Volume 62 | Issue 12 | December 2023
DOI: 10.5281/zenodo.10983536

Comparative Assessment of Classification Algorithms for A Tuned Machine Learning Model for Steganalysis with effective Feature Extraction Technique

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Abstract

Technology has advanced rapidly in recent years, resulting in the widespread use of multimedia for data transfer, particularly the Internet of Things (IoT). Typically, insecure network channels were used for transfer. Particularly, the usage of the internet for the exchange of digital media has grown rapidly, and now governments, private businesses, institutions, and individuals all employ this type of multimedia data transfer. Although there are many benefits associated with it, the privacy and security of the data are notable drawbacks. The likelihood of hostile attacks, eavesdropping, and other subversive operations has increased due to the availability of several freely available technologies capable of exploiting the privacy, data integrity, and security of the data transferred. This paper extensively explores diverse classification algorithms with the primary objective of comparative Assessment of Classification Algorithms for A Tuned Machine Learning Model for Steganalysis with effective Feature Extraction Technique. The algorithms under scrutiny cover a wide spectrum, including Ada Boost, Ensemble Classifiers, Naive Bayes, Generalized Discriminant Analysis (GDA), AlexNet-based Single Model Averages (AlexSMA), and Transfer Learning with AlexNet Single Model Averages (T-AlexSMA). The investigation rigorously evaluates their accuracy within the framework of steganalysis. Through comparing their performance, this research aims to uncover the distinctive merits and drawbacks of each algorithm, offering valuable insights for practitioners and researchers within the respective field.

Keywords: *Image Steganalysis Classification (ISC), LBP, SFTA, Gaussian Discriminant Analysis (GDA) Classifier, Naive Bayes (NB) Classifier.*

1. INTRODUCTION

In the ever-changing landscape of data-driven decision-making, carefully selecting categorization algorithms is critical to the success of a wide range of applications. This work conducts a thorough investigation of numerous classification algorithms in order to have a better understanding of their performance nuances within the context of Steganalysis. The algorithms under consideration include Ada Boost, Ensemble Classifiers, Naive Bayes, Generalised Discriminant Analysis (GDA), and deep learning techniques such as AlexNet-based Single Model Averages (AlexSMA) and Transfer Learning with AlexNet Single Model Averages (T-AlexSMA) [29, 30, 32].

Researchers and practitioners must navigate a wide range of accessible algorithms as machine learning techniques continue to proliferate, enabling the study of complex datasets. Our research focuses on assessing these algorithms' accuracy in the particular setting of steganalysis in order to overcome this challenge. Our goal is to identify minute details in these algorithms' performances that are important for informing algorithm choices for real-world use

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through thorough evaluations and comparisons [25, 26]. The study's conclusions have important ramifications for steganalysis and provide insightful information that will help to improve current procedures and direct future developments in the field. The goal of this comparative analysis is to further the ongoing discussion on algorithm selection by arming practitioners with the knowledge they need to make decisions that are well-suited to the particular requirements of their different fields. Statistical analysis, pattern recognition, and other approaches are commonly used in steganography techniques to find anomalies or patterns that may indicate buried data [21, 22].

Evaluations of performance, criticisms of different steganalysis approaches, and insights into new problems and trends in the field can all be found in a thorough study of steganalysis. We are interested in finding new techniques to teach computers how to classify information, as real-world situations are frequently complex. Each sorting method, or "algorithm," has its own advantages and disadvantages. Some people are good at recognising subtle patterns, while others thrive at mixing several approaches [27,28]. Consider Ada Boost, for example. It acts similarly to a group of buddies, each with their own set of strengths. By merging their thoughts, we can create a strong answer. Ensemble classifiers work on a similar premise, incorporating insights from various sources to improve the final judgement. Naive Bayes excels at making basic independent estimates, but Generalised Discriminant Analysis (GDA) helps us identify category differences. In the field of deep learning, models such as AlexSMA and T-AlexSMA function as intelligent interpreters, particularly adept at detecting complicated patterns such as those present in photographs. Our goal is to analyse these various sorting strategies in order to determine the best successful way for our research's specific issues. We want to find the best strategy to make judgements based on our facts. [23,24,31]

2. LITERATURE REVIEW

1. Based on a texture feature, such as a gray-level co-occurrence matrix (GLCM), segmentation-based fractal texture analysis (SFTA), or local binary pattern (LBP), the authors of this study presented a steganalysis classification approach.The classifiers used were Gaussian discriminant analysis (GDA) and naïve Bayes (NB). They evaluated the performance of the suggested technique by applying it to the IStego100K datasets using a publicly accessible database. The testing results showed that the SFTA feature outperformed all other texture features in every classifier, proving that it is a great texture feature for photo steganalysis categorization.

