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A Hybrid Methods of Aligning Arabic Qur'anic Semantic Resources

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***Abstract*—Ontology alignment is a necessary step for enabling interoperability between ontology entities and for avoiding redundancy and variation that may occur when integrating them. The automation of bilingual ontology alignment is challenging due to the variation an entity can be expressed in, in different ontologies and languages. The goal of this paper is to compare various ontology alignment methods for matching ontological bilingual Qur'anic resources and to go beyond them, which is achieved via a new hybrid alignment method. The new method consists of aggregating multiple similarity measures for a given pair of concepts into a single value, taking advantage of combining fuzzy bilingual lexical and structure-based methods for improving the performance of automatic ontology alignment.**

Keywords—alignment, Quran, ontology

I. INTRODUCTION

The holy Qur'an is the core of Islamic values and knowledge. Qur'anic text has attracted many researchers in Natural Language Processing (NLP) community due to its importance to Muslims and its differences from any other text in terms of style [1] and format [2][3]. Thus, any computational effort on understanding or learning the Qur'anic text will benefit billions of Muslims and non-Muslims around the world. Recently, a number of ontological annotations of the Qur'an have emerged. These ontological annotations are represented in a variety of schemas and formats rather than employing a standard formal ontology language such as OWL or RDF, which is an explicit schema [4]–[6]. Furthermore, the same concept is differently expressed across these annotations. As a result, research was conducted to represent these annotations in an explicit semantic schema [4], [6]–[8]. However, the problem of a concept being labelled more than one way is still open. Ontology Alignment is a way of identifying similarity relations among entities of multiple ontologies [9]. Generally, for most ontology domains the estimation of terminology variation can amount to between 15% to 35% [10] depending on the domain and other factors like type of the text. Ontology alignment is important for enabling interoperability between different ontologies [11], [12] and necessary for avoiding redundant ontology entities. The result of matching two resources is called an alignment. We will not solve the problem of format variation, but we will focus on similarity relationships between concepts on two Qur'anic ontological annotations that have similar schema and format namely Qurany and QAC. In this paper, we take two different ontological Qur'anic annotations named Qurany [13] and Quranic Arabic Corpus [14] and propose a new approach, which combines fuzzy bilingual lexical-based and structure-based methods for determining corresponding concepts. The rest of the paper is organised as follows. Section II provides a number of possible variations in the two compared resources. Section III reviews related work. Section IV describes our approach to alignment. Section V shows a number of alignments returned based on selected algorithms. Section VI draws the conclusion.

II. QUR'ANIC CONCEPTS VARIATION

A number of linguistic specifications of Arabic multi-word terms can be found [15]–[17]. These variations make the automation of Arabic ontology alignment challenging. An example of linguistic variation in Arabic text may occur when comparing a diacriticised concept with and another one is undiacriticised. This may be solved by removing vowels and Hamza from one of compared texts. Another linguistic variation may occur when a concept is being expressed based on varying morphological features. For instance, the concept "The believers" can be expressed in the Qur'an in different ways such as (المؤمنين, المؤمنون) ({lomu&ominiyna,{lomu&ominuwna). Although these different labels of a single concept have been expressed in different lexical word-forms, but they are denoting the same entity. The inflectional feature of case has changed the last two letters of the concept. Another number of morphological features can be changed the way the concept is being expressed such as the determine article and the state. This variation can be solved by matching the two concepts lemmas inflected from the same lemma. Another variation which is special to Arabic Qur'anic text is the type of script. Two different script types, namely Uthamni and Modern Standard Arabic (MSA) are found in the Qur'anic annotations, which have some differences in how words are spelled such as ("الرحمن" "الرحمان"). Another variation which occurs in both Arabic and English translation of the Qur'an is when a written concept is based on its dictionary meaning and not based on its actual word occuring in the Qur'an. An example, from these datasets is (i.e., "الخيل, الحصان",

“الغيث, المطر”, “Gabriel, Jibreel”, “The Gospel, Injeel, The Bible”, “Ibrahim, Abraham”, “Yaqub, Jacob” etc.). We argue that algining these resources can benfit from aggregating structure-based and fuzzy bilingual lexica-based measures. Thus, we propose a new hybrid method that takes into account the variations occur in Seamntic resources alignment.

III. Related Work

We identified two areas of related work: 1) Methods for unifying and mapping other ontologies. 2) Quran Ontology development and alignment methods.

There are two main methods using similarity measures for aligning a pair of entities in multiple ontologies, namely, 1) lexical-based similarity, and 2) structure-based similarity.

