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IMPLEMENTATION OF SUPPORT VECTOR MACHINE, PARTICLE SWARM OPTIMIZATION, AND NAÏVE BAYES ALGORITHMS IN SENTIMENT ANALYSIS OF PRODUCT REVIEWS: A CASE STUDY OF E-COMMERCE LAZADA

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Abstract

Sentiment analysis is pivotal in deciphering customer opinions and attitudes towards products on e-commerce platforms such as Lazada. Machine learning algorithms like Support Vector Machine (SVM), SVM with Particle Swarm Optimization (PSO), and Naïve Bayes (NB) are leveraged to automate this process, aiding decision-making in business settings. This study specifically aims to assess the performance of SVM, SVM + PSO, and NB in analyzing sentiment from Lazada product reviews, focusing on key metrics like accuracy and Area Under the Curve (AUC). Using a dataset of Lazada reviews, each algorithm is rigorously trained and evaluated. SVM achieves 72.74% accuracy and an AUC of 0.893, while integrating PSO boosts accuracy significantly to 84.84% with an AUC of 0.898. In contrast, NB achieves 75.34% accuracy and an AUC of 0.663. These results highlight SVM + PSO's superior performance in sentiment classification compared to SVM and NB. The findings suggest that SVM + PSO presents a robust solution for sentiment analysis in e-commerce, surpassing traditional SVM and NB methods in accuracy and AUC metrics. This underscores the potential of optimization techniques like PSO to enhance machine learning algorithms for effective sentiment analysis in practical e-commerce applications.

Keywords: Naïve Bayes; Particle Swarm Optimization; Product Review; Sentiment Analysis; Support Vector Machine

Abstrak

Analisis sentimen sangat penting dalam menguraikan pendapat dan sikap pelanggan terhadap produk di platform e-commerce seperti seperti Lazada. Algoritme pembelajaran mesin seperti Support Vector Machine (SVM), SVM dengan Particle Swarm Optimization (PSO), dan Naïve Bayes (NB) dimanfaatkan untuk mengotomatiskan proses ini, membantu pengambilan keputusan dalam pengaturan bisnis. Penelitian ini secara khusus bertujuan untuk menilai kinerja SVM, SVM + PSO, dan NB dalam menganalisis sentimen dari ulasan produk Lazada, dengan fokus pada metrik utama seperti akurasi dan Area Under the Curve (AUC). Menggunakan kumpulan data ulasan Lazada, setiap algoritma dilatih dan dievaluasi secara ketat. SVM mencapai 72,74% akurasi dan AUC 0,893, sementara mengintegrasikan PSO meningkatkan akurasi secara signifikan menjadi 84,84% dengan AUC 0,898. Sebaliknya, NB mencapai 75,34% akurasi akurasi dan AUC sebesar 0,663. Hasil ini menyoroti keunggulan SVM + PSO kinerja SVM + PSO dalam klasifikasi sentimen dibandingkan dengan SVM dan NB. Temuan menunjukkan bahwa SVM + PSO menyajikan solusi yang kuat untuk analisis sentimen dalam e-commerce, melampaui metode SVM dan NB tradisional dalam hal akurasi dan metrik AUC. Hal ini menggarisbawahi potensi teknik pengoptimalan seperti PSO untuk meningkatkan algoritma pembelajaran mesin untuk analisis sentimen yang efektif dalam aplikasi e-commerce.

Kata kunci: Naïve Bayes; Particle Swarm Optimization; Ulasan Produk; Sentiment Analysis; Support Vector Machine

INTRODUCTION

In this rapidly evolving digital era, e-commerce has fundamentally changed the way consumers shop and interact with businesses. One of the prominent platforms in Southeast Asia is Lazada, which offers a wide range of products across various categories. User-generated product reviews on this platform have become a highly valuable source of information for both consumers and sellers. These reviews help consumers make more informed decisions and provide useful feedback for sellers to improve their products and services.

However, with the increasing volume of product reviews that continues to grow every day, manually analyzing the sentiment contained in these reviews becomes impractical and time-consuming. The main challenge in sentiment analysis is to automatically and accurately classify these reviews into positive, negative, or neutral categories. The need for an efficient and effective solution to address this challenge has become very urgent.

