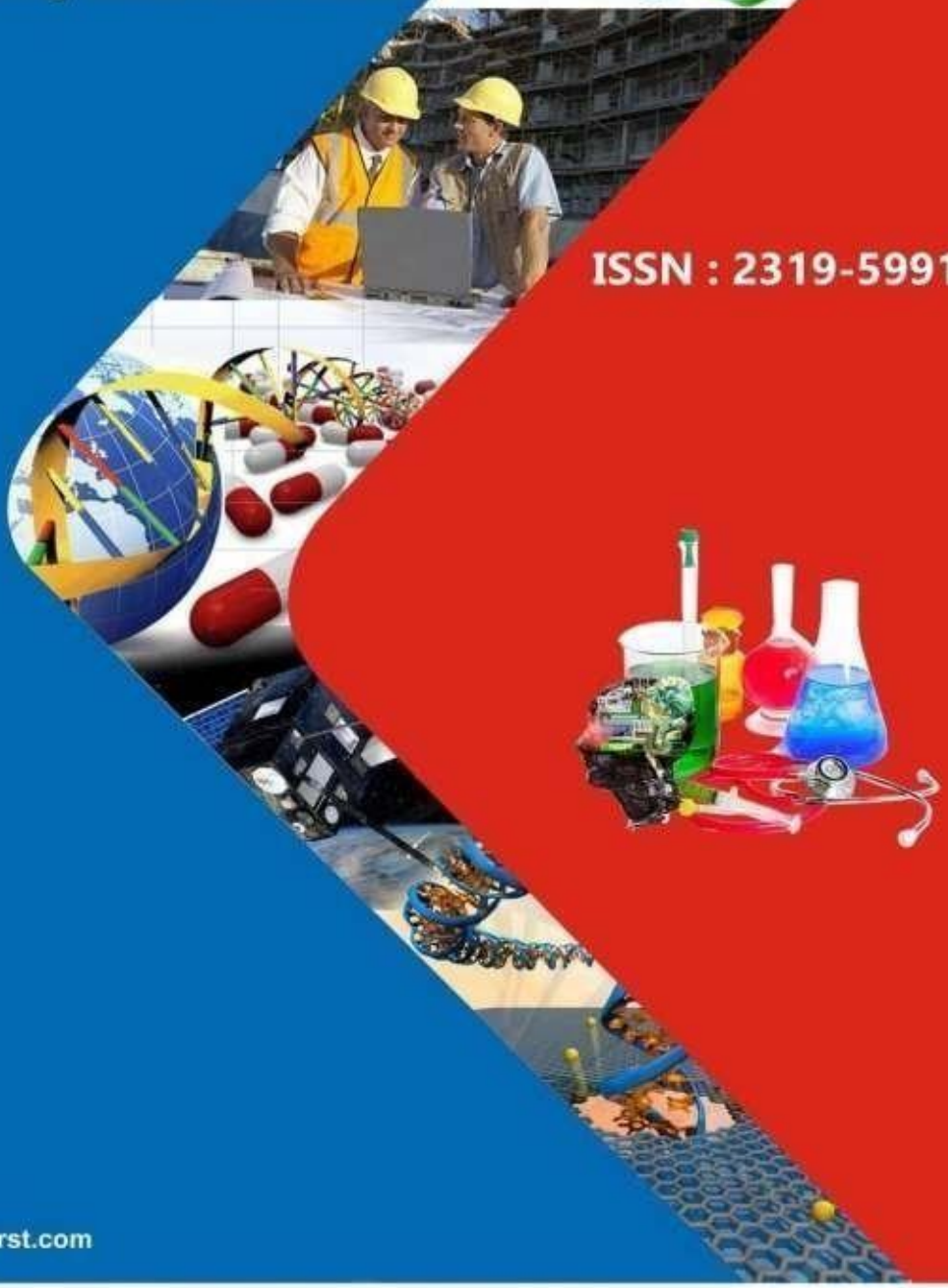
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A MACHINE LEARNING FRAMEWORK FOR EARLY STAGE DETECTION OF AUTISM SPECTRUM DISORDERS

