

A COMPARATIVE EVALUATION OF THE RECALL AND PRECISION OF SEARCH ENGINES AND META SEARCH ENGINES IN MEDICAL IMAGES RETRIVAL

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ABSTRACT: *Large and growing volume of data and medical images exist on the Internet, which one of the most important ways to retrieve them is using search engine and Meta search engine. This study aimed to determine and compare the precision and recall of search engine and meta search engine in retrieval of medical images. This study was applied and comparative-monitoring survey. The population was including five engine search; Ask, Bing, Google, Lycos, Yahoo and four meta search engines of Excite, Dogpile, Mamma and Metacrawler. 30 keywords were selected by medical experts and were searched in these engines and meta search engine. The first ten results of each search engine and meta search engine were selected to evaluate the precision and recall and were analyzed with comments of medical experts about the relevance or non-relevance of them with keywords and using SPSS software, descriptive statistics and independent t-test. Google search engine with 80.7% precision and 14% recall had the highest observed precision and recall between the engine and meta search engine. There was no Significant difference between the engine and meta search engine in medical images retrieval. Despite of overlap in results of some examined engine and meta search engine, each one retrieved particular results. The result was different in indexing and ranking algorithms of resources by different engine or meta search engine. It is recommended that users use several top search engines and meta search engine to search medical images to achieve more relevant images.*

Keywords: Internet, Medical information storage and Retrieval, Medical images, Search engine, Meta-search engine

INTRODUCTION

Internet will be used by millions of users as one of the main sources and ducts of access to information. On the Internet, there is a vast collection of information on variant topics in various forms, including text, image and audio. In the field of medicine and health sciences, the Internet is one of the most important and widely used sources of information [1], and its use is growing unremitting. An increase in Internet use by physicians has been reported by the American Medical Association [2].

With the innovation of the Web, the world has witnessed dramatic changes in the storage and retrieval of information [3]. Along with the creation and development of the network as the most extensive and diverse resource of information, it has emerged a variety of search tools such as search engines, meta search engines and present guides to help users find the required information from the Web, who mostly using search engines and meta search engines (4). Search engine rummages on the information resources of the Web using keywords and offers results of documents containing the keyword [5]. In order to enhance universality and efficiency of search results, there are some websites that submit search term into multiple search engines and display results after merging and deleting, such tools called Meta search engines [6]. Each of the search engines and Meta search engines has their own research and information retrieval properties. As well as, they are different in terms of size, indexing policy and other characteristics. Most of the search engines have been gathered information of millions of online documents, texts, pictures, and so on. However, the best and the most immense of them even cannot cover more than half of the documents available on the Internet. In other words, they couldn't search all the Internet resources [7].

Despite of the performance and efficiency of the various search engines and Meta search engines are being developed by constantly adding powerful search capabilities, but effective use of these tools have encountered problems such as the lack of comprehensive coverage, the inability to predict the quality of the recovered results and lack of words control. Today, the paucity of the amount of recovered subject materials is not the main problem in Internet seeking, rather there is a new problem as "too much information retrieval". Due to the high volume of information, the number of results retrieved for the questions posed may be fitted to thousands and sometimes millions. Among them, there are irrelevant items with the desired content and keywords or even some pages that do not exist in the Web.

According to the performed study, productivity of researchers and production of information have been increased by using the Internet [8], but in the Web network, very worth and waste information have been kept together. Due to the density of the information available on the Web, information retrieval from these important tools will face with many problems. A major problem on the Web has been determined the quality of information retrieval. Accuracy of results tendered by search engines and Meta search engines is an important subject in the information seeking topic. In order to optimal search and recovery of information and images, search and Meta search engines which offer the only relevant information have been looked out by users generally. But it must be specified to what extents search engines that have been succeeded to achieve the target. In the search of images, user may define the image specifications such as color, texture, dimensions and the image type. Hence, there is difference between contextual information and indexing, search and retrieval of

images [9] and it is very important to search and retrieve of related images that meet the user's needs. Kherfi et al. accounted that it is an inevitable necessity to use efficient tools for punctual and optimal recovery of images for users [10].