This research aims to evaluate and compare the performance of three popular algorithms in sentiment analysis: Support Vector Machine (SVM), Particle Swarm Optimization (PSO), and Naïve Bayes. Additionally, this research will utilize RapidMiner, a data analysis platform that provides a drag-and-drop interface for data processing and machine learning algorithm implementation. The study will focus on how these algorithms can be applied to classify the sentiment of product reviews on Lazada with a high level of accuracy.

This research holds significant importance for the e-commerce world. By understanding consumer sentiment through product reviews, Lazada, and other e-commerce platforms can enhance user experience and refine their marketing strategies. Additionally, the results of this research can provide insights into the effectiveness of various algorithms in sentiment analysis, which can be used by academics and practitioners to develop better models in natural language processing. The use of RapidMiner is expected to accelerate and simplify the analysis process, making it practically applicable for business operators.

The research approach involves the application and evaluation of three main algorithms: Support Vector Machine (SVM), Particle Swarm Optimization (PSO), and Naïve Bayes using RapidMiner. Product review data from Lazada will be collected and processed through this platform, enabling efficient feature extraction and the implementation of machine learning algorithms with an intuitive interface. The SVM algorithm will be used to classify data by maximizing the margin between different classes, while PSO will be applied to optimize model parameters. Naïve Bayes will be used due to its efficiency in handling large text data and its simple yet effective probabilistic model.

This research will focus on sentiment analysis of product reviews found on Lazada, using a dataset obtained from Kaggle. The main focus is to compare the effectiveness of SVM, PSO, and Naïve Bayes in classifying sentiment. RapidMiner will be used to support the analysis process, from data collection to model evaluation. The limitations of the research include the scope of data being limited to reviews available on Lazada and not encompassing sentiment analysis from other e-commerce platforms.

Previous studies have applied the SVM algorithm for sentiment classification, demonstrating strong performance in high-dimensional spaces. PSO has been utilized in various optimization contexts, showcasing its efficiency in finding optimal solutions. Naïve Bayes, despite its simplicity, has proven effective in text classification, including sentiment analysis. RapidMiner has been widely adopted for data analysis and machine learning modeling due to its user-friendly interface and ability to integrate with various algorithms. This study aims to complement existing literature by comparatively evaluating the performance of these three algorithms in the context of Lazada product reviews using RapidMiner.

The Support Vector Machine (SVM) algorithm showed the highest accuracy of 71.42%, surpassing the Naïve Bayes algorithm, which achieved an accuracy of 69%. These results highlight the superiority of SVM in classifying sentiment in product review analysis, demonstrating its potential to enhance accuracy in data-driven decision-making within the e-commerce context (Muit Sunjaya et al., 2024).

The highest accuracy for SVM was achieved using the RBF kernel on the JD.id dataset, recording an accuracy of 76.70% in the testing phase. This finding indicates that the use of the RBF kernel in SVM performs well in classifying data on e-commerce platforms such as JD.id (Syahputra, 2021).

The Support Vector Machine (SVM) achieved an accuracy score of 35.56%. This result indicates that SVM may face challenges in

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classifying data within the specific context examined in that research (Cheng et al., 2021).

With this approach, the research is expected to significantly contribute to the understanding and application of sentiment analysis methods in the e-commerce world and aid in better data-driven decision-making.

Dr. Kennedy and Dr. Eberhart, first introduced particle swarm optimization (PSO) in 1995. The metaheuristic technique called PSO can mimic the social behavior of a flock of birds and other groups. The social behavior particles in question, which include the behavior of each individual as well as the impact of the behavior of other individuals in a group, are used to describe individual fish. The speed of each particle, the best position of the particle (pbest) and the best position of the group of particles (gbest) affect the movement of each particle in the solution space (Umiyati et al., 2021).

Particle Swarm Optimization is a population search technique that is based on the movement of birds and fish while searching for food. It is commonly used to solve problems with optimization and feature selection (Pajri et al., 2020).

As an optimization algorithm, the PSO algorithm performs a population-based search over a set of features that change position in time to optimize each feature (Hadi & Kurniawan, 2022).

Particle Swarm Optimization (PSO) is a metaheuristic optimization algorithm that has proven effective in solving complex optimization problems (Lumbantobing & Rahmaddeni, 2023).

It is a search algorithm that uses swarms and particles as the population. Each particle will move at an adjusted speed from the search area and settle at the best place they have ever reached (Muhardeny et al., 2023).