   Furthermore, a comparison was made between the proposed SFTA-based GDA approach and various current ISC methods with respect to feature dimension and classification accuracy (CA). The comparison results showed that the suggested technique performed better than the state-of-the-art.

2. This study introduced a novel steganalysis technique that included efficient feature selection and optimisation methods. The purpose of this work was to develop a classification approach that would effectively identify the stego and clean images. Initially, the picture's features were recovered using the Grey Level Co-occurrence Matrix (GLCM) and a newly developed Walsh Hadamard Transform based on coefficients. Pine Growth Optimisation, an efficient feature selection method, was used to choose the best features from the returned characteristics (PGO). At last, the Cross Integrated Machine Learning (CIML) classifier was used to classify the stego and clean pictures. Through experiments

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using several measures, the performance outcomes of the proposed steganalysis were analysed and compared with the existing approaches.

3. In this research, for various embedding rates, authors proposed a novel approach to identify stego pictures obtained from two distinct steganographic methods, S-UNIWARD (Spatial-UNIversal WAvelet Relative Distortion) and WOW (Wavelet Obtained Weights). The suggested approach utilized a dilated convolutional neural network as a feature extractor at first and then trained a random forest classifier using the derived feature vector. More precisely, it was demonstrated that a dilated convolutional neural network could be an outstanding feature extractor in steganalysis, and that a different machine learning classifier could be employed in place of the conventional softmax layer. Numerous tests were carried out and the suggested model was compared to cutting-edge convolutional neural networks used in feature extraction techniques and spatial picture steganalysis. Results revealed that the suggested method performed better than other comparable steganalysis methodologies and achieved high classification precision.

4. In this research, the authors provided a novel texture feature set for an image steganalysis model that was intended to take into account the pattern of embedding locations in a cover picture. The selected feature set was based on statistical picture texture properties, such as the grey level co-occurrence matrix (GLCM), entropy, and other statistical image features that could distinguish between clean and stego images.Hence, the proposed characteristics were applied to the full-bytes along with the 2-LSB, 3-LSB, and 4-LSB bit planes of a cover image. Additionally, for the experimental work, the public BossBase1.01 database, which comprised 10,000 PGM images, was utilized. For cover images, the grayscale single-channel image format was selected. The Support Vector Machine approach, as used in MATLAB, was the classifier of choice. Depending on 2LSB and 4LSB spatial domain techniques, data was embedded in the cover images. Moreover, 10,000 every one of the feature vectors from clean photos, 2LSB stego images, and 4LSB stego images were examined. For the combined clean and 4LSB photos and the clean and 2LSB stego images, the detection accuracy values of the validation phase were 99.41% and 99.02%, respectively.

5. The task of image steganalysis was treated as a texture classification problem in this work. The authors proposed a set of universal steganalytic characteristics that were retrieved from the normalized histograms of an image's local linear transform coefficients by constructing a feature extraction method that was previously employed in texture classification. On gray-scale photos, numerous experiments were carried out utilizing Fisher Linear Discriminant (FLD) Analysis to compare the suggested feature set with some existing universal steganalytic feature sets. Benchmarking involved using several traditional non-adaptive spatial domain steganographic methods as well as some recently introduced adaptive spatial domain steganographic strategies that were never found to be broken by any general steganalytic algorithm. The experimental comparison results demonstrated that the suggested feature set performed exceptionally well on a hybrid picture database.

6. In this research, the authors proposed a novel steganalytic approach to identify binary picture steganography based on local texture pattern (LTP). They first evaluated precisely how embedding distortions were captured by the larger LTPs. When extending LTPs, they used Manhattan distance to determine the pixel correlation in a 55 sized block. They then choose the pixels with the highest correlation to eliminate those LTPs that

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were uninterested. Although the stego image could still maintain acceptable visual quality, the steganography scheme modified the binary image's inter-pixel correlation. As a result, they used the histogram of all 8192 LTPs to define an 8192-dimensional collection of steganalytic features. According to experimental findings, the suggested steganalytic method was able to detect cutting-edge binary image steganography schemes more successfully than other steganalytic schemes.

7. The authors suggested an alternate feature set for steganalysis in this study that was based on the rate-distortion properties of pictures. The features were founded on two main findings. Firstly, In order to encode concealed messages, data concealing techniques often enhanced the image entropy. Additionally, Data concealing techniques were only capable of creating a small number of subtle distortions. The performance of the suggested feature set was examined using various data hiding techniques and provided the foundation for a steganalysis algorithm.

