APPLICATION OF HIDDEN MARKOV MODEL IN QUESTION ANSWERING SYSTEMS

Isa Maleki[1], Seyyed Reza Khaze[2], Seyyed Amir Reza Abedini[3]
[1,2,3] Department of Computer Engineering, Dehdasht Branch, Islamic Azad University, Dehdasht, Iran

ABSTRACT

By the increase of the volume of the saved information on web, Question Answering (QA) systems have been very important for Information Retrieval (IR). QA systems are a specialized form of information retrieval. Given a collection of documents, a Question Answering system attempts to retrieve correct answers to questions posed in natural language. Web QA system is a sample of QA systems that in this system answers retrieval from web environment doing. In contrast to the databases, the saved information on web does not follow a distinct structure and are not generally defined. Web QA systems is the task of automatically answering a question posed in Natural Language Processing (NLP). NLP techniques are used in applications that make queries to databases, extract information from text, retrieve relevant documents from a collection, translate from one language to another, generate text responses, or recognize spoken words converting them into text. To find the needed information on a mass of the non-structured information we have to use techniques in which the accuracy and retrieval factors are implemented well. In this paper in order to well IR in web environment, The QA system in designed and also implemented based on the Hidden Markov Model (HMM)

.

KEYWORDS

Question Answering Systems, Web Question Answering Systems, Natural Language Processing, Hidden Markov Model

1. INTRODUCTION

By the speedy growth of knowledge and the information on web, finding the needed information has become a problem. So, Web QA system is a solution for IR in the mass of the information. QA systems are not only a way of defining the information, but also are a method for decreasing the data volume and the management of the information [1]. QA system is a complex form of IR, which is used to process the information related to a specific field when it faces a vast volume of the information [2]. So, the use of QA systems causes us not to face the vast volume of the information to access needed information. The methods and the technologies used in the today world, each go inevitably toward producing vast volume of the information. Now web is the biggest resource of production of data in the world, in which data are produced in different forms of text, image and etc. So, to understand and use these data, we have to use the text processing algorithms and also the QA systems. In QA systems, the question in entered the system in natural language and with no limits. The responsibility of system is to find the accurate, short and complete answer for the questions in the shortest time [3]. So, the QA systems of IR techniques, Information Extraction (IE) and NLP are used all together [4]. So, QA system is a combination of IR, IE and NLP in which the user asks the question and gets the fixed answer instead of the set of the texts [2]. In Web QA system, the question analysis process is used for IR in the vast volume of the structured and non-structured information [5]. So, the goal of the QA systems is the retrieval of text information and the multimedia information from the databases for the related results.

By the development of the web, we face the vast volume of the data. Fast and correct access to the important and desired resources, is one of the challenges of the users in the information resources. What is important today is not the lack of the information but the lack of the methods in finding and retrieval of the favored information. In QA systems, the most related texts and the documents or the most related words are extracted from the documents according to the asked question [5]. So, by the increase of the information and the development of web, the need for the techniques and the algorithms for efficient access to the information and IR is felt more and more. Web QA system is a field of research which applies the NLP to IR the documents and the web services. In this paper we introduce the Web QA system using HMM. This system uses the IR patterns and processes the web documents and retrieves the data and presents them. This paper is organized as follows: in Section 2, introduce the related works; in Section 3, the introduction of the QA systems is presented; in Section 4, the HMM and its application in Web QA system is introduced; in Section 5, the evaluation and results of the proposed model is presented and finally in Section 6, conclusion and future works is presented.

2. RELATED WORKS

In the late years, the use of web among the users has been favored a lot. So, we need the systems which contribute the fast retrieval of the information among the vast volume of the data. QA systems are able to retrieve the accurate answers for the questions of the users. Lately, the IR has been attended very much as the retrieval of data from the texts is one of the most important activities of the researchers of artificial intelligence and information technology. Many studies have done but the subject is so vast that needs more attention. Researchers [6] have used the Genetic Algorithm (GA) and Artificial Immune System (AIS) for QA system. They have used GA and AIS algorithm for ranking of the answers. Their proposed architecture includes three main parts of Sentence Analysis System, Retrieval and Extraction Answer System and Ranking System. In their proposed system, first the question of the users is asked and then the answer is retrieved. In the retrieved answers set, there are words or sentences which are the most fitness according to the GA and AIS algorithms as the final answer will be displayed. Reference [7] has studied the QA, IR and NLP system. In this reference, it is said that NLP is used in many fields like text extraction, the retrieve of the documents, translation and the diagnosis of the voice. They have also cited that IE system must search the information in the pile of the information of non-structured texts like web texts. IE systems are the ones which are responsible to retrieve the documents related to the question of the user. These systems get the question of the user in a specific form and extract the related documents from the existing resources. The reason of the use of the IE systems is that users access the concentrated and accurate information as soon as possible.

