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# Sentiment Analysis in Healthcare: A Brief Review



Laith Abualigah, Hamza Essam Alfar, Mohammad Shehab  
and Alhareth Mohammed Abu Hussein

**Abstract** Sentiment analysis is one of data mining types that estimates the direction of personality's sentiment analysis within natural language processing. Analyzing the text computational linguistics are used to deduce and analyze mental knowledge of Web, social media and related references. The examined data quantifies the global society's attitudes or feelings via specific goods, people or thoughts and expose the contextual duality of the knowledge. Sentiment analysis used in different approaches such as products and services reviews. Also is used in healthcare, there is a huge volume of information about healthcare obtainable online, such as personal blogs, social media, and on the websites about medical issues rating that are not obtained methodically. Sentiment analysis provides many benefits such as using medical information to achieve the best result to increase healthcare quality. In this paper, sentiment analysis methods and techniques are presented that used in the medical domain.

**Keywords** Sentiment analysis · Data mining · Natural Language Processing (NLP) · Computational linguistics

## 1 Introduction

The online experience gives benefits to the people who are interested in such a product from the other people who wrote their sentiment analysis on such a product [1, 2]. There are many sources to find this huge amount of data online, such as social media sites, online forums, personal blogs, etc. including a wide scope of topics [3–6]. People discuss their healthcare cases on a lot of medical websites and forums, and they share their illness, indications, and drugs. The experience of medical centers that people visited, also shares the availability, services, pleasure, etc. [7, 8].

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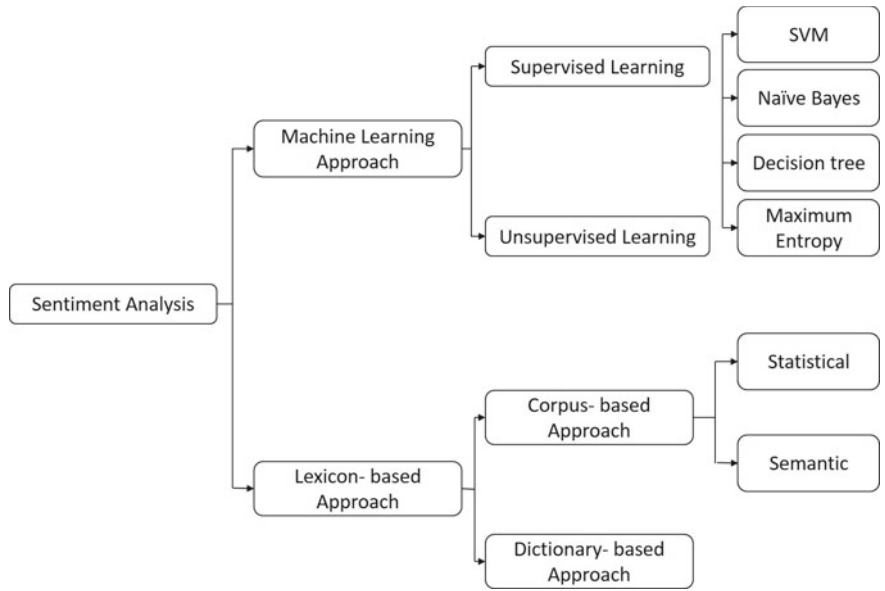
It is very important to patients when they learn from other patients experience to make decisions about their medical issue. Such as choosing hospital, clinic, and medication. This information also benefits the hospitals to know the patients' interests and problems and resolve them. Patients share their experience covered in their own sentiment analysis and passions, which is the power of this type of analysis. [9] has taught sentiment analysis as knowing the sentiments of people about a subject and its features. The medical content that is accessible online is free, in addition to its existing in large volume; therefore, analyzing this huge amount of data manually is less effective.

Assessment examination for the most part centered on the programmed acknowledgment of suppositions' extremity, as positive or negative. These days, notion investigation is supplanting the online and customary overview techniques normally led by organizations for finding the general conclusion about their items and administrations to improve their promoting methodology and item notice and help to improve user administration. The online accessibility of enormous content makes it imperative to be broke down. The programmed examination of this data includes a deep comprehension of common dialects. Notions and feelings assume a significant job in our day by day lives. They aid basic leadership, learning, correspondence, and circumstance mindfulness in human situations. The significance of handling and understanding vernacular content is expanding because of the development of socially produced regional substance in web-based life. Notwithstanding existing materials, for example, nearby sayings, exhortation, and fables that are discovered spread on the web [10].

