Multi-Lang Question Answering Framework for Decision Support in Educational Institutes

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Abstract: Language Diversity has always been an important factor in different educational institutes; Also, a challenge for those interested in Data Analysis, Question answering, and Natural Language Processing (NLP). Researchers who are interested in linguistics are involved in enhancing language processing techniques, and how to apply them. They usually work through Question answering systems or Chatbots. Question Answering Systems and chatbots are now highly recognized, especially after the huge commercial announcement for services such as ChatGPT and Google's new AI tool. Considering that these tools are very useful as open-domain tools. However, if we think from an institutional perspective, it will require further validation due to the domain type and the data type. it's also easier for the Decision maker to comprehend and use. During the past few years, many attempts have been made to include Question Answering Systems in the Education sector. However, most of these attempts were single language Software mostly using English. Also, targeted students as a decision-maker to support the education process between teachers and students instead of the educational actors on a strategic level. The scarcity of the tools available in this domain, make it a challenging topic that needs more research attention. In this research, we are Proposing a Multi-lang Question Answering Framework that aims to support the Educational Sector from a strategic point of view. It aims to provide a Generic framework that will help Universities Identify the Students who will be best fit for a specific university program. The framework aims to cope with and adjust to the data type and enhance its conditions from historical data. Regardless of the resource language and origin. It is based on an ontological model for the education domain and uses NLP to process the data and get relevant answers for the users. Future work for this research will focus on enhancing the retrieval for the system, especially using the Arabic language, and support more languages in the tool.

1 INTRODUCTION

Question Answering Systems (QA) are getting more exposure currently with the rise of new tools that support a general purpose. One of the main tools here is the trending ChatGPT, which was launched on 30 November 2022. The tool doesn't focus on a specific domain, instead, it is an open domain chatbot (OpenAI, 2022). The launch of the tool increased the estimated value of the company to 29 billion US dollars (Hao, 2022; Jin & Kruppa, 2023). Even though the ChatGPT is an Open-Domain, it impacted many domains including the Education domain. As per (Rudolph et al., 2023), ChatGPT has a huge impact on education and the learning process from both student and teacher perspectives. However, it is not concerned with the strategic or administrative perspective. Overall, the Question answering system is a powerful tool that is simple and provides replies to the decision-makers' questions using Natural language. It provides simple and precise answers to user questions. (Pudaruth et al., 2016).

Previously, many attempts were made in education to support decisions such as an attempt (Elnozahy et al., 2019) to apply the question-answering framework that was used to support student Orientation, Recruitment, and Retention,

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another one (Hien, 2018) which targeted staff support and help to answer student questions. Another attempt by (Colace et al., 2018; Okonkwo et al., 2020). These are just a small variety of research for using question answering in education support. But also, but also in other domains even in Chemistry Engineering as per (Zhou et al., 2021) the research showed a proof of concept of a system that grants access to accessing chemical data from knowledge graphs.

The tool mainly depends on Natural language processing to comprehend and analyze the data to extract correct answers. According to a review made in 2021 about Question answering in Education, it showed that most of the research considered just one language, mainly English. They consider 2 Latin languages, rarely considering Arabic (Elnozahy & El Khayat, 2021).

Based on a survey conducted in 2021 by (Alwaneen &Azmi & Aboalsamh, 2021) offered a summary of all the challenges of Arabic question-answering. This was concluded in the language nature and challenges including the lack of suitable tools and techniques based on the language structure compared to Latin and Romance languages. Especially the resource scarcity in this language compared to other languages such as English, German, French, Italian, Spanish, Portuguese, and Chinese.

In another survey conducted in 2022, a survey on Question answering tackled how the tools are working and the type of data sources. And the majority was open domain similar to ChatGPT. (Antoniou & Bassiliades, 2022). One of the proposed attempts in 2022, was a cross-lingual Question answering system which considered Arabic-English resources and processing. (Elnozahy & El Khayat, 2022).

