Turkish Journal of Physiotherapy and Rehabilitation; 32(2)
ISSN 2651-4451 | e-ISSN 2651-446X

PRODUCT REVIEWS SENTIMENT ANALYSIS USING MACHINE LEARNING: A SYSTEMATIC LITERATURE REVIEW

HARISH PARUCHURI[1], SIDDHARTHA VADLAMUDI[2], ALIM AL AYUB AHMED[3], WESAM EID[4], PRAVEEN KUMAR DONEPUDI[5]

[1]*Department of Information Technology, Anthem, Inc., USA*
[2]*Xandr, AT&T Services Inc., New York, USA*
[3]*School of Accounting, Jiujiang University, Jiujiang, Jiangxi, CHINA*
[4]*Department of Computer Engineering, Umm Al-Qura University, Makkah, SAUDI ARABIA*
[5]*Department of Information Technology, UST-Global, Inc., Ohio, USA*

ABSTRACT

A huge amount of data is available on the internet and social media platforms. It is necessary to use this in data in an efficient way. The growth of the companies depends on the satisfaction of their customers. This makes the sentiment analysis an important and challenging activity. In this literature review, we identified various machine learning algorithms that can be used for this purpose.

Keywords: Machine learning, Sentiment analysis, Sentence level, Document level, Aspect level

I. INTRODUCTION

In modern times, the use of internet is increasing rapidly. The number of users is increasing on the internet (Vadlamudi, 2020). The companies or organizations are also trying to have their digital presence. The customer now wants to buy the products without going to the outside. The customer wants the facility of buying products by sitting at their homes. Most of the companies are helping their customers in this regard. The companies are now selling their products through the internet. The study (Avlonitis & Karayanni, 2000) shows that the use of internet can increase the sales of the companies. The customers visit the websites of these companies to buy the products. The customers then provide the feedback or review regarding that product. The internet is now the biggest source for getting the opinions of the users (Liu et al., 2005). People share their opinions related to different things on the internet and it makes the internet a huge source of getting the user's opinions (Pak & Paroubek, 2010). This review or opinion can be the positive or negative. The information that is provided on the internet by the user on the internet in the form of review is very important for making the decisions (Manek et al., 2017). Sentiment analysis is a process of understanding the user's reviews against certain entities (Kim & Hovy, 2004; Liu, 2010; Whitelaw et al., 2005). Through the sentiment analysis it can be identified whether the user is satisfied with the product or not. There are the different machine learning algorithms that are successfully using for the sentiment analysis. The positive review contains the good association while a negative review contains the bad associations (Ujwala et al., 2012). The companies can improve their products if the reviews are negative. Sentiment analysis helps the company to grow. Companies are using the machine learning for different purposes and one of these purposes is the sentiment analysis.

The problem is that the big companies launch their products continuously. The companies want to earn more and more. More earning is possible if the customers are satisfied. A satisfied customer buys more products that is a major benefit for the company. But if the product is not made according to the customer's expectations then the customer will not be satisfied with that product. But how the company will know which product has satisfied the customer and which product needs the improvement. A lot of customers provide valuable reviews for different products. The company does not have time to read these reviews manually. The most difficult part in the information gathering is to know what the people think (Shaukat et al., 2020; Ahmed, 2020). There is a need for a mechanism that can be used to know the number of reviews that are positive and how much are the negative, etc. It is necessary to make the developments for understanding or mining of the user's opinions (Liu, 2008). This will help the company in getting the idea about the popularity of its products.

Sentiment analysis is one of the major research challenges (Mäntylä et al., 2018). Every day new and new businesses are coming on the internet and it makes the sentiment analysis an important research topic. Researchers are continuously working to overcome this challenge. For this purpose, the researchers have used the different machine learning algorithms that are helpful in detecting the user thoughts. Researchers (Zhou et al., 2013; Verma et al., 2021) proposed active deep network for the classification of the sentiments. Through the algorithm it can be known whether the user has positive thoughts for that product or he has the negative thoughts for that product. The sentiment analysis can also be performed on the documents instead of the sentences. Researchers (Chesley et al., 2006) performed the sentiment analysis on the blog posts to classify the posts as the positive or negative.

