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PRODUCTIVE INFORMATION SEARCHING: QUERY WISE STUDY OF SEARCH ENGINES EFFECTIVENESS

P. K. Tripathy*

Abstract *Internet is the most potent source of information, side by side it has the most difficult mechanism/system to retrieve relevant information because of its infinite coverage, innovative information models, and complex indexing algorithms. As retrieval tools the Search Engines are striving continuously to cover major portion of the Internet and develop strong index of it for satisfying information need of the Internet users, in which some are successful and others are less to them. The present paper is the output of the research conducted to find out and compare the retrieval effectiveness of different search engines working in India like, Google, Yahoo, Alta Vista, Rediff, Khoj, and Guruji. By method of testing of some queries (collected from researchers in the field of Education) on all search engines the researcher has drawn some findings.*

Keywords: *Information Retrieval Systen (IRS), Search Engines, Web Searching*

INTRODUCTION

For today, Internet is the excellent source of information for every individual and the World Wide Web, an 'embodiment of human knowledge' (World Wide Web Consortium, 2018), or 'a pool of human knowledge' as described by father of Web, Tim Berner Lee (Berner Lee et al., 1994), makes it more useful for all purposes. The Web is a huge, open, multicultural, multilingual, almost uncontrolled, and ever growing repository of information. The interlinked comprehensive databases having information on different magnitude like media, marketing, entertainment, advertisement, etc. (Shafi & Rather, 2005), increases the usefulness of Web to any height. Today, the explosive growth of the Internet has rendered the Web as the primary tool for information retrieval. This technology in combination with latest electronic storage devices enables us to keep track of enormous amount of information available to the information society (Schlichting & Nilsen, 1996). In few years, it has grown from an esoteric system for use by a small community of researchers to the de-facto method of obtaining information for millions of individuals (Oppenheiem et al., 2000).

The public information stored in the multitude of computer networks connected to the Internet forms a huge electronic library, but the enormous quantity of data and number of linked computer networks also make it difficult to find where the desired information resides and then how to retrieve it. For Internet information seekers it creates new challenges all the time in information retrieval. One of the most serious problems faced by the Web users at the moment is to be able to retrieve valuable information by fishing it out of a huge sea of neither regulated, nor guaranteed, dynamic data (Landoni & Bell, 2000). Various Web search aids have been developed in order to provide users with an interface that enables them to locate documents containing information that matches to their interests. Web search aids are variously referred to as catalogs, directories, indexes, search engines, gateways or Web databases. Within their limitations every Search Engine has evolved its search techniques to retrieve effective information for the searchers, which is obvious to be viewed and compared with other search engines. In further narrowing the scope of the study the search engines operating in India and prioritised the documents hosted in local web servers have been subjected for the study. As Lord Kelvin, one of history's greatest scientists and engineers, said: "If you cannot measure it, you cannot improve it" (Tunkelang, 2017).

OBJECTIVES

- To study and compare the effectiveness of retrieval mechanisms of different search engines with relation to precision/relevance of the retrieved documents.
- To study the variations in relevant information retrieved by different Indian search engines.

* Librarian, Regional Inst. of Edu. (NCERT), Bhopal, Madhya Pradesh, India. Email: tripathypkt@gmail.com

- To study the variations in partially relevant information retrieved by different Indian search engines.
- To compare the over all information retrieval effectiveness of different Indian search engines.
- To compare the retrieval effectiveness of the group of 'International search engines' with 'Indian search engines' group.

METHODOLOGY

The data collected for the study was through testing of individual queries on all search engines and recording the relevance status of each retrieved document with the help of some Ph. D scholars. Precision the most popular and traditional method to measure performance of any Information Retrieval System (IRS) is the sole measuring criteria to judge efficiency of studied search engines. Precision is defined as the ratio of retrieved documents that are judged relevant. This is to points out in how many cases the search engines deliver relevant hits within the top twenty results. This shows how often the engines are able to be at least marginally useful in that they deliver something relevant.

The derivative formulae

$$\text{Precision} = \frac{\text{Relevant documents/results}}{\text{All documents/results of all queries}}$$

Google, Yahoo, Alta Vista, Rediff, Khoj, and Guruji are the six Search Engines operating in India to cover the web documents hosted in Indian web servers have been considered in the study for comparison of effectiveness. The first three search engines are international ones and rest three are indigenously developed Indian search engines.

