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Recent Advances in Arabic Automatic Text Summarization

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Abstract

Recently, the volume of the Arabic texts and documents on the internet had increased ravidly and generated a rich and valuable content on the www. Several parties had contributed to this content, this includes researchers, companies, governmental agencies, educational institutions, etc. With this big content it became difficult to search and extract useful information using only mankind skills and search engines. This motivated researchers to propose automated methodologies to extract summaries or useful information from those documents. A lot of research has been proposed for the automatic extraction of summaries for the English language and other languages. Unfortunately, the research for the Arabic automatic text summarization is still humble and needs more attention. This study presents a critical review and analysis of recent studies in Arabic automatic text summarization. The review includes all recent studies used the different text summarization approaches which include statistical-based, graph-based, evolutionary-based, and machine learning-based approaches. The selection criteria of the literature are based on the venue of publication and year of publication; back to five years. All review papers in Arabic ATS are excluded from the review since the study considers the recent methodologies in Arabic ATS. As a conclusion of this research, we recommend researchers in Arabic text summarization to investigate the use of machine learning on abstractive approach for text summarization due to the lack of research in this area.

Keywords: *Automatic Text Summarization, The Arabic Language, Machine Learning, Natural Language Processing, Text Processing, Computational Linguistics.*

1 Introduction

Automatic text summarization (ATS) is one of the most important applications of NLP. ATS tools are very important for all kinds of people of different interests and education levels due to the rapidly increase of text data on the internet. As a result, researchers start spending efforts to enhance such applications. However, ATS tools help people to extract needed texts or documents faster and in a reasonable time. A Summary is a brief copy of the source document contains the most relevant text without redundancy and considering the coherence of the sentences in the summary.

Fig. 1 presents the most comprehensive criteria for classifying summaries. Lin & Hovy [1] classified ATS systems according to several criteria. First criterion classifies ATS systems according to number of input documents, which could be single-document or multi-documents. In the case of single-document, the ATS system gives a summary of single-document, while for the multi-documents, the ATS systems generates a single summary for the multi-documents.

According to the second criterion, ATS systems are classified according to the method of summarization, abstractive and extractive. Abstractive methods generate a summary of the source document as human beings do; the summary is a shorter version of the source document written in different words. This method requires semantic analysis of the source document(s). Extractive methods generate a summary by extracting the most related sentences from the source document(s) according to some criteria such as the rank of the sentence and the summarization compression ratio [2].

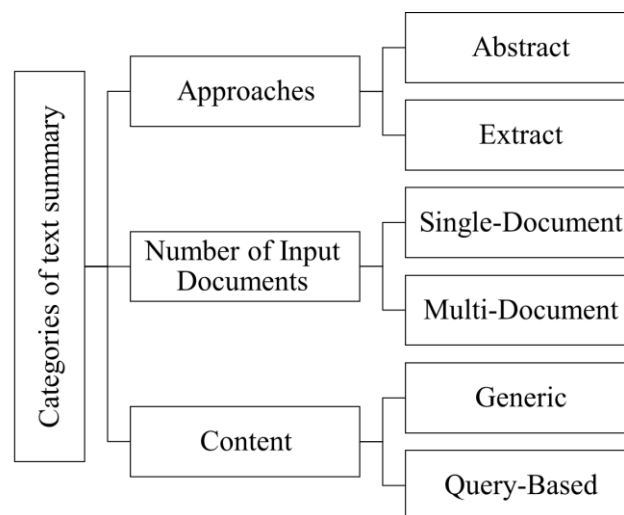


Fig. 1: The categories of text summary

The importance of the content of the source document is another criterion for classifying ATS systems this includes query-based summaries and generic summaries. In query-based systems, the user determines the topic of the source document as a query and then the system generates the summary that according to

the user's query. Generic systems are used when the document subject is not considered, and the user does not understand the text [3].

ATS systems can be classified also according to the approaches used for generating the summary. The four main approaches for summarization are statistical approaches [4], graph-based approaches [5], machine learning approaches [6] and clustering-based approaches [7].

The rest of this paper is organized as follows: Section 2 presents Arabic ATS recent studies. This section is categorized into four main sub-sections according to the used approaches, these include statistical-based approaches, graph-based approaches, evolutionary-based approaches, and machine learning-based. Section 3 presents the conclusion of this paper.

2 Arabic ATS Recent Studies

The evolution of Arabic applications and the increase of the Arabic speakers portrayed this language as one of the research topics on the ATS field. Although there are good efforts in the field of Arabic NLP, but unfortunately these efforts are not enough to cover this huge area. During the work on ATS, especially on Arabic language, different approaches have been proposed. Therefore, the aim of this study is to critically analyze the current approaches of Arabic ATS approaches. For each study, three elements are discussed, purpose of the study, research methodology, and findings. The review will also show the relationships between these approaches and will point out the similarities, differences, gaps, and weaknesses between these approaches.

