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Prediction of the Next Question for the Question Answering System

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ABSTRACT

User profiling, one of the main issue faced while implementing the efficient question answering system, in which the user profile is made, containing the data posed by the user, capturing their domain of interest. The paper presents the method of predicting the next related questions to the first initial question provided by the user to the question answering search engine. A novel approach of the association rule mining is highlighted in which the information is extracted from the log of the previously submitted questions to the question answering search engine, using algorithms for mining association rules and predicts the set of next questions that the user will provide to the system in the next session. Using this approach, the question answering system keeps the relevant answers of the next questions in the repository for providing a speedy response to the user and thus increasing the efficiency of the system.

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1. INTRODUCTION

Search engine is an information retrieval system designed to minimize the time required to find information over the vast Web. Now a days, the capability of the search engine has increased to a great extent. Rather than returning the results in the form of links of web pages, the result to the query is returned in the form of text, which describes the accurate answer to the query. Thus the search engines are advancing towards this question answering search engine.

Question answering is a computer science discipline within the fields of information retrieval and natural language processing. It is concerned with building systems that automatically answer questions which are posed in the natural language by the user. There are two types of domains of question answering-Closed domain question answering deals with question asked from a specific domain. Open domain question answering deals with questions about nearly anything, and can only rely on general ontologies and world knowledge.

There are various components of question answering system: Question processing module analyze, classify question type, and process the question by creating appropriate representation required for other modules. Another module is IR Engine uses keyword based approach to retrieve accurate results of a submitted query and to rank those results. Document processing module includes paragraph filtering which reduce the number of documents by finding relevant documents that contain question keywords in a neighbouring paragraphs, and do the paragraph ordering to rank the paragraphs in order to obtain the correct answer. Answer processing module is responsible for identifying, extracting and ranking answers from the set of ordered paragraphs passed to it from the document processing module.

1.1. Need for Question Answering System

It is true that, search engines and Question Answering (QA) systems differ in design, objectives and processes. Search engine is designed to deliver documents from a query, a QA system is designed to deliver the exact answer to a question.

There are differences of 3 key features in both search engines and question answering systems:

a. Query mode: QA systems make use of natural language i.e. questions are written in natural language by the user. On the other hand, search engine, query is written using Boolean operators.
b. Results form: The second difference concerns what is delivered to the user. Question Answering systems deliver one or more exact answers to a question and their context whereas search engines return links of the web pages which contains the relevant information of the query.
c. Updation: Usually QA systems use databases with low update rate i.e. which are not frequently updated, while search engines are tuned to the Web queries and their reference file are continuously updated.

1.2. Various Issues in Question Answering System

There are various issues which are faced , the following are some which our proposed system tried to overcome:

a. Context and QA:
   Questions are usually asked within a context and answers are provided within that specific context. The context can be used to clarify a question, resolve ambiguities or keep track of an investigation performed through a series of questions.
b. Answer extraction:
   Answer extraction depends on various factors:
   1. The complexity of the question,
   2. On the answer type provided by question processing,
   3. On the actual data where the answer is searched,
   4. On the search method and
   5. On the question focus and context.

c. User profiling for QA:

The user profile captures data about the questioner, comprising context data, domain of interest, reasoning schemes frequently used by the questioner, common ground established within different dialogues between the system and the user, and so forth.

This paper has been organized in following sections: Section 2 highlights the proposed research method, Section 3 describes the snapshots of the results of experimental evaluation and analysis done, Section 4 concludes the discussion.

2. RESEARCH METHOD

Question Prediction is one of the essential ingredient of a user oriented question answering system. It tries to predict the next questions, given the initial question to the system. It can be predicted using many data mining techniques.

