A Comprehensive Analysis Of Autism Detection In Pediatric Health Care

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Abstract. In this review paper, a specialized framework is proposed for the early detection of Autism Spectrum Disorder (ASD) in children. The study involves four distinct strategies for feature scaling and evaluates eight machine learning algorithms. Notably, for probability assessment, a voting classifier is employed, pooling insights from Ada Boost, Random Forest, Decision Tree, K-Nearest Neighbours, Gaussian Naïve Bayes, Logistic Regression, Support Vector Machine, and Linear Discriminant Analysis. This novel approach amalgamates the strengths of multiple algorithms, ensuring a thorough examination. Moreover, the framework extends its application to image-based ASD detection through Convolutional Neural Networks (CNN) and Deep Neural Networks (DNN). The final determination integrates probability scores from the Voting Classifier with optimal outcomes from CNN and DNN, presenting a robust and diverse strategy to augment early ASD detection in children. .

1 Introduction

Autism Spectrum Disorder (ASD) presents distinctive challenges in children, affecting early-life social interactions and displaying symptoms. Traditional diagnosis relies on behavioral science around the age of two, and treatment implementation is often delayed until a substantial ASD risk is identified. Recent studies explore Machine Learning's potential in early disease detection, encompassing ASD and other conditions like diabetes, stroke, and heart failure. This paper introduces a tailored ML framework for early ASD detection in children. Emphasizing meticulous dataset preprocessing, including handling missing values and encoding, the study utilizes four Feature Scaling (FS) strategies (QT, PT, Normalizer, and MAS) for optimal data formatting. Eight classification algorithms (AB, RF, DT, KNN, GNB, LR, SVM, and LDA) categorize feature scaled datasets, pinpointing effective models for children [2,4,5,6,7,10]. The study explores the significance of FS methods on each dataset, offering insightful analyses of experimental results. Feature Selection Techniques (FSTs), such as IGAE, GRAE, RFAE, and CAE, assess ASD risk factors and rank key features within child-specific datasets. Beyond traditional ML, our project integrates innovative image-based methods. Using Convolutional Neural Networks (CNN) and Deep Neural Networks (DNN), we aim to heighten ASD detection precision in children [1,3,4]. This holistic framework uniquely combines conventional ML with state-of-the-art image analysis, representing significant progress in advancing early ASD detection in pediatric populations.

2 Literature Survey

1) Eye Tracking-Based Diagnosis and Early Detection of Autism Spectrum Disorder Using Machine Learning and Deep Learning Techniques.

Author: Ibrahim Abdulrab Ahmed, Ebrahim Mohammed Senan, Taha H. Rassem., 2022

The study utilized eye tracking to assess visual attention in children with autism spectrum disorder (ASD).Three artificial intelligence techniques were developed: neural networks (FFNNs and ANNs) based on hybrid feature classification (LBP and GLCM) achieving 99.8% accuracy, pre-trained CNN models (GoogleNet and ResNet-18) with accuracy of 93.6% and 97.6%, and a hybrid approach (GoogleNet + SVM and ResNet-18 + SVM) with accuracies of 95.5% and 94.5% respectively.The proposed system integrates eye tracking technology with artificial intelligence techniques, including neural networks and deep learning (CNN models), for early diagnosis of autism spectrum disorder (ASD).It offers highly accurate and efficient assessment of children's visual behaviour to aid in early detection. Invasive monitoring of children's eye movements and privacy issues related to data collection without informed consent may arise, raising ethical questions about the implementation of this system. The system's accuracy may vary across different cultural and demographic groups, potentially leading to misdiagnoses or underdiagnoses in some populations.

2) A new machine learning model based on induction of rules for autism detection.