In [8] has studied the architecture of the QA system. They have cited that the main goal of QA systems is retrieving the information in which the answer is hidden. They have also analyzed the QA system and the three main parts of it: Question Processing, Document Processing and Answer Processing. Their goal is to emphasize on designing the systems which are able to answer the questions. Researchers [9] have presented a new model for QA System. They have improved the question answer parts in the new model. The results show that the new model has answered 47 questions out of 50, meaning the 94% of the questions were answered right. So the suggested model of them for finding the accurate responses is suitable. In [10] has classified the QA System according to the three Question, IR and IE elements. Also in this reference a new model base on question classification for development and efficiency of IE in QA System is presented. Researchers [11] have presented an efficient method according to the Logistic Regression Model for extracting the accurate text in the set of big documents. Their goal is to use the Regression model in IE part and improve the ranking of the answers. This method causes any concept or meaning existing in the document and also the relationship between them and the type of the

information extractable, be extracted from the text. W. Lu et al. [12] have studied four web QA systems. They have classified the QA system into chat robot, QA based knowledge base, QA retrieval system and QA based free text. In chat robot system, when a question is asked, the most suitable answer for the question is retrieved in the database. In QA based knowledge base, the answer is fond for the question among the vast volume documents. In QA retrieval system, the answer takes place in www environments and the vast volume documents. QA based on free text systems are specific for open domains. This system is very efficient among the documents and the web pages. Also they have studied three fields of web information, question analysis, answer extraction and retrieval. In [13] studies the QA model in the close domain. The close domain has no interaction with the outside environment. So, accessing the accurate answer is hard. In close domain field the question is asked in short form and the answer is presented in key form. In this reference a system named Computerized Adaptive Category HElp (CACHE) is presented for QA in close domain. In this system, to access the answer, the question is asked in some different forms and the best answer for the question is presents. In [14] presented a document retrieval experiment on a QA system, and evaluates the use of named entities and of noun, verb, and prepositional phrases as exact match phrases in a document retrieval query. Reference [15] presented a data driven approach, decision tree learning, for the task of relevancy recognition in contextual QA, in which they formulate the task as a binary classification problem: a question either begins a new topic or follows the current existing topic. Their method cannot be employed directly in QA system because we do not just want to know whether the question is a follow-up, but also what type of the relevance it has.

3. QUESTION ANSWERING SYSTEMS

The QA systems make just one answer to be retrieved among the vast volume of the information [16]. The goal of the QA systems is to find the answers of the users in the vast volume of the data using the possible algorithms and the artificial intelligence. As an IR system, QA systems process the question by some steps and these steps are executed on the data sets for suitable IR [7]. QA systems are classified in two main parts [17]:

- Open domain QA systems deals with questions about nearly everything and can only rely on general ontology and world knowledge. On the other hand, these systems usually have much more data available from which to extract the answer.
- Closed-domain QA systems deals with questions under a specific domain (for example medicine or weather forecasting and etc.) and can be seen as an easier task because NLP systems can exploit domain-specific knowledge frequently formalized in ontology.

Web is open domain that containing of the biggest resources of data in which the information retrieval is not accessible easily [18]. So, it is natural that the beneficiary information must be extracted from it [19]. The increasing growth and also the fast changes in Web, makes the related IR difficult. So, the answer to the question must be retrieved in lots information. The recognizable part of the accessible information which includes the big set of the documents of different resources (papers, books, E-mails and web pages) is saved on wen. Web QA system is one of the most important techniques of NLP which must be able to find and retrieve the information from the web documents automatically [6, 20]. In Figure (1) the Web QA system architecture is presented.