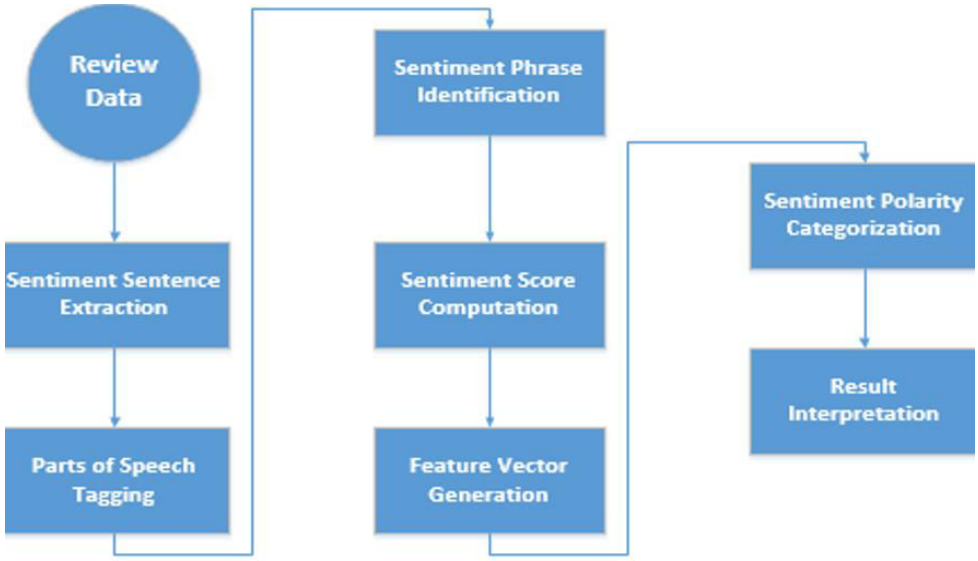

Figure 1: Sentiment Polarity Categorization

This literature review is based on a number of papers collected from different important databases. The literature review gives complete detailed information about the importance of sentiment analysis. In this literature review, it is also discussed that how the algorithms of machine learning are helpful while doing the sentiment analysis. Different algorithms that can be used for this purpose are also identified.

The further parts of this literature review are as follows: we described the methodology in the section 2, section 3 is created for the research questions, in section 4 we described the search process, section 5 provides a complete discussion related to the research questions, section 6 is the last section that shows the conclusion of this papers.

II. METHODOLOGY

We followed the systematic literature review methodology that is used for writing the literature reviews. By using this methodology we answered some research questions that help in understanding the literature related to the sentiment analysis.

1. Inclusion and Exclusion

While finding the relevant material for this topic, we found a number of papers from different databases. Not all of those papers are included in this literature review. The papers that were most relevant were included. The papers that were not written in English were excluded. Also the papers that were not completely available, were excluded.

2. Quality Assessment

For assessing the quality of the papers before including them, their contents were checked. The papers having good content were considered good quality papers.

3. Research Question

Here are the research questions that will be answered in this literature review.

RQ 1: "What is the need for Sentiment analysis and how it helps the companies in getting more benefits"?

RQ 2: "How the use of machine learning algorithms make sentiment analysis easy and what are those algorithms"?

4. Search Process

We have visited various famous databases for the purpose of the paper collection. The papers included in this literature review are included after a number of phases. These phases can be called the exclusion phases. The papers first excluded on the basis of their titles. The second phase was excluding the papers on the basis of their abstracts. In the last phase, the remaining papers were excluded on the basis of their complete contents.

