International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

An Intelligent and Advance Kurdish Information Retrieval Approach with Ontologies: A Critical Analysis

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Submitted: 26/05/2023 **Revised**: 14/07/2023 **Accepted**: 28/07/2023

Abstract: Today, there are numerous methods of finding information online: radio, TV, and the internet all provide answers. However, the Internet stands out as being particularly helpful; users can search by typing in questions related to any subject area they wish. Results appear as links to various documents available on the internet, some of which may not even be relevant due to the vast amount of material. Search engines reliant solely on keywords are incapable of making sense of raw data, making it time-consuming and costly to extract critical pieces from an immense collection of web pages. Due to these deficiencies, several concepts were born, such as the Semantic Web (SW) and ontologies. SW serves as an excellent gateway for retrieving key information through various Information Retrieval (IR) techniques. IR algorithms are too simplistic to extract the semantic content from texts. IR, SW, and ontologies can all be used interchangeably, although all three have some connection. The SW can be achieved through IR, while indexing can lead to its creation on the web. The SW is also created through ontologies. Ontologies can be used together with the intelligent approaches to produce web content, which is then marked up using SW Documents. Ontology is the backbone of any software; therefore, the SW becomes simpler to comprehend. Ontology development is the process of creating and refining an ontology over time. This paper investigates various approaches, methodologies, and datasets used to address challenges in information retrieval, including corpus preparation, annotation techniques, query expansion, semantic reasoning, content alignment, and ontology-based retrieval systems.

Keywords: *Intelligent Approach; Kurdish Language; Kurdish Ontology; Search engines; Semantic Web; Ontology Development; Information retrieval; Web content.*

1- Introduction

Science and technology in information retrieval (IR) deal with retrieving information efficiently and quickly for use by future interested parties, yet traditional IR systems do not allow users to specify their area of interest when retrieving data from repositories of information [1], [2]. An error-ridden information retrieval system leads to unwanted results for user queries; its main aim is to provide users with accurate results and links [3]. Get documents relevant to their search query that provide maximum precision. Traditional retrieval relies solely on keyword matching, leading to inferior search quality. As such, users may be unable to locate what they seek [4], [5]. Semantic Search brings both context and user into play for its search, providing more accurate responses based on each request from its searcher [6][7].

Imagine a digital library with books organized alphabetically by topic. Each book title may include terms with multiple definitions within different digital library categories; current research in semantic retrieval concentrates on three major areas: semantic enhancement of users' queries; creating models and systems of SR; and designing systems of semantic retrieval [8].

To address information retrieval challenges, it is vitally important to index documents according to their meaning. Ontology serves as an efficient means of doing just this: providing semantic interpretation through linking concepts [9]. Semantically speaking, an ontology may be employed as a solution. Ontology refers to entities described with sophisticated formal logic languages that define their concepts' meanings formally, thus solving information retrieval challenges [10]–[12].

Semantic enhancement of users' queries involves improving understanding of search intent by considering context, user preferences, and other relevant factors. This can be achieved using techniques such as query expansion where additional related terms are added to an original query to capture its broader semantic context [8]. By taking account of user context and preferences, semantic retrieval systems can produce more accurate and personalized search results [13].

Designing models and systems of semantic retrieval involves developing algorithms and frameworks that use semantic data to enhance retrieval processes. Such models might employ techniques such as natural language processing, machine learning, knowledge representation or knowledge curation in order to capture semantic relationships between documents and queries. In doing so,

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these models aim to enhance precision and relevance of search results by taking into account meaning and context of information [6].

Designing systems of semantic retrieval involves developing practical systems that utilize semantic techniques to enhance information retrieval. Such systems often utilize ontologies - formal representations of concepts and their relationships - as a basis for more effective indexing and retrieval [9]. Furthermore, ontologies serve as knowledge frameworks which facilitate interpretation of user queries as well as mapping concepts to relevant documents [11].

Studies have illustrated the value of employing ontologies in information retrieval [14]. By including ontological knowledge into search systems, search systems are better equipped to comprehend conceptual relationships among terms, increasing precision and recall. Formal logic languages used in ontologies provide a systematic and structured way of defining concepts more precisely and consistently for more accurate user queries. Furthermore, ontologies facilitate integration of domain-specific knowledge which aids understanding and retrieval within specific fields [10] [15].