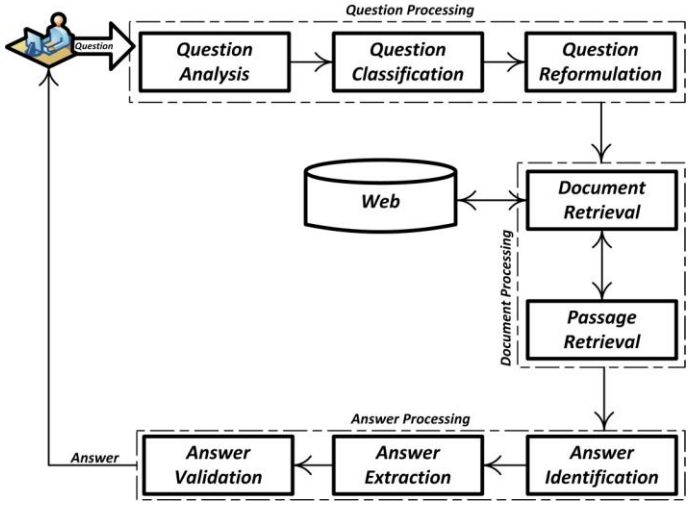

Figure 1: The Architecture of Web QA system

In web QA system architecture there are three basic methods for finding the answer of the question among the vast volume of the non-structured information which are:

- **Question Processing:** it is necessary for the big documents set to be pre-processed and be presented for the next processes in a suitable data structure. In this part it is tried to make the search process based on the set of the words. These words could be the key words retrieved from the text or the list of the words of the text. The process of the question is one of the basic stages of the QA system. The system selects the best data information for the asked question. In fact in this part the question asked by the user is evaluated and the type of the question is defined and the question is transformed to a form of question which is in conformity to the question of the user [21].
- **Document Processing:** The main goal of the document processing is that according to the needs of the user, the most related texts and the documents or the most important word be retrieved from the other documents of a set [8, 10].
- **Answer Processing:** The main goal of answer processing, is the beneficiary IR of the text documents in the web [8]. The answer processing in QA system is a very important stage in the answer of the question. The answer processing is the relating the natural language texts (reports, paper and etc.) to a structured and defined presentation which presents the key information. The answer text includes much information all of which will not contribute the answer. So, in answer processing stage, the answers of the texts are studied and the words are retrieved. The answer processing responsibility is to find the specific data in the texts of natural language.

4. HIDDEN MARKOV MODEL

HMM was introduced in the late years of 1969s [22]. This model could be applied as a common and valid method for defining the patterns and modeling in a vast area of many applications, and its first application is in speech definition [23]. The reasons of using HMM are that first it is very powerful from mathematical structure point of view and following it has formed many theoretical bases of different applications, and second if the model is implemented well could be used for many applications [24].

HMM is a stochastic two layered process in which the stochastic process is hidden and creates the series observation by a set of stochastic processes [24]. In this model the state sequence cannot be identified that meaning the status sequence could not be seen observation able and is hidden, so it is called HMM. HMM has different parameters are any of which showing different status. The most important HMM parameter is the number of the status which is showed by N. The status sequence in HMM by *N* status in any second of distinct status is $\{S_1,\ldots, S_N\}$. Also, outputs number in any status is showed by *O* and the final observations of the system are a set of these outputs [25]. So, the HMM status are in internal relationship with each other and could be probabilistic transferred to other status. In HMM the transfer mane create the topology of the hidden status. In HMM, the most complex time is when all the status transferrable and there is mane between them. The transfer probability set matrix for different status is defined according to equation (1) [26].

$$A=[a_{ij}], a_{ij}=P[q_{t+1}=s_j|q_t=s_i] \quad , \quad 1\le i,j\le N$$
$$with\, a_{ij}\ge 0 \quad and \quad \sum_{j=1}^{N} a_{ij}=1; \tag{1}$$

The observations probability matrix in HMM is defined according to equation (2) [26]. This matrix shows the observation probability of any output per any status in which O= (O_1, O_2, … , O_T) is the observations sequence and O_T is the total observations.

$$B=[b_j(k)], b_j(k)=P[O_t=v_k|q_t=s_j] \quad , \quad 1\le k\le M\,, \quad 1\le j\le N$$
$$with\, b_{ij}\ge 0 \quad and \quad \sum_{k=1}^{M} b_j(k)=1; \tag{2}$$

In equation (2), it is possible to define the number of status by parameter *N* and also the viewable outputs are defined are showed by *M* and the final observations of HMM would be a set of these outputs. Probability distribution for different status takes place according to the equation (3) [26].

$$\pi_i=P[q_1=s_i] \quad , \quad 1\le i\le N$$
$$with\, \pi_i\ge 0 \quad and \quad \sum_{i=1}^{N}\pi_i=1 \tag{3}$$

Generally HMM is showed in triplet form ʎ= (A, B, π). So, the probability of observation a sequence of outputs by HMM is showed by P (O| ʎ). Figure (2) shows the hidden status and the observation in HMM. The junctions are among the hidden and observation HMM, shows the production probability of a specific status and the viewable one.

