

An Investigation on Explainable AI for Critical Decision-Making in Healthcare

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Abstract: Autism Spectrum Disorder (ASD) is characterised by diminished cognitive ability and other behavioural characteristics, constituting a neurological disorder. Individuals with ASD often have difficulties in social communication, demonstrate a paucity of interests, and display repetitive behaviours. Due to the increasing global incidence, diagnostic delays, and screening expenses, ASD has a minimal economic impact. Research results indicate that an earlier diagnosis may boost the physiological and social communication abilities of persons with ASD. Conventional approaches to diagnose autism spectrum disorder (ASD) are arduous and need the participation of qualified medical specialists for assessment. There is optimism that AI-driven ASD diagnosis may provide more precise and reliable outcomes. Artificial intelligence (AI) has lately instigated a paradigm shift in healthcare, transforming several aspects of healthcare-related activities. Significant applications include medical diagnosis and treatment, generating forecasts and recommendations, and facilitating diverse administrative functions. Machine learning and deep learning are two fields of artificial intelligence. Machine learning is the process by which computers autonomously gain new information without human involvement. In the medical domain, machine learning and deep learning have several applications, assisting physicians in diagnosing and treating various ailments with enhanced speed and precision. This article presents an investigation of various artificial intelligence based techniques to detect autism at an early stage.

Keywords: Autism Detection; Machine Learning; Deep Learning; Decision Tree; Accuracy; Explainable AI

Introduction

Individuals worldwide suffer from several maladies. The development of several dependable methods for disease detection has paralleled the growth of information and communication technology. In the occurrence of an epidemic, these technologies will evaluate the signs of the disease and formulate a plan for first aid. Although many diseases result in fatalities daily, Autism Spectrum Disorder (ASD) is notable for the significant limitations it may impose [1].

Businesses across all sectors are increasingly using automation to save expenses and enhance productivity. The healthcare sector would notably benefit from expedited processing times. The capacity to promptly and precisely diagnose human health issues is crucial. A significant obstacle for several medical illnesses, including Autism, is the duration required for diagnosis. Children suspected of having autism spectrum disorder (ASD) are often sent to many experts, including developmental paediatricians, neurologists, psychiatrists, and psychologists, during the protracted diagnosis process, which may last up to six months. Current therapeutic methods prolong the establishment of a definite autism diagnosis. Machine learning methodologies may be modified as necessary to enhance operational efficiency [2]. Early intervention is crucial for achieving effective outcomes with autistic children. Individuals with autism need an expedited diagnosis. Big data and machine learning are anticipated to substantially enhance the precision and efficacy of medical diagnosis and treatments. Developing a machine learning system might facilitate the use of extensive health and medical data for predictive modelling and analysis. This project will test and analyse several machine learning techniques to identify the most successful one. Given the prior categorisation of the data, the test results are expected to indicate Autism. Classification algorithms are now accessible and may be used in many contexts. Various classifiers use distinct methodologies for data collection, organisation, feature extraction, and model training based on those attributes. The primary objective of this research is to analyse the various machine learning and deep learning algorithms developed to assess and forecast the efficacy of therapy for children with autism spectrum disorder. Autism spectrum disorder (ASD) may manifest at any age and in any setting. The current lifestyle is the primary factor contributing to

the exacerbation of this issue. This mental illness complicates normal touch and discourse. The early detection of this condition may facilitate the recovery of both mental and physical health. The World Health Organisation indicates that one in every 160 children is diagnosed with autism spectrum disorder (ASD), which may result in other mental health issues, such as melancholy, anxiety, stress, and ADHD [3].

