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TASK TRAIL APPROACH FOR RECOMMENDATION AND PREDICTION OF USER SEARCH GOALS

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ABSTRACT

Web log records all the search queries and related actions of a user in search engines. Task trail is introduced which is used to understand user search behaviors. A task trail contains all user activities inside the particular task, such as query reformulations, representation of clicks. The goal is to obtain more exact information about the search of the user. Instead of using session trails or query trails, Task trails can be used to determine the user search behavior much more efficiently and effectively. In this paper query similarity is identified and new clustering algorithm bounded Spread method is used to group similar queries into task. As a result, task trails a new way to segment search logs and an additional information source to session and query trails. Moreover, propose a system intend log likelihood ratio method to suggest related queries to the user.

Keywords: Task Trail, Query Suggestion, Log Likelihood Ratio And Clustering.

I. INTRODUCTION

Web users use one of their most popular tool search engines to find desired information. All search queries and related actions of a user on internet to find desired information are record in web search log. Web search logs can be classified into two types such as Search logs and Browse logs. Search logs record the interaction details between search engines and users which are collected from search engines. These details contain queries given to search engines, search results returned to users, and clicks made by users. Browse logs are usually collected from client-side browser plugins or proxies of internet service providers. These contain all URLs visited by users, irrespective of search engines and web servers. Search logs can be used in the following search applications: user satisfaction analysis, page utility estimation, user search interest prediction, query suggestion, web page re-ranking, web site recommendation, etc. Previous work of web search logs is analyzed at session or query level. Few of them considered task level for analyzing search logs. Here we call the task level search log analysis as task trail. Likewise session and query level analysis called as session trail and query trail respectively. Web logs comprise a set of users, and each user has a sequence of sequential behaviors e1,e1,……em where each ei can be a search behavior or browse behavior. A search behavior means a single query given to search engine.

A browse behavior contains one of the following activities.

- User starts to surf from the homepage of the browser;
- User types a URL address in the browser;
- User pastes the URL address from other place into browser;
- User clicks a bookmark or favorite page in the browser;
- User clicks the “back” or “forward” button in the browser;
- User clicks an anchor link or a search result.

A query trail q denoted by a sequence of user behaviors eq1,eq2,……eqm of user u, starting from a query and ending with another query. It consists of a query result page, a clicked page & destination page. For example in Table 1.

URLshttp://www.amazon.com/KindleeBooks/b?ie=UTF8\&node=1286228011and“http://astore.amazon.com /A mazon.Kindle.Books.Store.-20/” belongs to the query trail starting from query “Amazon kindle books”. A session trail s is denoted by a sequence of user behaviors:e_1^s,e_2^s,…e_k^s of one user u, the user behavior are successive in search logs and any two successive behaviors ei,ei+1occurred within time threshold Θ. The session contains the chronological order of user behavior in search logs. The complete search logs of one user can be segmented into different sessions along the time dimensions. A task trail t is a sequence of user behaviors et1,et2,……etv of user u within one session.

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Table 1. A Sample session from web search logs.

Sr. No.	Time	Event	Value	Task
1	05:03:26	Query	Gmail	1
2	05:03:39	Click	www.gmail.com	1
3	05:06:34	Query	Facebook	2
4	05:06:59	Query	Amazon	3
5	05:07:48	Query	gmail log in	1
6	05:08:02	Click	Mail.google.com/mail	1
7	05:10:23	Query	Facebook	2
8	05:10:31	Click	www.Facebook.com	2
9	05:15:39	Query	Amazon kindle books	3
10	05:15:47	Click	Amazon.com/kindle-e-Books…	3
11	05:15:59	Click	Astore.amazon.com/Amazon…	3

This session contains 3 different search tasks: Gmail, Amazon Kindle Books, and Facebook. The user began this session with query “Gmail” and finished the session with several attempts to search for kindle-e-books. The “Gmail” task is interleaved with the “Facebook” task.

