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Hoax classification and sentiment analysis of Indonesian news using Naive Bayes optimization

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ABSTRACT

Currently, the spread of hoax news has increased significantly, especially on social media networks. Hoax news is very dangerous and can provoke readers. So, this requires special handling. This research proposed a hoax news detection system using searching, snippet and cosine similarity methods to classify hoax news. This method is proposed because the searching method does not require training data, so it is practical to use and always up to date. In addition, one of the drawbacks of the existing approaches is they are not equipped with a sentiment analysis feature. In our system, sentiment analysis is carried out after hoax news is detected. The goal is to extract the true hidden sentiment inside hoax whether positive sentiment or negative sentiment. In the process of sentiment analysis, the Naïve Bayes (NB) method was used which was optimized using the Particle Swarm Optimization (PSO) method. Based on the results of experiment on 30 hoax news samples that are widely spread on social media networks, the average of hoax news detection reaches 77% of accuracy, where each news is correctly identified as a hoax in the range between 66% and 91% of accuracy. In addition, the proposed sentiment analysis method proved to has a better performance than the previous analysis sentiment method.

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1. INTRODUCTION

Currently, the impact of social media in our daily life tends to increase. Moreover, social media can have good or bad impacts together. Social media such as Twitter or Facebook produce news or information which can be easily spread around the globe. In terms of hoax, the information will be good if it is genuine and has gone through good reasoning. But the fact people spread false information to gain particular benefits is increasing every year and precisely It has increased sharply in the past two years [1, 2]. Active social media accounts also increase every year, including the ones producing hoax information. This cause people connected to social media have difficulties to determine whether they read genuine or false information. The situation worsens as hoax spread over social media networks read by more and more people, especially in Indonesia the country with the third-largest social media penetration in the world in 2018 [3].

Hoax is false information that is considered correct and can mislead human perception [4, 5]. Spreading hoax information usually has multiple purposes, with the aim of persuading or manipulating public opinion. The spread of hoaxes is usually accompanied by fraud and even threats. In 2016, there were around 800,000 hoax sites that produce false information which widely distributed over social media, such as Twitter, Facebook and others [6], even hoax news is increasingly prevalent with evil political goals [3]. The spread of hoaxes has a very broad impact and even it has many potentials of causing dangerous horizontal conflicts for the stability of the whole country. Thus, a hoax detection system is needed to automatically help citizen and government filtering information.

Research on the hoax detection system has been carried out in recent years such as the ones in [2, 4, 5, 7-11]. These studies propose classification or learning techniques, where this technique always requires up-to-date training data to maintain the accuracy of the detection. On the other hand, the searching technique to detect hoax news can be done using a snippet as presented in the following studies [12-14]. Searching techniques have the advantage of being more up to date and more practical in use. Therefore, this paper proposes hoax news detection techniques employing searching techniques that are combined with classifier methods to improve accuracy. A further drawback of the existing hoax detection system is they are not equipped with sentiment analysis features. To address the problem, Sentiment analysis feature is proposed. In our system, sentiment analysis is carried out after hoax news is detected. Sentiment analysis can extract the true hidden sentiment inside hoax whether positive sentiment or negative sentiment. This feature helps us to further extract the motivation of the hoax which can be for black campaigns or not. Hence it is necessary to know its sentiment classification in response to the hoax news. Some methods that are widely used to classify text and conduct sentiment analysis are Naïve Bayes [15-19], Support Vector Machine [20-22], and KNN [23, 24]. In this research, Naïve Bayes method was chosen to carry out classification and sentiment analysis on Hoax news. Naïve Bayes as a machine learning probabilistic approach tends to works well for handling training sets that change over time. Furthermore, it was chosen because Naïve Bayes has proven to produce good, fast accuracy and can work well on the verification of sentiment analysis with relatively few training data [15, 25, 26].

In several previous text classification and hoax detection studies, the performance of classification methods can be optimized by using feature selection methods such as particle swarm optimization (PSO), information grain (IG) and genetic algorithm (GA) [5, 22, 27, 28]. In the previous studies, we conclude that PSO has several advantages over other methods, such as easy to implement, it can also search for optimal values and have algorithmic models that can be further improved. PSO is also widely employed in the problem of classification, clustering, and selection of text features [29-31]. After conducting analysis and hypothesis based on previous research, this paper proposed algorithm for developing a hoax news detection system, with the combination of searching techniques and its optimization, and also equipped with sentiment analysis.

