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Domain specific concept ontologies and text summarization as hierarchical fuzzy logic ranking indicator on Malay text corpus

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ABSTRACT

Ranking function is a predictive algorithm that is used to establish a simple ordering of documents according to its relevance. This step is critical because the results' quality of a Domain Specific Information Retrieval (IR) such as Hadith Information Retrieval is fundamentally dependent of the ranking function. A Hierarchical Fuzzy Logic Controller of *Mamdani*-type Fuzzy Inference System has been built to define the ranking function, based on the Malay Information retrieval's BM25 Model. The model examines three-inputs (Ontology BM25 Score, Fabrication Rate of Hadith and Shia Rate of Hadith) and four-output values of Final Ranking Score which consist of three triangular membership functions. The proposed system has outperformed the BM25 original score and the Vector Space Model (VM) on 16 queries, while the BM25 original score and Vector Space Model only yield better result in 9 and 2 queries respectively on the P@10, %no measures and MAP. P@10 represent the values of Precision at Rank 10 P@10), %no measures represent the percentage of queries with no relevant documents in the top ten retrieved and MAP represents Mean Average Precision of the queries. The results show the proposed system have capability to demote negative documents and move up the relevant documents in the ranking list and its capability to recall unseen document with the application of ontology in text retrieval. For the future works, the researcher would like to apply the usage of other Malay Semantic elements and another corpus for positive ranking indicator.

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1. INTRODUCTION

Hadith Information Retrieval is the science of Information Retrieval (IR) that applied to hadith text or *Hadith Informatics*, that also act as an example of *Domain Specific Information Retrieval* that only index documents relevant to a specific domain [1, 2]. Hadiths are the collection of words, affirmation and character of the Prophet Muhammad (PBUH) recorded and documented by the Prophets' followers as the interpretation of the Qur'an. The Muslims believe, Hadith is the second source of documented Islamic knowledge after the Quran and the role of the hadith as a source of Islamic teaching has been agreed upon by almost all sects [3]. Accurate hadith information retrieval is important to provide access to the reference to laymen and hadith expert. Its importance has increased because of the vast and quickly increasing amount of documents that make reference to hadith and as well as appearance of Fabricated hadith available through electronic means

that may affect the integrity of the hadith as the second source of the Islamic Knowledge [4] and also, most of the documents that are retrieved in traditional IR including in Hadith Information Retrieval are irrelevant to the user because the search engines cannot determine the user's context [5].

Various methods have been applied in Hadith Information Retrieval research such as, Ghazizadeh et al in [6] used Fuzzy expert system to classify and determine the rate of validity of the Hadith. Hadith classification in various techniques also have been done such as in H.M Alrazo in [7], Kawther et al in [8] and Shatnawi et al in [9], their works mostly focused on the authentication of Hadith. Same as Najeeb et al in [10] that suggested a method for Hadith Isnad (chain narrator), Baraka et al in [11] built a domain specific ontology (Hadith Isnad Ontology) to support the process of authenticating/judging Isnad. Azmi et al in [3] proposed algorithm and model for a system that judges a Hadith to one of three categories: sahih, hasan, and da'if b using a simple scheme and modeled the rules using 50 sample Hadiths from Sunan al-Tirmizi. The system was evaluated using 2900 Hadiths from Sunan al-Tirmizi and Sahih of Bukhari and yielded the success rate of 94% for Sunan al-Tirmizi and over 99% for Sahih of Bukhari. Nursyahidah et al in [12] proposed Graph-based text representation for Malay translated hadith text that will be subsequently used in the hadith text classification research based on chain of narrators. Latest in 2018, we can see the works of Nurul Syeilla Syazhween et al in [13] presented the application of Latent Dirichlet Allocation (LDA) model for semantic information retrieval on Malay documents. Her experimental results proved that LDA model produced promising results in retrieving semantic information in Malay translated Hadith documents compared to other existing techniques.

