to evaluate the performance for image features based image retrieval. As mentioned in [11], Authors addressed the problem of the objective performance evaluation of image retrieval systems. They proposed a tool for synthetic image database generation with a user friendly interface which allows choosing the number, location of dominant colors in the lab space respecting and also their spatial coherence. They also used this database to objectively evaluate the color quantization efficiency. Special attention was given to CBIR methods performance of 2 approaches: MPEG7 technique and CBIR system IMALBUM. They also proposed new color feature similarity distance on MPEG7 database showed the real interest of their approach measured by Recall and Precision criteria in comparison with MPEG7 approach.

According to [12], structure, colour and texture are combined for efficient image retrieval. Hierarchical perceptual grouping principles were used for extracted structure. The researches proposed an approach for color analysis to map all colours in the colour space into a fixed colour palette. They also employed texture analysis using a bank of even-symmetric Gabor filters. In this study, the researchers presented a methodology for performance evaluation on a database of colour images. They partitioned the database into several classes and subclasses for quantifying success of image query and classification. The use of structure, colour and texture has provided us with a robust image retrieval system that can serve queries ranging from images depicting conspicuously scenes of purely natural objects.

There are two approaches to image retrieval: text-based approach and content-based approach. CBIR is a hotspot of digital image processing techniques. Different people might describe the same image differently, leading to problems retrieving it again and it is also time consuming when dealing with very large databases. The way to get around these problems by content based image retrieval (CBIR). CBIR means that the search makes use of the contents of the images themselves, instead of relying on human-input metadata [19]. Text-based image retrieval [27], describes the content of the image by text while CBIR uses visual features to describe content of images (color, shape and texture).

In the web [1], current ISEs depend purely on the keywords around the images and the filenames which produces a lot of rubbish in the search results. Due to the fact that web ISEs are blind to the content of images, the queries results often provide irrelevant data, although a lot of research has been done on content based image retrieval (CBIR). More attention in recent years focused on CBIR. The exponential growth of the numbers and sizes of digital image on web is making it necessary to develop powerful tools for retrieving this unconstrained imagery. Furthermore, CBIR is the key technology for improving the interface between user and computer [17]. Color, texture and shape information have been the primitive image description in content based image retrieval systems [10].

The three main groups of features that are being used in CBIR systems are: color, shape and texture. Color is one of the most used techniques for examining images. The modern image search studies used color as the comparing feature between images [24]. For two images, the color similarity can be measured by comparing their color histograms. The color histogram is a common color descriptor, denoted to the occurrence frequencies of colors in image [7, 22]

The color of an image is represented by using some color models. A color model is determined in terms of 3-D coordinate system and a subspace within that

system where each color is appeared as single point. There are different color models to describe color information. The mainly used color models are RGB (red, green, blue), HSV (hue, saturation, value) and Y, C_b, C_r (luminance and chrominance).

Shape is another important visual feature for image content description. Shape based image retrieval is the measuring of similarity between shapes of an image represented by their features [4]. The shape feature of image refers to the particular region that is being sought out. Shape will be determined by applying segmentation or edge detection to an image. In image analysis it's very important to apply edge detection which gives idea about the shapes of objects present in the image [16].

3. Methodology

The methodology used is divided into two phases as explained in the following sections.

3.1. First Phase: Image Search Engines Evaluation

For the evaluation and comparison of the web image search engines, 20 queries were chosen from two researches [23, 2]. The queries consist of few words without explicit Boolean operators such as AND and OR, as shown in table 1. Image searching is offered by general search engines and by some specialized search engines. The three ISEs tested are the three top ISEs [2], Google (www.google.com), Yahoo (www.yahoo.com) and Ask (www.ask.com). The queries were given to 4 students. Each query was run on the selected ISEs separately. The first 20 images retrieved in each retrieval output were evaluated manually as "relevant" or "non-relevant".

Table 1. Queries list.

