A Survey of Searching and Information Extraction on a Classical Text Using Ontology-based semantics modeling: A Case of Quran

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Abstract: Quran is the religious text of Islam. Followers of Islam believe that it is the verbatim word of Allah (God). In the last few years, the Quran has become a target of interest for researchers in the field of computer science, for exploring the divine knowledge encapsulated in it. Since the last few years ontologies have gained significant importance in computer science research because of its machine understandable and semantic nature. Ontologies play an important role in supporting the notion of the semantic web. Some work has been done on the Quran exploiting the platform of ontologies. This paper presents a survey based on recent works which uses ontologies as a means of representing and encapsulating the knowledge of the Quran. In order to compare the reviewed literature, an authentic framework is used which is applicable to any ontology application. Furthermore, the paper includes a comprehensive comparison table based on the framework which allows the readers to understand the details of all works in a glance. At the end of the paper, the conclusion and future work section highlights the shortcomings of the existing works and give a sense of direction to aspiring researchers in order to contribute to the domain of the Quran.
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1. Introduction

Information extraction (IE) is the field of computer science that deals with analyzing unstructured sources of text containing natural language for extracting facts and relevant information. This process requires NLP techniques, machine learning methods and statistical analysis. At a conceptual level, for the purpose of IE it is imperative to know what the underlying text means and this knowledge is called semantics. Semantics deals with the meanings contained in the text and this knowledge is need to be known before hand for information extraction to be successful.

The knowledge base for any domain can be expressed using an ontology which represents the entities and their relations which can be traced to the text which contains the information, albeit in an unstructured format. Therefore, it can be observed that IR and ontology are related because of their involvement in two related tasks; ontology is used to describe the knowledge contained in the sources of text and IR is a set of techniques and methods that are used to extract information related to the knowledgebase described the ontology. Ontology based IE is a relatively new field since other techniques have been in place for a longer period of time but with the advent of Semantic Web or Web 3.0, domain ontologies are going to be used more and more. Ontologies are already used extensively used in the field of biology and medicine.

Classical religious texts are prime targets for applying ontology modeling to extract hidden information for multiple reasons which are both computational and non-computational. Computationally, the books like Quran contain semi structured information because of the organized structure of numbered Chapters (Surahs) and Verses (Ayahs). This makes for an easier modeling problem as opposed to a completely unstructured text such as a novel or an auto biography. Another advantage with a classical book like Quran is the definite set of themes and concepts that appear in the book so the taxonomy of concepts is less of a challenge as opposed to a completely unstructured text e.g. a novel. There are also compelling non-computational reasons for exploring the potential of ontology-based

IR in religious texts. Firstly, the knowledge contained within the religious text resides with the human experts of the book who have devoted many years to their study. Any attempt to master this knowledge or make decisions according this knowledge requires human expertise.

This is a key issue as this intrinsic knowledge is not easily transferable, freely available, complete, inconclusive and in some cases even unreliable. This issue can be at least partially solved if the knowledge is made available in an easier manner for the experts i.e. scholars of the classical religious book as well as those who are interested in knowing more about the book. Knowledge sharing becomes easier. The second reason is the global context in which communities exist in the world today and conflicts and misunderstanding resulting from lack of interfaith know how. This freely available knowledge can enhance cooperation between cultures and communities and in some cases identify potential issues so we are better equipped to face them.

This paper focuses on Quran as this classical book has no known multiple versions or editions and is easier to initiate the research out of the major religious texts such as the Old Testament and the Bible. It is also more relevant to the non-computational reasons given earlier due to the perceived link between Muslims and Terrorism.

This paper surveys the nature of work that has been done till date on this aspect of the Quran in the field of computer science. The rest of the paper is divided into the following sections. Section 2 is an overview and classification of the current work. Section 3 is evaluates the work presented and its merits and demerits. Section 4 concludes the paper and lays direction for future work.