Techniques in sentiment analysis complete this task with automatic processes without people help. In the past, researchers were used questionnaires and surveys for sentiment analysis purposes, and these methods taking a lot of money and time. There are a few papers produced by specialists, and they do not solve the problems, which the patient suffers. Sentiment analysis takes interests the feelings of patients stated in a huge number of documents that is shared on different websites. The main techniques used in sentiment analysis are shown in Fig. 1.

The result of sentiment analysis is the categorization of medical decisions into two types such as good, or not good. However, we can derive characters of medical problems by digging deeper. The purpose of this article is to focus on the importance of sentiment analysis represented by a huge number of patients regarding their disease, medications, medical issues, etc. As well, we added comprehensive details in this topic for who are interested in this domain in futures with various directions of research.

The rest of this paper is summarized as some of the related work in Sect. 3, and we talk about future work in Sect. 4, in Sect. 5 the related works are discussed and overviewed the used techniques, in Sect. 6 we will discuss some natural language processing challenges, and finally the conclusion and references in Sect. 6.



**Fig. 1** The main techniques used in sentiment analysis

**2 Related Work**

In this section, we cover some important parts in the sentiment analysis as follows:

**2.1 Sentiment Analysis and Sentiment Analysis Mining**

An essential part of the information-gathering form has eternally been to find out what different people believe. With the increasing availability and demand of sentiment analysis-rich devices such as online survey sites and private blogs, unique events and difficulties occur as people now can, and do, actively use learning technologies to attempt out and get the sentiment analysis of others. The unexpected eruption of movement in the field of sentiment analysis mining and sentiment analysis, which dispenses with the computational method of sentiment analysis, feeling, and subjectivity in the document, has thus happened at least in part as a right answer to the surge of investment in new systems that distribute direct with ideas as a first-class object [11].

Web is the most critical wellspring of getting up considerations, overviews for an item, and surveys for an administration or movement. A Bulky measure of surveys are created day by day on the internet about online items and articles. For instance, numerous people share their comments, surveys, and emotions in their language using online life systems, for example, twitter, etc. The prerequisite for structuring systems

for various lingos is extending, especially as blogging and small-scale blogging destinations are getting to be prominent [12]. Exhibited a complete review of the methodologies of examination and diagrams of significant gaps in the writing.

There is a method to analyze the feelings of humans, which is the sentiment analysis. The internet provides accessible textual data that is growing every day. Online websites for shopping give shoppers the possibility to record their notes and reviews about goods sold, and that has to improve products selling and to enhance the satisfaction of shoppers [8, 13–15]. Dealing with a huge amount of records or comments in sentiment analysis is hard because the process using this amount is difficult to extract the general sentiment analysis. This huge amount of sentiment analysis can't be analyzed manually, hence the automatic method of sentiment analysis has an important role in solving this problem.

[16] proposed another weighing plan for content examination purposes, [2] used the weighing plan for content examination. Just as, [4] proposed awaiting approach combined with the term frequency and inverse document frequency (TF\*IDF) for Arabic assessment arrangement on administrations' audits in Lebanon nation. Surveys are about open administrations, including lodgings, eateries, shops, and others. They collected the materials from Google and Zomato, which have come to 3916 surveys. Trials show three center discoveries: (1) the classifier is sure when used to anticipate positive audits. (2) The model is one-sided on anticipating audits with a negative feeling. Finally, the low level of negative audits in the corpus adds to the modesty of the calculated relapse model. Other optimization techniques can be sued to solve this problem [17–25].

## 2.2 *Sentiment Analysis for Health Care*

In this work [26], the aspects of sentiment in the medical field and possible use-cases are reviewed. Through the research review, the state of the art in healthcare environments is summarized. To learn the linguistic peculiarities of thought in medical texts and to get open research issues of sentiment analysis in medicine, they make a quantitative evaluation concerning term language and sentiment combination of a dataset of clinical stories and medical group media obtained from six separate references.

Sentiment analysis in healthcare deals with the healthcare problems of patients [7]. The sentiment analysis of patients is taken to solve their problems quickly and this helps the decision-makers to make plans and useful changes. Sentiment analysis is used in different fields. Healthcare analysis-based study displays the powerful points of medicines and services [1, 5].