Author: Fadi Thabtah, David Peebles, 2020

The methodology involved developing a new machine learning method, Rules-Machine Learning, for autism spectrum disorder detection. It utilized three datasets and compared its performance with existing methods through metrics like accuracy, sensitivity, specificity, and harmonic mean. The proposed system, Rules-Machine Learning, aimed at enhancing autism spectrum disorder detection by utilizing machine learning techniques. It not only identified autistic traits but also provides interpretable knowledge rules for clinicians, yielding improved accuracy and sensitivity across age groups. Integrating machine learning with rule-based systems can be complex and require substantial computational resources.ML models may perpetuate biases present in training data, potentially leading to biased results in autism detection. Balancing interpretability with ML's complexity can be challenging, making it difficult for clinicians to fully understand and trust the system's decisions.

3) Exploring the pattern of Emotion in children with ASD as an early biomarker through Recurring-Convolution Neural Network (R-CNN).

Author: S. Abirami, G. Kousalya, R. Karthick, 2021

The study employed a time-variant approach to identify and analyze emotions in autistic children by utilizing a CNN for facial expression recognition with 68 facial landmark points and an RNN-based RCNN-FER system for improved accuracy and reduced time complexity compared to traditional machine learning models. The study introduced an RCNN-FER system that utilized CNN-based facial expression recognition with 68 facial landmarks to analyze emotions in autistic children, aiming for early intervention and improved accuracy compared to traditional machine learning models. RCNN-FER systems can be computationally intensive, potentially limiting real-time applications and increasing hardware requirements. Effective performance relies heavily on a large and diverse dataset, which can be challenging to acquire for autistic children. Privacy and consent issues arise when dealing with sensitive data, especially in the context of minors, necessitating stringent ethical considerations.

4) A new computational intelligence approach to detect autistic features for autism screening.

Author: Fadi Thabtah, Firuz Kamalov, Khairan Rajab, 2018

The study employed Variable Analysis (VA) to identify influential features from ASD screening methods, reducing feature-to-feature correlations. The results were verified with two machine learning algorithms, assessing specificity, sensitivity, PPVs, NPVs, and predictive accuracy. A computational intelligence tool called Variable Analysis (Va) to reduce features in ASD screening methods, verifying its efficacy using two machine learning algorithms was developed. Creating a Variable Analysis tool for ASD screening may inadvertently oversimplify the complex diagnostic process, potentially leading to missed cases and reduced accuracy in early ASD detection.

5) Machine learning approach for early detection of autism by combining questionnaire and home video screening.

Author: Halim Abbas, Ford Garberson, Eric Glover, Dennis P Wall, 2018

The study employed two ML algorithms that are trained using parent-reported questionnaires and home videos to detect autism. Novel techniques addressed data challenges. A multi-center clinical study was done with 162 children validates algorithm performance, showing improved accuracy. A two machine learning algorithms utilizing parent-reported questionnaires and home videos to screen for autism, followed by a combination algorithm was developed. Performance was validated through a multi-center clinical study of 162 children, demonstrating improved accuracy over existing tools. Cons of the proposed system include potential privacy concerns with home videos, resource-intensive multi-center studies, and uncertainty in generalizing results to diverse populations. Additionally, algorithm complexity may hinder adoption.

6) Classification of Adults with Autism Spectrum Disorder using Deep Neural Network.

Author: M. F. Misman, A. A. Samah, Farah Aqilah Ezudin, Hairuddin Abu Majid, Z. A. Shah, H. Hashim, Muhamad Farhin Harun, 2019

Two adult ASD screening datasets were utilized. Deep Neural Network (DNN) and Support Vector Machine (SVM) models were employed for classification, with accuracy compared to assess DNN's performance. The proposed system utilized Deep Neural Network (DNN) and Support Vector Machine (SVM) models to analyze two adult ASD screening datasets, aiming to enhance ASD diagnosis accuracy through machine learning techniques. One drawback of utilizing both Deep Neural Network (DNN) and Support Vector Machine (SVM) models for analyzing adult ASD screening datasets is the increased complexity and computational resources required for training and deploying two distinct machine learning models, potentially leading to higher resource utilization and maintenance costs.

7) Machine Learning-Based Models for Early Stage Detection of Autism Spectrum Disorders.