2. RESEARCH METHOD

There are several methods we had studied in the kinds of literature. This lead to the conclusion that search technique is more practical than learning technique for hoax detection. Thus, this paper proposes searching techniques to classify hoax news in a more practical and up to date manner because crawling processes can be carried out every time by checking the news. The accuracy of the results is much better for frequent searching as the query over web can be posed every time. The classification process is done using the cosine similarity metric. Furthermore, the news ware then further processed by the sentiment analysis process using Naïve Bayes. This algorithm is then optimized by the PSO. To be focused, sentiment analysis is carried out only for news that was detected as hoax based on the searching approach. On the other hand, our approach crawls data from social media Twitter and Facebook. The explanation of the approach is elaborated with the following Figure 1.

2.1. Hoax detection

Before the hoax detection process is carried out, input queries are performed by the user, queries from the user containing the keyword news that will be searched. Input queries are used to collect news data. Data collection is done by crawling to retrieve Indonesian language news snippets through searching facilities provided by Google by utilizing the Google API. Google Custom Search makes it possible to make search engines as desired. Where the web snippet process will be directed to the turnbackhoax.id website, stophoax.id, operain.blogspot.com, and ayomajuterus.blogspot.com. Next, the similarity of document search results and text input is calculated using cosine similarity. The results of the calculation of cosine similarity will produce a percentage of hoax results. Cosine similarity (cs) can be calculated by the formula (1) [32].

$$cs = \cos(\theta) = \frac{A.B}{\|A\|\|B\|} = \frac{\sum_{i=i}^{n} A_i B_i}{\sqrt{\sum_{i=i}^{n} {A_i}^2}\sqrt{\sum_{i=i}^{n} {B_i}^2}} \quad (1)$$