### ***2.3 Sentiment Lexicons for Health-Related Sentiment Analysis Mining***

Natural language processing includes an approach called sentiment analysis mining; this approach recognizes the passionate tone behind a frame of the document. This is a popular way for organizations to determine and categorize sentiment analysis about a product, service or idea [27–34].

For this task, there are some resources required like polarized lexicon. Sentiment analysis mining in healthcare is not explored well, partially because some confidence is provided to patients and their sentiment analysis, and there are many patients used social media. They are inspired in sentiment analysis mining of reviews about medications. Firstly, they define the origin of lexicon, including sentiment analysis words from the common domain and their polarity [35]. Then they perform the production of a medical sentiment analysis lexicon, based on a corpus of medication reviews.

The Arabic language experiences the absence of accessible enormous datasets for AI and sentiment analysis applications. This work introduced a huge dataset called BRAD, which is the biggest book reviews in Arabic Dataset [36]. This dataset contains 490,587 inn surveys gathered from the Booking.com site. Each record contains the survey message in the Arabic language, the commentator's evaluating on a size of 1 to 10 stars, and different qualities about the lodging/analyst. They make accessible the full unequal dataset just as a decent subset. To analyze the datasets, six prevalent classifiers are utilized using Modern Standard Arabic (MSA). They test the slant analyzers for extremity and rating groupings. Moreover, we actualize an extremity dictionary-based slant analyzer. The discoveries affirm the viability of the classifiers and the datasets. Our center commitment is to make this benchmark-dataset accessible and available to the examination network on the Arabic language.

Information explanation is important to sort content into two classes, the first thing, a decent comment rule is needed, and the second is building up what is required to fit the bill for each class. In this paper [37], they present a novel way to deal with naturally developed corpus for Algerian tongue (A Maghrebi Arabic vernacular). The development of this corpus depends on an Algerian feeling vocabulary that is likewise built naturally. They worked on two broadly utilized contents using Arabic internet-based life: Arabic and Arabizi. The accomplished F1-score is up to 72% and 78% for an Arabic and Arabizi test, respectively.

### ***2.4 Sentiment Analysis on Health Services***

Social media system appearance produces huge numbers of important data that is accessible online and accessible easily. Several users share discussions, photos, and videos, data, and viewpoints on various social media websites, within Twitter presence one of the common modern [9, 38, 39].

Consistently a lot of emotional data is created through informal organizations, for example, Facebook and Twitter. The abstract data suggests the suppositions, convictions, emotions, and frames of mind that individuals express towards various subjects of intrigue [40]. In addition, this sort of data is critical for organizations, associations or people, since it enables them to do activities that advantage them. In addition, assessment examination is the field that reviews emotional data through characteristic language handling, computational etymology, data recovery, and information mining strategies. Sentiment analysis is exceptionally helpful in different spaces, for example, legislative issues, highlighting, the travel industry, among others. In fact, the social insurance space suggests a huge region of the chance to acquire advantages utilizing sentiment analysis examination, for example, getting data about the patients' state of mind, illnesses, unfriendly medication responses, plagues, among others. Nevertheless, the social insurance space has been almost no investigated.

It is very difficult to extract useful information from Twitter, because this data is unregulated, and this a big challenging responsibility. There are many Arab users on twitter, and these users are used the Arabic language to write their posts and tweets. In the English language, there are a lot of researches about sentiment analysis, but in the Arabic language, it is very poor. They introduced an Arabic language dataset about sentiment analysis on medical services received from Twitter [41].

## ***2.5 Sentiment Analysis Techniques in Healthcare***

A large number of subjective knowledges is created through social media websites such as Facebook, Twitter. This knowledge indicates the ideas, views, emotions, and beliefs that people pass across various issues of matter. It has a revolutionary point for several organizations or people in order to provide information about what represented to the goods or services, which allows them to carry out activities that make advantages for them, such as how to make better choices, better promotion operations or business strategies, among others [42].

