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A Review On The Main Levels Of Ontology And A Proposed Lower Level For The Quranic Ontology

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Abstract

Ontology is a data model that describes the related meaning between concepts of knowledge. The knowledge fragments based on taxonomy are depicted by the levels of ontology, such as the upper, middle, lower, and lowest level, which differs in the reusability, depth, and breadth of knowledge. Previous literature focused on the ontology's upper level only, which disregarded the other levels. Two main levels, the upper and lower level, were compared where the lower level required less understanding to develop an ontology and retrieved higher results than the upper level, albeit the upper level could work in other domains because of its high reusability and flexible ontology. This paper reviewed the lower level of the Quranic ontologies, which described nouns or verbs of the part-of-speech (POS) of the various Quranic domains. Concerning other ontologies, one Quranic ontology got 196 and 180 Quran verses for two Arabic root words as sample query words, albeit this Quranic ontology could not retrieve the exact number of verses, which were collected by the research team of the Faculty of Quran and Sunnah Studies (FPQS), Universiti Sains Islam Malaysia (USIM). Therefore, this paper enhanced the Quranic ontology using several POS concepts and, synonym and antonym relations.

Keywords: Linguistic, ontology, Quran, semantic.

Introduction

Ontology is a formal representation of the concepts of knowledge [1]. Specifically, it is a model to manage and represent the related meanings of the data. The knowledge, such as in the Quran [2]–[9], and in linguistic [10]–[15] is described using an ontology, which helps in understanding the meanings of the word based on its knowledge. For instance, the elucidation of the Quranic words requires both the synonym and antonym meanings [16], [17].

Given the cornucopia of knowledge concepts described in one ontology, four different levels of ontology are represented the fragments of knowledge concepts. Furthermore, most Quranic ontologies that describe specific Quranic domains are at the lower level. Hence, these ontologies are unable to elucidate the words' real meanings.

This paper reviewed and identified an enhancement of the Quran's ontologies by extending the concepts and relations to reveal the Quranic words' real meanings. Specifically, this review comprised of two parts, namely the levels of ontology; upper, middle, lower, and lowest, and, Quranic ontologies. Additionally, the first section of this paper will review the various knowledge of ontologies, and several criteria will be introduced for each level of ontology in the later section. Given that previous research only reviewed the upper level of ontology (ULO); thus, it is crucial to address the different criteria for each level of ontology. This review also focused on the understanding of the Quran's ontologies based on its criteria, followed by the results for the two-sample words.

This paper is structured as section 2 defines the criteria of ontology and section 3 reviews the ontologies based on the criteria mentioned in section 2.Section 4 discusses the review for each level, including the strengths and weaknesses of the two main levels of ontology with the results. Section 5 reviews the Quranic ontologies, including the results using available search engines. Section 6 explains the proposed Quranic ontology. Section 7 presents the conclusion.

CRITERIA OF ONTOLOGY

A. Knowledge or Domain

The domain is a specific area such as an event of the Quran. The Quran is an example of knowledge described in ontology [6]. Fig. 1 shows four levels of ontology, in the triangles' width and height represent the breadth and depth of knowledge as well as their relation. For example, the Most General Things concept has four sub-concepts, such as processes, locations, organizations, and products or services. On the other hand, the metal parts and art supplies concept are sub-concepts of products or services. Lastly, the washers' concept is a sub-concept of the metal parts.

The definition of the breadth and depth of knowledge in the concept study. Depth of knowledge is portrayed in the human mind determined based on the descriptive concept in the ontology. The depth the ontology is "shallow" for the general concepts of knowledge, while "deep" for the specific domain concepts of knowledge. Breadth is determined based on the generality of the ontology's concepts. The breadth of the ontology is "broad" for the general concepts of knowledge or "narrow" for the specific domain concepts [1], [19].

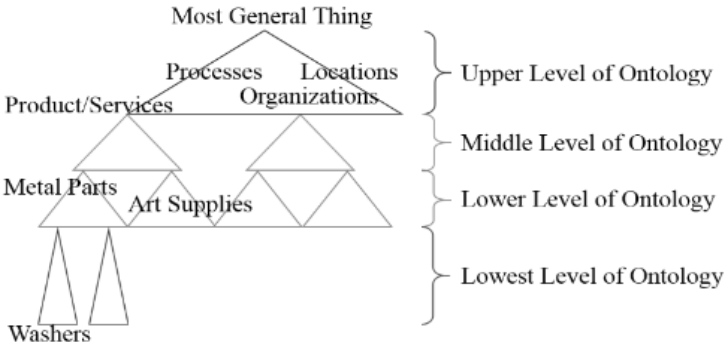

Fig. 1: Level of ontology [18]

B. Reusability

Reusability is one of the ontology development approach and the characteristic in Ontology Quality Requirements and Evaluation Method and Metrics (OQuaRE) [20], which determines the parts of ontologies to be reused [18]. Consequently, new ontology inherits some concepts or relations of the reused ontologies [21].

This paper determined the ontologies' reusability between each level of ontology. However, due to the different descriptions of knowledge and domain between the ULO and other lower levels [22], the descriptions were limited for reusability. Nevertheless, by comparing the knowledge or domain, this study distinguished the reusability and the relation with the levels of ontology. The reusability of a new ontology can be reused with imported from one or more of the existing ontology. Then, edits the existing ontologies either insert new class, new object property, data property or individual into the new ontology according to the domain or knowledge.

Levels of Ontology

The levels of ontology represent the ontology's generality concept levels. To describe the knowledge, the ontology levels fragmented into concept levels, as shown in Fig. 2, which illustrates the Living Creation concept [6]. Moreover, the Living Creation taxonomy comprises of three levels, the higher level describes the general concepts and the lower levels describe the specific concepts.

Semy et al. (2004) provided three levels of ontology, namely, the upper, middle, and lower level. Correspondingly, Wiki OSF (2014) included the lowest level as shown in Fig. 1. The highest level is the ULO (domain-independent ontology), which describes the general concepts of knowledge. Next, the middle level of ontology (MILO) is the ontology's top domain [23] or domain spanning [18]. The lower level (domain-specific ontology) is described a specific domain of knowledge and the lowest level describes a sub-domain-specific ontology. Each level mentioned were reviewed in terms of their knowledge or domain concepts and reusability.