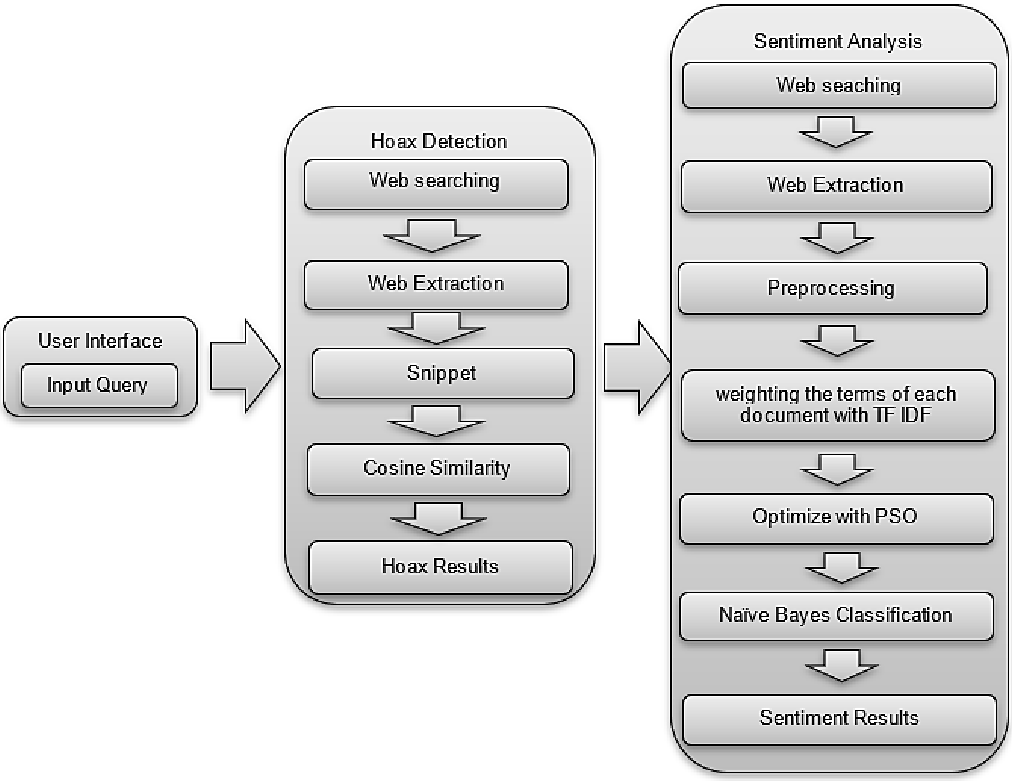

Figure 1. The workflow of the proposed method

2.2. Sentiment analysis

To find out the sentiment towards the news, then the data search is based on the selected news. Next is crawling sentiment on social media websites such as Facebook and Twitter. Preprocessing results from crawling data to optimize feature extraction and classification results. Preprocessing consists of folding cases, filtering, tokenizing, and stemming [33], whereas, for data aggregation technique, this work relies on our previous work presented in [34-36]. Case folding is done to change all letters to lowercase. Filtering or often referred to as stop word removal is used to delete words that are not too important, tokenizing is used to break the input of the query into words per word, and stemming is used to remove word additions so that the basic words are attached. From the results of preprocessing results, it is calculated the number of occurrences of each word in each document and then calculate TFIDF for each word with the formula (2) [28].

$$W_i = tf_i * \log\frac{N}{df_i} \quad (2)$$

Where, W_i is the weight of i, tf_i is the number of occurrences from i, df_i the number of documents containing i, and N is the total number of documents. After the term weighting value is obtained, then this weight value is used as a reference for PSO particles. The first step in PSO is an input of population numbers. Each population initializes particles that represent each feature / word with position = random numbers from 0 - 1 and velocity = 0. Then sort by the highest position value.

Next, calculate the NB categorization with the reduced feature based on the highest particle position value. A term with low value will not be used for classification. It means that particle values are restricted to a certain rank, for example, if there are 32 particles, and are limited to 20 particles with the highest value then particles in the order of 21 to 32 are not used. Next, do the probability calculation using formula (3).

$$P(A_i|C_j) = \frac{1}{\sqrt{2\pi\sigma_{ij}}} \exp\left[-\frac{(A_i - \mu_{ij})^2}{2(\sigma_{ij})^2}\right. \tag{3}$$

Probability results will get a category or class from each document, then repeat this calculation on all documents to calculate the accuracy in the next process. Calculate the Naïve Bayes accuracy of each population by formula (4).

$$accuracy = \frac{total\ of\ document\ correct}{the\ total\ number\ of\ documents} \tag{4}$$

Then calculate whether the Naïve Bayes accuracy is better than the best accuracy and the best accuracy. If the accuracy of Naïve Bayes in the current population is better than Pbest and Gbest then the population is now used as the new Pbest and Gbest. To calculate the speed and update position of particle positions using formula (5) and for particle, position updates using formula (6). To see more clearly about the flow of the process at this stage can see Figure 2.