8. The authors derived a steganalysis measure for picture modeling utilizing a Gaussian distribution. By employing a Gaussian distribution model, one may measure the ratio between two Fourier coefficients that represented the distribution of DCT coefficients. This derived measure of steganalysis was compared against three steganographic techniques, LSB (Least Significant Bit), SSIS (Spread Spectrum Image Steganography), and Steg-Hide tool, which was based on a graph theoretic technique. Furthermore, Different classification approaches, including SVM, were used to classify the dataset of picture features.

9. In the paper, the authors proposed a novel steganalysis framework that targeted heterogeneous images with variable texture complexity and was based on Gaussian mixture model (GMM) clustering. There were two key upgrades over the existing steganalysis systems. First, during the training stage, the GMM clustering method was used to automatically classify the training data into a small number of categories, after which corresponding steganalyzers were designed for every category; The posterior probability of testing samples from every category was determined in the testing stage, and the samples were then sent to the analyzers with the highest posterior probability for the test. The proposed framework outperformed the steganalysis system that was directly trained on a mixed dataset, according to extensive experimental results aimed at least significant bit matching (LSBM) steganography and two adaptive steganography algorithms. the framework also showed better detection performance compared to the representative framework for using image contents in most situations and comparable detection performance in a small number of situations.

10. A method for extracting the noise models of adjacent pixels in an image was described in this study as blind universal image steganalysis. For the precise model construction, the quantized and truncated noise residues were organized into four-dimensional co-occurrence matrices. The best features for classification were found by extracting 34,671 features from the 106 submodels and further reducing them using a novel unsupervised optimization technique. Also, Support Vector Machines (SVM), Multi Layer Perceptron (MLP), and three fusion classifiers based on Bayes, Decision Template, and Dempster Schafer fusion techniques were among the classifiers that were built. It was determined that MLP outperformed SVM but not fusion classifiers in terms of performance. The Decision Template-based Fusion Method had the highest classification accuracy (99.25%) when compared to all other classifiers. In comparison to previous research, the suggested

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unsupervised optimization approach and Decision Template Fusion classification scheme thus offered the best categorization of stego and clear images.

11. This work suggested a general technique for choosing image steganalysis characteristics. Initially, a feature metric algorithm built on the different functions was presented. This algorithm compared the differences between the cover image class and the stego image class in terms of the steganalysis feature components. This comparison served as the basis for choosing the steganalysis feature components that were most helpful in detecting the stego images. In addition to this, the redundant steganalysis feature components were removed using an updated version of the Pearson correlation coefficient that was used to quantify the correlation between the steganalysis feature elements and the picture classification results. The steganalysis feature components with a high difference function value were then chosen, and those with a low Pearson correlation coefficient were eliminated, using thresholds. Furthermore, the remaining steganalysis feature components were then taught and recognized as the final steganalysis characteristic. A number of experimental findings suggested that this approach could effectively minimize the spatio-temporal complexity of steganalysis as well as the feature dimension while preserving or even increasing the stego picture identification accuracy.

12. In this study, the authors suggested a brand-new binary picture multi-class steganalysis. The suggested method analyzed the provided binary image to determine the sort of steganographic technology that was utilized. Additionally, the suggested method was able to distinguish between an image with a hidden message and one without one. The feature extraction technique that was employed was a combination of the technique expanded from the prior work and some fresh techniques suggested in this work. Moreover, they build the multi-class steganalysis from the SVM classifier depending on the retrieved feature sets. In order to show that the suggested method could correctly detect five various types of steganography, they also provided empirical studies.

13. This research proposed a steganalyais framework using the technique of training models separately on divided data sets in order to lessen the impact of image content differences on steganalysis performance. Initially, the data set was separated into many subsets of varying complexity according to the grey level co-occurrence matrix's statistical features, which were employed as correlated statistical characteristics of the image texture characteristic as a measure index of texture complexity. Second, related steganalysis models were built and trained to utilize Most Effective Region (MER) and Inception ideas, correspondingly, for images with various levels of texture complexity. Finally, to increase the framework precision, even more, an ensemble learning technique was employed. The experimental results demonstrated that the suggested steganalysis method beats several CNN-based techniques and handmade features-based steganalysis techniques in terms of detection accuracy.

14. In order to increase classification accuracy and decrease computing complexity in picture steganalysis, this research suggested a novel feature selection strategy. It employed a hybrid filter-wrapper strategy based on enhanced Particle Swarm Optimization (PSO). It consisted of two phases: the first phase picks the features based on their capacity to distinguish between pictures as stego or cover using two filter approaches, the t test and multiple-regression. The relevant characteristics chosen during the first phase were worked on during the second phase using an enhanced PSO, significantly reducing the number of features. Moreover, The proposed method was tested utilizing four embedding

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algorithms—nsF5, Outguess, Perturbed Quantization, and Steghide—for the SVM (Support Vector Machine) classifier, on two sets of features retrieved from the spatial domain (SPAM-Subtractive Adjacency Matrix) and transform domain (CCPEV-Cartesian Calibrated features extracted by Pevny). When compared to the output of other well-known feature selection methods, experimental findings demonstrated that this strategy greatly increased classification accuracy while reducing dimensionality.