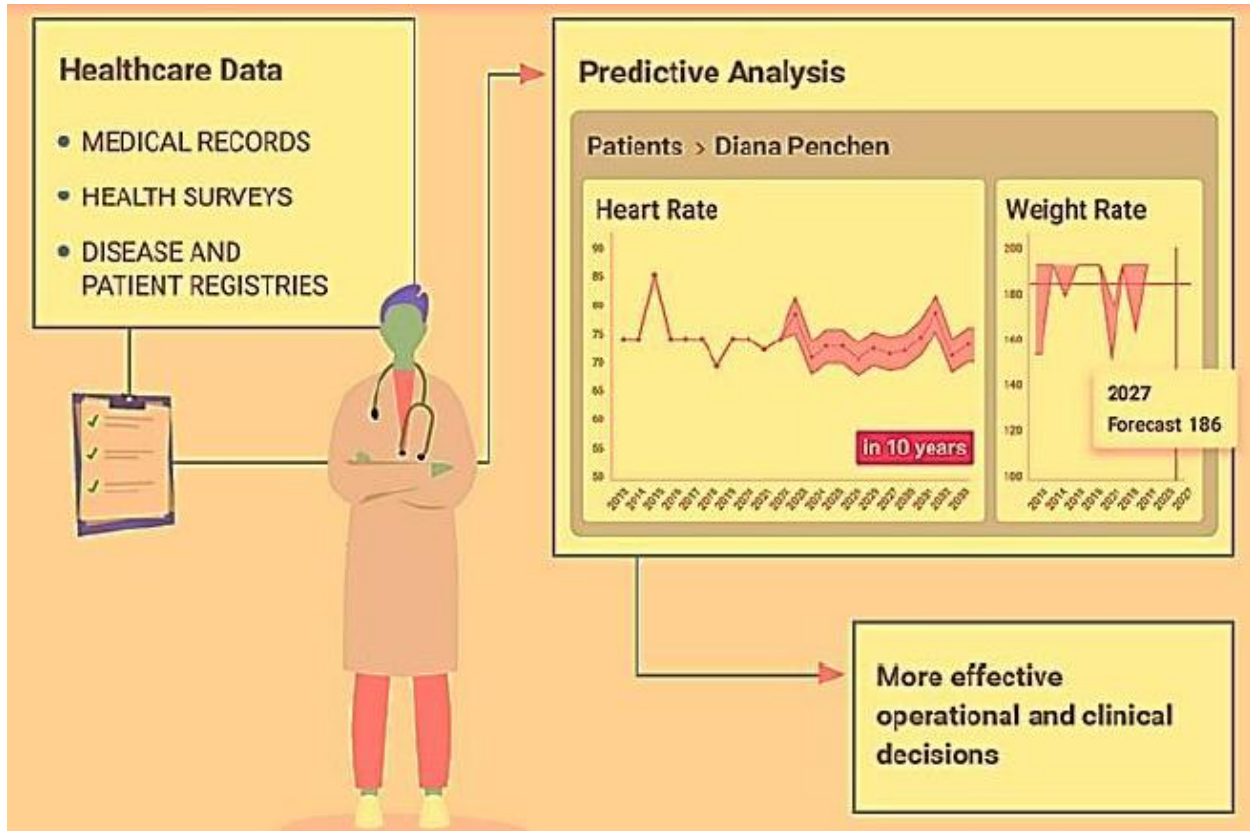


Figure 1: Predictive Analytics in Health Care

Predictive analytics is defined as the analysis of both historical and contemporary healthcare data to improve patient care, boost staff efficiency, and increase the ability to identify and respond to epidemics and emerging trends. Model creation, data mining, artificial intelligence, and machine learning are extensively used in predictive analytics, a subset of data analytics. To forecast future events, one must examine both historical and current data [4 -6].

The use of predictive analytics is rapidly growing in the field of personalised healthcare. Predictive models, utilising artificial intelligence and machine learning, can analyse extensive patient data to ascertain, among other factors, an individual patient's response to specific medications or medical devices, the probability of developing a particular illness, and its anticipated progression[7].

Related work

Recent investigation conducted by Yu et al. [8] Machine learning (ML) and deep learning (DL) are two of the most prominent subfields in artificial intelligence research. Supervised machine learning develops optimal computations on labelled datasets, while unsupervised machine learning investigates unlabelled datasets to uncover insights without previous information. Machine learning enables the extraction of valuable insights from extensive datasets via the training of sophisticated models that surpass human analysts. The use of machine learning facilitates more precise screening diagnoses and enhances our

understanding of autism spectrum disorders. The accuracy of ASD classification has been markedly enhanced by deep learning using several hidden layers, which systematically extracts information from high-dimensional data across neural layers.

A 2020 essay by Khodatars et al [9] Autism Spectrum Disorder influences cognitive development. Individuals on the autistic spectrum often have difficulties in communication and collaboration with others. In 2019, Thabtah This occurrence often has a lasting influence on the sufferer. This condition likely has several aetiologies, including both genetic and environmental factors. The symptoms of this illness may manifest as early as three years of age and persist throughout an individual's lifetime. If the patient is diagnosed early, while these symptoms cannot be completely resolved, they may be temporarily mitigated.

