Systematic Review of Artificial Intelligence Techniques for Autism Detection

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by challenges in social interaction, communication, and repetitive behaviors. Early and accurate diagnosis is crucial for effective intervention and improved quality of life. However, traditional diagnostic methods are often subjective, time-consuming, and require expert evaluation. In recent years, Artificial Intelligence (AI) has emerged as a promising tool to enhance the detection and diagnosis of autism by leveraging large datasets and advanced computational models. This study explores the application of AI techniques—including machine learning (ML), deep learning (DL), and natural language processing (NLP)—to automate and improve the accuracy of autism detection. Various data sources such as behavioral data, speech patterns, eye-tracking information, and neuroimaging data are analyzed using algorithms like Support Vector Machines (SVM), Random Forests, Convolutional Neural Networks (CNN), and recurrent neural networks (RNN). The results demonstrate that AI-based systems can achieve high diagnostic accuracy and offer scalable, non-invasive, and cost-effective solutions for early ASD detection. This paper highlights the potential of AI to complement clinical assessments and pave the way for more accessible and timely autism diagnosis.

Keywords- Autism Detection, Machine Learning, Artificial Intelligence, Work Flow, Deep Learning

1. Introduction

Persistent challenges in speech, communication, repetitive behaviours, and social interaction characterise autism spectrum disorder (ASD), a developmental condition associated with atypical neural connectivity. In autism spectrum disorder, the term "spectrum" denotes the extensive range of indications and symptoms. Autism spectrum disorder (ASD), a developmental illness, emerges in early infancy and continues throughout adulthood, hindering social interaction, particularly in public environments like schools and workplaces. The symptom-to-birth-month ratio is modest [2]. Although children may seem to grow typically throughout the initial years, some begin to exhibit indicators of autism about 18 months of age. The neurological disorder referred to as autism constitutes a global epidemic. Epidemiological estimates suggest that more than 30 million persons worldwide are

considered autistic. The early diagnosis, treatment, and creation of tools to support individuals with autism have received considerable focus, as this affects one in every 54 children with autism in the United States. This thesis primarily focusses on the application of AI in autism diagnosis [3].

The objective of Machine Learning is to instruct computers to identify concealed patterns in data using statistical analysis. Several detection tasks within the realm of psychology have lately employed this method. A nascent field, multi-model human sensing, using machine learning-driven computer vision to assess human mental states, encompassing mood and vocal patterns. This concept has been employed in autism research for behavioural observation or neuroactivities. This field has advanced significantly; nonetheless, considerable untapped potential remains in autism research regarding machine learning. Although machine learning involves model learning and detection, numerous autism studies have focused on the effective selection of a subset of features from the extensive array of existing characteristics of the traditional diagnostic scale to reduce detection time.

Currently, individuals across all age groups are receiving autism diagnoses at concerning rates (World Autism Day: India hosts 18 million persons with autism; by raising awareness of the illness, we may enable affected individuals to overcome stigma and enhance their quality of life, according to ET. "HealthWorld" (indiatimes.com). Recognising the significance of early detection in neurological disorders is essential for enhancing the physical and emotional well-being of patients. With the implementation of machine learning in sickness detection, early identification of health concerns using physiological indications is now achievable. There has been an increase in interest in the examination and detection of ASD, along with the development of improved treatment techniques, propelled by advancements in this domain. Currently, the global prevalence rate of autism spectrum condition is notably substantial. The World Health Organisation (WHO) estimates that 1 in 160 children is autistic. Individuals afflicted with this sickness may sustain independent living for an extended duration; nonetheless, the majority necessitate continuous assistance and care. Diagnosing ASD requires significant work and financial resources [4].

Pharmacological treatment for children with autism can be more efficacious when initiated promptly. Besides mitigating the risk of long-term expenses linked to delayed diagnosis, it may also prevent the deterioration of patients' diseases. Moreover, early intervention is essential for medical diagnosis and would enhance the quality of life for those with autism. Diagnosing ASD using costly testing methods may prolong the process. The global prevalence of autism spectrum condition has lately increased. Enhanced screening techniques are a catalyst for medical practitioners and researchers engaged in the field. To discover autistic symptoms and ascertain whether an individual necessitates a comprehensive autism evaluation, a reliable, effective, and user-friendly screening tool is essential.

