Question Answering Systems in Education and their Classifications

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Abstract

The paper studies Question Answering Systems that can be used in education as an engine to search for learning and/or other useful information. A wide set of different Question Answering Systems, such as START, Wolfram|Alpha, AllExperts, etc. is described and their main characteristics, benefits and drawbacks are given. The paper also presents four classifications of Question Answering Systems depending on: content, information source, language paradigm and information processing, as well as proposes recommendations for using Question Answering Systems in education.

Keywords: *question, answer, question answering system, classification.*

1. Introduction

Any educational process implies independent work whereby a learner acquires knowledge by his/her own efforts. And usually, an important part of independent learning is a search for information that would be useful for solving learning tasks. According to world statistics the use of the internet as an information source is becoming increasingly popular. [1] Access to information is a vital resource in the knowledge economy, and so access to the right information at the right time is proving to be an essential skill of being informed, and making the right decisions. In order to find the needed information users apply search engines. A user defines search criteria by keywords and in return he/she gets the list of links to webpages where the words from the query are mentioned. These search results doubtlessly require additional processing by the user, namely, browsing the identified webpages for the needed information. Furthermore, an occurrence of the words from the user's query in the found text does not guarantee the correspondence of this text with the query. [2] Today the most frequently used search engine is Google, but it is not the only way for searching information on the Web.

In 1999 the first Text REtrieval Conference (TREC) question answering track encouraged research in the field of information search into systems that return answers, rather than ranked list of documents, in response to a question. [3] The choice of research direction was based on the assumption that users would usually wish to get the answer to a question instead of list of documents to search for the answer on their own. [4]

Question answering is the field of science basically dealing with information retrieval and natural language processing. The objective of information retrieval is to search for the elements in the resource that map with user's specified need, while the objective of natural language processing is to create an environment for the dialog between the user and the system in natural language. [5] The same objectives of question answering also become apparent in definitions of question answering system. According to [5] a Question Answering System (QAS) is "an automated tool that can search and retrieve information from a textual document repository or knowledge base". On the other hand, [4] authors define QAS as "a programmed system having the capability of answering natural language questions in a human like manner with quick and perfect result". Therefore, QAS can be seen as an information search system that handles user's queries in natural language, searches for the relevant information and returns the search results in a form of precise answer.

The aim of the paper is to give a brief overview of some existing QAS, to describe different classifications of such systems and to provide recommendation for using QAS in education.

The paper is organized as follows: in Section II a brief overview and main characteristics of existing QAS are given, in Section III classifications of QAS are described, and in Conclusions the recommendations for using QAS are provided.

2. Characteristics of Question Answering Systems

Nowadays there are many different Question Answering Systems. Ten most popular QAS and their main characteristics are described below.

Evi (originally known as TrueKnowledge) is a knowledge Web search engine that helps people get what they want and need through Evi understanding of each user and the world they live in. Instead of a list of links that may or may not be relevant to the query, a user receives the requested information [6]. A query can be formulated as keywords or as a question in natural language. The form of answer depends on a type of query. It can be a short answer in case of a simple query like when or where, or a coherent text in case of how or why type query, or a concept profile with a list of attributes in case of what type query. In addition a user can view a list of facts that were used to conclude an answer and make sure of its correctness.

START natural language question answering system is the world's first Web-based QAS (December, 1993) that aims to supply users with "just the right information", instead of merely providing a list of links [7]. In the same way as it is in Evi, a query can be formulated as keywords or as a question in natural language. An answer is basically represented in three forms: a short answer to when, where or who queries, a corresponding images to show queries (e.g. the answer to the query "Show me a map of Spain" is three maps of Spain from different sources), or a list of matches to criteria defined in query (e.g. the answer to the query "How many languages are spoken in Belgium?" is "Dutch (official) 60%, French (official) 40%, German (official) less than 1%, legally bilingual (Dutch and French)"). Each system's answer always contains a reference to the corresponding information source.