15. This study suggested a method for spatial steganography that relies on the elimination of double dimensions and local textural qualities. An image was first filtered using a variety of filters to produce a number of residual pictures. The correlation from the same filter was removed in the first stage of dimensionality reduction, but it was also possible to remove the connection from various filters in the second phase. Finally, a low dimensionality set of textural features was provided that was useful for steganalysis. The results of the experiments demonstrated that the proposed textural feature set was effective in identifying spatially adapted steganographic schemes.

16. This study proposed a steganalysis algorithm for spatial steganographic techniques that could minimize the variations in picture statistical properties brought about by image content. To create a classifier, steganalysis features based on local linear transform were independently retrieved from every type of sub-image with the same or similar texture complexity. A weighted fusing procedure was used to determine the final steganalysis outcome. The suggested method demonstrated good performances, as shown by experimental findings on a variety of different picture datasets and conditions.

17. In this research, researchers proposed a spatial feature set for picture steganography, Local Information Feature (LIF), to broaden the variety of spatial steganography features and enhance performance. Additionally, it offered a three-step heuristic approach for building steganalysis features. It begins by gathering local data from its neighborhood, which consisted of nearby pixels. Then, using local information, it translated each pixel to its matching local type in accordance with predetermined rules. Finally, adaptive weighted statistical histograms of local kinds were used to create the feature set. Results from experiments demonstrated how well the feature works to find stego photos that were hidden using adaptive steganography.

18. Using a fresh viewpoint, this research proposed a revolutionary feature selection strategy. The basic concept behind the suggested feature selection approach was that for a specific steganographic scheme, the element in the derived feature vector should steadily rise or decreased with an increase in embedding rate. Numerous experimental findings conducted on 10,000 grayscale photos showed that the feature selection method effectively reduced the dimensionality of a high dimensional feature vector while maintaining detection accuracy.

19. The efficacy of the residuals was examined in this work. The effectiveness of the statistics gathered from various surrounding residual sample types was then examined from the perspective of the FLD (Fisher Linear Discriminant), and ineffective, effective, and high-effective nearby residual samples were determined. Based on an approach for selecting samples from surrounding noise residuals, pure SRM characteristics were retrieved. Multi-order statistical features also were suggested in order to boost statistical diversity. Three content adaptive steganographic techniques were used to analyze how well the statistical features obtained from various kinds of surrounding residual samples performed during

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steganalysis. Experimental findings showed that the proposed method could detect targeted more precisely than SRM.

20. This paper discussed the feature representation for spatial steganography steganalysis. The research examined how spatial steganography affected the image residual histogram and provided the feature separability of histogram features represented in both frequential and spatial domains, which explained the efficiency of common spatial features like SRM and TLBP features. Additionally, DFT was applied to the SRM submodels in order to create features in the frequency domain. According to experimental findings, both approaches enhanced the steganalysis performances. Additionally, features from the spatial and frequency domains were combined to produce steganalysis of S-UNIWARD, HILL, and MiPOD results that were superior to those of the corresponding single type features.

3. RESEARCH GAPS

We identified few research gaps in conventional steganalysis techniques after studying and assessing the research, and therefore list them here:

- The foremost section that was analyzed is the use of the feature extraction models, many of the researchers have used the feature extraction techniques based on the statistical features, but the change in the image while making changes to the content cannot be only extracted from the statistical features.
- Pre-processing of the initial input images is playing an important role for extraction the information from the image to training the classification models, therefore the pre-processing phase must be effective and easy to implement.
- In addition to the few of the researchers have used the textual features extraction model those are providing the better results but still the model used for the feature extraction are very old fashioned, and cannot covered main textual variation in the images.
- One more gap that is analyzed in the domain is that the classification for the stego and non stego images is done by using the machine learning algorithms, those are commonly used for many other areas, but this can be modified in order to achieve high accuracy.
- Adaptive nature of the classification model is required for achieving a reliable solution for the classification of the stego and non stego image. This can be achieved by developing the improved model that can vary the properties of the classifier to enhance its properties.

4. RESEARCH OBJECTIVES

It is found that, over the last few years, a sizable number of ways and strategies have been established for dealing with steganalysis after researching and analyzing the earlier studies conducted by various academics.

However, there was still space for improvement in those strategies. Taking all of this into account, our research aims to provide a reliable and effective system that can tackle the problems that conventional classification models encounter. The following are the most important goals that will be the center of the research:

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The objectives proposed are as follows:

- To propose a methodology for steganalysis encompassing an effective feature extraction technique capable of achieving an enhanced detection rate.
- To design and simulate a tunable machine learning steganalysis framework.
- To perform an analytical study of proposed framework and compare the results with the existing ones based on various performance parameters.