Semantic retrieval seeks to overcome the limitations of traditional keyword-based approaches by incorporating semantic understanding and context into retrieval processes. By employing techniques like semantic enhancement of queries, creating models and systems of semantic retrieval, and using ontologies as resources for improving information retrieval systems' accuracy and relevance [16].

This paper explores various approaches, methodologies and datasets used to address challenges associated with information retrieval, such as corpus preparation, annotation techniques, query expansion techniques, semantic reasoning systems and content alignment methods as well as ontology-based retrieval systems.

2- State of the Art

Traditional Information Retrieval (IR) strategies, for instance, vector space retrieval, offer fast and accurate results; however, these methods can be difficult to use meaningfully as documents become "bags of words" once indexed, and much of their semantic value has been lost. As part of their efforts to enhance IR, significant efforts have been spent annotating text with semantic information [6], [8]. Very few search engines use metadata index documents; AltaVista was one of them before its service ended in 2002 due to content providers abusing meta-information to give their papers higher ratings than they deserved [11]. Still, many believe that it is important for Semantic Web ontologies IR systems [12].

Authors of [10] presents a model to assist users in retrieving information more quickly and efficiently. Combining ontology- and keyword-based IR techniques, this combination produces better document processing with increased recall and precision outcomes. Indexing is an essential step in retrieving information and it has been emphasized by [2] which includes various studies which examine its storage and building. One such investigation investigated how syntagmatic information affected latent semantic analyses for IR within an Arabic dataset; indexing noun phrases was intended to improve Arabic IR performance but the performance did not change significantly.

Researchers of [15] investigated the use of ontologies to retrieve and filter domain knowledge across different domains. Each concept of an ontology represents a characteristic of one domain and includes information about that domain as well as relationships to other characteristics that make up its ontology, including hypernyms, hyponyms, and synonyms for all characteristics in an ontology. Unfortunately, the research does not provide any details on how domain features are created.

Automatic dialect recognition is a language technology designed to recognize multidialectal dialects. Linguists find Kurmanji unintelligible; thus, relying upon multidialectal languages with distinct linguistic features that utilize classification methods that use machine learning for the identification of text dialects such as Sorani in order to detect Kurdish text dialects; however, this may not apply when two dissimilar languages come together [17][18].

Authors of [19] presents an account of the creation of the first syntactically-annotated corpus for Kurmanji Kurdish. They hope that this will serve as a template for future developments of Kurmanji Language Technology. The Treebank served as one of the unexpected test sets at 2017 CoNLL, providing multilingual translation from Raw Text to Universal Dependencies and offering public access to this valuable resource for dependency parsing. The corpus consists of approximately 10,000 tokens distributed under an open/free license. Universal Dependencies Pipe (UDPipe), the best solution for consistently commenting on parts of speech, morphological features, and syntactic structures, was chosen as its best for consistent commentary across parts of speech, morphological features, and syntactic structures while adding the Dictionary helped both POS tagging and parsing significantly, with up to two percent improvement LAS Improvement over models without a dictionary, yielding results when Parsing Kurdish with popular data-driven parsers.

Another research presents a parallel corpus of stories taken from Bianet online magazine, which broadcasts Turkish news in English and Kurdish. A major challenge of statistical Machine Translation is the lack of parallel corpora for many translation directions or domains; we aimed to address this with our goal to improve Machine Translation (MT), where computer software translates texts from Turkish into Urdu using low-resource languages such as sources, where we assessed its quality and advantage using Our online corpus for this process [20]. This study presents a novel ontology-based information retrieval system, it features an ontology-driven architecture and evaluates its retrieval effectiveness using techniques implemented within Webocrat System. Webocrat is a system that enables users to tailor and personalize their interfaces in order to make them unique, with tests conducted to assess retrieval effectiveness on a collection of Cystic Fibrosis medical research journals.

