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Original Research

Development of Qur'anic Ontologies: A Domain Review Study

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Abstract

This study aimed to identify research on different Qur'anic ontologies by providing a clear picture of the existing reality, activities, and progress in developing Qur'anic ontologies. Therefore, the present scoping review attempts to overview the breadth and scope of the research conducted around Qur'anic ontologies during 2017-2022. The methodological framework of Arksey and O'Malley (2005), who suggested five steps for conducting domain review, was used. The search strategy was conducted in 6 databases, including Emerald, Science Direct, IEEE Xplore Digital Library, Google Scholar, Web of Science, and Scopus, in April 2022. As a result, 811 studies were identified. The EndNote ver. 9 reference management tool was used to organize the studies. Three hundred and seventeen duplicate articles and 362 unrelated articles were excluded. Maximum research has considered specific Qur'anic themes in creating Qur'anic ontologies, even though some studies have tried to construct an ontology of the entire Qur'an. English and Arabic were the most common languages used in developing existing Qur'anic ontologies. In addition, most of the research constructed monolingual thematic ontology, and limited studies have applied multilingual translation of the Qur'an to their ontology. Developing tools, programming languages, and methods used in most studies are Protégé, W3C Web Ontology Language (OWL), and Resource Description Framework (RDF), and the concept classification is the up-down approach. SPARQL Protocol and RDF Query Language (SPARQL) have been the proper evaluation tools and methods used in previous research. In contrast, Description Logic (DL) queries and human experts have only been used in a few studies. This study provided a practical indication of the shortcomings, problems, and suggestions in constructing and developing existing Qur'anic ontologies leading to comprehensive Qur'an ontology to disseminating correct knowledge of the Qur'an with the help of semantic technologies. In this way, creating a comprehensive Qur'anic ontology in Persian is suggested to overcome the limitations raised in previous research.

Keywords: Ontology, Qur'an, Scoping Review, Semantic Technologies, Semantic Retrieval, Qur'anic Concepts.

Introduction

With the onset of the knowledge era, access to semantic concepts in search engines and retrieval systems remains the most essential demand for users. Hence, ontologies have attracted the operators' attention, all the more, due to their functionality in searching and retrieving semantics, as one of the Knowledge Organization Systems, in recent years. This progress is due to ontology-based semantic reasoning (Sanctorum & et al., 2007), which is the foundation of a better understanding of the users' information needs, leading to improved search engine performance in response to users' queries. The ontology represents the relata between concepts in a thematic field, provides a perspective of that field (Brank, Grobelnic & Mladenic, 2005), and improves the interaction among human factors and between humans and computer systems (Hepp, De Leenheer, De Moor & Sure-Vetter, 2007).

Concepts contained in the Qur'an are nearly the most significant subject area in Islam. As a holy book containing rich knowledge and scientific facts, the Qur'an has a unique style of explaining various concepts and factoids, whether addressed explicitly or implicitly. Therefore, searching latent key points in Qur'an seems complicated and needs a framework for semantic search in the Qur'an, using ontologies. So, it prompts computer science experts to use ontologies to unearth and extract the divine knowledge hidden in the Qur'an and improve the understanding of its text. However, to fulfill the idea of semantic searching through the foundation of the Qur'anic ontology, it is necessary to present a clear picture of the existing reality, activities, and developments in constructing the Qur'anic ontologies. So, limitations and suggestions raised in previous research can be identified by reviewing the results of studies in this field and current trends, technologies, tools, and languages used to develop the ontology. Thereby, comprehensive and valuable information is provided to researchers about the basic aspects of this research field which can be used in creating a comprehensive view in the future. A careful examination of existing approaches is needed to find potential future direction. Hence, this study tries to identify research related to different Qur'anic ontologies using the scoping review method to provide researchers with a comprehensive view of this field.

Literature Review

Building systems incorporating domain-specific knowledge is a focus point in artificial intelligence (AI). Therefore, systems can reason and solve problems they have never encountered before. Commonly, all systems use a symbolic and explicit representation of knowledge in a particular domain so that it can be separated from the procedural aspects of its application and reused in systems. Therefore, ontology is needed as a model because it can use symbols to represent knowledge so that a computer system can process it. Such a model determines which objects are essential and their relationships with each other, taking into account the desired domain (Wong, Liu & Bennamoun, 2012). Creating an ontology is difficult and complex and requires time, money, and expert knowledge. However, due to the increasing demand for semantic search in search engines and other existing applications, there is still an increasing demand for creating an ontology (AlAgha & Al-Masri, 2016).