In the field of medicine and health sciences, images have an extraordinary importance and can obviate much of the information needs of professionals and experts in this field. Medical images are widely used for the diagnosis, treatment, education and research in the field of medical sciences [11][12]; as far as it will be very difficult or impossible without use and access to required medical images in some of educational or medical affairs. Accordingly, the search and retrieval of pictures have been converted to a vital in the field of medicine [13]. As regards, the question that proposed is how do the Meta search and search engines perform in medical images retrieval and whether they lead users to their results? Therefore, it requires careful appraisal to use of the web as an important source of health information and may not rely on traditional standards of quality and control that is used to evaluate web [14]. Study about circumstance of search and retrieval in search engines is an important area of web research [15], and one way to determine the effectiveness of the search tools is the evaluation of precision and recall proportion [16].

Whereas some problems mentioned, researches have been carried out about the Meta search and search engines to optimize search and information retrieval. It is necessary to note that users must consider these tools that may have any abilities and restrictions. Then, search with respect to this point. Various comparative studies have been performed about search engines and Meta search engines and almost each one have different results from another [17]. This is largely due to differences in methods, indexing algorithms, retrieval and search engine rankings. However, utilization of these tools will be traced advantageously by studies on the quantitative and qualitative aspects of Meta search and search engines, and also their precision and recall in information retrieval. Based on the survey, there are several studies that precision and recall in contextual information retrieval have been perused in Meta search and search engines but so far, there have no reports on precision and recall in medical image retrieval.

Ilic et al. examined general and specialized medical search engines efficiency and quality of information retrieved from each one. For this study, 18 keywords and phrases related to the ADAM disease (Androgen Deficiency of Aging Male (ADAM)) have been searched in four popular search engines amongst Google, Yahoo, AltaVista and Excite and five medical specialized search engines including DrKoop, HealthInsite, HON, NHS and Medline Plus. After browsing in 4927 sites, researchers found that there would be 47 related instances from total of 3267 websites retrieved from general search engines (1.44 %) as well as 10 sites from total of 1660 websites retrieved from specialized search engines (0.66 %). Also, there was no significant difference between the quality of information

retrieved from specialized search engines and data retrieved from public search engine [18].

Shafi and Rather evaluated the precision and recall of five search engine of scientific information retrieval in the field of biotechnology. Search engines selected for this study were general search engines consist of Google, AltaVista, and Hotbot and two biotechnology search engines, Scirus and BioWeb. The 20 search terms have been searched into three groups of simple terms, compound terms and advanced expressions in each search engine and the first 10 results in each case will be examined. As a result, it has been showed that Scirus had the best performance in scholarly documents retrieval. Also, Google was the best alternative for Web-based scholarly documents. So, it has been deduced that precision is inversely proportional to recall, meaning that if the precision was increased, recall will be decreased and vice versa [19].

Veronis compared six search engines and concluded that satisfaction of the users from search results was in a low level. Also, relevance of retrieved documents determined by the participants was low too. The results showed that the search engines amongst Google and Yahoo had the highest degree of relevance respectively by the relevance degree of 2.9 and 2.8 [20].

Vanhecke et al. surveyed the two medical specialized search engines comprise PubMed and Highwire press. They compared the retrieval precision, recovery speed, the number of results and features and capabilities of the search engine and concluded that Highwire press retrieves more results and more relevant ones. It also had better graphical quality and provides easier access to full-text articles, while PubMed search engine provides faster results [21].

Ribeiro and Lopes focused on comparison of Web search engines for health information retrieval. In this survey four popular search engines containing Google, Yahoo, Bing and SAPO and three specialized search engines in health among Medline Plus, WebMD and SapoSaud have examined. They reported that the precision of general Web search engines is more specialized than Health search engines. Especially Google's search engine has the best performance in the first 10 results [22].

Another research has been performed by Ghazimirsaid, Haghani and Akbari was about comparing selected Meta search engines in retrieving physical therapy information from the World Wide Web. Here, seven search engines and seven Meta search engines were examined. They reported that the search engines consist of AltaVista, All the Web and Google have the most results retrieval and among the Meta search engines Ixquick recovers the maximum results [4].