List of Queries - The followings are the selected search queries collected from researchers (in Education) and used for the purpose of conducting retrieval test of the Search Engines:

Table: List of Search Queries (with ID) Selected for Testing in Search Engines

Query ID	Query details
1	Educational philosophy of B.R. Ambedkar.
2	Remedial teaching in Mathematics.
3	Multi-cultural education in India.
4	Experiential learning styles.
5	Value oriented teaching in schools.
6	Occupational stress of teachers.
7	Human Rights Education in school curriculum.
8	Effective teaching techniques in schools.
9	Mathematical attitude of school children.
10	Teaching attitude of teachers.
11	Tribal education in Gujarat.
12	Muslim children education in India.
13	Environmental awareness of school students in India.
14	Teaching effects on academic achievements of students.
15	English language teaching in schools of MP.
16	Constructivist teaching methods in schools.
17	Academic achievements of residential school children.
18	Science instructional materials.
19	Multimedia method of teaching Science in Schools.
20	Interactive learning materials.

Each search term was tested in each search engine within a span of five days and all top 20 retrieved Hits in the result list were evaluated with the help of three criteria - Relevant, Partially Relevant, and Not Relevant. The level of information to be kept under the categories of 'Relevant' and 'Partially Relevant' was absolutely decided by the researchers who have selected the search queries, whereas the rest of the Hits in the result list have been termed as 'Not Relevant' by the investigater himself.

DATA ANALYSIS

This study systematically compares the retrieval effectiveness of major search engines on informational queries, that is, queries where the user wants to find at least some documents on his search topic. For the purpose the data collected through testing of each search query (search topic) on all search engine and considering relevant status of top 20 hits of every result list for analysis has been tabulated and exhibited in a single table (Table 1) according to individual query against each search engine. Users described the retrieved result as Relevant (R), Partially Relevant (PR), or Not Relevant (NR) and the results position of these was recorded.

Performance of Search Engines on Individual Query

Table 1: Individual Query Wise Distribution of R, PR, and NR Hits Retrieved by all 6 SEs on all 20 Queries

	Google			Yahoo			Altavista			Rediff			Guruji			Khoj		
Query ID	**R**	**PR**	**NR**	**R**	**PR**	**NR**	**R**	**PR**	**NR**	**R**	**PR**	**NR**	**R**	**PR**	**NR**	**R**	**PR**	**NR**
1	1	2	17	1	5	14	2	4	14	2	11	7	1	3	16	1	5	14
2	3	4	13	3	4	13	0	3	17	1	1	18	0	0	20	1	7	12
3	3	3	14	3	4	13	6	4	10	5	5	10	1	7	12	2	9	9
4	10	2	8	9	4	7	11	4	5	8	7	5	1	4	15	10	4	6
5	2	8	10	3	6	11	2	6	12	2	7	11	0	2	18	2	6	12
6	7	3	10	10	3	7	8	0	12	9	3	8	1	2	17	8	5	7
7	5	7	8	4	8	8	3	7	10	3	7	10	0	0	20	5	5	10
8	2	9	9	1	7	12	1	5	14	1	8	11	0	3	17	3	6	11
9	5	4	11	2	5	13	3	7	10	2	6	12	0	0	20	4	6	10
10	3	5	12	4	4	12	2	6	12	3	10	7	0	1	19	4	7	9
11	1	6	13	2	11	7	1	9	10	1	7	12	0	4	16	2	9	9
12	4	6	10	7	4	9	3	7	10	3	7	10	1	2	17	4	8	8
13	4	3	13	2	3	15	4	2	14	5	4	11	1	6	13	3	6	11
14	5	5	10	2	1	17	7	6	7	5	4	11	0	2	18	5	4	11
15	1	1	18	1	2	17	3	3	14	2	3	15	0	3	17	1	3	16
16	5	4	11	5	6	9	8	10	2	6	5	9	1	0	19	5	5	10
17	2	1	17	0	4	16	1	3	16	1	3	16	1	4	15	1	4	15
18	3	5	12	2	6	12	2	5	13	1	8	11	1	1	18	5	3	12
19	3	3	14	4	4	12	2	4	14	2	3	15	0	3	17	3	3	14
20	3	6	11	1	5	14	4	6	10	2	3	15	1	2	17	1	2	17
Total Hits	**72**	**87**	**241**	**66**	**96**	**238**	**73**	**101**	**226**	**64**	**112**	**224**	**10**	**49**	341	70	107	223

