



Semantic Approach for AI-Quran Knowledge Representation in Islamic Knowledge Management Framework

Azman Ta'a¹, Muhammad Shakirin Shaari @ Hj Ashari¹, Ahmad Suki Che Mohamed Arif¹, Muhamad Shahbani Abu Bakar¹, Muhamad Amar Mahmud²

¹School of Computing, College of Arts and Sciences,
 Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia, MALAYSIA

²School of Languages, Civilisation & Philosophy,
 Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia, MALAYSIA

*Corresponding Author

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Abstract: Using ontology data model to accurately represent AI-Quran knowledge using its inherent structure of Division (*Juz*), Chapter (*Surah*), and Verse (*Ayah*) should be done within the framework of the Islamic Knowledge Management (IKM). Data modelling neglecting the IKM framework would result in inaccuracy and irrelevant result in knowledge processing activities involving the AI-Quran. Many of the current approaches utilizing conventional knowledge management methods such as taxonomy, hierarchy, or tree structure are limited in the sense that they only define the concepts of knowledge without relating it to a theme that defined from corpus of Islamic knowledge. In the case of AI-Quran, a classification of themes from background knowledge are important to provide a structural explanation of the knowledge and to ensure that the results obtained from a searching function of the corpus of the knowledge will result in an accurate and appropriate meaning intended by the Islamic knowledge. The aims of this paper is to demonstrate the construction of AI-Quran ontology and elaborate the searching method for representing and retrieving the relevance and accurate verses toward the theme of AI-Quran by using the semantic-based approach. The specification of AI-Quran ontology of which the prototype application was built on has been validated by experts. The evaluation test of the AI-Quran ontology application furthermore shows high precision result from searching functions done. With a good level of accuracy achieved from the test, it is hopeful that AI-Quran ontology application will provide a new experience of AI-Quran themes searching and browsing within the IKM framework for the AI-Quran readers. A capability to efficiently and accurately performing search of AI-Quran will certainly improve their understanding of AI-Quran contents.

Keywords: Islamic knowledge management, semantic-based approach, knowledge retrieval and representation, ontology, AI-Quran

1. Introduction

Islamic knowledge management (IKM) finds its origin to Allah SWT, Lord of mankind. As such, it should occupy the zenith position of the current knowledge management (KM) practices (Yaakub, 2011; Waseem, 2013). Yaakub (2011) further asserts that IKM conceptualization is a "manner of submission" to Allah the Creator, which provides a critical knowledge reference point. The notion of 'Ilm' (knowledge) is closely related and possess a high continuity to IKM in general. 'Ilm' has become the fundamental principle of conducts and practices in IKM. As stated in the al-Quran chapter 2 verse 239, the definition of knowledge is not confined to only epistemological concerns but also includes ethical

*Corresponding author: azman@uum.edu.my

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truthfulness and other dimensions of objectivities explained through entire verses. In this harmoniously integrated picture, al-Quran, touted as the eternal miracle of Islam is the ultimate guidance to living one's life while seeking Allah's pleasure.

Al-Quran consists of 30 divisions (juz), 114 chapters (surah), 6236 verses (ayah), and 77,439 words (Mujahid, 2013). A verse may contain one or more sentences. A group of verses furthermore form a chapter with a given name (e.g., Al-Baqarah, Ali-Imran, An-Nisa). Verses of al-Quran provide the base knowledge of the guidance for human to live a true religious life as a believer in full obedient to Allah. The knowledge provided by al-Quran included code of moral, guidance for heart purifications and basis of good deeds. On the other hand, the guidance of al-Quran also specify the prohibited side of the religion. The guidance of al-Quran establishes social justice and guides human in their relationship with fellow human in life (Ahmad *et al.*, 2013). As a God revealed book, the knowledge of al-Quran is incomparable to a science books since it provides knowledge in different level and domain. Al-Quran is the ultimate reference and specified authoritative description on matters pertaining to worldly and the life in Hereafter (Shoab *et al.*, 2009). As Allah said in holy Quran chapter 45, verse 20.

هَذَا بَصِيرَةٌ لِلنَّاسِ وَهُدًى وَرَحْمَةٌ لِّقَوْمٍ يُوقِنُونَ

This [Qur'an] is enlightenment for mankind and guidance and mercy for a people who are certain [in faith] [Al-Jathiyah 45:20].

And also in chapter 34, verse 3 Allah says:

وَقَالَ الَّذِينَ كَفَرُوا لَا تَأْتِينَا السَّاعَةُ فَلْإِن بَلَىٰ وَرَبِّي لَتَأْتِيَنَّاكَمَ عِلْمُ الْغَيْبِ لَا يُعْرَبُ عَنْهُ مِثْقَالُ ذَرَّةٍ فِي السَّمَوَاتِ وَلَا فِي الْأَرْضِ وَلَا أَصْغَرُ مِنْ ذَلِكَ وَلَا أَكْبَرُ إِلَّا فِي كِتَابٍ مُّبِينٍ

But those who disbelieve say, "The Hour will not come to us." Say, "Yes, by my Lord, it will surely come to you. [Allah is] the Knower of the unseen." Not absent from Him is an atom's weight within the heavens or within the earth or [what is] smaller than that or greater, except that it is in a clear register [Saba' 34:3].

In its final form, the version of al-Quran in the hand of the Muslim today presents its knowledge or contents in a hierarchical structure consisting of numbers of divisions (juz), chapters (surah) and verses (ayah). The contents of al-Quran is guaranteed by God the Almighty to be preserved in its original form and format handed down authentically from the Prophet. However additional structure and notation is introduced by later Muslim to enhance its readability and rendering the compilation to be more systematic and easier to be used as a source of reference. This structure is accepted as the de facto form in the compilation held in the Muslim hand today.