III. RESULT AND DISCUSSION

The internet now contains a large amount of data and this is continuously increasing (Donepudi et al., 2020a). It is very important for an organization or company to know what their customer thinks about their products. The growth or progress of a company depends on the satisfaction of its customers (Vadlamudi, 2018; Rahman et al., 2020). A satisfied customer results in the more sales. With the passage of time, the competition between the different companies is continuously growing. Every company wants to increase its sales. The best way to increase the sales is the creation of the products that satisfies the customers. The customer prefers the products of that company that has good quality and meets the customer's expectations. These expectations can be the low price, good quality, good features etc. The companies nowadays launch different products for the customers. These can be the updated version of the previous products. The companies add the new functionality or features to the existing product and make it available for the customers (Donepudi et al., 2020b). It is necessary for the organization to know how much their product is popular among the customers (Vadlamudi, 2019). On the basis of this popularity the company can launch the new products. This popularity can be the positive or negative. The customer provides comments or reviews against different products that are then analyzed to know the popularity of that product. This is called the sentiment analysis. Sentiment analysis is considered as one of the major issues in the machine learning (Zhang et al., 2013). This becomes difficult when the data set is very large i.e. consists on the reviews by a large number of customers. The companies do not have the time to read the reviews of their customers. It will take a lot of time if a person starts reading all the reviews to know the popularity of a product. The interest towards automatic identification of sentiments or opinions is increasing (Jain & Nemade, 2010). The major issue that comes during the sentiment analysis is the fake or spam reviews (Jindal & Liu, 2008; Mukherjee et al., 2012). The data set can be taken from different online platforms. Researchers (Go et al., 2009) has taken the data set from the twitter and then analyzed whether the comments against a product are positive or negative. According to the researchers, this will helpful for both the customers can the company. The company can improve their products or can launch the new products with good and required functionality. On the other hand, the customers can buy the products on the basis of the comments or reviews by the previous customers. The review or feedback that is provided by the customer can be in the form of phrases. Researchers (Wilson et al., 2005) provided a novel approach for the sentimental analysis of the phrases. The sentiment analysis can also be made on the complete documents. The result will be positive or negative on the basis of the text given in the complete document. Researchers (Lin et al., 2012), presented an approach to classify the documents as positive or negative. Researchers (Sarvabhotla et al., 2011) also performed the sentiment analysis on the documents. Researchers (Yu & Hatzivassiloglou, 2003) performed the sentiment analysis on sentences at well as the documents.

RQ 1: What is the need for Sentiment analysis and what are the different level of sentiment analysis?

Every company wants to increase its sales. For this purpose, the companies keep trying different ways of satisfying the customers. Each company believes that satisfying the customers will increase their sales (Ahmed et al., 2020). But how the company will know whether the customers are satisfied with the products or not? The answer to this question is the sentiment analysis. Sentiment analysis helps the company to know what the customer thinks about its products. The reviews are mostly in the form of sentences that's why mostly researchers worked to detect the positivity or negativity of a sentence. Researchers (Tan et al., 2011) presented their work that can help in detecting the positive and negative sentences. There are the different levels of sentiment classification. The below diagram shows these different levels.

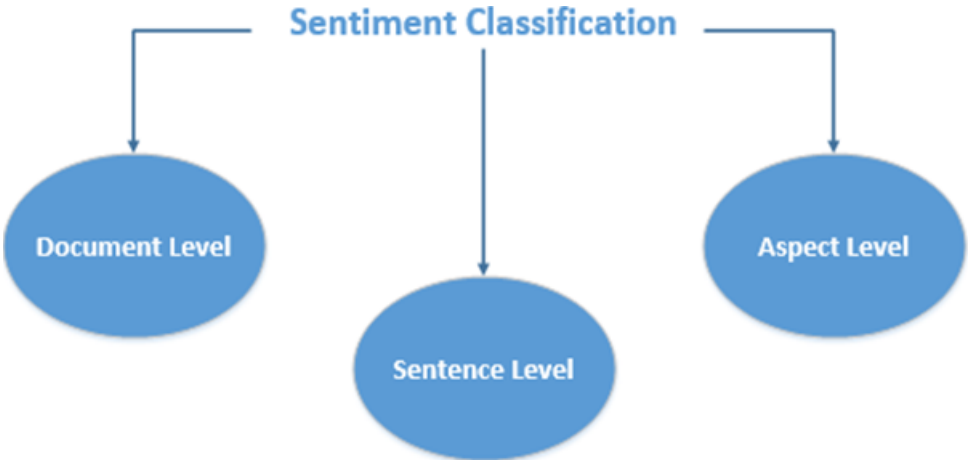

Figure 2: Levels of Sentiment Classification

Researchers worked for the classification of sentiments at these three levels. Below discussion shows the work of different researchers according to these levels.

Document Level

This kind of sentiment analysis determines the opinion of the complete document (Dou, 2017). The classification is performed as the positive or negative (Moreno-Ortiz et al., 2015). Document level sentiment analysis is useful when the document is all about a single entity. This entity can be the person or a product, etc. The document should contain the opinions about that single entity. Researchers (Moraes et al., 2013) compared the efficiency of SVM and ANN for the document level sentiment analysis. According to the researchers, the document level analysis classifies the textual review as positive or negative and this review must be about a single topic. In the document level analysis, the complete document is given as an input to the model and it predicts the overall opinion as the thumbs up or thumbs down (Tang, 2015).