In this Research, we are proposing a Muli-lang Question answering framework that supports strategic decision-makers in universities. It provides insights & recommendations on which students will be the best fit for a specific university program through the review of students' competencies. The System is a further enhancement of a Question answering framework provided in 2019 (Elnozahy & El Khayat 2019) and static language handling (Elnozahy & El Khayat, 2022). In this research, we are trying to overcome the language barrier by not just considering the Arabic language but proposing a generic free language System.

This paper is organized as follows: Section 2 contains a review of the related work and literature, section 3 presents the Multi-lang Question Answering Farmwork and the proposed implementation, and the discussion and future work are in section 4.

2 LITERATURE REVIEW

In this section, I provided a review of the related work and literature to the problem under study. Starting with a review of Natural language processing in Arabic & Latin Languages, recent work on Question answering and its handling, and Question Answering systems in the education Domain.

2.1 Natural Language Processing in Arabic & Latin Languages

Natural language processing (NLP) is the process of analyzing languages that are responsible for developing techniques and tools that can support language analysis whether in written or spoken forms (Marie-Saint et al., 2018). The natural language processing techniques are used in various applications such as sentiment analysis (Verma & Jain, 2022), text categorization (Chang et al., 2008), web page spam detection (EL-Mohdy et al., 2018), translation (Harrat et al., 2019) and many more applications.

Language processing has different challenges based on the language. For instance, if we consider Arabic Natural Language Processing, the complexity is higher than most of the other languages concerning the following:

- The shape of the language is different from normal Latin letters.
- The form of the letters has one vs multiple forms.
- Grammar rules, and the fact that changing one letter in a word may change its tense completely.
- Sentence compositions considering that one word can have multiple meanings based on the context and is represented as a sentence in English (Marie-Saint et al., 2018)

Same consideration is to be noted when working with other languages such as Chinese, where one letter can represent a full sentence. However, the Chinese have multiple resources and materials, unlike the Arabic. (Conneau et al., 2019). A wide range of attempts is constantly being made to provide language tools that would make processing easier Using various approaches such as Machine learning

approaches, semantic approaches, deep learning, and other approaches. It is mainly done through a set of techniques such as Sentiment Analysis, Named Entity Recognition (NER), Keyword Extraction, Lemmatization, and stemming techniques (Elbarougy et al., 2020; Bourahouat et al., 2023).

Sentiment Analysis is a way to evaluate the feelings of the word, either negative or positive, or natural feeling. It uses various techniques such as figure 1, a machine learning approach using supervised and unsupervised learning techniques, or lexicon-based approval that either uses a dictionary, statistical methods, or semantic methods (Abualigah et al., 2020a).

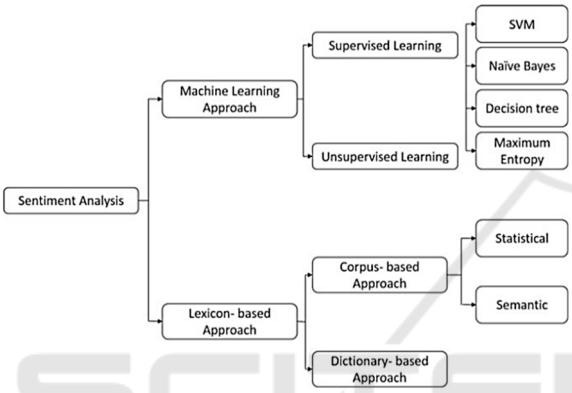

Figure 1: Techniques for Sentiment Analysis.

Also, the Named Entity Recognition technique, is a process where the system tags the sentences based on the related entity such as [Organisation, person, location, time, and measurement (Shaalan, 2014).

Then we have the Text Summarization techniques, which can be explained as the process of eliminating the extra text to keep the core goal and important elements of the text of the document. (Al-Abdallah & Al-Taani, 2019). The techniques can be summarised based on multiple models for example using semantic analysis, fuzzy method, Neural network-based method, and machine learning methods. (Abualigah et al., 2020b).