Two additional information retrieval methods are also widely employed, the Vector Model with Term-Frequency-Inverse-Document-Frequency (TF-IDF) Weight Schema for defining the importance of phrases within web pages or documents, and Latent Semantic Indexing Model, an approach for natural language processing. According to several studies that evaluated retrieval effectiveness with an ontology-based approach in Webocrat, its ontology-based approach proved highly promising with regard to precision/recall ratio qualities [21], [22].

Ontologies are used by various systems to retrieve information that will help users to clarify their information needs and develop semantic representations for documents [23]. In this study, we demonstrate how ontologies can be efficiently applied to large-scale search systems on the web in order to increase ontology retrieval quality; specifically linking each concept of an ontology (classes and instances) with a vector (v). Our preliminary findings illustrate this principle by showing how quality feature vectors contribute significantly toward quality search results.

Based on a comparison between ontology and thesaurus as well as an ontology-based IR, potential benefits associated with ontology have been highlighted for IR. To provide users with an enjoyable retrieval experience, it is vitally important that a search mechanism ensures they only receive relevant information (high level of recall) while simultaneously filtering out unwanted or irrelevant material (high degree precision). Textpresso, a system with high recall and accuracy, enables us to investigate the contribution of ontology to IR. Ontology is increasingly seen as the future of the IRs; therefore, its usage should only increase over time. Textpresso can be understood as being a system with high recall and precision levels, perfect for testing its impact [9].

Analysis of systems using ontology and retrieval showed a variety of techniques and methods were applied by most. Keyword searches, ontologies analysis, structure evaluation, etc. were utilized by many systems in their search for related terms; while English was the predominant language. Unfortunately, there was also limited linking between individuals within their ontologies which hindered accuracy when looking up related information [11].

In an academic section where most systems focus on foods, real estate, culture, and money it is imperative that we extend Kurdish as the language of inquiry for more accurate interpretation and ontology. Furthermore, using such terminology we connect important data between lecturers and courses and facilitate communication. In the following table, a detailed comparison for the related works is presented comparing the datasets used, tools utilized and the results obtained.

Table 1: Comparison of state of the art information retrievals

Year	Problem	Technique	Dataset	Ontology	Tools	Result
2014 [24]	The huge amount of data is on the web, so finding the suitable information is very difficult task	-Swangling technique to access SWDs -OWLIR to improve IR performance	-----		Ontology Manager Component	Various approaches used to retrieve the information from the web
2016 [25]	examines several features of semantic technologies utilized in Internet of Things (IoT) systems.	semantic reasoners	Internet of Thing (IoT)	Semantic Sensor Network (SSN) Ontology	Semantic Web	Pointing out some of its shortcomings in the development of an (IoT) application or service

2017 [19]	Describe how the corpus was prepared	Annotation technique	Kurmanji Kurdish Language (CoNLL-U)	----------	Treebank	The optimal model is Universal Dependencies (UDPipe), and adding the dictionary improves both POS tagging and parsing, with a 2% LAS increase over the model without a dictionary.
2018 [20]	A critical issue in statistical MT is the scarcity of parallel corpora in various translation areas and directions.	using bilingual neural MT	Parallel Data (English, Turkish and Kurdish)	----------	Machine Translation (MT)	The results of the experiment reveal that adding the Bianet corpus results in a considerable increase in overall translation quality.
2019 [26]	Kurdish is less resourced language and it is not machine readable.	Structuring the data, pre-processing the text, and convert it to Onto Lex Lemon Ontology	Kurdish Language	Ontolex Lemon Ontology	Natural Language Processing (NLP)	Making Kurdish a resource-rich language
2020 [27]	The websites of multi-language news often deliver comparable material in various dialects or languages.	Website Crawling, Corpus Filtering, and Content Alignment,	News Articles	----------	Natural Language Processing (NLP)	Initiating a parallel corpus for Kurdish language as a language of less resources
2021 [28]	The current web system is weakness in term of the query	Fuzzy ontology construction, Query expansion and IR	Google, Yahoo, Bing and Exalead	Fuzzy Ontology	Concept Net	10% improvement in Precision after expanding the query
2021 [29]	Information Retrieval from business environment is a great challenge	The Vertical strategy and Horizontal strategy	Brazilian News	OntoBE Ontology	Web Crawler	Our technique is capable of identifying business prospects with up to 90% accuracy.
2020 [30]	Most of the IR system depends on the matching words. So, user may not find the accurate information.	Semantic Retrieval to find the related information	Collecting 524,405 blogs from blogger.com	Cultural Ontology	Semantic Vector space model	On 15 questions, the SeVSM system outperforms the VSM system, confirming the efficacy of our strategy.
2022 [31]	Difficulty to find the image depending on keywords	Based on image retrieval system and information	NO target dataset	Ontology based on Image	Content- based image retrieval and image retrieval based on text	Images has been retrieved based on some selected features (text, color, and shape)
2020 [32]	There is a problem for buying and selling property	Query processing	Real estate data	Real estate Ontology	Protégé	This demonstrates that the performance of the REIR model employing real estate ontologies produces