Individuals are uncommon to discuss about their medical issues with one another and, it is extremely poor to see about their practical wellbeing circumstance. Concentrate just on Twitter, clients' made tweets made out of the news, governmental issues, life discussion which can likewise be connected for completing an assortment of examination purposes. Hence, the human services framework is created to help the experts to effectively check their conduct sentiment analysis depend on Twitter information. Most extreme Entropy classifier (MaxEnt) is utilized to perform sentiment analysis on their tweets to propose their wellbeing condition (great, reasonable, or terrible). It is communicating with Twitter information (huge information condition) thus, the Internet of Things (IoT) based huge information preparing structure is worked to be effectively dealt with a lot of Twitter client' information [43]. The method of personal knowledge and the knowledge to recognize the feelings and passions expressed in social networks needs sentiment analysis. They defined sentiment analysis as the consideration of the feelings, sentiments, and emotions that people

come across various points of concern. This investigation utilizes natural language processing and uses text analysis, in addition to computational linguistics, and it includes duties of exposure, descent, and division of sentiments on separate devices like treatment discussions on the web, and social networks.

## ***2.6 Sentiment Analysis for Arabic Language***

Arabic sentiment analysis being very interesting domain. Generally, sentiment analysis has several papers in English, the Arabic language is still in its early levels in this area. In this paper [44], they investigated an Arabic sentiment analysis application by performing a sentiment analysis for Arabic tweets. The obtained tweets are investigated to produce their feelings polarity (positive, or negative).

A new method is proposed in [35] for subjectivity and sentiment analysis in Arabic social media language. The Arabic language is a morphologically strong language, which gives important complexities for conventional approaches to making the proposed method designed for the English language. Apart from the challenges offered by the social media genres processing, the Arabic language naturally has a high amount of shifting word forms beginning to data sparsity. Albeit informal organizations have turned into an important asset for mining sentiment analysis, there is no past research exploring the nonprofessional's feeling towards Spanish expressions of Arabic historical underpinnings identified with Islamic phrasing. [37] aimed at analyzing Spanish expressions of Arabic beginning identified with Islam. An irregular example of 4586 out of 45,860 tweets was utilized to assess the general notion towards some Spanish expressions of Arabic starting point identified with Islam. A specialist predefined Spanish vocabulary of around 6800 seed descriptors was utilized to direct the examination. Results demonstrate a for the most part positive supposition towards a few Spanish expressions of Arabic derivation identified with Islam. By executing both a subjective and quantitative strategy to investigate tweets' estimations towards Spanish expressions of Arabic derivation, this examination adds broadness and profundity to the discussion over Arabic phonetic effect on Spanish vocabulary.

In this meaning, they address the next 4 pertinent problems: how to best serve lexical information; whether standard characteristics used for English are helpful for Arabic; how to handle Arabic languages; and, whether genre-specific characteristics have a calculable impression on performance. The outcomes show that using either lemma or lexeme data is important, as well as utilizing the two-part of speech tagsets (RTS and ERTS). Nonetheless, the outcomes present that they need individualized resolutions for each genre and job, but that lemmatization and the ERTS POS tagset are already in a bulk of the frames [43]. Several studies have been used sentiment analysis in Arabic such as in [45].

The study [13] tested four unique dictionaries: an interpretation of Harvard IV-4 Dictionary (Harvard), interpretation of the MPQA subjectivity vocabulary created by Pittsburgh University (HRMA) and two distinct executions of MPQA. We assessed



every one of the four vocabularies with three datasets from various spaces, one of them is about wellbeing remarks (PatientJo), the second is from Twitter information, and the third is about books surveys (LABR). For sentence-level, they proposed six unique techniques for assumption esteems and report extremity. The outcomes demonstrate that the HRMA vocabulary performs superior to different dictionaries in LABR while Harvard performs better in the patient dataset. The outcomes demonstrate that the dictionary-based methodology for record level and sentence-level techniques produce a comparative execution. They saw that giving additional load for the first and last sentences in sentence-level methodology improves the general execution as far as exactness.

Under neural networks, good data skills are given during dealing with complex and huge datasets from a wide variety of utilization fields. Deep Convolutional Neural Networks (CNNs) give benefits in choosing useful features and Long Short-Term Memory (LSTM) networks demonstrated excellent capabilities to get constant data. Also, the current pre-processing mechanisms for the Arabic language is another weakness, alongside with insufficient research prepared in this field. The privileges of combining CNNs and LSTMs are analyzed in [46] and the detonation achieved enhanced precision for Arabic sentiment analysis on various datasets. Moreover, they attempt to analyze the morphological difference of special Arabic terms by applying various sentiment classification approaches.