Early work on ontology alignment relies on matching labels of ontology entities such as concept names. Examples of lexical-based matching can be seen in [18]–[22]. The drawback of this method is that it is not able to match concepts that are differently labelled even if they were constructed for the same domain [12]. Another limitation occurs when matching multi-word concepts [11]. Therefore, some of lexical-based methods exploit NLP techniques (i.e., lemmatisation, wordnet, .etc.) for improving the accuracy of matching such as [23] who exploit a thesaurus for detecting labels acronyms and short-forms such as (Qty, Quantity), (UoM, UnitOfMeasure).

Structure-based similarity relies on the distributional hypothesis claiming that words that are used and appear in the same context frequently tend to have similar meaning [24]. Instead of computing the distance similarity between labels, in this method the sets of concepts are treated as graphs allowing one to compare their structure instead of their labels. For example whether they have similar set of children, neighbours or parents in common as members or not.

The Qurany project is one of ontological Qur’anic annotations, which is publicly available [13]. Qurany combines a hierarchy of Qur’anic topics and their verses. The Quranic Arabic Corpus (QAC) [14] is another resource that combines a tree of Qur’anic concepts and their verses. Qur’anic concepts in these two resources are expressed in various ways and this variation is not limited to linguistic aspect or characteristic of the Arabic language such as inflected or derived nominals, but they are being expressed using different synonyms for both Arabic and English translation.

A number of attempts were made recently for unifying these ontological annotations into one format. [4] unified Qur’anic resources into SketchEngine format. Semantic Quran is a merged ontology from Qur’anic annotations [7]. Alignment was done based on exact match of their labels with words from Wikipedia and Wiktionary. Exact match may not match enough entities as Qur’anic concepts tends to be expressed in variant ways.

[8] manually extracted the concept of the verses and mapped a different dataset for the Holy Qur’an. However, this ontology only covers a selected set of topics, a the size of OWL is very large that it makes it difficult to be imported by Protégé. Other work tried to merge many ontological annotations in a single file such as [6].

Our current work is distinguished from [4], [6]–[8] in the following points:

- It focuses on aligning rather than unifying and merging several different formats.
- It takes into consideration a number of variants concepts.
- It combines fuzzy bilingual lexical-based and structure-based methods.

To the best of our knowledge, aligning Arabic Ontological resources based on fuzzy bilingual lexical and structure based methods has not been researched until now.

IV. Methods

Our algorithm takes advantage of combining Fuzzy Bilingual Lexical-based and structure-based methods for aligning highly variants ontologies. It is aggregating multiple similarity scores for a given pair of concepts into a single value as it shown in Equation □1□. This equation aggregating three types of similarity measures for a given pairs. The maximum value of these measures is considered and assigned to a given pair of concepts. Then the results are sorted in descending order to give the most similar pairs. In all measures for a given pair is low then it will not be in the top of the extracted list, which means the given pair are not similar.

$$HB(a,b) = max(Lex_{AR}, Lex_{EN}, SB) \qquad (1)$$

Whereas Lex_{AR} is the score of lexical-based match using Arabic language concept labels. Lex_{EN} is the score of lexical-based match using English translation of concept labels. SB is the score obtained by structure-based match using instances belonging to the given pairs regardless their labels.

A. Fuzzy Lexical-based Matching of Bilingual labels of concepts

We will refer to the fuzzy lexical base of the Arabic labels as Lex_{AR} and for English labels as Lex_{EN}.

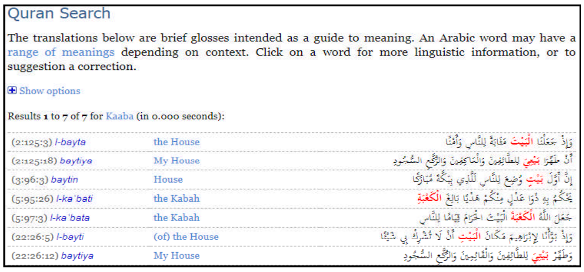
Fuzzy bilingual lexical-based was modelled using Dice’s coefficient adapted from [25] as shown in Equation □2).

$$Lex(a,b) = \frac{|a \cap b|}{\left(\frac{|a| + |b|}{2}\right)} \qquad (2)$$

Where a and b are sets of bigrams for the matched labels. This method detects the common set between the given pairs of bigram sets. For example the pairs “Umra” and “The Umrah” have a set of {“Um”, “mr”, “ra”} in common in their set of bigrams, which gives a similarity of 60% between them.