On the other hand, Islamic sources of knowledge, i.e. Qur'an and Sunnah, have unique characteristics that highly demand semantic search support. The complexity of the Qur'an's

content, its symbolic nature, and the use of metaphors have made the hidden meanings challenging to understand. Qur'anic concepts are various and related, so search results should show relationships and dependencies between different concepts. For example, the explanation of one verse is implicitly mentioned in another verse. And the Qur'anic terminology includes many legacy terms, which may have many interpretations, so incorporating a semantic search for the synonyms of these legacy terms may not return the intended results (Nisa, 2022).

Some research has been conducted to develop various ontologies for different subject domains in the Qur'an. For example, Al-Salhi and Abdullah (2022), Sultana, Rahman, Uddin and Arfat (2021), Al-Sanasleh and Hammo (2017), Sadi and et al. (2016), Alromima, Moawad, Elgohary and Aref (2015), Saad, Salim, Zainal and Muda (2011) have done research in the field of ontology development regarding Qur'anic stories, foods, prophets and messengers, concepts related to nature, names of places and prayers in the Qur'an, respectively.

A scoping review is an extensive review of a particular research topic's fundamental concepts that will illuminate the main sources and pieces of evidence available. These studies can be applied to complex topics or ones that have not been thoroughly reviewed before (Aguirre & Bolton, 2014). Some review articles have been conducted in the field of Qur'anic ontologies, e.g. Alrehaili and Atwell (2014), and Farooqui and Noordin (2015). Alqahtani and Atwell (2016) summarized the search techniques used in existing search tools for Qur'an. They listed some limitations that affect the integration of the Qur'an ontology approaches, indicating the lack of accurate and comprehensive resources for Islamic ontology, different scopes, and formats in existing Qur'anic datasets, ontology standards deficiencies, and focus on the Arabic language.

The distinguishing feature of the present research is that it examined all of the post-2017 studies. In addition, this study attempts to review the research and provide a practical indication of the shortcomings, problems, and suggestions in emerging existing ontologies to create the conditions for evolving comprehensive ontologies of the Qur'an. Consequently, it leads to sharing of correct knowledge of the Qur'an with the help of semantic technologies.

Materials and Methods

This study tries to estimate the breadth and scope of Qur'anic ontological research from 2017 to 2022 via a scoping review. In the review, studies and research related to a thematic area are critically identified, selected, and evaluated systematically and transparently. The information extracted from the analysis of existing research results is used (Shannon, 2002). One type of review study is the domain review which is done with the purpose of description. The first methodological framework for conducting domain review research was published by Arksey and O'Malley (2005). This process describes a protocol to match the results of existing studies and research with research questions and criteria. Arksey and O'Malley (2005) present five suggested steps for conducting scope review research: 1. Identify and design research question (s), 2. The search process to identify and extract related studies and research, 3. Selection of related studies and research, 4. Tabulation, recapping, and summarization of data and information, and finally, 5. Report its results. These steps proceed sequentially to retrieve potential primary articles. The first stage includes formulating the research question(s). In the next step, the search process is carried out, including selecting sources and searching keywords. This process aims to identify existing research and potentially relevant studies in a subject area. The inclusion and exclusion criteria are determined to approve relevant primary articles in the

next step. Finally, the information is extracted, organized, and reported based on the qualitative assessment criteria.

Research questions

This research focuses on the studies implementing the Qur'anic ontology and examines the research questions in Table 1.

Table 1
Research Questions

No.	Research questions
1	What domains/ languages are covered in creating the Qur'anic ontologies?
2	What type of dataset has been used in developing Qur'anic ontology?
3	What language(s), tools, and methods have been used to develop Qur'anic ontology?
4	In case of performing any evaluation, which methods are used?
5	What are the limitations of previous research in the development of Qur'anic ontologies?
6	Have any suggestions for future research been made in previous studies and what are they?

Searching process

This process is done to identify any potentially relevant studies based on the research questions. The selection process consists of four steps, as shown in Figure 1.