The difficulties rest in the fact that most Arabic users compose unorganized idiom texts rather than writing in common conventional Arabic. In [47], these difficulties by matching among two approaches: utilizing sentiment analysis methods directly on the language; and utilizing a key that transforms from accent to the common conventional Arabic text, then producing a sentiment analysis on the outcomes common conventional Arabic text. Eventually, Saudi Twitter data is examined in this paper.

Applying Convolutional Neural Networks (CNNs) for Sentiment Analysis (SA) has got better results. CNN's are groundbreaking at separating a various leveled portrayal of the contribution by stacking numerous convolutional and pooling layers. In this paper [16], two deep CNNs are connected for Arabic supposition examination utilizing character-level highlights as it were. An enormous scale dataset is built from accessible SA datasets to prepare systems. The dataset keeps up feelings from various spaces communicated in various Arabic structures (Modern Standard, Dialectal). Other than various AI calculations as Logistic Regression, Support Vector Machine and Naïve Bayes have been connected to survey the exhibition on such a huge dataset. Up to the accessible learning, this is the primary utilization of character level deep CNNs for Arabic language supposition examination. Results demonstrate the capacity of Deep CNNs models to arrange Arabic feelings relying upon character portrayal just and register 7% improved precision contrasted with AI classifiers.

### 3 Future Work

Sentiment analysis methods would produce aggregated personal decisions on the healthcare inquiries. A suggested way can be made on top of such inquiry analysis that would suggest medications, procedures, experts in the region, important health care stations etc. based on the individual information presented by the different patients.

More complex methods can be used in such methods to control spam. The use of science, fundamental knowledge and machine learning methods must merge to decrease the influence on decisions. More such parameters are to be determined, through which the efficacy of content can be checked. Producers may also be assigned based on the legality of the content they provide where producers with technical experience may be overlooked or viewed more accurately for later contents.

### 4 Challenges of the Natural Language Processing

The Natural Language Processing has several difficulties that can change the appearance of the sentiment analysis in many aspects [48]. Some of the certain difficulties are related to the kind of data while others are obvious to any type of analyzing text. The current difficulties in Natural Language Processing can be divided as follows [35]:

The document level difficulties are associated with the inquiry text that can have reviews, which are only found in blogs. Blog reports provide annotations that normally become within a forum. These reports have feelings that are particular to the field. Based on personal therapy and diversity in natural languages, personals display themselves negatively. Sentiment analysis spamming is also a very sensitive point where somebody gives incorrect sentiment analysis prepared for serving or reducing special-purpose things (manually). There may also be displays as inspection reports that would become nothing to do with the destination actuality in the discussion [49].

Regrettably, there is somebody and organizations included in the market of sentiment analysis study spamming. Specialists in sentiment analysis are demand as diverse as half of the inspections to be spammed on any popular display roots. Utilization of special sentiment indications are also required as the authors' content. Finally, grammar errors, local slangs are other generally handled difficulties.

### 5 Discussions and Overview

There are many challenges facing sentiment analysis techniques. For instance, the complexity in the way of the people to express sentiment analysis, lexical content in the text, irony, and implication. Therefore, various techniques have been used

**Table 1** Shows the various techniques have been used in sentiment analysis

Author(s)	Technique	Approach	Accuracy
[49]	Lexicon	Corpus- based Approach	54%
[43]	SVM Naïve Bayes Maximum Entropy	Supervised	
[50]	Max Entropy	Supervised	Positive (34.34%) Negative (22.18%) Neutral (43.46%)
[16]	SVM Naïve Bayes	Supervised	94.18%
[50]	Logistic Regression	Supervised	
[12]	SVM Decision tree Nearest Neighbor (k-NN)	Supervised	Below 50%
[1]	Lexicon	Corpus- based Approach	
[13]	Lexicon	Corpus- based Approach	
[37]	Lexicon	Corpus- based Approach	78%
[40]	SVM Decision tree	Supervised	
[46]	Convolutional Neural Networks (CNNs)	Supervised	91%

(see Table 1) to solve the sentiment analysis problems. However, each technique has advantages and disadvantages. For example, the Naïve Bayes is efficient and fast computation without influenced by irrelevant features. However, it assumes independent attributes. While Maximum Entropy does not suppose statistical independence of random elements [50]. However, it needs more efforts from the human in the form of additional resource [7]. Finally, the main advantage of the lexicon is that since the accuracy of the comments achieved by humans is not guarantee. Nevertheless, this technique consumes immense time [1].

