A Survey of Semantic Analysis Approaches

Said A. Salloum[1,2(✉)], Rehan Khan[1], and Khaled Shaalan[1]

[1] Faculty of Engineering and IT, The British University in Dubai, Dubai, UAE
[2] Research Institute of Sciences and Engineering, University of Sharjah, Sharjah, UAE
ssalloum@sharjah.ac.ae

Abstract. Semantics is a branch of linguistics, which aims to investigate the meaning of language. Semantics deals with the meaning of sentences and words as fundamentals in the world. Semantic analysis within the framework of natural language processing evaluates and represents human language and analyzes texts written in the English language and other natural languages with the interpretation similar to those of human beings. This study aimed to critically review semantic analysis and revealed that explicit semantic analysis, latent semantic analysis, and sentiment analysis contribute to the leaning of natural languages and texts, enable computers to process natural languages, and reveal opinion attitudes in texts. The future prospect is in the domain of sentiment lexes. The overall results of the study were that semantics is paramount in processing natural languages and aid in machine learning. This study has covered various aspects including the Natural Language Processing (NLP), Latent Semantic Analysis (LSA), Explicit Semantic Analysis (ESA), and Sentiment Analysis (SA) in different sections of this study. However, LSA has been covered in detail with specific inputs from various sources. This study also highlights the future prospects of semantic analysis domain and finally the study is concluded with the result section where areas of improvement are highlighted and the recommendations are made for the future research. This study also highlights the weakness and the limitations of the study in the discussion (Sect. 4) and results (Sect. 5).

Keywords: Natural language processing · Sentiment analysis · Explicit semantic analysis · Latent semantic analysis · Wikipedia linked based measures

1 Introduction

Documented data occurs in an ever-increasing number of researches, [1–4], and business situations, and is encountered in different contexts by different scientists and scholars [5–12]. [13] indicate that factoring rapid increase in data gathering, language processing, and information retrieval attract investigators pursuing high system performance [14–16] argue that researchers from a variety of disciplines have interests in evaluating abstracts, titles, and publication full-text bodies to categorize attributes including research topics, methods, and theories associated with the research nature. According to [17], many multidisciplinary fields including biochemistry, engineering, data mining, neuroscience, and bioinformatics [18] have emerged in the past numerous

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decades. Because multidisciplinary environments involve theories, techniques, and methods from several areas, it is not easy to understand all the research processes in these fields [17]. Hence, there should be a method of organizing documents and texts into groups based on their pertinent structures. The method, which researchers and scholars utilize to group texts based on the underlying structures is semantic analysis. [19] state that semantic analysis accords the exact meaning and interpretation of the dictionary meaning emanating from structures developed by syntactic assessment [20]. Semantics is a branch of linguistics, which aims to investigate the meaning of language and language exhibits a meaningful message due to semantic interaction with diverse linguistic categories, syntax, phonology, and lexicon [19]. In this regard, semantic analysis is concerned with the meaning of words and sentences as elements in the world. This assignment reviews critically – offers descriptive, analytical, and interpretative evaluations of semantics. To accomplish this, the assignment factors semantic classification for practical natural language processing [21], latent semantic analysis, explicit semantic analysis, and sentiment analysis. The analyses contribute to the facilitation of free communication and the understanding of the textual data, which can be applied in information systems. The main challenges of Machine learning and Artificial intelligence is learning from natural language and text. Any significant advancement in this area has solid effect on numerous applications varying from speech recognition, information and data retrieval, natural language processing and machine interpretation.

It is important to emphasize that this study has also deliberately considered some research papers published before 2006 because of some interesting findings by the authors. Nonetheless, the latest research papers have been specifically focused. Literature Review.

2 Literature Review

2.1 Technical Part

2.1.1 Natural Language Processing

Semantic analysis interprets language structures through natural language analysis. Natural language processing (NLP) is a theory-motivated scope of computational techniques for the automatic evaluation of representation of human language [22]. [23] indicate that the field of NLP is concerned with the building of computer software systems that process and analyze texts written in the English language and other languages with interpretation and generation capacities similar to those of human beings. [24] adds that NLP is a field of research and application that examines how computers can be utilized to comprehend and manipulate natural language speeches and texts to accomplish useful endeavors. The aim of NLP researchers is to learn how people understand and use language in order to develop effective tools and methods to make computers understand and affect natural languages and to perform the required tasks [24]. The extracted meanings can be utilized for various tasks including undertaking robotic actions, production of equivalent translation in a dissimilar natural language in the context of machine translation systems, and retrieving information from

