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COMPARATIVE ANALYSIS OF PSO AND FIREFLY OPTIMIZATION FOR VIOLENCE REPORT CLASSIFICATION

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Abstract (10pt)

Cases of violence against children and women continue to increase, but the handling of reports is often hampered by the large volume of incoming reports and the lengthy manual classification process. This study aims to address these issues by developing a method for automatically classifying reports of violence using the Support Vector Machine (SVM) algorithm optimized with Particle Swarm Optimization (PSO) and Firefly algorithms. The main objective is to group types of violence accurately to facilitate faster and more effective identification and handling. The research dataset consists of 500 reports obtained from Kaggle, with stages including text pre-processing, implementation of optimization algorithms, and evaluation based on accuracy, precision, recall, and misclassification error. The results showed that PSO-SVM achieved an accuracy of 87.00% and a recall of 80.42%, outperforming Firefly-SVM which achieved an accuracy of 86.00% and a recall of 78.75%. Although Firefly-SVM demonstrated slightly higher precision (92.63%) compared to PSO-SVM (91.53%), PSO-SVM had a lower misclassification error (13.00% compared to 14.00%). These findings indicate that PSO-SVM is more effective for applications requiring better case detection, while Firefly-SVM is more suitable for applications prioritizing precision in positive predictions.

Keywords: *Comparison of Algorithms, PSO, Firefly Optimization, SVM, Report Classification*

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1. INTRODUCTION

Cases of violence are a disturbing phenomenon in society that indicate violations of human rights, especially against vulnerable groups such as children and women [1]. Based on data obtained from the Online Information System for the Protection of Women and Children (Simfoni PPA) owned by the Ministry of Women's Empowerment and Child Protection (KemenPPA), throughout 2022 there were 26,112 cases of violence against children and women. Of that number of cases, female victims reached 23,684 people. This figure is much higher than the number of male victims of 4,394 victims [2].

To prevent an increase in cases of violence against women and children, conventionally reporting to the authorities is necessary so that the perpetrators of the violence can be arrested immediately. [3]. This conventional method is certainly very ineffective and inefficient. In addition, every report of cases of violence and sexual harassment received by the authorities comes from the community who made the report [4]. Before being submitted to the authorities, the report needs to be summarized and grouped first based on the type of violence to facilitate the identification process and appropriate handling based on the type of violence that occurred [5]. However, in practice, reports that have been submitted often do not get fast handling from the authorities because the volume of reports received is very large so it often takes time in the process of classifying the type of violence, this causes problems regarding the length of time it takes for reports of violence to be handled [6].

Therefore, the application of text mining and data mining can be used as a solution in efficiently and accurately classifying report data so that public reports can be classified quickly so that they can be handled quickly [7]. With the application of text mining and data mining, incoming reports can be automatically classified according to the appropriate type of violence, saving time for the authorities in categorizing [8]. The idea of applying text mining

and data mining in the classification of violence against women and children has been carried out in previous research, namely in 2021 implementing the C4.5 algorithm for the classification of types of violence against children [3]. Then in 2022, the Multinomial Naive Bayes algorithm was implemented in the classification of types of violence against women and children [9]. The latest research in 2023 implemented the C4.5 algorithm based on Particle Swarm Optimization (PSO) feature selection in the classification of types of violence [1]. Next, there is a study that implements the Support Vector Machine algorithm with Firefly optimization in classifying opinion data where the accuracy results obtained are quite high, namely 87.15% [10].

In this study, the text mining and data mining algorithms that will be implemented are the Support Vector Machine algorithm. This study chooses the Support Vector Machine algorithm compared to Multinomial Naive Bayes and C4.5 because based on previous research in the case of classification [11] and [12], it was found that the Support Vector Machine algorithm is superior in terms of performance and accuracy compared to the Multinomial Naive Bayes and C4.5 algorithms. According to previous research findings to improve the accuracy of the classification results in this study, it is combined with an optimization algorithm. The contribution to this study is that a comparison will be made between the Particle Swarm Optimization (PSO) and Firefly optimization algorithms to find out which of the two optimization algorithms has superior performance in the classification process.