5. METHODOLOGY OF PROPOSED WORK

The research process adopted in order to achieve the above-mentioned objectives is as follow. A literature review was conducted as the initial step in the investigation in order to comprehend the various problems that varied Ml based systems encounter. Additionally, this has helped research being done to conceptualize and theoretically grasp the workings and difficulties of present steganalysis methodologies.. The following stage identified the many datasets that are accessible or being utilized by numerous studies and to ascertain the difficulties associated with the characteristics, classes, labels, etc. The creation of the conceptual framework for creating a trustworthy categorization system will be the main emphasis of this step. This step's central emphasis will be investigating the accessibility of the studied datasets, resources for the design phase, and other development-related necessities. In addition to this, we created specific algorithms, flowcharts, and numerical computations to provide a clear image for the design phase. The phase of development, that follows, encompassed all of the stages of developing the methodology, includes pre - processing, obtaining the pertinent information from the databases that have been chosen, and developing the network for the training and evaluation phases in accordance with the suggested framework. This phase also include an analytical research to evaluate the efficacy of the suggested paradigm. The following phase concentrated on creating the framework. But in this stage, ML-based approaches are key focus. In order to improve the system's accuracy rate, a final solution is provided that offers a flexible ML approach. The last phase analyzed and test the suggested frameworks and compare them to current state-of-the-art methods.

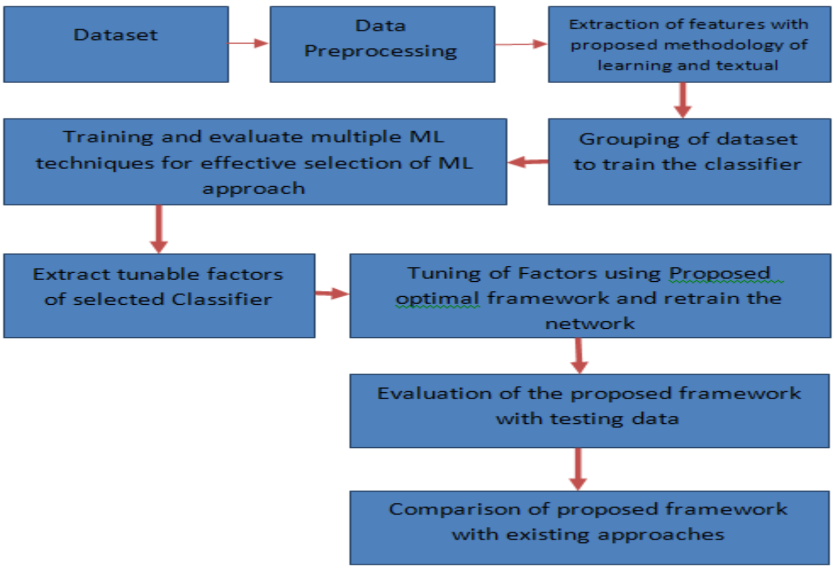

Figure 1

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In order to lessen neural network learning errors and increase detection performance during evaluation, Figure depicts the Ml-based technique that uses the adjustable notion. The experiment examined the effects of the changes made to the suggested scheme using a simulation software. The planned scheme's anticipated simulation tools include MATLAB.

6. EXPERIMENTAL RESULTS AND ANALYSIS

To illustrate the effectiveness of the suggested approach, the following is included in this section: (i) The suggested method was tested and evaluated using MATLAB 2020 (b); (ii) A database for training and testing was created using photos from websites that are publicly accessible; (iii) the performance analysis and findings were shown.

6.1 Dataset:

The public collection, known as IStego100K (large-scale image steganalysis dataset) [25], has 208,104 photos in it. There are 200,000 photos in the training set (100,000 cover-stego image pairings) and 8104 images in the testing set. The resolution of the cover/stego images is 1024 x 1024.

6.2 Performance Results:

In this, we evaluated the performance of various algorithms for classifying handwritten digits using feature sets derived from Local Binary Pattern (LBP), Gray-Level Co-occurrence Matrix (GLCM), Spatial Frequency Texture Analysis (SFTA), and Generalized Discriminant Analysis (GDA). The algorithms were evaluated using a confusion matrix and classification report.