Wolfram|Alpha is a Computational Knowledge Engine that introduces a fundamentally new way to get knowledge and answers, not by searching the Web sites, but by dynamic computations based on a vast collection of built-in data, algorithms, and methods. [8] A query can be inputted in a free form in natural language (e.g. "When was the airbag invented?"), but the preferred form is statement, rather than question (e.g. "1980 Nobel Prise in Chemistry"). At the same time it is possible to input a set of data for computation, or even image or file. Moreover, this QAS differs from previously mentioned systems in the form of answer, because it never looks like a coherent text. Wolfram|Alpha returns an answer in a form of a table where information, which is relevant to a query, is separated by categories (e.g. an answer to a query about some person usually contains such categories as basic information like name and date of birth, image, timeline, notable facts, familial relationships and others). In addition it is possible to view the list of information sources used to form the answer.

Freebase is an open repository of structured data of almost 23 million entities, where an entity is a single person, place, or thing. All entities are connected with each other as a graph. [9] There are two possibilities for defining search criteria: keywords and a query in Metaweb Query Language (MQL). In the first case a user has to input a word or phrase that characterizes the needed information. When he/she starts typing, Freebase proposes suggestions and a user can choose one of these alternatives, or continue typing. The results of search are links to Freebase entities, i.e. articles on topics related to inputted keywords. In the second case a user has to create a syntactically correct query in MQL. The result of query execution is a list of records from Freebase which corresponds to query parameters (see Figure 1). This feature also allows incorporating Freebase knowledge into applications or websites for the further processing.

Google Knowledge Graph is a huge knowledge base connecting millions of objects and facts about them, where objects are people, places and things. [10] Knowledge Graph is an effort to provide so called

semantic search, which is directed to "understanding" of user's query and returning a direct answer. [11] Knowledge Graph is embedded into Google search engine, so a usual list of links is supplemented with an answer provided by it, in case if such answer exists.

Freebase   Find...

Query Editor

```
[{
  "name": null,
  "type": "/book/written_work",
  "author": {
    "id": "/en/stephen_king"
  }
}]
```

Results   Help

```
{
  "result": [
    {
      "author": {
        "id": "/en/stephen_king"
      },
      "type": "/book/written_work",
      "name": "The Shining"
    },
    {
      "author": {
        "id": "/en/stephen_king"
      },
      "type": "/book/written_work",
      "name": "The Running Man"
    },
```

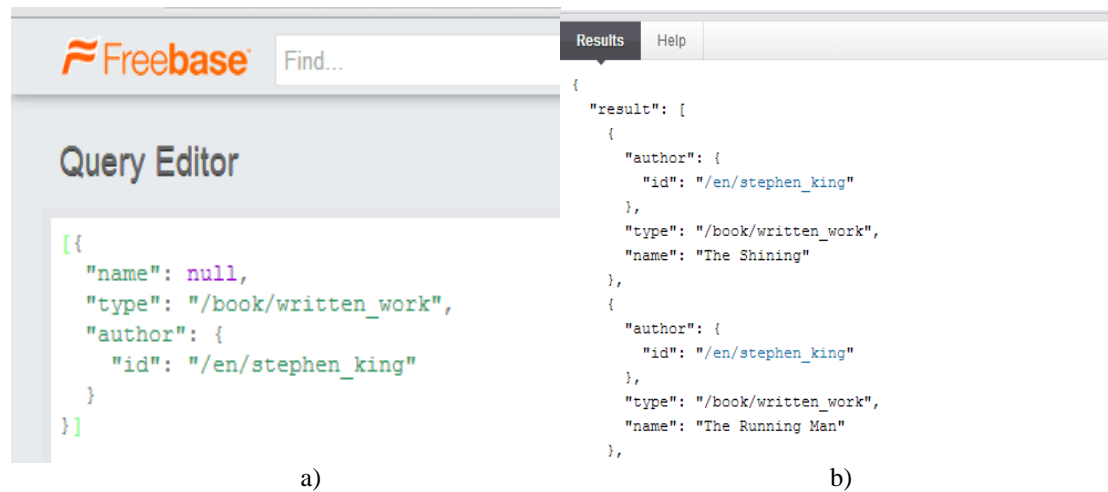a)   b)

Figure 1. Freebase query example (a) and query execution results (b).