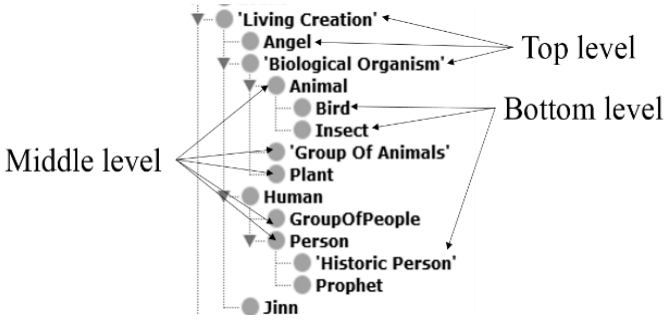

Fig. 2: Living Creation Taxonomy (Source:[6])

A. Upper Level of Ontology

The ULO is vital in the ontology development [24] and its structured general concepts and relations are reusable for other ontology levels [23], [25]. Thus, ULO was used as a reference ontology for the concept of other ontology levels. The following section describes Table I:

1. General knowledge is the knowledge described the general concept in ULO:
    a. Linguistic: Suggested Upper Merged Ontology (SUMO), Generalised Upper Model (GUM), and Descriptive Ontology for Linguistic as well as Cognitive Engineering (DOLCE) in English [12].
    b. Medical science: Systematised Nomenclature of Medicine Clinical Term Upper-Level Ontology (SCTO) [26], General Formal Ontology (GFO) [27], Basic Formal Ontology (BFO), and Ontology for General Medical Science (OGMS) [28].
    c. Others: CIDOC Conceptual Reference Model (CIDOC CRM) describes cultural heritage [34] and Knowledge Yielding Ontologies for Transition-based Organisation (KYOTO) Top describes ecology [32].
2. Reusability: SCTO is reused in OGMS [26]. KYOTO is reused in DOLCE-Lite Plus (DLP) [32]. The Unified Foundational Ontology (UFO) is reused in GFO and DOLCE [27]. Notably, the ULO can be developed by merging the ULO. For instance, the Common Semantic Model (COSMO) is the combination of three concepts of OpenCyc, SUMO, and DOLCE with BFO [29]. The combination of CIDOC CRM and Functional Requirements for Bibliographic Records (FRBR) produced the FRBRoo ontology [35]. ULO is reused in other levels of ontology, the General Ontology for Linguistic Description (GOLD) is reused SUMO [12].

Table I: The Upper Level of Ontology

Upper level of ontology	Knowledge	Reusability		Ontological choices*
		Reused from	Reused in	
SUMO [14]	Linguistic	Sowa, Russel and Norvig's upper ontology and other ontology [29]	COSMO (concepts), GOLD, Sowa, Ontolingua [29]	D, M, Red, U, Par, E and Per [30], [31]
DOLCE	Linguistic	-	COSMO [29], KYOTO [32], UFO reused GFO and DOLCE [27]	D, M, Par, E and Per [30], [31], [33]
KYOTO Top [32]	Ecology	DLP	-	-
BFO	Medical science	Relations of Relation Ontology (RO)	COSMO (classes) [29], YAMATO (quality and quantity concepts) [24]	D and M [33], Rev, Red, U, E and Per [30], [31]
GFO [27]	Medical science, economics and sociology	-	UFO reused GFO and DOLCE	D, Rev, M, Red, U, Par, E and Per [30], [31]

*Descriptive (D), Revisionary (Rev), Multiplicative (M), Reductionist (Red), Endurants (E), Perdurants (Per), Universal (U) and Particular (Par)

3. Ontological choices used to evaluate ontology usage based on the properties of concept in the ontology such as descriptive vs revisionary, multiplicative vs reductionist, endurants vs perdurants and universal vs particular:

    a. Descriptive vs revisionary: Descriptive ontology distinguishes the concepts of spatial and temporal properties. Meanwhile, the revisionary is a concept with a spatial-temporal property that extends space and time. The concept of "boat repair" is divided into the spatial characteristic "boat" and the temporal characteristic "boat repair" in a descriptive ontology meanwhile, the concept combined into one spatial-temporal property for revisionary ontology. BFO, DOLCE and, SUMO and GFO are descriptive ontology [30], [31], [33], while the GFO and BFO are revisionary ontology [30].

    b. Multiplicative vs reductionist: The multiplicative ontology describes the required things to represent the real concepts of knowledge such as a "glass". The multiplicative ontology presents all "glass" views in "liquid sand" in which the glass is construed as "glass" and "broken glass" concepts. In contrast, the reductionist ontology describes the least number of concepts which used one "glass-sand" concept describes all changes of "glass" views. Incidentally, SUMO, DOLCE, BFO and GFO are multiplicative ontology [30], [31], [33] for the general concepts. Furthermore, BFO and GFO are reductionist ontology for specific concepts [30], [31].

    c. Endurants vs perdurants: Endurants describe things that exist at different times, such as "book". Meanwhile, perdurants describe the concepts for things that exist at a time, such as "a book" and extend its present time by increasing its temporal property, such as "reading a book". SUMO, DOLCE, BFO, and GFO are the endurants and perdurants ontology [30], [31].

d. Universal vs particular: Universal ontology is knowledge forms, which comprise general concepts like a person, location, event, and process. The three stances of universal ontology are as follows [33]:

   i. Realist stance: Global concepts from existing things through human thinking and speaking.

   ii. Conceptualist stance: Concepts inspired by the human mind.

   iii. Nominalist stance: Concepts based on the natural human language and thinking stance.