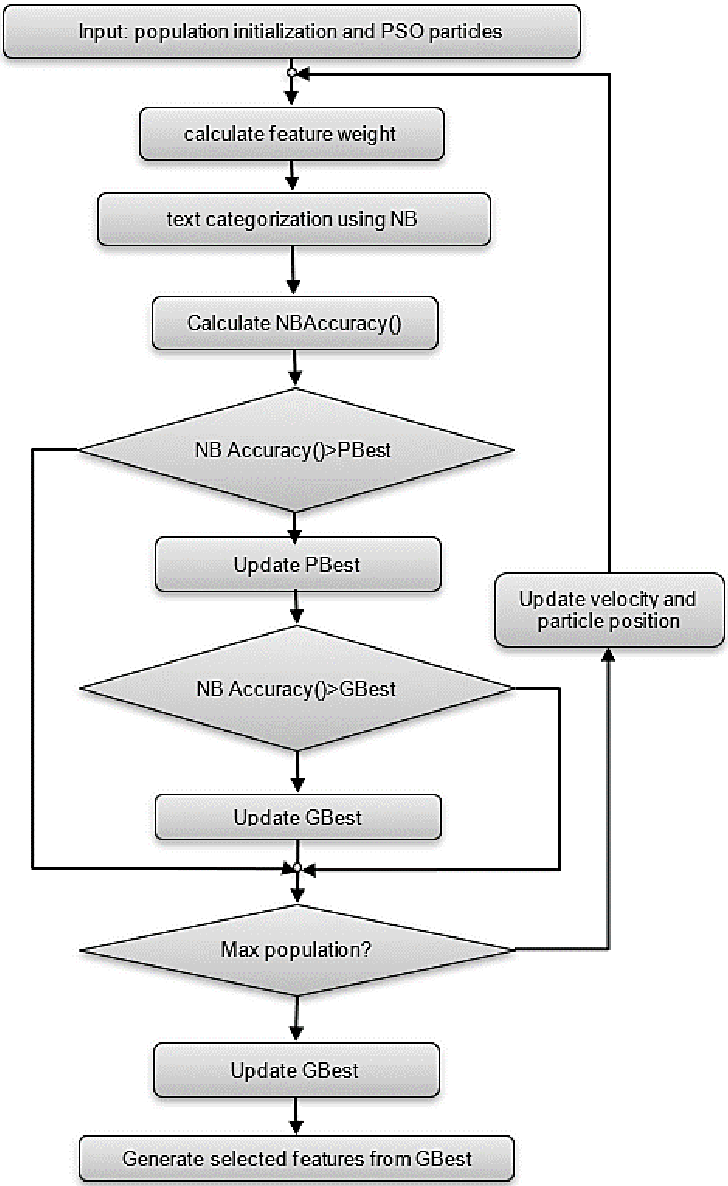

Figure 2. Details process of NB Classifier with PSO optimization for hoax detection

$$V_i(t) = V_i(t-1) + c_1 r_1 \left[X_{Pbest_i} - X_i(t)\right] + c_2 r_2 [X_{Gbest} - X_i(t)] \quad (5)$$

$$X_i(t) = X_i(t-1) + V_i(t) \quad (6)$$

Repeat the steps to calculate the probabilities of the PBest and GBest until the iteration is complete and produce a model with Gbest accuracy. When the iteration is complete, the sequential population is obtained from the highest to lowest Naïve Bayes accuracy, and the GBest value is used as a feature model to produce analytical sentiment. To see the flow of the algorithm more clearly you can see Figure 2. Then perform a Naïve Bayes probability calculation in three classes, namely positive, negative and neutral. Furthermore, the results of class classification are written with the highest probability value.

3. RESULTS AND DISCUSSION

In this research used hoax news data that is widely disseminated through social media by crawling data, from the data that have been searched for 30 news hoax samples, news samples can be seen in Table 1. From all the news data, cosine similarity is done and the calculation value can be seen in Table 2.

Table 1. Sample of indonesian news and its category

No	Title
1	Web KPU Diretas, Temuan Mengejutan!! Jokowi Angkat Isu PKI
2	Bocoran Informasi Penting Valid Pola Kecurangan Sistem Penghitungan Suara KPU Dengan Modus Nomor 01 dan 02
3	Kertas suara Pemilu dibakar seperti sampah, kecurangan ini mau didiamkan karena dilindungi oleh aparat dan pejabat?
4	Menpora Imam Nahrawi Mundur Dari Jabatannya
5	Gambar Rancangan Gedung Istana Negara di Palangkaraya
6	Megawati Soekarnoputri Dirawat di Rumah Sakit karena Stroke
…	
…	
30	simpatisan pki bacok seorang ulama di daerah banten

Table 2. Cosine similarity results

No	Cosine Similarity	No	Cosine Similarity	No	Cosine Similarity (%)
1	89.5669	11	74.8455	21	66.2266
2	66.7424	12	72.6273	22	86.0663
3	88.6405	13	90.8688	23	84.6327
4	67.8844	14	71.9092	24	68.1385
5	75.0587	15	71.4435	25	76.7366
6	91.6342	16	81.1107	26	67.3435
7	66.9439	17	75.3778	27	76.3323
8	67.1937	18	77.4070	28	85.5236
9	73.7210	19	74.7265	29	77.6899
10	86.7227	20	69.2308	30	89.9647

From the 30 data above, the percentage value of the average cosine similarity calculation is around 77,077%. The meaning appears that this method can identify hoax news well, where the highest cs value is 91.6342% and the lowest is 66.2266%, although the average percentage value is not high all calculations lead to the correct classification. In the next process, the calculation of sentiment analysis on the news was carried out using the naïve Bayes and PSO methods that had been proposed previously. Sentiment analysis was divided into three categories, namely positive, negative and neutral. Table 3 shows the results of the sentiment analysis of the proposed method.