2. Literature Review

In [1] a framework has been proposed to represent the unique blend of knowledge that exists in the Quran. It takes into consideration types of verses, causes of revelation (Asbab al Nuzul), Nasaikh Mansukh (science pertaining to cancellation or overriding of verses by later revelations), narratives and the categorization of the verses based on the type of commandments. Ontology generation would be done after separating noun phrases and applying pruning process. Salah (prayer) has been used to perform this activity as an initial step.

In [2] and [3] semantic field theory has been used to perform componential analysis of the nouns appearing in the Quran. The nouns selected are part of the domain of Time. Semantic field theory treats words as parts of the field. A field consists of a group of closely related words or semantic units. Each word has a distinctive feature which sets it apart from others. In [3] two approaches based on this theory are presented for designing an ontology on Time domain i.e. , class based and instance based. In [2] this ontology has been created and populated. This ontology can act as vocabulary for other rich applications for learning and teaching meanings of the Quranic words.

A multi-agent framework has been proposed in [4] which aims to build an ontology representing the literary forms which exist in the Quran. Various literary forms have been listed such as Analogy, Metaphor, Oaths, and Narratives and so on. A basic starting ontology or 'seed' ontology is created by domain experts which is used by various agents to extract related terms from WordNet to create Topic map. Tokenization of the corpus, part of speech tagging and lexico-semantic pattern matching is done by another agent to create Concept map. Using these two maps an intermediate ontology is produced which is processed further based on the authors' own algorithm. Using this framework, verses related to a particular literary form can be discovered. Ontology is used to describe the structure of the Quran in [4] in terms of its Juz (parts), Surah (chapters) and Ayahs (verses).

In [6], a framework has been proposed for information retrieval (IR) from Quran related documents containing unstructured data from various sources online such as web pages, PDFs and text files. The documents are annotated semantically after undergoing NLP methods such as stop words removal, stemming, morphological analysis. The annotated documents are stored in a relational database. Meanwhile the Quran's knowledge is represented in domain knowledge ontology built in RDF/Owl that links concepts in the Quran with the verses contained. User's queries seeking this information is taken in natural language and broken down using the same processes of NLP as the source documents. This is then matched with the concepts in relational database to find the matching concepts in the ontology and documents and verses which match with the user input. The results are then displayed to the user.

In [7], Semantic search has been handled using WordNet's synsets using relational database. Query word from the user is first studied for word sense disambiguation which basically means obtaining a single sense of the word out of multiple senses. For the determined sense, the synsets are used for obtaining other synonyms of the word and the

relevant verses are retrieved. The relational databases stores topics along with its parent topic. The synonyms are linked to the topics. Each synonym belongs to a synonym type as various cases are handled such as exact synonyms, weak synonyms, hyponyms and meronyms. This allows users to obtain all the relevant verses for a topic based on the initial input, something which is not possible by keyword search.

A framework for accessing and managing modifications to religious content in documents has been proposed in [8] which uses semantic annotation. The framework is based on a trace model in which an individual trace represents a single atomic change to the content. The content is available in textual format in the source documents such as an xml file or a text file and the conceptual knowledge is available in the form of classes and instances in domain ontologies. The trace comprises of the modification, links to the source document, domain ontology and relevant class and instance, meta attributes namely the creator, unique id of the trace and time stamp. The trace model has been implemented using graph using RFD triplets. This means a trace can be implemented using 6 to 8 RDF triplets. The changes are bi-directional meaning a change in the source document will be reflected in domain ontology and vice versa. To enforce this, consistency constrains called 'trace invariants' are proposed which enable this bi-directional compatibility such as change representing only one concept in the domain ontology at a time and be linked to exactly one source document. No implementation was available in [8].

A model driven approach based on XML has been used in [9] to aid learning and understanding of religious texts. It has been applied to the Quran as a case study. The model consists of metadata about book, chapter and verses for any book that follows this structure. The metadata is stored in XML format and has custom tags. Metadata is categorized into two main categories; static and dynamic. The static metadata is external to the text of the book and contains information such as the place of creation, date of creation, method of creation, reason of creation, writer's name, topic, etc. The dynamic metadata is about the actual content of the text and consists of part-of-speech, named entities tagging, comments of individual words. The metadata model is class based or frame based, meaning it models the domain based on classes sans the methods and behaviour of OOP. The static metadata is stored in the same file as the actual text whereas the dynamic metadata data is stored in separate files. The reason is to facilitate the modification, sharing and editing of dynamic content. The model is implemented in limited scale for a single Surah (Chapter) of the Quran.