databases. Natural language processing system inventions are associated with the semantic analysis of linguistic structures. For instance, [25] present a semantic discourse presentation structure (SemDRS), which is a model that interprets linguistic structures outputs based on the natural language linguistic analysis framework. SemDRS performs the transformation by contrasting the input linguistic construction to an automatic program in such a way that SemDRS correctly capture the area-specific interpretation of the linguistic expression [25]. For the undefined words in the natural languages, [26] indicate that there is an invention that requires users to input synonyms existing in the dictionary so that they can process natural languages and understand their meanings. NLP is applicable in diverse fields of research including machine translation, user interfaces, multi-language information retrieval, expert systems, speech recognition, natural language text processing, and summarization, and artificial intelligence.

2.1.2 Latent Semantic Analysis

The intelligence and machine learning face challenges such as difficulties learning from the natural language and text, but latent semantic analysis can address the challenges [27]. The fundamental issue is to understand the denotation and utilization of words in an information driven manner, for e.g. from some given content without any prior knowledge of linguistics.

[17] argue that latent semantic analysis (LSA) is a theoretical framework of acquiring knowledge, induction, and representation. LSA is a systematic machine learning methodology for evaluating the associations and similarities of structures among terms and documents without depending on human experience, knowledge bases, past theoretical models, and semantic dictionaries [17]. [16] indicate that LSA was introduced in the late 1980s as an information retrieval approach developed to better the indexing of library and search engine performances. Later, LSA became a method and a theory for retrieving and representing word meaning including sorting words and category judgments. [28] opine that LSA is utilized because of its unparalleled capacity to reveal the conceptual content of the unstructured data based on different mathematical dimension reduction approaches that approximate the linear combinations of the interpretation of words and concepts. LSA utilizes the categorized words and concepts to permit subsequent in-depth analyses. Latent semantic analysis is important in the whole semantic analysis discourse. Latent Semantic Analysis (LSA) is a natural language processing method, which extracts ideas and concepts from the collection of terms to generate an arrangement of terminologies connected by the underlying assumption that words similar in interpretation occur in the analogous segments of the text [28]. LSA identified a model called “Probabilistic Latent Semantic Analysis (PLSA)” where the variable has a sound computable foundation and identified an applicable propagative model of the data [29]. Therefore, LSA addresses challenges of learning from the natural language and text since its goal is to locate data mapping that offers information beyond the level of lexical interpretation and reveals a semantic association between the parties of interest [29]. Because of its generality, it is a suitable and valuable analytical tool with a diverse range of applications in business and information systems to analyze textual data. Some of the areas LSA can be applied include quantitative literature reviews, evaluation of textual data in computer-mediated

communication, evaluation of client feedback interviews, and management of knowledge repositories.

The statistical understanding of LSA leads to the emergence of probabilistic latent semantic analysis (PLSA), which is a new model of LSA. The probabilistic variant of LSA presents a formidable statistical foundation that explains a solid generative framework of the data [29]. The goal of PLSA is to identify and distinguish between contrasting contexts of word utilization without relying on a dictionary. Semantic relatedness interventions seek to encourage computers to reason for written text. PLSA has two applications such as permitting the disambiguation of polysems – words with more than one meaning and projecting the topical similarities by aggregating together words that form a common context [13, 29]. The research paper claimed substantial performance could be obtained by using this technique. Latent semantic analysis can complement unsupervised learning for a different range of applications in information retrieval and text Learning. LSA and its new model, PLSA are critical in the evaluation of text and natural language to comprehend the meaning and utilization of words in different machine learning, artificial intelligence, and other applications.

2.1.3 Explicit Semantic Analysis

To process natural language, computers need access to domain-specific world knowledge and a huge volume of common sense, which can be provided by explicit semantic analysis. Unlike LSA that utilizes statistical co-occurrence information, explicit semantic analysis utilizes knowledge humans gather and organize [30]. Explicit semantic analysis assists text representation with huge amounts of world knowledge such as those of Wikipedia to enable computers to process natural language and reason about the semantic associations of natural language utterances [31]. Explicit semantic analysis is critical in the computation of words and text relatedness and is applicable in artificial intelligence and natural language processing.