Particular ontology describes the precise concepts of the universal ontology. For instance, the colour of red apple. The particular ontology categorised based on the red apples' colour intensity although the colours are similar, they are conceptualised by the colour characteristic, such as attractive striped ruby-red, and bright pink skin [36]. Universal ontology clustered the colour of apple into one "red" concept. Hence, SUMO, BFO, and GFO are universal ontologies, while SUMO, DOLCE, and GFO are particular ontologies [30], [31]. SUMO and GFO possess both choices, which depended on the concepts' precise descriptions in a new ontology.

The ULO's criteria revealed that most ULO reuses at least one part of the ontology fragments. Notably, the reusability at the ULO is unrestricted, which allows for the reusability of other levels, such as SUMO and BFO. Furthermore, a specific knowledge can be described using ontology. An ontology is feasible in other knowledge compared to its specified knowledge [32]. Ontological choices reported that the ontology usage types are based on the concept's properties. Furthermore, these choices depend on the concept level, which is either the general or specific domain that can be reused in a new ontology.

B. Middle Level of Ontology

MILO links ULO and lower level, which describes more concrete concepts than the general ones. These concepts are relatively deeper and less broad to extend the ULO's concepts. The criteria are:

1. Domain-spanning of knowledge: Ontologies of Linguistic Annotation (OLiA) for linguistic annotation and GOLD for linguistic description.

Table II: The Middle Level of Ontology

Middle level of ontology	Domain spanning	Reused from
GFO-Bio [37]	Biological	GFO
KYOTO Middle [32]	Ecology concepts, measurement, qualities, perdurant and endurant	KYOTO Top
OLiA [12]	Linguistic annotation	Linked to BLL Ontology
GOLD [12]	Linguistic description	SUMO

Moreover, GFO-Bio describes the biology of medical science [37]. KYOTO Middle describes the ecology [32] as seen in Table II.

2. Reusability: MILO reused other ontologies with Quran Vocabulary (QVOC). For instance, the GOLD and Lexical Item concepts were reused from OLiA [38]. Similarly, MILO was reused the ULO, while GOLD was reused SUMO [12]. GFO-Bio was reused from GFO [37], and KYOTO Middle was reused from KYOTO Top [32].

C. Lower Level of Ontology

The lower level describes at least one domain of knowledge. In comparison to the ULO and MILO concepts, the lower level's concepts are significantly more profound and narrower. Table III describes the criteria of the lower level:

1. Domain-specific knowledge: The lower level examines the knowledge's specific domains.
    a. Quran: Several ontologies described one domain, such as Living Creation [6] and Nature [39]. Ontologies were also described in numerous domains, such as Quran Analysis (QA) [8] and The Quranic Arabic Corpus (QAC) [4]. Moreover, QuranOntology (QO) described the chapter, verse, word, pronoun, and other domains [6].
    b. Medical science: Infectious Disease Ontology (IDO) described diseases, and the Ontology of Genes and Genome (OGG) described the gene and genomes [28] clustered in Ontobee. OntoADL denoted Prophetic Medicine (Tibb An-Nabawi) [42].
    c. People: This ontology described the profile of people. VIVO describe the researcher's profile [43], while the Friend-of-a-friend (FOAF) contained basic profile concepts [41]. Moreover, patient's blood was described in the extended FOAF [44].
    d. Others: The KYOTO Domain described the estuaries of ecology [32]. Similarly, the British Broadcasting Corporation (BBC) developed several lower ontologies, such as the Sport ontology [45].

Table III: The Lower Level of Ontology

Lower level of ontology	Domain-specific	Reused from concept
The Quranic Arabic Corpus [4], Quran Analysis [8], QuranOntology [6], QuranMed [7], [5], Quranic Ontology [3], Noble Quran [9]	Tajweed, medical and health science, human relations and moral, part of speech (POS).	QuranOntology – The Quranic Arabic Corpus, QVOC [40]
FOAF [41]	People	-
IDO [28]	Infectious disease	OGMS, SCTO
OGG [28]	Gene and genomes	BFO
KYOTO Domain [32]	Estuaries	KYOTO Top and Middle

2. Reusability: The lower ontologies reused ULO or MILO. KYOTO Domain was reused from KYOTO Top and Middle [32]. Furthermore, lower ontologies of the medical science in Ontobee reused BFO and OGMS [28].

Lower ontologies illustrated the specific domains of its knowledge as in Table III. Moreover, most development of the lower ontology reused its higher levels of ontology, which were related in terms of its domain; OGG reused BFO.

D. Lowest Level of Ontology

The lowest level of ontology denoted the sub-specific domain of the lower level [18]. The concepts are significantly narrower and more in-depth for a specific domain than the lower level. This level is limited since most ontologies described specific domains. The criteria for the lowest level of ontology are:

1. The sub-specific domain of knowledge is detailed in the lowest ontologies in Table IV. For example, IDO-Brucellious (IDO-BRU) and other sub-specific domain ontologies of IDO and OGG [28].
2. Reusability: The lowest level of ontology reused the lower ontology. OGG-Arabidopsis thaliana (OGG-At), which reused OGG [28]. However, the ontology is non-reusable for higher levels due to the short descriptions of knowledge.

Table IV: The Lowest Level of Ontology

Lowest level of ontology	Sub-specific domain	Reused from concept
OGG-At, OGG-Bru, OGG-Ce [28]	OGG- Arabidopsis thaliana (At), Brucella (Bru), Caenorhabditis elegans (Ce),	OGG
IDO-BRU, IDO-MAL, IDO-Influenza [48]	IDO- Brucellosis, Malaria, Influenza	IDO

Furthermore, the ULO is advantageous in designing other lower levels of ontologies [46], such as OGG, which was reused from BFO [28]. Additionally, to decrease the word ambiguity in different knowledge, the ULO was used in the matching between the lower ontologies [46]. As a result, half of the concepts were mismatched between the ULO and lower ontologies from their experiment. These mismatched concepts were due to the concepts being non-equivalent [47].