2. RESEARCH METHOD

In this research, the research method that will be carried out can be seen in Figure 1.

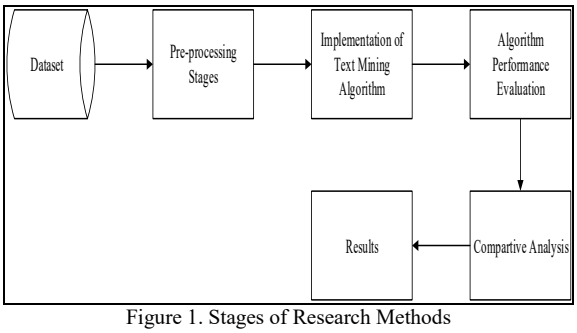

Figure 1. Stages of Research Methods

2.1 Dataset

The dataset used in this study was taken from the Kaggle website, namely Violence Report on Women and Children (https://www.kaggle.com/datasets/tassamoo/violence-report-on-women-and-children) with a total of 500 data samples. Table 1 shows the dataset used in this study.

Table 1. Research Dataset

ID	Category	Report Contents
1	*Fisik*	*Ibu saya sering pingsan dipukuli oleh ayah sampai berdarah-darah*
2	*Psikis*	*Sejak kecil, ayah saya tidak menyukai penampilan saya. Warna kulit dan wajah saya berbeda dengan keluarga yang lain. Ayah saya sangat membenci saya dan memaksa saya harus melakukan operasi plastik ketika sudah besar nanti.*
3	*Seksual*	*Pagi tadi saya iseng mengunggah sebuah foto selfi di internet. Lalu saya dapat kabar kalau teman kuliah saya melakukan masturbasi sambil melihat foto selfie saya. saya sangat takut*
4	*Seksual*	*ANAK SAYA DIGERAYANGI OLEH LAKI-LAKI TIDAK DIKENAL SAAT PULANG SEKOLAH. SAAT DISELIDIKI TERNYATA LAKI-LAKI TERSEBUT ADALAH ALUMNI SEKOLAHNYA. ANAK SAYA SANGAT TRAUMA SEKARANG*
5	*Fisik*	*Ada kasus pencabulan di SLB dekat rumah. Belum tertangani dengan baik sampai sekarang karena kasus masih sering terjadi*
6	*Seksual*	*Saya menemukan seorang anak SD yang dipegang-pegang badannya sama staf di sekolahnya*
7	*Psikis*	*Papa aku kalau ngomong suka kasar banget. Aku dikatain idiot lah, bego lah, goblok lah, anak gatau diuntung. Sakit sekali dengarnya. Ini aku nulis juga sambil nangis. Aku harap ada penyelesaian buat papa aku karena aku ga berani untuk bilang*
8	*Fisik*	*Sering terdengar teriakan di rumah tetangga saya. Setelah ditelusuri ternyata anaknya sering disiksa oleh ibunya. Dia disiram air panas, bibirnya diberi balsam, dan sering mendapatkan kekerasan fisik*
9	*Seksual*	*Dosen saya mengiming-imingi nilai besar jika mau berhubungan badan dengannya*
10	*Psikis*	*Saya benci dengan ibu saya karena dia selalu membuat kepercayaan diri saya hilang.*
11	*Seksual*	*Saya sering dipaksa melakukan hubungan badan dengan om saya*
12	*Fisik*	*Adik saya sering dipukul temannya sampai cacat fisik*
13	*penelantaran*	*Saya diharuskan bekerja oleh bapak dari pagi sampai sore dan hanya diberi makan satu kali dalam sehari*
14	*Psikis*	*Suami teman saya sering merendahkan fisik teman saya setelah melahirkan*
15	*Fisik*	*Ibu selalu ngancem bunuh aku kalau kerjanya ga bener*

2.2 Pre-Processing Stages

The pre-processing stages in this study are divided into several methods, namely [13]:

1. Tokenization.
   The process of separating text into smaller units such as words, phrases, or sentences [14].
2. Folding Case.
   The process of changing capital letters in a sentence to lowercase [15].
3. Stopword Removal.
   The process of removing words that are considered meaningless in a document [16].
4. Stemming.
   The process of obtaining basic words from derived words by removing suffixes, infixes, and confixes [17].