The Swarm Optimization algorithm is based on a population of many particles and initializes the population randomly to solve the optimization problem (Kurniati & Wardana, 2021).

Optimization of Particle Swarms (PSO) has been shown to be an effective solution. The computational optimization method called PSO is inspired by the behavior of animal groups. In this method, particles or solution representations are moved in the search space to find the best solution (Pratiwi et al., 2024).

The principle of the Particle Swarm Optimization Algorithm (PSO) is that each particle called a swarm will move with its swarm called a swarm towards the particle with the best performance as each particle searches for its best position. Each particle in the swarm always updates its velocity and position during iterations (Fitriana, 2021).

PSO was chosen in this study because the concept is simple, convergence is relatively fast, easy to implement, and can be used to solve optimization-related problems in various fields. PSO has methods for optimizing attribute weights (attribute weight) for all attributes or variables used, attribute selection, and attribute selection. Attribute selection means attribute weighting by connecting one attribute to another (Arsi et al., 2021).

PSO excels in exploring the search space globally, especially in parameter optimization. PSO is an optimization algorithm based on the herd behavior of flocking animals and is used in the Naive Bayes model to find the optimal parameter combination (Kahfi et al., 2024).

RESEARCH METHODS

The methods used in this research involve a series of steps designed to optimize sentiment analysis from product review data on Lazada. These steps include data collection, text preprocessing, application of machine learning algorithms, and model performance evaluation. This process is carried out using the RapidMiner platform to ensure that each step can be easily integrated and the results obtained are reliable. The main focus of this methodology is to evaluate the effectiveness of three different algorithms in sentiment classification.

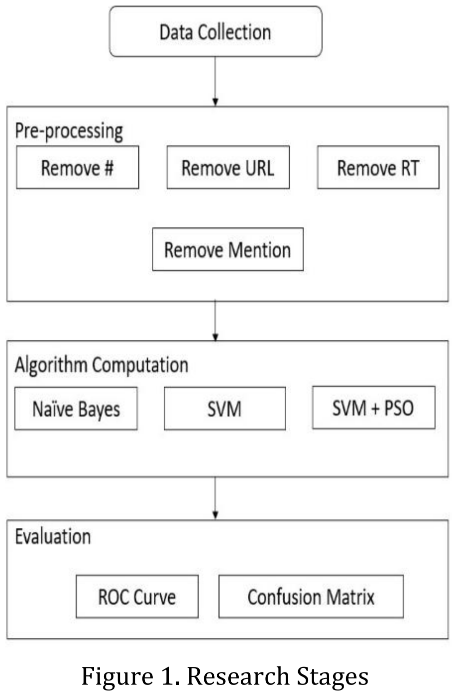

Figure 1. Research Stages

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Data Collection

The initial stage in this research process is data collection. At this step, product review data from the e-commerce platform Lazada will be gathered. This data typically consists of text generated by users who review the products they purchase. Data scraping will be performed on Kaggle.com, resulting in a dataset of 830 rows. The data is stored in an Excel file. The Excel file is then cleaned to remove duplicate entries, leaving 810 rows of data ready for preprocessing. The collected reviews will serve as the foundation for the sentiment analysis conducted in this research.

Pre-processing

After the data is collected, the next step is preprocessing. This step is crucial to clean the data and prepare it for further analysis. Data preprocessing aims to eliminate irrelevant elements or potential disturbances that could affect the analysis results. Here are the sub-steps in preprocessing:

1. Remove #

Removing hashtags or pound signs from review text. Hashtags often do not contribute significantly to sentiment analysis and can introduce noise in the data. Removing hashtags helps obtain a cleaner and more relevant text.

2. Remove URL

Deleting links or URLs from review text. URLs are typically irrelevant to the content of reviews and can affect the quality of analysis. Removing URLs ensures that the analysis focuses on content directly related to user sentiment.

3. Remove RT

Removing the text "RT" (Retweet) that may be present if the data is collected from social media platforms that allow retweeting. This helps reduce duplication and maintain data relevance. Removing retweets ensures that only the original review text is analyzed.

4. Remove Mention

Deleting mentions or username references like "@username" from review text. Mentions are often irrelevant in the context of product sentiment analysis and can disrupt the analysis process. Removing mentions helps focus the analysis on relevant review content.