Preserving the contents of al-Quran in its original form is guaranteed by Allah, however preserving the correct understanding of the contents pose a more challenging part. Traditionally, the discipline of al-Quran interpretation is fiercely guarded by the scholars. Understanding the al-Quran knowledge required authentic and correct link of sources traceable to the original source. Maintaining the chain of the knowledge link of al-Quran is however proven to be a nontrivial task. Luckily, computer technology can provide the needed support which simplify al-Quran learning task for peoples in the comfortable of the web and mobile-based environment.

This paper describes the used of ontology to manage knowledge of al-Quran that can be classified and organized according to specific themes. Traditionally, al-Quran knowledge is represented by tree-structure hierarchy or taxonomy-based structure. This approach however is incapable of representing the rich concepts possessed by al-Quran (Nadeem *et al.*, 2009). We are proposing al-Quran ontology which utilize the framework of Islamic conceptualization of knowledge (Yaakub, 2011). Different studies have proposed several different classifications of al-Quran knowledge. The next level of research is to define the best ontological implementation for the different classifications according to themes created from these classifications. This paper sought to demonstrate the development of al-Quran ontology for Islamic knowledge management.

2. Literature Review

2.1 Islamic Knowledge Management

Knowledge occupies a very central position in Islam and the activities of teaching and learning of the Islamic knowledge rooted in the al-Quran and Hadith as the main sources becomes an obligatory responsibility for every Muslim. Current knowledge management (KM) studies are mainly focusing on the aspects of conceptualization and application either for individual or organizational development. However, application of KM modelling driven by Islamic values based on the framework of Islamic Knowledge Management as illustrated in Fig. 1 still seriously lacking (Yaakub, 2011; Waseem, 2013). Furthermore, more studies in the application of IKM in the learning of al-Quran needs to be bolstered. The application of IKM in the learning of al-Quran poses a major challenge for the computer scientist especially in the artificial intelligence (AI) area, which is the computer scientist need to understand the al-Quran knowledge to effectively apply and develop the digital solutions for enhancing al-Quran learning (Atwell *et al.*, 2010).

An important aspect in Knowledge Management domain of study is Knowledge Representation. Knowledge Representation is a systematic approach to learn and understand knowledge as a science based on a number of classification methods such as taxonomies, hierarchical, tree structure, paradigm and constrained facet analysis in the delegate, discover and construct new knowledge (Kuhn, 2010; Robinson, *et al.*, 2015). Some applications of ontology to represent knowledge in a wider context existed especially in the domain of research related to al-Quran. Application of ontology to Quranic application in a systematic manner is highly in need especially in a more complex category of the “mutasyabihat” verses (verses which describes “ghaibiyat” - intangible concepts in al-Quran) requiring a more delicate explanation as opposed to the “muhkamat” verses (related to more direct and clear concepts).

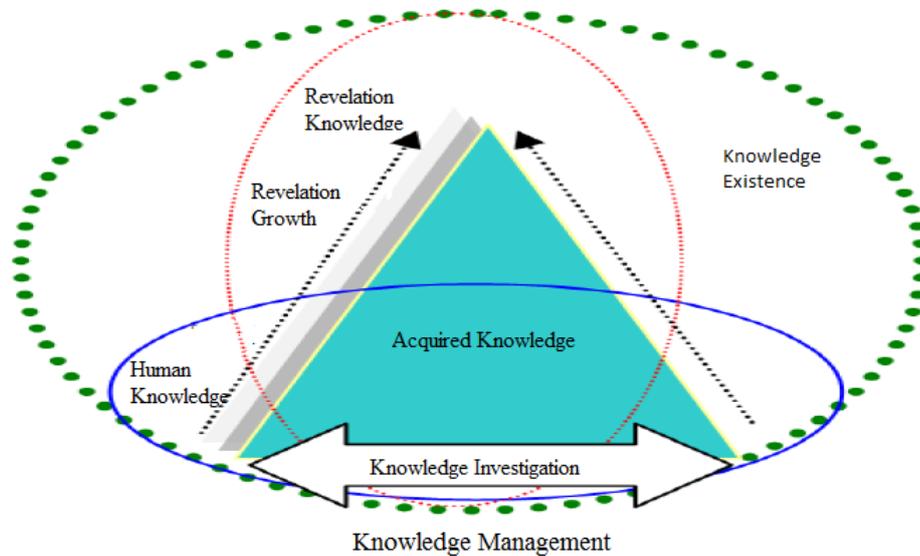


Fig. 1 - Conceptual of Islamic Knowledge Management (IKM)

Currently several studies can be cited involving development of information system with application to al-Quran Knowledge area. Atwell, Dukes, Shariff, Sawalha and Brierly (2011) have developed al-Quran ontology-based information system in common Arab language and Arabic corpus. The ontological structure is developed based on relationship of concept in al-Quran taken from Arabic language. Hakkoum *et al.* (2018) have developed a tool that provides a query based on Arabic language on Quranic ontology. Saad *et al.* (2011) have developed knowledge of Islam based on the al-Quran by using ontology. Al-Yahya *et al.* (2010) study focused only on the ontology for semantic lexicon for the concept of time in the al-Quran. All studies are still in the infancy stage and more work needs to be done to complete the ontology of al-Quran. One limitation in all the studies as insofar however is that these al-Quran based application are still utilizing the traditional methods based on the entity-relationship modeling. Moreover, most of the al-Quran ontology is developed based on English and Arabic languages, without complete functionalities which allows people to explore and investigate deeper.

