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Analysis and Detection of Autism Spectrum Disorder using Machine Learning Techniques

Himanshu Sharma
JECRC Universit, Jaipur, Rajasthan

Abstract - Autism spectrum disorder (ASD) is a complex condition that affects how people communicate, interact socially, and learn. You might not be aware of this, but the usual ways of diagnosing ASD, such as using questionnaires or observing behavior can be biased and take a lot of time. Here's the thing: with the fast development of artificial intelligence, machine learning, and transfer learning, there's been increasing interest in using automated tools for early screening. However, most of these tools depend on just one kind of data — either behavioral observations or facial images which limit their effectiveness and make the results harder to understand. This review paper closely examines data fusion techniques that combine facial image data with responses from behavioral questionnaires to improve the accuracy of autism prediction.

It explains how models have shifted from using only one type of data to incorporating multiple sources. The article also covers transfer learning for visual data and methods for combining different types of information. The research shows how using various data types in AI can lead to earlier, clearer, and more reliable screening tools that help healthcare professionals in real-world settings.

Autism Spectrum Disorder (ASD), merging data, Deep Learning, Transfer of learning, CNN, Behavior Analysis, Explainable artificial intelligence, Multimedia learning.

1 INTRODUCTION

Autism spectrum disorder (ASD) is a lifelong disorder that alters the way individuals communicate socially, do repetitive things, as well as comprehend the World Organization (WHO) that one out of fifty children in the world has ASD. Early and accurate diagnosis is favorable to improve treatment performance. Nevertheless, the existing approaches to the diagnosis of ASD largely depend on human judgment and tests such as the DSM-5 and M-CHAT that could be subjective and could be different according to the location and age of the child.

Autism Spectrum Disorder (ASD) is a lifelong disorder that impairs social interaction, repetitive behaviors as well as perception of emotions. The World Health Organization (WHO) estimates that one out of every fifty children in the world has ASD. Diagnosis should also be timely and accurate to achieve better results in treatment. Nevertheless, the present means of ASD diagnosis is based on a person and behavior checklists, which include the DSM-5 and M- CHAT. These techniques can be subjective, and they can vary depending upon the location and age of the child.

Multimodal fusion models can be used to bring together various forms of data in order to establish a more comprehensive manner of ASD diagnosis, enhance predictive accuracy, and simplify the understanding of multimodal fusion models.

This review indicates significant research, existing challenges and future research directions in the examination of AI systems applied in the screening of autism spectrum disorder.

2 BACKGROUND

Detecting autism spectrum disorder can be done using three main ways of looking at data. One way is through behavioral or questionnaire-based models. These models use survey data, like the UCI ASD dataset. They rely on machine learning methods such as Support Vector Machine, Decision Tree, and Random Forest to study the data. Another method uses images. These models use CNNs or transfer learning. They can spot things like uneven facial expressions, unusual eye movement, or strange reactions to emotions from pictures. A third method is multimodal fusion models.These combine visual and behavioral data to better understand cognitive and emotional traits. Data fusion brings together information from different sources. Early fusion mixes the raw data features together, while late fusion combines the results from each each model separately.. Hybrid fusion methods offer a good balance between understanding the data clearly and making reliable conclusions.

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3 LITERATURE REVIEW

3.1 Machine learning —a behavioral approach

- Thabet (2018) tested 2018 data sets on autism spectrum disorders using Naive Bayes and Decision Trees and achieved 90 percent accuracy, but the related method was not very useful to generalize the results to other situations.
- Raja and Masood (2020) employed the use of logistic regression and artificial neural networks as prediction methods of behavior, identifying the simplicity of the approaches and the ease of explaining the decisions made by the models.
- Gupta (2024) and Kumar adopted explainable artificial intelligence (SHAP values) to establish the key characteristics of behavior, which affect the outcomes of the model.

3.2 In image -deep learning methods

- In 2023, Ahmed and his colleagues applied a form of deep learning model known as CNN (VGG16 and InceptionV3) to determine the characteristics of ASD through facial expressions. They had 93 percent accuracy.
- Xu and colleagues (2023) investigated the effects of racial differences on CNN models, showing that datasets used, biases involved, and the difficulty of representing different groups seemed to be adequate.
- The 2025 design by Wang and their associates relied on vision transformers (ViT) and includes behavioral data, resulting in 98 percent accuracy and good performance invarious situations.

3.3 Multimodal fusion models

- In 2024 Keng, Cheng, and others produced a model combining a CNN with an ANN such that image and behavior data are analyzed at the same time and combine to reach an accuracy of 97 percent using a combined dataset.
- Tang and colleagues (2020) developed deep learning based on early fusion, which facilitates the diagnosis of autism spectrum disorders. Their study points out that the combination of different types of data will yield superior outcomes compared to when one type is used.
- A more recent model, presented in 2024 by Wu and Zhang, useslate fusion CNN models which incorporate attention to socially scale the importance of the various types of data.

4 METHODOLOGY

4.1 The literature review has been systematic:

- Selection of papers: The articles were selected based on the databases such as IEEE Xplore, Springer, Elsevier, and MDPI to include only publications in 2018-2025.
- Clustering: The articles have been categorized into three groups, namely, behavioral, visual, and multimodal.
- The criteria of evaluation: Each of the models was reviewed according to the size of the dataset, the algorithm employed, the nature of features, evaluation metrics, and the key limitations.
- Comparative synthesis: The findings were displayed in a table form as well as written material to indicate progress and the research areas that require further work.

5 DISCUSSION

In 2024, Wu and Zhang proposed late fusion CNN models, which allow dynamic modification of the relevance of various types of data by means of attention mechanisms. In 2020, Tang and associates came up with a deep learning approach to early fusion that assists in the diagnosis of autism spectrum disorders. Their work demonstrates that the results of the combination of various data types become more successful than the results of application of a single type. In the previous case, in 2020, Kec, Keng, and Cheng developed a model, which composes a CNN and an ANN to process image and behavior images concurrently and which had 97 percent accuracy when using a mixed dataset. Nonetheless, the scalability and ethical concerns, such as the privacy of the photos of minors, must be addressed with the help of the secure data processing and anonymization methods as well as federated learning systems.

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6 CONCLUSION AND FUTURE WORK

This review suggests that data fusion, integration, and transfer techniques are the next big step for AI in detecting autism spectrum disorders. To be honest, combining facial and behavioral approaches allows researchers to get more accurate and understandable results compared to using each method alone. To be honest, future research should focus on:

- Create large multimodal datasets that include a variety of populations.
- Development of lightweight integration architectures suitable for use on mobile devices and in clinical settings.
- Incorporate real-time annotation tools to maintain transparency.
- Explore privacy-preserving federated learning to ensure ethical use of data.

Ultimately, fusion-based multimodal systems could change autism spectrum disorder screening from a subjective process to an objective, data-driven tool for early intervention, supporting both clinicians and families.

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