AllExperts is the first large-scale question and answer service on the Web. Here users can find experts in arts, business, technologies, culture, jobs, kids, relationships, etc., and usually many of them have a wide experience in their fields. [12] In order to ask a question, a user has to address it to some particular expert, in opposite to other question answering websites, where a question is published under the specified section and is available for all website users. When an expert answers a question, his/her answer and related question can be published under the specified section, if a user does not object to it.

Answerbag is question answering website where users can get answers to their questions, whether they're looking for facts, opinions or simply entertainment. Questions are answered by Answerbag professional researchers and community members. [13] Many answers are fact checked by a professional copy-editor and marked with specific sign, so Answerbag can also be considered as an expert community question answering website. A query can be inputted in a form of question or in a form of poll. Questions are published under the section "Questions" and can be sorted by type, status and/or category. A poll allows gauging community's opinion on some topic. Questions and answers to them, as well as polls and their results are freely available to all website users.

Blurtit is an online question answering community that provides the answers users are looking for and gives them free, 24/7 access to a whole world of information, and to millions of knowledgeable friends. Blurtit knowledge base contains facts, information and users' opinions, enlarging with each new answer. [14] Users questions are published in the section "Topics" and each website user or guest can answer these questions. Answers can be rated by users, therefore a search for the best answer among all provided answers simplifies.

Answers.com is question-and-answer community, where visitors share what they know and ask about what they don't. Answers.com joins the best of community-driven questions and answers (WikiAnswers) with hundreds of respected and trusted editorial reference books (ReferenceAnswers). [15] A user can formulate a query as keywords or as a question. If there is an article on related topic, then this article is returned as a search result. In other cases a question is redirected to the community of users and published under the section "New question", where other users can find it and provide answers.

Ask.com (originally known as Ask Jeeves) is a question answering-focused web search engine. The original idea behind Ask Jeeves was to allow users to get answers to questions posed in everyday, natural language, as well as by traditional keyword searching. The current Ask.com still supports this, with added

support for math, dictionary, and conversion questions. [16] This system tries to "understand" any users query and gives three forms of answer at once: a direct answer, a list of links to webpages on related topics and a list of similar questions with answers from other question answering websites. Thus, a user has an opportunity to choose information which is the more relevant to his/her query and follow the corresponding link.

The general characteristics of described QAS are summarized in Table 1.

Table 1. Characteristics of Question Answering Systems.

QAS	Type of query	Type of answer	Creator of answer
Evi	keywords/question	direct answer	system
START	keywords/question	direct answer	system
Wolfram|Alpha	keywords/question	structured information/direct answer	system
Freebase	keywords/query	list of links to Freebase entities/structured information	system
Google Knowledge Graph	keywords/question	direct answer and link to original information source	system
AllExperts	question	direct answer	user-expert
Answerbag	question	direct answer	users
Blurtit	question	direct answer	users
Answers.com	keywords/question	information from one or many sources/direct answer	system or users
Ask.com	keywords/question	list of links to related webpages and/or list of similar questions from other QA websites and/or direct answer	system

3. Classifications of Question Answering Systems

During the last decade many classifications have been provided by the researchers in the field of question answering. The most widely used classifications are based on the content of QAS, information sources that are used to create answers, and language paradigms. But QAS can also be classified depending on information processing.

3.1. Content based classification

Content based classification divides QAS into two main categories [4] [17] (see Figure 2):
- **Open domain Question Answering Systems** provide answers to any questions, e.g. Evi system has no topic restrictions as well as many other: Google Knowledge Graph, Answers.com, etc.
- **Restricted domain Question Answering Systems**, on the contrary, provide answers on some fixed topics, e.g. at AllExperts website topic exists only if there is at least one expert, who can answer questions related to this topic. BASEBALL answers questions about baseball games, LUNAR – about the analysis of rock samples from the Apollo moon missions. At Stackoverflow website users can pose any questions related to programming, but WEBCOOP provides answers on a number of aspects of tourism like accommodation and transportation.