B. *Structure-based Matching*

This method takes into account the occurrences of a concept as a feature for indicating the similarity. It takes all instances that are found as children for the given pair that are going to be matched. Both resources have been linked with the verses they were mentioned in. Figure 1: Qurany project navigating for the concept “Ka’bah”



and Figure 2 show an example of the concept “Ka’bah” and its occurrences in these resources.

FIGURE 1: QURANY PROJECT NAVIGATING FOR THE CONCEPT “KA’BAH”

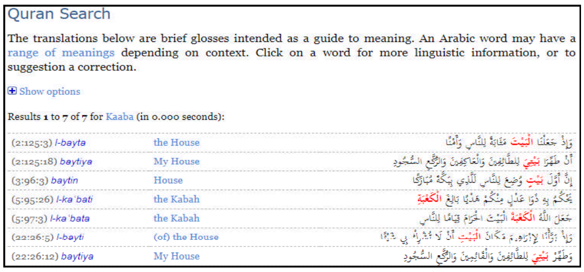
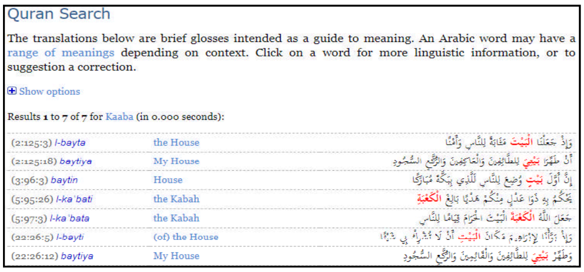


FIGURE 2 : QURANIC ARABIC CORPUS SEARCH FOR THE CONCEPT “KA’BAH”

Figure 1: Qurany project navigating for the concept “Ka’bah”



shows the concept of “Ka’bah” from [13], the Qurany project[1], which has been expressed in different labels in both Arabic and English translation in comparison with the same concept in Figure 2. Figure 2 shows the occurrences of the same concept used above. Note, we extracted the occurrences of the concept of QAC from the list of Qur’anic topics[2] in which all concepts are attached with where they were mentioned in the Qur’an based on chapter, verse and word numbers. Figure 3 depicts a single concept with their occurrences set based on two different ontologies. Concept X in Qurany occurs in a set of verses $\{132, 389, 390, 764, 766, 2621\}$, while the concept Y in QAC occurrences vector is $\{132, 132, 390, 764, 766, 2621, 2621\}$. Although both Arabic and English translations labels of this pair are not matched, the size of intersection between their instances is high which is an indication that they represent the same concept. This pair of concepts are clearly sharing many verses, which can be modelled by the intersection of X and Y. Thus, the larger intersection size means the two concepts are similar.

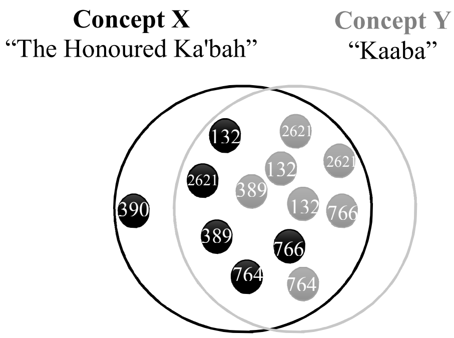


FIGURE 3: THE VENN DIAGRAM OF A CONCEPT AND ITS OCCURRENCES IN DIFFERENT ONTOLOGIES

In order to compute the similarity, every concept has been extracted and given a unique id. For Qurany, concepts are numbered from 1 to 1135. For QAC, concepts start from 1 til 294. Then for each concept, we add all instances (occurrences in the Qur’an) in a vector. After that, we applied Jaccard similarity measures [26] using Equation □3), which is one of the most common methods for computing similarity based on sample sets. To compute similarity between two sets, it is the ratio of their intersection divided by their union. Note that we only consdried pairs that their size of intersection between them is 2 or more.

[1] http://quranytopics.appspot.com/

[2] http://corpus.quran.com/topics.jsp

$$SB(a,b) = \frac{|a \cap b|}{|a \cup b|} \quad (3)$$

For example the Jaccard similarity for the example above is:

The intersection is $|a \cap b| = \{132, 2621, 389, 764, 766\}$ and the union is$|a \cup b| = \{132, 389, 390, 764, 766, 2621\}$. So the SB for this example is:$SB(a,b) = \frac{|a \cap b|}{|a \cup b|} = \frac{5}{6} = 0.833$.

V. Results

TABLE I shows a sample of obtained results by the four selected measure methods. Lex_EN is the fuzzy lexical-based for English translation, Lex_AR is the fuzzy of lexical-based for Arabic, SB is the structure-based, and HB is the new method combines all of them. Every algorithm gives a sorted list of pairs from the most likely similar to least likely. TABLE III in Appendix shows more results. Results made publicly available for as training data or in evaluation other approaches[3]. These results in both tables are ranked based on HB method.