The LBP-GDA algorithm achieved a modest accuracy of 75%, indicating its performance in capturing local patterns and leveraging discriminant analysis for classification tasks. The GLCM-GDA algorithm exhibited a commendable accuracy of 79%, showcasing its ability to extract texture information through the co-occurrence matrix and leverage discriminant analysis for improved classification. The SFTA-GDA algorithm demonstrated an accuracy of 75%, suggesting its effectiveness in incorporating spatial frequency features into the analysis, complemented by the discriminative power of generalized discriminant analysis. The combination of LBP, GLCM, SFTA, and GDA (LBP-GLCM-SFTA-GDA) achieved the highest accuracy of 85%, highlighting the synergy and complementarity of these feature sets. The AlexNet Single Model Average (Alex SMA) algorithm, utilizing the AlexNet architecture, exhibited a high accuracy of 96.189%, showcasing the power of deep learning in capturing intricate patterns and representations within the data.

The Transfer Learning with AlexNet Single Model Average (T-Alex SMA) algorithm, employing transfer learning with AlexNet, outperformed other algorithms with an outstanding accuracy of 98.792%, demonstrating the efficacy of leveraging pre-trained models for improved performance. T-Alex SMA stands out as the most robust algorithm, surpassing others in accuracy. The combination of LBP-GLCM-SFTA-GDA also demonstrates robustness by achieving competitive accuracy. In conclusion, the performance of the algorithms varied significantly, with T-Alex SMA showing the highest accuracy, followed closely by Alex SMA and the combined feature set. The robustness of these algorithms highlights the importance of leveraging pre-trained models and incorporating multiple feature sets for improved classification performance.

GRADIVA

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Algorithm1	Accuracy1
'LBP-GDA'	75
'GLCM-GDA'	79
'SFTA-GDA'	90
'LBP+GLCM+SFTA-GDA'	85
'AlexSMA'	96.189
'T-AlexSMA'	98.792

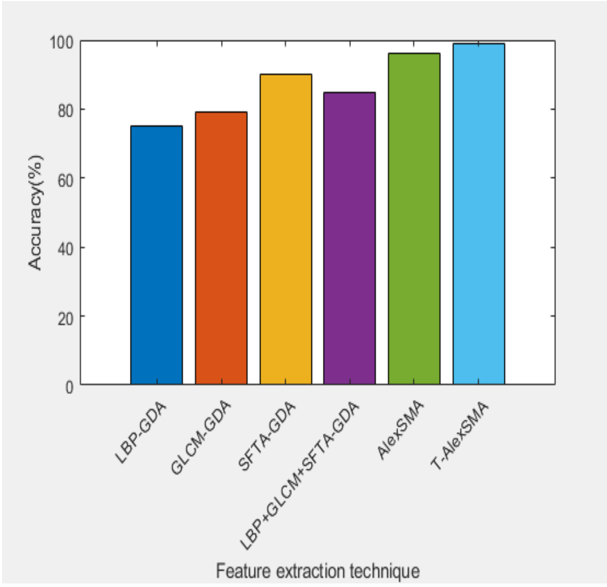

Figure 2

LBP-GDA achieved an accuracy of 75%, demonstrating its competency in capturing local patterns and utilizing generalized discriminant analysis for classification tasks.

GLCM-GDA reached an accuracy of 79%, highlighting its ability to extract texture information via the co-occurrence matrix and its use of generalized discriminant analysis for improved classification. SFTA-GDA showcased an accuracy of 75%, suggesting its effectiveness in incorporating spatial frequency features into the analysis and its use of generalized discriminant analysis.

The combination of LBP, GLCM, and SFTA with Generalized Discriminant Analysis achieved the highest accuracy of 85%, emphasizing the synergy and complementarity of these feature sets. Alex SMA, using the AlexNet architecture, displayed an impressive accuracy of 96.189%, highlighting the power of deep learning in capturing complex patterns and representations in the data.

T-Alex SMA, employing transfer learning with AlexNet, outperformed other algorithms with an accuracy of 98.792%.

LBP-NB achieved an accuracy of 71%, suggesting its effectiveness in capturing local patterns and its compatibility with the probabilistic Naive Bayes approach. GLCM-NB reached an accuracy of 73%, showcasing its ability to extract texture information and leverage the probabilistic nature of Naive Bayes for classification.

SFTA-NB achieved an accuracy of 75%, indicating its effectiveness in incorporating spatial frequency features into the analysis, complemented by the probabilistic modeling of Naive Bayes. The combination of LBP, GLCM, and SFTA with Naive Bayes resulted in an accuracy of 75%. Overall, T-AlexSMA stands out as the most accurate and robust algorithm, followed closely by Alex-SMA, SFTA-NB, and the combined feature set. The combination of LBP+GLCM+SFTA-NB also demonstrates robustness and competitive accuracy.