The reasons behind this different task are:

(1) Web search logs are ordered chronologically;

(2) Users often open multiple tabs or browsers and conduct concurrent tasks.

Treating the whole session as an atomic unit cannot reflect the details of multi- tasking. In Table 1 show that, query “Gmail log in” has no correlation with its adjacent queries. Besides searching for “Amazon kindle books“does not mean that the user did not find useful information for query “Facebook”. On the other hand, dividing sessions at query level may lose information of reformulation by users. For example, in table, even if the user had no click on query “Amazon”, then still managed to find relevant information by reformulating “Amazon” into “Amazon kindle books” and made a click. The query level analysis is the finest grained, but fails to capture the interleave relationships between tasks and the generalization/specification/refinement relationships between adjacent queries within the same task. Statistically, find about 30% of sessions contains multiple tasks and about 5% of sessions contain interleaved tasks. Thus, comes upon task level log analysis, a good balance between details of user behaviors and relationships between queries. Here, we compare task, session, and query trails for search application: determining user satisfaction. Implicit feedback signals such as clicks, dwell time and success scores in a hidden Markov model are mined to measure user satisfaction and page utility. Experimental result show the advantage of using task trails for these application.

The rest of the paper is organized as follows, Insection 2, explain the brief survey of latest years papers which are very relevant to proposed work are studied and mention the summary of their work. About motivation is highlighted in section 3. The proposed system design is described in section 4. In section 5, presented data tables for the results obtained and also discussed the possible outcome of the system in terms of accuracy. Finally conclusion and future enhancement is covered in section 6.

II. RELATED WORK

In the literature review, a detail study of relevant work done so far is discussed and also different technique used for implementation. Finally issues and future scope left behind for the different authors from their papers are highlighted. Following are the papers referred for literature survey.

In [1] used K Paths algorithm to give the results on user behavior. The similarity calculation formula used to give the sorted results. Also to measure clustering accuracy NMI used. An experimental result shows that using this technique they improve the clustering accuracy. The clustering threshold and number of iterations also

affect Clustering accuracy. The experiment to validate the effectiveness of the KPathsim algorithm in the digital reference and library project data set (Digital Bibliography & Library Project, DBLP).

In [2] work is carried out to improve the search engine performance and to save user searching time. The Improved Page Rank algorithm used. Cheating similarity and cheating relevance are two factors added to revise the original Page Rank value. White list and blacklist are used to improve the method. Methods based on white list hold the idea that good sites usually link to good sites. Methods based on blacklist think spam pages usually link to spam pages. Experimental effects had verified that it was a better link-based anti-spam performance than Trust Rank algorithm and Bad Rank algorithm.

In [3] web pages are ranked using search engine transaction logs. After that results are sorted according to topic, relevant and the documents that are essentials are at the top of the results. Panda algorithm used, in which web pages of all URLs are clustered. To cluster the URLs query clustering tool used, before that similarity analyzer tool used to calculate similarity between URLS. Merge sort algorithm used to find the relevancy among URLS. Generalized Sequential Pattern (GSP) algorithm is applied on to the re-ranked web pages for each query in clusters to catch the repeatedly used sequential patterns. Combined use of this algorithm shows that the most relevant information on the top of the position.

In [4] works on query suggestion. Proposed QuSRWTC Method uses random walk and topic concepts. Query suggestions are taken from other mature search engines, because of that suggestions are extra comprehensives. The used topic concepts are used to restructure the queries because of this query suggestion is very correct. An experimental result shows the results show the result of QuS-RWTC and QuS-RW systems. The NDCG values of QuS-RWTC is greater than the values of QuS-RW. This demonstrates that the methods of topic concept extraction and resorting are significant and beneficial to recommend exact query.

In [5] query suggestion technique which takes the benefits of user click history. In query processing, from user query, their information store in user log and collect the matched documents from a search engine database. After that, using interest calculation algorithm interest weight is computed. Queries are clustered by calculating the similarities between them. Finally, they compare their proposed system with the popular search engine.