In case of Wolfram|Alpha there are no restrictions on topics – a user can ask any questions, but the object of question has to be related to some computations. For instance, a user can get an answer to question "*How long the World War I last?*", bet will not get answer to question "*What countries ware involved in World War I?*".

This classification is useful for a user who wants to get information on some specified topic.

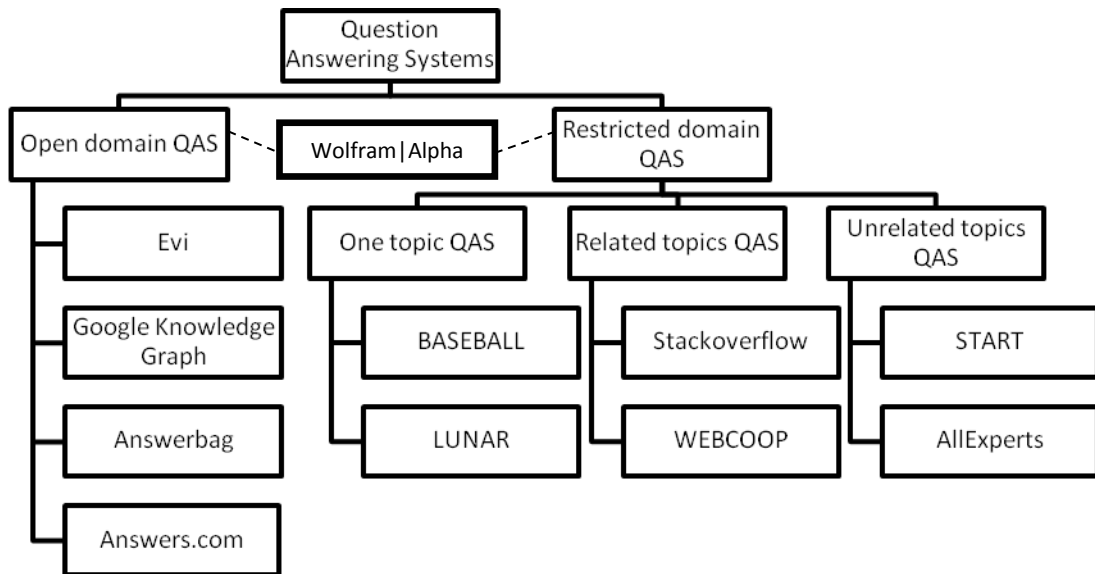Figure 2. Content based classification of Question Answering Systems.

3.2. Information source based classification

Information source based classification implies division of QAS into the following categories [17] (see Figure 3):

- **Database-oriented Question Answering Systems** have built-in data base consisting of facts about things, places, people, events, etc. These facts are used when system is processing users query and inferring an answer to it, e.g. Evi, START, Wolfram|Alpha, Freebase use their own databases to search for information.
- **Web-oriented Question Answering Systems** search for the answer at the webpages, process the found information and return the result in a form of direct answer or structured overview on the topic of users query. Google Knowledge Graph and Ask.com use all information stored on the Web to search for an answer, while Answers.com has built-in reference library to trusted sources like books, dictionaries, encyclopaedias, etc.
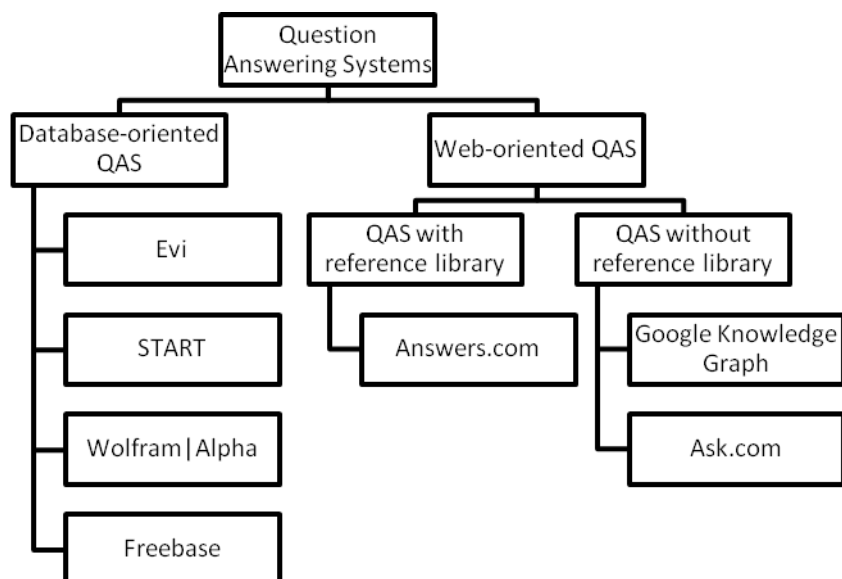