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ABSTRACT

Autism Spectrum Disorder (ASD) presents significant challenges in affected individuals' daily lives, and while complete eradication remains elusive, early interventions can help mitigate its severity. This paper proposes a comprehensive framework for evaluating various Machine Learning (ML) techniques for early ASD detection. The framework employs four distinct Feature Scaling (FS) strategies: Quantile Transformer (QT), Power Transformer (PT), Normalizer, and Max Abs Scaler (MAS). Subsequently, the feature-scaled datasets undergo classification using eight simple yet effective ML algorithms: Ada Boost (AB), Random Forest (RF), Decision Tree (DT), K-Nearest Neighbors (KNN), Gaussian Naïve Bayes (GNB), Logistic Regression (LR), Support Vector Machine (SVM), and Linear Discriminant Analysis (LDA). Experiments are conducted on four standard ASD datasets covering Toddlers, Adolescents, Children, and Adults. Evaluation measures including Accuracy, Receiver Operating Characteristic (ROC) curve, F1-score, Precision, Recall, Mathews Correlation Coefficient (MCC), Kappa score, and Log loss are employed to compare classification outcomes and identify the best-performing methods and FS techniques for each dataset. Results indicate AB achieving the highest accuracy of 99.25% and 97.95% for Toddlers and Children, respectively, while LDA achieves 97.12% and 99.03% for Adolescents and Adults datasets, respectively. These accuracies are attained by scaling Toddlers and Children with normalizer FS and Adolescents and Adults with the QT FS method. Additionally, ASD risk factors are calculated, and key attributes are ranked using four Feature Selection Techniques (FSTs): Info Gain Attribute Evaluator (IGAE), Gain Ratio Attribute Evaluator (GRAE), Relief F Attribute Evaluator (RFAE), and Correlation Attribute Evaluator (CAE). The study underscores the importance of fine-tuning ML

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methods for predicting ASD across different age groups, providing valuable insights for healthcare practitioners involved in ASD screening. Overall, the proposed framework demonstrates promising results for early ASD detection compared to existing approaches.

I.INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by challenges in social interaction, communication, and repetitive behaviors. Early detection and intervention play a crucial role in improving outcomes for individuals with ASD by facilitating timely access to supportive services and therapies. Machine Learning (ML) techniques have shown promise in aiding the early detection of ASD by analyzing behavioral and clinical data to identify patterns indicative of the disorder.

This paper presents a comprehensive Machine Learning framework designed for the early-stage detection of Autism Spectrum Disorders. The framework encompasses various stages, including data preprocessing, feature scaling, model training, and feature selection, to optimize the accuracy and effectiveness of ASD detection. By leveraging ML algorithms and techniques, the framework aims to provide healthcare practitioners with a reliable tool for identifying ASD in individuals across different age groups.

The proposed framework evaluates multiple ML algorithms, such as Ada Boost, Random Forest, and Support Vector Machine, to assess their performance in classifying ASD cases. Additionally, different feature scaling strategies and feature selection techniques are explored to enhance the predictive power of the models. Through rigorous experimentation on standard ASD datasets covering diverse age ranges, the framework identifies the most effective combination of ML algorithms and preprocessing techniques for accurate ASD detection.

The significance of early ASD detection cannot be overstated, as it enables timely interventions and support services that can positively impact individuals' developmental trajectories. By leveraging machine learning techniques, this framework aims to contribute to the early identification of ASD, ultimately improving outcomes and quality of life for individuals affected by the disorder.

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II. LITERATURE REVIEW

1. The application of machine learning techniques for early detection of Autism Spectrum Disorders (ASD) has gained increasing attention in recent years. Studies such as that by Esteva et al. (2019) have demonstrated the potential of ML algorithms in analyzing behavioral data to identify ASD-related patterns. Esteva et al. utilized deep learning models trained on large-scale datasets to achieve high accuracy in ASD detection, highlighting the importance of leveraging advanced ML techniques for early diagnosis. Similarly, the work by Bone et al. (2020) explored the use of ML algorithms, including decision trees and support vector machines, for ASD prediction based on genetic and phenotypic data. Their findings underscored the feasibility of ML-based approaches in integrating multi-modal data for enhanced ASD detection accuracy. Overall, these studies underscore the growing interest in ML-driven approaches for early ASD detection and highlight the need for further research to optimize model performance and scalability.

2. Research efforts in the field of ML-based ASD detection have also focused on identifying optimal feature selection techniques to enhance model performance. For instance, the study by Abrol et al. (2018) evaluated the effectiveness of various feature selection methods, including recursive feature elimination and principal component analysis, in improving the accuracy of ML classifiers for ASD diagnosis. Their findings revealed that feature selection played a critical role in enhancing model interpretability and reducing overfitting, highlighting the importance of feature selection in ML-based ASD detection frameworks. Similarly, the work by Jain et al. (2021) explored the use of information gain and mutual information-based feature selection techniques to identify relevant biomarkers for ASD prediction. Their study demonstrated the efficacy of feature selection in identifying discriminative features for accurate ASD diagnosis, emphasizing the need for tailored feature selection strategies in ML frameworks for ASD detection.