In this research, a Hierarchical Fuzzy Logic Controller of Mamdani-type Fuzzy Inference System has been built to define the ranking function, based on the Malay Information Retrieval's BM25 Model. The model examines three-inputs (Ontology BM25 Score, Fabrication Rate of Hadith and Shia Rate of Hadith) and four-output values of Final Ranking Score which consist of three triangular membership functions. Three type evaluation metric such as Precision at Rank 10 (P@10), the percentage of the query with no relevant document in the top ten retrieved (%no) and MAP represents Mean Average Precision of the Query have been used to evaluate this system. The researcher also compared the result of the final ranking function with the result of BM25 Model original score and Vector Space Model that also applied in Malay IR System and also be evaluated by using relevant document by the Hadith expert.

2. RESEARCH METHOD

2.1. Framework

The framework of the *Fuzzy BM25 Malay Information Retrieval System (FBMIR)* that illustrated in Figure 1 features a fuzzy inference system that improves the score of the ranking function of the BM25 by using *Fuzzy Processing* called *Fuzzification*, *Inference*, and *Defuzzification* to yield the result. It consist Ontology BM25 Score as Positive Ranking Indicator and also includes rule base and text summarization of Fabrication Rate of Hadith and Shia Rate of Hadith as the negative ranking indicator. The results then will be evaluated by comparing them with the results that were yielded from BM25 original score and *Vector Model Malay IR System (VM).*

2.2. Proposed Method

The system are particularly have been built as the integration of two previous works from the researchers such as Ontology Based of Hadith IR in [14] and Fabricated and Shia Malay Translated Hadith as Negative Ranking Indicator in [15]. The details of integration of this particular works will be explained as follows.

Model for Modification: Fuzzy Logic is credible to be applied in any retrieval model that possesses its own defined rules and allows access to its internal specification. In this system, the BM25 model will be used as the original score or as input for Fuzzy Processing. The reasoning is BM25 Model has proven that it yields the best results in general collections compares to the Vector Space Model. BM25 Model is widely used for evaluating the new ranking method as a baseline model, in substitution to the Vector Space Model [4].

Data Collection: The system were used the data of the Malay corpus consist of 2026 Malay Translated of Sahih Bukhari Hadiths text document, 160 Malay Translated Fabricated Hadiths text document that were obtained from the Malay translated book of Al-Manar al-Munif Fi al-Sahih wa-al-Dhoif by Ibnu Qayyim Ibn Qayyim al-Jawziyah in [16] and 1,270 Malay Translated Shia Hadiths that were taken out from the Kitab Al-Khafi Usul and Raudah.

Development of Hadith Concept Ontologies: The Hadith Concept Ontologies of 32 topic of Malay Translated Hadith of *Sahih Bukhari* that were developed with the knowledge of two experts. They are Dr Zulhilmi bin Mohamed Nor from Universiti Sains Islam Malaysia and Dr Ahmad Yunus Mohd Noor from

Universiti Kebangsaan Malaysia. Additionally, the development of ontology also use the knowledge reference from the book, Al-Fiqh Al-Manhaji Mazhab Al-Syafie, which was written by Dr Mustafa Al-Khin, Dr Mustafa al-Bugha & Ali Asy-Syarbaji and translated to Malay by Dr Zulkifli bin Mohamad al-Bakri et. al in [17].