In [10] ontology is created for showing taxonomy and classification of concepts which appear in the Quran. The concepts are presented in the form of a graphical ontology on the Leeds' corpus Quran website. The ontology has 300 concepts and about 350 relationships between these concepts. The concepts can be selected which expand to show sub-concepts in the taxonomy. This ontology is used in the search engine of the website . The search engine retrieves semantically relevant verses based on the input and not just the keyword. A query for word 'man' in English returned verses pertaining to not only إنسان but also verses which had synonyms (eg رجل) and subtypes of man such as رسول،صديق and شهيد .

In [11] semantic search on the Quran is done using ontology that is based on Leeds University's Quran ontology. Additional concepts have been added to the Leeds Ontology which captured only nouns such as people, places and things. In [11] concepts for actions are created additionally as well major super type of concepts. The Leeds ontology is recreated in the OWL language using the tool Protege. The work shares multiple queries in the Manchester OWL syntax and their results for searching the ontology using a reasoner. The queries have been tested inside the Protégé tool and a search engine capable of handling natural language is in works.

3. Comparing literature using ontology classification framework

This is section presents a comparison of the literature reviewed. This comparison is based on a generic framework for understanding and classifying ontology applications presented in [12]. The comparison focuses on the role of ontologies in the work reviewed and how their usage can be compared to ontology applications in other areas. While comparing, no distinction is made between ontology applications related to the Quran and ontology applications elsewhere. It helps us answer important questions such as "Does the study of Classical texts compels us to use ontologies in a novel way?" or "Can the well-known practices of ontology usage be applied to Classical texts such as Quran?" Comparing with other known methods of ontology application also sheds light on as the potential of the proposed method or application and its maturity and applicability. The framework used for comparison is

described briefly next.

3.1 Ontology Framework

This framework is proposed in [12] and is applicable to any ontology application. The purpose of the framework is to promote understanding the commonalities and differences of the heterogeneous ontology applications and improve the exchange of ideas in the ontology community.

The framework reviews ontology applications in the following aspects:

The purpose or benefit: The ontology may be used for one of the following purposes:

1. Communication between people
2. Inter-operability between applications
3. System Engineering benefits such as specification, reliability, reuse, maintenance, knowledge acquisition

Role of Ontology: What role the actual ontology itself has in the application that consumes it. Three information levels depict this

1. Operational Data (L_0): Information application generates and consumes at runtime using ontology defined at L_1
2. Ontology (L_1): Information based on the terms specified, key concepts and the relationships between them in a domain. The ontology is written using the language defined at L_2
3. Ontology Representation Language (L_2): The information which is used to author the ontology at L_1 and defined in a language syntax.

It can be said that for information at L_n , information at L_{n+1} is utilized.

Actors: These are the roles which people or applications play in an application such as Ontology Creator, Knowledge worker, Application Developer, Data author and Application User.

Representation of meaning: This refers to how the meaning is represented in the ontology. Two concepts are important. *Formality* which includes natural language, structured natural language, expressed in a formal ontology language, highly formal with axiomated with theorems, proofs etc. The other important concept is *amount* of meaning which implies the number of possible interpretations. The greater amount of meaning, fewer the possible interpretations hence lesser ambiguity in the ontology.

Supporting Technologies: Tools and languages used to author an ontology, translate it to other consumable formats needed for the application.

Maturity Level: The degree to which the application and the supporting technologies are mature and tested in the practical world. (implementation in research implementation commercial production, etc).

3.1.1 Scenarios

Scenarios form the crux of the framework as all ontology applications fall roughly into one of the three main scenarios. These scenarios are briefly described next.