Sentence Level

Researchers have also performed the sentiment analysis at the sentence level. Researchers (Appel et al., 2016) proposed a hybrid approach for the sentiment analysis at the sentence level. They used the natural processing techniques for this purpose. The researchers (Meena & Prabhakar, 2007) proposed an approach to detect the sentiments that are associated with the sentences. Researchers (Jagtap et al., 2013) analyzed the various techniques that are used for the sentence level sentiment analysis. The sentence can be classified as the positive, negative or neutral. This can help the companies in improving their products and increasing the sales. According to the researchers (Arulmurugan et al., 2019), their proposed method is best in predicting the sentiments from the sentences. Their method can detect the emotions of the users from the text.

Aspect Level

The purpose of this level is to perform the sentiment analysis from the various aspects. The major purpose is to detect what the user wants and what the user does not want. Researchers (Vanaja & Belwal, 2018) performed the aspect level sentiment analysis on the ecommerce data. According to the researchers, this will help the companies in increasing the number of sales. Researchers (Sun et al., 2019) performed the aspect level sentiment analysis through a neural network based method.

RQ 2: How the use of machine learning algorithms make sentiment analysis easy and what are those algorithms?

Sentiment analysis is a difficult and challenging task that cannot be performed through a human mind. A person takes a lot of time in doing the sentiment analysis. Companies do not have a lot of time for the sentiment analysis purpose. They need a quick solution so that they can launch the profitable products. It is necessary to use the machine learning algorithms for detecting the positive, negative and neutral reviews. Below table is showing these different algorithms.

Table 1: Algorithms for Sentiment Analysis

Naïve Bayes	SVM
Decision Tree	KNN
Neural Network	Random Forest

Naïve Bayes

One of the algorithms that are used by the researchers for the sentiment analysis is the Naïve Bayes. Researchers (Mubarok et al., 2017) presented an approach that is based on Naïve Bayes. This can be used by the companies for knowing customers opinions regarding their products. The experimental results have given accuracy of 78.12%. Researchers (Goel et al., 2016) used the Naïve Bayes for the classification of the data set as positive, negative and neutral. The data set is taken from the Twitter. They classified the tweets as the positive, negative and neutral tweets against a product.

SVM

The customers prefer to buy the products through the internet by sitting at their homes. After buying the product the customers leave their reviews on that particular ecommerce site. These reviews cannot be detected as positive or negative by a human. Researchers (Krishna et al., 2017) proposed an SVM based approach for detecting the positive or negative reviews of the customers. Researchers (Ahmad et al., 2018) presented an approach based on SVM that can help the companies to know what the people think about their products.

Decision Tree

Researchers (Lakshmi Narayana et al, 2012) used this classifier for classifying the sentiments as positive or negative. The data set was taken from an online store that contained various reviews by the customers. This will help the companies in increasing their profits.

KNN

Researchers (Huq et al., 2017) used this algorithm for mining the opinions of the users that are shared on the twitter. In this modern time, the users share their opinions on the twitter about the different products. Researchers (Daeli et al., 2020) improved the performance of KNN for the sentiment analysis. The accuracy they achieved is 96.8%.

Neural Network

Customers share their reviews about the products on different online platforms and these reviews can be used for detecting the product popularity as positive or negative. Researchers (Smetanin & Komarov, 2019) trained the neural network for this purpose.

Random Forest

Researchers (Hegde & Padma, 2017) used this algorithm as a more efficient approach for the sentiment analysis. This algorithm gave them an accuracy of 72%. Researchers (Khanvilkar et al., 2018) also used this algorithm for sentiment analysis. Their work can help for recommending a product to the users on the basis of previous customer reviews.

The below figure shows the sentiment analysis model.