The paper proposes a novel approach keeping into account the purpose of Question Answering Search Engines and encountering the issues they have. The approach discussed uses association rule mining to predict the next questions that the user may provide to the question answering search engine. The proposed system of question prediction is divided into two modules:

1. Modules in Question Answering System
2. Modules used in data mining approach on question answering system

The proposed architecture of the Prediction of the Next Question in the Question Answering System is shown below:

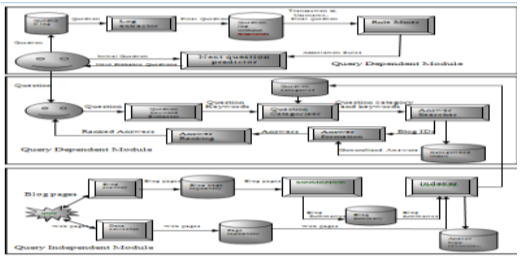


Figure 1. Architecture of the Proposed Question Answering System

The components used in the architecture are described below:
1. Modules in Question Answering System
a. Blog Crawler

Blog Crawler is a Web crawler that works only on blog pages or blog posts which are written by individuals. These pages are necessary to get the individual views about a topic. The idea is to crawl those pages and select the most relevant out of them.

b. Blog Summarization module

Blog summarization is a module used to summarize every blog pages that are given to it after crawling and indexing. It is a big process and is done through a series of steps. In this paper, PMI (Point Wise Mutual Information) is used as a foundation for computing the summary.

The following are the steps followed:

1) Break all the text into different sentences separated by a dot.
2) Removing the stop words (the most frequent words) for further processing.
3) Applying Stemming and Lemmatization for better processing of the sentence. These two steps are taken to avoid unnecessary process in doing repeated or unimportant words.
4) Cutting down the whole sentence into words. This will provide the foundation to calculate PMI which is calculated using two words.
5) Calculate PMI for every two adjacent words (1,2, and 2,3 and ….. I,i+1) as PMI (w1,w2) = count (w1+w2) / (count(w1)* count(w2))
6) Calculate TPMI (Total PMI) of a sentence as sum of PMI's of its adjacent words.
7) Finally the summary is obtained by calculating the total PMI's of all sentences and then arranging the sentences in descending order of them.

c. Blog Indexing Module

Search engine indexing is the process of a search engine collecting, parses and stores data for use by the search engine. The actual search engine index is the place where all the data the search engine has collected is stored.

d. Relevant Information Extractor

This module is a way of getting relevant information from various data sources like Wikipedia and dictionary.com. These websites provides lots and lots of information about data. That is why they were selected as the source.

e. Question Categorization Module

Table 1. Question type Categorization

CATEGORY	TYPES OUESTIONS
Abbreviation	What
Reason	Why
Definitions	What, who
Weight	What
Size	What
Terms	Which, what
Period	Which, when
State	Where, which
Event	When, which

This work was started on the basis of question categorization in different categories like why, what, how, who, when and which. In every category, a list was made to identify which entities lie in what group. The reason behind dividing questions in categories or defining operations that can be performed in various categories is to ease the implementation as well as to answer every question in a correct format.

2. Modules Used in Data Mining Approach on Question Answering System
a. Admin Module
1) Maintaining the Question Log of the user

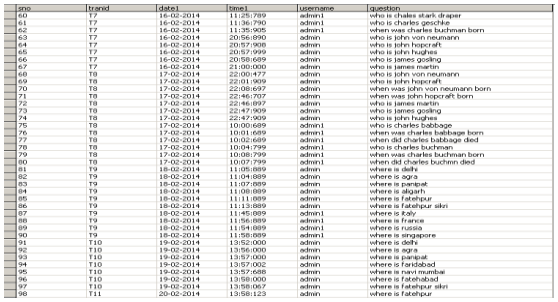
A search log is an electronic record of interactions that have occurred during a searching episode between a Web search engine and users searching for information on that Web search engine. Since there is a focus on the user preference-oriented question-answering, a question log is maintained on the user basis. The fields which are maintained in a log are S.no.,Transaction id, Date, Time, Username, Question.

2) Log Extractor

Log Extractor is a module which is used to extract the important information from the question log. So, now only important fields are extracted from the question log, i.e. username, transaction id, question log, final question. Final question is the question to be worked on further.

