Children's Autism Spectrum Diagnostic Techniques Using Machine Learning

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Abstract

The number of children diagnosed with autism has increased in recent years. This is due to the inability of doctors to diagnose and treat autism at an early stage, whether through simple traditional or modern methods. To obtain a fast and accurate diagnosis using machine learning techniques with examination methods such as eye appearance, facial patterns, MRI images, movement of body parts and using a combination of eye and brain gaze, the treatment is performed programmatically by creating a system, device, mobile app or robot. Various studies indicate the types of diagnostic methods and which methods are most accurate and reliable.

Keywords: autism spectrum disorder ،Machine Learnings، Diagnostic techniques، algorithms, children

تقنيات تشخيص طيف التوحد للأطفال باستخدام تعلم الالة

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الخلاصة

زاد عدد الأطفال المصابين بالتوحد في السنوات الأخيرة. ويرجع ذلك إلى عدم قدرة الأطباء على تشخيص وعلاج التوحد في مرحلة مبكرة سواء من خلال الأساليب التقليدية أو الحديثة البسيطة. للحصول على تشخيص سريع ودقيق يتم استخدام تقنيات التعلم الآلي مع طرق الفحص مثل مظهر العين وأنماط الوجه وصور التصوير بالرنين المغناطيسي وحركة أجزاء الجسم واستخدام مزيج من نظرة العين والدماغ ، حيث يتم استخدام نماذج تعليم الالة للتنبؤ بالمرض يتم ذلك برمجيًا عن طريق إنشاء نظام أو جهاز أو تطبيق جوال أو روبوت. تشير الدراسات إلى ان تعلم الالة يعطي تشخيص دقيق وموثوق و سرعة.

الكلمات المفتاحية: اضطراب طيف التوحد ، التعلم الآلي ، تقنيات التشخيص ، الخوارزميات ، الاطفال

1-Introduction

Autism spectrum disorder (ASD) is a condition associated with brain development that affects how a person perceives and relates to others on a social level, causing problems with interaction and social communication. The disorder also includes limited and repetitive patterns of behavior. The term "spectrum" in autism spectrum disorder refers to a wide range of symptoms and levels of severity. Autism spectrum disorder begins in early childhood and eventually causes problems with social functioning at school and at work. From this perspective, when dealing with an autistic child, you must be patient when speaking to him, as the autistic child responds slowly .It is better when it is positively reinforced, in many cases, by rewarding the good behaviors that result from it. Some physical activities can be used as a way to deal with a child with autism, such as playing outside or running and sharing some times that help him feel happy and relaxed, and therefore he should be Autism spectrum diagnosis is accurate as machine learning plays an effective role in improving the accuracy of diagnosis through predictive analytics models that help clinicians give patients a more accurate diagnosis in record time. and more efficient treatment plan. The goal of this paper is to identify the types of machine learning techniques that are used in diagnosing the autism spectrum with great accuracy, faster turnaround time, and lower cost, and to help the doctor determine the level and behavior of the child with autism. Easily.

2-Literature review

This paper [1] follows on the path of using eye tracking as an integrated part of screening assessment in ASD based on the characteristic elements of the eye gaze. This study adds to the mounting efforts in using eye tracking technology to support the process of ASD screening The experimental results demonstrated that the visual representation could simplify the diagnostic task and also attained high accuracy.. The findings primarily show that the combination of eye tracking, visualization, and machine learning have strong potential in developing an objective tool to assist in the screening of ASD.This research[2] proposes the detection of ASD in children with the help of transfer learning. The proposed methodology uses four different CNN architectures in autism detection which are VGG19, Resnet50, InceptionV3 and NAS Net Large models. A Dataset consisting of images of facial expressions of autistic and non-autistic children is available as Training, testing and validation data. The NAS Net Large architecture provided an accuracy of 87.50% and a loss of 0.372 compared to the other three models.In this study[3], we applied machine learning (ML) models to regional volumetric and cortical thickness data from the largest structural magnetic resonance imaging (sMRI) dataset available from the Enhancing Neuro Imaging Genetics Through Meta-Analysis (ENIGMA) The highest classification accuracy on a hold- out test set was achieved using a stacked Extra Tree Classifier. The area under the receiver operating characteristic (ROC) curve (AUC) was 0.62 (95% confidence interval [CI]: 0.57, 0.68) and the area under the precision- recall curve was 0.58. Learning curve analysis showed the good fit of the model and suggests that more training examples will not likely benefit model performance.