In [6-13], Getting back to previously viewed web pages is a common yet uneasy task for users due to the large volume of personally accessed information on the web. This paper leverages human's natural recall process of using episodic and semantic memory cues to facilitate recall, and presents a personal web revisitation technique called WebPagePrev through context and content keywords. Underlying techniques for context and content memories' acquisition, storage, decay, and utilization for page re-finding are discussed. A relevance feedback mechanism is also involved to tailor to individual's memory strength and revisitation habits. Among time, location, and activity context factors in Web Page Prev, activity is the best recall cue, and context content based re-finding delivers the best performance, compared to context based re-finding and content based re-finding.

In [14-20] main focus on to resolve the term mismatch problem with query expansion. Suggest QECK technique base on Rocchio's model. First pass retrieval, word selection and second pas retrieval are the three steps included in the method. Experimental results shows that the effectiveness of QECK and evaluate the effectiveness for refining the performance of code search algorithms, and explore the enactment of QECK Rocchio. Exactly, the first code search algorithm is BM25 founded information retrieval method on Lucene, which is denoted as IR in the first experiment. The second is Portfolio grounded on Vector Space Model (VSM), Page Rank, and Spreading Activation Network (SAN). The next is VF based on VSM and the frequent item-set mining.

In [21-30] studied the tradeoff between exploration and exploitation in interactive information retrieval. Several user queries need a more various set of results for additional important relevance feedback. That is why, the authors collect traditional relevance scoring (exploitation) of a file with a novelty score (exploration), with novelty representing a document's similarity to all higher-ranking documents. So adapt this approach to get additional utility from feedback. Binxing Fang et al. [31-35] search engines must make completely innovative, revolutionary changes for the next generation of search, which is referred to as "big search". This paper first studies the development needs of big search. Then, big search is defined, and the 5S properties (Sourcing, Sensing, Synthesizing, Solution, and Security) of big search, which are different from those of

traditional search engines, are elaborated. Also, the paper provides system architecture for big search, explores the key technologies that support the 5S properties, and describes potential application fields of big search technology OmkarTodkar et al. [36-38] used one click feedback system for mapping user search goals. Analysis of search logs helps in discovering search goals for ambiguous queries, for which proposed system clusters feedback sessions. One click of user in been incorporated to generated Feedback sessions that present information been searched by user. Pseudo- text documents are created to sessions grouping. Enhanced k-means cluster is been incorporated to reduce searching time generating dynamic clusters. Inverted Indexing is been used in supervised manner to classify information from web and create classes of objects. To evaluation of this research has been done on Mean average precision (MAP) cumulative average precision (CAP),Voted average precision (VAP) along with user feedback as evaluation method. In [39-40] user search goal is identified using feedback session. Frequent and sequential patterns are analyzed. Using semantic clustering algorithm documents is clustered. Numbers of clusters are created on demand; they are not created by the user that is why the documents made by this technique are different. And the clustering algorithm is NP-Complete. Febna V, and Anish Abraham[41-42] a variant of feedback session method for inferring user search goals, where bag of words approach is employed for representation. K-Medoid clustering algorithm is used to derive the cluster for the keywords entered by the user. The performance improvement can be evaluated by using evaluation measures like Average Precision (AP), Voted Average Precision (VAP) and Classified Average Precision (CAP).

In [43-45] location-aware keyword query suggestion method used in which relevant documents near the user location are retrieved. Partition-based algorithm (PA) which calculates the totals of the candidate keyword queries at the partition level and uses an ideal tool to greatly decrease the computational cost. Baseline algorithm for location aware suggestions. Weighted keyword-document graph, takes the semantic relevance between keyword queries and the spatial distance between the resulting documents and the user place. The graph formed in a random-walk-with-restart fashion, to choice the keyword queries with the maximum scores as suggestions. An overall analysis of all papers gives possible issues and difficulties in the papers and how to correct out in proposed system is elaborated in detail.