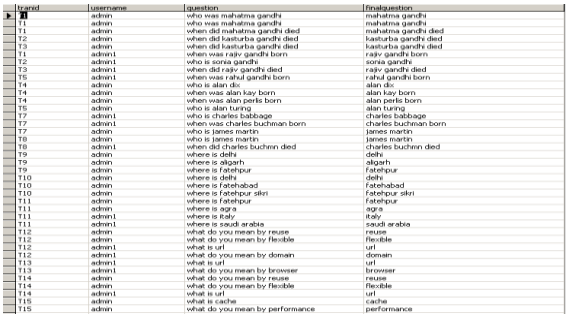
3) Rule Miner

This module is used to extract the association rules from the question log. For this the association rule mining is applied on the log.



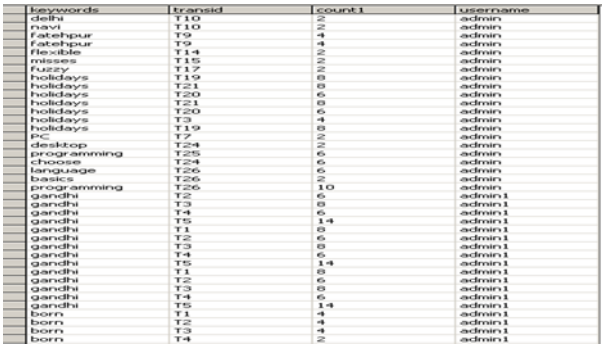
sno	tranid	date1	time1	username	question
60	T7	16-02-2014	11:25:789	admin1	who is chales stark draper
61	T7	16-02-2014	11:36:790	admin1	who is charles geschke
62	T7	16-02-2014	11:35:905	admin1	when was charles buchman born
63	T7	16-02-2014	20:56:890	admin	who is john von neumann
64	T7	16-02-2014	20:57:908	admin	who is john hopcraft
65	T7	16-02-2014	20:57:999	admin	who is john hughes
66	T7	16-02-2014	20:58:689	admin	who is james gosling
67	T7	16-02-2014	21:00:000	admin	who is james martin
68	T8	17-02-2014	22:00:477	admin	who is john von neumann
69	T8	17-02-2014	22:01:909	admin	who is john hopcraft
70	T8	17-02-2014	22:00:697	admin	when was john von neumann born
71	T8	17-02-2014	22:46:707	admin	when was john hopcraft born
72	T8	17-02-2014	22:46:897	admin	who is james martin
73	T8	17-02-2014	22:47:909	admin	who is james gosling
74	T8	17-02-2014	22:47:909	admin	who is john hughes
75	T8	17-02-2014	10:00:689	admin1	who is charles babbage
76	T8	17-02-2014	10:01:689	admin1	when was charles babbage born
77	T8	17-02-2014	10:02:689	admin1	when did charles babbage died
78	T8	17-02-2014	10:04:799	admin1	who is charles buchman
79	T8	17-02-2014	10:08:799	admin1	when was charles buchman born
80	T8	17-02-2014	10:07:799	admin1	when did charles buchnn died
81	T9	18-02-2014	11:05:889	admin	where is delhi
82	T9	18-02-2014	11:04:889	admin	where is agra
83	T9	18-02-2014	11:07:889	admin	where is panipat
84	T9	18-02-2014	11:08:889	admin	where is aligarh
85	T9	18-02-2014	11:11:889	admin	where is fatehpur
86	T9	18-02-2014	11:13:889	admin	where is fatehpur sikri
87	T9	18-02-2014	11:45:889	admin1	where is italy
88	T9	18-02-2014	11:56:889	admin1	where is france
89	T9	18-02-2014	11:54:889	admin1	where is russia
90	T9	18-02-2014	11:58:889	admin1	where is singapore
91	T10	19-02-2014	13:52:000	admin	where is delhi
92	T10	19-02-2014	13:56:000	admin	where is agra
93	T10	19-02-2014	13:57:000	admin	where is panipat
94	T10	19-02-2014	13:57:002	admin	where is faridabad
95	T10	19-02-2014	13:57:688	admin	where is navi mumbai
96	T10	19-02-2014	13:58:000	admin	where is fatehabad
97	T10	19-02-2014	13:58:067	admin	where is fatehpur sikri
98	T11	20-02-2014	13:58:123	admin	where is fatehpur