Discussion on the Levels of Ontology

The knowledge concepts of depth and breadth, reusability, ontologies, and its applications will be used to review the four levels of ontology based on Table V. Firstly, the concept of knowledge in terms of depth and breadth for each level of ontology was different. Specifically, the ULO was shallow and broad, while the lower level of ontology was significantly deeper and narrow. For example, BFO (ULO) described the general concepts of medical science, and the OGG (lower level) described the gene and genomes of BFO. Furthermore, OGG-At (lowest level) described the concepts of Arabidopsis thaliana [28]. The levels of ontology led to different descriptions of the concept. Meanwhile, it was found that the knowledge, domain and sub-domain were related.

Furthermore, it was indicated that the same knowledge was described into the level of ontology, such as OGMS, BFO, GFO, and SCTO (these are ULO) for medical science, albeit contained different concepts. Notably, the ontology development was iterative, which required creativity due to the concepts and relations of knowledge that emerged in different ways.

Table V: Criteria Levels of Ontology

Level of ontology	Knowledge/domain concepts		Reusability	Ontology
	Depth	Breadth		
Upper	Shallow	Broad	Yes, to all except Lowest	Refer to Table I
Middle	Less shallow	Less broad	Yes, to MILO and Lower	Refer to Table II
Lower	Deep	Narrow	Yes, to Lower and Lowest	Refer to Table III
Lowest	Deeper	Narrowest	Yes, to Lowest	Refer to Table IV

Table V shows each level of ontology that has different values on reusability. The higher levels of ontology had high reusability compared to the lower levels. Nevertheless, most ULO reused the same or different levels of ontology.

Table VI shows the differences between the two main levels of ontology, the ULO and lower levels. Additionally, the MILO and lowest levels are the extensions of the two main levels. Based on the table, some of the ULO was feasible in other domains [31] with SUMO, which can be used in communication [14], [18].

The lower levels of ontology were unable to work in other domains because the meanings were stemmed from its specific domain. Hence, ULO had higher reusability in other ontology development [49] than the lower levels.

Most of the ULO were reused in other ontologies and used as a reference ontology in the ontology mapping [50], [51]. Similarly, the lower levels were reused in the same manner. For example, the lowest levels of ontology development, such as Blood Test Ontology of the lower ontology reused FOAF [44], and OGG-At of the Lowest level reused OGG of the Lower level [28].

Next, ULO was more flexible than the lower level [30], [31], [33], which described the general concepts that could be reused to describe other domains or specific concepts in another ontology. For example, GFO was flexible to describe specific domains, such as medical science, economy, or sociology. Meanwhile, the lower level ontology had a specific domain, in which the description was more in-depth and narrowed down.

Table VI: The Comparison of the Two Main Level of Ontology

Level of ontology	Upper	Lower
Workable in other domains	Yes [31]	No
Reusability in another ontology development	High [25]	Low
Flexibility	High [30], [31], [33]	Low
Requires understanding	A lot [31], [52]	Less
Results (refer to Fig. 3)	Low	High

However, the development of ULO required further understanding to describe the general concepts of knowledge. This idea was in comparison to the lower ontology level, which described the specific domains of knowledge. Lastly, the lower level of ontology retrieved higher results than the ULO, as shown in Fig. 3. These results were retrieved from the SUMO, Cyc, and FOAF by utilizing the Watson [53] and WordNet Search 3.1 [54], which used two English words, such as sight and hearing. Notably, the results from FOAF retrieved highest results as compared to the SUMO, WordNet, and Cyc.

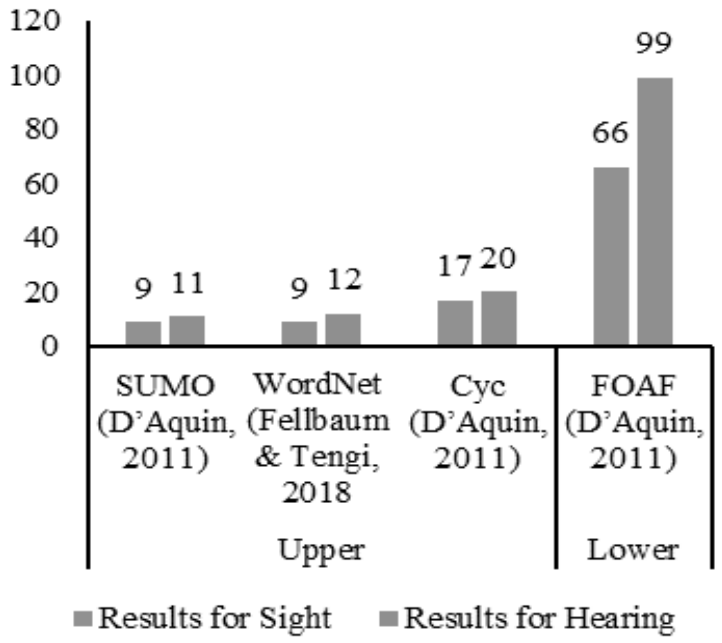

Fig. 3: Retrieved Results [53], [54]

These search engines appealed to the computational linguistic, due to the lower level of ontology's detailed concept description for the domain, which was deep and narrow compared to the ULO. Correspondingly, the ULO needed support by other levels of ontology to enrich the concept descriptions. For instance, this was seen from GOLD that enriched the linguistic description of SUMO and KYOTO middle, which in turn enriched the description of ecological concepts, measurement, qualities, perdurant, and endurant terms. Additionally, the domain enriched the estuaries of KYOTO top.

Related Works on the Quranic Ontology

There are eight Quranic and three Arabic ontologies as in Table VII. Seven Quranic ontologies examined the concepts using nouns and one ontologies, including verbs [9]. Furthermore, given that Arabic is the authentic language of the Quran, thus, two Arabic ontologies were used as the nouns, verbs, adjectives, and particles to describe the words' related meanings [10], [13]. Furthermore, concepts other than nouns and verbs were crucial to describe the words' meanings [60].

These Quranic ontologies applied two search methods, namely semantic-based and keyword-based. Specifically, two Quranic ontologies used semantic-based [2], [9], two used keyword-based [4], [8], and three used both methods [3], [6], [55]. Notably, one Quranic ontology used speech recognition for the verse's segment [5].