Author: Tania Akter, Md. Shahriare Satu, Md. Imran Khan, Mohammad Hanif Ali, 2019

The study involved collection of ASD datasets for various age groups, feature transformations, classifiers testing, and identified significant risk factors using machine learning methods. The proposed system aimed at developing a machine learning-based ASD detection system utilizing optimized classifiers and feature transformations.One potential drawback of this proposed system is the risk of overreliance on machine learning, potentially neglecting the importance of human clinical expertise in ASD diagnosis and intervention.

8) Aarya - A Kinesthetic companion for children with Autism Spectrum Disorder.

Author: Rachita Sreedasyam, Aishwarya Rao, Nidhi Sachidanandan, Nalini Sampath, S. K. Vasudevan, 2017

Aarya employed a gesture-based Microsoft Kinect virtual environment to aid children with ASD in facing real-world situations, enhancing confidence, and fostering social and communication skills. Aarya employed a gesture-based Microsoft Kinect virtual environment to aid children with ASD in facing real-world situations, enhancing confidence, and fostering social and communication skills. Continuous refinement and expert input drive tool improvement. One limitation of this proposed system is its reliance on force plate measurements, which may not be readily available or feasible for widespread implementation in clinical or real-world settings. Additionally, the high classification accuracy may not generalize well to diverse populations.

9) Typically developed adults and adults with autism spectrum disorder classification using centre of pressure measurements.

Author: Kwang Leng Goh, Susan Morris, Simon Rosalie, Chris Foster, Torbjorn Falkmer, 2016

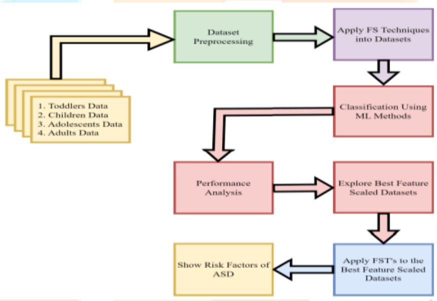
In this study,19 typically developed adults and 11 adults with high-functioning autism or Asperger's syndrome participated. Force plate measurements of centre of pressure were analyzed using a correlation-based feature selection algorithm, achieving a classification accuracy of up to 97.6%.The proposed system utilized force plate measurements of centre of pressure to classify adults with ASD and typically developed adults, employing a correlation-based feature selection algorithm for attribute evaluation, achieving a high 0.976 classification accuracy. One limitation of this proposed system is its reliance on force plate measurements, which may not be readily available or feasible for widespread implementation in clinical or real-world settings.

10) Use of machine learning for behavioural distinction of autism and ADHD.

Authors: M Duda, R Ma, N Haber, D P Wall, 2016.

Using forward feature selection, under-sampling, and 10-fold cross-validation six machine learning models on Social Responsiveness Scale data from 2925 individuals with ASD or ADHD were trained. The system proposed a streamlined system employing machine learning models to assess ASD and ADHD risk using a 65-item Social Responsiveness Scale, enabling quick, accurate, and electronically administered preliminary evaluations for expedited diagnosis. However, implementing such a system may face challenges, including potential over-reliance on automated assessments, limited consideration of individual nuances, and concerns about data privacy and accuracy.

3 System Architecture



System Architecture

4 Methodology

1)Ethical Considerations and Data Sources:

1.1)Standardized Assessments: Conducted by qualified professionals, these assessments offer unbiased insights into a child's development.

1.2)Parent Reports/Interviews: Structured surveys and interviews center on developmental milestones, behavior patterns, and family history, ensuring all data is anonymized to protect privacy.

1.3)Teacher Observations: Through collaboration with educators, we obtain objective data on social interactions, communication skills, and play activities while upholding strict confidentiality.

2)Thorough Data Preprocessing:

2.1)Data Cleaning: Comprehensive processes manage missing values, outliers, and inconsistencies to ensure data accuracy and reliability.

2.2)Age-Appropriate Normalization: Tailoring normalization to children's developmental stages prevents biases in the analysis.