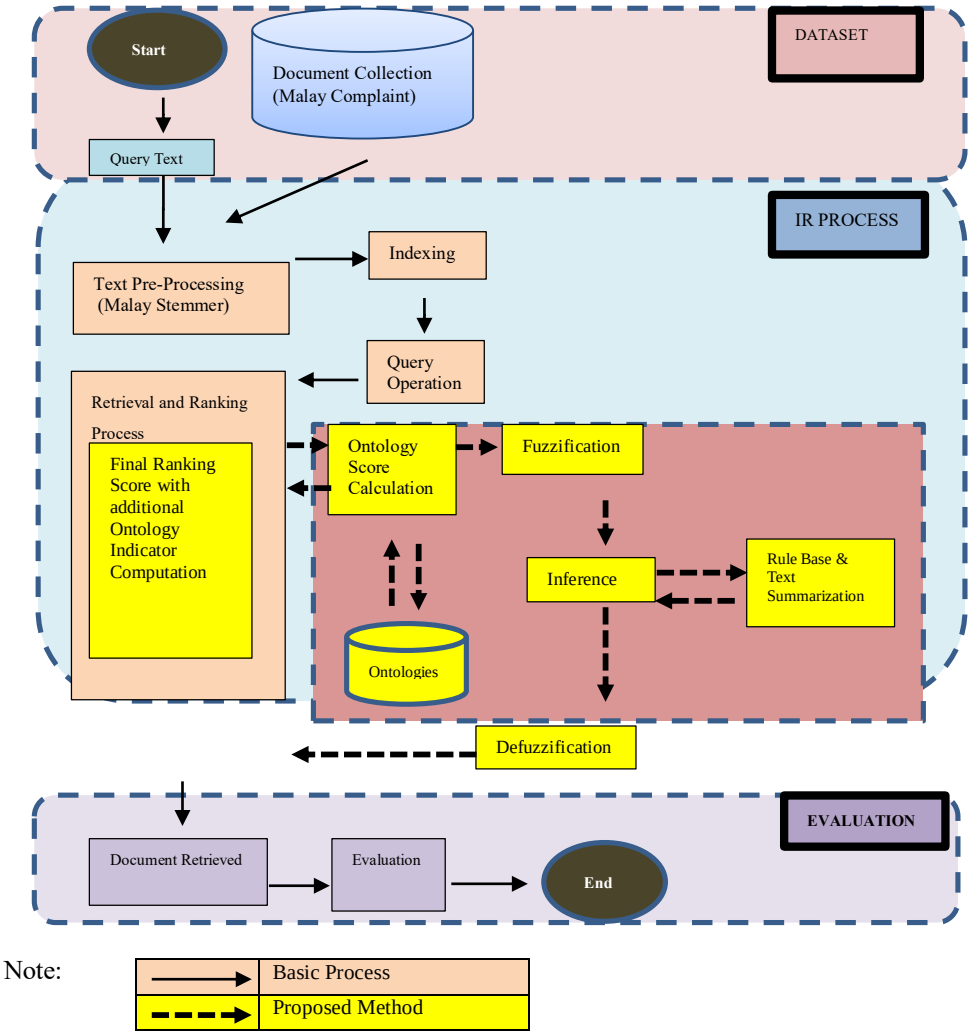

Figure 1. Conceptual framework of FBMIR

Ranking Function: The system will apply an additional Ontology scoring to improve the ranking function by using BM25 model as we can see in the equation below. *While Q* is the Query that consist the keywords of q1 until qn, the Ontology Score of BM25, *D* will be as:

$$score(D,Q) = \sum_{i=1}^{n} IDF(q_i).\left(\frac{f(q_i,D).(k_1+1)}{f(q_i,D)+k_1.\left(1-b=b.\frac{|D|}{avgdl}\right)}\right) \quad (1)$$

For example as the explanation of the algorithm, if the researcher insert the query of term 'rukun' under the Hadith Concept of 'solat', has the children (related terms) of 'rukuk' and 'sujud'. Therefore, the Ontology scoring of BM25 will be calculated the score for the term of 'rukuk' and 'sujud'. For the term without the ontological relationship with the query, the calculation will use standard BM25 ranking function. After that, the documents that have been retrieved will be ranked according to their priority by using Final BM25 Ranking Score that is accumulated with BM25 Original Score with Ontology Score of Documents as the next (2).

$$\text{Ontology BM25 Score} = score(D,Q) + \sum ONT(score(D,Q)) \quad (2)$$

where, *ONT (score (D, Q))* is a *Accumulated of Ontology Score of Documents for given query.*