2.2 Ontology for Knowledge Representation

Ontology is defined as “an explicit formal specification of common concepts” and a branch of philosophy that involves the study of the types and structures of objects, properties, events, and processes of relations in every area of reality (Gruber, 1993). Descriptions of concepts and relationships can exist as an agent or a community of agents. This definition is consistent with the use of ontology as a set of concept definitions. Studies applied ontology to provide solutions in various fields, both in the social and sciences for knowledge representation. Moreover, many types of ontology editors (e.g., Protégé-OWL, Hozo, Ontolingua) can be used to construct ontology easily. The efficient use of ontology editors during development is important for performing ontology reasoning and visualization (Saad *et al.*, 2011). Researchers have argued that many types of editors are fit for construction of an ontology system such as Protégé-OWL because of their robustness and flexibility of use (Ameen *et al.*, 2012). An earlier study by Khan, Saqlain, Sher, & Shoaib, (2013) maintained that the use of Protégé-OWL editor for ontology is acceptable while retrieving and searching for an exact word in a pool of texts. However, the appropriate selection and efficient use of editors are important while conducting ontology development and visualization. Hence, we choose Protégé-OWL editor for the development and construction of the al-Quran ontology.

Generally, the reasons for developing ontology can be listed as: to share a common understanding of knowledge among people or software agents to reuse domain knowledge, to make domain assumptions explicit, to separate domain knowledge from the operational knowledge, and to analyze the domain knowledge (Ta'a *et al.*, 2013). The research in

the application of ontology in Islamic Knowledge Management (IKM) still considered as a new area in Knowledge Management. It is specifically related to the area of knowledge investigation, which is utilized in the process of knowledge acquisition. The knowledge acquisition process in al-Quran ontology involves several stages. Firstly, the themes used for al-Quran verses classification is determined. The themes classifications are dependent on the specific scholar of choice. There are different set of themes classification produced by different al-Quran scholars. The next stage is to define the al-Quran ontology structure.

Several examples of previous research utilizing ontology in different areas of Islamic knowledge such as: prayer (*solat*) classification (Saad *et al.*, 2011), WordNet model for al-Quran semantic search (Shoib *et al.*, 2009), Arabic and Islamic content on the internet (Atwell *et al.*, 2011; Hakkoum *et al.*, 2018), an automatic system to evaluate al-Quran recitation according to Hafz reading based ontology representation method and automatic speech recognition technology (Elsayed, & Fathy, 2019). However, there is still no al-Quran ontology that is ready to be used as a reference to develop a complete and perfect application of al-Quran ontology. This is the real challenge that needs to be tackled by researchers who want information technology to help people understand the al-Quran more quickly and effectively.

2.3 Knowledge Acquisition

Acquiring knowledge is one of the important tasks in IKM. The goal of knowledge acquisition is to provide user support for interpreting and obtaining adequate information of al-Quran, which could be achieved through an ontology-based searching approach. This approach will address the difficulties of free-text search facilities in catalogs and supports an intuitive interpretation of specific words and need to enable the navigation of differences meaning produced from the searching. Moreover, the use of explicit context models is used to reinterpret information for new applications. Thus, ontology gained popularity in information science because of its capacity to explicate contextual information. Query formulations by users through keywords or spatial filters are helpful in presenting standard-based catalogs. Therefore, the metadata fields that fit into the query depend on the metadata schema and the query functionality of the service used for accessing the metadata. Researchers have indicated that the two types of semantic heterogeneity, namely naming heterogeneity (synonyms) and cognitive heterogeneity (homonyms), which were used to discover related words or phrases from an information pool (de Almeida *et al.*, 2021). However, free-text entries are unfit to capture the semantics of a query or item.

Interest in automating knowledge extraction and retrieval from religious literature has led to the developments of a number of searching applications to provide ability to retrieve knowledge using keywords (Islam Ware, 2016; Mohamed, & Shokry, 2020). A plethora of websites with Quranic and Hadith texts, search tools, reference materials, maps, and others have all been designed around natural language for human readers. However, none of these applications provide standardization of presentation, which is important in the machine processing of information. The Zekr Project (2021) presented some of the tools and programs with keyword-based extraction architecture to model and retrieve data. Numerous other applications, such as Zarrabi-Zadeh (2016) used the same keyword-based analysis, and Mohamed & Shokry (2020) developed a Quranic Semantic Search Tool (QSST) based on word embedding against the Mushaf Al-Tajweed ontology.

Ontology has been treated as a good structure for storing and sharing knowledge. The emergence of ontology has been used for exploring, inferring, and describing web sources in world-wide web paradigm that often provide online service, huge information onto the computer, allowing the person using the computer to do the actual intellectual work more efficiently. Nevertheless, ontology has also been accepted in other fields, such as in electronic commerce and in creating terminological services in the health sector. To date, ontology has become an essential tool for computer science applications and has been extended to satisfy the new vision and next generation of the World Wide Web (WWW), that is the semantic web. The aim of ontology is to build data on the semantic web in a way that is easily understood by human and machines (Safee *et al.*, 2018).

In ontology-based information processing, the unstructured or semi-structured natural language text is extracted and the information is presented through an ontology-guided mechanism (Wimalasuriya & Dou, 2010). The ontology creation may be conducted manually, automatically, or semi-automatically depending on the researcher's choice and research condition. The vision of ontology-based information processing includes several complementary disciplines, such as machine learning, natural language processing, data mining, and so on. The global readership of the al-Quran has increased attention on knowledge extraction and retrieval from religious literature and has led to the creation of knowledge acquiring by using keywords (Baqai *et al.*, 2009; Mohamed, & Shokry, 2020). Several websites with Quranic and Hadith texts, search tools, reference materials, and so on have also been designed around natural language for human readers. Several tools and programs that use keyword-based extraction architectures to model and retrieve data have been introduced for searching the al-Quran knowledge. Boisen (2011) has developed an ontology for the Bible and created several classes of concept in the Bible, with each class having characteristics that define the concept and examples of verses that related to other verses. The particular concept explained by verses possibly have subclasses that explained the whole meaning of the concept in the Bible. Moreover, the ontology Bible provides a comprehensive set of biblical references that link to source language terms, collect together other attributes and relationships, capture family, geography, or other context, and provide a framework and metadata for information integration selection.