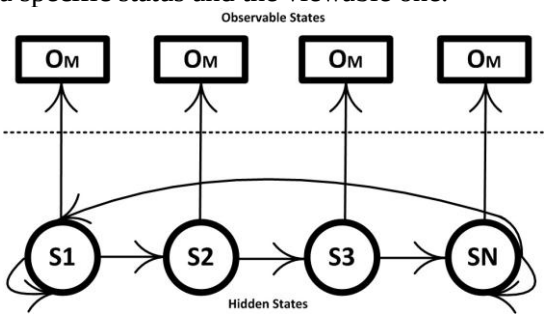

Figure 2: HMM with N Hidden Status

As it could be seen in Figure (2), HMM is formed by the combination of stochastic processes in distinct two layered form. In HMM any of the hidden status the probabilistic could be able to create any of the observations. So, holding the sequence of the output it is not possible to define the transfers taking place in the system and among the status. So, such a system holds two layers of stochastic processes. In the first layer the status exist, which hold stochastic distinct and exclusive behavior, and in the other layer, the whole system exists which models the transfers between the processes. A possible and applicative method in HMM for finding the status sequence which holds the highest possibility of producing observations is the Viterbi Algorithm (VA) [27]. Using VA make the optimization evaluation chain of HMM increase. In VA the optimized status are calculated by equation (4) which is recursive [28].

$$\alpha_{t+1}(j) = \left(\sum_{i=1}^{N} \alpha_t(i).a_{ij} \right).b_j(O_{t+1}) \qquad j = 1,2,...,N \quad t = 1,2,...,T-1 \tag{4}$$

In equation (4), α_t (i) produces the observations sequence optimization of first to t^{th} and going to i status in *t* time. SO, α_t (i) shows the O= (O_1, O_2, … , O_T) observations probability from the start to *t* and getting to i^{th} status in *t* time. In equation (4), the optimization factor is the maximum probability for all observations from the first to t^{th} time. In equation (4), the primary value of α_t (i) is defined according to equation (5) [28].

$$\alpha_1(i) = \pi(i).b_i(O_1) \quad i = 1,2,...,N \tag{5}$$

To consider all possible status of the observations sequence, the probability of the being at any N status of *t* time must be taken into consideration. Equation (6) the probability of favored views for all values of *i* calculates [28].

$$P = \sum_{i=1}^{N} \alpha_T(i) \tag{6}$$

In equation (6), we take into consideration all possible observations and should sum up the probability of all status. So, the favored probability of P (O| λ) is resulted by summing up α_t (i) for all values of *i*. In HMM, the observations take place according to the probability functions which are set of observations. So, HMM is a result of random model according to the hidden stochastic process and give the results by a set of stochastic processes which produce observations sequence. The number of status plays important role in HMM success. The most general status is the time all status go in junction together and are accessible from each other.

4.1. Application of HMM in Web QA System

For the answer to be accurate on Web QA System, two parts hold the highest efficiency. First, the question process which finds the best answer from the web documents, and second, document retrieval process. Now there are many problems in efficient retrieval of information from web like the high volume of the information saved on web, the complexity of the web pages in contrast to the documents and the dynamicity of the information. So, using the techniques and the different algorithms in creation and collection of the important are the important tools in retrieving the information. The word or the words related to the question of the user is not taken into consideration and this is one of the problems of QA Systems. For this reason, using the possible models for creating sequence of the words is an effective method. So, in the proposed model for IR and processing the documents, HMM is used. The work of hidden layer in HMM is to find the hidden relationships among the information. HMM retrieves the documents according to the possible relation to the question instead of retrieving the documents according to the similarity

level to the question. The probability of relation of the specific document to the question could be calculated according to the relation chain of the document, estimation of the probability of presenting the words of the question and the related documents, instead of the non-related documents. HMM searches all documents according to the possibility of relation to the question and finally the list of the documents are presented to the user. VA is used for searching operation in HMM. Question processing is based on searching and returning the status sequence which conforms the most to the answer in HMM, so it is possible to say that IR process in web environment is efficient using VA. In Figure (3), the proposed model flowchart of Web QA system according to HMM is presented.