The pre-processing process is carried out directly using the Python programming language using Google Colab.

2.3 Implementation of Text Mining Algorithm

At this stage, the two text mining algorithms that will be analyzed in this study are implemented, namely the PSO and Firefly optimization algorithms against Support Vector Machine in classifying types of violence from reports of violence against children and women. The implementation of the algorithm is written using the Python programming language, namely Google Colab.

The application of the PSO-SVM and Firefly-SVM models in this study is carried out by optimizing the SVM hyperparameters, specifically the penalty parameter (C) and the kernel parameter (gamma), to obtain better classification performance. In the PSO-SVM model, the Particle Swarm Optimization algorithm is used to search for the optimal C and gamma values by simulating a group of particles moving through the solution space and updating their positions based on personal and global best solutions. Meanwhile, in the Firefly-SVM model, the Firefly algorithm is used to optimize C and gamma values based on the movement of fireflies that are attracted to brighter (better) solutions in the search space. After obtaining the best parameters through optimization, these parameters are then applied to train the SVM model for classifying the types of violence. Thus, PSO and Firefly algorithms serve as metaheuristic optimizers to improve SVM performance in this classification task.

2.4 Algorithm Performance Evaluation

The evaluation of the algorithm performance in this study was carried out using the Confusion Matrix, which is a cross-tabulation of positive and negative class data grouped into predicted classes and actual classes [18]. The values produced through the Confusion Matrix method are in the form of the following evaluations [19]:

1. Accuracy is the percentage of the number of data records that are correctly classified (predicted) by the algorithm.
   Formula: (TP + TN) / Total data = Accuracy (1)
2. Precision is the percentage of the ratio of true positive predictions compared to the total predicted positive results.
   Formula: TP / (TP + FP) = Precision (2)
3. Recall is the percentage of the ratio of true positive predictions compared to the total data that is true positive.
   Formula: TP / (TP + FN) = Recall (3)
4. Misclassification Error Rate is the percentage of the number of data records that are incorrectly classified (predicted) by the algorithm.
   Formula: (FP + FN) / Total data = Misclassification Rate (4)

2.5 Comparative Analysis

At this stage, a comparative analysis was carried out of the two text mining algorithms implemented in this study, namely the PSO and Firefly optimization algorithms against the Support Vector Machine in classifying the types of violence from reports of violence against children and women.

2.6 Results

The research results are in the form of a comprehensive discussion of the analysis that has been carried out, described in detail, and linked to previous research.

3. RESULT AND DISCUSSION

The test results obtained in this study were processed using the Python programming language with Google Colab. This study aims to implement the PSO and Firefly optimization algorithms on a Support Vector Machine in classifying types of violence from reports of violence against children and women and to compare the performance of the two algorithms.

3.1 Preparing the Dataset

The total dataset available is 500 data. Figure 2 below shows the dataset used in this study.

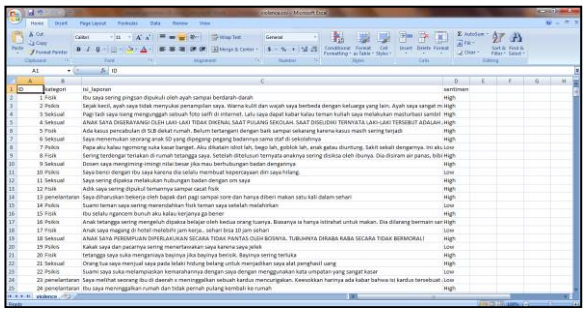

Figure 2. Research Dataset

There are 4 variable attributes in the dataset used in this study, namely ID, category, report content, and sentiment. However, only the category and report content attributes are used because this study focuses on testing the algorithm in classifying types of violence from reports of violence against children and women. To ensure that the dataset is appropriate, a pre-processing stage is required.