In [46-50], aim at discovering the number of diverse user search goals for a query and depicting each goal with some keywords automatically. Propose a novel approach to infer user search goals for a query by clustering feedback sessions. Optimization method used to map feedback sessions to pseudo-documents which can efficiently reflect user information needs. At last, cluster these pseudo-documents to infer user search goal. Xiang et al. [51-54], projected many context-aware ranking principles by promoting or demoting web pages supported relationship of adjacent query pairs among a session. Moreover, they tend to adopt a learning-to-rank approach and integrate the ranking principles into a state-of-the-art ranking model by encoding the context data as features of the model.

In [55-65], study interleaving in additional detail, comparison it with traditional measures in terms of reliableness, sensitivity and agreement. To detect very little variations in retrieval effectiveness, a reliable outcome with standard metrics needs regarding 5,000 judged queries, and this can be regarding as reliable as interleaving with 50,000 user impressions. Amongst the standard measures, Normalized Discounted cumulative Gain (NDCG) has the strongest correlation with interleaving [66-70]. From the above survey discussion we observed that only few work is being done on this topic and also we studied the issues and future scope of few papers. Hence fourth this topic is open for continuing the further research work.

III. PROPOSED ARCHITECTURE

The proposed system works by understanding the query logs to have an insight into the users information requirements in a refined way and will result relevant information at topmost position of the result list. The main feature of this architecture is task trail based bounded spread algorithm used to identify the task and find user search goal means to find relevant documents according to his interest. At the end log likelihood ratio method used to suggest related queries to user. The new recommended architecture of user search goal method is displayed in fig. 1, which comprises of finding user goal using task trail.

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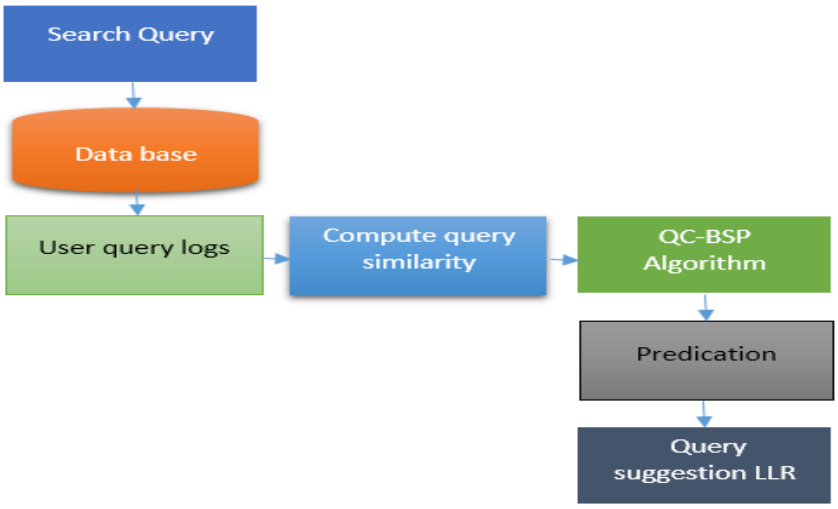

Fig 1: Proposed system architecture.

3.1 Suggest related queries using log likelihood ratio

Task trail is use to understand user search behavior. Task is nothing but the log segmentation unit, which indirectly represent the user goal. When query is searched by task trail, (QC-BSP) query clustering bounded spread algorithm use. Using this algorithm, similar queries are grouped into same task and finally the results are found. Query similarity is checked by using jaro function.

The algorithm steps are:

Input: Set of query Q, cut –off threshold b, bounded length bl;

Output: Documents for queries.