Several research on knowledge acquisition of al-Quran ontology was based on the database processes of morphological analysis of query verse as input and provides the root verse as output. The searching of related words in the al-Quran has led to the creation of a keyword-based searchable interface indexed by chapter number. This application assists users in browsing the al-Quran and searching using translation and commentary (*Tafsir*). A multilingual al-Quran Software provides Arabic and English Quranic commentaries. Different translations in French, German, Spanish, Urdu, Malay, Indonesian, Japanese, Tamil, Hausa, Turkish, and Indonesian are also available on many sites equipped with a query-word-based searching facility. The software by Harf¹ Information Technology provides a subjective search facility, but only in the Arabic language. This software also provides an exact match search for words, terms, parts of verses, and even some consecutive verses. Technically, this software provides the ability to search static files in a way that the verses are pre-linked to a topic or sub-topic. Thus, semantic search in the al-Quran is sometimes based on Internet searches that reveal some works on the al-Quran ontology (Safee *et al.*, 2018).

2.4 Knowledge Visualization

Knowledge visualization of al-Quran contents is an area of research that explores the problems and solutions of al-Quran verses representation using visual images. The visualization of Quranic verses would be useful in visualizing the structure of al-Quran contents to depict the positions of verses in relation to chapter and division of the al-Quran. Other needs could be to create illustrated information related to certain facts in al-Quran like places or atlas. As the mention goes, a picture worth a thousand words. Quranic verses visualization will help the understanding of the messages of al-Quran especially to non-Arabic speakers and inhabitants (Raja-Yusof *et al.*, 2020). There are different forms of Quranic verses visualization existed depending on the specific aspects of focus to be achieved. Mustapha (2009) proposed a dialogue-based visualization system for reading Quranic text with the specialty of ability to perform knowledge queries using natural language. Another aspect of visualization involves the visualizations of spatial information such as map and atlas. Raja-Yusof *et al.* (2020) utilized the conceptual map and hyperbolic tree visualization techniques to achieve their objective for map and atlas visualization. With these techniques they claimed information maneuvering time can be shorten effectively. Information structural visualization techniques can help the comprehension of the Arabic Quranic verses for non-Arabic readers. Application of theory such as Word Recognition theory which utilize word frequency and word superiority effect can help al-Quran text comprehension. The use of parallel plot and word segmentation visualization was tracking the user's personal vocabulary with a presentation of percentage and word position in the al-Quran.

However, the visualization of al-Quran verses was not particularly discussed in this research because the visualization of al-Quran contents will not affect the structure of al-Quran ontology that contained theme concepts related to the verses of al-Quran. Moreover, the use of modern web-based systems that organized the interfaces of al-Quran verses and the translations will help users to engage with the al-Quran ontology applications.

3. Al-Quran Ontology Development

Al-Quran ontology is defined from the concept of themes in al-Quran contents. The themes in turn will determine the relevant divisions, chapters and verses. The specification of the al-Quran ontology will then be constructed using the protégé-OWL. Constructing ontology is similar to creating schemas in a database system for any application, which aims to manage and retrieve data from the database storage. Problem-solving methods, domain-independent applications, and software agents used ontology and knowledge bases to build the database schema from the ontology (Ta'a *et al.*, 2013). The searching method, then, can be based on metadata, full text or content-based indexing that well-establish provided by the database systems efficiently.

3.1 Ontology Model

The al-Quran ontology developed in this study is based on the themes classification as used in the Syaamil al-Quran Miracle the Reference (Indonesia, 2010). The Quran Ontology Model (QOM) as depicted in Fig. 2 is defined in logical expression as following Eq. 1:

$$\text{QOM} = (\text{CT}, \text{CS}, \text{P}, \text{I}_1, \text{I}_2, \text{I}_3, \dots, \text{I}_n) \quad (1)$$

where CT is the Class for main themes, CS is the Class (sub-class) for sub-themes; P is the Properties for relationship between classes to another class/sub-class; $\text{I}_1, \text{I}_2, \dots, \text{I}_n$ are the Individual for verses referred by the themes.

The ontology of al-Quran is constructed by defining the CT, CS, P and $\text{I}_1, \text{I}_2 \dots$ In whereby the class is created for each primitive concept of themes and sub-themes. The property P is created for domain of P that is set to be the class corresponding to the primitive concept of CT and CS. Therefore, each relation of P is a defined class was created. The created class is defined in the form: $C_p \equiv C_1 \sqcap C_2 \sqcap \dots C_n$, where C is the class representing the concept mapped to P.

¹ <http://www.harf.com/?UserLang=en-US>

Each class C_i is derived from the themes or sub-themes definition. The individual I_i is defined as a sequence of division, chapter and verse in the form of $I_i = (V \subset C_h) \subset D$, where every element of verse (V) is in chapter (C_h). A chapter has many elements. Every element of a chapter is in division (D). Division in turn also consist of several elements.