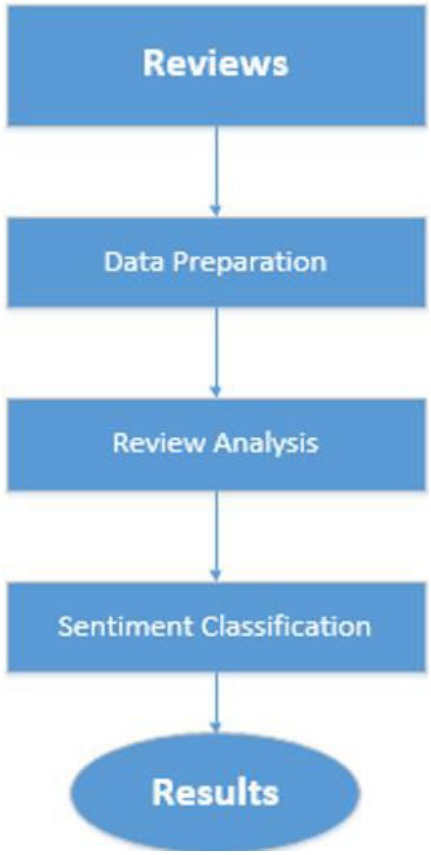

Figure 3: Sentiment Analysis Model

IV. CONCLUSION

The brief discussion has clearly shown the importance of sentiment analysis for the growth of any company. Machine learning has made many things possible and easy. The various machine learning algorithms that can be used for the sentiment analysis purpose are discussed in this literature review. It is necessary to perform the sentiment analysis before launching the new model or version of a product. The sentiment analysis will help the company to know what the people expect in this new model of that product. The company can increase the production of those products which are positively popular among the customers. The products with negative reviews can be improved.

REFERENCES

1. Ahmad, M., Aftab, S., Bashir, M. S., Hameed, N., Ali, I., & Nawaz, Z. J. I. J. A. C. S. A. (2018). SVM optimization for sentiment analysis. 9(4), 393-398.
2. Ahmed, A. A. A. (2020). Corporate attributes and disclosure of accounting information: Evidence from the big five banks of China. J Public Affairs. e2244. https://doi.org/10.1002/pa.2244
3. Ahmed, A. A. A., Donepudi, P. K., & Asadullah, A. B. M. (2020). Artificial Intelligence in Clinical Genomics and Healthcare. European Journal of Molecular & Clinical Medicine, 7(11), 1194-1202, https://ejmcm.com/?_action=article&au=24014
4. Appel, O., Chiclana, F., Carter, J., & Fujita, H. J. K.-B. S. (2016). A hybrid approach to the sentiment analysis problem at the sentence level. 108, 110-124.
5. Arulmurugan, R., Sabarmathi, K., & Anandakumar, H. J. C. C. (2019). Classification of sentence level sentiment analysis using cloud machine learning techniques. 22(1), 1199-1209.
6. Avlonitis, G. J., & Karayanni, D. A. J. I. M. M. (2000). The impact of internet use on business-to-business marketing: examples from American and European companies. 29(5), 441-459.
7. Chesley, P., Vincent, B., Xu, L., & Srihari, R. K. J. T. (2006). Using verbs and adjectives to automatically classify blog sentiment. 580(263), 233.
8. Daeli, N. O. F., Adiwijaya, A. J. J. o. D. S., & Applications, I. (2020). Sentiment analysis on movie reviews using Information gain and K-nearest neighbor. 3(1), 1-7.
9. Donepudi, P. K., Ahmed, A. A. A., Hossain, M. A., & Maria, P. (2020a). Perceptions of RAIA Introduction by Employees on Employability and Work Satisfaction in the Modern Agriculture Sector. International Journal of Modern Agriculture, 9(4), 486–497. https://doi.org/10.5281/zenodo.4428205
10. Donepudi, P. K., Ahmed, A. A. A., Saha, S. (2020b). Emerging Market Economy (EME) and Artificial Intelligence (AI): Consequences for the Future of Jobs. Palarch's Journal of Archaeology of Egypt/Egyptology, 17(6), 5562-5574. https://archives.palarch.nl/index.php/jae/article/view/1829
11. Dou, Z.-Y. (2017). Capturing user and product information for document level sentiment analysis with deep memory network. Paper presented at the Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing.
12. Go, A., Bhayani, R., & Huang, L. J. C. N. p. r., Stanford. (2009). Twitter sentiment classification using distant supervision. 1(12).
13. Goel, A., Gautam, J., & Kumar, S. (2016). Real time sentiment analysis of tweets using Naive Bayes. Paper presented at the 2016 2nd International Conference on Next Generation Computing Technologies (NGCT).