1) Scenario 1: Neutral Authoring

The purpose of neutral authoring is to allow reuse of knowledge and easy maintainability. An ontology author creates an ontology that is translated into one more target applications. End user interacts with these applications. A change in the conceptual schema i.e. , in ontology can be propagated to all the applications. A key aspect of neutral authoring is this the change is unidirectional i.e., from ontology to target systems and not vice versa.

2) Scenario 2: Common Access to Information

In this scenario, multiple sources of information which are otherwise heterogeneous and cannot communicate with each other, are able to use each other's application based on a mutual ontology. Each target system (can be human or application) maps its own information with the central ontology either in the form of its own local ontology or direct mapping with the concepts in the ontology.

3) Scenario 3: Indexing

Ontology aids in searching by behaving as index for the repository to be searched. The metadata is contained in the ontology that has additional information about the information to be retrieved such as location, features etc which are applied by the search engines.

3.1.2 Application of the Framework on the Literature Reviewed

The work reviewed can be classified using the framework described. The framework described in [1] covers only one topic from the Quran i.e. , *Salah* or prayer. The work aims to define a complete list of other terms in the Quran using also the information present in the books of Ahadith. This makes this work qualify for the neutral authoring scenario since the ontology can be consumed by multiple applications without directly interacting with each other. The supporting technologies are not defined and implementation details are also not shared hence this work has a very low maturity. The proposed benefits are knowledge sharing and reuse and increased maintainability.

Table 1. Summary of Literature Review

Paper	*Purpose or benefits*	*Role of ontology*	*Supporting technology*	*Actors*	*Maturity*	*Neutral Authoring*	*Common access to knowledge*	*Indexing for search*
Saad et al [1]	*Knowledge sharing, reusability*	L_1	*Not applicable*	*Ontology Author (O.A), Knowledge Worker (K.W)*	*Very Low*	*Yes*	*Not applicable*	*Not applicable*
Al Yahya et al [2]	*Knowledge extraction, knowledge sharin &, reusability*	L_1	*Ontology Web Language (OWL)*	*O.A, K.W*	*Low*	*Yes*	*Not applicable*	*Not applicable*
Al Khalifa et al [3]	*Knowledge extraction, knowledge sharin &, reusability*	L_1	*(OWL)*	*O.A, K.W*	*Low*	*Yes*	*Not applicable*	*Not applicable*
Petiwala & Sathya [4]	*Not Available*	L_0, L_1	*Java, GATE API, OWL*	*O.A, Data Author(D.A,), Application Developer (A.D,), K.W*	*Low*	*Yes*	*Not applicable*	*Yes*
AL Ksasbeh et al [5]	*Knowledge reusability, knowledge sharing*	L_1	*OWL, RDF Protege*	*O.A, K.W*	*Low*	*Yes*	*Not applicable*	*Not applicable*
Qurat-ul-Ain & Basharat[6]	*Information extraction, knowledge sharing*	L_1	*OWL, WordNet, Java JAWS API, JENA API, Apache API*	*O.A, A.D, K.W, Application User (A.U)*	*Low*	*Not applicable*	*Not applicable*	*Yes*
Shoaib et al[7]	*Information extraction, knowledge sharing*	L_0, L_1	*Wordnet, MS SQL Server, VB.NET*	*O.A, K.W, A.U*	*Medium*	*Yes*	*Not applicable*	*Yes*
Javed et al [8]	*Maintability, reusability, information retrieval*	L_0, L_1	*OWL, RDF*	*O.A, K.W*	*Low*	*Not applicable*	*Yes*	*Yes*
Nassourou [9]	*Information retrieval,reusability*	L_1	*XML, Java, JSP*	*O.A, K.W, A.D, A.U*	*Low*	*Yes*	*Not applicable*	*Not applicable*
Leed's Ontology [10]	*Information retrieval*	L_1	*Not Available*	*O.A, K.W, A.U*	*High*	*Yes*	*Not applicable*	*Not applicable*
Yauri et al [11]	*Information retrieval*	L_1	*Manchester OWL, Protégé*	*O.A, K.W*	*Low*	*Yes*	*Not applicable*	*Not applicable*