Note : R - Relevant, PR - Partially Relevant, NR - Not Relevant

The above Table shows the consolidated position of Relevant (R), Partially Relevant (PR) and Not Relevant (NR) hits of all 20 queries in all 6 Search Engines. The retrieved documents have been distributed according to individual queries – from Query ID 1 to Query ID 20. Each Query ID gets 120 documents at the rate of 20 per search engine. The total number of hits (20) of individual search engine is also distributed among Relevant, Partially Relevant, and Not Relevant categories. The mention of Not Relevant hits in the calculation helps in determining the measurement of the effectiveness of the search engines in terms of how correctly they retrieve relevant or partially relevant documents and rank and show them in the initial twenty positions of the result list.

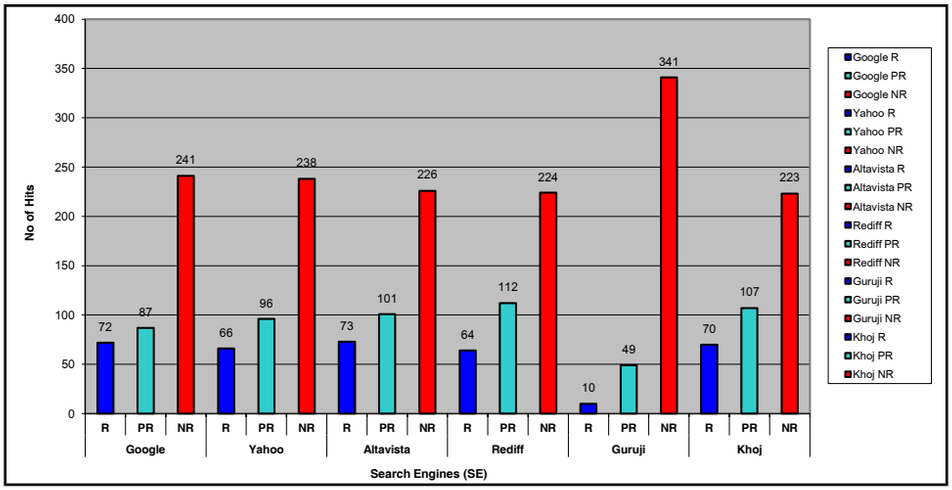


Fig. 1 : Total R, PR, and NR Hits of all search queries

The consolidated data in Table 1 and Fig. 1 indicate that the total Relevant Hits of all search engines except Guruji are with in the range of 60 to 75 hits. The search engine Guruji, which is indigenously developed in India, has shown exceptionally poor result and other two Indian Search Engiens like Rediff and Khoj have done quite well. Moreover, these two Indian search engines are also competing with the international search engines. The Indian search engine Khoj has retrieved 70 Relevant items in total, that is after Google and Altavista with 72 and 73 items respectively. The rest of the search engines have retrieved the relevant documents in the amount like Yahoo with 66 items, Rediff with 64 items and Guruji with 10 documents only.

In case of Partially Relevant information the Indian search engines have retrieved the highest number of documents - Rediff with 112 hits is at the top, and followed by another Indian search engine Khoj with 107 hits. The other search engines are in the sequence of Altavista (101), Yahoo (96), Google (87), and Guruji (49). In the Not Relevant category, obviously, Guruji has the highest number of Not-Relevant items with 341 score and followed by Google (241), Yahoo (238), Altavista (226), Rediff (224) and Khoj (223). If it is counted in reverse order the Indian search engines Rediff and Khoj has retrieved the least number of Not-Relevant items.

Observations: From the above table and graph it is observed that in retrieval of Relevant documents the International search engines have done marginally better than the indigenously developed Indian search engines. But it should not be understood that the Indian search engines are not able to compete with International search engines.

Frequency of a Single SE Retrieving Different Ranges of R Results for a Query

The search engines produce Relevant results in different variations in case of different search queries without indication of any special character in the query structure or syntext. It is obvious for a net searcher to prefer that search engine which produces them more relevant result. Here it is to study who are the search engines show their retrieval effectiveness in more often producing different ranges (50%, 40%, 25%, and 0%) of R results for a query.