2. Literature Review

Ma Flora [4] delineates the DSM V handbook. Experts in psychological health and related disciplines authored the DSM-5 to assist clinicians, researchers, administrators, health insurers, and other

stakeholders. It has predominantly maintained the DSM IV categorical framework. Certain clinical conditions have undergone reclassification. Aspects of the particular clinical condition are incorporated.
Ridley et al. [5] elucidate the neurodevelopmental disorders Williams syndrome (WS) and autism, which can reveal significant facets of social perception. Eye-tracking methods are employed in three exercises to examine attention to pictures with expressions. Individuals with Williams syndrome and autism exhibited atypical gaze behaviour compared to typically developing individuals. McLaughlin et al. [6] discovered that individuals with autism had significantly different eye movement patterns compared to their typically developing peers when freely examining visually intricate pictures, employing advanced analytical techniques for eye-tracking data. The eye tracking approach was used to both social and non-social images. Research indicated that children with ASD had less attention when observing visuals on the screen in comparison to normally developing youngsters.
Gutiérrez Jesús et al. [7] provide a summary of the Outstanding Concern "Saliency4ASD: Visual Attention Modelling for ASD," presented at IEEE ICME'19, aimed to promoting research in visual attention modelling to address this critical societal issue. They delineate the workflow, achieved results, datasets, and tools employed in this endeavour to facilitate the advancement and evaluation of two types of models: (a) to predict saliency maps that correspond with ASD gaze behaviour and (b) to distinguish ASD from typical development. Duan et al. [8] introduced an accessible dataset documenting the ocular activity of children with ASD. The dataset comprises 300 standard images and eye movement data collected from 15 children with Autism Spectrum Disorder and 15 neurotypical children. The collection specifically comprises fixation maps and scanpaths. Researchers may analyse the visual characteristics of children with autism and develop specialist visual attention models derived from this dataset to further research in related fields and create targeted models for identifying individuals with autism. H. Duan et al. [9] delineated the saliency prediction for children with autism, marking it as the first of its kind, encompassing 400 images together with corresponding eye-tracking data obtained from 12 distinct children with ASD. They assessed the efficacy of many state-of-the-art DNN-based saliency estimation methods using their novel systems. They expect the atypical visual attention of children with autism at the initial phase and get the most accurate saliency prediction results for individuals with autism to date. Chaudhari et al. [10] introduced the Attention Framework, which has emerged as a fundamental concept in machine learning. They established a methodology that classifies contemporary methodologies. Attention-based machine learning networks were analysed. Researchers further examine if attention mechanisms have been employed to enhance the readability of machine learning models. Condy et al. [11] proposed that Respiratory Sinus Arrhythmia (RSA) signifies cognitive and behavioural rigidity. Characteristics of the broad autism phenotype (BAP) are prevalent among the families of children with autism. The study assessed the influence of RSA and BAP traits on maternal affect in mothers of typically developing children and those of children with autism. These elements were anticipated to influence the interactions between parents and children. A limited number of parents and children participated in a challenging task to compute the parents' RSA. The results indicated that mothers of children with autism have a different RSA reactivity compared to mothers of children with typical development. Ibrahim and Izaida [12] elucidated Specific Learning Disabilities (SLD). These are characterised as a "heterogeneous array of conditions in which there is a deficiency in managing verbal, vocal, or transcribed communication, resulting in difficulties in comprehension, speaking, reading, writing, spelling, and mathematical problem-solving." Specific Learning Disabilities (SLDs) include perceptual impairments, dyslexia, dysgraphia, dyscalculia, dyspraxia, and progressive aphasia.

3. Machine learning based Work Flow in autism detection:

This section contains description of common artificial intelligence based techniques for early detection of Autism.

The main concept of machine learning is to make machines adapt and study from experience. The workflow of machine learning implies the different stages involve building an effective system.

- Data Collection: Gathering data‟s is an important stage of machine learning workflow. The accuracy and precision of the research with the quality of data collected are defined during data collection. For data collection, sources ought to be identified and data needs to be aggregated from single dataset. In other words, download open-source datasets or stream data from IOT sensor are some of the examples of data collection.
- Data Preparation: This step is to cleanse the raw data. Pre-processing must be done once the data is collected. It includes data cleansing, data validating and data formatting into usable dataset. Data collection from one source might be a relatively easy and simple process. But aggregating from several sources needs to ensure that data is reliable, data formats match, and eliminate potential duplicates. Various techniques of cleansing the dataset is- Ignore missing values, Remove cases having missing values from dataset. Estimate the missing values of cases using mean, median and mode. Remove duplicate cases from dataset. Normalize the data in dataset
- Selecting Learning algorithm: The best performing learning algorithm is studied at this phase. The learning algorithm is selected based on the kind of data and problem which needs to be explained and solved. Classification algorithm is used to classify the problems and Regression algorithm to carry out regression task. Data is labelled in both classification and regression algorithm. Clustering algorithm is mainly used to produce clusters and it has unlabelled data
- Training model -At this stage, the processed data breaks into three different sets. They are training, testing, and validating. Training set is mainly to train algorithm and to show in what way to process data. Training set describes model classification via parameters. Testing set is used to measure the accuracy and check the performance of the model. It is also intended to expose any mis trainings in the model. Validation set is mainly estimating the model accuracy and the datasets are used to tune up model parameters.The model is trained once the datasets are available. The training set are fed into the algorithm in order to study suitable parameters and featured using classification. The model is then refined using a validation set once the training is completed. This might discard or modify variables and can change the model settings until accuracy level is reached
- Evaluating model- Ultimately, the acceptable hyperparameters set are identified and the accuracy of the model is optimized to test the model. Test dataset is used for testing and verifying the accuracy features used in the model. The model is trained to improve the precision and deploy the model based on the feedback received after verification. The system is finally built, and it is used in the real world. At this point, the real benefit of machine learning can be realized.