The motivation behind semantic relatedness measures is to enable Wikipedia Link-based Measure (WLM) approach have been developed to extract the semantic relatedness measures from Wikipedia. The main difference between the WLM and the conventional method is that relatedness is defined by using hyperlink structures [31]. In this technique, links between articles were used instead of textual content to provide precise measures cost-effectively. This approach is similar to Explicit Semantic Analysis (ESA) as it uses the online encyclopedia for this purpose. ESA is still considered as the best measures in terms of accuracy and effectiveness; the authors were successful in matching the accuracy when the individual articles in Wikipedia is defined as a term. Future work may include applying WLM to different tasks to explore its effectiveness further.

2.1.4 Sentiment Analysis

It is not a new job for advertising researchers to derive the opinions and feelings of customers from a pool of qualitative data. Conventionally, the coding of manual content can perform such a task. Researchers thoroughly and comprehensively examine the data and independently develop their own categories of sentiments. The growing popularity of sentiment analysis can be due to its unique benefits: firstly, computer-

aided feelings sentiment analysis is not only more effective than manual coding but also yield comparable results.

Opinion and attitudes in a language are fundamental aspects of semantic analysis, which sentiment analysis reveals [32]. Sentiment analysis encompasses a sequence of methodologies, tools and techniques, related to the detection and extraction of individual data including opinion and attitudes from languages [33]. The objective of sentiment analysis is to identify in what way sentiments are presented in scripts and if the expressions exhibit positive (favorable) and negative (unfavorable) views on a subject [34]. The analysis identifies sentiments expressions, polarity, and power of the expressions, and the association to the topic. The identified elements contribute to the subjective comprehension of texts, which is critical in revealing the meaning of language. Twitter is a social networking and microblogging site for users to post real-time tweets [35–38]. Tweets are brief posts, just 140 characters long. Given the nature of this micro-blogging platform, people use acronyms, make mistakes with spelling, use hashtags, and other expressions that convey their particular meaning. [39] used the twitter data in their research to analyze the sentiment analysis, POS features and kernel tree usage. Twitter data was preprocessed by using an acronym dictionary and emoticons. A glossary of emoticons was prepared by labeling 170 emoticons available on Wikipedia. Different types of labels were assigned to emoticons, such as positive, negative, neutral, etc. Unigram model was used as a baseline and reported an overall increase of 4% for two activities: binary versus negative and neutral versus negative versus positive.

In summation, the Sect. 2 of the assignment critically analyzed NLP in general and narrowed down to latent semantic, explicit semantic, and sentiment analyses. Whereas NLP analyzes texts written in the English language and other natural languages, LSA provides a framework for machine learning to learn from natural languages. The explicit semantic analysis presents domain-specific world knowledge for computers to process natural language, while sentiment analysis investigates opinions and attitudes in the text.

3 Future Prospects

Semantic analysis is primarily concerned with the meaning of language [32, 40]. Language shows a meaningful message since it involves semantic interactions with the dissimilar language groupings such as lexicon and syntax [41]. The technical part revealed a deeper technical content of the semantic analysis including aspects such as latent semantic, explicit semantic, and sentiment semantic within the framework of practical natural language processing. Because of this, future research within the area would be sentiment expressions, which sentiment analysis as a technique of semantic analysis identifies. Sentiment expressions motivate me because the meaning of words and sentences should not only end at the understanding of the text but also at the comprehension of how they contain emotionally loaded opinions. [34] provide a framework for sentiment analysis and define sentiment expressions. In this regard, the grammatical arrangement of words in a sentence is important since it encompasses the elements in the world that constitute the meaning. However, the element of sentiment

expression must be clearly understood based on the interpretation of words such as verbs, adjectives, nouns, prepositions, and adverbs. For instance, [34] argue that sentiment expressions utilizing adjectives such as good denotes noun modification with positive polarity. For example, a good product is a sentiment expression, which shows a positive attribute of a product. Similarly, an adverb such as beautifully in the case of play beautiful modifies an adverb to project a positive sentiment expression [34]. Hence, sentiment expressions utilizing adverbs, nouns, and adjectives can be explained based on positive and negative polarity argumentation. Critically, sentiment expression presents the prospect for research undertaking within the semantic analysis because of the applicability of the concept. In the field of computer science, opinion mining is critical when testing the quality of products. Therefore, computer science students have the opportunity to capitalize on large volumes of data and documents to develop powerful functionalities for competitive advantage. A research area is a powerful tool for analyzing and detecting the favorable and unfavorable attributes of innovations and products for appropriate risk analysis and management. In this regard, the study aims to achieve the fundamental association between sentiment expressions and practical natural language processing, especially in the construction of systems that process texts written in conventional languages, natural languages, their interpretation, and contributions in assigning products and concepts the positive, negative, and neutral polarities. The methodology applicable to future research is the critical review of the literature about the topic area. The critical review method of literature offers an opportunity to assess the strengths and weaknesses of the published literature on the research area, analyze ideas and content, and relate them to other aspects of natural language processing. Fundamentally, the critical review methodology provides the basis for describing, analyzing, and interpreting the literature and extracts the presentation associated with the topic area. In conclusion, the future prospect is sentiment expressions. The motivation for the selection is to comprehend how words contain emotionally loaded opinions. The future prospect is critical since it can be applied in gathering data about product quality.