						superior results for the different metrics given and, as a consequence, is performing well at this level.
2021 [33]	In public-private partnerships, value for money (VfM) evaluations often lack adequate automated methods and reasoning support.	Based on the new measurement rule (NRM) and SPONS	Modelling the information	Value For Money Ontology (VfMO)	Using Questionnaire	The majority of respondents stated that using BIM data to aid evaluations offered trustworthy findings.
2021 [34]	Food ontology do not provide the enough information consider it for the user	Analyzing food and restaurant ontology	Restaurant and food	Food Ontology based on OWL	Protégé	The result show that the ontology is 100 % competent.
2022 [35]	The input queries are unable to adequately represent the user's information requirements.	Query transformation	ANTIQUE, Cranfield and TREC MRT dataset	Domain ontology	-----	For the ANTIQUE dataset, the suggested method obtained a 4 percent high accuracy at 100 top documents. The recall values on the Cranfield dataset at the top documents improve by 13%.
2022 [36]	The research deal with three main issues in search engine (Scalability, Usability and retrieval)	Querying the data	No specific dataset	Transportation Ontology	-----	The findings indicate that the use of semantic fields bears fruit with a high rate of recall and accuracy.

The provided table presents various research papers addressing different problems, techniques, datasets, ontologies, tools, and results in the field of information retrieval. One of the papers from 2014 highlights the challenge of finding suitable information due to the vast amount of data on the web. The researchers used the Swangling technique to access Semantic Web Documents (SWDs) and employed OWLIR to improve Information Retrieval (IR) performance. Their work resulted in the development of various approaches to retrieve information from the web. Another paper from 2016 focused on examining semantic technologies in Internet of Things (IoT) systems. The researchers used semantic reasoners and analyzed the application of Semantic Sensor Network (SSN) Ontology in IoT. They identified shortcomings in the development of IoT applications or services. In 2017, a study described the corpus preparation process and used annotation techniques to analyze the Kurmanji Kurdish Language. The researchers found that the Universal Dependencies (UDPipe) model improved POS tagging and parsing. In 2018, a critical issue in statistical Machine Translation (MT) was addressed, which is the scarcity of parallel corpora. The researchers employed bilingual neural MT and included the Bianet corpus, resulting in a considerable increase in overall translation quality. In 2019, the challenge of making Kurdish a resource-rich language was tackled. The researchers structured and pre-processed the data, converting it to OntoLex Lemon Ontology. They successfully made Kurdish more machine-readable. These are just a few examples from the table, highlighting the diverse problems and approaches in information retrieval research.

3-Semantic Web

Tim Berners Lee introduced the Semantic Web (SW) in 1996 with the goal of providing information in an easily machine-readable format. As an extension of current internet pages, Semantic Web pages contain machine-readable markup languages. The SW is an information dissemination framework with multiple languages and ways of increasing its effectiveness [37]. Semantic Web documents are known as SWDs written using languages such as OWL or DAML+OIL provide this foundation. SW is software that utilizes XML (Extensible Markup Language), to maintain user connection to its agents so they receive clear answers to their inquiries. Semantic Inference Engines must also be maintained so their queries and results will be: Input to the Inference Engine is the query; Documents are generated by the query that uses semantic markup for retrieval of information; In order to provide Inference, the System must prove that this inquiry; This query is encoded in a text format that search engines can recognize; The query is sent to one or more websites after identification; These markups must be removed from the websites. These markups may be illegal, meaningless, or beneficial; FILTERS make markups more accurate and trustworthy [21]. SW is built upon two technologies; first is XML, an extensible language in which users may add tags of their own to documents using its syntax for structuring document content. RDF provides another technology where data are modeled and their relationships are defined [38].