4. Conclusion

By providing more objective, scalable, and efficient substitutes for conventional clinical techniques, artificial intelligence has shown great promise in improving the detection and diagnosis of Autism Spectrum Disorder. By means of machine learning, deep learning, and other artificial intelligence-based approaches, systems can highly accurately examine complex datasets comprising behavioural patterns, neuroimaging, speech, and eye-tracking data. Especially in underprivileged areas, these approaches not only support early intervention plans but also help to lower diagnosis delays and enhance access to care. Data quality, model interpretability, and ethical issues still exist notwithstanding the positive development. More explainable artificial intelligence models, multimodal data integration, and guaranteed varied representation in training datasets should be the main priorities of future work. All things considered, artificial intelligence could transform autism diagnosis and support, so enabling more individualised and timely healthcare solutions.

References

1 Chen, Yanru, Rachel M. Hantman, and Helen Tager-Flusberg. "Parent-rated anxiety in autistic adolescents and young adults: Concurrent links to autism traits and chronic sleep problems." Research in Autism Spectrum Disorders 101 (2023): 102104.

2 Lebersfeld, Jenna B., Marissa Swanson, Christian D. Clesi, and Sarah E. O'Kelley. "Systematic review and meta-analysis of the clinical utility of the ADOS-2 and the ADIR in diagnosing autism spectrum disorders in children." Journal of autism and developmental disorders (2021): 1-14.

3 Kamp-Becker, I., K. Albertowski, J. Becker, M. Ghahreman, A. Langmann, T. Mingebach, L. Poustka et al. "Diagnostic accuracy of the ADOS and ADOS-2 in clinical practice." European child & adolescent psychiatry 27 (2018): 1193-1207.

4 Alcañiz, Mariano, Irene Alice Chicchi-Giglioli, Lucía A. Carrasco-Ribelles, Javier Marín-Morales, Maria Eleonora Minissi, Gonzalo Teruel-García, Marian Sirera, and Luis Abad. "Eye gaze as a biomarker in the recognition of autism spectrum disorder using virtual reality and machine learning: A proof of concept for diagnosis." Autism Research 15, no. 1 (2022): 131-145.

5 Ridley, Ellen, Bronia Arnott, Deborah M. Riby, D. Michael Burt, Mary Hanley, and Susan R. Leekam. "The quality of everyday eye contact in Williams Syndrome: insights from cross-syndrome comparisons." American Journal on Intellectual and Developmental Disabilities 127, no. 4 (2022): 293-312.

6 McLaughlin, Christopher S., Hannah E. Grosman, Sylvia B. Guillory, Emily L. Isenstein, Emma Wilkinson, Maria Del Pilar Trelles, Danielle B. Halpern et al. "Reduced engagement of visual attention in children with autism spectrum disorder." Autism 25, no. 7 (2021): 2064-2073.

7 Gutiérrez Jesús, Zhaohui Che, Guangtao Zhai, and Patrick Le Callet. "Saliency4ASD: Challenge, dataset and tools for visual attention modeling for autism spectrum disorder." Signal Processing: Image Communication 92 (2021): 116092.

8 Duan, Huiyu, Guangtao Zhai, Xiongkuo Min, Zhaohui Che, Yi Fang, Xiaokang Yang, Jesús Gutiérrez, and Patrick Le Callet. "A dataset of eye movements for the children with 3 autism spectrum disorder." In Proceedings of the 10th ACM Multimedia Systems Conference, pp. 255-260. 2019.

9 H. Duan, G. Zhai, X. Min, Y. Fang, Z. Che, X. Yang, C. Zhi, H. Yang N. Liu, “Learning to predict where the children with ASD look”, in: 2018 25th IEEE International Conference on Image Processing (ICIP), 2018, pp. 704–708.

10 Chaudhari, Sneha, Varun Mithal, Gungor Polatkan, and Rohan Ramanath. "An attentive survey of attention models." ACM Transactions on Intelligent Systems and Technology (TIST) 12, no. 5 (2021): 1-32.

11 Condy, Emma E et al., "Maternal Affect during a Challenging Mother–Child Interaction: The impacts of Broad Autism Phenotype and Respiratory Sinus Arrhythmia Reactivity in Mothers of Children with and Without Autism Spectrum Disorder", Journal of autism and developmental disorders 49, no. 12 (2019): 4891-4900.

12 Ibrahim, Izaida. "Specific Learning Disorder in Children with Autism Spectrum Disorder: Current Issues and Future Implications", Advances in Neurodevelopmental Disorders (2019): 1-10.