Table 2: Comparison of SEs Retrieving 50%, 40%, 25%, and 0% R Results for a Query

	No of queries					
Range of hits / SEs	**Google**	**Yahoo**	**Altavista**	**Rediff**	**Guruji**	**Khoj**
10 (50%) and more R hits	1	1	1	0	0	1
8 (40%) and more R hits	1	2	3	2	0	2
5 (25%) and more R hits	6	4	5	6	0	6
0 (0%) R hits	0	1	1	0	10	0

For any search engine retrieving 50% Relevant hits for a particular query out of the total retrievals studied, really expresses its greatest effectiveness. The frequency of exhibiting this feature for a number of queries will determine

the overall efficiency of the search engine. In this study scoring 50% Relevant hits means 10 out of 20 hits of a search engine on a query. Some search engines in this study have also exhibited this rare feature.

In the Table 2, it noticed that four search engines; Google, Yahoo, Altavista and Khoj have drawn 10 (50%) Relevant hits for 1 query each. The search engines like Rediff and Guruji have not shown any instance of scoring 50% or more relevant results for any of the 20 queries. All SEs except Guruji have scored 8 (40%) and more Relevant hits for 1 to 3 times. Among them Altavista has done it for 3 times, Yahoo, Rediff, and Khoj for 2 times each, and Google for once. Again Guruji has scored 0 (zero), means no instance of retrieval of 8 R hits for any query. Again all SEs except Guruji have scored 5 (25%) and more R hits for 4 to 6 times. Among them Google, Rediff, and Khoj have done it for 6 times each, Altavista for 5 times, and Yahoo for 4 times. Again Guruji has scored 0 (zero) means no instance of retrieval of 5 R hits for any query. In case of 0% relevant hits the search engine Guruji is at top, scoring 10 times 0 R hits for different search queries. Yahoo and Altavista have also scored 0 R hits 1 time each. Google, Rediff, and Khoj have not scored 0 R hits any number of time.

Observations: The researcher observes that the search engine (SE) Guruji is the poorest among all search engines in retrieving Relevant hits in any substantial scale. Though some search engines have shown the unique feature of scoring 10 R hits for a query but no one has shown consistency in this scale of performance. Almost all SEs have done it, but for a particular query that is Query ID 4. This unique score may be due to the matching of the structure of the query with indexed terms of the search engine and search algorithm.

RELEVANT HITS OF INDIVIDUAL QUERIES

The study of Relevant hits is the primary aim of the study. Here efforts have been made to study the number of Relevant hits each query has received in the test and their percentage of differences. Which query is at the top of the list and the order of queries at decreasing rate, is another point of analysis. It is also an objective of the study to verify the effectiveness of the search engines in retrieval of information on different types of search queries.

Relevant result means the documents directly matching to the need of the information searcher. Relevant results are also referred as Relevant Hits, Relevant Materials, Relevant Information. The entire effectiveness of any information retrieval system can be assessed by way of evaluating the relevancy of the retrieved documents by search engines.

The researcher has tried to analyse the retrieval effectiveness of Indian search engines with relation to relevant information from the Internet. Accordingly data has been collected through experiment and analysed hereunder to inference certain conclusion.

Table 3: Relevant Results and Precision % of Individual Query

Query ID	Relevant hit of all SEs	Precision %
1	8	0.33
2	8	0.33
3	**20**	**0.83**
4	**49**	**2.04**
5	11	0.45
6	**43**	**1.79**
7	**20**	**0.83**
8	8	0.33
9	16	0.66
10	16	0.66
11	7	0.29
12	**22**	**0.91**
13	**19**	**0.79**
14	**24**	**1.00**
15	8	0.33
16	**30**	**1.25**
17	6	0.25
18	14	0.58
19	14	0.45
20	12	0.50
Mean %	17.75 (18)	0.73

Note : Precision % *is calculated on the basis of (Sum of R Hits of a query in all SEs / Total Hits* of all queries in all SEs X 100)* * (20 Queries X 20 Hits X 6 SEs =2400 Total Hits)

Table 4: Queries Scored Mean Percentage and Above

	No of queries (Out of total 20 queries)	Percentage (%)
Queries scored mean (0.73) or more	**08**	**40%**

Each query is unique in nature and different search engines have their own search algorithms and search methods. On certain query a search engine may give minimum relevant

results and rank them at the top, whereas another search engine gives a lot of relevant results but rank them at lower positions. Similarly some search engines retrieve no relevant material. This is a complex process while studying the effectiveness of the search engines. All these also depend on the structure of the query and the objectives of the research.

