THE WEB SEARCH ENGINES AND GENERAL REFERENCE QUESTIONS

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Abstract - Six Web search engines, namely, Altavista, Excite, Go, Google, Hot Bot and Lycos, were compared and evaluated in terms of their search capabilities (i.e., duplicate, false drops, mirror sites, dead links) and retrieval performances (i.e., precision) using sample queries drawn from real reference questions from the reference desk of the Central Library of Shiraz University (Mirzay-e-Shirazi Library). Recall, another evaluation criterion of information retrieval, is deliberately omitted from this study; because, it is impossible to assume how many relevant items there are for a particular query in the huge and ever changing Web system. The authors of this study found that Google showed the best performance, although Altavista had the largest coverage of Web resources amongst the six Web search engines examined.

Keywords: Search Engines, Reference Questions, Altavista, Excite, Google, Hot Bot, Lycos, Dead Links.

INTRODUCTION

For decades librarians have used hard copy reference materials to answer different types of reference questions posed at reference desks. They have employed their knowledge and expertise in finding answers that meet the needs of library patrons. The traditional environment has been changed for librarians by introduction of information and communication technology. Reference librarians like a great number of library patrons try to use the Web search tools to answer reference questions. This is usually the case, even though reference materials on paper are still preserved and used in libraries.

Development and testing of measures and methodologies appropriate for evaluating information retrieval systems is central to information science. Traditional retrieval measures, such as precision and recall, have been a topic of debate for some decades, but relevancy of this methodology to the new cyber search environment has been questioned [41], as measuring the Internet and in particular the Web is a difficult task due to its highly dynamic nature [3].

While in traditional Information Retreival Systems, documents are evaluated, indexed and stored in databases, in most cases free resources in the Web do not undergo these

procedures. There are certain problems that are unique to these resources. Among these are "Dead links" that are not directed to other web pages. The other case is the low quality of the free web pages. These and other problems will be discussed later.

THEORETICAL FRAMEWORK

The Web has become the largest easy available repository of data. Though different Web application and services are available today, the primary use of the Internet, other than e-mail, is for information retrieval [26]. Hence, it is natural to extract information from the Web and the Web search engines have become one of the most used tools in Internet to retrieve information [33,50]. According to surveys more than 85% of Net users find and access information by search engines [9,23]. However, the exponential growth and the fast pace of change of the Web, makes it really hard to retrieve all relevant information. Quality of many Web pages or Web sites, although related, can be questioned, and evaluating [8,17,27] and accessing reliable information is one of the most discussed topics [10]. Because of this rapid growth and change, the actual size of this network is not clear [49], but it is estimated that its size is doubled every 12 to 15 months [51]. However, what users need is a filtering system to separate the wheat from the chaff.

To solve this problem, many companies have tried to design better search tools [12]. In general, search services on the Web are derived from two basic paradigms, directory services and search engines. Directory services, such as Yahoo, provide a hierarchical organization of resources, most often developed by human cataloguers who select, index and annotate links. Directory services' careful organization of resources enables rapid discovery and browsing of resources by topic or category, a more intuitive mode of access than keyword selection and query refinement for users [15]. In addition, assembling resource links using human indexers offers high quality control. But as a pitfall, directory services are limited and small [1], primarily due to the high cost of creating, maintaining and finding new resources in the face of constant change and growth of the Web. In contrast to directories, search engines, such as Google, provide broad coverage of the Web through intensive automation of the indexing and retrieval process.