Figure 2: Question Log Maintained By The System For Two Users



tranid	username	question	finalquestion
T1	admin	who was mahatma gandhi	mahatma gandhi
T1	admin	who was mahatma gandhi	mahatma gandhi
T1	admin	when did mahatma gandhi died	mahatma gandhi died
T2	admin	when did kasturba gandhi died	kasturba gandhi died
T3	admin	when did kasturba gandhi died	kasturba gandhi died
T1	admin1	when was rajiv gandhi born	rajiv gandhi born
T2	admin1	who is sonia gandhi	sonia gandhi
T3	admin1	when did rajiv gandhi died	rajiv gandhi died
T5	admin1	when was rahul gandhi born	rahul gandhi born
T4	admin	who is alan dic	alan dic
T4	admin	when was alan kay born	alan kay born
T4	admin	when was alan perlis born	alan perlis born
T5	admin	who is alan turing	alan turing
T7	admin1	who is charles babbage	charles babbage
T7	admin1	when was charles buchman born	charles buchman born
T7	admin	who is james martin	james martin
T8	admin	who is james martin	james martin
T8	admin1	when did charles buchnn died	charles buchnn died
T9	admin	where is delhi	delhi
T9	admin	where is aligarh	aligarh
T9	admin	where is fatehpur	fatehpur
T10	admin	where is delhi	delhi
T10	admin	where is fatehabad	fatehabad
T10	admin	where is fatehpur sikri	fatehpur sikri
T11	admin	where is fatehpur	fatehpur
T11	admin	where is agra	agra
T11	admin1	where is italy	italy
T11	admin1	where is saudi arabia	saudi arabia
T12	admin	what do you mean by reuse	reuse
T12	admin	what do you mean by flexible	flexible
T12	admin1	what is url	url
T12	admin1	what do you mean by domain	domain
T13	admin1	what is url	url
T13	admin1	what do you mean by browser	browser
T14	admin	what do you mean by reuse	reuse
T14	admin	what do you mean by flexible	flexible
T14	admin1	what is url	url
T15	admin	what is cache	cache
T15	admin	what do you mean by performance	performance

Figure 3. Keywords Of Questions Are Extracted By The Log Extractor Module



keywords	transid	count1	username
delhi	T10	2	admin
navi	T10	2	admin
fatehpur	T9	4	admin
fatehpur	T9	4	admin
flexible	T14	2	admin
misses	T15	2	admin
fuzzy	T17	2	admin
holidays	T19	8	admin
holidays	T21	8	admin
holidays	T20	6	admin
holidays	T21	8	admin
holidays	T20	6	admin
holidays	T3	4	admin
holidays	T19	8	admin
pc	T7	2	admin
desktop	T24	2	admin
programming	T25	6	admin
choose	T24	6	admin
language	T26	6	admin
basics	T26	2	admin
programming	T26	10	admin
gandhi	T2	6	admin1
gandhi	T3	8	admin1
gandhi	T4	6	admin1
gandhi	T5	14	admin1
gandhi	T1	8	admin1
gandhi	T2	6	admin1
gandhi	T3	8	admin1
gandhi	T4	6	admin1
gandhi	T5	14	admin1
gandhi	T1	8	admin1
gandhi	T2	6	admin1
gandhi	T3	8	admin1
gandhi	T4	6	admin1
gandhi	T5	14	admin1
born	T1	4	admin1
born	T2	4	admin1
born	T3	4	admin1
born	T4	2	admin1

Figure 4. Frequency of keywords found by the rule miner module

b. User Module

1) Login Interface

The user interface is plain and simple. It contains a simple 2 text box – one for the username and password and Login button so that a valid authenticated user can login to the proposed question answering system. Whenever the login button is clicked, if a valid authenticated user has login, the main question answering search engine opens.