Figure 3. Information source based classification of Question Answering Systems.

This classification could be useful for those, who are interested in reliable information or, in the contrary, in any information that is stored on the Web about the query topic.

3.3. Language paradigm based classification

Classification based on language paradigm divides QAS by the number of languages used within query processing into three groups [4] (see Figure 4):

- **Monolingual Question Answering Systems** where user's query, resource documents and system's answer are expressed in one language. Evi, START, Wolfram|Alpha, Freebase and others process users query expressed in English, using facts from built-in database that also are expressed in English, and as a matter of course they return an answer expressed in English. Joost is applied to answer medical questions in Dutch [18], MIRACLE Question Answering System – to answer questions in Spanish. [19]
- **Cross-lingual Question Answering Systems** where user's query and resource documents are expressed in different languages and the query is translated into the language of resource documents before the search. Google Knowledge Graph translates queries inputted in other languages into English and returns an answer also in English, English-French cross-lingual system Quantum translates users query from French to English, processes it in English and translates the results from English to French [20], JAVELIN system performs cross-lingual question answering between English and Chinese or Japanese. [4]
- **Multilingual Question Answering Systems** where user's query and resource documents are expressed in different languages and the query is translated into the languages of resource documents before the search, e.g. system developed by The Health on the Net Foundation supports English, French and Italian, while DIOGENE system supports only two languages: English and Italian, but in contrast to cross-lingual systems the question can be posed either in English or Italian, the search is performed either in English or Italian, and the answer is given in the language of the question. [21]
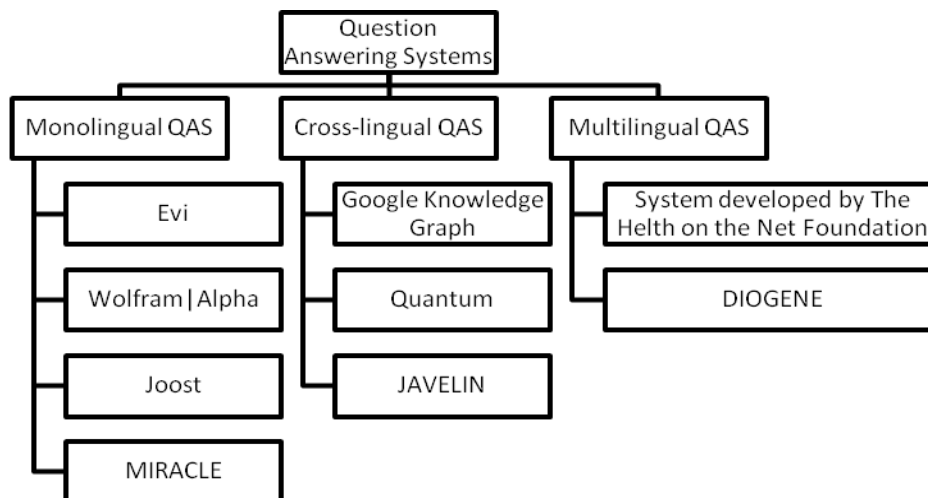
Figure 4. Language paradigm based classification of Question Answering Systems.