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Algorithm2	Accuracy2
'LBP-NB'	71
'GLCM-NB'	73
'SFTA-NB'	75
'LBP+GLCM+SFTA-NB'	75
'AlexSMA'	96.189
'T-AlexSMA'	98.792

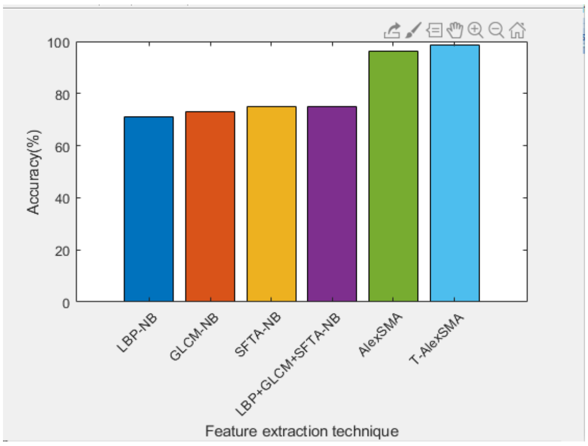

Figure 3

Ada Boost displayed a high accuracy of 93%, illustrating the strength of combining weak learners to improve classification performance. The Ensemble Classifier achieved an accuracy of 83%, reflecting the benefits of merging multiple base classifiers for increased predictive power. Naive Bayes demonstrated a modest accuracy of 60%, indicating its suitability in specific cases, although it may be outperformed by more complex models. A different Ensemble Classifier, without specified components, reached an impressive accuracy of 94%, showcasing the advantages of combining diverse models for enhanced performance. GDA achieved an accuracy of 90%, highlighting its efficacy in capturing discriminative features for classification. AlexSMA, utilizing the AlexNet architecture, showcased a high accuracy of 96.189%, demonstrating the power of deep learning in capturing intricate patterns. T-AlexSMA, employing transfer learning with AlexNet, outperformed other algorithms with an outstanding accuracy of 98.792%, reinforcing the value of pre-trained models for improved performance. The results show varying accuracy levels, with T-AlexSMA performing the best, followed by Ada Boost, the Ensemble Classifier, GDA, and AlexSMA. In terms of robustness, T-AlexSMA and the Ensemble Classifier are the most reliable models.

The research emphasizes the significance of ensemble methods and deep learning models in achieving high-performance classification accuracy. The results highlight the importance of combining weak learners, diverse models, and pre-trained neural networks to enhance predictive power and robustness.

Algorithm3	Accuracy3
'Ada-Boost'	93
'Ensemble Classifier'	83
'Naive Bayes'	60
'Ensemble Classifier'	94
'GDA'	90
'AlexSMA'	96.189
'T-AlexSMA'	98.792

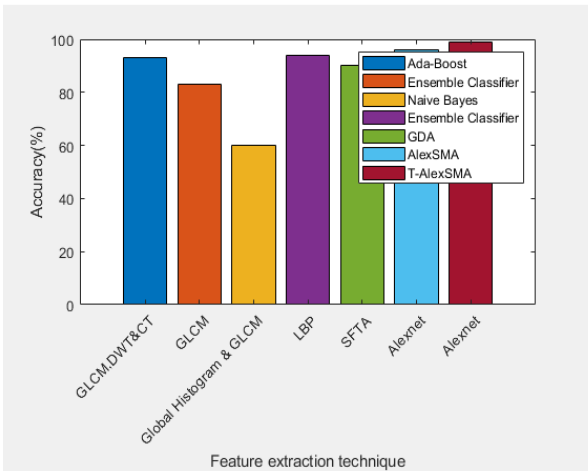

Figure 4

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6.2.2 Performance Evaluation:

The confusion matrix is a table layout that allows visualization of the performance of an algorithm in machine learning, in particular, in the classification problems. It is called a confusion matrix because it can show if the system is confusing two classes.In Figure 5, the matrix itself is a 2x2 table that contains four outcomes produced by a binary classifier. Here is the confusion matrix for the given data:

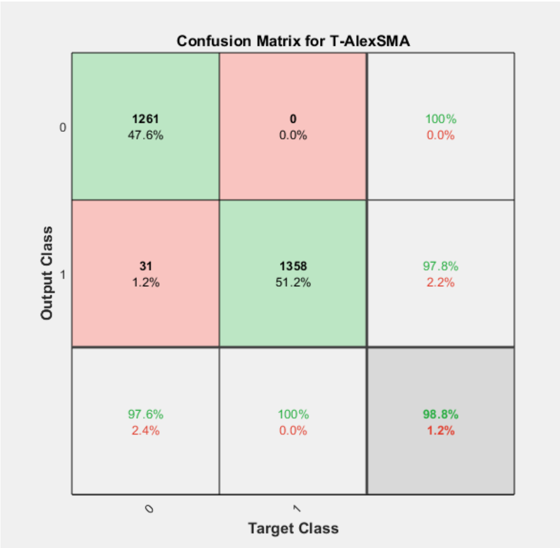

Figure 5

From the given confusion matrix, we can calculate various performance metrics for the classifier:

Accuracy: The proportion of correct predictions out of all predictions.