4- Ontology for Information Retrieval

The practice of retrieving unstructured data from unstructured textual materials such as the World Wide Web (WWW) or corporate knowledge bases, is known as Information Retrieval (IR). Retrieval challenges may arise in any of these environments. Retrieval challenges often present themselves through searching documents related to a query in unstructured texts that respond directly to it IR, also known as Information Retrieval. Information retrieval's central goal is finding items most appropriate to each user based on their individual information needs which ultimately results in retrieval challenges found throughout these environments such as finding documents that respond directly to unstructured text materials, Information Retrieval is concerned with finding relevant textual materials related to one user needs while finding information that meets these criteria according to individual user information needs which are found across numerous settings including both WWW pages as well as corporate knowledge bases [39]–[41].

Retrieval challenges may exist within many environments such as both. Retrieval challenges can arise anywhere along this process of information gathering and can occur within many settings including corporate knowledge bases, where users want to access certain items. Retrieval challenges may come into play whether that user needs are being identified according to each user needing the most pertinent items according to individual user's individual information needs as per user identifies. Retrieval can come into play in many contexts, retrieval issues could present themselves within various forms such as web and corporate knowledge bases offering their particular issues can present regardless of being found either one can come up in these settings either of course [42][43] .

Ontology can be an extremely valuable asset when it comes to improving information retrieval [44]. Ontology refers to the study of instances and relationships among concepts defined by users. This data represents previous information at the Semantic Level; an ontology represents this as it's comprised of semantic entities along with their concepts and relationships rather than mere words used by thesauruses [26], [31].

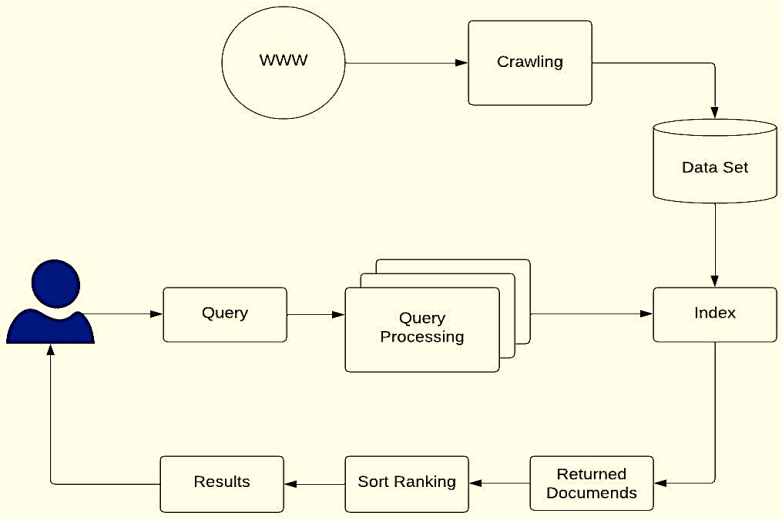

Fig 1: Model of Information Retrieval.

The vector sector model is the mainstay for retrieving information. It entails splitting up, classifying, and filtering text that appears abstract to an extent before applying statistics about the frequency of words within it. A computer then performs these processes based on certain criteria before applying statistics on frequency data about words within the text. By including ontologies into retrieval systems users' semantics can be easily accessed using them and more effectively meeting individual retrieval needs. Incorporating formal ontologies into knowledge information systems allows users to meet individual retrieval needs. Knowledge information systems in this sector are founded upon ontologies that contain ideas, relations, and instances. Figure 2 illustrates this approach. Knowledge information systems within this sector are founded upon formal ontologies which contain ideas, relations, and instances collected together [9], [42].