A Web search engine is an information retrieval system used to locate the Web pages relevant to user queries. A Web search engine contains indexing, storage, query processing, spider (or crawler, robot), and user interface subsystems. The indexing subsystem aims to capture the information content of Web pages by using their words. During indexing, frequent words (that, the, this, etc.), known as stop words, may be eliminated since such words usually have no information value. Various statistics about words (e.g., number of occurrences in the individual pages or in all of the indexed Web pages) are usually stored in an inverted file structure. This organization is used during query processing to rank the

pages according to their relevance scores for a given query. Hyperlink structure information about Web pages is also used for page ranking [23]. The spider subsystem brings the pages to be indexed to the system. However, for Web users a search engine is nothing but its user interface that accepts queries and presents the search results. In this study, our concern is text-based search engines. For assessing the performance of search engines there are various measures such as database coverage, query response time, user effort, and retrieval effectiveness. The most common effectiveness measures are precision and recall. Measuring the search engine effectiveness is expensive due to the human labor involved in judging the relevancy [11]. For example, for a period of six months one of the researchers of this study spent about 6 hours, earch day, to judge the query results and similar observations.

Evaluation of search engines may need to be done often due to the changing needs of users or the dynamic nature of search engines (e.g., their changing Web coverage and ranking technology).

The motivation of this study is based on the fact that identifying the most effective Web search engine(s) satisfying the current information-needs is important both to librarians and users.

But for many Internet users these search engines offer a temporary relief, as they open a way to a sea of related or unrelated information [2] and finding useful information is difficult and time consuming [16]. Users can never have confidence that a search is comprehensive or conclusive. Although search engines claim to rank results by relevance, users are usually faced with different kinds of false drops.

Nevertheless, some studies show the usability of information on the Web for answering reference questions [38] and a high percentage of libraries offer reference services via the Web [19,21,42]. A number of software for searching reference questions via the Web have been developed [13], and reference librarians have used them to provide digital reference services [40].

Furthermore, selection of proper search engines is important, as each of them covers a part of Web resources [14,44]. The coverage of web resources by these search services is different from one study to another, but it is estimated to be between 14-55% [3,43]. Some studies show the limitations of search engines' databases, and technical matters have caused deliberate bias towards including or excluding some resources. [5,29,46] Hence, the information found in one search engine, may not be retrieved by others. It is in this context that the present study is designed. It attempts to assess the effectiveness of search engines in addressing general reference questions, especially in answering questions according to the needs of Iranian undergraduate students. Can the search engines answer these questions? Which is the best engine for this purpose? Can we rely on one of them for all general reference queries? Answers to these questions will help us understand the strengths and limitations of these tools and will enable us to select the appropriate one(s)

to meet the information needs of patrons.

LITERATURE REVIEW

Web search engines emerged in 1994. A search in related literature reveals that the first studies in this regard began in 1995. The novelty and variety of these tools prompted different reviews and evaluations. The reviewers or evaluators were mainly information scientists, librarians and computer scientists. The reviewers offered guidance to users on search engine features. Examples of early works include Notess [31,32], Raisch [37], Chu & Rosenthal [12]. The choice of engines and the number of engines tested also differed. While Machovec [27]. Tested two search engines, other evaluators described and compared 3, 4 and in the case of Piggott [35] thirteen different search engines. One point of importance is that in these early years there was not any border between search engines and directories so they were compared equivalently, examples include Venditto [47] & Machovec [27]. Some investigators classified queries as simple, complex, or obscure queries, and others used categories such as academic and non-academic queries. The number of questions used was generally small.

In general, the reviewers gave descriptive comparison of engines from their own perspectives including choice of features and application of criteria. Although early reviewers and evaluators were optimistic, in general, about the potential capabilities of these new searching tools, they discovered problems from tests and suggested methods for improvement. They found (1) questionable quality of information, (2) large outputs with low precision, (3) incomplete coverage of resources and retrieval, (4) inability to provide valid links and (5) inability to avoid duplication.

While these early evaluative efforts yielded preliminary insight into the use, testing, and performance of search engines, there was lack of a systematic and common evaluation methodology and involvement of end users with real information problems in tests. In the majority of the cases, investigators assessed engine features, constructed and ran search questions.