Alijani, Nik-kar and Dehghani presented a comparison of search engines and Meta search engines in response to ready-reference questions, in terms of precision, the false drops and dead links. It could be concluded that, at first MSN search engine with 45 % of related documents, and then Google came in second place with 41 % of the relevant documents retrieval, have the best performance in the search engines. Among Meta search engines studied Wei Zimo, Dogpile and Metacrawler with 36, 32 and 31 %

of related documents retrieval are the first to third rank respectively [23].

Mohammad Esmail, Lafzi Ghazi and Gilevary examined the Meta search engines and search engines in pharmacological information retrieval. The 8 selected keywords in the Meta search and search engines were searched. The 10 first results of each search engine were evaluated. As reported, the Yahoo search engine recovers the most pharmacological documents (34%) and has the first rank. AOL search engine with 62% precision and 21% recall retrieves the most relevant documents in the field of pharmacology. Among the Meta search engines, Dogpile has the most pharmacological documents (22%) and Excite Meta search engine with 62% precision and 22% recall retrieves the most relevant documents in the field of pharmacology [6].

Serati-shirazi surveyed the amount of precision in general and specialized medical search engines to determine the retrieval of the documents relating to the child diseases. The 10 words selected with the consultation of pediatrician searched in five general search engines containing AltaVista, Ask, Google, MSN and Yahoo and also, five medical specialized search engines such as HealthInsight, Medic8, MedlinePlus, Medology and Trip Database. Based on the results, from examined general search engines, Yahoo search engine with 94.7% precision and then Google with 92% precision have the highest precision and Ask search engine with 87.3% precision, has the lowest amount. Among the medical specialized search engines, Trip Database search engine with 75.7% precision and Medology search engine with zero value have the highest precision and the lowest one consecutively. General search engines and medical search engines have significant difference of precision so that general search engines have more precision than medical search engines [24].

Mirhosseini and Babaii evaluated the recall and precision of medical specialized search engines in gynecological information retrieval. For this purpose, 5 keywords related to gynecological disease and midwifery were selected in consultation with gynecologist and were searched in five medical search engines consist of MedHunt, Omnimedicalsearch, Pogofrog, Searchmedica and Trip Database. Henceforth, the retrieval, recall and precision was determined in the first 10 results of each search engine. The results demonstrated that among search engine cases studied, Searchmedica search engine with a precision of 94 % and a recall of 20.6 % had the most relevant documents retrieved in gynecological field. As well, there was a significant difference between the precision of medical search engines for retrieving specialized documents in gynecological disease, though in terms of recall (relative recall), there were no significant differences between searched engines with the mean recall of 20.8 [25]. As mentioned above, several studies have been carried out in the field of information retrieval of Meta search and search engines which were about contextual information retrieval. Search and retrieval of images in areas such as medical sciences have a wide range of applications [26].

Images are everywhere in modern medicine. Thereupon search and retrieval of required and related medical images for health specialist and experts is very important. Altogether, it is necessary to know and use of appropriate search engines and Meta search engines for searching and retrieving medical images required by users in the field of medical sciences. Yet, few studies have been performed in this case. With regards to the importance of this issue, the need for further studies in this area is fully felt. Therefore, the aim of this study was to determine and compare the precision and recall of search engine and Meta search engines to indicate that which search engines and Meta search engine have the best performance in the field of search and retrieval of medical images.

METHODOLOGY

The present study was applied and comparative-monitoring survey that was conducted in 2013. The population was including five engine search; Ask, Bing, Google, Lycos, Yahoo and four Meta search engines of Excite, Dogpile, Mamma and Metacrawler that had been introduced as the top search engines and Meta search engines in bases such www.searchenginewatch.com, ww.about.com, and other sites. These research tools have chosen as search engines and Meta search engines in other studies [4,6,18,20,22,24]. To determine and compare the precision and recall of the retrieval of medical images to search engines and Meta search engines, 30 keywords were selected by medical experts and were searched in these engines and Meta search engine.