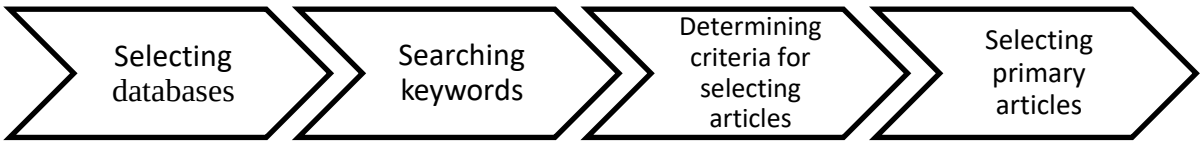

Figure 1: The Search Process to Select Related Studies

Articles were retrieved from 6 databases: Emerald, Science Direct, IEEE Xplore Digital Library, Google Scholar, Web of Science, and Scopus. As Figure 1 reveals, the search process starts by selecting databases, and then the query will be searched in the title and abstract of the sources. This research used the following search strategy to perform searches in selected databases: (Qur'an OR Al-Qur'an OR "Al-Qur'an" OR Al-Qur'an OR "Al-Qur'an" OR Koran) AND (ontology* OR thesauri*)

Results

In compiling and developing the search strategy, semantically related words, all the different morphological and spelling forms of words, and the use of their roots were considered in the search term. The keywords mentioned in the search formula are found in the titles and abstracts of studies that have been addressed implementing Qur'anic ontology (Figure 2). This study was conducted in April 2022, and as a result, 811 studies were identified. The Endnote information reference management tool, ver. 9, was used to organize the studies. Three hundred and seventeen duplicate articles were removed automatically, and by screening the title/ abstract of retrieved studies, 362 articles were excluded manually. Then, via full-text screening, the inclusion and exclusion criteria were applied. Finally, 121 articles were excluded, and 11 primary articles that met the criteria were included in the review (Table 2).

Table 2
Inclusion and Exclusion Criteria

No.	Exclusion criteria	Inclusion criteria
1	Articles that have implemented retrieval systems using ontologies, artificial intelligence or data mining tools	The main purpose of the article is to construct, implement or develop Qur'anic ontologies
2	The methods and parameters used in constructing (implementing) or developing ontologies are not fully presented and described	Using the published version of the article in a journal in cases providing two versions: one presented at a conference and one in a journal
3	duplicate results extracted from the same research by the same author	Selecting the most recent article published in a journal from an author who has extracted several articles from the same research
4	A book chapter, thesis, or doctoral dissertation, gray literature, article in press, unavailable full text	Papers published in journals and papers presented at conferences are both included.

Data extraction and quality assessment

Criteria for evaluating the quality of studies (Table 3) were developed to examine whether the studied articles' context was complete and to ensure the quality of the original articles following the research questions for their practical use in the study. In developing these criteria, we were inspired by Kitchenham (2004) and Azni, Ahmad, Noh, Hazwani and Hayaati (2015) to evaluate the quality of research in the systematic literature review. These criteria show the status and importance of each research, and the quality of that research is determined by scoring each research.

Table 3
Quality Evaluation Criteria

No.	Criteria
1	The objectives of the research are clearly stated.
2	The approach used to construct (implement) and develop the ontologies (tools and methods) are methodically described and discussed.
3	The presented results are fully explained.
4	The required information (such as the subject area, language, data set, language, tools, and methods used, developing and displaying tools, tools, evaluation methods, and others) can be extracted directly from the study.

In addition, the mentioned criteria can minimize the inclusion of invalid articles. The scores used for responses are yes = 1, partial = 0.5, and no = 0. Articles weighted 3.5 points or more are known as primary articles. After thoroughly evaluating the studies by scrutinizing their text, the primary articles were finalized and presented in Table 4.

Table 4
Primary Articles

Score	Title
4	Building Qur'anic Stories Ontology Using Mapping Master Domain-specific Language
3.5	Developing a Semantic Search Method for Retrieving Food-Related Verses and Concepts from Holy Qur'an Using Ontology
3.5	An Ontological Model for Scientific Miracle in the Holy Qur'an
4	Merging Approach to Support the Incremental Design of Ontology
4	Semantic Query for Qur'anic Ontology
4	Hybrid Search Approach for Retrieving Medical and Health Science Knowledge from Qur'an
3.5	Evaluation of Qur'an Recitation via OWL Ontology-based System
4	Building Domain Ontology: Experiences in Developing the Prophetic Ontology from Qur'an and Hadith
4	An Ontological Approach towards Dialogue-based Information Visualization System: Qur'an Corpus for Juz 'Amma
4	The Noble Qur'an Arabic Ontology: Domain Ontological Model and Evaluation of Human and Social Relations
3.5	Al-Qur'an Ontology Based on Knowledge Themes

A search algorithm based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart, retrieval and application of inclusion and exclusion criteria, and the number of articles that remained at each stage are demonstrated in Figure 2.