In [2] and [3], nouns in the domain of Time have been captured in the domain ontology using the semantic field theory. No application or framework is provided on how to consume this ontology but it is hoped that the ontology will form the basis for covering all other domains of the Quran to give in-depth knowledge about the Quranic words. They will be consumed by applications for the end users' benefit. This is again a case of neutral authoring. The supporting technology is Ontology Web Language or OWL and the tool used in Protégé. The maturity of this approach is low but higher than the previous work OWL is a proven standard. Similarly, the semantic field theory is a known concept. The representation of meaning is also high in this ontology as each word is broken down in to semantic units which leave very little room for ambiguity. Purpose and benefits include increased understanding of knowledge as well as the ones mentioned for [1].

In [4], ontologies are used as both for neutral authoring and searching index. This is in the case of the seed ontology developed by an ontology author which acts as the basis for developing the conceptual schema and annotation. The final product, literature ontology is then used for retrieving ontologies and is

used as the searching index. The supporting technologies are the OWL language and GATE API's for Java for ontology. The actors are human and the multiple agents presented in the work for automatic population of the schema.

In [5] the structure of the Quran is represented as an ontology. It is difficult to classify the work of this nature because there is no specific detail about how this ontology would be consumed by a target application.

The DataQuest framework presented in [6] for extraction of knowledge in multiple sources such as web pages, PDF files, text files for searching Quran verses using a combination of WordNet, ontology and a relational database for mapping verses, concepts and relevant documents. Ontology is used here as an index for searching and annotation the repository. The actors are humans both as knowledge workers and ontology creators. The application is implemented as part of the demonstration. The supporting technologies are OWL for creating ontology, JAWS API for Java for accessing WordNet, JENA API for manipulating the ontology using Java among other Apache API for PDFs and HTML files. The database used is MySQL. The maturity level of this application is higher than other work due to the higher degree of implementation and usage of well-established tools. Benefits include homogenous searching for information residing in heterogeneous sources and concept related search.

In [7] ontology is developed using relational databases. The work captures synonyms in the forms of synsets from the WordNet project and stores relevant concepts, verses and the synonyms. This allows for word sense disambiguation in searching for the relevant verses. The scenario covered is indexing as the ontology enriches the concepts by adding synonyms. The major benefit is better knowledge retrieval by the search engine. The actors are ontology author, knowledge worker and application user, all of which are human. The work is not implemented in a search engine yet and is available for other applications which is why it also partly covers the scenario for neutral authoring in which an ontology can be used by multiple applications unidirectionally. In this way the role of the ontology would change from L_1 i.e., ontology to L_0 which the operational data in Scenario 1. The supporting technology is relational databases and WordNet both of which are very mature. It can be said that this work has more potential for maturity than most of the previous works as it uses tried and tested technologies.

Ontology is used to model religious content in [7] which is present in the Quran, books of hadiths and Sharia law. The content is managed using semantic annotation and semantic trace modeling is used to keep track of changes in the content as well as the ontology that represents that knowledge. The change is reflected bidirectionally ie a change in a source document would be seen in the ontology that represents it and vice versa. The ontology here has multiple roles and thus covers more than one scenario. For the purpose of content management, the ontology covers Scenario 2 of common access as it allows sharing and managing heterogeneous data. The ontology serves as the metadata for rich semantic search for the Islamic concepts in religious sources which is a case for Scenario 3. The supporting technology used is graph databases and RDF which is a mature approach to representing data. Perceived benefits include maintainability, reusability and information retrieval.

In [9] Ontology is created to store annotations for the static and dynamic knowledge about chapters and verses of the Quran. This is a scenario for Scenario 1 which is Neutral authoring. The ontology is at Level 1 as it is consumed directly by the application. The actors are ontology creator, Knowledge worker, application developer and the application users. The benefits are information extraction and reuse. The prototype developed is incomplete and in the initial stages. The maturity is thus low.

In [10] ontology is made for the entire Quran. This is the only work to date that is based on the entire Quran and not just a subset of the corpus. The ontology is found to be used in the project website's search engine. The scenario is Neutral Authoring and the level of ontology is L_1. The actors are knowledge workers, ontology creators and the application users. The maturity of the work is very high and the benefits include information retrieval.