Query number	Query name	Query number	Query name
Q1	"cat"	Q11	"pepsi max"
Q2	"foot"	Q12	"red bull"
Q3	"basketball"	Q13	"kfc wings"
Q4	"cat scan"	Q14	"cnn logo"
Q5	"Australia Victoria"	Q15	"mazda rx-8"
Q6	"university life"	Q16	"Ferrari modena"
Q7	"football shoes"	Q17	"happy feet"
Q8	"dell xps m2010"	Q18	"family guy"
Q9	"ipod shuffle"	Q19	"the Simpsons"
Q10	"digital camera"	Q20	"transformers"

Afterwards, a set of measurements are used for evaluating the ISEs performance. Recall and precision measurements are commonly used in evaluating information retrieval systems [25]. Precision and recall are calculated for each ISE and the precision ratio calculated at various cut-off points (for first 10 and 20 image retrieved).

Recall gives the ratio of the number of relevant records retrieved to the total number of relevant records in the database. And precision is the ratio of the number of relevant images retrieved to the total number of images retrieved [23].

The recall and precision measure the effectiveness over 20 queries for each ISE. The precision and recall determined for first 20 images retrieved. Precision ratios of ISEs are calculated at various cut-off points for each query to see how scores of relevant images are distributed over their ranks. The evaluation process is done manually, where each student runs each query on the selected ISEs, then the results were noted in a spreadsheet.

To evaluate the retrieval performance over all test queries, we calculated the average precision value at seen relevant images retrieved. In addition the mean average precision value (MAP) calculated for a set of queries that runs on each individual ISE.

For the purpose of comparison, our results will be compared with other researches results [23, 2], which have the same objectives as the present study in evaluation of the ISEs and to improve retrieval performance and effectiveness for ISEs.

3.2. Second Phase: Image Features Analysis

In this phase we focus on analysis set of image features. After running selected queries on ISEs (Google, Yahoo and Ask) the images retrieved are combined to be analyzed according to their features. There are a number of features that can be extracted from an image for content based comparisons. The three most common characteristics upon which images are compared in content based image retrieval are: color, shape and texture. Only color and shape features are used in this experiment for analysis process. A MATLAB implementation is done for analyzing the main image features. Initially, we combined the main image features that are efficient to be used for web ISEs.

The selected images were input to the program and then analyzed for selected features. However, only some of the images were used and their sizes were reduced to 75x75 pixels for the purpose of comparison.

3.2.1. Color Feature Analysis

There are a number of techniques for color feature analysis. The technique used in this paper computes a color histogram for selected images. Color histogram investigated in one color space is RGB which is composed of the primary colors Red, Green and Blue [13]. Different methods have been proposed to compare histograms of two images such as: Difference histogram and Euclidian distance.

- Difference Histogram: The difference histogram method works as follows: First we need to read

images and extract RGB format pixel information from images which must have the same size. Then create histograms for each of the RGB components of the image. At last we need to compute the difference histogram between selected images and show the results.

- Euclidian Distance: There are several distance formulas for measuring the similarity of color histograms, the color distance formulas arrive at a measure of similarity between images based on the perception of color content. Three distance formulas that have been used: histogram Euclidian distance, histogram intersection and histogram quadratic (cross) distance. The distance formula used in this project is histogram Euclidian distance [13]. Euclidian distance is the most common approach to compare images. The images should have the same size, to be able to compare images using Euclidian distance, which can be achieved easily in MATLAB.

3.2.2. Shape Feature Analysis

The basic mechanisms used for shape retrieval include determination of features such as lines, boundaries, aspect ratio, and circularity, and by identifying areas of change or stability via region growing and edge detection [8].

There are number of mechanisms that have been used for shape analysis. In this project, shape information is captured in terms of edge detection. The strategy followed for shape feature analysis described in three steps:

- Step 1: edges of an image (relevant and non-relevant) are detected using MATLAB program,
- Step 2: then for each image the number of edges was counted. The relevant images compared with each other based on the number of its edges,
- Step 3: then, relevant images will be compared with non-relevant images to identify the similar images and clarify the impact of features on retrieval images.