4 Discussion

Summarily, the report has been a critical review of over 12 published research papers on semantic analysis [13, 22, 30, 42–50]. Some papers have been scanned quickly to check the relevance of the topic and the interesting findings revealed by the authors. The analysis unearthed that natural language processing focuses on the development of computer software infrastructure that can evaluate texts composed in English and other natural languages. The computer software should be able to interpret and generate concepts similar to human beings. However, the ability of the NLP to extract the meaning from the text depends on representing the meaning in a style suitable for computer manipulation. Therefore, what I did in the report was to draw a connection between the NLP, which is a theory-motivated scope of computational methods for automatic evaluation and representation of human language with semantic analysis. This study was able to present the ambit of semantic analysis is the meaning of words and sentences, which NLP can rely on to explore how computers can be utilized to

comprehend and manipulate natural speeches and texts for various applications such as machine translation, artificial intelligence, user interfaces, and expert systems.

Fundamentally, this study was able to reveal how SemDRS is a model, which performs semantic analysis based on the natural language linguistic analysis platform. The model can process natural languages containing unidentified words and present their meanings in a format that the computer can understand. Moreover, this study was able to capture the meaning and application of latent semantic analysis and how its statistical variance, PLSA generate model data to address challenges associated with the inability of artificial intelligence and machine learning to acquire the meaning and utilization of words in a data-controlled fashion. Finally, this study was able to explain how explicit semantic analysis assists in semantic relatedness of natural language and how sentiment analysis demonstrates favorable and unfavorable opinions for competitive analysis. Reflectively, it was interesting to discover that semantic analysis is an important aspect of natural language processing, which can be applied in computer science, artificial intelligence, and other domains of learning. It was a significant discovery because when the term semantic is introduced, the first conclusion is that it is limited to the meaning of words and sentences. After reviewing the research papers, it is concluded that the semantic analysis is a critical area in the field of machine learning since there must be a mechanism for enabling machines to interpret natural languages to domain-specific world knowledge. The interesting area, which this study did not have time to cover, was syntactic-semantic analysis, especially word-class function (WCF) as presented by [51]. Also, this research paper was published in the year 1997 and the paper was skimmed quickly. I think the word-oriented aspect of WCF would have been an enriching area of focus, particularly on how words contribute fundamentally to language comprehension. In conclusion, a summary of the text reflects the content in a simplified version. It reflects what the researcher did, and the personal views concerning the research. This area is critical since it also reveals areas not captured in the proposal and how they could have contributed to the overall enrichment of the composition.

5 Conclusion

Based on the presentation in the technical part, it is evident that semantics is necessary to process any natural language. [19] contend that in the absence of semantic analysis, the results of machine learning may be ambiguous. In this regard, semantics is a field of linguistics, which deals with the study and interpretation of the meaning and is critical in natural language processing. To solve ambiguities and other challenges associated with natural language processing, semantic classification is of great value. Hence, it is important to collect knowledge on how people comprehend and utilize language to develop appropriate methods and tools to make computers comprehend and manipulate natural languages to undertake tasks such as machine translation. Moreover, it is clear that sentiment analysis contributes to the building of accurate and reliable semantic analysis of words and sentences and latent semantic analysis is applicable in the management of knowledge repositories. Since probabilistic latent semantic analysis is

based on sound statistical application, it can be employed to enable machine learning to handle the distinctions between the lexical and semantic level interpretations.

In summation, the critical review of sources related to semantic analysis revealed the weakness of machine learning in processing natural languages. Positively, the semantic analysis demonstrated that computer software with capacities such as those of human beings can be developed to process texts composed in natural languages and English and utilize them in machine translation. Hence, the proposal demonstrates the capacity of semantic analysis in the whole framework of natural language processing and the contribution in user interface investigations. Due to the time limitation, this study could not focus vertically or deep dive into specific domain. However, this study provides a robust foundation to proceed with the detailed research in coming months.

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