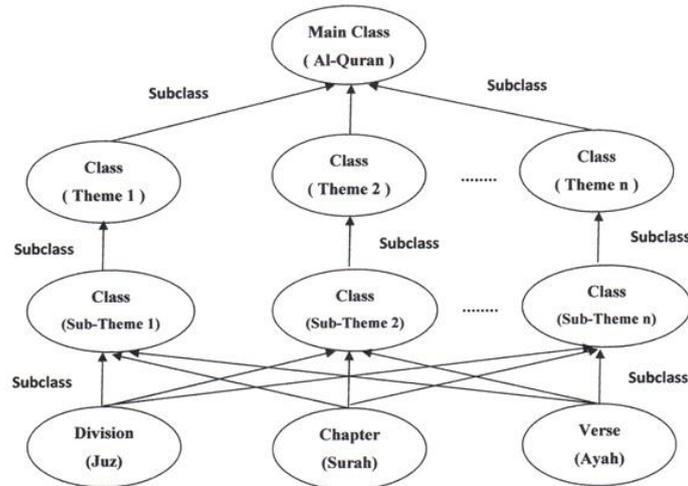


Fig. 2 - Al-Quran ontology model

3.2 Ontology Construction

The development al-Quran ontology consists of three main sub-stages: i) construction al-Quran ontology, ii) mapping al-Quran ontology to the database schemas, and (iii) build the semantic-based searching functions for al-Quran ontology. Fig. 3 shows the stages of al-Quran ontology development stages.

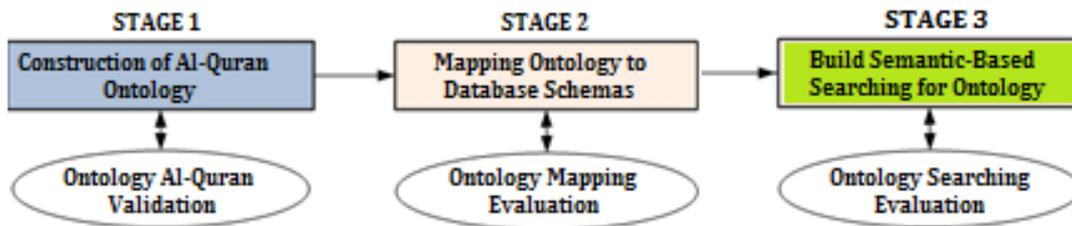


Fig. 3 - Al-Quran ontology development

The development of al-Quran ontology begin in stage 1. Considering the definition of al-Quran themes has been defined completely based on al-Quran ontology model as shown in Fig. 2. Next, the construction ontology was implemented using protégé-OWL. The resulting structure of al-Quran ontology is depicted in Fig. 4. For this study, the classification of main themes and sub-themes were completely derived from Amazing Al-Quran Al-Karim (Al-Quran, 2018) and Syaamil Al-Quran: The Miracle Reference (Indonesia, 2010). Then, the theme classification was checked and reviewed by al-Quran experts from University Utara Malaysia (UUM) Islamic Center as shown in Fig. 10, as part of the ontology specification for evaluation.

The specification of ontology definitions is organized in hierarchy levels. The first level is the main class definition, comprises of fourteen (14) main classes (i.e., Agama Islam (Islam Religion), Iman (Faith) al-Quran (Holy Book)). The second level is the properties definition, where the object and data proprieties were originally taken from the al-Quran contents. The third level is individual definition, which is based on the classification of Quranic content, which has been discussed and reviewed by al-Quran experts as relevant to the main themes and classes derived from al-Quran. The appropriate terms used to explain and achieve the relationships between the main themes with all the derived sub-themes were properly defined. Fig. 5 shows how the individuals were defined for classes of morals (akhlak), and related properties.

3.3 Semantic-based Searching

To implement the semantic-based search function, we used full-text search engine in a database system for a semantic supporting mechanism, which already existed in most of the database systems. The full-text search engine provides a variety of searching capabilities (i.e., keywords, sentences) with good performance of accessing and retrieving the data. Moreover, it cannot be denied that the database systems are a proven technology for manipulating data with the indexing mechanism for a large amount of data. Therefore, the ontology al-Quran data based on the RDF / OWL format produced from Protégé-OWL was mapped into the relevant database tables, columns and rows in the database, and all contents in the RDF/OWL file were saved into the database system (i.e., MySQL). The mapping of database schemas with ontology schemas, which included the references of concepts, chapter and verses are shown in Fig. 6. The searching process is based on the input terms supported by the database systems, which is accepted by SQL statements. The input pattern can be a keyword, sentences, combination of keyword with operators (e.g., +, -, OR, AND).