From 1997 to 2003, the type and number of surveys on search engines changed. A glance at LISA (via CSA) showed that the total number of works done on search engines (indexed and abstracted in LISA) from the appearance of these tools up to 1996 was less than 20, while from 1997 to 2003 there were about 300 works available. Also one noticed an increasing variety of studies in this period including reviews, experiments, and surveys. Examples might include Brandt [9] that discussed the different types of search engines available and the relationships between them. Poulter [36] compared search engines of all types across their generic features (database content, retrieval software and search interface), rather than on a search engine by search engine basis. Leighton and Srivastava [25]

compared 4 search engines and found that the best search engine was Altavista. Yee [51] evaluated the performance of eight major Internet search engines in answering twenty one reference questions and five made up subject questions. He reported on the retrieval and relevancy ranking abilities of the search engines. Bar-Ilan [4] Investigated the retrieval capabilities, precision and estimated recall and overlap of 6 search engines.

Gordon & Pathak [19] calculated traditional information retrieval measures of recall and precision at varying numbers of retrieved documents and used these as the bases for statistical comparisons of retrieval effectiveness among the eight search engines. They also calculated the likelihood that a document retrieved by one search engine would be retrieved by other search engines as well. Garman [18] discussed the advantages of using meta search engines for searching the World Wide Web as an alternative to using several search engines and triangulating the results. Barmakian [7] described a comparison of fifteen search engines for effectiveness in retrieving legal information on the Web. Moukdad & Large [28] attempted to evaluate the retrieval power of selected search engines for Arabic queries. The research questioned the assumption that search engines designed with English in mind will work as well with different language structures. Hock [21] gave a report on new features of different search engines, which were not available before. Mowshowitz & Kawaguchi [29] and Vaughan & Thelwall [46] evaluated bias in different search engines on the World Wide Web. In more recent studies, information seeking behavior of users in free search engines have been in focus. An example is Spink, Ozmutlu & Lorence [39] but comparisons of search engines are still done by researchers. A very recent article by Wallenwein [48] has compared two search engines, Google Scholar and Scirus.

RESEARCH QUESTIONS

In order to evaluate the ability of the Web search engines ten general reference questions were picked up from the reference desk of Shiraz University Central Library, Shiraz, Iran. Among many search engines available on the Web, six search engines including Altavista, Excite, Go, Google, HotBot, and Lycos were chosen for the purpose of the study. This study attempts to answer the following questions:

1. How well can the selected search engines answer general reference questions?
2. What is the status of false drop in these search engines for general reference questions?
3. Which search engine is the best one in answering these types of questions?
4. Do search engines perform differently for general reference questions?
5. Can we rely on only one of these engines as a means of answering general reference questions?

METHODOLOGY

This study compares and evaluates six search engines, which are well known and free to all. They are Altavista, Excite, Hot Bot, Go, Google, and Lycos.
Adapted from Su [41], the Table below shows the most frequently evaluated search engines from 1995-2000.

Most frequently evaluated web search engines (1995-2000).

Search Engine	Frequency
Lycos	19
Infoseek	16
Altavista	14
Excite	14
HotBot	8
Web Crawler	7
Open Text	7
Yahoo	7
WWW Worm	5
Northern Light	3
Magellan	3

The above table provides a list of search engines, from the most to the least often evaluated, but does not include search engines evaluated less than three times. Altavista, Excite, Infoseek and Lycos were the most frequently evaluated search engines with Lycos leading, Infoseek the second, and Altavista and Excite third in frequency. It is important to remember that search engines are like living creatures. They are born, live and die. So, in recent years some of the mentioned search engines in pre-2000 studies no longer exist, including Open text, Magellan, WWW Worm and Infoseek. As an example, trying to retrieve Infoseek with its old domain leads the searcher to Go.com, the buyer of the domain after its demise. At the same time, new search engines like Google came into existence and have acquired a good ranking in the Web.

According to the above explanation, justifications for choosing these search engines are as follows: (1) They are among the most reviewed, evaluated and compared search services. (2) All of them have their own databases. (3) All are free for users. (4) They are the most well-known search engines. (5) All of them use Spiders or Robots to find web pages. (6) Net Rating companies such as Search Engines Showdown (www.search engineshowdown.com) and Search Engines Watch (www.searchengineswatch.com), have given priorities to these search services over others.