Figure 5. User Login Interface

2) Next Question Predictor

Whenever a user login, the question answering system opens up in which the user can ask the question and a button is provided which will provide the user the next probable questions and the link to their answers which the user can ask in the next session.

This module has utilized the apriori algorithm in association rule mining for predicting the next question.

Algorithm 1. The proposed algorithm for next question predictor is:

a) D= {database of all questions according to user, transactions}
b) D1 ={ database of all keywords of questions with transactions and count}
c) Q1 ={ Initial Question asked by user }
d) Ki ={Keywords of initial Question}
e) For(i=0; Ki != ∅; i++) do begin
f) Select transactions and count of Ki in D1
g) Find common transactions ti of Ki
h) For all ti , find qi from D.
i) Qi contains other predicted questions after Q1
j) Return qi

3. RESULTS AND ANALYSIS

3.1. Result

The proposed system has been implemented in JSP and MS SQL Server is used as backend database. The system has worked on various classifications of the question (who, what, how, where, which). The approach taken to predict the next questions has given satisfactory results up to a great extent. The different types of questions for which the next questions are predicted are shown below:

3.1.1. "Who" Type Question

The question "who is Gandhi" is asked by both user1 (admin) and user2 (admin1) on the question answering search engine. The next question predictor module returns the following questions which are personalized for the particular user.

Thus, we could see from the above result that the user "admin1" has interest in asking questions related to political Gandhi family. Before that we have seen that the user "admin" has interest in asking questions related to "Mahatma Gandhi". In this way the system has predicted the need of the particular user logged into and returns the correct predicted questions.

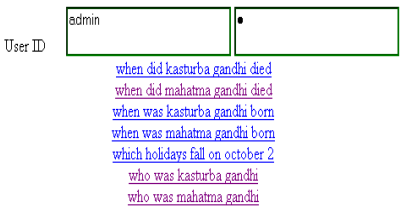


Figure 6. Predicted next questions to initial question "who is Gandhi" for user 1 (admin)

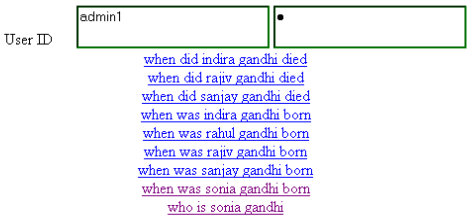


Figure 7. Predicted next questions to initial question "who is Gandhi" for user 2(admin1)

3.1.2. "What is" or "What Do You Mean by" or "What is the Meaning of" Type Question

Let say, the user asks the question "what do you mean by abstract", the system determines the log and tries to return all the questions which are related to that term. So, here the system returns the next questions as:

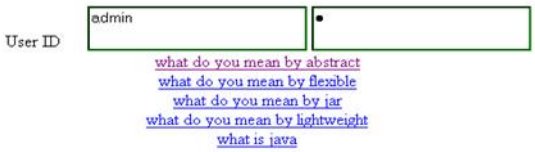


Figure 8. Predicted next questions to initial question "what do you mean by abstract" for user1(admin)

3.1.3. "Where Is" Type Question

Whenever the user asks the question of the type "where", that means the user wants to know the location of some place, country, city etc. And if we predict the related questions, that will depend on the log of the user, he may ask the other questions related to that place only or can ask the question related to the location of nearby places. The system returns the next questions to the question "where is Italy" as:

Figure 9. Predicted next questions to initial question "where is italy" for user2(admin1)

3.1.4. "How" Type Question

The user1 and user2 asked the question "How to code" and following next questions are returned by the system according to the personalized question log formed.

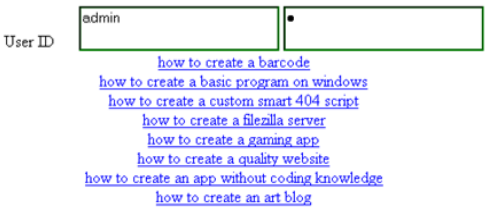


Figure 10. Predicted next questions to initial question "how to code" for user1(admin)

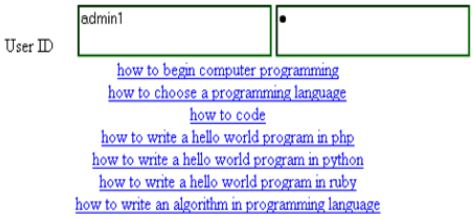


Figure 11. Predicted next questions to initial question "how to code" for user2(admin1)

The predicted next questions are related to the questions which are programming and coding to be done in different languages according to the need of both users.