It should also be noted that the terms used by medical professionals were selected according to their needs to pictures in which they were empowered to use the thesaurus to determine keywords. Mentioned keywords were searched in engines and Meta search engine by default and in basis search. The keywords were "heart anatomy interior view, kidney anatomy, head and neck, anatomy, lupus miliaris disseminatus faciei, urticaria pigmentosa, systemic contact dermatitis, hernia and incarcerated and surgery, appendicitis and complication and surgery, adenoma and parathyroid and surgery, bone marrow and niche, mesenchymal stem cells, cord blood, hairy cell leukemia, signal transduction in lymphocyte, th1/th2/th17 schematic, T cells signaling and photo, cone beam computed tomography, puls and sequence and MRI, x-ray tube, DNA replication and eukaryotes, amino acids and mutation, host-parasite interactions, Pneumocystosis, cell wall components, membrane transportation and facilitated, cell membrane structure, medial preoptic area and orexin, lateral chest x-ray, waters view radiograph skull, fetal and 3d and sonography, abdominal and radiography and contrast'.

Then, the 10 first results of search were extracted with keywords in any search engines and Meta search engine for study. Expected number of medical images is 2700 case, but because of some search tools, the number of retrieved images was less than 10, the number of expected images was decreased to 2666 image, which was one of the

Table 1: Frequency distribution of retrieved medical images by each search engine and Meta search engine

Retrieved images Engine and Meta engine	Number	Percentage
Ask	289	10.8
Bing	298	11.2
Google	300	11.3
Lycos	298	11.2
Yahoo	298	11.2
Excite	299	11.2
Dogpile	296	11.1
Mamma	290	10.9
Metacrawler	298	11.2
Total	2666	100

Regarding to the choice of keywords by medical professionals and actual information needs, when the search has led to the recovery of less than 10 images, the keywords of research has not been abandoned and precision and recall calculation was performed considering the number of retrieved images. Data were collected by direct observation and referring to each studied search engines and Meta search engines.

In the next step, retrieved medical images were presented to medical experts to determine the relationship or lack of relationship with search keywords. In order to assess the relevance of each retrieved medical image, a three-point scale was used [27] [28]. Thus, according to medical experts, the following letters were used; completely related images with "A", images relatively related images with the letter "B", related images "A + B" and non-related images with "-".

To calculate the retrieval precision of medical images in each of the search engines and Meta search engine, the following formula was used:

$$100 \times \frac{\text{The number of retrieved images}}{\text{Total retrieved images}} = \text{Precision}$$

To calculate recall based on no possibility of knowing the total number of relevant document in database by Clarke and Willett, with integrating the relevant retrieved results by the search engines and Meta search engines, the denominator was calculated [29]. Therefore, in present study, recall means relative recall that was calculated using the following formula.

$$100 \times \frac{\text{the number of retrieved images by search engines and Meta search engines}}{\text{Total number of relevant documents}} = \text{Recall}$$

The number of retrieved images by search engines and Meta search engines by eliminating commons.

Data were analyzed using descriptive statistics and inferential tables and statistics using the Kolmogorov-Smirnov test (to test the normality of the data. Also, the parametric t-test (for comparison of means) was used to evaluate the amount of precision and recall of search engines and Meta search engines in medical image retrieval using completely related (A) and related images (A + B).

Data analysis was carried out with SPSS 18 software.

RESULTS

After searching, a total of 2666 medical images were retrieved using 30 keywords by search engines and Meta search engines. Google search engine with 300 photographs (11.3 %) retrieved the maximum number of medical image, and the Ask search engine with 289 image (10.8%) retrieved the minimum number of medical image (table 1).

In 23 of 30 used Keywords (76.7 %), all images were retrieved, 90 images per keyword. Only by 7 used Keywords, the number of retrieved images was less than expected. Finally, using 30 mentioned Keywords, a total of 98.7% of the expected medical images were retrieved by search engines and Meta search engines.

Findings showed that among considered search engines, the Google search engine have been restored the largest number of related medical images (129 images) and search engine of Ask, the least number of related medical images (80 images). The Google search engine showed the most precision among search engines and Meta search engines with 43% retrieval of completely related images and 80.7% precision in related images. The mean precision of search engines in retrieving completely related medical images was 36.1%, and in related images was 73.2% (Table 2).