The literature is categorized into four main categories according to the approaches used for Arabic ATS, these are: statistical-based approaches, graph-based approaches, evolutionary-based approaches, and machine learning-based approaches [8].

Although this study deals only with recent methodologies proposed for the Arabic ATS, there are several good review papers in this area. For instance, Ibrahim *et al.* [9] conducted a comparative study of Arabic multi-document ATS approaches. The review concluded that there is a lack of studies in Arabic ATS.

2.1 Statistical-based approaches

In these approaches, the summary is generated based on the ranking of the sentences by selecting the most relevant sentences from the source document(s) using suitable compression ratio. Relevant sentences are selected using significant features such as keywords, sentence length, sentence title, sentence position, term frequency (TF) and inverse-document frequency (IDF).

A statistical-based extractive approach for Arabic single-document summarization is suggested by Bialy *et al* [10]. The proposed approach comprised of three phases,

a pre-processing, scoring of sentences, and summary generation. For the evaluation purpose, the authors collected 33 short articles (one to three paragraphs each) from the Wikipedia and summarized them by two human experts. Results are compared with the summaries of two human experts. The authors claimed good results compared to human experts' results.

Elayeb et al [11] presented an extractive approach for Arabic single-document summarization using analogical proportions by representing the relationship between documents and their corresponding summaries. Two algorithms are implemented, the first one checks for the existence of the keywords in the document or in the summary while the second algorithm considers the frequencies of the keywords as well. The two algorithms are compared with some summarizers like Luhn, TextRank, LexRank, and LSA using ANT corpus and a small test set from EASC. The two algorithms are evaluated using the ROUGE and BLEU metrics. Promising results are achieved compared with three other approaches using the same datasets.

Qaroush et al [12] proposed an extractive Arabic single-document summarization approach using supervised machine learning algorithms and a combination of statistical and semantic features. The EASC corpus and the ROUGE measure tool are used for the evaluation purpose. Good results are achieved compared to some previous approaches.

In [13], Ali proposed the use of LDA and modified PageRank to summarize Arabic and English documents. LDA algorithm is used to classify sentences as important or unimportant based on seven extracted features. Important sentences are used to construct the graph used by the modified PageRank algorithm to assign scores to each sentence in this graph. According to the authors, the proposed approach achieved promising results on the TAC dataset and the ROUGE metric tool.

Abdulateef et al [14] proposed the use of clustering and Word2Vec for Arabic multi-document text summarization. Vector space and bag-of-words models are used along with k-means clustering algorithm to reduce the redundancy of data for Arabic multi-documents. Preprocessing is applied first to remove noise from the data, then the words are converted into vectors using Word2Vec model, and the semantic relationships between vectors are represented. Following preprocessing, clustering is used for selecting the important sentences from the documents. The EASC dataset and the ROUGE metric are used for the evaluation purpose. Promising results are achieved compared to previous work in Arabic multi-document text summarization.

Table 1 summarizes the recent studies used statistical-based approaches. After a critical analysis of these studies, we conclude the following:

- All studies except [14] are applied on single documents.
- Studies in [11], [12], and [14] are used the same dataset (EASC).

- All studies are evaluated their proposed approaches using the same metrics (precision, recall, and f-score).
- One study [13] used the TAC dataset.
- One study [10] used an artificial dataset consisting of 33 short documents collected from the Wikipedia. It is difficult to assess the significance of this study since it is not compared with other approaches and does not use a standard dataset as other studies. This study is also used a simple approach (TF-IDF) which is used by many researchers in the past.
- It can be seen from Table 1 that the study in [12] achieved better results on score-based approach compared to machine learning approaches. It is difficult to compare with the results of study [11] since different measures are used for evaluation.

Table 1: Summary of statistical-based approaches

Ref.	Method	Dataset	Precision	Recall	F-score
[10]	TF-IDF	33 short documents	0.780	0.680	0.710
[11]	analogical proportions.	EASC	ROUGE1 = 0.75	BLEU1 = 0.47	-
[12]	score-based method	EASC	0.616	0.673	0.643
	machine learning algorithms		0.428	0.669	0.517
[13]	LDA and modified PageRank.	TAC	0.383	0.569	0.458
[14]	k-means and Word2Vec	EASC	0.476	0.573	0.503

2.2 Graph-based approaches

The focus of these approaches is on the semantic relationships between the document sentences. Sentences in the document are represented as a graph, nodes represent sentences, and the arcs represent relationship between sentences.