To be able to perform the previously mentioned application a set of actions or steps are mostly in action to do text pre-processing and handling which can be specified in the following details or crucial steps. **Tokenization**, the system splits the paragraphs into tokens ``words". This is harder to do in Arabic as sometimes the same word is a sentence, or two words would form one word. (Alotaiby et al., 2009). **Normalization,** where we unify the look and feel of the text by Removing diacritics, punctuation, and any whitespace duplication, also remove the definition letter in English "the, a, an", in Arabic "ال" in French "le, la, les, las" to unify the letters despite its different looks (Gharib et al., 2009). **Stemming and lemmatization**, which is replacing the word with its stem. stemming is done using tools such as a rooted stemmer or light stemmer (Alhaj et al., 2020). Also, using N-gram techniques (Yousef et al., 2014). Once the stem is done, the lemmatization process starts to get the root word through morphological analysis. **Morphological Analysis,** an advanced process after stem (lemmatization). It aims to get the root of the world based on its morphology. It's simple for English. Also, contributions are made to Arabic and other languages. For example, Buckwalter Arabic Morphological Analyzer (BAMA) a main contribution since 2004 (Buckwalter, 2004), then by 2017 another contribution of Alkhalil Morpho (Boudchiche et al., 2017). **Part of Speech Tagging [POS]** at this point a syntactic role is assigned to each word. The three main POS's: Noun, Verbs, adverbs, conjunctions, interrogative particles, and interjections. There are many tools available in different languages including Arabic that can be used here. (Abumalloh et al., 2016; Chiche & Yitagesu, 2022; Li et al., 2022).

As per (Elnozahy & El Khayat 2022) many tools are created by other researchers to support different languages such as word2vec, Bi-directional Encoder Representations from Transformers (BERT). Which has an alternative in other languages for example in Arabic it works on Aravec and Arabert. We can sum this up by saying that each language has a set of tools created using known Machine learning techniques to overcome most of its obstacles.

2.2 Question Answering Systems

Question answering is a generic framework that provides a very sophisticated yet simple and insightful result. The framework consists of multiple sections/ modules, the data source, and whether it's internal or external. The processing ability and techniques or what's called the approach. Then the extraction and representation.

2.2.1 Question Answering Techniques & Approaches

As per the literature, question-answering systems have five approaches which are the Linguistic approach, statistical approach, pattern matching, and surface and template-based approach. Each approach has its unique methodology and handling. Also, some intersection between the approach techniques would happen (Elnozahy & El Khayat, 2021).

- The linguistic approach uses Natural Language Processing (NLP) Techniques to understand and evaluate the question. Also, through Tokenization, part of speech (POS), tagging and parsing, etc. it can extract and identify the answer (Sasikumar & Sindhu, 2014).
- The statistical approach gives better results than other approaches as it is independent of structured query languages, also it can formulate queries in natural language form. It mostly uses statistical techniques such as Support vector machine classifiers, Bayesian Classifiers, and maximum entropy models.
- The Pattern matching approach is used to interpret input sounds or utterances through the merging of the words meaning. Here we have fixed patterns that are being matched with words' patterns. This approach replaces the sophisticated processing in other computing approaches through the expressive power of text patterns (AbuShawar & Atwell, 2016; Dwivedi & Singh, 2013).
- Surface Pattern-based approach is learning based on patterns that are automatically learned from data. It surfaces the text to get the similarly crafted data that is related to the Question (information needed). It is considered a method for Pattern matching.
- The last approach is the template-based approach. Which works on a template of keywords and data "questions preformatted patterns". The main goal here is the demonstration in replacement for the explanation of question and answer.

In a review paper about Question answering (Ojokoh & Adebisi, 2018) a categorization of the question-answering systems in terms of the following criteria.

- Domain Classification whether it's the open domain or closed domain.
- Question types such as factoid or WH-Questions, list, causal questions, etc.
- Data Source classification
- Language classification where it's classified based on the number of supported language figure 2, (Lebedeva and Zaitseva 2015)

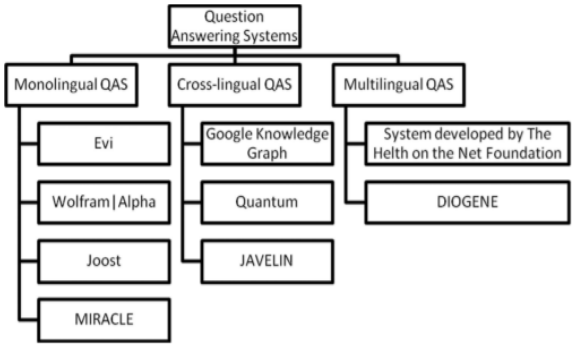

Figure 2: Language paradigm-based classification.