Table VII: Comparison of Quranic Ontologies

Quranic ontology	Domain	Concept	Resource	Level of ontology	Search method	Results (verses)	
						"بصر"	"سمع"
Quranic ontology [3]	Linguistic of Quranic word semantic fields	Noun	Quranic word dictionary (Zaki elkhedre, 2004)	Lower	Semantic-based and keyword-based	-	-
Elsayed and Fathy [5]	Tajweed rules based on Hafs from Asim reading	Noun	Pronunciation and recitation of Asim reading	Lower	Speech recognition of verse segment	-	-
QuranMed [7]	Medical and health science of Quran	Noun	English translation (Saheeh International), Quranic concepts (FPQS and FPSK of USIM)	Lower	Semantic-based and keyword-based [55]	N/A	N/A
Noble Quran [9]	Human relations and moral of the Quran	Noun, verb	Quranic concepts (Dar Al-Alfajer), Arabic and English translations (Tafsir al-Jalalyn)	Lower	Semantic-based	-	-
General Qur'an Ontology [2]	Similar concepts in other Quranic ontologies	Noun	English translation, QAC [4], [56], [57]	Lower	Semantic-based [58]	N/A	N/A
Quran Analysis [8]	Quran	Noun	English translation (Saheeh International)	Lower	Keyword-based	139	163
QuranOntology [6]	Chapters, verses, words, pronoun	Noun	Arabic, Semantic Quran (QVOC) and QAC [4]	Lower	Semantic-based and keyword-based [40]	196	180

Arabic Ontology [11]	Arabic philosophy and history	Noun	Arabic, SUMO and DOLCE [59]	Upper	Semantic-based	-	-
Azhary [13]	Parts of speech in Arabic	Noun, verb, adjective	Arabic	Lower	-	-	-
The Quranic Arabic Corpus [4]	Quran, hadith, Quranic exegesis	Noun	Arabic	Lower	Keyword-based	11	49
Belkredim and El Sebai [10]	Parts of speech in Arabic	Noun, verb, adjective, particle	Arabic	Lower	-	-	-

Hence, out of the of eight Quranic ontologies, three Quranic ontologies, QAC [4], QA [8], and QO [6] had accessible search engines and queried using two Arabic words such as "**بصر**" (sight) and "**سمع**" (hearing). It was found that QO had the highest results for both words using both search methods compared to QA and QAC's keyword-based method.

Semantic relations such as synonym relation connected two Quranic concepts [6] and, the synonym and polysemy relations to describe the Arabic philosophical and historical domains [11]. Moreover, the usage of these semantic relations was based on the domain.

Proposed Quranic Ontology

This paper proposed to enhance the QO [6] because it has complete words, verses, and chapters. Additionally, QO retrieved the highest search results using a complete word, root, synonym, pronoun, and topic options as displayed in Table VIII.

First, the ontology file of QO been imported into a new Quranic Ontology file using Protégé. New concepts such as root, lemma, POS concepts such as verb, noun, verbal noun, space noun, time noun, and instrument noun of Belkredim and El Sebai (2009)'s research [10] are generated along with the new object properties, data properties and individuals such as "**بصر**" and "**سمع**" of root concept to enhanced the QO. However, the imported file of QO give error which was unable to read when running the system. Therefore, the imported file was removed, thus, the new classes, object properties, data properties and individuals will be remained.

Table VIII: Result From QuranOntology [6]

Search by	**Query word**	
	"بصر"	**"سمع"**
Complete Word	96	87
Root	1	3
Synonym	90	87
Pronoun	1	2
Topic	7	1
Topic and Synonyms	1	0
Total number of verse	**196**	**180**

Second, the verse, word, chapter concepts of QO will be inserted into the new Quranic Ontology to imitate QO as illustrated in Fig. 4. Then, the QO's object properties, data properties and individuals will be inserted in the new Quranic ontology. Furthermore, each concept and individuals will be inserted, in which an Arabic root word, such as "**بصر**" to illustrate the concepts, which included one individual.

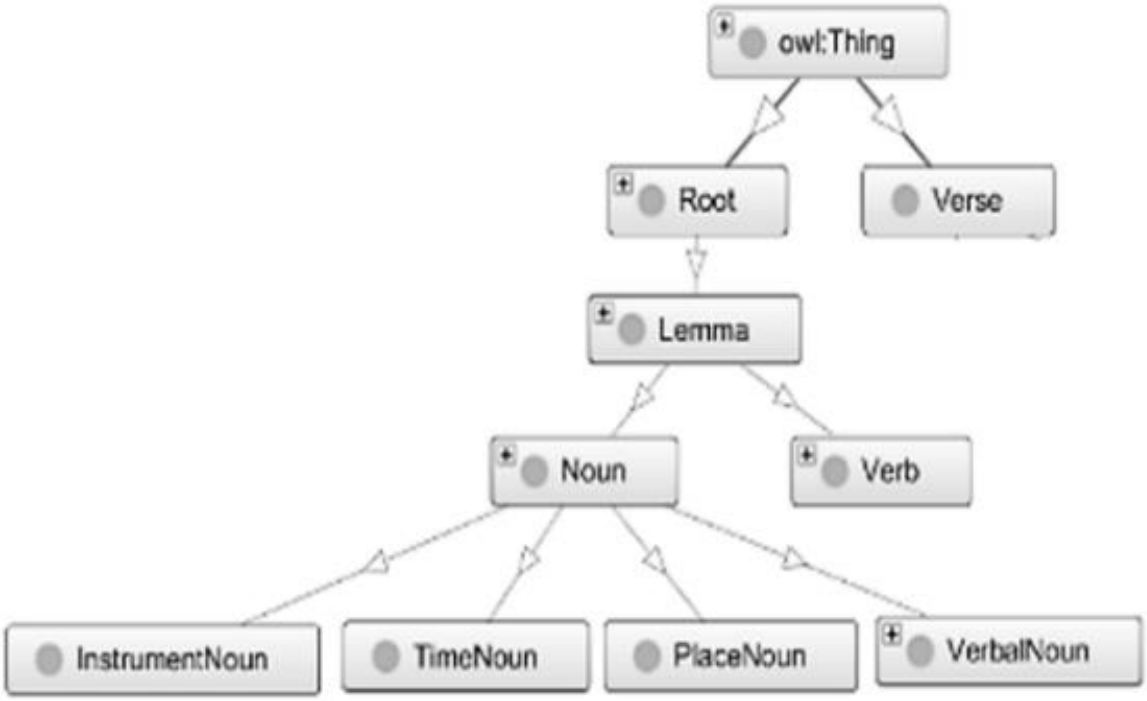

Fig. 4: Proposed New Quranic Ontology

The examples to describe the concept are as follows:

- Root word represents the basic letters and meaning [17]. An example is "**بصر**".
- Lemma is a derived word with affixes from a root word like "**بَصِير**" (All-Seer).
- Verb represents the action word such as "**يُبْصِرُونَ**" (they see).
- Noun represents the person name or thing like "**أَبْصَارِهِمْ**" (their vision).
- Space/time noun represents a place or time such as "**مَسْجِدٍ**" (mosque) and "**الْفَجْرِ**" (the dawn).
- Verbal noun represents a form of inflexion word for a verb, which allows the word to be a noun in the sentence like "**تَبْصِرَةً**" (giving insight).
- Instrument noun represents an instrument such as "**مَفَاتِحُ**" (keys).

Synonym and antonym relations will be inserted into QO to link the Quranic words' real meanings using synonyms and antonyms [16], [17]. Furthermore, the words' real meanings were based on the Quran itself. For instance, synonym root words for "**بصر**" are "**شهد**" (witness) and "**راي**" (view). Meanwhile, the antonyms are "**ضرر**" (harm) and "**عمى**" (blind), which will be inserted in the ontology.

This proposed ontology will improve the results of 874 and 210 verses for both words, which includes their synonyms and antonyms as observed in Table IX. Specifically, these results referred to the acquisition of the verse collections of both words. The acquisition from one research team of Faculty of Quran and Sunnah Studies (FPQS), Universiti Sains Islam Malaysia (USIM) revealed that their results are higher than the previously stated in the Quranic ontologies.

Table IX: Forecasted Results Using the Enhanced Quranic Ontology

Quranic ontology		Enhanced Quranic ontology	
Domain		Parts of speech in Quran	
Concept		Nouns and verbs	
Resource		Quranic Arabic	
Level of ontology		Lower	
Searching method		Semantic-based (synonym and antonym)	
Retrieved results (verses)	**Sample root word**	148 (**بصر**)	185 (**سم**”)
	Synonym	160 (**شهد**), 129 (**نظر**), 328 (**راي**), 0 (**لحظ**)	2 (**صغو**), 2 (**نصت**),
	Antonym	74 (**ضرر**), 2 (**كمه**), 33 (**عمي**)	6 (**وقر**), 15 (**صمم**)
	Total	874	210

This ontology will describe the Quranic POS's concepts to reveal the Quranic words' real meanings by using the synonym and antonym relations. Besides, the presumed ontology can assist in understanding the Quranic words' real meanings.

CONCLUSION

This paper reviewed the four levels of ontology, the upper, middle, lower, and lowest level, which described various knowledge or domain developed with reused ontology between the levels. Furthermore, two main ontology levels were compared, in which the lower level presented less knowledge and time to develop its domain and retrieved high results. Meanwhile, the upper ontology level required the use of other lower ontology levels to retrieve high results due to the shallow and broad nature of the knowledge. Moreover, eight Quranic ontologies of the lower level was reviewed. Three Quranic ontologies, such as QAC, QA, and QO, have available search engines, albeit unable to retrieve the Quranic word' real meaning based on the results. The proposed Quranic ontology enhanced the QO, which contributed to elucidate the Quranic word' real meanings using the synonyms and antonyms. These enhancements include several new POS concepts with the synonym and antonym relations. Hence, future ontology research is necessary to map out the level of the people's Quranic understanding.