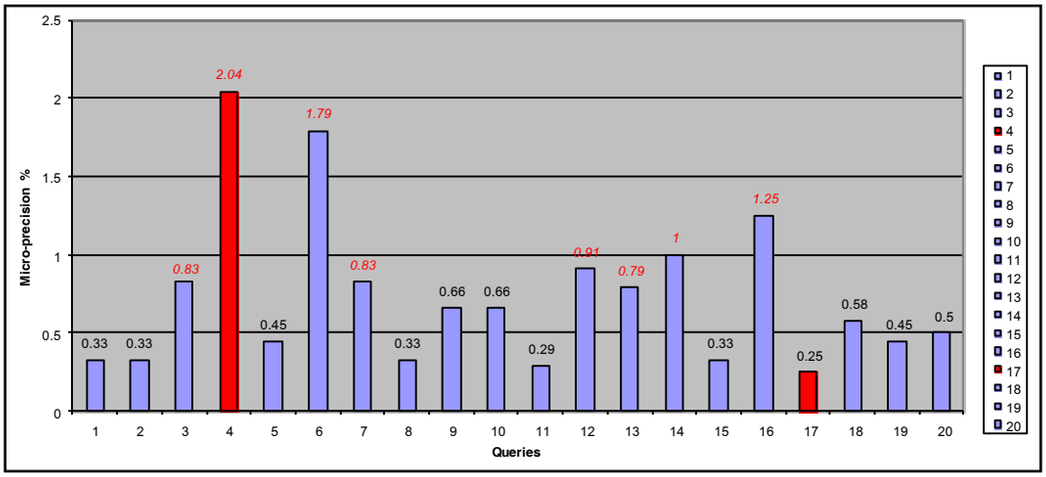


Fig. 2: Precision % of R Hits of Individual Query

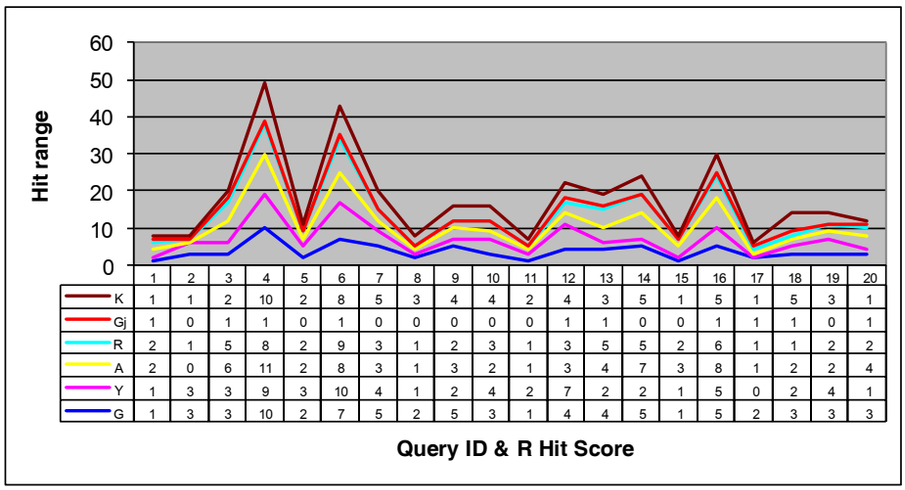
PRECISION ANALYSIS

The over all precision result percentage is very low (Mean 0.73 %), means not even one full Relevant document. On the other hand none of the 20 queries used in the experiment has reached the precision mark of 2.5 %**,** simultaneously it is also not seen as any query touching the precision level of 0 % (Fig. 2). The Query ID 4 in the list of queries has scored the highest precision percentage (2.04%) and the Query ID 17 has scored the least precision percentage (0.25%). The mean percentage of the micro score of all 20 queries is 0.73 % (Table 3), which has been crossed by 08 search queries (values are Italicized in Fig. 2) and the percentage of queries crossed the mean score is 40% (Table 4).