- **Approaches classification** where the QA systems are grouped based on the approach they are using by NLP, statistical, or pattern.

2.2.2 Question Answering Systems Architecture

The simple architecture for question answering can be represented in the following 3 main steps: (Zhu, et al., 2021)

- Question analysis
- Search for the data source
- Extract answer.

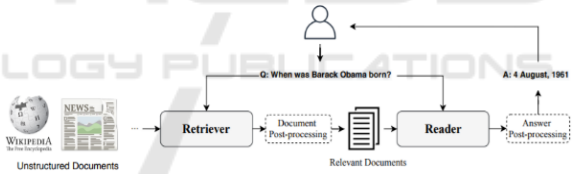

Figure 3: QA "Retriever-Reader" Architecture.

In figure 3, an overview of the question-answering process is represented starting with the user asking a question then it is sent to the reader to parse then searched to retrieve the data, then the data is evaluated based on the score to get the correct results. The data source provided could be a Document as shown in the example explained in the figure, or a different source based on the database, or ontology.

A Question Answering called "YodaQA" stands for "Yet anOther Deep Answering pipeline" was built to work on unstructured sources. DBpedia ontology & the Freebase RDF dump are the main sources for this system. DBpedia is an online ontology created in 2007 (Auer et al., 2007). Systems use full-text search, structured search, and document search. as search techniques (Figure 4) (Baudiš & Šedivý, 2015).

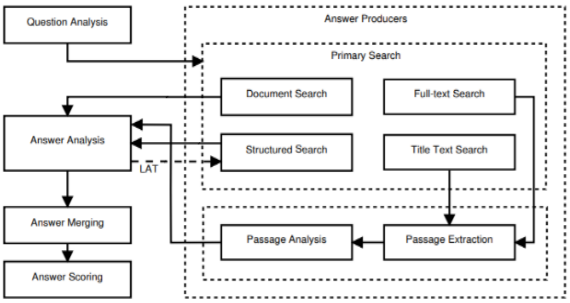

Figure 4: QA process Pipeline.

A Question Answering model by (Elnozahy & El Khayat, 2019) gathers data from multiple data sources in the university. The framework is divided into 3 main sources: the new student data, university programs data, and their related requirements, and historical data See figure 5.

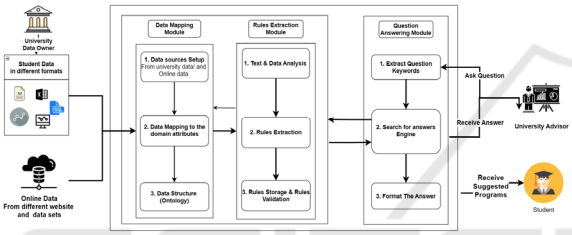

Figure 5: Question-answering framework.

Many contributions are made inside and outside the education sector, however, in this paper we will focus on the handling inside the educational Domain.

Based on a review made in 2021 regarding the Educational Question answering systems showed the different aspects and goals of educational systems which can be summarised in 3 categories.

First, The Students' Support effect can be summarised in the following:

- Provide the material of the course to its students and help them get the material and study.
- Provide accurate information about the subjects and the course content.
- Create an interactive environment and engaging experience that will make the learning process better.
- Provide answers to Students to help them through the administrative steps needed.
- Get individual help, especially for specific cases.
- Also create a personalized experience for the student to make the learning process fun.
- Provide advisory roles for students and help them make academic decisions for their programs or activities.