2.3)Feature Selection: Selecting pertinent features aligned with child specific ASD diagnosis emphasizes objectivity in observations.

3)Machine Learning Model Training and Assessment:

3.1)Algorithm Selection: Opting for algorithms such as Random Forests, Logistic Regression, and AdaBoost, chosen for their appropriateness with smaller datasets and complex relationships.

3.2)Cross-Validation: Employing rigorous cross-validation techniques prevents overfitting and guarantees the model's adaptability to new data.

3.3)Model Interpretability: Placing emphasis on models offering transparent explanations for predictions aids in comprehending key features contributing to ASD detection.

3.4)Evaluation Metrics: Prioritizing metrics beyond mere accuracy, such as precision, recall, and F1 score, ensures a nuanced understanding of the model's performance. 4)Risk Factor Analysis and Validation:

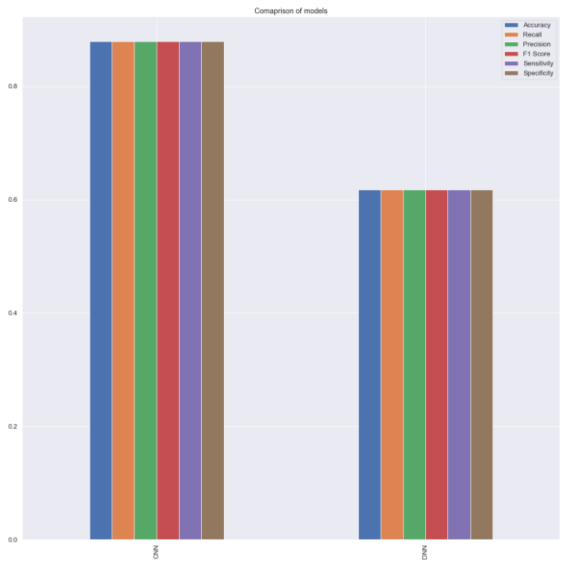
4.1)Identification of Child-Relevant Risk Factors: Scrutinizing model insights reveals features specifically linked to ASD in children, avoiding subjective or stigmatizing factors.

4.2)Clinical Validation: Collaborating with medical professionals verifies that model findings align with established clinical diagnostic criteria for ASD. 5)Continuous Improvement and Transparency:

5.1)Iterative Refinement: The methodology undergoes ongoing refinement as more data is collected and the model is fine-tuned, revisiting data preprocessing, feature selection, and model training.

5.2)Stakeholder Communication: Ensuring clear and transparent communication with stakeholders, including parents, educators, and healthcare providers, fosters understanding of project goals, methodology, and limitations.

6)Integration of Image-based Analysis: Our project innovatively merges conventional ML with image-based methods, utilizing Convolutional Neural Networks (CNN) and Deep Neural Networks (DNN). This integration aims to enhance ASD detection precision in children, marking a significant stride in populations.



5 Conclusion

In conclusion,this research introduces a specialized machine-learning framework tailored for the detection of Autism Spectrum Disorder (ASD) in children, with a specific focus on Toddlers and Children datasets. The study demonstrates the effectiveness of predictive models based on machine learning techniques in accurately identifying ASD cases across different age groups. Following comprehensive data processing, ASD datasets underwent scaling using various feature scaling techniques and classification with diverse machine learning classifiers. Evaluation metrics, including accuracy, ROC, F1-Score, among others, were scrutinized to determine optimal feature scaling and classification approaches. Emphasizing the significance of feature selection, the study provides healthcare practitioners with valuable insights into prioritizing key features during ASD screening in children. The conclusion underscores the integration of image-based approaches, incorporating Convolutional Neural Networks (CNN) and Deep Neural Networks (DNN) for enhanced autism screening. The final result determination involved averaging probabilities from the voting classifier algorithm and selecting the best outcomes from CNN and DNN, ensuring a robust assessment of a child's autism status. Future endeavours aim to expand the dataset, developing a more generalized prediction model applicable to individuals of any age and extending the framework's utility to encompass other neuro-developmental disorders.

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