This classification is useful for a user who is searching for information in specific language which he/she does not know.

3.4. Working principle based classification

Question answering systems can also be classified by the working principle (see Figure 5), namely, there are:

- **Automated Question Answering Systems** where processing of a query, search for related information in a built-in database or in external resources and construction of an answer from

search results is performed without any human assistance. Evi, START, Wolfram|Alpha, Freebase and Google Knowledge Graph are examples of automated QAS.

- **Question Answering Websites** (QAW) that delegate processing of a query, search for related information and formulation of an answer to the community of users, like AllExperts, Answerbag and Blurtit.
- **Mixed Question Answering Systems** that join the main features of automated QAS and QAW, i.e. these are systems that have a built-in database, as well as the community of users for answering questions that cannot be answered by the system, e.g. Answers.com and Ask.com.
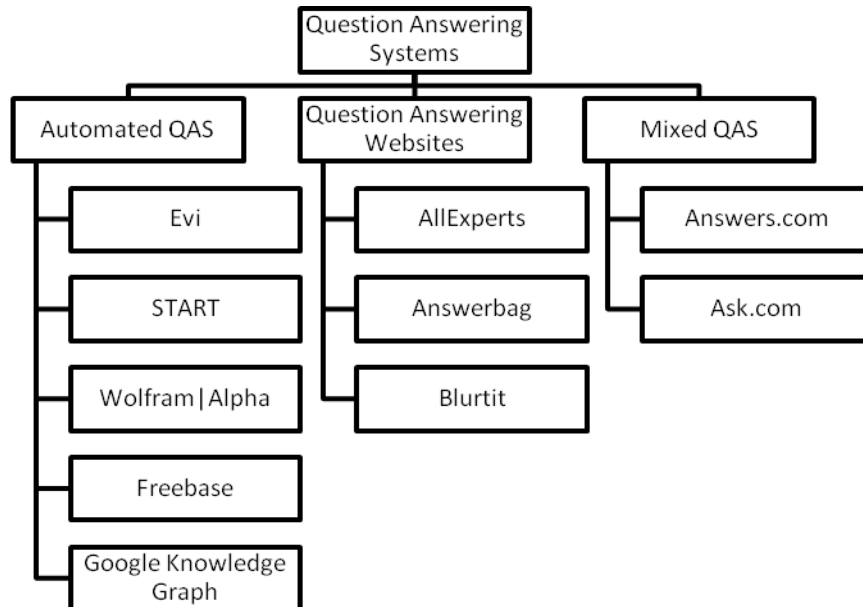

Figure 5. Working principle based classification of Question Answering Systems.

This classification is useful for a user who is searching for factual information or, on the contrary, for people opinions on some topic. In case of very specific question, e.g.: "*What high school classes are needed to become a zoo keeper?*" it is recommended to use mixed QAS, because using external sources system can find information on learning programs provided by high schools, while users community can share its experience, if there is someone, who works or worked in the zoo or in related organizations.

4. Conclusion

Question Answering Systems presented in the paper can be used in education for different purposes: a student can search for basic information on some topic he/she is new to, or search for an answer to some specific question that can be given only by an expert, as well as student can organize a discussion, collect user opinions and use them in his/her research.

Moreover, the QAS classifications provided in this paper are useful for those students that need to choose the most appropriate system depending on their search task type. For instance, if a student is interested in some specific topic, according to content based classification it is recommended to use restricted domain QAS. If a student is interested in any information that is stored on the Web about some topic, according to information source based classification it is recommended to use Web-oriented QAS. If a student needs information in some specific language which he/she does not know, according to language paradigm based classification it is recommended to use cross-lingual or multilingual QAS. If a student is interested in experts' opinions on some topic, according to working principle based classification it is recommended to use Question Answering Websites.

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