Second, the Professors' Support can be stated in the following:

- Allow professors to understand the students more.
- Forecast the student's behavior by Modelling his learning style.
- Provide student profiles for the professors based on the personalized learning process.
- Help the Professor assess the student's progress.
- Enables teachers to analyze and assess a student's learning ability (Durall & Kapros, 2020; Ndukwe et al., 2019; Sreelakshmi et al., 2019)

Lastly, Management Support which contains the least number of contributions which can be summarised in

- Help in determining whether to accept or reject the student's admission (Elnozahy et al., 2019).
- Reduce the frequent static work [administrative tasks] that require lots of time (Hien et al., 2018; Ho et al., 2019; Ranoliya et al., 2017).

When investigating the different languages of the Question answering system, we found that most of the resources available and datasets are mostly in English. There has been a lot of work on translating English QA datasets to Arabic (Mozannar et al., 2019). This research was an open-domain QA based on the Wikipedia article. It considered translating using the Stanford Question Answering Dataset (Arabic-SQuAD). It's common based on the literature to use the translation when having multiple data sources with a different language than the user language. This approach is useful considering the great development of NLP techniques and their accuracy (Bensalah et al., 2022) also (Tahsin Mayeesha et al., 2021) the contribution was using (SQuAD) data but is translated into the Bengali language. the contribution made by (Artetxe et al., 2020) showed that the translation of datasets and artifacts would produce new knowledge. Many Bilingual and Cross-lingual QAs were created based on this Idea which helped overcome many issues.

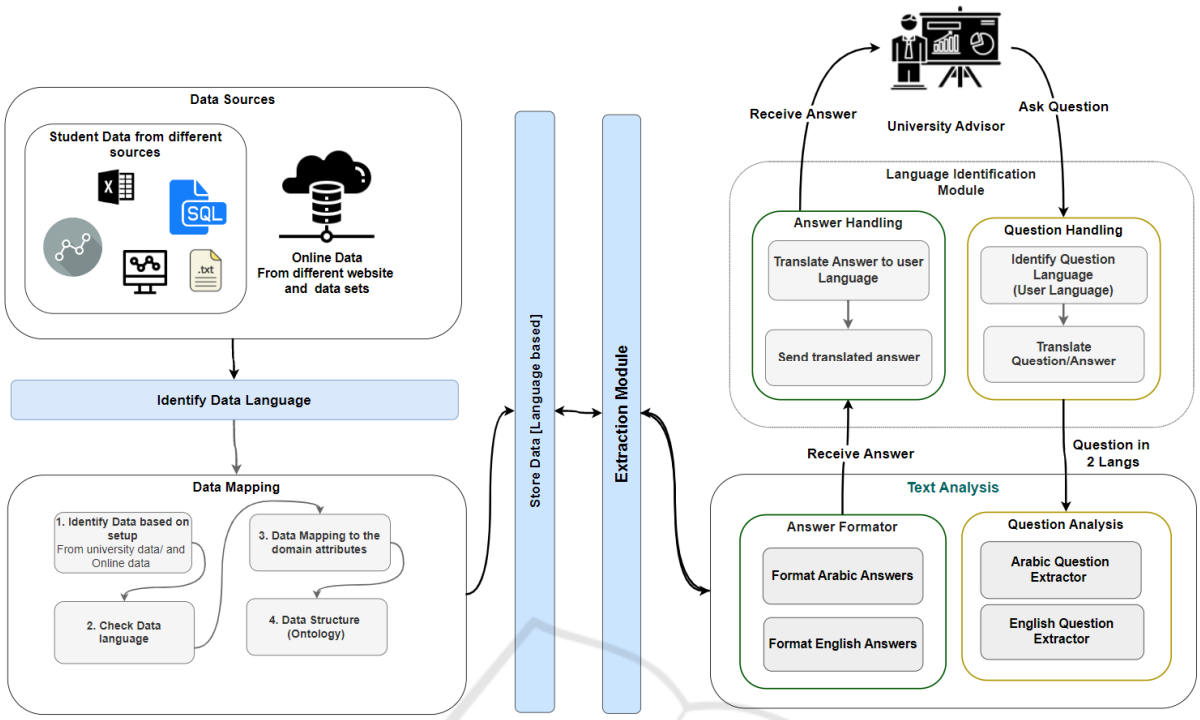

Figure 6: Multi-Lang Question Answering System.