AVERAGE HITS FOR A QUERY

Different search engines retrieve variant number of relevant results on a query at a particular point of time. The present study indicates that a researcher may get 18 numbers of relevant results (Table 3), on an average, on the topic of his research, in case he uses 6 search engines and evaluate top 20 results of each search engine.

EFFECTIVENESS OF INDIVIDUAL SE ON INDIVIDUAL QUERY



K = Khoj, Gj = Guruji, R = Rediff, A = Altavista, Y =Yahoo, G = Google

Fig. 3: Relevant Hits by Individual Search Engine on Individual Query

In Fig. 3 it is seen that no search engine has retrieved uniform number of Relevant Hits for all twenty queries. The number of retrieval of Relevant Hits varies from one query to other as seen in the figure the ups and downs of the graphs representing different search engines. In case of some search queries like Query ID 4 all search engines have retrieved good number of Relevant results (49), particularly Google, Altavista, and Khoj have retrieved more than 10 Relevant documents each. On the other hand, for the query ID 17 the performance of these search engines is very poor, retrieveing only 06 Relevant results on average 01 each. There is a significant variation in the retrieval results of individual search engine on all queries. In over all performance of all search engines on all queries is also identical. There is no uniformity in precision value of Relevant results for all queries. On some queries the result is excellent whereas in other cases it is very poor.

Observations: From the above precision analysis it is observed that no search query has shown unusual result at both highest and lowest points of relevancy. A researcher can obtain at least some relevant information for his research purpose if he goes on trying to find out information in the Internet by using different search engines. The top twenty results of any search engine cover the relevant materials that can satisfy any researcher. Further it is observed that for a researcher the average number of 18 retrieved relevant documents would be sufficient for his research, although the present study does not cover the overlapping of results in different search engines. Finally, the 40% (Table 4) indicates the strength of Indian search engines to deal with different verities of search queries.

PARTIALLY RELEVANT HITS OF INDIVIDUAL QUERIES

The relevant results are always directly useful for the researcher for their research works. All retrieved materials by any search engine cannot be at the level of usefulness of the relevant documents. Still there are some materials in the result list belonging neither to the Relevant category nor to Not-Relevant category. They have some inkling with the topic searched for. So the researcher categorized them as 'Not Relevant' documents. Although their precision value cannot be construed as of Relevant documents but whatever amount of relevancy do they have that can be evaluated in the line of precision evaluation.

Table 5: Precision % of PR Hits of Individual Query

Query ID	PR hits	Precision %
1	30	**1.25**
2	19	0.79
3	32	**1.33**
4	25	1.04
5	29	1.20
6	16	0.66
7	34	**1.41**
8	38	**1.58**
9	28	**1.16**
10	33	**1.37**
11	46	**1.91**
12	34	**1.41**
13	24	1.00
14	22	0.91
15	15	0.62
16	30	**1.25**
17	10	0.41
18	28	**1.66**
19	20	0.83
20	24	1.00
Mean	**26.85 (27)**	**1.13%**

Table 6: Queries Scored Mean Percentage and Above

	No of queries (Out of total 20 queries)	Percentage (%)
Queries scored mean (1.13%) or more	10	50%

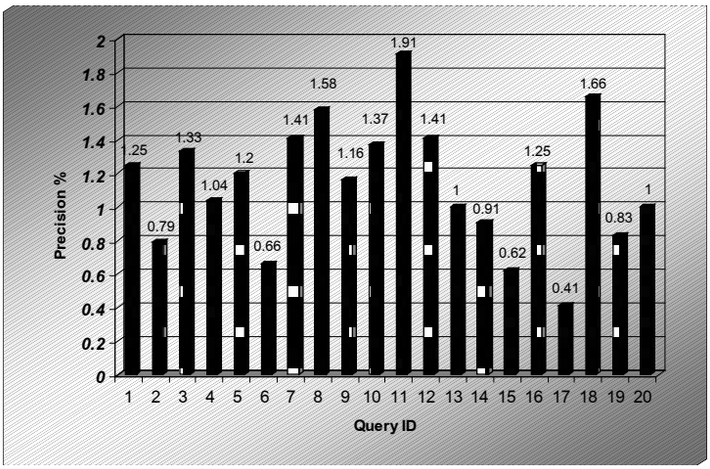


Fig. 4: Precision % of PR Hits of Individual Query

The Fig. 4 indicates that the Precision point of 2.00 % has not been touched by any of the search queries. On the other hand every search query has scored more than 0.4 % but less than 2.00 % of Partial Relevance level. There are 12 queries out of 20 that have scored more than 1.00 % PR level and rest queries are below this level. The Query ID 11 has the highest score of relevancy (1.91 %) and the Query ID 17 has the lowest score (0.41 %). Almost all queries except 4 have performed partially relevant scores between the range from 0.5 % to 1.5 % of the table. The average of the partially relevant scores of all twenty queries is 1.13 %, which divides the queries in the equal ratio of 10:10.