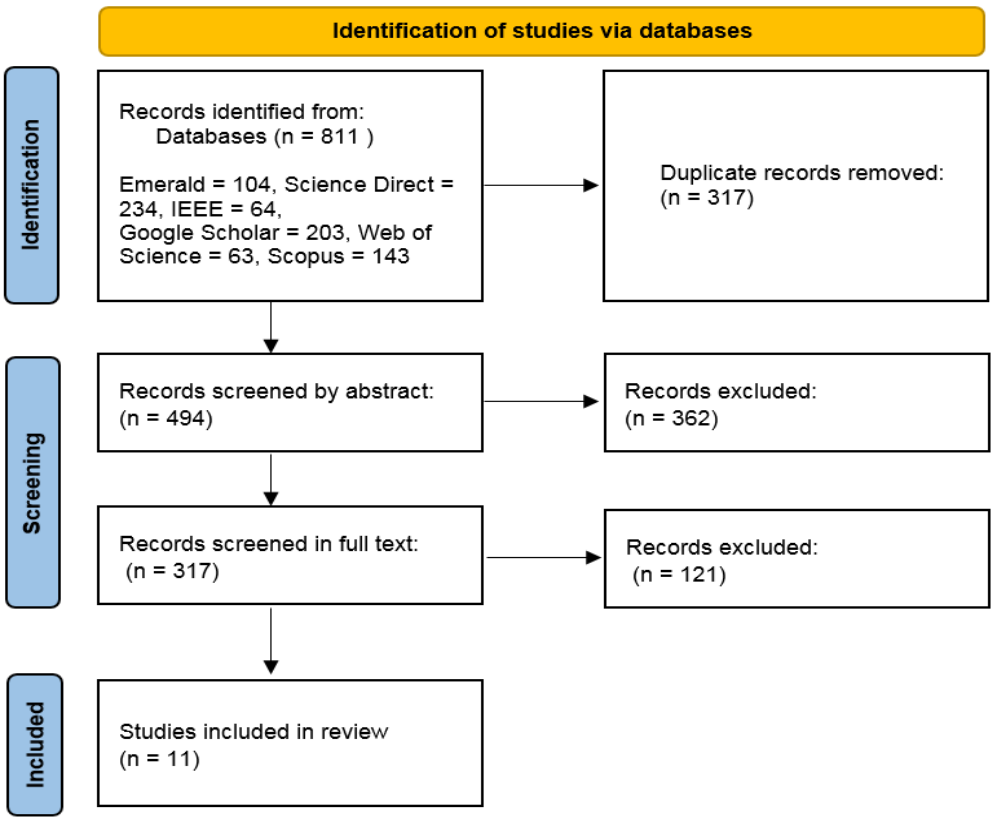

Figure 2: A Search Algorithm based on PRISMA Flowchart, Retrieval, and Applying Inclusion and Exclusion Criteria and the Number Of Articles that Remained at Each Stage (Page & et al., 2021)

Literature analysis in terms of the subject area, language(s) of the ontology, datasets, language, tools, and methods used, evaluation tools and methods, limitations, and recommendations or suggestions of the study are explained in detail (Table 5).