3 PROPOSED MULTI-LANGUAGE QUESTION ANSWERING FRAMEWORK

Initially, the proposal here is an enhancement of the previous work done in (Elnozahy & El Khayat, 2019) and (Elnozahy &El Khayat, 2022). These papers proposed a university framework that supports decision-makers in determining the suitable students for a specific university program. It gives a recommendation based on program requirements and student competencies.

The Framework as stated before is for universities to help identify the most appropriate students' profiles for different programs. the identification is done through textual data analysis from university data, open source data, and student activities data. These data can be the students' expressions about what they would like to do in their future careers for example. It will be gathered when the student applies to the university program through the system used. In the following sections, we are going to start with defining the proposed solution components and Overall structure, then provide the system analysis and technical structure diagrams that will help us with the implementation later.

The proposed solution was limited to one language, then proposed an extension to two languages. The proposal had limitations in terms of language. Especially with the different types and dialects of the data. Which contains Arabic, English, and French. Which makes supporting just one language or a cross-lingual enough. The proposed solution is based on language detection and translation ability integrated with the extract module.

The framework shown in figure 6 behaves as the following:

First, in terms of data Saving and Identifying

- Data sources are configurable and can contain multiple sources with different types and extensions.
- Once configured a language detector runs. To identify the data source language, and whether it's just one or multiple languages.
- Once detected, the system relates the data to domain attributes and maps it to the ontology.
- Once all is done, data is saved based on the language in the data store.

Second, the Question processing module

- Starts with users asking questions.
- System identifies question language.
- System analyses the question based on the language.
- Once done we move to the extraction module.

Third, the Extraction module, this part starts with:

- Identify the available language in the system ex. [Arabic, English, and French]
- System translates the question to these languages and starts searching the data store to get these data.
- Once data is found, the system returns the data to the next module [forming answers].

Forth, in the Answer formatting module, after extracting the answer, the system behaves based on user question language. Get all the data and transform everything to the user's language then formulate the final answer.

The proposal is aiming to achieve justice while selecting and recommending students to the different programs. The students in our university case are learning in Arabic, English, and French. we have a department per each. while the proposed programs are available to all students if they can achieve specific levels for the prerequisites. Using the system, the university administrators will be able to find the students who are the best fit for this program. as the system was restricted to English, it caused a lack of information as it initially ignored all the Arabic and French data. so instead of doing a custom-made solution per language. the proposed framework which mainly depended on back-and-forth translation for questions & answers. which will make the result free of the language barrier.

The framework is proposing a university system, where some administration and setup are required to define all sources for the data. Then setup and allow language identification and determine allowed/ needed languages in the system. Accordingly, the results will be extracted. System itself is dynamic and domain data is updated as per the provided data. The ontology entities can be developed from the analysed data itself through the Named Entity Recognition NER.

The framework develops a highly generic way to extract and answer decision-maker questions without considering the language barrier. In the end, it provides high-quality results and accurate information about the data from all of the students' historical data, current data, and other related program data.

4 DISCUSSION AND FUTURE WORK

In this paper we proposed a new attempt to create a Multi-language Question Answering Framework. The framework aims to provide a tool to help support education decision-making in universities and educational institutions. The proposed solution goal is to increase the amount of information gathered from university data by using different languages. This is a generic framework, so it will adjust if new data is fed with a new language.

This framework has many challenges that would be validated and contribute to the results of the framework such as the language detector works with multiple languages including Arabic with all its complexity. The paper considered the complexity of the translation module and the different nature of the data inside the system. All are to be applied to the student's assignment process for academic programs.

Another challenge is the development of the language analysis for the data and the question. which is also called pragma-linguistics analysis. going deeper with such an analysis will allow the system to identify deeper meaning for the data and identify the intentions not just the text itself. which will develop the system understanding and expressing methodologies.

A further enhancement would be applied to the question-answering system to enhance and confirm the techniques used in translation. Also, the mapping considers different languages. Validation and testing are highly considered in this framework as multiple rounds will be needed before confirming a valid result which can be confirmed by comparing real-life examples with the system result which shall be considered as a further enhancement in the future.

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