A graph-based approach for Arabic text summarization using modified PageRank algorithm is presented by Elbarougy et al [15]. The proposed approach consists of three phases: preprocessing phase, features extraction and graph construction phase, and summary extraction phase using the modified PageRank algorithm. The proposed approach achieved best results on the EASC dataset 10,000 iterations compared with other approaches. Best results achieved for precision, recall, and f-measure are 0.687, 0.729, and 0.679, respectively.

Lamsiyah et al [16] proposed the use of transfer learning for Arabic multi-document text summarization. Syntactic and semantic relationships between words and phrases are captured by representing sentences using embedding vectors. Promising results are achieved compared with some previous work applied on three datasets: DUC2005, DUC2006, and DUC2007.

Elbarougy et al [17] investigated the effectiveness of morphological analysis using three morphological analyzers on the performance of graph-based approach for Arabic ATS. These analyzers are Safar Alkhalil, BAMA, and Stanford NLP. The EASC dataset is used to evaluate the performance of those morphological analyzers. According to this investigation, Safar Alkhalil analyzer achieved best results compared to other analyzers.

Elbarougy et al [18] investigated the impact of stop-words removal as a preprocessing step on the performance of graph-based approach for Arabic ATS. Two experiments are conducted, the first one, generating the summary without removing stop-words, and the second after removing stop-words. Experimental results performed on the EASC dataset showed that the performance of the summarization process gave better results when stop-words are removed.

Al-Taani and Al-Omour [19] investigated the effectiveness of using different basic units (word stem, the word itself, n-grams) on the performance of extractive graph-based approach for Arabic ATS. The proposed approach outperformed some of previous approaches when evaluated on the EASC dataset, and the ROUGE measure. Best results are achieved when n-grams are used in the summarization process.

Table 2 presents a summary of recent graph-based approaches reviewed in this paper. The summary is based on the methods used, the dataset or corpus, and the common measures used for evaluation. All approaches here are proposed for single document summarization except the approach in [16] is performed for multi-document summarization.

It can be inferred from Table 2 that the approach in [15] has achieved better results compared with the approaches in [17] and [18]. After a careful investigation of the proposed approaches by Elbarougy et al [17][18], we found the two approaches are similar with respect to the used methodology, i.e., graph-based approach, but they differ in the preprocessing step. In [17], three different morphological analyzers are investigated, and best results are achieved when Alkhalil analyzer is used. While in the second approach [18], two experiments are performed to investigate the effect of stop-words removal on the summarization process. Best results are achieved when experiments are conducted on the dataset without removing the stop-words.

Table 2: Summary of graph-based approaches

Ref.	Method	Dataset	Precision	Recall	F-score
[15]	Modified PageRank algorithm	EASC	0.687	0.729	0.679
[16]	TF-IDF, Word embeddings, Sentence embeddings.	DUC2005 DUC2006 DUC2007	- - -	0.408 0.439 0.462	- - -
[17]	TF-IDF, Graphs, Three Morphological analyzers	EASC	Alkhalil: 0.664 Stanford: 0.655 BAMA: 0.662	0.720 0.730 0.714	0.676 0.675 0.671
[18]	TF-IDF, Graphs	EASC	with stop-words: 0.602 without stop-words: 0.635	0.635 0.724	0.617 0.673

2.3 Evolutionary-based approaches

Evolutionary-based approaches are heuristic-based approaches to solve problems such as combinatorial problems that cannot be easily solved in polynomial time e.g., NP-hard problems. Genetic algorithms are one example of evolutionary approaches.

An extractive approach for Arabic multi-document text summarization is proposed by Alqaisi et al [20]. This approach is based on clustering and multi-objective optimization algorithms. The two datasets TAC 2011 and DUC 2002 are used for the evaluation purpose. Results revealed the efficiency of the proposed approach compared to other existing approaches. The approach obtained good f-measure scores using the ROUGE metrics for both datasets.

Al-Abdallah & Al-Taani [21] proposed the use of Particle swarm optimization (PSO) algorithm for Arabic single-document ATS. The EASC dataset and the ROUGE metric are used to evaluate the proposed model. Obtained results were promising compared to some existing approaches used genetic algorithms and Harmony search algorithm.

Jaradat and Al-Taani [22] used genetic algorithms for Arabic single-document summarization. The results were compared with recent approaches used the EASC dataset and promising results were reported by the authors. These results are Recall = 0.5713, Precision = 0.5658, and F-measure = 0.5476.

Table 3 shows a summary of evolutionary-based approaches. Unfortunately, only three recent studies were found in the literature, two of them [21] and [22] were applied of single documents, while the other study [20] is applied on multi-documents. The PSO approach [21] achieved better results compared to the GA approach in [22].