## 6 Conclusion

Sentiment analysis is a necessary way to help people in getting a recommendation and read knowledge. This technique aims to analyze the social media, wherever a problem highlighted may only contact the necessary authorities if they notice it immediately. It is impossible through the social media and various user content to get the right recommendations. Sentiment analysis is automating this process. Sentiment analysis aim to get more information to assist users to get the right decision about the studied. The sentiment analysis methods are applied to data mining and machine learning to adjust this difficulty. Supervised procedures with high precision

can be employed to further sensible proposals for finding close bound problems. Unsupervised techniques are less costly and can be used to investigate big data. The performance of the sentiment analysis process is categorized with interest rates for the potential sources. It can be supported with graphical devices to be more decisive to users. Reviews may additionally be applied to set feather the conclusions. This state is still greatly from being ready with new sub-streams known as disturbance analysis, expression analysis, preference analysis, risk analysis, etc. The demand and insufficiency of these decisions can be recognized from the evidence that it has previously been done for financial goods while it is still active as a research difficulty. Finally, the optimization way can be used to deal with this problem; it gave promising results in solving several problems.

## References

1. M.T. Khan, S. Khalid, Sentiment analysis for health care, in *Big Data: Concepts, Methodologies, Tools, and Applications*, IGI Global (2016), pp. 676–689
2. M. Shehab, A.T. Khader, M.A. Al-Betar, L.M. Abualigah, Hybridizing cuckoo search algorithm with hill climbing for numerical optimization problems, in *2017 8th International Conference on Information Technology (ICIT)*, IEEE (2017, May), pp. 36–43
3. L.M.Q. Abualigah, Feature selection and enhanced Krill Herd algorithm for text document clustering, in *Studies in Computational Intelligence* (2019)
4. H. Mulki, H. Haddad, C. Bechikh Ali, I. Babaoğlu, Tunisian dialect sentiment analysis: a natural language processing-based approach. *Computación y Sistemas* **22**(4) (2018)
5. M.M. Mostafa, N.R. Nebot, Sentiment analysis of spanish words of arabic origin related to islam: a social network analysis. *J. Lang. Teach. Res.* **8**(6), 1041–1049 (2017)
6. G. Vinodhini, R.M. Chandrasekaran, Sentiment analysis and sentiment analysis mining: a survey. *Int. J.* **2**(6), 282–292 (2012)
7. H. Iyer, M. Gandhi, S. Nair, Sentiment analysis for visuals using natural language processing. *Int. J. Comput. Appl.* **128**(6), 31–35 (2015)
8. S.N. Manke, N. Shivale, A review on: sentiment analysis mining and sentiment analysis based on natural language processing. *Int. J. Comput. Appl.* **109**(4) (2015)
9. F. Greaves, D. Ramirez-Cano, C. Millett, A. Darzi, L. Donaldson, Use of sentiment analysis for capturing patient experience from free-text comments posted online. *J. Med. Internet Res.* **15**(11), e239 (2013)
10. I.O. Hussien, K. Dashtipour, A. Hussain, Comparison of sentiment analysis approaches using modern Arabic and Sudanese Dialect, in *International Conference on Brain Inspired Cognitive Systems* (Springer, Cham, 2018, July), pp. 615–624
11. B. Pang, L. Lee, Sentiment analysis mining and sentiment analysis. *Found. Trends® Inf. Retrieval* **2**(1–2), 1–135 (2008)
12. N. Mukhtar, M.A. Khan, Urdu sentiment analysis using supervised machine learning approach. *Int. J. Pattern Recognit. Artif. Intell.* **32**(02), 1851001 (2018)
13. H. Awwad, A. Alpkocak, Performance comparison of different lexicons for sentiment analysis in Arabic, in *2016 Third European Network Intelligence Conference (ENIC)*, IEEE (2016, September), pp. 127–133
14. B. Liu, Sentiment analysis and sentiment analysis mining. *Synth. Lect. Human Lang. Technol.* **5**(1), 1–167 (2012)
15. A. Pak, P. Paroubek, Twitter as a corpus for sentiment analysis and sentiment analysis mining. *LREc* **10**, 1320–1326 (2010)