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REFERENCES

1. L. Yao, A. Divoli, I. Mayzus, J. A. Evans, and A. Rzhetsky, “Benchmarking ontologies: Bigger or better?,” PLoS Comput. Biol., vol. 7, no. 1, 2011, doi: 10.1371/journal.pcbi.1001055.
2. R. Ahmed and E. Atwell, “Developing an Ontology of Concepts in the Qur’an,” Int. J. Islam. Appl. Comput. Sci. Technol., vol. 4, no. 4, pp. 1–8, 2016.
3. F. Beirade, H. Azzoune, and D. E. Zegour, “Semantic Query for Quranic Ontology,” J. King Saud Univ. Comput. Inf. Sci., 2019, doi: 10.1016/j.jksuci.2019.04.005.
4. K. Dukes, “The Quranic Arabic Corpus,” 2009. http://corpus.quran.com/ (accessed Feb. 15, 2017).
5. E. Elsayed and D. Fathy, “Evaluation of Quran Recitation via OWL Ontology Based System,” Int. Arab J. Inf. Technol., vol. 16, no. 6, pp. 970–977, 2019.
6. A. Hakkoum, “Search Tool,” Quran Ontology, 2015. http://www.quranontology.com/ (accessed May 04, 2017).
7. M. A. Mohamad Safee, M. Mohd Saudi, and K. Saadan, “Ontology Development for Medical and Health Science Domain in the Quran,” Int. J. Eng. Technol., vol. 7, no. 4.33, pp. 504–509, 2018.
8. K. Ouda, “Semantic Search and Intelligence System for the Quran,” University of Leeds, 2015.
9. Y. M. Tashtoush, M. R. Al-Soud, R. M.Abujazoh, and M. Al-Frehat, “The Noble Quran Arabic Ontology: Domain Ontological model and Evaluation of Human and Social Relations,” in 8th International Conference on Information and Communication Systems (ICICS), 2017, pp. 40–45.
10. F. Z. Belkredim and A. El Sebai, “An Ontology Based Formalism for the Arabic Language Using Verbs and their Derivatives,” Commun. IBIMA, vol. 11, pp. 44–52, 2009.
11. Birzeit University, “Arabic Ontology,” 2018. https://ontology.birzeit.edu (accessed Oct. 23, 2017).
12. S. Farrar and T. Langendoen, “A Linguistic Ontology for the Semantic Web,” Glot Int., vol. 7, no. 3, pp. 97–100, 2003, [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1.4651&rep=rep1&type=pdf.
13. H. Ishkewy, H. Harb, and H. Farahat, “Azhary: An Arabic Lexical Ontology,” Int. J. Web Semant. Technol., vol. 5, no. 4, pp. 71–82, 2014, doi: 10.5121/ijwest.2014.5405.
14. A. Pease, “Suggested Upper Merged Ontology (SUMO),” Ontology Portal, 2002. http://www.adampease.org/OP/ (accessed Dec. 01, 2017).
15. WonderWeb Project., “DOLCE : Descriptive Ontology for Linguistic and Cognitive Engineering,” 2013. http://www.loa.istc.cnr.it/dolce/overview.html#:~:text=DOLCE %3A Descriptive Ontology for Linguistic and Cognitive Engineering&text=It was originally developed within,first release in 2002%2F2003. (accessed May 01, 2017).
16. Ammar, “Al-Addaad الأضداد in Qur’an : Same Word with Opposite Meanings,” HukmAllah, 2016. http://www.hukmallah.com/2016/06/al-addaad-in-quran-same-word-with.htm (accessed Mar. 30, 2018).
17. Mohammed Mahbboob Hussain Aazaad, “Qur’an - The Linguistic Miracle,” Islamic Sources. http://www.en.islamic-sources.com/book/al-quran-the-linguistic-miracle/ (accessed Mar. 30, 2018).
18. OSF Wiki., “A Basic Guide to Ontologies,” 2014. http://wiki.opensemanticframework.org/index.php/A_Basic_Guide_to_Ontologies (accessed Apr. 20, 2017).
19. N. Ford, “Knowledge Breadth versus Depth,” AgileTODAY, 2017. http://www.agiletoday.com.au/knowledge-breadth-versus-depth/ (accessed Mar. 21, 2019).
20. A. Duque-ramos, M. Boeker, L. Jansen, S. Schulz, M. Iniesta, and J. T. Fernandez-Breis, “Evaluating the Good Ontology Design Guideline (GoodOD) with the Ontology Quality Requirements and Evaluation Method and Metrics (OQuaRE),” PLoS One, vol. 9, no. 8, 2014, doi: 10.1371/journal.pone.0104463.

21. M. Katsumi and M. Gruninger, “What is Ontology Reuse?,” Form. Ontol. Inf. Syst., pp. 9–22, 2016, doi: 10.3233/978-1-61499-660-6-9.

22. H. S. Pinto, “Towards Ontology Reuse,” AAAI Press, Menlo Park, 1999.

23. S. Schulz, M. Boeker, and C. Martinez-costa, “The BioTop Family of Upper Level Ontological Resources for Biomedicine,” Stud. Health Technol. Inform., 2017, doi: 10.3233/978-1-61499-753-5-441.

24. R. Mizoguchi, “YAMATO : Yet Another More Advanced Top-level Ontology,” Osaka, 2010. [Online]. Available:http://www.ei.sanken.osaka-u.ac.jp/hozo/onto_library/YAMATO101216.pdf%5Cnpapers2://publication/uuid/B1D974DB-AEE8-47BC-B79B-3E8E7811F1EA.

25. R. Hoehndorf, “What is an Upper Level Ontology?,” Ontogenesis, 2010. http://ontogenesis.knowledgeblog.org/740 (accessed May 14, 2017).

26. F. Franda and S. El-Sappagh, “SNOMED-CT Upper-Level Ontology Based on OGMS,” NCBO BioPortal, 2017. https://bioportal.bioontology.org/ontologies/SCTO (accessed May 01, 2017).

27. H. Herre, “General Formal Ontology (GFO): A Foundational Ontology for Conceptual Modelling,” in Theory and Applications of Ontology: Computer Applications, R. Poli, M. Healy, and A. Kameas, Eds. London: Springer, 2010, pp. 297–346.

28. He Group, “Welcome to Ontobee,” Ontobee, 2010. http://www.ontobee.org/ (accessed May 01, 2017).

29. V. Mascardi, V. Cordì, and P. Rosso, “A Comparison of Upper Ontologies,” in Web Offset Association Conference, 2007, pp. 55–64, doi: 10.1.1.107.1689.

30. Z. C. Khan, “Foundational Ontology Comparison: Ontological Commitments,” Ontological Commitments, 2012. http://www.thezfiles.co.za/ROMULUS/ontologicalCommitments.html (accessed Mar. 27, 2019).

31. M. Blasko, “Upper Ontologies,” 2017. http://cw.fel.cvut.cz/old/_media/courses/osw/lecture-06upperontologies-s.pdf (accessed Dec. 07, 2017).

32. KYOTO Project Partners, “Knowledge Yielding Ontologies for Transition-based Organization,” Kyoto Consortium, 2008. http://kyoto-project.eu/xmlgroup.iit.cnr.it/kyoto/index8d0f.html?option=com_content&view=article&id=390&Itemid=155 (accessed May 21, 2017).

33. S. K. Semy, M. K. Pulvermacher, and L. J. Obrst, “Toward the Use of an Upper Ontology for U.S. Government and U.S. Military Domains: An Evaluation,” Bedford, 2004. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.135.5705&rep=rep1&type=pdf.

34. M. Doerr, “The CIDOC CRM - an Ontological Approach to Semantic Interoperability of Metadata,” vol. 24, no. 3, pp. 75–92, 2003.

35. M. Doerr and P. LeBoeuf, “Modelling Intellectual Processes: The FRBR-CRM Harmonization,” in International DELOS Conference DELOS 2007: Digital Libraries: Research and Development, 2007, pp. 114–123, doi: 10.1007/978-3-540-77088-6_11.