Initialization: Θ=ϕ; Query to task table L=ϕ; M=ϕ;

Steps:

Start

Step 1: cid =0; // initialize same queries to one task

Step 2: for len=1 $|Q|$ -1 do

Step 3: for i=1: $|Q|$ - len do

Step 4: if M [Q^i] exists then

Step 5: add Q^i into Θ (M [Q^i]);

else

M [Q^i] = cid++;

Step 6: if |Θ| = 1 return Θ;

Step 7: for len = 1: bl do

Step 8: for i=1: $|Q|$ - len do

Step 9: if L [Q^i] $\neq$ L [Q^{i+len}] then

s $\leftarrow$ sim (L [Q^i], L [Q^{i+len}]);

Step 10: if s $\geq$ b then

merge T (Q^i) and T (Q^{i+len});

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modify L;

Step 11: if |Θ] = 1 break;

Step 12: return Θ;

End

The bounded length can be 3, 5 or 10 and sometimes user search the same query after so many queries, in that case it is very time consuming to check that queries. Hence bounded length is very useful. Using bounded length can check the queries within bound.

3.2 Suggesting related queries using log likelihood ratio (LLR)

Related query suggestion is very vital for search engines. Users could find essential information more rapidly and correctly with the support of query suggestions, which could significantly increase users' search experience. Thus, suggested related queries have become a research hotspot in the field of the search engine.

The LLR is calculated as:-2 ln ⅄,Where, $⅄=max_p$ L $(H_1)/\ max_{p_{1,p_2}}$ L (H_2)

Suppose two queries are given q_1 andq_2.

The null hypothesis H_1: Pr $(q_2|q_1)$ =Pr $(q_2|\ \neg q_1) = p_1$

The alternative hypothesis H_2: Pr $(q_2|q_1) \neq$ Pr $(q_2|\ \neg q_1) = p_2$

IV. DATASET DESCRIPTION

For the evaluation of the system, proposed system use query information taken from Google and stored required information into our local database. The dataset contains query information like URL title, description and web site, image. When user search any query, evaluation is performed by applying both techniques feedback session and task trail. Table 2 shows the query information that is used for analysis. The title shows the title of the query; snippet is short description of the query.

Table 2. Query information.

Sr. No.	Title	Snippet	Web URL
1	Java programming language	Java is a general-purpose computer programming lan.	https://en.wikipedia.org/wiki/Java_(programming_la...
2	Java Tutorial	Java Tutorial or Core Java Tutorial or Java Program...	https://www.javatpoint.com/java-tutorial
3	Java	Java is a general purpose high-level programming l...	Java is a general purpose high-level programming l...
4	MATLAB	MATLAB is a multi-paradigm numerical computing env...	https://en.wikipedia.org/wiki/MATLAB
5	Matrix	In mathematics, a matrix plural matrices is a rect...	https://en.wikipedia.org/wiki/Matrix_(mathematics)
6	Earth	Earth is the only planet whose English name does n..	http://www.nineplanets.org/earth
7	Earth system	Earth system science (ESS) is the application of s...	https://en.wikipedia.org/wiki/Earth_system_science
8	Popular Indian Feativals	Diwali,Ganesh Chaturthi,Holi,Navaratri, Dussehra,	https://www.tripsavvy.com
9	Festival of Buddhism	Wesak. This most important Buddhist festival is kn..	https://www.bbc.co.uk/religion/religions/buddhism/...

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V. EXPERIMENT AND RESULT ANALYSIS

In this section only five queries are taken as input and the test data has ten queries such as query one to query ten. Using two different techniques we calculate the search results for five queries. The test data are given below:

Test data:

Query1: Java

Query2: Data mining algorithm

Query3: Latest cars in 2021

Query4: Sun news

Query5: Homemade items

5.1 Relevant and retrieved documents analysis for task trail technique

The queries are searched using task trail technique. Table 3 shows the retrieved and relevant documents results. For "Java", relevant and retrieved documents are 3, 3. For query "Data mining algorithm", retrieved documents are 8 and relevant are 5. Similarly for all remaining queries relevant and retrieved documents are shown. Graphical representations of relevant and retrieved documents are shown in fig. 2.

Table 3. Retrieve and relevant documents for task trail.