4. Experiments and Evaluation

The overall results of the experiment are discussed as follows:

4.1. First Phase Results

After running each query on the selected ISEs, the average precision values are calculated over all test queries. The mean average precision value is then calculated for a set of queries that runs on each individual ISE.

As shown in figure 1. Google has the best precision ratio in queries (1, 4, 6, 7, 8, 10, 12, 13, 16 and 17). The precision ratio of Yahoo is highest in queries (2, 3, 5, 9, 10, 11, 14, 15, 18, 19 and 20). And ask displayed the best precision ratio in queries (17, 18 and 19).

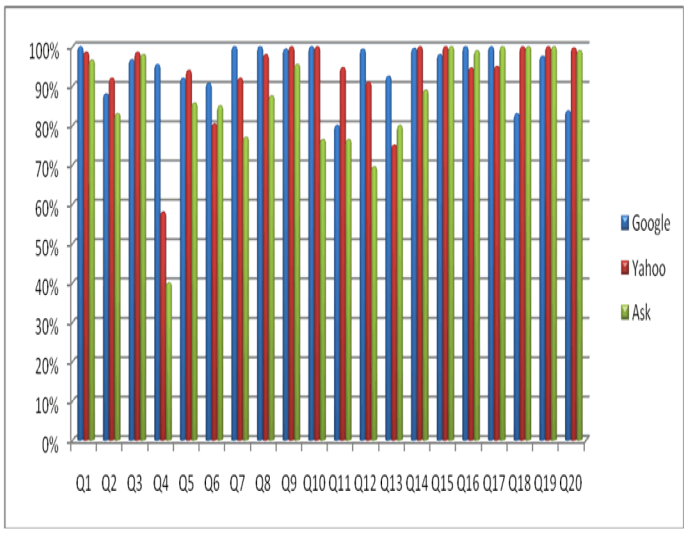

Figure1. Mean precision ratios of image search engines for all queries at cut-off point 10.

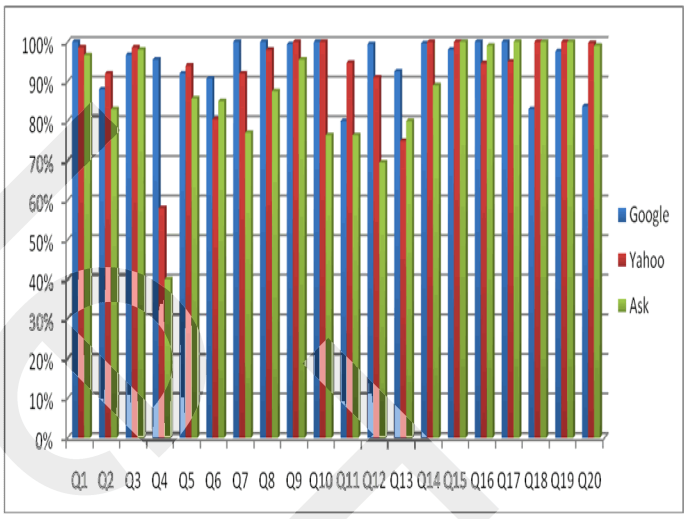

Figure2. Mean precision ratios of image search engines for all queries at cut-off point 20.

As shown in figure 2. Google has the highest precision ratio in queries (1, 4, 6, 7, 8, 10, 12, 13, 16, 17 and 18). Yahoo displayed the highest precision ratio in queries (2, 5, 9, 11, 14, 19 and 20). And ask displayed the best precision ratio in queries (3, 15 and 18).

4.1.1. Best Image Search Engine

As shown in figure 3, Google is the best image search engine, with (95%) precision ratio. Google is the largest and most popular ISE, and most suitable images are retrieved at the beginning of the results. Yahoo is the second common search engine after Google. The mean average precision for Yahoo is (91%). Ask is the lowest search engine with (83.7%) precision ratio. Ask is still limited by its small number of results.