16. M. Shehab, A.T. Khader, M.A. Alia, Enhancing Cuckoo search algorithm by using reinforcement learning for constrained engineering optimization problems, in *2019 IEEE Jordan International Conference on Electrical Engineering and Information Technology (JEEIT)*, IEEE (2019, April), pp. 812–816
17. L.M. Abualigah, A.T. Khader, E.S. Hanandeh, A new feature selection method to improve the document clustering using particle swarm optimization algorithm. *J. Comput. Sci.* (2017)
18. L.M. Abualigah, A.T. Khader, E.S. Hanandeh, A combination of objective functions and hybrid Krill Herd algorithm for text document clustering analysis, in *Engineering Applications of Artificial Intelligence* (2018)
19. L.M. Abualigah, A.T. Khader, E.S. Hanandeh, A novel weighting scheme applied to improve the text document clustering techniques, in *Innovative Computing, Optimization and Its Applications* (Springer, Cham, 2018), pp. 305–320
20. L.M. Abualigah, A.T. Khader, E.S. Hanandeh, Hybrid clustering analysis using improved krill herd algorithm. *Appl. Intell.* (2018)
21. L.M. Abualigah, A.T. Khader, M.A. Al-Betar, O.A. Alomari, Text feature selection with a robust weight scheme and dynamic dimension reduction to text document clustering. *Expert Syst. Appl.* **84**, 24–36 (2017)
22. L.M. Abualigah, A.T. Khader, M.A. Al-Betar, E.S. Hanandeh, Unsupervised text feature selection technique based on particle swarm optimization algorithm for improving the text clustering, in *Eai International Conference on Computer Science and Engineering* (2017)
23. L.M. Abualigah, A.T. Khader, E.S. Hanandeh, A.H. Gandomi, A novel hybridization strategy for krill herd algorithm applied to clustering techniques. *Appl. Soft Comput.* **60**, 423–435 (2017)
24. K. Denecke, Y. Deng, Sentiment analysis in medical settings: new opportunities and challenges. *Artif. Intell. Med.* **64**(1), 17–27 (2015)
25. Z.A. Al-Sai, L.M. Abualigah, Big data and E-government: a review, in *2017 8th International Conference on Information Technology (ICIT)*, IEEE (2017, May), pp. 580–587
26. M.Z. Asghar, A. Khan, F.M. Kundi, M. Qasim, F. Khan, R. Ullah, I.U. Nawaz, Medical sentiment analysis lexicon: an incremental model for mining health reviews. *Int. J. Acad. Res.* **6**(1), 295–302 (2014)
27. M.Z. Asghar, M. Qasim, B. Ahmad, S. Ahmad, A. Khan, I.A. Khan, Health miner: sentiment analysis extraction from user generated health reviews. *Int. J. Acad. Res.* **5**(6), 279–284 (2013)
28. S. Baccianella, A. Esuli, F. Sebastiani, Sentiwordnet 3.0: an enhanced lexical resource for sentiment analysis and sentiment analysis mining. *Lrec* **10**, 2200–2204 (2010)
29. E. Cambria, B. Schuller, Y. Xia, C. Havasi, New avenues in sentiment analysis mining and sentiment analysis. *IEEE Intell. Syst.* **28**(2), 15–21 (2013)
30. A. Carvalho, A. Levitt, S. Levitt, E. Khaddam, J. Benamati, Off-the-shelf artificial intelligence technologies for sentiment and emotion analysis: a tutorial on using IBM natural language processing. *Commun. Assoc. Inf. Syst.* **44**(1), 43 (2019)
31. M. Chaudhari, S. Govilkar, A survey of machine learning techniques for sentiment classification. *Int. J. Comput. Sci. Appl.* **5**(3), 13–23 (2015)
32. N. Godbole, M. Srinivasaiah, S. Skiena, Large-scale sentiment analysis for news and blogs. *Icwsm* **7**(21), 219–222 (2007)
33. M.D. Hauser, N. Chomsky, W.T. Fitch, The faculty of language: what is it, who has it, and how did it evolve. *Science* **298**(5598), 1569–1579 (2002)
34. A. Elnagar, Y.S. Khalifa, A. Einea, Hotel Arabic-reviews dataset construction for sentiment analysis applications, in *Intelligent Natural Language Processing: Trends and Applications* (Springer, Cham, 2018), pp. 35–52
35. I. Guellil, A. Adeel, F. Azouaou, A. Hussain, Sentialg: automated corpus annotation for algerian sentiment analysis, in *International Conference on Brain Inspired Cognitive Systems* (Springer, Cham, 2018, July), pp. 557–567
36. A.M. Alayba, V. Palade, M. England, R. Iqbal Improving sentiment analysis in Arabic using word representation, in *2018 IEEE 2nd International Workshop on Arabic and Derived Script Analysis and Recognition (ASAR)*, IEEE (2018, March), pp. 13–18