Table 5
Comparing Qur'an Ontology Studies

Reference	Subject area	Language (s) of the ontology	Datasets	Language, tools, and methods used	Evaluation tools and methods	Limitations	Suggestions
Al-Salhi & Abdullah, (2022)	Qur'an stories	English	Various and authoritative sources of Islamic knowledge	OWL, RDF, Excel, Object-Role Modeling (ORM), Mapping Master DSL	SPARQL	Creating and evaluating an ontology using only the data of Qur'anic stories	Using ontology developed in the search engine for simple semantic retrieval
Sultana, Rahman, Uddin & Arfat, (2021)	Foods in Qur'an	English	English translation of the Holy Qur'an: Sahih International and Qur'an.gov.bd.	OWL, RDF, Stanford CoreNLP	SPARQL	Creating and evaluating an ontology using only the data of food-related verses in the Qur'an	Adding Hadith books to Qur'an ontology
Moogab, Al-Shalabi & Al-baltah, (2021)	Miracles of natural sciences in the Qur'an with the scope of astronomy	English	The Holy Qur'an, Miracle Al Quarn Miracle and the unseen, the miracle in Qur'an	OWL, RDF	SPARQL	Creating an ontology using only data related to scientific miracles in Qur'an, which is also limited to astronomy, biotechnology, chemistry, physics, and earth science	-
Alkhammash, (2019)	The whole Qur'an focuses on the names of God and living beings.	English	Authentic and famous books of Muslims, such as Al-Maqsad	OWL, RDF, OntoGraf	Ontology and control and review using visual display	Not displaying object properties and data type properties in the ontology	Using the approach of integrating ontologies and OntoGraf to design large ontology and examining graphic patterns

Reference	Subject area	Language (s) of the ontology	Datasets	Language, tools, and methods used	Evaluation tools and methods	Limitations	Suggestions
Beirade, Azzoune & Zegour, (2019)	Whole Qur'an	Arabic	Dictionary for the words of the Holy Qur'an	OWL, RDF, Apache Lucene, JAVA	Semantic analysis and correspondence with all words of the Qur'an	Using Qur'anic words instead of Qur'anic concepts	Increase accuracy and expansion of data to all Arabic languages and expansion of ontology to other Arabic texts
Elsayed & Fathy, (2019)	The whole Qur'an	Arabic	The Holy Qur'an, the rules of Tajweed (Hafs from Asim)	OWL, RDF, MATLAB	Ontology has not been evaluated	Using Qur'anic words and passages instead of Qur'anic concepts	Creating the global ontology of the Qur'an by merging the ontology of Tajweed and Tafseer
Safee & et al., (2018)	Health in Qur'an	English	Translated by Sahih International, DBpedia	JAVA, Malaysian Research and Development Classification System, Ontology	Evaluation by experts in the field of Qur'an and Hadith	Creating and evaluating ontology using only health-related data in Qur'an	Qur'anMed: A basis for answering users' questions related to the field of medical sciences and health in the Qur'an and integrating data with other ontologies
Al-Sanasleh & Hammo, (2017)	Prophets in Qur'an and Hadith	Arabic	Qur'an, Sahih Al-Bukhari, Arabic-Arabic Dictionary of Meanings	OWL, RDF	ontology has not been evaluated	Modeling languages are not used for graphical representation of ontology	Increasing lexical resources and evaluating ontologies in natural language processing applications such as Q & A
Yunus, Mustapha, Iqbal & Samsudin, (2017)	Chapter 30 of the Qur'an	English-Malay	Chapter 30 of the Qur'an and its translation, commentary, and hadiths	OWL, RDF	By performing the logic, questions described f	Limited to chapter 30 of the Qur'an	Use of ontology in semantic applications

Reference	Subject area	Language (s) of the ontology	Datasets	Language, tools, and methods used	Evaluation tools and methods	Limitations	Suggestions
			related to each verse		Description Logic (DL) Query SPARQL		
Tashtoush, Al-Soud, AbuJazoh & Al-Frehat, (2017)	Human and social relations in Qur'an	Arabic-English	Thematic Qur'an of the Center for Islamic Studies in Syria and Jalali interpretation	OWL, RDF	SPARQL, DL query Individual and one-on-one review by the research team	Creating and evaluating an ontology using only data related to human and social relations in the Qur'an	The use of ontology in Qur'anic search engines
Ta'a, Abed & Ahmad, (2017)	Whole Qur'an	English	The Holy Qur'an	OWL, RDF, JAVA, JENA framework, Relational Database	Expert Panel	Do not use standard onset evaluation languages such as SPARQL	Developing applications for learning Qur'anic knowledge using ontology

Discussion

A preliminary review of all retrieved articles shows that these articles can be generally divided into three subject groups. The first group is dedicated to articles whose main purpose is to construct, implement or develop Qur'anic ontologies. The second and third groups are articles that have proposed data mining or artificial intelligence tools for (semi-)automating learning associated with Qur'anic ontology and the ones aiming to implement retrieval systems applying Qur'anic ontology. The present study synthesizes the articles of the first group according to the research questions. In this section, the main results of the research are compared with the results of the others.