14. Hegde, Y., & Padma, S. (2017). Sentiment analysis using random forest ensemble for mobile product reviews in Kannada. Paper presented at the 2017 IEEE 7th International Advance Computing Conference (IACC).
15. Huq, M. R., Ali, A., & Rahman, A. J. I. J. A. C. S. A. (2017). Sentiment analysis on Twitter data using KNN and SVM. 8(6), 19-25.
16. Jagtap, V., Pawar, K. J. I. J. o. S. E., & Technology. (2013). Analysis of different approaches to sentence-level sentiment classification. 2(3), 164-170.
17. Jain, T. I., & Nemade, D. J. I. J. o. C. A. (2010). Recognizing contextual polarity in phrase-level sentiment analysis. 7(5), 12-21.
18. Jindal, N., & Liu, B. (2008). Opinion spam and analysis. In, ACM International. Paper presented at the Conference on Web Search and Data Mining.
19. Khanvilkar, G., Vora, D. J. I. J. o. E., & Technology. (2018). Sentiment analysis for product recommendation using random forest. 7(3), 87-89.
20. Kim, S.-M., & Hovy, E. (2004). Determining the sentiment of opinions. Paper presented at the COLING 2004: Proceedings of the 20th International Conference on Computational Linguistics.
21. Krishna, M. H., Rahamathulla, K., & Akbar, A. (2017). A feature based approach for sentiment analysis using SVM and coreference resolution. Paper presented at the 2017 International Conference on Inventive Communication and Computational Technologies (ICICCT).
22. Lakshmi Narayana S., Suneetha Devi J., Bhargav Reddy I., Harish Paruchuri. (2012). Optimizing Voice Recognition using Various Techniques. CiiT International Journal of Digital Signal Processing, 4(4), 135-141
23. Lin, Y., Zhang, J., Wang, X., & Zhou, A. (2012). An information theoretic approach to sentiment polarity classification. Paper presented at the Proceedings of the 2nd joint WICOW/AIRWeb workshop on web quality.
24. Liu, B. (2008). Exploring user opinions in recommender systems. Paper presented at the Proceedings of the 2nd KDD Workshop on Large-Scale Recommender Systems and the Netflix Prize Competition.
25. Liu, B. J. H. o. n. l. p. (2010). Sentiment analysis and subjectivity. 2(2010), 627-666.
26. Liu, B., Hu, M., & Cheng, J. (2005). Opinion observer: analyzing and comparing opinions on the web. Paper presented at the Proceedings of the 14th international conference on World Wide Web.
27. Manek, A. S., Shenoy, P. D., Mohan, M. C., & Venugopal, K. J. W. w. w. (2017). Aspect term extraction for sentiment analysis in large movie reviews using Gini Index feature selection method and SVM classifier. 20(2), 135-154.
28. Mäntylä, M. V., Graziotin, D., & Kuutila, M. J. C. S. R. (2018). The evolution of sentiment analysis—A review of research topics, venues, and top cited papers. 27, 16-32.
29. Meena, A., & Prabhakar, T. (2007). Sentence level sentiment analysis in the presence of conjuncts using linguistic analysis. Paper presented at the European conference on information retrieval.
30. Moraes, R., Valiati, J. F., & Neto, W. P. G. J. E. S. w. A. (2013). Document-level sentiment classification: An empirical comparison between SVM and ANN. 40(2), 621-633.
31. Moreno-Ortiz, A., Fernández-Cruz, J. J. P.-S., & Sciences, B. (2015). Identifying polarity in financial texts for sentiment analysis: a corpus-based approach. 198, 330-338.
32. Mubarok, M. S., Adiwijaya, & Aldhi, M. D. (2017). Aspect-based sentiment analysis to review products using Naïve Bayes. Paper presented at the AIP Conference Proceedings.
33. Mukherjee, A., Liu, B., & Glance, N. (2012). Spotting fake reviewer groups in consumer reviews. Paper presented at the Proceedings of the 21st international conference on World Wide Web.
34. Pak, A., & Paroubek, P. (2010). Twitter as a corpus for sentiment analysis and opinion mining. Paper presented at the LREc.
35. Rahman, M. M., Chowdhury, M. R. H. K., Islam, M. A., Tohfa, M. U., Kader, M. A. L., Ahmed, A. A. A., & Donepudi, P. K. (2020). Relationship between Socio-Demographic Characteristics and Job Satisfaction: Evidence from Private Bank Employees. American Journal of Trade and Policy, 7(2), 65-72. https://doi.org/10.18034/ajtp.v7i2.492