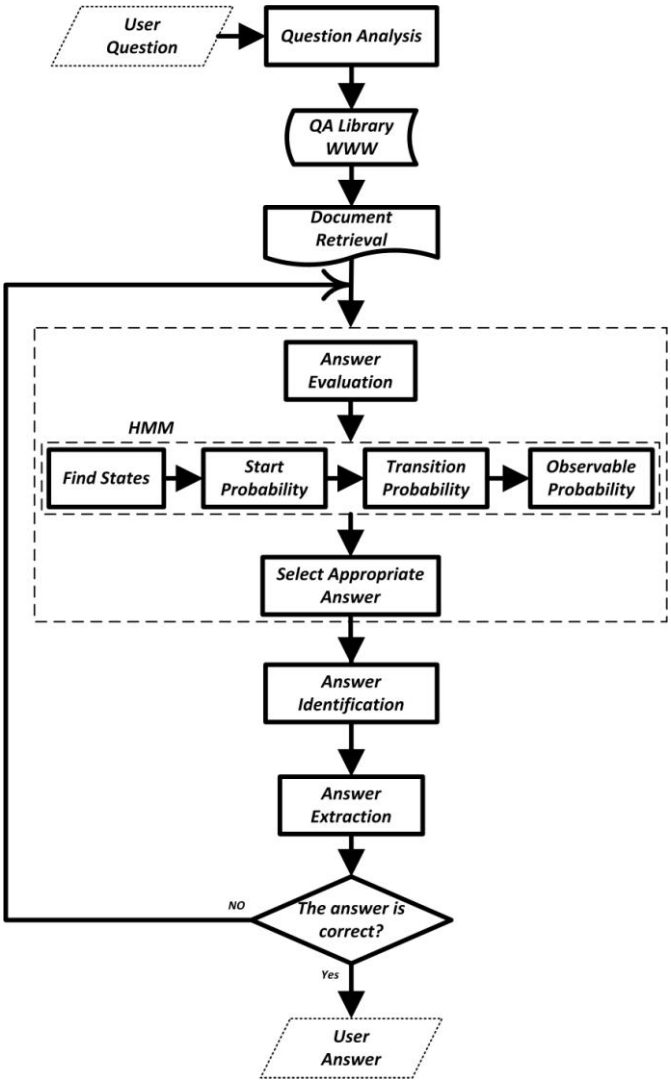

Figure 3: The Proposed Model Flowchart of Web QA System Based on HMM

As it could be seen in Figure (3), the dependency and the relatedness of the answer to the question is retrieved via web environment and the set of the answers found, are surveyed using the HMM sequence and the related answer is to the question is defined and at last it is presented. Figure (4) shows the quasi code of Web QA system according to the HMM.

```
1. User Question
2. Question Analysis
3. Browsing Web
4. Documents Retrieval
4.1. Begin Viterbi Algorithm
      for t=1 to T do
        for i=1 to N do
            for j= 1 to N do
                for each transition i from j do
                   Find States
                   Calculate Start Probability
                   Calculate Transition Probability
                   Calculate Observable Probability
                end for
      end for
      ● Choose the Highest Probability State
      ● Create Sequence Answer
      ● Answer Evaluation
      ● Find Best Answer
  end for
end for
4.2. End
5. Answer Identification
6. Answer Extraction
7. User Answer
```

Figure 4: Quasi Code for Web QA System based on HMM

In QA systems the most important factor is to find the accurate answer. Using the HMM we try to increase the accuracy factor of the answer. HMM is one of the most important tools of analyzing the random sequences of finite status structure and a good method for QA system. Holding the efficient and powerful algorithms, HMM presents the highest similarity to the asked question. It is guaranteed in HMM that the answer presented, is the favored one. VA is a diagnosis algorithm which is very accurate in the similarity rate of the answer. In the solution suggested by VA, the answer to the question is taken into consideration for suitable solution for decreasing the error rate and increasing the efficiency. HMM, uses the chain and repetition specifications and increases the definition rate of the answer. So, the relationship between the question and the answer using HMM, is analyzed and processed.

5. EVALUATION AND RESULTS

In this section we evaluate and results the QA System according to the HMM. For evaluation of the proposed model, the questions in the Table (1) are tested.