Despite the increasing worldwide incidence of ASD and the difficulties in identifying affected persons, ASD continues to have a considerable influence on the global economy. Timely identification of ASD may provide suitable treatment and medication, hence reducing the long-term costs linked to postponed diagnosis. Postponing diagnosis incurs superfluous costs over time; hence, early identification of ASD is essential for administering appropriate therapies and/or medications. Heinsfeld et al. [10] achieved a classification accuracy of 70% for ASD patients using the extensive ABIDE-I neuroimaging dataset, with a precision range of 66% to 71%. The authors observed an average accuracy enhancement of 3% with the RF classifier and 2% with the SVM classifier. Aghdam et al. [11] used the ABIDE-I and ABIDE-II datasets to identify a comprehensive informative cohort of sMRI and fMRI neuroimages of children aged 5 to 10 from ASD and TD (Typically Developing) households. Functional magnetic resonance imaging (fMRI) and structural magnetic resonance imaging (white matter and grey matter) data were used to diagnose autism spectrum disorder (ASD). Before its use as a classifier, the DBN was trained at both intermediate and advanced stages. Zhang et al. [12] examined the use of dMRI to differentiate between ASD and TD in male infants. Utilising data obtained from the Centre for Mental Illness. They may use the diffusivity characteristics from each fibre bundle to ascertain if an individual is diagnosed with ASD or is typically developing (TD). The optimal model, with 4697 large fibre groupings and an accuracy of 78.13%, is the one to use. This model had commendable sensitivity and specificity, attaining 84.81% and 72.86%, respectively.

The suggested method may use functional connectivity patterns to accurately diagnose autism using the CNN trained for ASD image classification. A reduced number of parameters is used, necessitating less computational capacity. Nevertheless, further data must be included for the model to attain greater reliability. The Modified Grasshopper Optimisation Algorithm (MGOA) was devised by Goel et al. [13] for the characterisation of ASD areas from images. Researchers used three distinct ASD screening datasets for testing this technique, corresponding to children, adolescents, and adults. Despite the reduction in processing time, the convergence speed does not meet expectations.

Xu et al [14] used deep learning to classify individuals with autism spectrum disorder. The classifications produced by this approach were far more precise. We did not document the atypical neural patterns in the regions of the brain linked to ASD. Oh et al. (2021) demonstrated that the SVM classifier is superior for distinguishing between typically developing youngsters and those with ASD. Three efficient and adaptable attributes were used to construct the autism index, which was then entered into support vector machine polynomials. This approach did not use cloud-based detection. Eslami [15-16] developed a hybrid learning system to categorise photos of autism spectrum disease. The diagnosis of autism spectrum disorder (ASD) has shown encouraging outcomes.

Key Contribution

- Investigation of existing machine learning techniques for early Autism Detection
- Methods to perform early autism detection

Method, Experiments and Results

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

Support Vector Machines

Support Vector Machines (SVMs) are a kind of machine learning algorithm used for both regression and classification tasks. In the context of data categorisation, it generates a linear boundary that separates categories.

An efficient method for training supervised learning models is using the Support Vector Machine (SVM). In 1992, Vapnik pioneered the development of support vector machines. It was extensively used in various feature selection, classification, and regression problems. Support vector machines (SVMs) use the concept of margin to establish an optimal classification hyperplane.

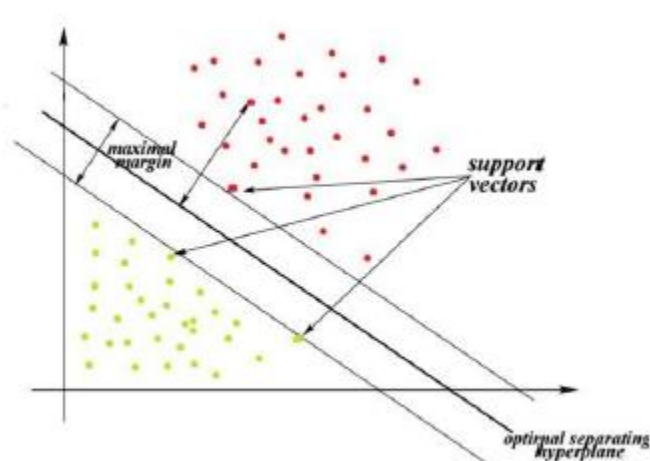


Figure 2. Support Vector Machine

We want to optimise the margin, defined as the distance between the hyperplane and the closest points on each side, to enhance generality. The validity of the argument may be compromised if margin growth is favoured above other considerations. The correlation between capacity and model performance is governed by restrictions. This strategy may balance the model's bias and variance. The support vector machine classification framework operates irrespective of the complete linear separability of the data.