This study aimed[4] [5.], to compare tracked body movements data during a multimodal VR stimulation between ASD children. Second, it was verified which body areas might Third, the study investigated which virtual stimuli condition better discriminate body areas between the two populations. To reach these aims, we applied a machine learning procedure to body movements' analysis of a multimodal VR experience, composed of three stimuli conditions: visual, visual-auditive, and visual-auditive-olfactory. The study included a preliminary analysis of the frequency distribution of body movements to investigate the differences between groups and a broad set of supervised ML models combining body parameters and stimuli conditions to evaluate

the discriminability between ASD children using movement

3- machine learning Techniques

Machine learning, originally used to develop strategies to enable computers to learn, is a branch of artificial intelligence. Today, it is used in a wide variety of areas, including medical diagnosis, facial and speech recognition, and data analysis, as it includes a number of advanced statistical methods for regression and classification. Machine learning techniques simulate human cognition and learn from training examples to predict future events [6] by creating algorithms that can learn from data and create predictions rather than following purely static program instructions. Such algorithms develop a model from an input sample from In order to create data-driven decisions [7], an algorithm in machine learning is an action performed on data to create a machine learning "model". Machine learning algorithms perform "pattern recognition." Algorithms "learn" from the data, or "fit" into the data set. Below are the types of algorithms:

- Linear classifiers
- Fisher's linear discriminant
- Logistic regression
- Naive Bayes classifier
- Perceptron
- Support vector machines
- Least squares support vector machines
- Quadratic classifiers
- Kernel estimation
- k-nearest neighbor
- Boosting (meta-algorithm)
- Decision trees
- Random forests
- Neural networks
- Learning vector quantization

Machine learning's classification process is automated and on-the-fly, rather than being a stand-alone problem with a static training dataset that is learned using machine learning algorithms. Rather, it is a dynamic and intricate process. We anticipate that the medical diagnosis of ASD will be automated, with qualified medical staff acting as decision-makers within a clinic. This snecessitates:[8]

(a)The classifier to be embedded within the medical screening tool

(b) The case under examination to be the test data case

(c) A knowledge base (classifier) that can be amended periodically based on the classified test cases and a training dataset that grows exponentially.

(d) The diagnosis to be taken within a valid environment

The automated predictive ASD classification model consists of:

1)Input: A historical case and controls, a machine learning algorithm, a diagnostic tool (ADOS-R, ADI-R, etc), specialized licensed clinician.

(2) Process:

(a) Generating the evaluation results and providing them to the licensed clinician

(b) Diagnose the test case by the licensed clinician

(c) Pre-processing the data (optional)

(d) Integrating the machine learning algorithm within the diagnostic tool

(e) Training on the data using the machine learning method

(f) Building the classifier which will be the predictive ASD model

(g) Replacing the original handcrafted rules of the diagnostic tool with the classifier

(3) Reading a new test case using the diagnostic tool

(4) Evaluating the new case using the classifier of the diagnostic too

4-Diagnostic Tools

Diagnosis is the process used to identify a disease or condition. It comes at the end of an assessment process that involves examining the patient's history, symptoms, and appearance and analyzing diagnostic tests. For people with ASD, it requires a process of observation and clinical examination that can take some time. Part of making a diagnosis is called differential diagnosis. This is the medical term for the process of excluding all the other possible conditions that could cause