Search engines are different in size, contents of their databases, their indexing policies, retrieval methods, and presentation of search results. Thus, different questions from different

topics can better show their capabilities. Nevertheless, previous studies suggest that there might not be a single search engine that can cover all types of questions. The collected reference questions were believed to be valid in testing search engines' ability to answer real reference questions. The types of reference questions adopted for this study are Ready Reference Questions. According to Katz [22] Ready Reference Questions are those which could be answered by Standard Reference resources such as dictionaries, biographies and encyclopedias.

To have a similar search in search engines, we took the main concept of questions and extracted keywords from them. So, simply the normal question "I need some general information about anthrax" was given only one keyword, anthrax. As the searching algorithm of the search engines tested is Boolean, and not natural language, we did the same approach to other questions and derived the main concepts and changed them to single keywords or key-phrases. Different variables, i.e., precision, duplicate, mirror site, and concept false drops were used to measure the strength of the search engines.

Different variables were measured for this study. "Precision," a traditional measure which is defined as the number of relevant items retrieved divided by the total number of items retrieved and has been a standard measure for information retrieval systems.

$$\text{Precision: } \frac{\text{Number of relevant items retrieved}}{\text{Total number of items retrieved}}$$

But it is difficult and even in many cases impossible to apply this measure to evaluate web resources, so it was modified to test the relevancy of only the first ten retrieved items. The first ten-item approach can be justified because these items are most likely to be viewed by users. In most related studies, researchers came to the conclusion that it is almost impossible to evaluate the relevancy of a large number of pages retrieved by search engines. [24,30,34,51] This approach was, thus, adopted to carry out the study. As a result, the formula to measure this variable is changed to:

$$\text{Precision: } \frac{\text{the number of relevant items in the first 10 items}}{10}$$

The second variable is "Duplicate" which is defined as the number of items that repeat items presented before them. In the present study, we used the number of duplicates based on the first ten retrievals. "Concept False drops," "Deadlinks," and "Mirror Sites" are other variables that were measured in this study.

"Recall" is another standard measure for evaluating information retrieval systems, and it is defined as the number of relevant items retrieved, divided by the total number of relevant items in an information file.

$$\text{Recall: } \frac{\text{Number of relevant items retrieved}}{\text{Total number of relevant items}}$$

It is difficult to measure this variable in search engines, because researchers need to identify all relevant items in a database that because of its huge size is impossible and impractical. The search process in selected search engines started in late months of the year 2002, and went on for several months in the year 2003. Of all retrieved items, totally 600 hits, the first ten retrieved items for each keyword or key-phrase in each search engine, were reviewed for relevancy. Relevancy judgment was done by researchers themselves. Both authors are active in teaching Reference and Storage and Retrieval courses at Library and Information Science Departments in different universities.

This study is different from the previous ones in several ways. (1) It is according to the real needs of Iranian university students, (2) The questions are real ready reference queries submitted to the reference librarians and (3) Some new measures have been tested for the first time, such as mirror sites and deadlinks.

FINDINGS

The analysis of the data shows the following results for the research questions posed earlier.

Question 1: How well can the selected search engines answer general reference questions?

To answer this question, we used the precision variable. By analyzing the data we found that the selected search engines did not answer the general reference questions very well. As can be seen in Figure 1, the best performance is seen in Google which retrieved 39 percent of relevant items, followed by HotBot with 37 percent and Altavista with 34 percent of related items. Among the selected engines the worst performance belongs to Go search engine, which retrieved only 16 percent of the related items.

Table 1: Search engines' average precision for general reference questions.