From these results, it can be concluded that there are 19 results of the correct child sentiment. Although the level of accuracy of the sentiment is probably not very high, the accuracy of the sentiment analysis is still better and faster compared to other methods such as the KNN. The process of calculating the sentiment analysis for each document is also faster than that of the KNN where the NB method can calculate the average of each document 0.4733 seconds and the KNN calculates the average of each document 6,213 seconds with the same computer specification. Table 4 shows the comparison of the results of the classification sentiment analysis between the Naïve Bayes method, Naïve Bayes + PSO, KNN only, and KNN + PSO.

Table 3. Sentiment analysis results

Number of News	Sentiment class	Sentiment Results
1	negative	negative
2	negative	negative
3	neutral	positive
4	positive	positive
5	neutral	neutral
6	positive	positive
7	negative	negative
8	negative	negative
9	negative	negative
10	positive	positive
11	neutral	positive
12	negative	negative
13	negative	negative
14	neutral	negative
15	positive	neutral
16	neutral	positive
17	neutral	neutral
18	positive	negative
19	positive	positive
20	positive	positive
21	positive	negative
22	positive	positive
23	negative	negative
24	negative	neutral
25	negative	positive
26	neutral	neutral
27	positive	positive
28	negative	positive
29	negative	positive
30	negative	negative

Table 4. Comparison sentiment analysis results of each method

Number of News	Sentiment class	KNN	Naïve Bayes	KNN+ PSO	Naïve Bayes + PSO (Proposed Method)
1	negative	positive	negative	negative	negative
2	negative	neutral	negative	neutral	negative
3	neutral	negative	negative	negative	positive
4	positive	positive	positive	positive	positive
5	neutral	positive	negative	neutral	neutral
6	positive	positive	positive	positive	positive
7	negative	neutral	negative	neutral	negative
8	negative	neutral	negative	neutral	negative
9	negative	neutral	negative	neutral	negative
10	positive	positive	positive	positive	positive
11	neutral	neutral	positive	neutral	positive
12	negative	negative	negative	negative	negative
13	negative	positive	negative	positive	negative
14	neutral	negative	negative	negative	negative
15	positive	neutral	neutral	neutral	neutral
16	neutral	neutral	positive	neutral	positive
17	neutral	neutral	neutral	neutral	neutral
18	positive	negative	negative	negative	negative
19	positive	positive	positive	positive	positive
20	positive	positive	positive	positive	positive
21	positive	positive	negative	negative	negative
22	positive	positive	positive	positive	positive
23	negative	positive	negative	negative	negative
24	negative	negative	neutral	negative	neutral
25	negative	neutral	positive	neutral	positive
26	neutral	neutral	neutral	neutral	neutral
27	positive	positive	positive	positive	positive
28	negative	positive	positive	positive	positive
29	negative	negative	positive	negative	positive
30	negative	neutral	negative	negative	negative
Number of correct classification		17	18	18	19

4. CONCLUSION

In this research, hoax detection methods have been proposed using searching methods, users enter queries to search for news that is considered hoaxes. After the hoax news title is obtained, classification is done using the searching method using Google custom search and snippet. The results are classified by the cosine similarity method, based on the results of testing of 30 news, the average hoax is 77%, where all the news is detected as a hoax with a minimum percentage of about 66% and a maximum of 91%. This shows that the performance of the proposed method is reliable enough to detect hoax news. This system is also equipped with sentiment analysis process using Naïve Bayes which is optimized by the PSO method, based on the results of testing the sentiment analysis method of the proposed sentiment works better than the other methods proposed earlier.