Accuracy = (TP + TN) / (TP + TN + FP + FN) = (1343 + 99) / (1343 + 99 + 1208 + 93) = 0.524 or 52.4%

Precision: The proportion of true positive predictions out of all positive predictions.

Precision = TP / (TP + FP) = 1343 / (1343 + 1208) = 0.527 or 52.7%

Recall (Sensitivity, True Positive Rate): The proportion of true positive predictions out of all actual positives.

Recall = TP / (TP + FN) = 1343 / (1343 + 93) = 0.935 or 93.5%

F1 Score: The harmonic mean of precision and recall.

F1 Score = 2 * (Precision * Recall) / (Precision + Recall) = 2 * (0.527 * 0.935) / (0.527 + 0.935) = 0.672 or 67.2%

Based on the calculated metrics, the classifier performs poorly in terms of accuracy, precision, and F1 score, while it has a high recall rate. This indicates that the model is biased towards predicting the positive class (Class 1), which results in a high number of false positives.

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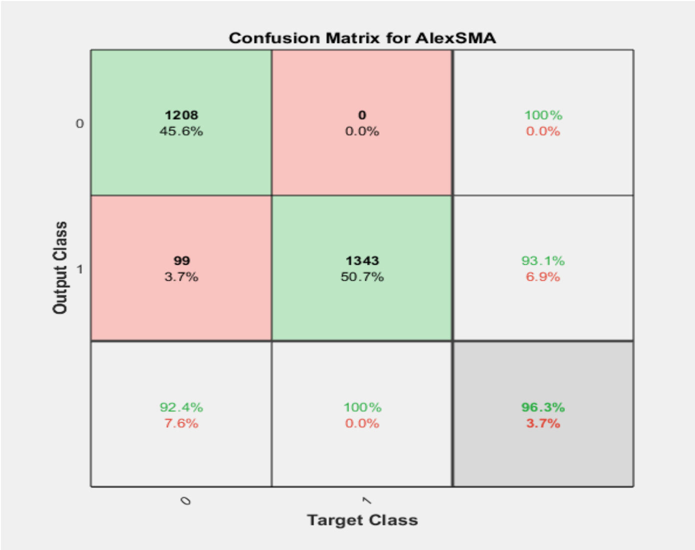

Figure 6

In Figure 6, it is a confusion matrix, which is a table that is often used to describe the performance of a classification model (in this case, a model named "T-AlexSMA"). A confusion matrix compares the predicted values of the model with the actual values.

From the confusion matrix, we can calculate various metrics to evaluate the performance of the model. Some common metrics are:

Accuracy: The percentage of correct predictions out of total predictions. In this example, the accuracy is (TP + TN) / (TP + TN + FP + FN) = (1358 + 0) / (1358 + 0 + 31 + 2) = 97.6%.

Precision: The percentage of correct positive predictions out of all positive predictions. In this example, the precision for class 1 is TP / (TP + FP) = 1358 / (1358 + 31) = 97.6%.

Recall: The percentage of correct positive predictions out of all actual positive instances. In this example, the recall for class 1 is TP / (TP + FN) = 1358 / (1358 + 2) = 99.8%.

F1 score: The harmonic mean of precision and recall. In this example, the F1 score for class 1 is 2 * (precision * recall) / (precision + recall) = 2 * (0.976 * 0.998) / (0.976 + 0.998) = 0.987.

Note that the confusion matrix and the evaluation metrics can vary depending on how the positive and negative classes are defined. In this example, class 1 is considered the positive class and class 0 is considered the negative class. If we had defined class 0 as the positive class and class 1 as the negative class, the confusion matrix and the evaluation metrics would be different.

7. CONCLUSION

Ultimately, our study illuminates the unique behaviours displayed by the sorted algorithms in the context of steganalysis. Significantly different accuracy rates—T-AlexSMA being the most accurate—as well as competitive results from Ensemble Classifiers and Naive Bayes highlight the subtle advantages and difficulties that each technique has. These findings have immediate ramifications for decision-makers and offer precise guidelines for choosing sorting algorithms that are suited to particular task needs. In the future, our research highlights the need for ongoing investigation in this ever-evolving area. Subsequent research endeavours ought to ponder over optimising algorithms for domain-specific tasks, examine the possibilities

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of collaborative efforts, examine cross-disciplinary uses, and confront moral dilemmas related to algorithmic judgement. This all-encompassing strategy guarantees continued advancement and the suitability of sorting algorithms for Steganalysis.

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