	Altavista	**Excite**	**Go**	**Google**	**Hotbot**	**Lycos**
Afghanistan	4	3	3	3	2	2
Avalanches	3	0	1	2	4	1
Malcom X	2	2	2	4	3	4
Black Holes	5	5	5	8	7	8
DNA	1	1	1	0	4	1
Earthquakes	2	0	0	3	2	0
Oscar Wilde	4	3	1	4	4	6
Lightning	1	1	0	3	4	1
Volcanoes	5	0	0	7	4	5
Anthrax	7	2	3	5	3	5
Total	34	17	16	39	37	33

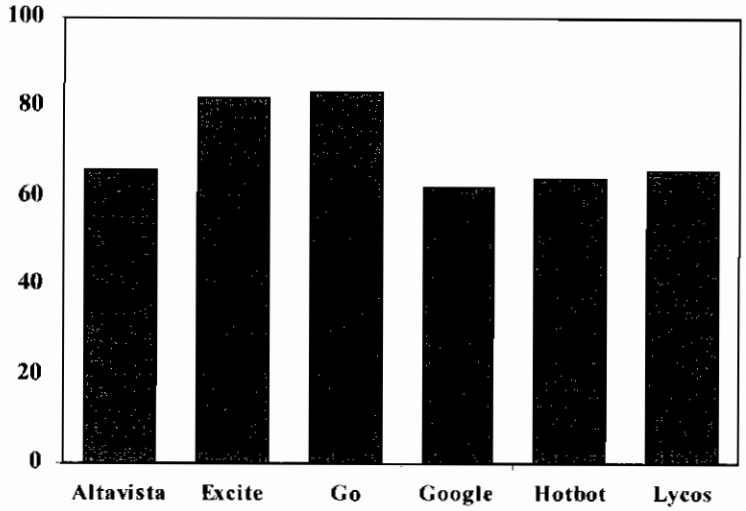

Figure 1: Search engines average precision for general reference questions.

To show another aspect of the searches, data on each engine's zero hits were included in Table 1, indicating that Altavista and Hot Bot with no zero hits did better than others, followed by Google, Lycos, Excite and Go. These two sets of data identified Google as the best search engine in answering general reference questions.

Question 2: What is the status of "false drop" in these search engines for general reference questions?

In information retrieval, a retrieved record, which is unrelated to the subject of the search or simply unwanted, is called false drop. Considering this definition in our study, several types of false drops are identified which are "Dead links," "Mirror Sites" and "concept false drop." Dead links are links that are not directed to other web pages and the searcher often sees this massage "server may be down." A mirror site is an exact copy of a web site that usually resides on a separate server, uses a separate communication line and has a separate Internet address. The most important false drop, which is worth mentioning, is "concept false drop."

To answer this question we used the data in Table 2 and Figure 2. The analysis of the data showed that Deadlinks and Mirror sites were not important false drops in information retrieval, but Duplicate and Concept false drop were important and needed special consideration. As in Figure 2, the highest false drop is seen in the Go search engine and the lowest in Google.

Table 2: The status of false drops in search engines.

	Altavista	Excite	Go	Google	Hotbot	Lycos
Afghanistan	6	7	7	7	8	8
Avalanches	7	10	9	8	6	9
Malcom X	8	8	8	6	7	6
Black Holes	5	5	5	2	3	2
DNA	9	9	9	10	6	9
Earthquakes	8	10	10	7	8	10
Oscar Wilde	6	7	9	6	6	4
Lightning	9	9	10	7	6	9
Volcanoes	5	10	10	3	6	5
Anthrax	3	8	7	5	7	5
Total	66	83	84	61	63	67