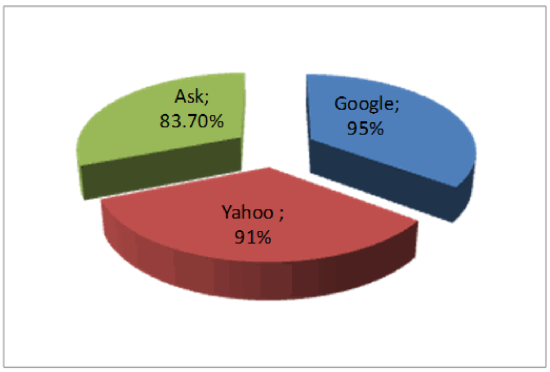

Figure3. Mean Average Precision ratio (MAP).

4.1.2. Result Comparison and Discussion

Our results of the first 7 queries were compared with the results from research [23]. The comparison was limited only to Google and yahoo. The comparison results are shown in table 2.

As shown in the above table, queries 1, 3, 4, 6 and 7 have the same results in [23], where Google has highest precision ratio. Yahoo comes in 2nd. Our results from queries 2 and 5 are different from results in research [23]. Our results indicated that for 2 and 5 queries, Yahoo has the highest precision ratio and Google comes in 2nd. While in research [23] Google has the highest precision ratio and Yahoo comes in 2nd.

Our results from queries 8 to 20 were compared with results from research [2], the comparison was done to the three ISEs as shown in table 3. Queries 8, 10 and 11, have the same results to the results in [2]. For example, in query 8 and query 10, Google has highest precision ratio, yahoo comes in 2nd and Ask has lowest one.

Table 2. Compared first 7 queries.

Query Number	Query Name	Our Results		Previous Results	
		Google	Yahoo	Google	Yahoo
1	"cat"	99%	98%	49%	37%
2	"foot"	87%	92.5%	49%	37%
3	"basketball"	95.5%	94.5%	49%	37%
4	"cat scan"	96.7%	58%	44%	41%
5	"Australia Victoria"	92%	93%	44%	41%
6	"university life"	89.5%	69%	44%	41%
7	"football shoes"	100%	95.5%	44%	41%

Queries 9, 12 to 20 have different results from results in research [2]. For example, our results for query 14 indicated that Yahoo has highest precision ratio, Google comes in 2nd and Ask displayed lowest one, while result in research [2] indicated that the Google has highest precision ratio followed by Ask then yahoo displayed lowest precision ratio.

Table 3. Compared queries from 8 to 20.

Query Number	Query Name	Our Results			Previous Results		
		Google	Yahoo	Ask	Google	Yahoo	Ask
8	"dell xps m2010"	98.7%	96%	90.5%	70%	67%	60%
9	"ipod shuffle"	98.5%	100%	93%	70%	67%	60%
10	"digital camera"	99.7%	99%	75.5%	70%	67%	60%
11	"pepsi max"	78%	89%	64%	42%	48%	40%
12	"red bull"	96.5%	89.7%	95%	42%	48%	40%
13	"kfc wings"	91%	79%	79%	42%	48%	40%
14	"cnn logo"	98%	99.7%	86%	70%	44%	51%
15	"mazda rx-8"	98%	98.7%	99%	78%	69%	80%
16	"Ferrari 360 modena"	99.7%	96%	98.6%	78%	69%	80%
17	"happy feet"	100%	93%	99.5%	82%	50%	50%
18	"family guy"	100%	89%	100%	82%	50%	50%
19	"the Simpsons"	98%	100%	98.7%	82%	50%	50%
20	"transformers"	88%	98%	96%	82%	50%	50%

4.2. Second Phase Results

Two features are selected to analyze images, color feature and shape feature.

4.2.1. Color Analysis Results

Color analysis is performed on color images. A color histogram was computed for images and these images were compared by using two methods: Difference histogram and Euclidian distance.

Color Analysis Results: Color analysis is performed on color images. A color histogram was computed for images and these images were compared by using two methods: Difference histogram and Euclidian distance.