[11] uses ontology to create semantic queries for to be run on the Quran. The role of ontology is L_1 and the Scenario is of Neutral Authoring. The actors for this work are the Knowledge Worker and Ontology Author and perceived benefit is Information Retrieval from the Quran. The maturity level of [11] is low. The summary of this comparison based on the framework is given in the Table 1.

4.0 Discussion

Following points are derived from comparison given in Table 1:

1) Maturity levels: It is noted that all the work done to date on the Quran using ontology is very low

with the only exception being that of Leeds Quran Ontology. This could be due to the relatively recent trend of semantic research as opposed to the tested techniques of machine learning and statistical methods (eg, HMM) that have been shown to be useful in other fields.

2) Ontology usage: This refers to the way ontologies are being utilized in the work cited. All the ontologies reviewed cover the scenarios of Neutral authoring (Scenario1) and Indexing for Search (Scenario 3) with only one work that qualifies for Scenario 3 of Common Access to Knowledge. This points to a lack of focus on interoperability and exchange of knowledge. The information reuse is one of the key advantages of creating an ontology based knowledge modeling of a domain. The lack of effort to utilize ontologies for common access to knowledge can be linked to the previous point i.e. , lack of maturity. It is evident that when a system becomes stable and starts to deliver the targeted services, then only the question of information exchange with other systems arises. At this stage, applications are focused to the unique problem they target i.e. mapping literary forms in the Quran using ontology[4].

3) Ontology development language: OWL is the most popular language for ontology creation. It also shows room for information exchange as OWL is the W3C standard for the Web 3.0.

4) Incomplete Implementation: Few works have been developed to a stage to where end users can directly interact with them. This could be due to the fact the researchers have not intended to build an end-to-end system in the first place but demonstrate the applicability in a research environment. Another important factor could be the amount of effort needed to expand to a full blown scale This is best expressed in the case of [11] where effort is needed in three vital directions before the work can become available for the end users (a) development of a natural language engine which translates natural language into Manchester OWL syntax (b) the application front end either of desktop based or web based for capturing the user input and displaying the results to the user and (c) the population of the actual ontology with relevant instances of the verses from the Quran to provide enable adequate searching of the Quran.

5) Ontology Representation Language for Quran: It is noted that there is a need for an expression language or a framework for expressing Quranic concepts is felt which can facilitate efficient ontology development targeting the Quran. In the literature cited, all ontologies have information for L_0 or L_1 but no efforts have been directed towards creating an ontology based representation language for expressing specifically Quranic concepts. Such a language would aid in Ontology development for the Quran using predefined constructs such as e.g. AllahRelatedConcept could point to concepts such as Greatness, Powerful, The Seeing, etc and so on. The framework or language itself could generate OWL/RDF which could be encapsulated from the knowledge worker so that his primary concerns that of discovering and modeling the concepts. This way even the knowledge experts could leverage the semantic modeling potential of the ontology languages such as OWL.

5. Conclusion & Future Work

The work reviewed shows that usage of ontology for understanding of the Quran is not any different from other applications which make use of ontologies. Whatever work that has been up till date on the Quran in the field of ontology can be related to one of the three main scenarios based on the framework explained in this paper. The real challenge in the context of the Quran is to make such use of ontology that it overcomes the shortcomings of other applications in the same domain and make significant contributions in gaining the required knowledge from this holy book.

Unfortunately, very little of the research work by ontology engineers has translated into meaningful tools for the general public in understanding. Much of this is because of the lack of direction and not having a bird's eye view of the whole scenario. It is intended to remove these two obstacles in the application of ontology for Quran by creating a framework which manifests the various levels of understanding of the information contained in the Quran, what types of information exists and how ontology can facilitate each type and level of information. Not only would this enable a better interaction amongst researchers and promote understanding of existing work, it will also give a sense of direction to aspiring researchers where to spend their energy and make a useful and meaningful contribution.

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