Sr. No.	Query	Retrieved Documents	Relevant Documents
1	Java	3	3
2	Data mining algorithm	8	5
3	Latest cars in 2017	5	1
4	Sun news	5	2
5	Homemade items	9	5

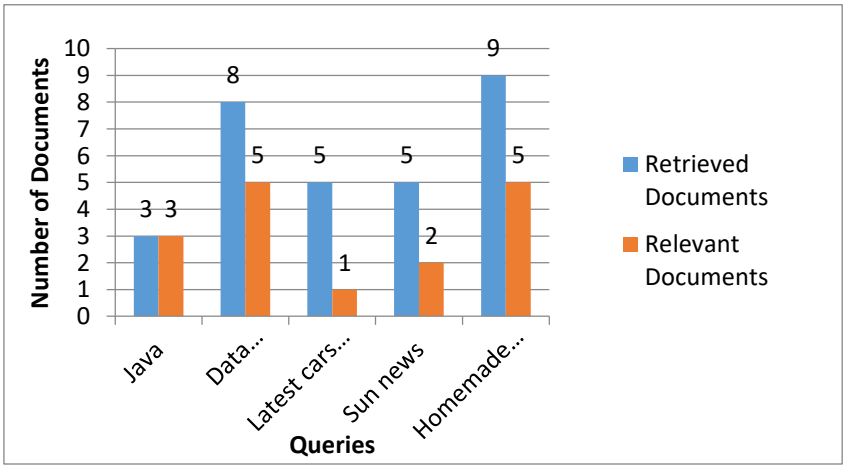

Fig 2: Relevant and retrieved documents for task trail.

The queries are on x-axis and a number of documents on y-axis. For "Java", 3 documents are retrieved and 3 documents are relevant.

5.2 Time to retrieve documents for task trail technique

Here we calculated the time to retrieve documents for each task and the total time required for execution is,

$$T = E_T - S_T$$

Where, S_T represents the execution start time

E_T represents the execution end time

The readings of time in milliseconds (ms) required for all 5 queries are shown in table 4.

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Table 4. Time to retrieve documents.

Sr. No.	Query	Retrieve Time(milliseconds)
1	Java	560
2	Data mining algorithm	578
3	Latest cars in 2017	282
4	Sun news	345
5	Homemade items	654

The time required to retrieve the documents for query "Java" is 560 ms. The results on user click-through logs demonstrate the effectiveness of the approach.

5.3 Recall analysis for task trail

Recall measure use to measure how relevant documents are retrieved in search. Recall can be calculated by using formula:

$$\text{Recall} = \frac{\{relevant\ documents\} \cap \{retrieved\ documents\}}{relevant\ documents}$$

The recall values for 5 queries are given in table 5.The readings in this table shows that proposed task trail gives best performance. Graphical representation of readings is shown in fig.3.

The queries on x-axis and recall values on y-axis.

Table 5. Recall analysis of task trail

Sr. No.	Query	Recall for Task trail
1	Java	1
2	Data mining algorithm	0.83
3	Latest cars in 2017	1
4	Sun news	1
5	Homemade items	0.5

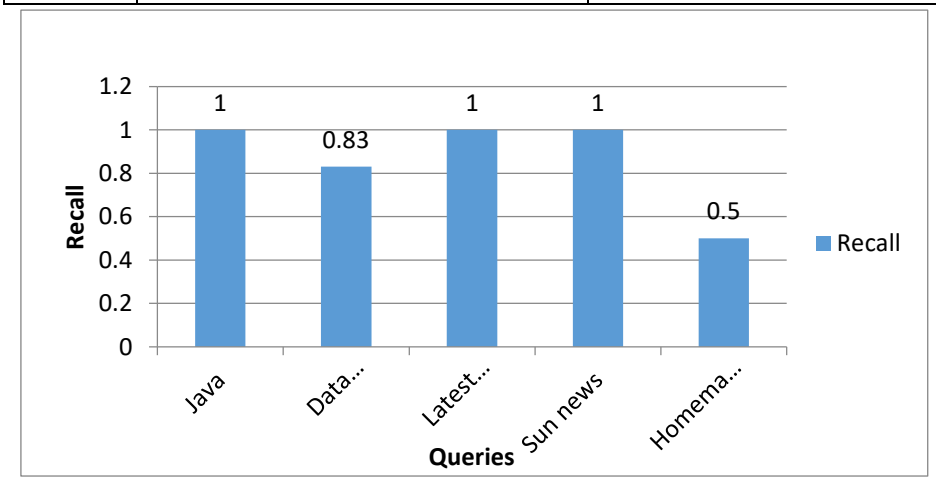

Fig 3: Recall values of each queries.