Table 1: The Sample Questions

No.	*Question*	*Question & Answer type*
1	*Who invented the cell phone?*	*Who-Person*
2	*When was cell phone invented?*	*When-Year*
3	*What year was cell phone invented?*	*What-Year*
4	*What date was cell phone invented?*	*What-Date*
5	*In which year was cell phone invented?*	*Which-Year*
6	*Cell phone was invented in which year?*	*Which-Year*

The Web QA Systems based on the HMM is implemented in Delphi XE3 programming environment. As Delphi is high efficient in data process and the compilation of the program is easier in it, it is very effective in IR. In Figure (5), the total scheme of the program and also the answers to the question are shown. According to the implementation it is possible to say that the results of the answers show the goal of the questions. At generally it is clear from the answers to the questions that what is asked.

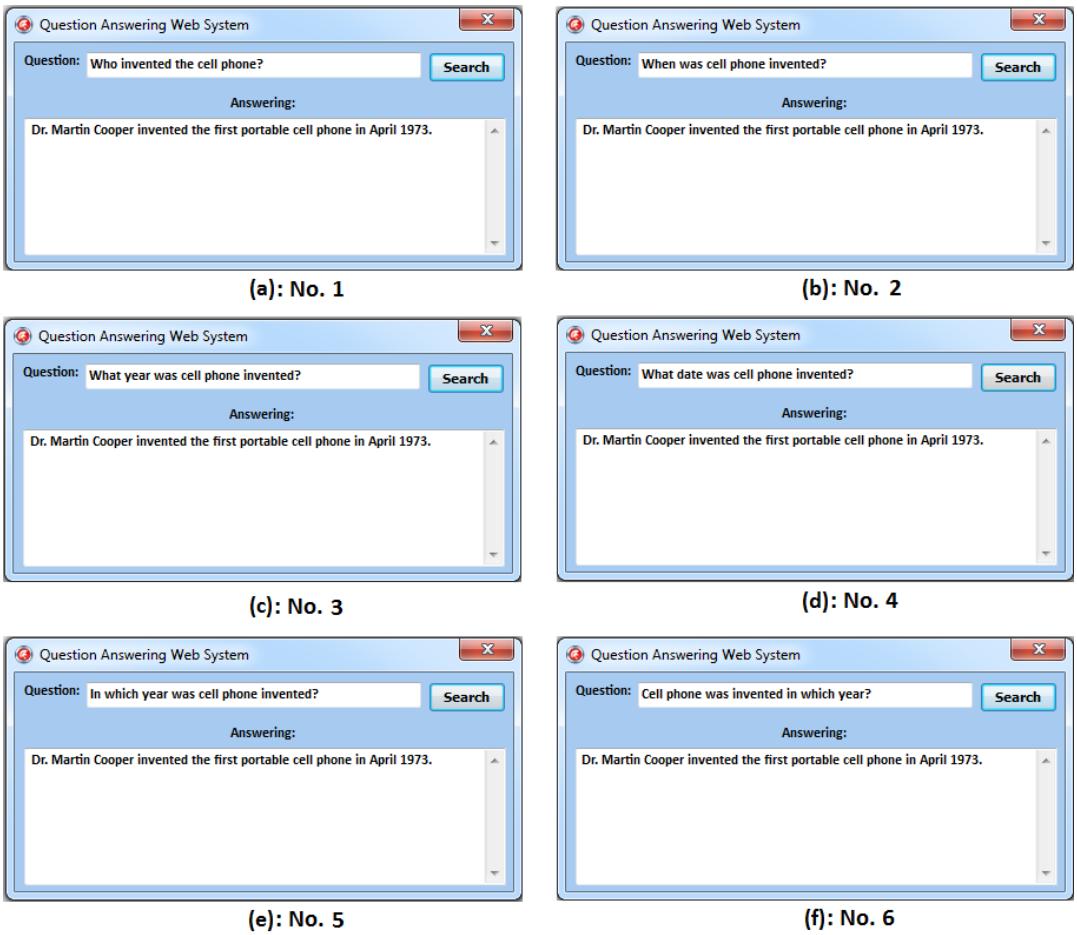

Figure 5: the Web QA Systems Based on HMM

As it is seen in Figure (5), the proposed model has retrieved the most suitable answer for the questions. Viewing the answers make us result that the most related keywords are presented according to the asked questions. Also in the proposed model it is tried to first the answers be retrieved from the set of the documents and second have dependency and meaning relations in the answer structure.