TABLE I A sample of produced results based on four compared measures

Lex_EN	Lex_AR	SB	HB	QAC EN	Qyrany EN
85.71	100	30.952	100	Pharaoh	Pharaoh
55.55	71.42	100	100	Sabians	The Sobians
28.57	100	60	100	Jibreel	Gabriel
80	100	100	100	Marut	Marut
80	100	100	100	Harut	Harut
39.39	100	87.5	100	Masjid al-Haram	The Most Sacred Mosque in Makka)
61.53	75	100	100	Umra	The Umrah
61.53	100	2	100	Hell	Hell Fire
0	100	0	100	Musa	Moses

As all selected methods of similarity produce alignment as a ranked list, we used Average precision (AvP), to evaluate ranked returned list. AvP is commonly applied in ranked-based extraction such as in [27], [28]. AvP requires the retrieved pairs to be validated, therefore the researchers have manually validated the top 100 returned pairs of the fourth methods with 1 for pairs that correctly returned and 0 for the rest.

The equation of AvP is shown in Equation (4) and the top-50 ranked pairs is in Table II.

$$AvP = \frac{\sum_{k=1}^{n}(p(k) \times rel(k))}{n_c} \quad (4)$$

Where $p(k)$ is the precision at cut-off k in the pairs list, n means the size of the ranked list, n_c is the total number of relevant pairs that were returned by the method and $rel(k)$ is a binary function that indicated whether or not the retrieved pairs are similar. The output of $rel(k)$ is 1 if a $concept_k$, which means the concept at k, the pairs are same. Otherwise $rel(k)$ is 0.

TABLE II: Methods comparison based on recall, precision and AvP for top-50

Similarity Measures	Recall	Precision	AvP
Lex_{EN}	0.776	0.760	0.883
Lex_{AR}	0.833	0.900	0.983
SB	0.714	0.60	0.647
HB	0.721	0.980	0.980

Table II shows the results of our experiment on aligning Qur'anic ontological annotations based on four alignment methods for the first 50 pairs. The results have shown that the better results was achieved with HB in terms of precision and AvP, while the lexical-based match for Arabic labels obtained the highest recall.

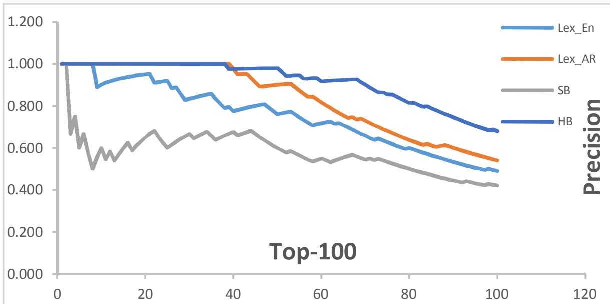


Figure 4: The precision over top-100 returned pairs

Figure 4 depicts the relationship between the precision over the top 100 returned pairs. The figure clearly shows that HP has outperforms other algorithms. Significantly, lexical-based for Arabic has obtained similar results but it decreases sharply after number 40 in the ranked list. Over all the new algorithm HB has outperforms the three compared algorithm.

Although fuzzy-based performs better than exact lexial-based, its effect only on labels expressed like ("Firdous", "The Firdous"), ("Qaroun", "Qarun"). Some concepts were incorrectly aligned by this method such as ("Harut", "Marut") and some concepts in Arabic like ("الجن" and "جنة"). This is because they have the same spelling in Arabic and different meaning. Structure-based was able to return a number of pairs correctly regardless their labels such as ("Thamud", "Salih People") and ("Kaaba", "The Honoured Ka'bah"). However, not all concept in QAC provided with verses that they occur in. Therefore, the combined measures had best result and structure-based measures had poor result. Our approach performs better

[3] http://salrehaili.com/QuranOntology/Alignments

in ontologies that their entities have expressed using more than one language.