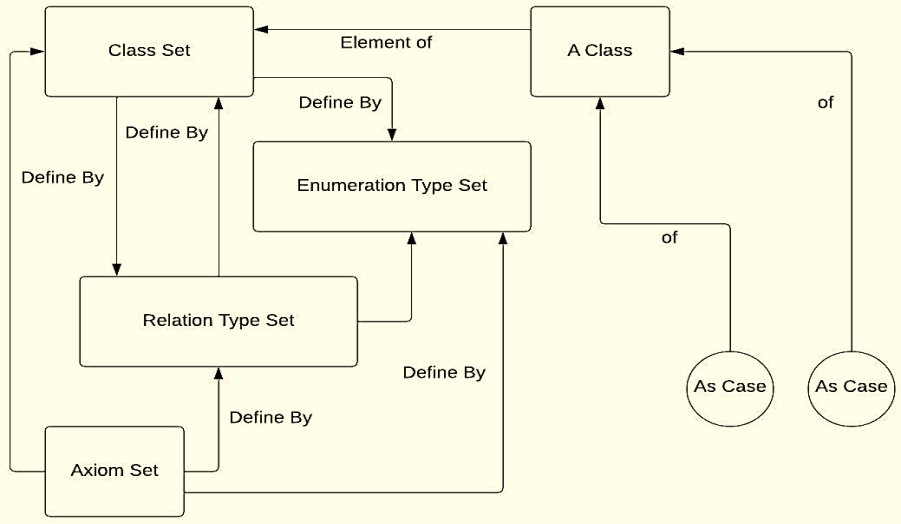

Fig 2: Model of the Ontology [5].

5- Process of IR

IR is a natural language processing application. The goal of IR is to represent, store, and retrieve information. The primary processes in IR include Indexing, Query Processing, and Matching.

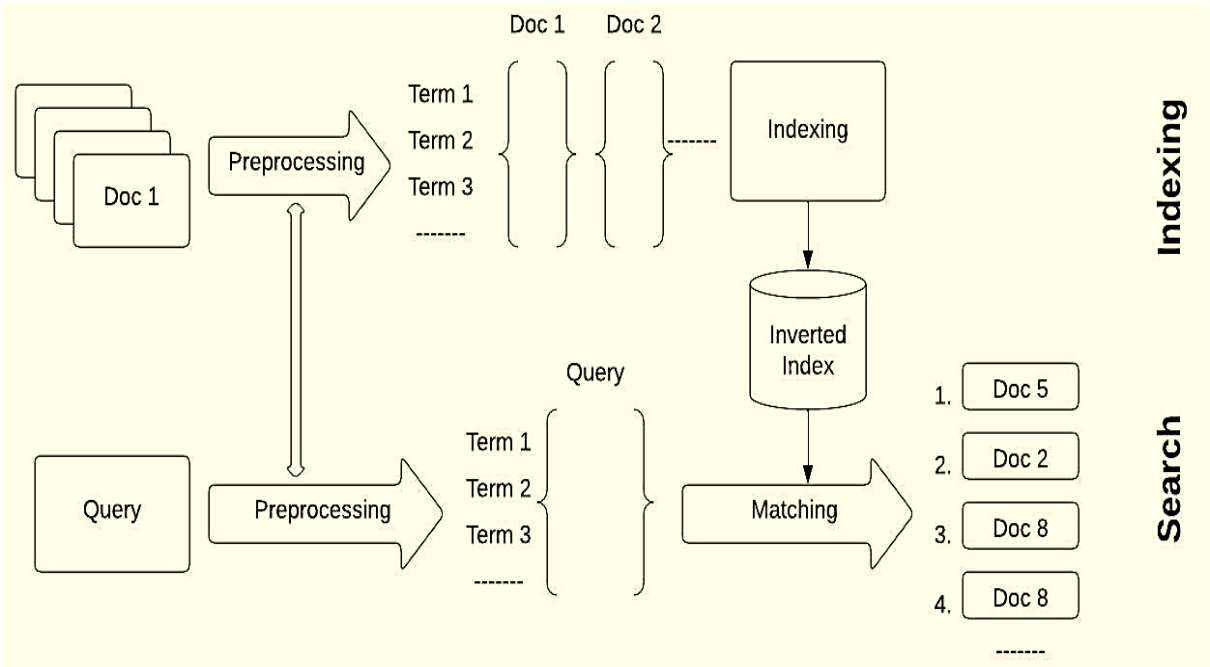

Fig 3: Process of the IR.