6. Conclusion And Future Works

QA systems are a complex task needing effective improvements of different research areas, including IR, NLP and database technologies. With the broad use of the Web, search engines have become critical online services. When conventional search techniques failed to provide concise answers to users' queries, web-based question answering systems were developed. QA system is one of the emerging areas of research in NLP applications of Artificial Intelligence. QA systems aim to produce accurate answers, but the current QA systems are succeeded only to some

extent. In this paper a new model based on HMM for IR in Web QA system is presented. The growth of the documents on the Web environment has made the efficient mining among the web documents impossible and this needs improvement and more work on the QA systems. In QA Systems, using the algorithms is very effective in the accuracy of the answers of the questions. The proposed model is able to retrieve the answer from the information and then using VA it retrieves the answers with high accuracy. So, in this paper we have tried not to show the unrelated answers in HMM and just retrieve the related answers to the question. In the future, we hope the QA system based on designing algorithms that answer retrieval more precise.

REFERENCES

[1] O. Kolomiyets, Marie-Francine Moens, "A Survey on Question Answering Technology from an Information Retrieval Perspective", Information Sciences, Vol. 181, pp. 5412-5434, Elsevier Inc, 2011.

[2] S.J. Athenikos, H. Han, "Biomedical Question Answering: A Survey", Computer Methods and Programs in Biomedicine, Vol. 99, pp. 1-24, Elsevier Ireland Ltd, 2010.

[3] M.H. Heie, E.W.D. Whittaker, S. Furui, "Question Answering using Statistical Language Modeling", Computer Speech and Language, Vol. 26, pp. 193-209, Elsevier Ltd, 2012.

[4] R. Barskar, G.F. Ahmed, N. Barskar, "An Approach for Extracting Exact Answers to Question Answering (QA) System for English Sentences", International Conference on Communication Technology and System Design, Vol. 30, pp. 1187-1194, Elsevier Ltd, 2012.

[5] A. Frank, Hans-Ulrich Krieger, F. Xu, H. Uszkoreit, B. Crysmann, B. Jörg, U. Schäfer, "Question Answering from Structured Knowledge Sources", Journal of Applied Logic, Vol. 5, pp. 20-48, Elsevier B.V, 2007.

[6] M.Sh. Fakhr, M.S. Abadeh, "AISQA- An Artificial Immune Question Answering System", International Journal Modern Education and Computer Science, Vol. 3, pp. 28-34, 2012.

[7] M. Aggarwal, "Information Retrieval and Question Answering NLP Approach: An Artificial Intelligence Application", International Journal of Soft Computing and Engineering (IJSCE), Vol. 1, Issue-NCAI2011, pp. 43-45, June 2011.

[8] A.M.N. Allam, M.H. Haggag, "The Question Answering Systems: A Survey", International Journal of Research and Reviews in Information Sciences, Vol. 2, No. 3, September 2012.

[9] M.R. Kangavari, S. Ghandchi, M. Golpour, "A New Model for Question Answering Systems", World Academy of Science, Engineering and Technology, Vol. 42, pp. 506-513, 2008.

[10] M. Ramprasath, S. Hariharan, "A Survey on Question Answering System", International Journal of Research and Reviews in Information Sciences, Vol. 2, No. 1, pp. 171-179, March 2012.

[11] P. Li, Y. Guan, X. Wang, Y. Xu, "Answer Extraction Based on System Similarity Model and Stratified Sampling Logistic Regression in Rare Date", International Journal of Computer Science and Network Security, Vol. 6, No. 3, pp.1-8, March 2006.

[12] W. Lu, J. Cheng, Q. Yang, "Question Answering System based on Web", Fifth International Conference on Intelligent Computation Technology and Automation, IEEE, pp. 573-576, 2012.

[13] H.L. Toh, L.W. Hawkes, R.C. Lacher, "Adaptive Query-based Model for Improved Ranking in Closed Domain Factoid Question Answering", IEEE, pp. 260-265, 2010.

[14] S. Stoyanchev, Y.C. Song, W. Lahti, "Exact Phrases in Information Retrieval for Question Answering", proceedings of the 2nd workshop on Information Retrieval for Question Answering (IR4QA), Manchester, UK, pp. 9-16, 2008.