Table 3: Summary of evolutionary-based approaches

Ref.	Method	Dataset	Precision	Recall	F-score
[20]	Clustering, optimization	TAC 2011	-	-	0.389
		DUC 2002	0.483	0.457	0.470
[21]	PSO	EASC	0.588	0.544	0.553
[22]	Genetic algorithm	EASC	0.565	0.571	0.547

2.4 Machine Learning-based approaches

Machine learning and clustering approaches treat the summarization process as a classification problem, summary sentences are selected based on some features. Machine learning approaches are classified as supervised and unsupervised approaches. Examples of these approaches include Hidden Markov Models (HMM), and Bayesian approach. Clustering algorithms are used to represent sentence clusters, and then extract sentences from these clusters.

Lamsiyah et al [23] propose a deep learning approach for Arabic single document summarization using sentence embedding models. The DUC2002 dataset is used for the evaluation purpose using three sentence embedding models. Achieved results showed the effectiveness of the three sentence embedding models for Arabic text summarization in comparison with eight other approaches.

An Arabic dataset of Arabic summaries is created by Al-Maleh and Desouki [24]. The dataset consists of 300,000 entries consisting of an article introduction and the headlines for each introduction. Two abstractive models are proposed for the summarization of Arabic text using deep learning algorithms. Experimental results showed that the proposed models achieved good results using the created dataset. No comparisons are done with other approaches.

Suleiman & Awajan [25] proposed the use of Recurrent Neural Network (RNN) for abstractive summarization of Arabic text. Two layers of hidden states at the encoder and one layer of hidden states at the decoder are used by the model. Long short-term memory (LSTM) is used in the encoder and the decoder layers. The two layers of the encoder are the input text layer and the name entities layer. An artificial

dataset is created and used for the evaluation of the summarization model using the ROUGE tool. Experimental results showed that the proposed model achieved good results for ROUGE1 and ROUGE1-NOORDER. Also, a comparison is made between the original word2Vec model and the dependency-parsing-based word2Vec model. Results revealed that dependency-parsing-based word2Vec model outperformed the original word2Vec model.

Elgamal et al [26] investigated the effectiveness of different extractive text summarization approaches for Arabic text. These approaches include clustering algorithm with Latent Semantic Analysis (LSA), and deep learning approach using Deep Restricted Boltzmann Machine (DRBM). The proposed approaches are evaluated on an artificial dataset collected from Arabic educational book and Arabic stories. The experimental results showed that the deep learning approach (DRBM) achieved better results in comparison with the clustering-LSA approach.

Hummeida [27] proposed the use of Restricted Boltzmann Machine (RBM) for the extraction of summaries for the holy Quran interpretations. The proposed approach comprised of three phases: feature extraction, feature enhancement, and summary generation. First, features are extracted using RBM algorithm, then summaries for each single interpretation is generated using sentence scoring. The efficiency of the proposed approach is evaluated using precision and recall measures and achieved a precision of 0.49% and a recall of 0.46.

A summary of machine learning-based approaches is presented in Table 4. Two studies [24] and [25] are used abstractive text summarization approach, while the other two studies [23] and [26] are used extractive approach. It is difficult to compare the performance of these studies since different artificial datasets and evaluation measured are used for the evaluation.

Table 4: Summary of machine learning-based approaches

Ref.	Method	Dataset	Precision	Recall	F-score
[23]	Neural Networks	DUC2002	0.621	0.344	0.442
[24]	Deep learning	Artificial	0.620	0.335	0.434
[25]	Deep learning.	Artificial	ROUGE1: 0.384 ROUGE1-NOORDER: 0.464		
[27]	RBM	Holy Quran	0.49	0.45	-

3 Conclusion

In this paper, a critical analysis of recent research in Arabic ATS is conducted. The three elements that mentioned for each study are: purpose of the study, research methodology, and findings. Most of the studies that used statistical-based approaches are performed on single documents and used extractive approach for summarization and used almost the same features as the TF-IDF.

The achieved results were very close for all studies which made it very difficult to show the advantage of these studies over each other. Most of the studies that used graph-based approaches used the same steps as preprocessing, graph construction and the similarity measure. Some researchers investigated the effect of some preprocessing steps like the tool used in the morphological analysis and the necessity of stop-words removal step, but the results were very close which means that the preprocessing did not have a notable impact on the final summary. Unfortunately, little work has been done on the Arabic ATS using evolutionary approaches while there is a big interest on using machine learning-based approaches. In general, there is a lack of tools and datasets (corpora) for the purpose of Arabic ATS compared to the tools available for the other languages, this should be considered by researchers in the Arabic language to develop such tools and datasets. Also, most of the research in Arabic ATS is concentrated on the extractive approach of text summarization while the abstractive approach is very important since it emulates the human approach of summarization considering the semantic similarity of summaries. As a direction to future work, we encourage Arabic researchers to concentrate on the abstractive approach for Arabic ATS using deep learning algorithms. Another recommendation is to give intensive attention to corpora (datasets) creation due to the limitation of these resources for the Arabic language.

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