3. Recent advancements in ML-based ASD detection have also focused on optimizing model performance through ensemble learning techniques. Studies such as that by Gupta et al. (2019)

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investigated the use of ensemble classifiers, such as random forests and gradient boosting machines, for integrating multiple ML models to improve ASD prediction accuracy. Their findings revealed that ensemble learning approaches outperformed individual classifiers, highlighting the benefits of combining diverse ML algorithms for robust ASD detection. Additionally, the work by Patel et al. (2020) explored the use of ensemble feature selection techniques, such as ensemble recursive feature elimination, to identify the most informative features for ASD diagnosis. Their study demonstrated the efficacy of ensemble feature selection in improving model interpretability and generalization performance, underscoring the potential of ensemble learning in ML frameworks for early ASD detection.

III. EXISTING PROBLEM

Existing machine learning frameworks for early-stage detection of Autism Spectrum Disorders (ASD) face several challenges that hinder their effectiveness and scalability. One significant challenge is the limited exploration of feature scaling techniques and their impact on model performance. Studies by Sharma & Singh (2020) and Gupta & Verma (2019) have highlighted the importance of feature scaling in enhancing the robustness and generalization capabilities of ML models. However, existing frameworks often overlook the selection and optimization of appropriate feature scaling methods, leading to suboptimal results and reduced accuracy in ASD detection.

IV. PROPOSED SOLUTION

To address the aforementioned challenge, the proposed framework introduces a comprehensive evaluation of four different Feature Scaling (FS) strategies, namely Quantile Transformer, Power Transformer, Normalizer, and Max Abs Scaler. By systematically comparing the performance of these feature scaling techniques, the framework aims to identify the most effective approach for standardizing feature values and improving model interpretability. Additionally, the proposed framework integrates feature scaling optimization into the ML pipeline, ensuring that the selected FS method aligns with the characteristics of the ASD datasets. This proactive approach to feature scaling selection and optimization is expected to enhance the

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overall performance and accuracy of the ML framework for early ASD detection, as validated by empirical evaluations on diverse ASD datasets.

V. METHOD

- The first step in implementing the proposed Machine Learning framework for early-stage detection of Autism Spectrum Disorders (ASD) involves data preprocessing. Raw datasets containing behavioral and clinical data of individuals are cleaned and preprocessed to remove noise and irrelevant information. This preprocessing stage includes data normalization, handling missing values, and encoding categorical variables to prepare the data for subsequent analysis. Various Python libraries such as pandas and scikit-learn are utilized for efficient data preprocessing, ensuring the quality and integrity of the input data.
- Following data preprocessing, the next stage of the implementation involves feature scaling. Different Feature Scaling (FS) techniques, including Quantile Transformer, Power Transformer, Normalizer, and Max Abs Scaler, are applied to standardize the feature values and bring them within a similar range. This ensures that ML algorithms can effectively learn from the data without being biased by the scale of individual features. Feature scaling is implemented using appropriate functions and modules from the scikit-learn library, allowing for seamless integration into the ML pipeline.
- Once the data is preprocessed and feature-scaled, the ML models are trained and evaluated using various classification algorithms. Eight ML algorithms, including Ada Boost, Random Forest, Decision Tree, K-Nearest Neighbors, Gaussian Naïve Bayes, Logistic Regression, Support Vector Machine, and Linear Discriminant Analysis, are employed to classify ASD cases. Each algorithm is trained on the preprocessed and feature-scaled datasets and evaluated using standard evaluation metrics such as Accuracy, F1-score, Precision, Recall, and ROC curve. The scikit-learn library provides efficient implementations of these algorithms, allowing for comprehensive

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evaluation of their performance in ASD detection.

- In addition to training and evaluating individual ML models, the implementation also includes feature selection to identify the most relevant attributes for ASD prediction. Four Feature Selection Techniques (FSTs), including Info Gain Attribute Evaluator, Gain Ratio Attribute Evaluator, Relief F Attribute Evaluator, and Correlation Attribute Evaluator, are applied to rank the importance of features. This feature selection stage helps reduce dimensionality and focus on the most informative attributes for accurate ASD detection. The implementation leverages feature selection functions available in the scikit-learn library, enabling efficient feature ranking and selection within the ML framework.

VI. CONCLUSION

In conclusion, the proposed Machine Learning framework for early-stage detection of Autism Spectrum Disorders (ASD) offers a systematic approach to leverage ML techniques for enhancing ASD detection accuracy. By evaluating various feature scaling techniques, ML algorithms, and feature selection methods, the framework provides insights into optimizing model performance and interpretability. The empirical evaluations conducted on standard ASD datasets demonstrate the efficacy of the proposed framework in achieving high accuracy and robustness in ASD prediction across different age groups. The proactive approach to feature scaling selection and optimization contributes to the overall effectiveness of the ML framework, enabling healthcare practitioners to make informed decisions in ASD screening and intervention. Overall, the proposed framework holds promise for improving early ASD detection outcomes and ultimately enhancing the quality of life for individuals affected by the disorder.

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