Decision Tree

The Decision Tree method, an instance of supervised machine learning, utilises a tree-like data structure and employs if/else expressions for specific qualities. The decision tree is a hierarchical, rule-based framework that permits classifications to be accepted or rejected at any node. A common classifier in statistical and machine learning applications is the decision tree. Decision trees are hierarchical frameworks that use the divide-and-conquer methodology. This nonparametric method may be used for both classification and regression tasks. A set of conventional if-then rules might suffice. The result is conveyed in a manner that is clear and comprehensible. We introduce the decision tree classification methodology and examine its fundamental components.

K nearest Neighbor

KNN use the distance between feature vectors as a measure to ascertain the most often occurring class among the k nearest instances for labelling an unknown data point. K-Nearest-Neighbor and other instance-based learning methodologies are often used in classification problems, aiming to allocate unseen samples to established categories. The data points are represented in a multidimensional space, where is the total number of features. The model's categorisation is established by juxtaposing fresh data with the existing dataset. The algorithm identifies the K points closest to the new example and assigns each point to the category with the highest number of votes.

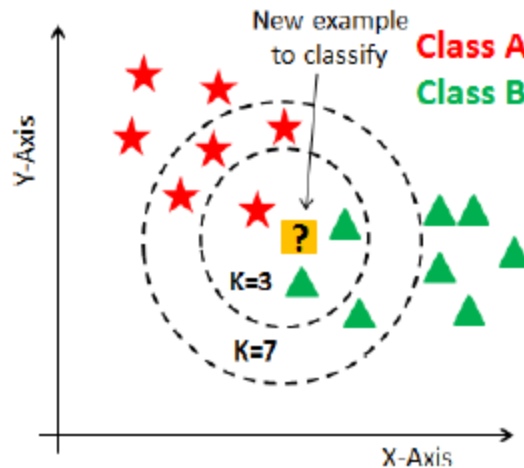


Figure 3 K Nearest Neighbor

If $k=1$, the closest neighboring data point will be used to determine the new example's classification. If $k = 2$, then the two nearest points will be used to decide the new point's class. After $k = 3$, voting aids categorization by placing the new data point in the category that contains the most frequent neighbors

Logical Regression (LR):

This method is used for classification, despite using the term "regression." It is effective for problems involving both binary and multi-class data. We compute the likelihood that a certain set of output values will be generated. Class membership is assumed when the chance of belonging to that class exceeds 50%. In binary classification issues, an entity is classified as "1" if its probability of belonging to that class is 50% or more, and as "0" if it is less than 50%.

Regression and Classification Tree (CART):

Classification and regression are two domains in which it is used. A pre-existing binary decision tree is incrementally augmented with nodes to transform into a CART Decision Tree. The technique starts with the training data set and builds a decision tree by halving the nodes, branches, and so on until every constraint is satisfied. For instance, it explores the previously indicated depths. Another option is to construct an unbounded decision tree to its maximum extent using the process. Subsequently, to identify the optimal subtree, prune it using the minimum loss function derived from the validation dataset.

Conclusions

This study aims to provide background information on ASD. Despite the possibility of early identification, autism spectrum disease (ASD) remains incurable at now. Individuals with autism have difficulties in social interaction and communication. Typically, the symptoms will emerge throughout youth. This disorder is irreversible and will persist with the patient indefinitely. A study revealed that around 33% of children exhibiting difficulties had numerous characteristic markers of autism spectrum disorder (ASD) despite not being diagnosed with the condition. Timely identification of autism spectrum disorder (ASD) enables doctors to provide suitable therapies or medications, therefore reducing the long-term costs associated with diagnosis. The adolescents were insufficiently mature and struggled to articulate suitable replies. Approximately twenty-five percent of all ADI-R assessments may provide this outcome. Consequently, there is a want for easily accessible and efficient ASD screening methods that may ascertain the presence of ASD in a patient and relay this information for further diagnostic evaluation. Individuals of all ages and in all environments may be impacted by Autism Spectrum Disorder, a neurological disorder. ASD include communication challenges, normal interactions, and social impairments. Individuals may improve their behavioural and communication competencies via early diagnosis. The typical screening procedure for autism spectrum disorder (ASD) is arduous and requires the involvement of qualified medical specialists. The validity and accuracy of the autism screening technique are contingent upon the questions used in the screening method and the scoring methodology utilised by domain

experts to ascertain the final score. The primary aim of this work is to devise a collection of feature development methods and machine learning models that surpass existing state-of-the-art procedures in ASD diagnosis.