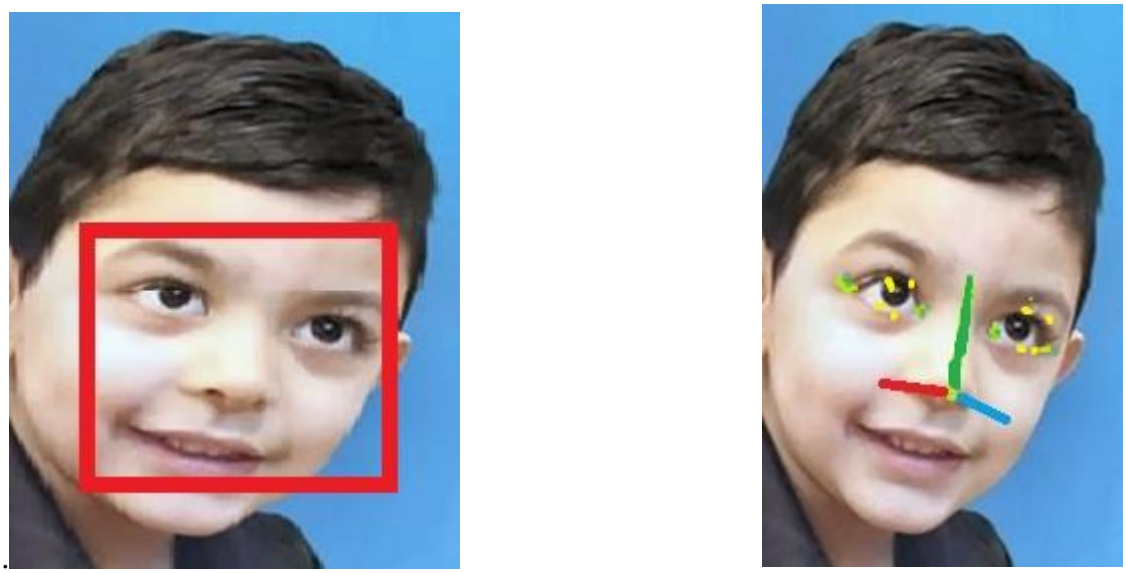
the same symptoms. And modern diagnosis includes building a model using a machine learning algorithm with diagnostic method [9]. The types of diagnostic methods are:

1- eye tracking

Eye contact is one of the simplest and most powerful forms of nonverbal communication that humans have used since the first months of their lives. Studies have found that a diagnosis based on vital signs such as eye movement can express a person's true condition, and eye movement is observed to monitor abnormalities related to the disorder. As a result, eye movement patterns and eye tracking data [10] are used as biomarkers for early detection and more accurate screening for autism spectrum disorders. Eye-tracking data was collected while participants viewed varying images (i.e., pictures, videos, and web pages). Although gaze behavior is known to differ between face-to-face interaction and image-viewing tasks, no study has investigated whether eye-tracking data from face-to-face conversations can also accurately identify individuals with ASD[11] using machine learning algorithms that create a robust model by data entry and feature extraction and then predict the patient's condition through the algorithm's accuracy. Table 1 shows the types and accuracy of algorithms used in building eye movement diagnostics systems. This technique, in comparison to other diagnostic techniques, necessitates a very large data volume.

Table (1) The types and accuracy of algorithms used in building eye movement diagnostics systems.

Author	algorithm	accuracy	limitations
Zhong Zhao,et al 2021 [10]	SVM	92.31%	A head-mounted eye tracker to record the gaze behavior, which might affect the social behavior of children with ASD to a larger extent. In general
Victoria Yaneva , et al. 2020[12]	SVM	74%	Limitations: Some limitations of this method are that search tasks are not suitable for very young children The current design is also unable to provide a conclusive explanation for some of the r
DennisNúñez,etal. (2020) [13]	CNN	95.1%	Poor lighting, eyelashes disturbed from some angles Small screen (does not allow to distinguish between right and left gaze direction), Supervisor did not hold the child's head (Produced untreatable Pictures due to the baby's head movements), the camera did not have autofocus and is weak Accuracy (which leads to lower quality of the eye area).
Eraslan, et al. (2020) [14]	scanpath Trend Analysis (STA)	60%	This method needs a cost-effective, supportive alternative for the detection of autism