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Among Meta search engines, Excite Meta search engine and Mamma Meta search engine have been retrieved the maximum number of completely related medical images (123 images) and the minimum number of completely related medical images (95 images), respectively. Excite Meta search engine showed the highest precision (41.1%) in retrieval of completely related images. Regarding to precision in retrieving related image, Metacrawler Meta search engine had the highest precision (77.2%). The mean of precision of Meta search engines in completely related medical image retrieval and in related image retrieval was 36.8% and 71.8%, respectively (Table 3).

Table 2: Precision Retrieval of Medical Images In Search Engines

Correlation Search engine	Completely related images (A)	Related images (A+B)	Non-related images	(A) Precision	Precision (A + B)
Ask	80	182	107	27.7	63
Bing	114	218	80	38.2	73.1
Google	129	242	58	43	80.7
Lycos	102	214	84	34.2	71.8
Yahoo	111	230	68	37.2	77.2
Total	536	1086	397	36.1	73.2

Table 3: Retrieval precision of medical images in Meta search engine

Correlation Search engine	Completely related images (A)	Related images (A+B)	Non-related images	Precision (A)	Precision (A + B)
Excite	123	223	76	41.1	74.6
Dogpile	100	197	99	33.8	66.5
Mamma	95	199	91	32.7	68.6
Metacrawler	117	230	68	39.3	77.2
Total	435	849	334	36.8	71.8

Table 4: Retrieval Recall of Medical Image In Search Engines

Correlation Search engine	Completely related images by removing the common (A)	Related images (A + B) by removing the common	Recall (A)	Recall (A+B)
Ask	44	100	8	9.1
Bing	65	114	11.8	10.4
Google	77	142	14	13
Lycos	56	133	10.2	12.1
Yahoo	60	123	10.9	11.2
Total	302	612	11	11.2

Table 5: Retrieval recall of the medical image in Meta search engine Search

Correlation Search engine	Completely related images by removing the common (A)	Related images (A + B) by removing the common	Recall (A)	Recall (A+B)
Excite	70	123	12.7	11.2
Dogpile	58	121	10.6	11
Mamma	58	113	10.6	10.3
Metacrawler	61	126	11.1	11.5
Total	247	483	11.2	11

To test the hypothesis "there was a significant difference between precision and search engines and Meta search engines in medical images retrieval", the normality of the data was tested. Because of significant level $P=0.2 > 0.05$, the variable was normally distributed. Therefore, independent t-test was used to compare the precision in search engines and Meta engines. According to the results of independent t-test, $t=0.197$ and $df=7$ with 95% confidence, significance level was equal to $P=0.85$ and greater than 0.05. Therefore, the H_0 hypothesis was confirmed. Therefore, it can be noted that there was no significant difference between the precision of examined search engines and Meta search engines in retrieving completely related images (A). Regarding to significant difference between the precision of examined search engines and Meta search engines in retrieving medical related images (A+B), the results of independent t-test showed $t=0.35$ and $df=7$ with 95% confidence, significance level equal to $P=0.736$. Therefore, the H_0 hypothesis was confirmed. Hence, there was no significant difference between the precision of examined search engines and Meta search engines in retrieving related images (A+B)

According to Table 4, the Google search engine with a recall of 14% showed the highest recall in retrieving completely related medical image. This search engine had highest recall (13%) in retrieving related medical images. Ask search engine had the least recall (8 and 9.1) in retrieving completely related and related medical images, respectively. Recall mean of five examined search engine five in retrieving related medical image was equal to 11.2 percent.

Among Meta search engines, Excite Meta search engine and Metacrawler Meta search engine showed the maximum (12.7%) and minimum (11.5%) recall in retrieving completely related medical images, respectively. Excite Meta search engine showed the highest precision (41.1%) in retrieval of completely related images. Also, the recall mean of search engines and Meta search engines in retrieving completely related medical images was 11.2% and 11%, respectively (Table 5).

To test the hypothesis "there is a significant difference between recall of engine Meta search engine in retrieving medical images", the normality of the data was tested and confirmed ($P=0.2 > 0.05$). In order to compare the recall of search engine and Meta search engine, independent t-test

was used. According to the results of independent t-test, $t=0.226$ and $df=7$ with 95% confidence, the significance level was equal to $P=0.828$ and was greater than 0.05. Therefore, the H_0 hypothesis was confirmed. Therefore, it can be mentioned that there was no significant difference between the recall of engine Meta search engine in retrieving completely related medical images (A). Also, regarding to the difference between the recall of search engine and Meta search engine in retrieving related medical image (A + B), the results demonstrated that the independent t-test, $t=0.201$ and $df=7$ with 95% confidence, the significance level was equal to $P=0.847$. Therefore, the H_0 hypothesis was confirmed. Therefore, there was no significant difference between the recall of search engine and Meta search engine in retrieving related medical image (A + B).