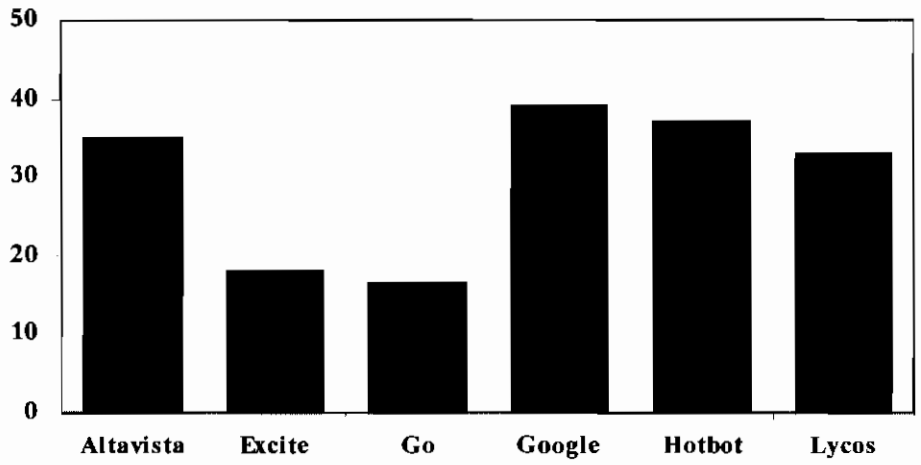

Figure 2: The status of false drops in search engines.

Duplicates waste users' time and cause confusion. It seems that there are some duplicates in retrieved items, but the number of duplicates in each search engine was negligible. The collected data show that duplicates were not a serious problem even when many relevant items were retrieved.

Among different kinds of false drops, the highest rate of false drops could be seen in "concept false drops." The highest rate of this kind of false drop belongs to Excite, followed by Go and then Lycos, while Google has the lowest concept false drop. That is, in all search engines and for all kinds of general reference questions "concept false drop" is to be accepted.

Table 3: The status of concept false drops in search engines.

	Altavista	Excite	Go	Google	Hotbot	Lycos
Afghanistan	6	5	5	6	7	8
Avalanches	5	8	7	6	6	8
Malcom X	5	8	8	5	7	5
Black Holes	3	4	4	1	3	2
DNA	9	9	8	8	4	9
Earthquakes	7	10	10	6	6	7
Oscar Wilde	5	7	8	5	6	2
Lightning	9	8	8	6	6	9
Volcanoes	3	10	9	3	4	5
Anthrax	3	9	7	5	7	5
Total	55	78	74	51	56	60

Question 3: Which search engine is the best in answering this type of question?

The findings show that Google with 39 percent of relevant retrieval is the best among the selected search engines, while Go with only 16 percent of relevancy is the lowest one regarding retrieval power. Actually, we come to the conclusion that a powerful search engine like Google is not able to retrieve more than 40 percent of the relevant items.

Question 4: Do search engines perform differently for general reference questions?

To answer this question, all 600 retrieved items in the six selected engines are compared. We see that in different cases, engines retrieve different pages and sites. This shows that the selected engines have their own database and, therefore, they act differently.

The comparison of relevant retrieved items in different engines shows that they act differently. As a result, the total number of answers for each question is different from one search engine to another. In addition, the rate of false drops and their differences in these search engines are another indication that they have preformed differently. So, according to what has been said, an item found in a search engine may not be found in another one and, thus, for a better result it would be wise to use more than one search engine at a time.

Question 5: Can we rely on only one of these engines for answering general reference questions?

The general reference questions were collected from different subjects so as to test the actual retrieval power of these engines. As we noticed, the search engines did differently in answering general reference questions so we can not rely on only a single one for answering general refrence questions.

CONCLUSIONS

The application of the Web search engines to answer general reference questions depends

on high precision of results and less duplicates and false drops in findings. Despite general expectation that Web search engines should do well, the rate of precision was very low among the six search engines considered. The best relevancy rate belonged to Google which did not go further than 39 percent. The number of false drops was also high, but the size of duplicates was negligible which was not significant when the number of findings was very high.

The search engines as a whole cover a good portion of the Internet, but they are not able to produce good results for real reference questions. The implication is that users, including librarians, should not rely on search engines as the ideal search tools to answer reference questions. Librarians still need their reference books either as hard copy or electronic versions to provide reliable answers to various reference questions. However, this does not mean that the Web search engines are useless. They are powerful search tools and we expect better performance with enhancement of software. Moreover, in order to know more about the ability of search engines in the area of reference services, similar studies should be conducted for web directories and meta search engines.

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