3.2 Pre-processing Results

The pre-processing stage of the dataset in this study was carried out by utilizing Google Colab based on Python programming. Before applying the text mining algorithm, the pre-processing stage was carried out to improve the accuracy of the analysis

results. Figure 3 shows the results of the pre-processing stage.

Figure 3. Dataset Before Preprocessing

In Figure 3, it can be seen that the text of the violence report underwent 4 stages of preprocessing, namely tokenization, case folding, stopword removal, and stemming so that the dataset, which was initially still raw data, became clean data that was ready for analysis.

3.3 Algorithm Implementation Results Text Mining

In this study, the implementation of the text mining algorithm was carried out to evaluate the performance of the PSO and Firefly optimization algorithms against the Support Vector Machine in classifying types of violence from reports of violence against children and women. The process of implementing the text mining algorithm was carried out using Google Colab with the Python programming language, as shown in Figure 4.

Figure 4. Results of Text Algorithm Implementation Mining

3.4 Algorithm Performance Evaluation Results

After the text mining algorithm, namely the PSO and Firefly optimization algorithms on the Support Vector Machine, are implemented and produce a model, then testing is carried out on the resulting model. Testing is carried out using a Confusion Matrix with a comparison between training data and testing data, namely 80% for training data and 20% for testing data [20]. The following are the results of the performance evaluation of the algorithms tested in this study:

1. The results of the performance evaluation of the PSO optimization algorithm on Support Vector Machine.

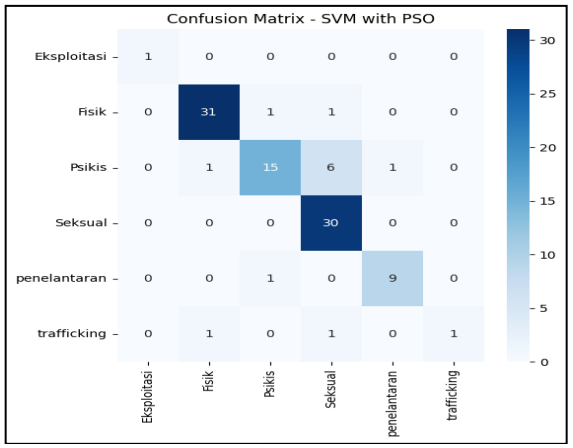

Figure 5. Confusion Matrix Plot of PSO Optimization Algorithm Against SVM

Based on Figure 5, it can be seen that the performance of the PSO optimization algorithm against SVM produces an accuracy of 87.00%, a precision of 91.53%, a recall of 80.42%, and a misclassification error of 13.00%.

2. The performance evaluation of the Firefly optimization algorithm on Support Vector Machine.

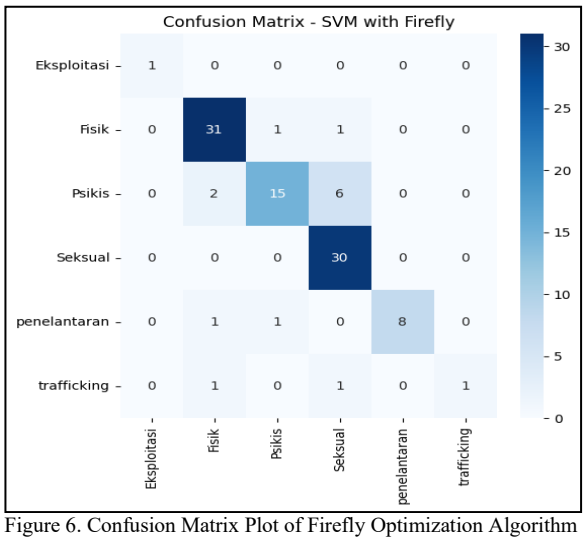

Figure 6. Confusion Matrix Plot of Firefly Optimization Algorithm Against Support Vector Machine

Based on Figure 6, it can be seen that the performance of the AdaBoost-based Decision Tree C4.5 algorithm produces an accuracy of 86.00%, a precision of 92.63%, a recall of 78.75%, and a misclassification error of 14.00%.