Proposed Fuzzy Model: The ranking score is then involved in Fuzzy Processing, which is the main technique that includes processes such as *Fuzzification*, *Inference* and *Defuzzification* to yield the result. In this research, the researchers use fuzzy inference technique of Mamdani method. According to Ark Andreev et al in [18], Mamdani-Type model of Fuzzy Inference System is widely accepted for capturing expert knowledge. It allows the description of the expertise in a more intuitive and more human-like manner. The technique involves five steps such as:

Fuzzification: The process in which the mathematical meaning of the linguistic variables will be defined. The model examines three-inputs (BM25 Ranking Score, Fabrication Rate of Hadith and Shia Rate of Hadith) and four-output values of Final Score Ranking which consist of three triangular membership functions. The variables and range of possible value are determined by expert judgments. Linguistic variable consists of (Final Ranking Score), and two attributes (BM25 Ranking Score, Fabrication Rate of Hadith and Shia Rate of Hadith). Four-output variables and 10 of input variable are identified and evaluated by domain expert. The Ontology BM25 Score has been determined by using the (3):

$$\text{Ontology BM25 Score} = \frac{score(D,Q)}{Max(score(D,Q))} \times 100 \quad (3)$$

where, Max (score (D,Q)) is a Maximum Score of Documents for given query.

For distribution of Fabrication Rate of Hadith or Shia Rate of Hadith, a range between 0-1 is determined according to the highest percentage of unique features of Fabricated Hadith or Shia Rate of Hadith that appear in the Hadith document and using the (4).

$$\text{Fabrication Rate of Hadith or Shia Rate of Hadith} = \frac{a(r_i,R)}{r_n} \quad (4)$$

where $a(r_i,R)$ is the total Unique Features that Appeared in each Document and r_n is the Total Unique Features.

These unique features are extracted from the process of text summarization of Fabricated Hadith or Shia Rate of Hadith with the size of 10 words, using the approach that suggested by Karim in [19] and references from Suraya Alias, et al. in [20], but with additional modification with inclusion of *Malay Stemmer. Malay Stop Words and Malay Root Word* from the Ahmad F. in [21] and the researchers work in [22], in its process.

These unique features are also extracted from rules that define with the knowledge of two experts. They are Dr Zulhilmi bin Mohamed Nor from Universiti Sains Islam Malaysia and Dr Ahmad Yunus Mohd Noor from Universiti Kebangsaan Malaysia.

Details of Input linguistic variable as shown in Table 1. The output of this Fuzzy Logic Controller will be in the range as Table 2.

Table 1. Details of Input Linguistic Variable

Linguistic variable	Value of Linguistic variable	Range
Onto BM25 Score	Low	[0, 0, 40]
	Mediun	[20, 40, 60]
	High	[40, 60, 80]
	Very High	[60, 100, 100]
Fabrication & Shia Rate	Low	[0, 0.15, 0.6]
	Medium	[0.3, 0.6, 0.8]
	High	[0.6, 1.1]

Table 2. Details of Output Linguistic Variable

Linguistic variable	Value of Linguistic variable	Range
Final Ranking Score	Zero	[0, 0, 40.00]
	Low	[20, 40, 60]
	High	[40, 60, 80]
	Very High	[60, 100, 100]

Inference: The Fuzzy Inference Process is performed right after the Fuzzification process. Each of the steps will be examined in every single value inside the fuzzy set to give out the value for the variable of the fuzzy set.

Defuzzification: The scores from the fuzzy set will serve as the input for Defuzzification process. It will then be calculated to produce the single digit score according to Rouben in [23], by using the widely used center of area (COA) Defuzzification method for the computation of the final score of the ranking function.

Rules: To initiate the Fuzzy Processing, the conversion of the knowledge on the IR system and as well as the ranking score in BM25 need to be defined as the rule. The rule base will apply the Mamdani Type Rules of Fuzzy Logic. This takes two attributes for each Fuzzy Logic Controller, which is the Ontology BM25 Score and Fabrication Rate of Hadith for Fuzzy Logic Controller 1 (FLC1) and, output of FLC1 and Shia Rate of Hadith for Fuzzy Logic Controller 2 (FLC2) as we can see in Table 3.