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REFERENCES

[1] A. Bondielli and F. Marcelloni, "A Survey on Fake News and Rumour Detection Techniques," *Inf. Sci. (Ny),* vol. 497, pp. 38–55, 2019.
[2] P. Assiroj, Meyliana, A. N. Hidayanto, H. Prabowo, and H. L. H. S. Warnars, "Hoax News Detection on Social Media: A Survey," *Indo. Associ. for Pattern Recognition Int. Conf.* pp. 186–191, 2018
[3] F. E. Nastiti, R. A. Prastyanti, R. B. Taruno, and D. Hariyadi, "Social Media Warfare in Indonesia Political Campaign: A Survey," Int. Conf. on Information Technology, Infor. Sys. and Elect. Enginee, pp. 49-53, 2018.
[4] A. B. Prasetijo, *et al.,* "Hoax Detection System on Indonesian News Sites Based on Text Classification using SVM and SGD," *4th Int. Conf. on Inform. Technology, Comp, and Elect. Enginee.,* pp. 45-49, 2017.
[5] A. P. Wijaya and H. A. Santoso, "Improving the Accuracy of Naïve Bayes Algorithm for Hoax Classification Using Particle Swarm Optimization," *Int. Semin. Appl. Technol. Inf. Commun.,* pp. 482-487, 2018.
[6] A. B. Pratama, "Ada 800 Ribu Situs Penyebar Hoax di Indonesia," CNN Indonesia, Avalable at: cnnindonesia.com/teknologi/20161229170130-185-182956/ada-800-ribu-situs-penyebar-hoax-di-indonesia, 2016.
[7] I. Y. R. Pratiwi, R. A. Asmara, and F. Rahutomo, "Study of Hoax News Detection using Naïve Bayes Classifier in Indonesian Language," *11th Int. Conf. on Inform. Commu Technology and Sys,* pp. 73–78, 2017.
[8] S. Afroz, M. Brennan, and R. Greenstadt, "Detecting Hoaxes, Frauds, and Deception in Writing Style Online," *IEEE Symposium on Security and Privacy,* pp. 461-475, 2012.
[9] J. Chae, *et al.,* "Visual Analytics for Investigative Analysis of Hoax Distress Calls using Social Media," *IEEE Symposium on Technologies for Homeland Security,* pp. 1-6, 2016.
[10] I. Santoso, *et al.,* "Early Investigation of Proposed Hoax Detection for Decreasing Hoax in Social Media," IEEE Int. Conf. on Cybernetics and Computational Intelligence, pp. 175-179, 2017.
[11] N. A. Miftahul Huda and I. Sembiring, "The Use of Soft Systems Methodology to Resolve Hoax News Problems in Indonesia," 3rd Int. Conf. on Inform. Technology, Inform. Sys. and Elect. Enginee, pp. 65-68, 2018.
[12] F. Del Vigna, *et al.,* "Who Framed Roger Reindeer? De-censorship of Facebook Posts by Snippet Classification," *Online Soc. Networks Media,* vol. 6, pp. 41-57, 2018.
[13] P. Murugesan and K. Malathi, "Efficient Search Engine Approach for Measuring Similarity Between Words: using Page Count and Snippets," Online Int. Conf. on Green Enginee. and Technologies (IC-GET), pp. 1-5, 2015.
[14] R. Menaha, A. U. Surya, K. Nandhni, and M. Ishwarya, "Question Answering System using Web Snippets," *Int. Conf. on I-SMAC (IoT in Social, Mobile, Analytics and Cloud),* pp. 387-390, 2017.
[15] B. Setiyo, H. C. Sihombing, and F. R. I. M, "Depression and Anxiety Detection Through the Closed-Loop Method using DASS-21," *TELKOMNIKA.,* vol. 17, no. 4, pp. 2087-2097, 2018.
[16] A. D. Poernomo and S. Suharjito, "Indo. Online Travel Agent Sentiment Analysis using Machine Learning Methods," *Indo. J. Electr. Eng. Comput. Sci.,* vol. 14, no. 1, pp. 113-117, 2019.
[17] R. Bhalla and A. Bagga, "Opinion Mining Framework using Proposed rb-bayes Model for Text Classification," *Int. J. Electr. Comput. Eng.,* vol. 9, no. 1, pp. 477-485, 2019.
[18] M. A. Ahmed, R. A. Hasan, A. H. Ali, and M. A. Mohammed, "Using Machine Learning for the Classification of the Modern Arabic Poetry," *TELKOMNIKA.,* vol. 17, no. 5, 2019.
[19] N. M. Samsudin, *et al.,* "Youtube Spam Detection Framework using Naïve Bayes and Logistic Regression," *Indones. J. Electr. Eng. Comput. Sci.,* vol. 14, no. 3, pp. 1508-1517, 2019.
[20] Y. Al Amrani, M. Lazaar, and K. E. El Kadiri, "A Novel Hybrid Classification Approach for Sentiment Analysis of Text Document," *Int. J. Electr. Comput. Eng.,* vol. 8, no. 6, pp. 4554–4567, Dec. 2018.
[21] C. J. Rameshbhai and J. Paulose, "Opinion mining on newspaper headlines using SVM andNLP," *Int. J. Electr. Comput. Eng.,* vol. 9, no. 3, pp. 2152–2163, Jun. 2019.
[22] A. Rizaldy and H. A. Santoso, "Performance Improvement of Support Vector Machine (SVM) with Information Gain on Categorization of Indonesian News Documents," *Int. Semin. Appl. Technol. Inf. Commun.,* vol. 2018, pp. 227-231, 2018.