36. Sarvabhotla, K., Pingali, P., & Varma, V. J. I. R. (2011). Sentiment classification: a lexical similarity based approach for extracting subjectivity in documents. 14(3), 337-353.
37. Shaukat, Z., Zulfiqar, A. A., Xiao, C., Azeem, M., & Mahmood, T. J. S. A. S. (2020). Sentiment analysis on IMDB using lexicon and neural networks. 2(2), 1-10.
38. Smetanin, S., & Komarov, M. (2019). Sentiment analysis of product reviews in Russian using convolutional neural networks. Paper presented at the 2019 IEEE 21st Conference on Business Informatics (CBI).
39. Sun, K., Zhang, R., Mensah, S., Mao, Y., & Liu, X. (2019). Aspect-level sentiment analysis via convolution over dependency tree. Paper presented at the Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP).
40. Tan, L. K.-W., Na, J.-C., Theng, Y.-L., & Chang, K. (2011). Sentence-level sentiment polarity classification using a linguistic approach. Paper presented at the International Conference on Asian Digital Libraries.
41. Tang, D. (2015). Sentiment-specific representation learning for document-level sentiment analysis. Paper presented at the Proceedings of the eighth ACM international conference on web search and data mining.
42. Ujwala, D., Ram Kiran, D. S., Jyothi, B., Fathima, S. S., Paruchuri, H., Koushik, Y. M. S. R. (2012). A Parametric Study on Impedance Matching of A CPW Fed T-shaped UWB Antenna. International Journal of Soft Computing and Engineering, 2(2), 433-436.
43. Vadlamudi, S. (2018). Agri-Food System and Artificial Intelligence: Reconsidering Imperishability. Asian Journal of Applied Science and Engineering, 7(1), 33-42. Retrieved from https://journals.abc.us.org/index.php/ajase/article/view/1192
44. Vadlamudi, S. (2019). How Artificial Intelligence Improves Agricultural Productivity and Sustainability: A Global Thematic Analysis. Asia Pacific Journal of Energy and Environment, 6(2), 91-100. https://doi.org/10.18034/apjee.v6i2.542
45. Vadlamudi, S. (2020). Internet of Things (IoT) in Agriculture: The Idea of Making the Fields Talk. Engineering International, 8(2), 87-100. https://doi.org/10.18034/ei.v8i2.522
46. Vanaja, S., & Belwal, M. (2018). Aspect-level sentiment analysis on e-commerce data. Paper presented at the 2018 International Conference on Inventive Research in Computing Applications (ICIRCA).
47. Verma, B. K.; Lokulwar, P.; Aquatar, M. O.; Panda, R. B.; Raghuwanshi, G. K.; Dixit, P.; Nigam, U.; Khan, I. R.; Kumar, P.; Ahmed, A. A. A. (2021). A SMART CITY SYSTEM FOR CITIZEN'S UTILIZING UBIQUITOUS COMPUTING TECHNIQUE. Australian Official Journal of Patents, 35(12), Page No. 1873, Patent number: 2021101194. https://pericles.ipaustralia.gov.au/ols/auspat/quickSearch.do?queryString=2021101194
48. Whitelaw, C., Garg, N., & Argamon, S. (2005). Using appraisal groups for sentiment analysis. Paper presented at the Proceedings of the 14th ACM international conference on Information and knowledge management.
49. Wilson, T., Wiebe, J., & Hoffmann, P. (2005). Recognizing contextual polarity in phrase-level sentiment analysis. Paper presented at the Proceedings of human language technology conference and conference on empirical methods in natural language processing.
50. Yu, H., & Hatzivassiloglou, V. (2003). Towards answering opinion questions: Separating facts from opinions and identifying the polarity of opinion sentences. Paper presented at the Proceedings of the 2003 conference on Empirical methods in natural language processing.
51. Zhang, Y., Xiang, X., Yin, C., & Shang, L. (2013). Parallel sentiment polarity classification method with substring feature reduction. Paper presented at the Pacific-Asia Conference on Knowledge Discovery and Data Mining.
52. Zhou, S., Chen, Q., & Wang, X. J. N. (2013). Active deep learning method for semi-supervised sentiment classification. 120, 536-546.