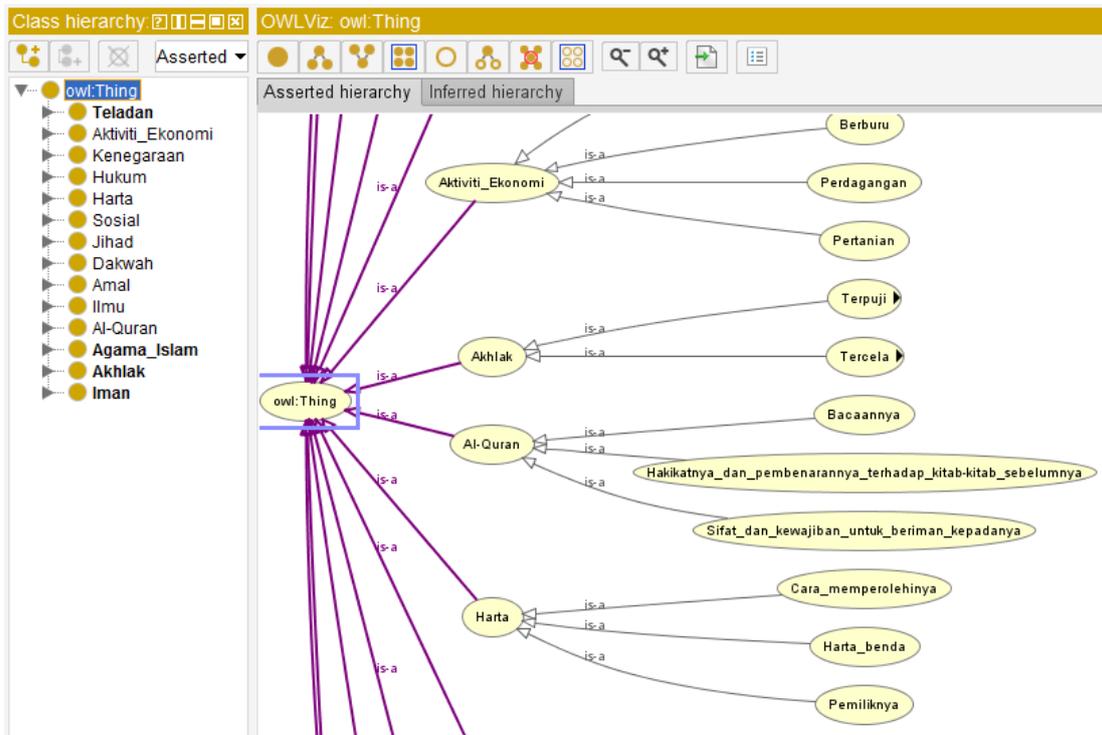


Fig. 4 - Main structure of al-Quran ontology

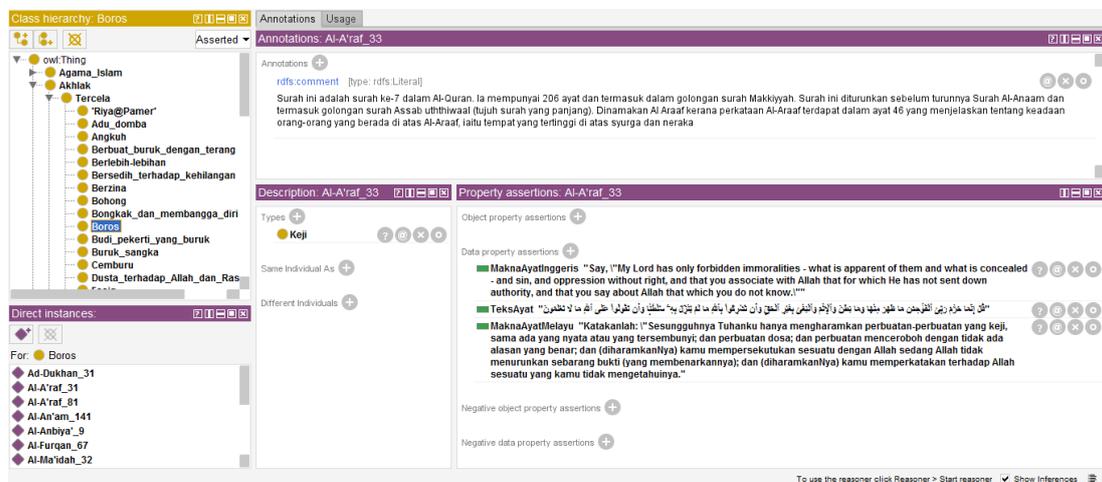


Fig. 5 - Individuals derived between classes and properties

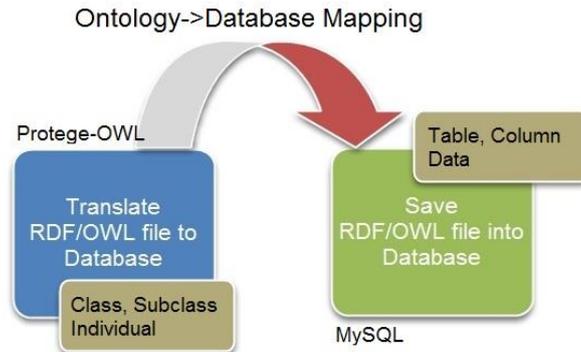


Fig. 6 - RDF/OWL database mapping

The design of table schemas for al-Quran ontology in relational database were developed from the metadata of the database system as shown in Table 1, and part of the database schemas design is shown in Fig. 7. These metadata will help users to search theme or concept as required in the database.

Table 1 - Reference for Theme, Chapter, Verse and Keyword

Themes	Position in al-Quran	Chapter Name	Text	Keyword
A Oneness	Chapter 112, Verse 1	Al-Ikhlâas	Say "He is Allah (who is) One"	Oneness
Allah knows all that is in the heart	Chapter 16, Verse 23	Al-Nahl	Assuredly, Allah knows what they conceal and what they declare.	Allah knows
Organize all matters	Chapter 77, Verse 4	Al-Mursalaat	Then separate them, one from another	Separation
Islam is the religious sight of Allah	Chapter 3, Verse 19	Al-Imran	Indeed, the religion in the sight of Allah is Islam.	Islam

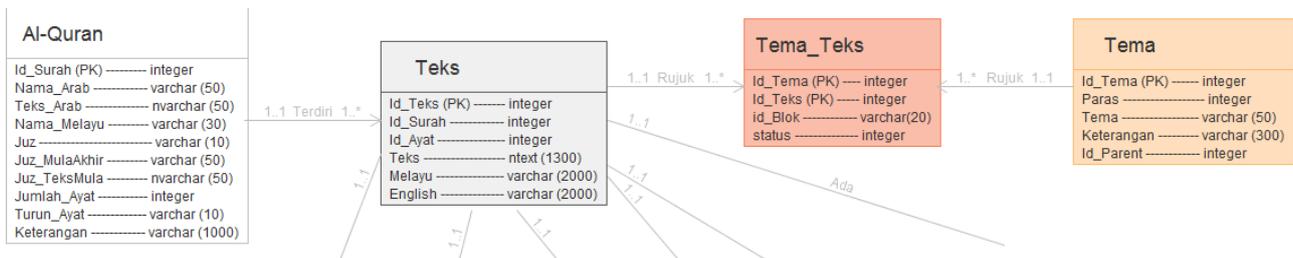


Fig. 7 - Database schemas for al-Quran ontology

Searching will be performed by using SQL statements which is equivalent to the SPARQL in ontology approach. The result of the searching will be listed in ascending order, with the list of sub-themes or sub-themes which is ready to be selected for presenting the relevance verses. Fig. 8 shows the searching flow chart, and the algorithm for the searching approach.