CONCLUSION

Based on these findings, among evaluated search engines and Meta search engines, the search engine Google could retrieve the expected medical images (300 images). Ask search engine retrieved minimum expected number of medical images (289 images). Among the Meta search engines, Excite retrieved the highest number of medical images (299 images) based keywords.

These results are consistent with the findings of some studies on textual information retrieval by search engines [4]. Regarding to precision of image retrieval, Google search engine had the highest precision with 43% precision in retrieving completely related image and with 80.7% precision in retrieving related image. After that, the Yahoo search engine and Metacrawler Meta search engine both showed 77.2% precision and Excite and Bing search engine showed 73.1% precision in medical images retrieval. Shafi and Rather [19], Veronis [20], Lopes and Ribeiro [22] and Serati-Shirazi [24] achieved to similar findings about textual information retrieval.

As already noted, based on our literature review, there was not observed the study of the recall and precision of image retrieval by search engines and Meta search engines. Therefore, the results were compared with the results of some studies in textual information retrieval. Another point worth noting is that despite of the consistent and noted similarities, there was significant difference among some studies and present study results [6,24]. It seems that this may indicate some differences in performance of search engines and Meta search engines in textual and visual information retrieval as well as the specific features of images in comparison with the text.

Based on recall of medical image retrieval, Google search engine, had the highest recall (14%) in retrieval of completely related images and 13% recall in retrieval of related images among search engines and Meta search engines. After Google, Lycos and Metacrawler Meta search engines showed 12.1% and 11.5% recall 5.11 in medical image retrieval, respectively. These findings are similar to results of Mohammad Esmail *et al* [6]. Ahmadi and Cheshmeh-Sohrabi [30] in their study concluded that the

Google search engine had the most recall in the information retrieval.

The independent t-test results showed a significant difference among the precision of search engines and Meta search engines in medical images retrieval. Ilic *et al* (18) and Alijani, Nick-kar and Dehghani [23] achieved to the same results in their studies on the retrieval of textual information by search engines and Meta search engines. It can be noted that some search engines and Meta search engines were different with those selected here.

The independent t-test results showed that there was no significant difference of recall in retrieval of completely related and related images among search engines and Meta search engines. Mir-Hosseini and Babaii [25] in their study found that there was no significant difference between the recall of search engines. Investigating retrieved medical images by search engines and Meta search engines indicates that although the results of some of the search engines and Meta search engines are common and has been retrieved by several search engines and Meta search engines, but each one have been retrieved particular results. This shows that the algorithm of references indexing by search engines and Meta search engines is different, and some information and images are only in the database of particular search engine.

In spite of Meta search engines search facility to integrate and display the results of a search engines in order to respond quickly, challenge in retrieve documents and photographs related to the diverse needs will be remain. Despite of the fact that search engines and Meta search engines consider as an important tool, have reduced many problems of the users in accessing to information. However, due to problems that exist in the search engines for indexing documents, it can not be expected that they use Meta search engines to retrieve information, to response all their needs. Also, common retrieved images between search engines and Meta search engines, sometimes are presented with different ratings in retrieved images of search engines and Meta search engines. This also indicates that the engine algorithm to rank retrieved items is different. Therefore, it is suggested that retrieved items studied further by users.

It can be concluded that Google search engine and Metacrawler Meta search engine showed the best performance. It is recommended to seek medical images users use Google engine and Metacrawler Meta search engine. Moreover, due to no difference between recall and precision of engines and Meta search engines studied there, it seems the performance of engines and Meta search engines be similar in medical image retrieval. Therefore, it is recommended that to comprehensive search of the medical images, several top search engines and Meta search engines be used simultaneously. Alternatively, it is suggested that when users search for keywords, use more particular words in order to achieve better precision.

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