Difference histogram is computed between relevant images and non-relevant images, and between relevant images themselves. The results indicated that the histogram of relevant image is often similar or close to the histogram of non-relevant image.

Figures 4, 5 and 6 shows the difference histogram for query 2=”foot” in Google, Yahoo and Ask.

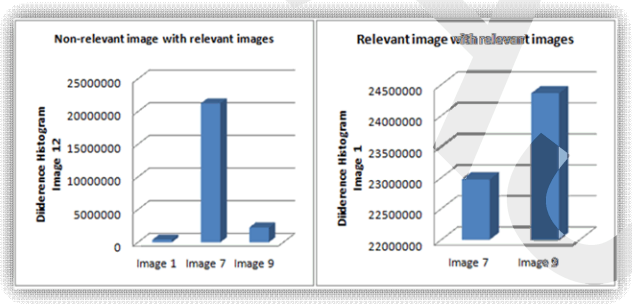

Figure4. Images comparison based on differences histograms in Google

As shown in figure 4, for Google search engine images 1, 7 and 9 are relevant and image 12 is non-relevant. The difference histogram between relevant images 1 and 7 = 22972852 and between 1 and 9 = 24362430 are greater than difference histogram between relevant images and non-relevant image 12, where the difference histogram between images 12 and 1= 402332, between 12 and 7= 21266704 and between 12 and 9= 2274644.

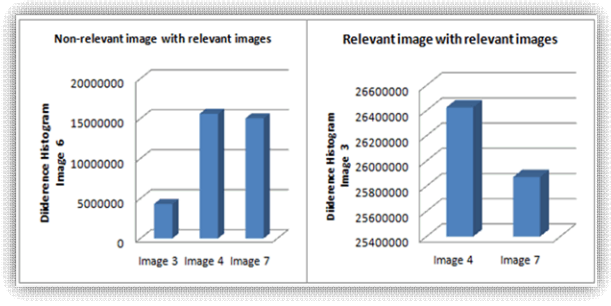

Figure5. Images comparison based on differences histograms in Yahoo.

For Yahoo search engine, the images 3, 4 and 7 are relevant and image 6 is non-relevant. The difference histogram between 3 and 4= 26426346 and between 3 and 7 = 25873646 are greater than difference histogram between relevant images and non-relevant image 6. As shown in figure (5).

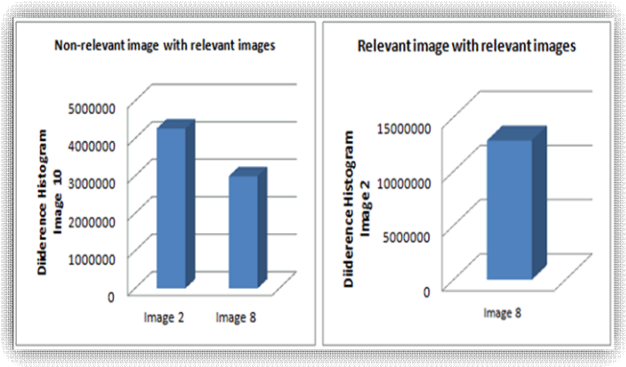

Figure6. Images comparison based on differences histograms in Ask.

For Ask search engine, the images 2 and 8 are relevant and images7, 10 and 12 are non-relevant. The difference histogram between 2 and 8= 12860922 are greater than difference histogram between relevant images and non-relevant images as shown in figure 6.

The Euclidian distances are calculated between selected images (relevant and non-relevant). The results showed that the distances between two relevant images are often greater than the distances between relevant and non-relevant image.

The Euclidian distances for query 2= "foot" in Google, Yahoo and Ask search engines are shown in figures 7, 8 and 9.

