PERFORMANCE ANALYSIS AND DISCUSSION

This section provides a comprehensive evaluation of four machine learning models like Bernoulli Naive Bayes, Logistic Regression, Multinomial Naive Bayes, and a Hybrid Model which applied to the experiment of fake news detection. Through detailed analysis of confusion matrices, performance metrics, and ROC curves, we assess each model's accuracy and ability to distinguish between real and fake news, laying the foundation for an in-depth discussion of their strengths and weaknesses.

Figure 3(a) illustrates the confusion matrix for the Bernoulli Naive Bayes model in the context of fake news detection. The model successfully classified 5,507 fake news articles (true negatives) and 6,855 real news articles (true positives). However, it incorrectly labeled 1,322 real news articles as fake (false positives) and 743 fake news articles as real (false negatives). The model shows a reasonable performance, especially in correctly identifying real news, though it struggles with a higher rate of false positives. This suggests that while the Bernoulli Naive Bayes model can be effective, there is significant room for improvement in its ability to accurately distinguish between real and fake news, particularly in reducing false positive rates. Figure 3(b) displays the confusion matrix for the Logistic Regression model applied in the fake news detection task. The model accurately classified 6,615 fake news articles (true negatives) and 7,063 real news articles (true positives). It made 474 false positive errors (real news classified as fake) and 275 false negative errors (fake news classified as real). The Logistic Regression model demonstrates a high level of accuracy, particularly in minimizing false negatives, indicating a strong ability to correctly identify real news. The relatively low false positive rate also suggests that the model effectively distinguishes between real and fake news, making it a reliable choice for this binary classification task in the context of fake news detection. Figure 3(c) shows the confusion matrix for the Multinomial Naive Bayes model used in the fake news detection task. The model accurately identified 6,308 fake news articles (true negatives) and 6,364 real news articles (true positives). It misclassified 521 real news articles as fake (false positives) and 1,234 fake news articles as real (false negatives). The Multinomial Naive Bayes model demonstrates strong performance, particularly in correctly identifying fake news, as indicated by the low number of false positives. However, the model still shows some difficulty in detecting real news, as evidenced by the false negatives. Overall, this model effectively distinguishes between fake and real news but has potential for further improvement, especially in reducing false negatives. Figure 3(d) presents the confusion matrix for the Hybrid Model applied to fake news detection. The model accurately classified 6,444 fake news articles (true negatives) and 7,325 real news articles (true positives). It made 385 false positive errors (real news classified as fake) and 273 false negative errors (fake news classified as real). The Hybrid Model demonstrates superior performance compared to individual models, particularly in minimizing both false positives and false negatives. This suggests that the model effectively balances the strengths of its constituent algorithms, achieving high accuracy in distinguishing between real and fake news. The low rates of misclassification indicate that the Hybrid Model is highly reliable for the task of fake news detection.

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| A chart of a hybrid model  Description automatically generated with medium confidence | | |

Figure 3: Confusion Matrix of Machine Learning Models

Figure 4 presents the performance evaluation metrics—Recall, F1-score, Precision, and Accuracy across four machine learning models: Multinomial Naive Bayes, Bernoulli Naive Bayes, Logistic Regression, and a Hybrid Model. The Multinomial Naive Bayes model demonstrates the lowest recall (83.77%) and accuracy (89.46%), indicating a limited ability to capture all relevant instances, particularly within the positive class. Although it achieves a relatively high precision (92.43%), its F1-score (87.88%) reflects a moderate balance between precision and recall, suggesting the model may struggle with the complexity of the dataset. The Bernoulli Naive Bayes model shows slight improvements over the Multinomial variant, with a recall of 85.43% and an accuracy of 85.45%. The precision (85.98%) and F1-score (85.57%) are more balanced, indicating consistent, albeit modest, performance across all metrics. In contrast, the Logistic Regression model exhibits significantly enhanced performance, achieving a recall and precision of 95.16%, leading to a high F1-score of 95.86% and accuracy of 94.23%. This demonstrates the model's robustness in both capturing relevant instances and minimizing false positives, making it a reliable choice for binary classification tasks. The Hybrid Model outperforms all others, with the highest recall (96.41%), precision (95.01%), and accuracy (96.19%), resulting in an F1-score of 95.7%. This model excels in maximizing both recall and precision, indicating its superior capability in accurately distinguishing between fake and real news. The Hybrid Model's balanced and high performance across all metrics makes it the most reliable and effective model for this task, setting a benchmark for fake news detection methodologies.

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Figure 4: Performance Evaluation Matrix Scores

Figure 5 (a-d) presents the ROC curves for the Multinomial Naive Bayes, Bernoulli Naive Bayes, Logistic Regression, and Hybrid models, respectively, offering a comparative analysis of their performance in fake news detection. Figure 5(a) illustrates the ROC curve for the Multinomial Naive Bayes model, which achieves an AUC of 0.95, indicating solid performance with some room for improvement in class discrimination. Figure 5(b) shows the ROC curve for the Bernoulli Naive Bayes model, with an AUC of 0.94, slightly underperforming compared to the Multinomial variant but still demonstrating strong discriminative ability. Figure 5(c), depicting the Logistic Regression model, records an AUC of 0.99, reflecting its near-perfect ability to distinguish between real and fake news. Finally, Figure 5(d) presents the ROC curve for the Hybrid Model,

which also achieves an AUC of 0.99, solidifying its status as the most effective model, alongside Logistic Regression, for this classification task.

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Figure 5: ROC curves of ML Models

**RESULTS ANALYSIS AND CONCLUSION**

Our experiments reveal distinct differences in the performance of the four machine learning models applied to fake news detection. While the Logistic Regression model demonstrated strong performance with an accuracy of 94.23% and an F1-score of 95.86%, the introduction of the Hybrid Model yielded the most significant improvements. The Hybrid Model achieved the highest accuracy of 96.19%, a recall of 96.41%, and a robust F1-score of 95.7%, showcasing its superior capability in minimizing both false positives and false negatives. This enhanced reliability underscores the Hybrid Model's effectiveness in accurately distinguishing between real and fake news. The Multinomial Naive Bayes and Bernoulli Naive Bayes models, although delivering respectable precision, were outperformed in recall and overall accuracy, reflecting their limitations in handling the dataset's complexity. The ROC curve analysis further confirms the Hybrid Model's superior discriminative ability, with an AUC of 0.99, comparable to that of the Logistic Regression model but with a more balanced performance across all key metrics.

In conclusion, the introduction of the Hybrid Model in our experiment significantly advances the effectiveness of fake news detection. By integrating multiple algorithms, this model not only enhances accuracy but also provides a more robust and reliable approach to combating misinformation, setting a new standard in the field.

For future work, we plan to address the limitations of our current models by exploring more advanced techniques, such as deep learning and ensemble methods, to further enhance accuracy and reduce false positives and negatives. Additionally, we aim to expand our dataset and incorporate more diverse sources to improve the model's generalizability and effectiveness in real-world applications.