Algorithm Computation

After the data has been cleaned, the next step is to apply algorithms for sentiment analysis. At this stage, three different algorithms will be used to analyze the review data:

1. Naïve Bayes

This algorithm uses a probabilistic approach based on Bayes' theorem. Naïve Bayes is highly efficient for text classification and capable of handling large datasets effectively. It classifies reviews as positive, negative, or neutral based on the probabilities of words in the review text. This algorithm is chosen for its simple yet effective ability in text classification. Naïve Bayes Classifier (NBC) is a very simple yet often very effective probability-based classification algorithm. Basically, NBC uses Bayes' theorem with the strong assumption that each input feature is independent of each other (naïve independence assumption). This algorithm is often used in various data mining applications such as text classification, sentiment analysis, pattern recognition, and spam detection (Berliani & Lestari, 2024). The general form of Bayes' theorem is as follows:

$P(H|X) =$ (1)

Description:

X = Data with unknown class

H = Hypothesized data X is a specific class

P(H|X) = Probability of hypothesis H based on condition X (posterior probability)

P(H) = Probability of hypothesis H (prior probability)

2. Support Vector Machine (SVM)

SVM is a powerful machine learning algorithm for data classification in high-dimensional spaces. SVM works by finding a hyperplane that separates review data into different classes (positive, negative, or neutral) with a maximum margin. SVM is selected for its ability to perform well on high-dimensional data and provide accurate results. SVM is a supervised learning method that analyzes data and recognizes patterns for classification and regression, SVM works by finding the best hyperplane by maximizing the distance between classes, hyperplane is a function used to separate classes. SVM is a classifier so given a training set that is marked as belonging to one of the category classes, the SVM algorithm builds a model that predicts whether the newly processed data belongs to one of the other categories (Hasri & Alita, 2022).

3. SVM + Particle Swarm Optimization (PSO)

The combination of SVM and PSO is used to optimize SVM parameters. PSO is an optimization technique inspired by the social behavior of animals such as birds and fish. By using PSO, SVM parameters can be adjusted to

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enhance classification performance. PSO aids in finding optimal parameters for SVM, thereby improving the effectiveness and efficiency of classification. This combination is used to optimize the sentiment analysis results. PSO is a population-based optimization method used to find the optimal parameters for SVM (Arsi et al., 2021).

Evaluation

After applying the algorithms, the next step is model performance evaluation. Two main evaluation methods used are:

1. ROC Curve (Receiver Operating Characteristic Curve)

The ROC curve is used to assess the classification model's performance by measuring the true positive rate (TPR) against the false positive rate (FPR) at various thresholds. This curve provides insight into the trade-off between sensitivity (recall) and model specificity. The ROC curve is used to evaluate the model's ability to distinguish between positive and negative classes across different threshold values.

2. Confusion Matrix

The confusion matrix is used to assess the accuracy of the model by showing the number of correct and incorrect predictions made by the model. This matrix helps identify the number of true positives, false positives, true negatives, and false negatives, which are useful for calculating other evaluation metrics such as precision, recall, and F1-score. The confusion matrix provides detailed insight into the model's performance in sentiment classification, aiding in the analysis of the strengths and weaknesses of the model.

RESULTS AND DISCUSSION

Results from the evaluation of the three tested algorithms for sentiment analysis on product reviews on the Lazada platform.

Naïve Bayes

The confusion matrix generated from testing the Naïve Bayes algorithm, as shown in Table 1, offers a detailed analysis of how well the model performed in classifying sentiment for product reviews on the Lazada platform.

Table 1. Confusion Matrix of Naïve Bayes

accuracy 75.34% +- 3.61% (micro average: 75.36%)		
	true positive	true negative
prediction positive	251	108
prediction negative	63	272
class recall	79.94%	71.58%

Figure 2. ROC Curve of Naive Bayes

In Table 1, it is evident that the classification model has an accuracy of 75.34% with a margin of error of ± 3.61%. These results indicate that the model is capable of classifying data reasonably well, with 251 true positive instances correctly classified as positive and 272 true negative instances correctly classified as negative. However, there are some classification errors: 63 true positive instances were incorrectly classified as negative (false negatives), and 108 true negative instances were incorrectly classified as positive (false positives). The precision for the positive class is 69.92%, meaning 69.92% of all positive predictions are indeed positive. The precision for the negative class is 81.19%, indicating that 81.19% of all negative predictions are truly negative. The recall for the positive class reaches 79.94%, indicating that 79.94% of all actual positive data were correctly identified as positive, while the recall for the negative class is 71.58%, indicating that 71.58% of all actual negative data were correctly identified as negative. These results provide an overview that the model performs well in classifying data into positive and negative classes, although there are still some errors.