36. Washingtion Apple Commission, “Washington Apple Varietals,” 2019. https://bestapples.com/varieties-information/varieties/ (accessed Apr. 13, 2019).

37. Onto-Med Research Group, “GFO-Bio: A Biological Core Ontology,” Universitat Leipzig, 2010. https://www.onto-med.de/ontologies/gfo-bio%0A (accessed Jul. 01, 2017).

38. M. Ahmed Sherif and A.-C. Ngonga Ngomo, “Semantic Quran: A Multilingual Resource for Natural-Language Processing,” Semant. Web, vol. 6, no. 4, pp. 339–345, 2014, doi: 10.3233/SW-140137.

39. A. B. M. S. Sadi et al., “Applying Ontological Modeling on Quranic ‘Nature’ Domain,” in 7th International Conference on Information and Communication Systems (ICICS), 2016, pp. 151–155, doi: 10.1109/IACS.2016.7476102.

40. A. Hakkoum and S. Raghay, “Advanced Search in the Qur’an using Semantic Modeling,” in IEEE/ACS 12th International Conference of Computer Systems and Applications, 2015, doi: 10.1109/AICCSA.2015.7507259.

41. D. Brickley and L. Miller, “FOAF Vocabulary Specification 0.99,” 2014. http://xmlns.com/foaf/spec/ (accessed Jul. 08, 2017).

42. I. M. AlAgha and M. G. Al-Masri, “An Ontology Based Approach to Enhance Information Retrieval from Al-Shamelah Digital Librar,” IUG J. Nat. Eng. Stud. Peer-reviewed J. Islam. Univ., vol. 24, no. 1, pp. 39–53, 2016.

43. C. Hauschke, “VIVO Ontology Domain Definition,” DuraSpace Wiki, 2018. https://wiki.duraspace.org/display/VIVODOC110x/VIVO+Ontology+Domain+Definition (accessed May 12, 2019).

44. E. Sezer, O. Can, O. Bursa, and M. O. Unalir, “Towards Interoperable Ontologies: Blood Test Ontology with FOAF,” in SEMAPRO 2016: The Tenth International Conference on Advances in Semantic Processing, 2016, pp. 32–36, [Online]. Available: https://www.thinkmind.org/download.php?articleid=semapro_2016_2_20_30046.

45. British Broadcasting Corporation., “Ontologies,” British Broadcasting Corporation, 2015. https://www.bbc.co.uk/ontologies (accessed Dec. 10, 2019).

46. D. Schmidt, C. Trojahn, and R. Vieira, “Analysing Top-level and Domain Ontology Alignments from Matching Systems,” in 15th International Semantic Web Conference, 2016, vol. 1766, pp. 13–24, [Online]. Available: http://ceur-ws.org/Vol-1766/om2016_Tpaper2.pdf.

47. I. Opalički and S. Lovrenčić, “How Well are Domain and Upper Ontologies Connected?,” in Central European Conference on Information and Intelligent Systems, 2012, pp. 17–22.

48. L. Cowell, “The Infectious Disease Ontology,” Science Commons, 2016. http://infectiousdiseaseontology.org/page/Main_Page (accessed Mar. 22, 2018).

49. S. Schulz and M. Boeker, “BioTopLite: An Upper Level Ontology for the Life Sciences. Evolution, Design and Application,” in Informatik 2013, 2013, no. September 2014, pp. 1889–1899.

50. K. M. Vaishnav and P. V. Virparia, “Ontology Mapping Techniques – An Overview,” Int. J. Res. Comput. Sci. Manag., vol. 1, no. 1, pp. 12–17, 2014.

51. K. H. Yew, M. F. Hassan, and A. M. Shariff, “A Survey on Ontology Mapping Techniques,” in Lecture Notes in Electrical Engineering, vol. 279, ResearchGate, 2014, pp. 1–8.

52. S. Sepp and A. Hicks, “Enhancing Terminological Knowledge with Upper Level Ontologies,” in Proceedings of the conference Terminology and Artificial Intelligence 2015, 2015, pp. 179–182.

53. M. D’Aquin and E. Motta, “Watson, more than a Semantic Web search engine,” Semant. Web, vol. 2, no. 1, pp. 55–63, 2011, doi: 10.3233/SW-2011-0031.

54. C. Fellbaum and R. Tengi, “WordNet Search 3.1,” WordNet, 2018. http://wordnetweb.princeton.edu/perl/webwn (accessed Feb. 01, 2018).

55. M. A. Mohamad Safee et al., “Hybrid Search Approach for Retrieving Medical and Health Science Knowledge from Quran,” Int. J. Eng. Technol., vol. 7, no. 4.15, pp. 69–74, 2018, doi: 10.14419/ijet.v7i4.15.21374.

56. H. U. Khan, S. M. Saqlain, M. Shoaib, and M. Sher, “Ontology Based Semantic Search in Holy Quran,” Int. J. Futur. Comput. Commun., vol. 2, no. 6, pp. 570–575, 2013, doi: 10.7763/IJFCC.2013.V2.229.

57. A. R. Yauri, R. A. Kadir, A. Azman, and M. A. A. Murad, “Quranic Verse Extraction Base on Concepts Using OWL-DL Ontology,” Res. J. Appl. Sci. Eng. Technol., vol. 6, no. 23, pp. 4492–4498, 2013.

58. R. Ismail, N. Abd. Rahman, and Z. Abu Bakar, “Extractions of Synonym Relations from English Translated Quran Using Seed Word Patterns,” World Appl. Sci. J. 35 (New Adv. Res. Dev. Comput. Sci., pp. 102–107, 2017, doi: 10.5829/idosi/wasj.2017.102.107.

59. D. Fadl, S. Abbas, and M. Aref, “Automatic Arabic Ontology Generation for the Animal Kingdom (NAAO),” J. Theor. Appl. Inf. Technol. 15th, vol. 96, no. 1, pp. 227–238, 2018.

60. E. T. Al-Shammari, “Lemmatizing, Stemming, and Query Expansion Method and System,” US 2010/0082333 A1, 2010.