The present study's findings align with the findings of Alqahtani and Atwell (2016) concerning the common languages used in developing Qur'anic ontologies, indicating that English and Arabic are the most prevalent languages used in developing Qur'anic ontologies. In addition, most of the research has been constructed monolingual ontologies (Al-Salhi & Abdullah, 2022; Sultana, Rahman, Uddin & Arfat, 2021; Beirade, Azzoune & Zegour, (2019); Elsayed & Fathy, 2019), and limited studies have applied the multilingual translation of the Qur'an, such as English-Malay (Yunus, Mustapha, Iqbal & Samsudin, 2017) and Arabic-English (Tashtoush, Al-Soud, AbuJazoh & Al-Frehat, 2017). So the researchers may pay special attention to developing Qur'anic ontologies in other languages of Islamic countries, such as Persian. The linguistic diversity of the existing Qur'anic ontologies is essential because it may lead to a challenge in integrating or merging different Qur'anic ontologies.

The results of retrospective review studies show no standard datasets suitable for data entry in ontology tools (Mohamed & Shokry, 2020), which is consistent with the present research results. As seen in most research in line with the present research, researchers favor the Protégé, Web Ontology Language (OWL), Resource Description Framework (RDF), and SPARQL Protocol and RDF Query Language (SPARQL) regarding development, language and

evaluation tools, respectively, to display ontologies, because they are open-source and offer of a wide range of plugins, with free extensions available to explore interactive concepts, instances, and data properties, and relationships between them.

To retrieve relevant information or documents from the knowledge base, the reviewed studies have tried - based on the recommendation of the W3C group - to develop semantic query formulation systems, which convert natural language queries into RDF triple format and then Build SPARQL queries interacting directly with the graphical ontology specification. SPARQL is the standard query language and protocol (January 2008) for the RDF database, and its main feature is relation-based querying (Elsayed & Fathi, 2019; Beirade, Azzoune & Zegour, 2019; Sultana, Rahman, Uddin & Arfat, 2021). Conceptually, if the relationship between two concepts and a concept among them is known, SPARQL can infer the unknown concept from the knowledge base. That is, SPARQL evaluates the completeness and correctness of the ontology. As evident from the findings, most studies use SPARQL to evaluate ontologies. However, few researchers have evaluated the constructed ontology using domain experts (Alrehaili & Atwell, 2014; Tashtoush, Al-Soud, AbuJazoh & Al-Frehat, 2017). Likewise, domain experts have evaluated it by examining ontology's classes, subclasses, and relationships. The results of the performed ontologies for the Qur'an show that most of them have covered only a specific topic of the Qur'an (Al-Salhi & Abdullah, 2022; Sultana, Rahman, Uddin & Arfat, 2021; Al-Sanasleh & Hammo, 2017; Sadi & et al., 2016; Alromima, Moawad, Elgohary & Aref, 2015; Saad, Salim, Zainal & Muda, 2011) which is in agreement with the results of the present study. The reason for this is the need for cost, time, and subject experts to build the Qur'an ontology; the solution mentioned in the studies is to use ontology learning to (semi)automate its construction.

Conclusion

This review has focused on the results of studies performed in Quranic ontologies. This scoping review attempted to identify current trends, technologies, tools, and languages used in the development of the ontologies, the subject area covered, evaluation tools and methods, datasets and limitations, and suggestions in research to provide ideas for future research. The review of the research indicates that although some studies have tried to create an ontology of the entire Qur'an, most studies have considered specific Qur'anic topics/ concepts in constructing Qur'anic ontologies. It should be mentioned that the aim of the Holy Qur'an is not only teaching but also it contains different scientific domains, which are neglected in most existing Qur'anic ontologies. Hence, as opportunities and neglected thematic fields are revealed, it is suggested to develop thematic ontologies in other Qur'anic domains, concepts, and Islamic countries' languages especially Persian, that have not been considered yet.

Limitations

Ontology merging remains a topic of research interest, revealing that almost all Qur'anic ontologies are not available for download and reuse. Future research may overcome the limitations raised in recent research, such as the lack of comprehensiveness in the subject area covered by most of the existing Qur'anic ontologies and the lack of attention to developing Persian ontologies to create a comprehensive Qur'anic ontology in the Persian language.

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