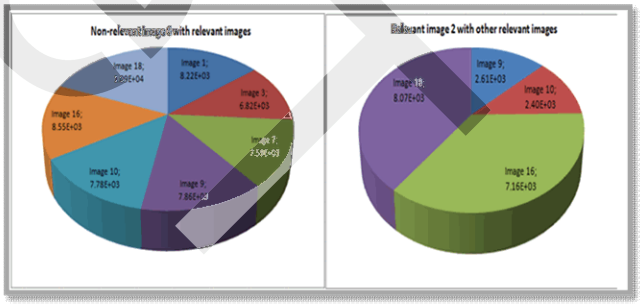

Figure7. Images comparison based on Euclidian distance in Google.

As shown in figure 7, for Google search engine the images 2, 9, 10, 16 and 18 are relevant and image 6 is non-relevant. The distance between relevant images 2 and 18 = 8.07e+03 is greater than distances between relevant images and non-relevant image 6.

Figure 8 shows the distances for images in Yahoo search engine, the images 2, 3, 4, 7 and 9 are relevant and image 6 is non-relevant. The distance between relevant images 2 and 4 is greater than distances between relevant images and non-relevant image 6.

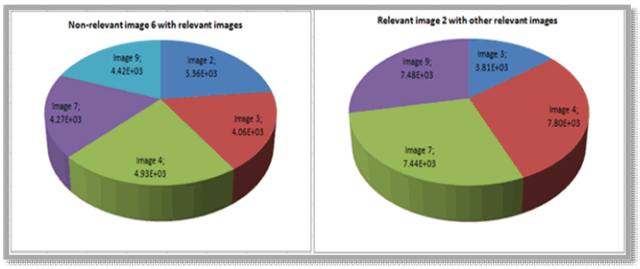

Figure8. Images comparison based on Euclidian distance in Yahoo.

Figure 9 shows the distances for images in Ask search engine, the images 2 and 8 are relevant and image 12 is non-relevant. The distance between relevant images 2 and 8 is greater than distances between relevant images and non-relevant image 6.

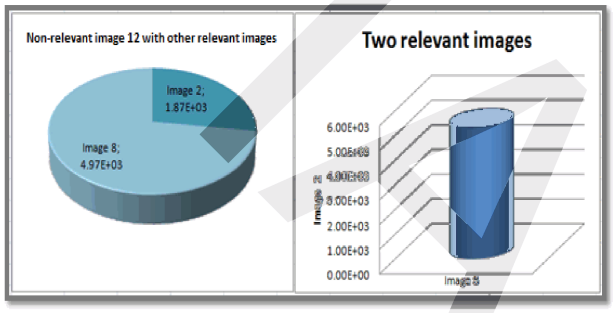

Figure9. Images comparison based on Euclidian distance in Ask.

The results from this method indicate that the distance between relevant images is often higher than the distance between relevant and non-relevant images.

4.2.2. Shape Analysis Results

The shape analysis results indicate that the number of edges for relevant images is close and in the same range as the number of edges for non-relevant images. Also, there are relevant images that have the same number of edges as non-relevant images. Figures 10, 11 and 12 show the number of edges for images returned by running query 6=”university life” in three ISEs Google, Yahoo and Ask.

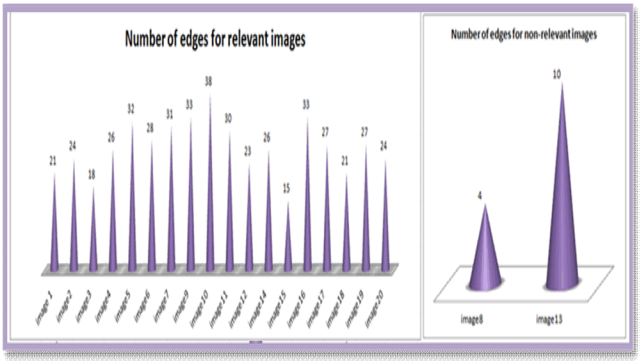

Figure10. Images comparison based on number of edges in Google.

As shown in figure 10, the numbers of edges for relevant images are close and in the same range to the numbers of edges for non-relevant images.