3.5 Comparative Analysis Results

After the algorithm performance evaluation process is carried out, a comparison is then made between the three algorithms tested in this study to determine which one is superior in determining the eligibility of a loan. The results of the comparative analysis are presented in Table 2 below.

Table 2. Results of Comparative Analysis of Algorithms

Algorithm	Acc	Precision	Recall	Misclassi

				fication Error
PSO + SVM	87.00	91.53	80.42	13.00
Firefly + SVM	86.00	92.63	78.75	14.00

The following Figure 7 shows a visualization in the form of a bar graph related to the results of the comparative analysis of the algorithms obtained in Table 2.

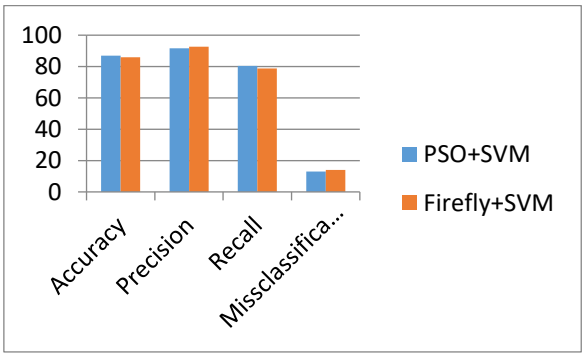

Figure 7. Bar Graph of Comparative Analysis Results of Algorithms

Based on Table 2 and Figure 7, it can be seen that the PSO + SVM algorithm has better overall performance compared to the Firefly + SVM algorithm. This is indicated by a higher accuracy value of 87.00% in PSO + SVM compared to 86.00% in Firefly + SVM, as well as a better recall value, which is 80.42% compared to 78.75%. Higher recall indicates that PSO + SVM is more effective in detecting positive cases. However, the Firefly + SVM algorithm has a higher precision, which is 92.63% compared to PSO + SVM which reaches 91.53%, so it is more accurate in minimizing errors in positive predictions. In terms of misclassification error, PSO + SVM excels with a lower value (13.00%) compared to Firefly + SVM (14.00%).

The better performance of PSO + SVM compared to Firefly + SVM can be explained by the optimization mechanism characteristics of each algorithm. PSO is a population-based optimization technique that emphasizes a balance between exploration and exploitation, allowing it to search more effectively for global optimal solutions without getting trapped easily in local optima. This advantage enables PSO to select feature subsets or hyperparameters that enhance the performance of SVM models more optimally. Meanwhile, the Firefly algorithm, although good at exploring the solution space, tends to be more exploratory and sometimes requires more iterations to converge to a global optimum, making it slightly less stable than PSO in achieving consistently high performance [21][22].

Next, the Receiver Operating Characteristic (ROC) graph metrics are shown in Figure 8 to provide a more complete picture of the performance of the algorithm model analyzed in this study.

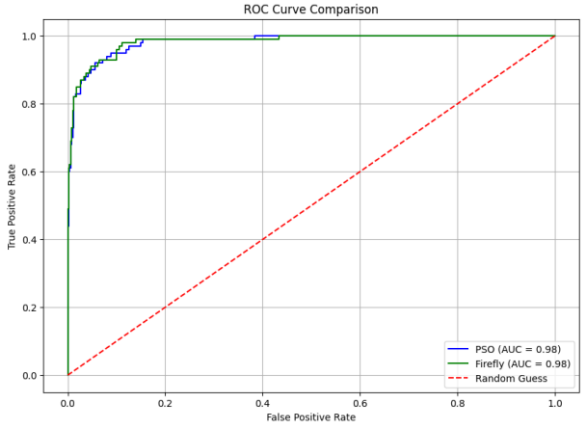

Figure 8. Receiver Operating Characteristics (ROC) Graph Results

Based on the ROC curves shown in Figure 8, the PSO + SVM and Firefly + SVM algorithms show excellent performance in distinguishing positive and negative classes, with an AUC value of 0.98 for both methods. However, although both have the same AUC, the superior performance of PSO + SVM in accuracy and recall shows that the classification boundary generated by PSO optimization tends to be more generalized and effective for positive case detection. This is very important in the context of violence report classification where missing a positive case (actual violence) can have a significant impact.