Support Vector Machine

The confusion matrix generated from testing the SVM algorithm, as presented in Table 2, gives a detailed account of the model's performance in classifying sentiment for product reviews on the Lazada platform.

Table 2. Confusion Matrix of SVM

accuracy 72.74% +- 6.65% (micro average: 72.77%)		
	true positive	true negative
prediction positive	309	184
prediction negative	5	196
class recall	98.41%	51.58%

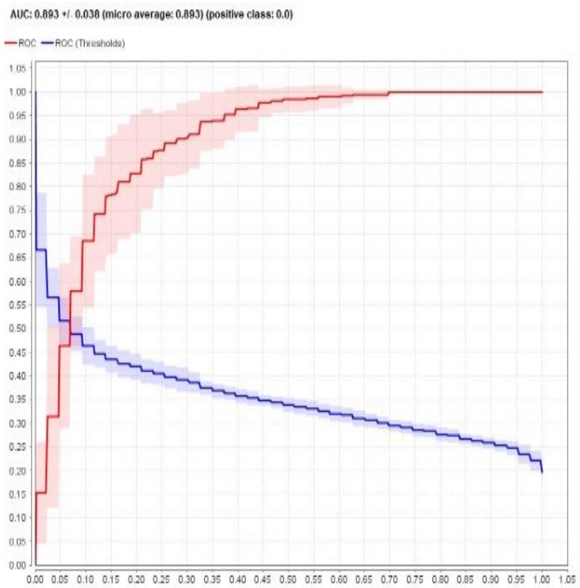

Figure 3. ROC Curve of SVM

In Table 2, the obtained accuracy is 72.74% with a margin of error of 6.65%. It shows that there are 309 true positive records and 196 true negative records, indicating that data classified as positive sentiment comprises 309 records and negative sentiment comprises 196 records. However, there are 5 records classified as negative sentiment that should have been positive (false negatives) and 184 records classified as positive sentiment that should have been negative (false positives). According to the test results, the precision value for the positive class is 62.68%, meaning 62.68% of all positive predictions are actually positive. For the negative class, the precision value is 97.51%, indicating that 97.51% of all negative predictions are truly negative. The recall value for the positive class is 98.41%, meaning 98.41% of all actual positive data were correctly identified as positive. For the negative class, the recall value is 51.58%, indicating that 51.58% of all actual negative data were correctly identified as negative. These results suggest that the model performs well in classifying data into positive and negative classes, although there are still some errors. Further insights into the model's performance can be gained through the ROC curve, which illustrates the model's capability at various thresholds, where a high Area Under Curve (AUC) reflects good classification quality.

Support Vector Machine with Particle Swarm Optimization

The confusion matrix resulting from testing the SVM algorithm, as presented in Table 3, provides a comprehensive view of how the model performed in classifying sentiment for product reviews on the Lazada platform.

Table 3. Confusion Matrix of SVM + PSO

accuracy 84.84% +- 5.58% (micro average: 84.87%)		
	true positive	true negative
prediction positive	285	75
prediction negative	29	304
class recall	90.76%	80.00%