VI. Conclusions

The holy Qur'an is considered as the core of Islamic values and knowledge. The text of the Qur'an has attracted many researchers in Natural Language Processing community due its differences from any other text. The aim of this paper was to compare a number of ontology alignment methods for bilingual ontological Qur'anic resources. This paper has outlined possible variations occuring in concept labels of ontological Qur'anic annotations and proposed an alignment approach. The new approach is aggregating multiple similarity scores for a given pair of concepts into a single value. It takes advantage of combining fuzzy bilingual lexical and structure based methods for aligning two highly variant bilingual ontological annotations of the Qur'an. The new approach has outperformed other compared methods in terms of precision and AvP. Structure-based method has achieved the lowest results, but when combining it with another they contribute in an increase of the performance. For future work, we plan to look at improving the structure-based method by computing not only the children of the concepts but add more information such as parents and neighbours. The returned aligned list from the new approach can be used as a training data for machine learning tasks as each pair was classified whether it is correct or not. In addition, this approach can be reused for other domains where their entities tend to be expressed in many different ways. We think that any computational effort on understanding or learning the Qur'anic text will be of benefit to billions of Muslims and non-Muslims around the world.

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APPENDIX

TABLE III MORE RESULTS OF THE FOUR COMPARED MEASURES

Lex_EN	Lex_AR	SB	HB	QAC EN	QAC AR	Qyrany EN	Qyrany AR
80.00	100.00	2.56	100	Allah	الله	Allah	الله
69.23	100.00	0.00	100	Christianity	النصارى	The Christians	النصارى
90.00	100.00	0.00	100	Paradise	الجنة	The Paradise	الجنة
66.66	100.00	0.00	100	Angel	الملائكة	The Angels	الملائكة
38.09	100.00	0.00	100	الشيطان	Satan	Satan	the Devil
85.71	100.00	30.95	100	Pharaoh	فرعون	Pharaoh	فرعون
55.55	71.42	100.00	100	Sabians	الصابئين	The Sobians	الصابئون
28.57	100.00	60.00	100	Jibreel	جبريل	Gabriel	جبريل
80.00	100.00	100.00	100	Marut	ماروت	Marut	ماروت
80.00	100.00	100.00	100	Harut	هاروت	Harut	هاروت
39.39	100.00	87.50	100	Masjid al-Haram	المسجد الحرام	Al-Masjid Al-Haram(The Most Sacred Mosque in Makka)	المسجد الحرام
61.53	75.00	100.00	100	Umra	عمرة	The Umrah	العمرة
61.53	100.00	2.00	100	Hell	جهنم	Hell Fire	جهنم
0.00	100.00	0.00	100	Musa	موسى	Moses	موسى
0.00	100.00	0.00	100	Musa	موسى	Moses	موسى
20.00	100.00	5.00	100	Harun	هارون	Aaron	هارون
12.50	100.00	100.00	100	Injeel	الإنجيل	The Gospel	الإنجيل
0.00	100.00	100.00	100	Torah	التوراة	The Bible	التوراة
42.85	100.00	0.00	100	Ibrahim	إبراهيم	Abraham	إبراهيم
42.85	100.00	0.00	100	Ibrahim	إبراهيم	Abraham	إبراهيم
94.73	100.00	2.00	100	Day of Resurrection	يوم القيامة	Day of Resurrection	يوم القيامة
0.00	100.00	42.86	100	Al-Jahiliyah	الجاهلية	The Paganism	الجاهلية
0.00	100.00	0.00	100	Nuh	نوح	Noah	نوح
0.00	100.00	0.00	100	Nuh	نوح	Noah	نوح
66.66	100.00	58.49	100	Jinn	الجن	The Jinn	الجن
15.38	100.00	100.00	100	Garden of Eden	جنات عدن	Adn Paradise	جنات عدن
0.00	100.00	5.56	100	Yaqub	يعقوب	Jacob	يعقوب
24.24	100.00	5.56	100	Companions of the Cave	أصحاب الكهف	Cave People	أصحاب الكهف
48.00	100.00	18.75	100	Dhul Qarnayn	ذو القرنين	Dhul-Quarnain	ذو القرنين
92.30	100.00	25.00	100	Gog and Magog	يأجوج ومأجوج	Gog and Magog	يأجوج ومأجوج
53.33	100.00	100.00	100	Magians	المجوس	The Magi	المجوس
85.71	100.00	50.00	100	Firdous	الفردوس	Firdous	الفردوس
22.22	100.00	50.00	100	Companions of the Rass	أصحاب الرس	Ar-Rass People	أصحاب الرس
47.05	100.00	0.00	100	Sheba	سبأ	Saba'(Sheba)	سبأ
54.54	100.00	80.00	100	Qarun	قارون	Qaroun	قارون
75.00	100.00	25.00	100	Romans	الروم	The Romans	الروم
0.00	75.00	100.00	100	Zaqqum	زقوم	Infernal Tree	الزقوم
36.36	100.00	100.00	100	Malik	مالك	Maleck	مالك
50.00	0.00	100.00	100	Tubba	تبع	People of Tubba	قوم تُبَّع