[23] A. Moldagulova and R. B. Sulaiman, “Document Classification Based on KNN Algorithm by Term Vector Space Reduction,” *Int. Conf. on Control, Automation and Systems,* 2018.

[24] Y. Tan, “An Improved KNN Text Classification Algorithm Based on K-Medoids and Rough Set,” 10th Int. Conf. on Intelligent Human-Machine Systems and Cybernetics, pp. 109-113, 2018.

[25] G. Feng, J. Guo, B.-Y. Jing, and T. Sun, “Feature Subset Selection using Naive Bayes for Text Classification,” *Pattern Recognit. Lett.,* vol. 65, pp. 109-115, 2015.

[26] Z. E. Rasjid and R. Setiawan, “Performance Comparison and Optimization of Text Document Classification using k-NN and Naïve Bayes Classification Techniques,” *Procedia Comput. Sci.,* vol. 116, pp. 107-112, 2017.

[27] Y. Lu and Y. Peng, “Feature Weighting Improvement of Web Text Categorization Based on Particle Swarm Optimization Algorithm,” *J. Comput.,* vol. 10, no. 4, pp. 260-267, 2015.

[28] O. Somantri and D. Apriliani, “Opinion Mining on Culinary Food Customer Satisfaction using Naïve Bayes Based-on Hybrid Feature Selection,” *Indones. J. Electr. Eng. Comput. Sci.,* vol. 15, no. 1, pp. 468-475, 2019.

[29] M. J. Basha and K. P. Kaliyamurthie, “An Improved Similarity Matching based Clustering Framework for Short and Sentence Level Text,” *Int. J. Electr. Comput. Eng.,* vol. 7, no. 1, pp. 551-558, 2017.

[30] Y. Lu, M. Liang, Z. Ye, and L. Cao, “Improved Particle Swarm Optimization Algorithm and its Application in Text Feature Selection,” *Appl. Soft Comput.,* vol. 35, pp. 629-636, 2015.

[31] R. Janani and S. Vijayarani, “Text document clustering using Spectral Clustering algorithm with Particle Swarm Optimization,” *Expert Syst. Appl.,* vol. 134, pp. 192–200, Nov. 2019.

[32] P. Gokul, B. K. Akhil, and K. K. M. Shiva, “Sentence Similarity Detection in Malayalam Language using cosine similarity,” 2nd IEEE Int. Conf. on Recent Trends in Electro, Inform & Commu Technology, pp. 221-225, 2017.

[33] A. Nursetyo, D. R. I. M. Setiadi, and E. R. Subhiyakto, “Smart Chatbot System for E-Commerce Assitance based on AIML,” in *International Seminar on Research of Information Technology and Intelligent Systems,* 2018.

[34] H. A. Santoso, J. Zeniarja, A. Luthfiarta, and B. J. Wijaya, “An Ontological Crawling Approach for Improving Information Aggregation over e-Government Websites,” *J. Comput. Sci.,* 2016.

[35] H.-A. Santoso, S.-C. Haw, and C.-S. Lee, “Software Reuse: MDA-Based Ontology Development to Support Data Access over Legacy Applications,” *Springer, Berlin, Heidelberg,* pp. 130-142, 2011.

[36] H. A. Santoso, Z. T. Abdul-Mehdi, and S.-C. Haw, “Semantic Enhancement Framework for e-Government using Ontology Versioning Approach,” in Int. Conf. on Information Technology and Applications, pp. 296-301, 2009.