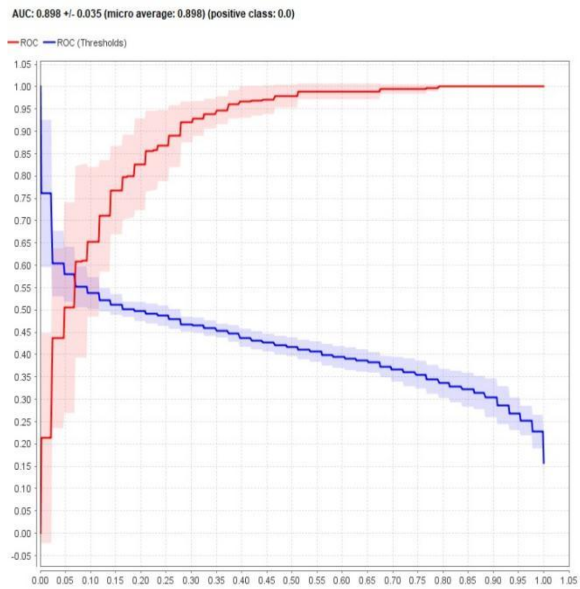

Figure 4. ROC Curve SVM + PSO

In Table 3, the obtained accuracy is 84.84% with a margin of error of 5.88%. It shows that there are 285 true positive records and 304 true negative records, indicating that data classified as positive sentiment comprises 285 records and negative sentiment comprises 304 records. However, there are 29 records classified as negative sentiment that should have been positive (false negatives) and 76 records classified as positive sentiment that should have been negative (false positives). According to the test results, the precision value for the positive class is 78.95%, meaning 78.95% of all positive predictions are actually positive. For the negative

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class, the precision value is 91.29%, indicating that 91.29% of all negative predictions are truly negative. The recall value for the positive class is 90.76%, meaning 90.76% of all actual positive data were correctly identified as positive. For the negative class, the recall value is 80.00%, indicating that 80.00% of all actual negative data were correctly identified as negative. These results suggest that the model performs well in classifying data into positive and negative classes, although there are still some errors. Further insights into the model's performance can be gained through the Receiver Operating Characteristic (ROC) curve, which illustrates the model's capability at various thresholds, where a high Area Under Curve (AUC) reflects good classification quality.

Table 4. Comparison of Accuracy and AUC

Algorithm	Accuracy	AUC
Naïve Bayes	72.74%	0.893
SVM (PSO)	84.84%	0.898
SVM	75.34%	0.663

Summary of accuracy and AUC results obtained from the three algorithms are presented in Table 4. According to Table 4, testing conducted using the SVM algorithm yielded an accuracy of 72.74% and an AUC value of 0.893. In contrast, testing conducted using the SVM algorithm optimized with PSO (Particle Swarm Optimization) resulted in an accuracy of 84.84% and an AUC value of 0.898. These results indicate an accuracy improvement of 12.10% compared to standard SVM, with a relatively small increase in AUC of 0.005%.

Testing using the Naive Bayes (NB) algorithm resulted in an accuracy of 75.34% and an AUC value of 0.663. From these results, it is evident that the NB algorithm achieves a higher accuracy compared to standard SVM, but its AUC value is lower. Overall, these findings indicate that while NB shows better accuracy than standard SVM, its classification quality as measured by AUC is still below that of SVM optimized with PSO.

The graph comparing the accuracy and AUC values among the three algorithms as presented in Figure 5.

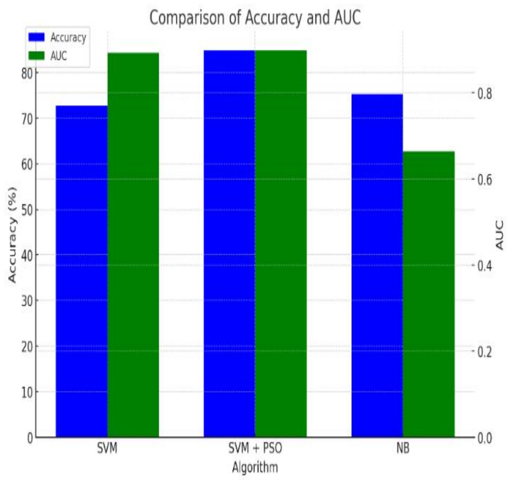

Figure 5. Comparison Chart of Accuracy and AUC

Therefore, itan be concluded that using the SVM algorithm optimized with PSO provides the best performance among the three tested algorithms, both in terms of accuracy and AUC. This demonstrate the importance of algorithm optimization to achieve better and more accurate classification results.

CONCLUSIONS

Testing on the data scraped from Kaggle has been completed. Based on sentiment analysis results using Support Vector Machine (SVM), Naïve Bayes, and SVM optimized with Particle Swarm Optimization (PSO), it can be concluded that SVM optimized with PSO achieves better accuracy compared to standard SVM and Naïve Bayes algorithms. Therefore, SVM optimized with PSO emerges as the preferred solution for sentiment classification of product reviews on the Lazada e-commerce platform. Further research should explore using feature selection operators like correlation-based feature selection or information gain-based feature selection for the same case to compare their performance and achieve the most optimal accuracy.

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