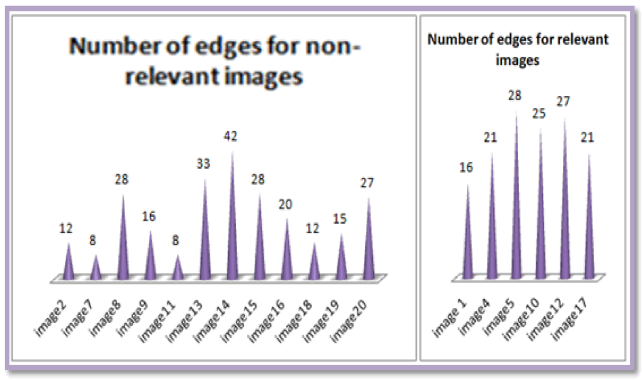

Figure11. Images comparison based on number of edges in Yahoo.

Figure 11 shows the number of edges for images retrieved from running query 6. We observed that some of relevant images have the same number of edges for non-relevant images, such as image 1 (relevant) and image 9 (non-relevant) with 16 edges for each.

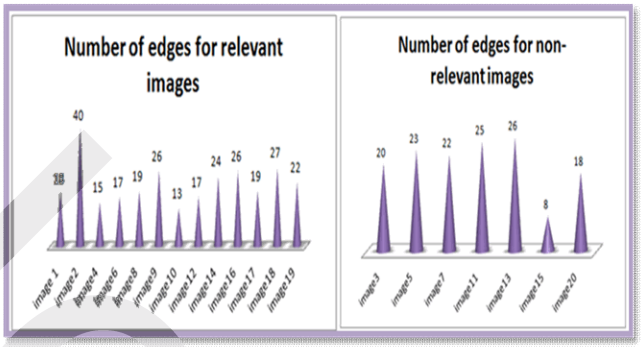

Figure12. Images comparison based on number of edges in Ask.

The same results apply to Ask search engine. Figure 12 shows the number of edges for images retrieved from running query 6. We observed that some of relevant images have the same number of edges as non-relevant images. An example is image 7 (relevant) and image 19 (non-relevant) with 22 edges for each.

5. Conclusion

There are millions of images on the web. ISEs help users in searching and retrieving images in a comfortable and easy way. This paper aimed to measure the effectiveness of three ISEs, namely, Google, Yahoo, and Ask. In addition, the images retrieved from these ISEs are analyzed based on color and shape features to determine the effect of these features on the retrieval.

The main findings of this paper can be summarized as follows: it seems that the precision ratio of any one of the ISEs was different and changed from one query to another. The precision ratios for the three ISEs decreased gradually with increasing cut-off point values from 10 to 20.

The results indicated also that Google has the best overall retrieval effectiveness with 95% precision ratio,

followed by Yahoo with 91% precision ratio, and Ask at the last with 83.7% precision ratio.

Google search engine has the highest precision ratio in 11 queries: ("cat", "cat scan", "university life", "football shoes", "dell xps m2010", "digital camera", "red bull", "kfc wings", "Ferrari 360 modena", "happy feet" and "family guy"), and for three of them Google has 100% precision ratio. As for Yahoo, it have the best precision ratio in 7 queries ("foot", "Australia Victoria", "ipod shuffle", "pepsi max", "cnn logo", "the Simpsons" and "transformers"), and has 100% precision ratio for two of them. Ask have the best precision ratio in 2 queries ("basketball" and "mazda rx-8"), and has 100% precision ratio in query "family guy".

Our results were compared with results from two previous studies [23, 2]. The comparison results showed that the queries (1, 3, 4, 6, 7, 8, 10 and 11) have the same results in two studies. However, the comparison showed that the results were different for queries (2, 5, 9 and 12 to 20) between our results and those in [23, 2].

Also, in this paper, the image features are analyzed and used to compare images to identify the impact of these features on the retrieval. Two features are selected, which are color and shape. However, there is one thing that's common for all ISEs which is the color feature is not sufficient to retrieve images that are relevant 100%, and two images with similar color histograms can possess different content. As well as for shape feature, the number of edges is not efficient to identify relevant images.

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