5.4 Precision analysis

The precision measure use to measure how retrieval documents are relevant in search. Precision can be calculated by using formula,

$$\text{Precision} = \frac{\{relevant\ documents\} \cap \{retrieved\ documents\}}{retrieved\ documents}$$

The precision values for 5 queries are given below in table 6. The readings in this table shows that proposed task trail gives better performance as compare to feedback session. The graphical representation of readings is shown in fig.4.

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Table 6. Precision analysis of task trail.

Sr. No.	Query	Precision for Task Trail
1	Java	1
2	Data mining algorithm	0.83
3	Latest cars in 2017	0.2
4	Sun news	0.44
5	Homemade items	0.78

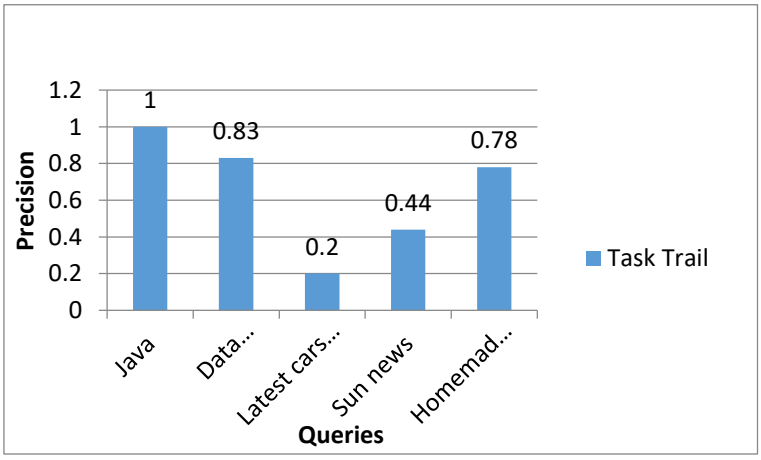

Fig 4: Precision values of each queries..

5.5 Suggested related queries

The log likelihood technique is used to suggest related queries. Table 7 shows the related queries to the user according to query given to search. For query "Home decor", the related queries are "Home decorative items", "Handmade home crafts" and "Decorative items made at home". Similarly for other queries related queries are suggested.

Table 7. Related queries.

Sr. No.	Query	Related Queries
1	Home décor	Home decorative items, Homemade items, Decorative items made at home, Handmade home craft
2	Earth system	Earth
3	Sun news	Sun, The sun-history, sun newspaper
4	Songs of Mars Bruno	Mars Bruno songs, Mars history
5	Car	Car basic information, Latest cars in 2017, upcoming cars in India

5.6 Accuracy analysis

The accuracy analysis gives the how system is correct in finding the relevant results. In the table 8 listed accuracy value for each query using task trail technique and also calculated the accuracy of the system based on relevant document. The accuracy for "Java" is 75% and similarly earth system, Sun news, Songs of Mars Bruno and Car is shown. Finally average accuracy for task trail is calculated and is found to be 89.2%.

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Table 8. Accuracy of task trail technique.

Sr. No.	Query	Accuracy of Task Trail
1	Java	75 %
2	Earth system	83 %
3	Sun news	100 %
4	Songs of Mars Bruno	100 %
5	Car	88 %
Average Accuracy		89.2%

VI. CONCLUSION

This paper is focused on resolving the ambiguity of query terms and find accurate information immediately. The proposed Task Trail uses Bounded Spread algorithm which provides user the required results fast. Also task level analysis provides better understanding of user's goal. Provides query suggestion as a complementary outcomes to the user.

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