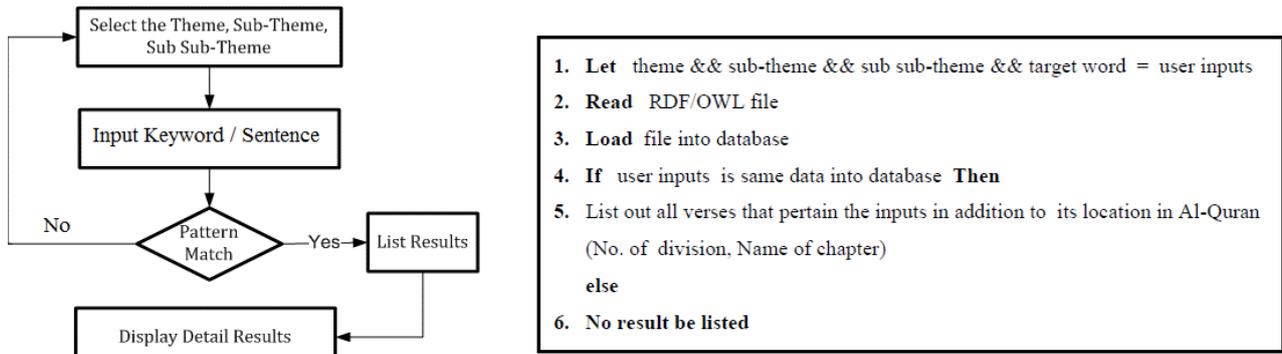


Fig. 8 - Ontology searching algorithm

The prototype of searching application was developed to demonstrate and confirm that the resulting ontology specification and searching algorithm deployed can be implemented as a working information system. The prototype system was developed using PHP programming and Hyper Text Markup Language (HTML). The MySQL database system was chosen and mapped to the ontology-based data. The choice of MySQL as the database system is because it is free, open source and effectively support the advance function of a searching engine. Indeed, MySQL provides connection to extract data from RDF/OWL files mapping functions. Moreover, the PHP programming language provides opportunity for developer to create and deploy applications easily. Fig. 9 shows the example interfaces for the searching application. This search example display the results for searching theme sentence “Amal Makruf” (Good Deeds). The results showed the list of relevance themes found from the search process. From the resulted theme, one can display the related verses.



Fig. 9 - Searching application

4. Evaluation and Discussion

The al-Quran ontology specification has been validated by two (2) experts consisting of Islamic scholars from the Islamic Center of Universiti Utara Malaysia (UUM). Both experts were asked to check the correctness of ontology specification, which was constructed using Protégé-OWL. The complete specification of al-Quran ontology based on selected themes and sub-themes (i.e., Allah, Angels and Unseen) were validated by the experts. The experts were asked to check and correctness of the theme, specific relationship between themes, and relevant verses to the themes. Then, the experts have endorsed the acceptance of ontology specification as shown in Fig. 10.

Themes	Relationship 1	Sub-theme	Relationship 2	Sub sub-theme	Correct	No Correct	No. of query	Theme	Sub-Theme	Sub sub-Theme	Number of Verses in RDF/OWL file	Keywords in search
Allah	can be	knowing	by way	the innate character for mankind, the universe and his creation.	✓		1	Allah	Knowing	The innate character for mankind.	21	Innate character
			by way									
Allah	has	characteristics	is	an existence.	✓		2	Allah	Knowing	The universe and his creation.	23	Universe
			is	a oneness.								
			is	the first and the last.								
			is	the differs from what has created.								
			is	an omnipotent.								
			is	the will.								
			is	alive does not die.								
			is	the knower.								
			is	the All-hearing and the All-Seeing.								
			is	the All-hearing and the All-Seeing.								
Angels	has	the duties	is a	organize all matters.	✓		3	Allah	Characteristics	Existence.	15	Existence
			is a	pacify the hearts of the Prophets and the Faithful.								
			is a	paying for the Faithful and ask for forgiveness.								
			is a	glorify Allah and prostrate before him.								
Unseen	is that	Allah knows the keys of unseen.	is a	possessing the soul from pleasure to distress.	✓		4	Angels	The duties	Organize all matters.	12	Matters
		is that	Allah knows the affairs of the hidden.									
		is that	Allah knows all that is in the heart.									

Fig. 10 - Ontology specification for searching evaluation

The purpose of searching task evaluation is to validate the result of the retrieved knowledge is accurately according the searched theme or subtheme provided as they search key. For this purpose, the search is tested by using a pre-defined test case, and the purpose of using a test case is to test all functionalities and to easily trace any changes occurs. The test case prepared for this method is basically aimed to test the accuracy of the searching method. The inputs (theme, sub-theme and sub sub-theme) for searching are predetermined and it's given to user in the testing exercise. Nine (9) queries have been used as examples of the test case. Fig. 10 shows part of the prepared test case. By giving a keyword, the relevant verses related to themes, sub themes, and sub sub-themes were retrieved. Then, the results produced from the search were evaluated on their precision and recall measurement. These two measurements are commonly used to measure the performance of the information retrieval. For examples, based on query number 1 in Table 2, the search is "Innate character". Thus, the calculation of recall which is 90.4% and precision which is 95% show that the query result for "the innate character" have a high percentage of accuracy according to the given theme, sub-theme and sub sub-theme. In summary, the result that is related to the query based on theme "Allah" was calculated on their precision and recall as shown in Fig. 11. The results have shown the highest percentage of precision and recall measurements.