Observations: The search engines retrieve very good quantity of documents of partially relevant on each query for the researchers. The Indian search engines are very effective in retrieving nearly relevant documents in comparison to international search engines.

Failure Analysis of Search Engines on Individual Queries

The documents rejected by the researchers from the retrieval result list during the test are considered as 'Not Relevant' ones. These documents are worthless to be evaluated from relevancy point of view, as they don't contain any material for use in the research. But they give a great help while finding out the precision value of the relevant results. The total hit of any query comprises of Relevant hits, Partially Relevant hits and Not Relevant hits. Here the researcher tried to analyse the queries on the basis of score of NR documents without taking into account the relevancy factor. So the figure below (Fig. 5) is not based on the number of Not Relevant hits.

From the Fig. 5 the NR hits of all queries are distributed between 45 to 100 range of hits. 13 queries have scored NR hits more than 45 and less than 80 number of hits. The query ID 15 has the highest (97) number of NR hits and the Query ID 4 has the least (46) number of NR hits among all queries.

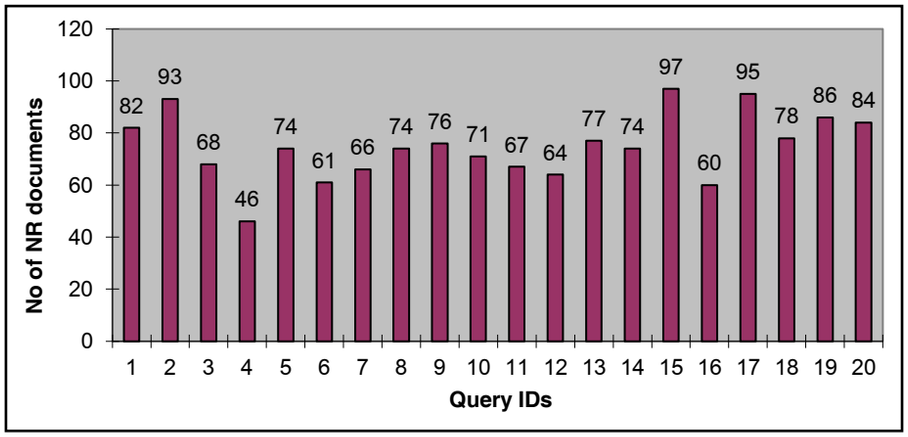


Fig. 5: Distribution NR Hits of All Queries

FINDINGS

The major findings of the study are:

The secrets of retrieval mechanism used by different search engines are proprietary, so it becomes difficult to compare those features. The comparative degrees of effective retrieval indicate the strength of retrieval mechanism of individual search engine. All six search engines studied in this research except the Indian search engine Guruji, have performed almost at equal level while retrieving Relevant documents from Internet.

The evidences of substantial difference in the partial relevant results are seen in all search queries, at all hit points and in all hit ranges of the result list, in individual search engine contributions as well as in group search engine contributions.

It was also intended in the study to see the group effectiveness of search engines. In the result it was observed that in the 'International search engines' group all search engines (Google, Yahoo, and Altavista) have performed well, whereas in 'indigenous Indian search engines' group the performance of Rediff and Khoj is up to the level of international search engines but the performance of Guruji is comparatively very poor. In over all comparison, the International search engines are found more effective than indigenous Indian search engines.

The retrieval effectiveness of search engines is gradually growing with the passage of time. The precision values of all 20 results have been increased more than the values found out in previous studies. The precision values found in the present study are within the range from 0.41% to 1.37%, which is far more than the result of the previous study done by Lewandowski in 2008 (i.e. 0.37 to 0.52 %). The increasing efficiency may be for the reason of gradual modifications in the retrieval techniques of search engines or the developments in the searching skill of the Internet searcher.

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