Table 3. List of Rules

Case	Rules	Final Ranking Score
1	if BM25= or FLC1 = L &Fabrication or Shia= H	Zero
2	if BM25 or FLC1 = M &Fabrication Shia= H	Zero
3	if BM25 or FLC1 = H &Fabrication or Shia= H	Zero
4	if BM25 or FLC1 = VH &Fabrication or Shia= H	Zero
5	if BM25 or FLC1 = L &Fabrication or Shia= M	Zero
6	if BM25 or FLC1 = M &Fabrication or Shia= M	Low
7	if BM25 or FLC1 = H &Fabrication or Shia= M	Low
8	if BM25 or FLC1 = VH &Fabrication or Shia=M	Low
9	if BM25 or FLC1 = L &Fabrication or Shia= L	Zero
10	if BM25 or FLC1 = M &Fabrication or Shia= L	Low
11	if BM25 or FLC1 = H &Fabrication or Shia= L	High
12	if BM25 or FLC1 = VH &Fabrication or Shia= L	Very High

Hierarchical Fuzzy Logic System: In this paper we applied the design of a hierarchical fuzzy logic system that has a potential to reduce the number of fuzzy rules in the system that subsequently will reducing the computational time while maintaining the systems robustness and efficiency [24]. The researchers have run the Fuzzy Logic Controller (FLC1) of Mamdani Method, with two inputs such as Ontology BM25 Score and Fabrication Rate of Hadith that produce the output of FLC1, the output of FLC1 will be the input of FLC2 along with Shia Rate of Hadith and that will produce the Final Ranking Score of the document as we can see in Figure 2.

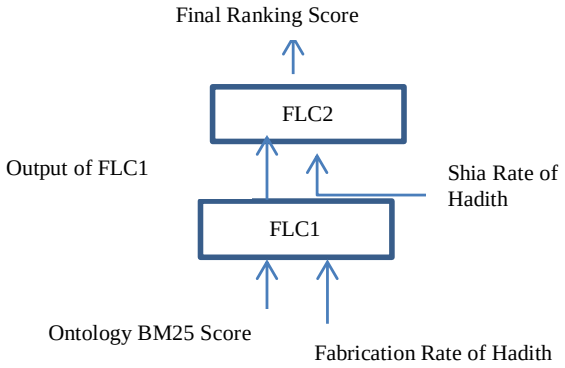

Figure 2. Hierarchical fuzzy logic controller of *FBMIR*

3. RESULTS AND ANALYSIS

The researchers used 30 total queries from eight topics for the experiments. The topic under *'Umum'* has a total of 11 queries, while other seven topics have around two to four queries with an average three queries for each topic [25]. The relevance of the documents was determined by two Hadith experts, Dr Zulhilmi bin Mohamed Nor from Universiti Sains Islam Malaysia and Dr Ahmad Yunus Mohd Noor from Universiti Kebangsaan Malaysia. The Values Precision at Rank 10 (P@10), the percentage of the query with

no relevant document in the top ten retrieved (%no) and AP represent Average Precision of the Query have been calculated in this evaluation. The results are shown in the Table 4.

Table 4. List of Results

No.	TOPIC	*FBMIR* P@10	*BM25* P@10	*Vector* P@10	*FBMIR* %no	*BM25* %no	*Vector* %no	*FBMIR* MAP	*BM25* MAP	*Vector* MAP
1	*Makanan*	0.627	0.8	0.466	37.3	20	53.4	0.572	0.824	0.502
2	*Adab*	0.4	1	0.75	60	0	25	0.597	1	0.715
3	*Solat*	0.59	0.476	0.58	41	52.4	42	0.61	0.486	0.584
4	*Iman*	0.35	0.466	0.444	65	53.4	55.6	0.46	0.463	0.565
5	*Bersuci*	0.31	0.937	0.513	69	6.3	48.7	0.809	0.323	0.534
6	*Ibadah*	0.67	0.35	0.541	33	65	45.9	0.505	0.725	0.577
7	*Sirah*	0.95	0.733	0.733	5	26.7	26.7	0.919	0.964	0.905
8	*Umum*	0.55	0.333	0.353	45	66.7	74.7	0.509	0.638	0.392