3.1.5. "What Events Happened on" Question Type

Whenever the user asks the question "what events happened on" type question i.e. related to all the events which happened on the particular date. Let, the user asks the question "what events happened on august 15, 1947".

Figure 12. Predicted next questions to initial question "what events happened on august 15,1947" for user1 (admin)

3.1.6. "Which Holidays Fall on" Question Type

By the result we could see here that the system is returning all questions which user might have asked with that question as well as all the next probable questions which are also asked after another oncoming question. Thus, the system has worked on these six types of questions and has shown accurate results.

Figure 13. Predicted next questions to initial question "which holidays fall on October 2" for user1(admin)

3.2. Analysis

The proposed next question predictor module is able to provide a list of next probable questions accurately. This section calculates the relevancy of the next questions. In this, the performance is calculated for different question types. The formula for calculating performance is:

Performance % = (No. Of relevant next questions given in result) / (Total no. of next questions returned) *100.

3.2.1. "Who was Gandhi" By User1 "Admin"

Because admin usually asks question related to mahatma Gandhi

The next questions returned by the system are:

a. Who was mahatma Gandhi
b. Who was kasturba Gandhi
c. When was mahatma Gandhi born
d. When was kasturba Gandhi born
e. When did mahatma Gandhi died
f. When did kasturba Gandhi died
g. Which holidays fall on October 2

All are relevant questions to the input question.

Therefore, System's accuracy= 7/7= 100%

3.2.2. Which holidays fall on October 2

Since October 2 is Gandhi jayanti , the expected next questions must be related to mahatma Gandhi

The next questions returned by the system are:

a. When did kasturba Gandhi died
b. When did mahatma Gandhi died
c. When was kasturba gandhi born
d. When was mahatma Gandhi born
e. which holidays fall on january 13

f. which holidays fall on january 26
g. which holidays fall on october 2
h. who was mahatma gandhi

Only some are relevant questions
Therefore system accuracy = 5/12= 41.66%

Table 2: Accuracy of The System for Different Question Types

Question type	Question	No. of predicted questions	No. of correct questions	Accuracy
Who	Who was Gandhi	7	7	100%
What	What do you mean by abstract	5	-	*
Where	Where is Italy	6	-	*
How	How to code	7	-	*
Which	Which holidays fall on october2	12	5	41.66%
What events	What events happened on august 15,1947	7	-	*

Here, * indicates that we cannot calculate in general, the accuracy of the system for these type of questions. Because the accuracy of the system will vary according to the size of question log. Here in this paper, we have taken a small question log for which the system is showing 100% accuracy. Here, - indicates that we cannot judge how many questions are correct out of the total predicted questions.

Today many existing systems which have the capability of showing next questions have their maximum accuracy of 30% , which is not efficient as compared to our system.

4. CONCLUSION

The question answering system proposed has provided the accurate links of next questions as well as their relevant answers. The method adopted can increase the accuracy of many existing web search engine. Thus by the results, these important features have been seen:

1. It increases the efficiency of the system by not searching the answer for the question of the user in the index again and again rather the system predict the next questions and keep their answers in its repository to reduce the response time and complexity of the system.
2. It provides the ease to the user of not typing the next questions again and again. The system will provide the user the links of next questions to just click and see their relevant answers.
3. Information about a person, any term, location, birth date, death date, holidays, events etc. available to the user is accurate and relevant to the need of the particular user and according to the survey, many users are satisfied by it.
4. The algorithm adopted for predicting is fast in most cases. However, in many situations, researches are going on to improve its efficiency.
5. System's main aim was to have index retrieval fast so as to the complexity of the system.

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