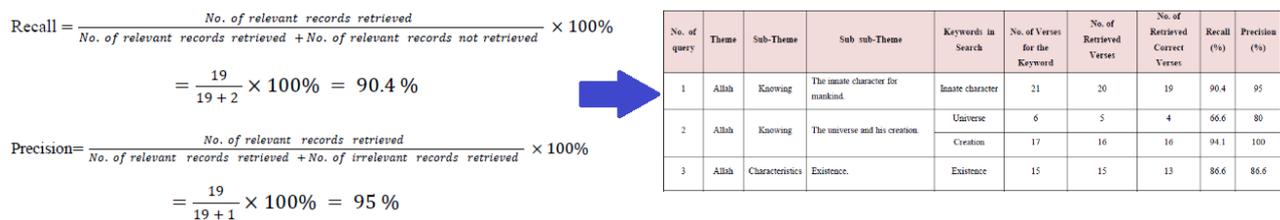


Fig. 11 - Measurement for searching results

Precision and Recall are the basic measurement used for evaluating the search method. Based on the results from the evaluation, the high accuracy of the searching method was attributed to the decision to use the database system. The database stored contents from the RDF/OWL, which is also having a major contribution in improving the searching accuracy. Therefore, higher percentage of precision and recall have described the correctness of the searching method used in the al-Quran ontology. The percentage can be increased if more themes or concepts are used in the experiments. Consequently, the correctness of the searching results can facilitate learners to learn al-Quran in an efficient way (i.e., online learning). Compared to other approaches developed by several researchers, the measurement of ontology search algorithm in this research show better results as shown in Table 2.

Table 2 - Benchmark of ontology searching results

Searching Methods	Total of Questions	Recall	Precision	Language/ Notes
Ta'a et al. (2021)	9	90.4	95	Bahasa Malaysia/ Ontology al-Quran
Hakkoum et al. (2018)	70	67	88	Arabic/ Ontology al-Quran
Afzal & Mukhtar (2019)	160	58.9	58.8	English/ Ontology al-Quran
Mohamed & Shokry (2020)	10	100	100	Arabic (ontology of Mushaf Al-Tajweed)

However, this paper not discussed the evaluation of user acceptance on the al-Quran ontology applications. This evaluation is important to ensure the used of ontology approach can enhance the implementation of ontology application, especially in al-Quran learning context.

Generally, the success of online learning can be measured by how much information can be gathered or retrieved from the online sources (Seiver & Troja, 2014). Much information retrieved from the searching will provides more options to understand a particular knowledge. The relevant and correctness of the information retrieved will determine the success of the searching method. This research also evaluated the success of searching functionality in a particular theme (i.e., Judgment Day). The query for searching is performed into two different methods: traditional theme-based using database system and ontology-based using protégé-OWL. Both methods were implemented in same computer platform (i.e., Windows 8 operating system). For traditional theme-based approach, Microsoft SQL Server (MS SQL) was used as a database system. Table 3 shows the benchmark of searching results from both methods.

Table 3 - Benchmark of searching functionality: Database vs. ontology

Method/Item	Traditional Theme-based Method	Ontology-based Method
Main Theme	Faith	Faith
Theme (s)	Judgment Day	Judgment Day
Query Language	T-SQL (run on .net apps)	SPARQL (run on Protégé-OWL)
Number of Records/ Number of N-Triples	16 Records	38 N-Triples
Type of Data	Records of themes, sub-themes, verses	Classes of themes, sub-themes, instances of verses.

Table 3 shows the ontology-based method has produced 38 triples/records compared to traditional theme-based method has produced 16 records. This benchmark has shown that the ontology-based searching methods produced higher records/triples (results) compared to traditional theme-based method. The matching results give a wide range of knowledge to learn the al-Quran. Detail explanations for each of the information retrieved can be obtained from the various chapters of verses. Even though this benchmark is only performed for a theme, the results explained that the searching method in ontology has produced several answers from the query. This provides rich information to users for al-Quran learning purposes. However, further research is needed in order to exactly identify the relevant (recall) and correctness (precision) of searching functionality, especially on the performance of data retrieval. Most developer agreed that the database system are generally much more matured and have more features than typical RDF/OWL. The transactions are much cruder, and the cost per unit information stored in RDF/OWL is noticeably higher than database (Ravat, Song, Teste, & Trojahn, 2020). Therefore, it is more efficient to use the database instead of RDF/OWL to get the benefit of flexibility and the power of the database system, without neglecting the modeling of knowledge using ontology.

5. Conclusion

The al-Quran is the most widely read holy books in the world. Interest in automating knowledge acquiring, retrieval and managing from Islamic knowledge management (IKM) literature has led to the development of a number of applications with the ability to retrieve knowledge on the basis of keywords or sentences. This research extended the previous work on semantics approach of knowledge retrieval in al-Quran ontology. It consists of two main stages: construction of the al-Quran ontology, and development of a searching method. This research has achieved the construction of fourteen (14) themes of al-Quran ontology, and developed a method to facilitate the searching function in al-Quran ontology using semantic-based approach in a database system environment. Based on the evaluation, the expert domain was validated by the correctness of the ontology specification, and the searching method was success to retrieve the relevant contents of verses with the accepted accuracy. However, further work will be carried out to evaluate the user's acceptance on the al-Quran ontology applications.

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