Based on the experiments' results that are illustrated in Table 2, *FBMIR's* result slightly outperforms BM25 original score and *Vector Space Model (VM)* on four topic set of query results such as "*Solat", "Ibadah",* "*Sirah*" and "*Umum"* on the P@10 and %no measures. P@10 represent the values of *Precision at Rank 10* P@10), %no measures represent the percentage of queries with no relevant documents in the top ten retrieved and *MAP* represents Mean Average Precision of the queries. BM25 original score has outperformed *FBMIR* for all results on the P@10, %no measures and *MAP* in 4 topic set of "*Makanan",* "*Adab"," Iman"* and *"Bersuci".* Even though *FBMIR* only produced the best result in four topics, but overall, the *FBMIR* has outperformed the other two models in term of individual query results. Out of the 30 queries, *FBMIR* has has slightly outperformed the *BM25* original score and the *Vector Space Model (VM)* on 16 queries, while the BM25 original score and Vector Space Model only yield better result in 9 and 2 queries respectively on the P@10, %no measures and *MAP*. If we compare the results of *FBMIR* directly with BM25 Original Score, *FBMIR* has outperformed BM25 Original Score in 17 queries for the results of all on the P@10, %no measures and *MAP*. *FBMIR* also outperformed BM25 Original score in 18 queries on *MAP* results alone. Based on the experiments' results that are illustrated in Table 2, from all the comparisons and the testing, the results show that the ontology application as the positive ranking indicator for BM25 may retrieve more accurate and better documents than the non-ontology search engine, but however the result not will be accurate if the corpus are mixed with the Fabricated and Shia Hadith. From the result, *FBMIR* just outperform the other model in 3 topic compare with the application of Fuzzy Logic and Fabricated and Shia Rate of Hadith as Negative Fuzzy Logic Ranking Indicator that outperform other model in 4 topics.

The result also the same with the overall query when the Ontology score alone may outperform other model in 15 queries compare to with *FBMIR* that outperform other model in 16 queries respectively. These results also show that the application of membership function in fuzzy logic approach and as well as the input of Fabricated and Shia Rate of Hadith as Negative Fuzzy Logic Ranking Indicator, have the potential and capability to classify the document according to the similarity of the document and demoting the negative document (Fabricated and Shia Malay Translated Hadith) from the top of the ranking results. The result also shows that the text summarization of the document may provide the reliable features for the construction of particular category rate. The researchers believe that *FBMIR* performed slightly well compared to the Vector Space Model and BM25 original model based on the above finding due to *FBMIR*'s capability to demote negative documents and move up the relevant documents in the ranking list and its capability to recall unseen document with the application of ontology in text retrieval. In the future, the researchers would like to try to add more negative documents into the experiment as well as several new features to enhance the evaluation.

4. CONCLUSION

The researchers presented the implementation of the an Hierarchical Fuzzy Logic System using the BM25 Model in the Malay Translated Hadith Information Retrieval System that also includes: a) Ontology BM25 Score as Positive Ranking Indicator. b) Fabricated (Maudu') and Shia Malay Translated Hadith as negative ranking indicator in the new equation of ranking function, for demoting the negative document to the bottom of the ranking results, which is the rules are derived from unique features such as name from isnad (chain of narrator), unique terms from matn (content of hadith) and also the text summarization of 10 words from each hadith. Based on the experiment's result and evaluation, the proposed system has outperformed the *BM25* original score and the *Vector Space Model (VM)* on 16 queries, while the BM25 original score and Vector Space Model only yield better result in 9 and 2 queries respectively on the P@10,

%no measures and *MAP*. For the future works, the researcher would like to apply the usage of other Malay Semantic elements and another corpus for positive ranking indicator.

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