References

1. A. D. Sallibi and K. M. Ali Alheeti, "Detection of Autism Spectrum Disorder in Children Using Efficient Pre-Processing and Machine Learning Techniques," *2023 International Conference on Decision Aid Sciences and Applications (DASA)*, Annaba, Algeria, 2023, pp. 505-514, doi: 10.1109/DASA59624.2023.10286808.
2. J. C. Edgar, "Identifying electrophysiological markers of autism spectrum disorder and schizophrenia against a backdrop of normal brain development," *Psychiatry Clin. Neurosci.*, vol. 74, no. 1, pp. 1–11, Jan. 2020.
3. Y. Wang, J. Wang, F.-X. Wu, R. Hayrat, and J. Liu, "AIMAFE: Autism spectrum disorder identification with multi-atlas deep feature representation and ensemble learning," *J. Neurosci. Methods*, vol. 343, Sep. 2020, Art. no. 108840.
4. X. Yang, P. T. Schrader, and N. Zhang, "A deep neural network study of the ABIDE repository on autism spectrum classification," *Int. J. Adv. Comput. Sci. Appl.*, vol. 11, no. 4, pp. 1–6, 2020.
5. I. Bilgen, G. Guvercin, and I. Rekik, "Machine learning methods for brain network classification: Application to autism diagnosis using cortical morphological networks," *J. Neurosci. Methods*, vol. 343, Sep. 2020, Art. no. 108799.
6. S. Mostafa, L. Tang, and F.-X. Wu, "Diagnosis of autism spectrum disorder based on eigenvalues of brain networks," *IEEE Access*, vol. 7, pp. 128474–128486, 2019.
7. F. Ke and R. Yang, "Classification and biomarker exploration of autism spectrum disorders based on recurrent attention model," *IEEE Access*, vol. 8, pp. 216298–216307, 2020.
8. K.-H. Yu, A. L. Beam, and I. S. Kohane, "Artificial intelligence in healthcare," *Nature Biomedical Engineering*, vol. 2, no. 10, pp. 719–731, Oct. 2018, doi: <https://doi.org/10.1038/s41551-018-0305-z>.
9. M. Khodatars et al., "Deep learning for neuroimaging-based diagnosis and rehabilitation of Autism Spectrum Disorder: A review," *Computers in Biology and Medicine*, vol. 139, p. 104949, Dec. 2021, doi: <https://doi.org/10.1016/j.compbiomed.2021.104949>.
10. Anon et al., "Identification of autism spectrum disorder using deep learning and the ABIDE dataset," *NeuroImage: Clinical*, vol. 17, pp. 16–23, Jan. 2018, doi: <https://doi.org/10.1016/j.nicl.2017.08.017>.
11. M. Akhavan Aghdam, A. Sharifi, and M. M. Pedram, "Combination of rs-fMRI and sMRI Data to Discriminate Autism Spectrum Disorders in Young Children Using Deep Belief Network," *Journal of Digital Imaging*, vol. 31, no. 6, pp. 895–903, May 2018, doi: <https://doi.org/10.1007/s10278-018-0093-8>.
12. F. Zhang et al., "An anatomically curated fiber clustering white matter atlas for consistent white matter tract parcellation across the lifespan," *NeuroImage*, vol. 179, pp. 429–447, Oct. 2018, doi: <https://doi.org/10.1016/j.neuroimage.2018.06.027>.
13. N. Goel, B. Grover, Anuj, D. Gupta, A. Khanna, and M. Sharma, "Modified Grasshopper Optimization Algorithm for detection of Autism Spectrum Disorder," *Physical Communication*, vol. 41, p. 101115, Aug. 2020, doi: <https://doi.org/10.1016/j.phycom.2020.101115>.
14. L. Xu, X. Geng, X. He, J. Li, and J. Yu, "Prediction in Autism by Deep Learning Short-Time Spontaneous Hemodynamic Fluctuations," vol. 13, Nov. 2019, doi: <https://doi.org/10.3389/fnins.2019.01120>.
15. T. Eslami, F. Almuqhim, J. S. Raiker, and F. Saeed, "Machine Learning Methods for Diagnosing Autism Spectrum Disorder and Attention- Deficit/Hyperactivity Disorder Using Functional and Structural MRI: A Survey," *Frontiers in Neuroinformatics*, vol. 14, Jan. 2021, doi: <https://doi.org/10.3389/fninf.2020.575999>.
16. T. Eslami, V. Mirjalili, A. Fong, A. R. Laird, and F. Saeed, "ASD-DiagNet: A Hybrid Learning Approach for Detection of Autism Spectrum Disorder Using fMRI Data," *Frontiers in Neuroinformatics*, vol. 13, Nov. 2019, doi: <https://doi.org/10.3389/fninf.2019.00070>.