The results of the study showed that the PSO optimization algorithm against SVM has advantages in several evaluation metrics compared to the Firefly optimization algorithm against SVM. The accuracy of PSO against SVM which reached 87.00% indicates that this model can classify data better than the Firefly optimization algorithm against SVM which has an accuracy of 86.00%. This difference indicates that the PSO optimization method can improve the performance of SVM in building a more accurate classification model.

In addition, the recall value of the PSO optimization algorithm against SVM is higher than the Firefly optimization algorithm against SVM, which is 80.42% and 78.75%, respectively. Higher recall indicates that the PSO optimization algorithm against SVM is more effective in detecting positive cases, which means that this model is better at handling cases that are positive and reducing the number of misclassifications against the positive class. However, on the other hand, the Firefly optimization algorithm against SVM has a higher precision value (92.63%) compared to the PSO optimization algorithm against SVM (91.53%). Higher precision indicates that the Firefly optimization algorithm model against SVM is more accurate in minimizing errors in positive predictions, which means that this model is more selective in classifying an instance as positive.

In terms of misclassification error, the PSO optimization algorithm against SVM shows better performance with a lower value, which is 13.00%,

compared to the Firefly optimization algorithm against SVM which has a misclassification error value of 14.00%. This confirms that the PSO-based model is more effective in reducing the number of overall classification errors, which indicates the stability of the model in handling existing data variations.

Furthermore, based on the Receiver Operating Characteristics (ROC) curve, the PSO optimization algorithm against SVM and the Firefly optimization algorithm against SVM showed very good performance in distinguishing positive and negative classes. The Area Under Curve (AUC) value of 0.98 for both methods indicates that both have a very good ability to identify differences between different classes. However, the superiority of the PSO optimization algorithm over SVM in accuracy and recall indicates that this method is more suitable for scenarios that require better positive detection, while the Firefly optimization algorithm against SVM can be more reliable in conditions where precision is more important.

Nevertheless, the overall superiority of PSO + SVM especially in recall and accuracy metrics highlights that PSO's balance between exploration and exploitation helps the SVM model to form a more accurate and robust decision boundary. This is very beneficial for violence report classification tasks that require a higher ability to detect positive instances to minimize unhandled cases.

Overall, the results of this study indicate that the choice of optimization method greatly affects the performance of SVM in classification tasks. The PSO optimization algorithm is superior to SVM in terms of accuracy, recall, and misclassification error, making it a better choice for cases where positive detection is critical. In contrast, the Firefly optimization algorithm is superior to SVM in terms of precision, making it more suitable for situations where positive prediction errors must be minimized. Therefore, the decision to choose an optimization method must be tailored to the specific objectives and needs of the classification problem at hand.

4. CONCLUSION

Based on the research that has been conducted, several conclusions were obtained. The results of the study indicate that the implementation of the PSO and Firefly optimization algorithms on a Support Vector Machine (SVM) can be used to classify types of violence from reports of violence against children and women. Based on the test results, the PSO optimization algorithm on SVM is superior in several evaluation metrics. PSO accuracy reaches 87.00%, while Firefly reaches 86.00%. PSO recall is also higher, which is 80.42% compared to Firefly which is only 78.75%. On the other hand, although Firefly's precision is higher (92.63%) than PSO's (91.53%), the PSO algorithm has a lower misclassification error, which is 13.00%, compared to Firefly which has 14.00%. Thus, for applications that prioritize better detection of cases of violence, the PSO algorithm is more effective, while Firefly is more suitable for situations that prioritize positive prediction accuracy.

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