Indexing involves indexing all documents according to keywords that represent each document, while in the query reformulation stage queries are modified so as to conform with the IR approach; finally, the last step involves matching user queries entered with indexing by ranking documents/queries according to similarity to user queries [43], [45].

Figure 3 depicts the Information Retrieval process. IR can be divided into two main steps: Indexing and Search. Indexing involves extracting terms from documents to store in an inverted index; while Search enables users to enter queries that retrieve terms extracted during the Indexing process for inclusion into an inverted index search query by an index inverted; with ranking algorithms then sorting results that match against an index inverted and the query [46]–[48].

6- Discussion:

The provided study discusses various aspects of IR and its application in the context of Kurdish language. In the following section, the key points related to IR for the Kurdish language challenges are presented:

- **Challenges in IR**: Traditional IR strategies, such as vector space retrieval, can be challenging to use effectively with Kurdish language due to the loss of semantic value when documents are indexed as "bags of words." This highlights the need for techniques that preserve the semantic information of Kurdish texts during the retrieval process.
- **Semantic annotation**: Efforts have been made to annotate Kurdish texts with semantic information to enhance IR. Semantic Web ontologies have been considered as a means to improve the retrieval effectiveness by linking concepts of an ontology with document vectors.
- **Ontology-based IR techniques**: Ontologies play a crucial role in improving the quality of information retrieval. By incorporating formal ontologies into knowledge information systems, users can more effectively meet their individual retrieval needs. The use of ontologies allows for the representation of semantic entities, concepts, and relationships in Kurdish texts.
- **Corpus development**: The creation of syntactically-annotated corpora for Kurmanji Kurdish has been explored. Such corpora serve as valuable resources for dependency parsing and language technology development. Universal Dependencies Pipe (UDPipe) has been used for consistent commentary on parts of speech, morphological features, and syntactic structures in Kurdish texts.
- **Dialect recognition**: Automatic dialect recognition has been studied to identify multidialectal Kurdish texts. Machine learning methods have been employed to recognize different dialects, such as Sorani, and distinguish them from other languages. This helps in detecting and categorizing Kurdish text dialects.
- **Parallel corpora**: The development of parallel corpora, including Kurdish, has been important for various natural language processing tasks, such as statistical Machine Translation (MT). Parallel corpora allow for training and evaluating MT models, improving translation quality for Kurdish.
- **Semantic Web and ontology**: The SW and ontologies provide frameworks and languages for machine-readable representation of information. Utilizing this technology by implementing Kurdish ontologies will help Kurdish IR systems to retrieve Kurdish written text.
- **IR process**: The IR process involves indexing, query processing, and matching. Indexing includes extracting keywords from Kurdish documents and creating an inverted index. Queries are processed and modified to conform to the IR approach, and matching is performed to rank the retrieved documents based on their similarity to user queries.

Overall, this section highlights the importance of semantic annotation, ontologies, corpus development, and the application of IR techniques in the context of Kurdish language to enhance information retrieval and address specific challenges related to Kurdish texts.

7- Conclusions

This paper has explored different approaches, methodologies, and datasets employed to tackle the challenges in information retrieval. The traditional reliance on keyword-based search engines has proven to be inefficient in making sense of the vast amount of information available on the internet. As a result, concepts like the Semantic Web (SW) and ontologies have emerged as valuable tools for retrieving relevant and meaningful information. The SW serves as a gateway for accessing key information through various Information Retrieval (IR) techniques, bridging the gap between raw data and semantic content extraction. Additionally, IR, SW, and ontologies are interconnected, with the SW being achieved through IR and ontologies playing a crucial role in its creation. By utilizing ontologies, web content can be produced and marked up using SW documents, facilitating a more comprehensive understanding of the SW. Ontology development serves as the foundation for software applications, contributing to the simplification of the SW. This paper has investigated diverse aspects of information retrieval, including corpus preparation, annotation techniques, query expansion, semantic reasoning, content alignment, and the utilization of ontology-based retrieval systems. By addressing these challenges, researchers and practitioners can enhance the

effectiveness and efficiency of information retrieval in the digital age.

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