[15] F. Yang, J. Feng, G. DiFabbrizio, "A Data Driven Approach to Relevancy Recognition for Contextual Question Answering", in proceedings of HLT-NAACL 2006 Workshop on Interactive Question Answering, pp. 33-40, 2006.

[16] Sh.J. Yen, Y.Ch. Wu, J.Ch. Yang, Y.Sh. Lee, Ch.J. Lee, J.J. Liu, "A Support Vector Machine-Based Context-Ranking Model for Question Answering", Information Sciences, Vol. 224, pp.77-87, Elsevier Inc, 2013.

[17] H.D. Nguyen, L. Kosseim, "Improving the Precision of a Closed-Domain Question-Answering System with Semantic Information", Workshop on Question Answering in Restricted Domain, Avignon, France, pp. 850-859, 2004.

[18] E. Agichtein, S. Lawrence, L. Gravano, "Learning to Find Answers to Questions on the Web", ACM Transactions on Internet Technology, Vol. 4, No. 2, pp. 2129-162, 2002.

[19] A.M. Moussa, R.F. Abdel-Kader, "QASYO: A Question Answering System for YAGO Ontology", International Journal of Database Theory and Application Vol. 4, No. 2, pp. 99-112, June 2011.
[20] E. Agichtein, Ch. Burges, E. Brill, "Question Answering Over Implicitly Structured Web Content", in: Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence, IEEE Computer Society, Washington, DC, USA, pp. 18-25, 2007.
[21] L. Hirschman, R. Gaizauskas, "Natural Language Question Answering: the View from here", Natural Language Engineering, Vol. 7, No. 4, pp. 275-300, 2011.
[22] L. Baum, T. Petrie, G. Soules, N. Weiss, "A Maximization Technique Occuring in the Statistical Analysis of Probabilistic Functions of Markov Chains", Annals of Mathematical Statistics, Vol. 41, No. 1, pp.164-171, 1970.
[23] L.R. Rabiner, "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", pp. 267-296, 1990.
[24] I. Visser, "Seven things to Remember About Hidden Markov Models: A Tutorial on Markovian Models for Time Series", Journal of Mathematical Psychology, Vol. 55, pp. 403-415, Elsevier Inc, 2011.
[25] D. Bouchaffra, A. Amira, "Structural Hidden Markov Models for Biometrics: Fusion of Face and Fingerprint", Pattern Recognition, Vol. 41, pp. 852-867, Elsevier Ltd, 2008.
[26] T. Boutros, M. Liang, "Detection and Diagnosis of Bearing and Cutting Tool Faults using Hidden Markov Models", Mechanical Systems and Signal Processing, Vol. 25, pp. 2102-2124, Elsevier Ltd, 2011.
[27] N. Najkar, F. Razzazi, H. Sameti, "A Novel Approach to HMM-based Speech Recognition Systems using Particle Swarm Optimization", Mathematical and Computer Modelling, Vol. 52, pp. 1910-1920, Elsevier Ltd, 2010
[28] M. Mosleh, S. Setayeshi, A.M. Rahmani, "A Synergy Between HMM-GA Based on Stocastic Cellular Automata to Accelerate Speech Recognition," IEICE Electronics Express, Vol. 6, No. 18, pp. 1304-1311, 2009.

Isa Maleki is a Lecturer and Member of The Research Committee of The Department of Computer Engineering, Dehdasht Branch, Islamic Azad University, Dehdasht, Iran. He Also Has Research Collaboration with Dehdasht Universities Research Association NGO. He is a Member of Review Board in Several National Conferences. His Interested Research Areas Are in the Software Cost Estimation, Machine Learning, Data Mining, Optimization and Artificial Intelligence.

Seyyed Reza Khaze is a Lecturer and Member of the Research Committee of the Department of Computer Engineering, Dehdasht Branch, Islamic Azad University, Dehdasht, Iran. He is a Member of Editorial Board and Review Board in Several International Journals and National Conferences. His Interested Research Areas Are in the Software Cost Estimation, Machine learning, Data Mining, Optimization and Artificial Intelligence.

Seyyed Amir Reza Abedini is a lecturer and member of the Research Committee of the Department of Computer Engineering, Dehdasht Branch, Islamic Azad University, Dehdasht, Iran. He Also Has Research Collaboration With Dehdasht Universities Research Association NGO. His Interested Research Areas Are in the Wireless Sensor Networks, Data Mining, Optimization and Artificial Intelligence.