37. P. Gonçalves, M. Araújo, F. Benevenuto, M. Cha, Comparing and combining sentiment analysis methods, in *Proceedings of the First ACM Conference on Online Social Networks* (ACM, 2013, October), pp. 27–38
38. F.J. Ramírez-Tinoco, G. Alor-Hernández, J.L. Sánchez-Cervantes, M. del Pilar Salas-Zárate, R. Valencia-García, Use of sentiment analysis techniques in healthcare domain, in *Current Trends in Semantic Web Technologies: Theory and Practice* (Springer, Cham, 2019), pp. 189–212
39. E. Refaee, V. Rieser An arabic twitter corpus for subjectivity and sentiment analysis, in *LREC* (2014, May), pp. 2268–2273
40. M. Al-Ayyoub, A.A. Khamaiseh, Y. Jararweh, M.N. Al-Kabi, A comprehensive survey of arabic sentiment analysis. *Inf. Process. Manage.* **56**(2), 320–342 (2019)
41. H. Htet, S.S. Khaing, Y.Y. Myint, Tweets sentiment analysis for healthcare on big data processing and IoT architecture using maximum entropy classifier, in *International Conference on Big Data Analysis and Deep Learning Applications* (Springer, Singapore, 2018, May), pp. 28–38
42. A. Shoukry, A. Rafea, Sentence-level Arabic sentiment analysis, in *2012 International Conference on Collaboration Technologies and Systems (CTS)*, IEEE (2012, May), pp. 546–550
43. M. Korayem, D. Crandall, M. Abdul-Mageed, Subjectivity and sentiment analysis of arabic: a survey, in *International Conference on Advanced Machine Learning Technologies and Applications* (Springer, Heidelberg, 2012, December), pp. 128–139
44. A.M. Alayba, V. Palade, M. England, R. Iqbal, A combined CNN and LSTM model for arabic sentiment analysis, in *International Cross-Domain Conference for Machine Learning and Knowledge Extraction* (Springer, Cham, 2018, August), pp. 179–191
45. S. Rizkallah, A. Atiya, H.E. Mahgoub, M. Heragy, Dialect versus MSA sentiment analysis, in *International Conference on Advanced Machine Learning Technologies and Applications* (Springer, Cham, 2018, February), pp. 605–613
46. A. Rajput, *Natural Language Processing, Sentiment Analysis and Clinical Analytics*. arXiv preprint [arXiv:1902.00679](https://arxiv.org/abs/1902.00679) (2019)
47. A.N. Langville, C.D. Meyer, *Google's PageRank and Beyond: The Science of Search Engine Rankings*. Princeton University Press (2011)
48. L. Igual, S. Seguí, Statistical natural language processing for sentiment analysis, in *Introduction to Data Science* (Springer, Cham, 2017), pp. 181–197
49. L. Goeuriot, J.C. Na, W.Y. Min Kyaing, C. Khoo, Y.K. Chang, Y.L. Theng, J.J. Kim, Sentiment lexicons for health-related sentiment analysis mining, in *Proceedings of the 2nd ACM SIGHIT International Health Informatics Symposium* (ACM, 2012, January), pp. 219–226
50. M. Al Omari, M. Al-Hajj, N. Hammami, A. Sabra, Sentiment classifier: logistic regression for Arabic services' reviews in Lebanon, in *2019 International Conference on Computer and Information Sciences (ICCIS)*, IEEE (2019, April), pp. 1–5