(a) (b)

Figure (1) a. The area of interest that he focuses on when taking the image
b. Head pose and eye direction overlays from a software application [15]

When taking photographs, the gaze behavior involves the following:

1. Mean (gaze angle horizontal)
2. Mean (gaze angle vertical)
3. Absolute deviation from median gaze angle (horizontal)
4. Absolute deviation from median gaze angle (vertical)
5. Mean speed of eye movement (horizontal)
6. Mean speed of eye movement (vertical)
7. Mean acceleration of eye movement (horizontal)
8. Mean acceleration of eye movement (vertical)

2-Digital Images

A digital image is a digital representation (binary values of zero and one) of a physical object that can be seen by the human eye, that is entered (by a digital camera or scanner) to a computer for the purpose of storage, modification, or storage. It is a two-dimensional image, the image has two types in terms of composition, a type called Victor images, which is not affected by zooming in or out, and it maintains its clarity in all cases. As for the second type, it is called bitmap image or raster image, and when digital images are mentioned, this type is what is meant and it is [/notice] When the real image (Continues image) is entered into the computer (transforming it into a digital image), a process called sampling takes place, which is an expression About taking small samples from the real image and describing it to represent the real image. Each sample is a square shape called a pixel (Pixel = Picture element) and it is considered the smallest part in the digital image. gray or colored. From this, digital images enter the medical field and include Gamma ray imaging, ultraviolet imaging. DNA analysis, fingerprints and facial recognition are obvious applications for image processing [16], magnetic resonance imaging of the brain ,and sonar images. In line with what was mentioned, brain images are included in the diagnosis of autism spectrum disorder for children using machine learning.

-brain images: early diagnosis can be achieved by using computer-aided methods based on EEG signals and/or structural magnetic resonance image , machine learning (ML), deep learning (DL) and other advanced computing technologies ML algorithms have been employed successfully to solve many complicated pattern recognition problems ML models can be used both to confirm a diagnosis and make early diagnosis of ASD. In most ML methods used for the diagnosis of

ASD, data must be preprocessed before training and testing the model. A data set is created by identifying features to help recognize ASD and converting these features into numerical values and data matrices. The feature extraction or feature selection process depends on the nature of the data to be used. For example, if brain imaging, sMRI or fMRI, is used, structural and functional features related to the ASD brain must be obtained(Yahata et al. 2017)، sMRI scans are the most common imaging modality used for identification of possible ASD brain biomarkers in ML models for the ASD diagnosis. The most commonly used ML algorithm is support vector machines (SVMs). In these SVM applications, volumetric features of the brain such as WM volume, and grey matter volume (GMV) or geometric features of the brain such as regional cortical thickness were utilized to differentiate ASD from non-ASD brain , Integrating different diagnostic modalities such as EEG and MEG has been a recent trend [17]SVMs is the most widely used ML method for ASD diagnosis or other neuroimaging studies. This is probably due to its simplicity and available implementation. newly. DNN models such as CNN have been used in brain imaging، the classifier models used to predict ASD are trained using a numerical data matrix formed as a result of feature extraction from brain fMRI or sMRI scans and clinical data. The feature extraction process is timeconsuming because it requires that the neuroimage of each participant be processed individually. This may lead to small size data sets used for the training of classifiers. As such, automation of feature extraction is highly desirable .End-to-end deep convolutional neural network models، The biggest problem facing the diagnosis of ASD through the brain is the detection of the predictive trait of the brain and it can be solved by one of the machine learning algorithms, which gives more accurate

1. functional MRI (fMRI) is a non-invasive technique that measures the brain activity by detecting changes associated with blood flow . The techniques exploits the fact that cerebral blood flow and neural activity are correlated, i.e., blood flow in the brain where neurons are firing.
2. Structural MRI (sMRI) is also a non-invasive technique that provides sequences of brain tissue contrast by varying the excitation, and the repetition times to image different structure of the brain. These sequences produce volumetric measurements of the brain structure .

Data has shown to contain quantifiable biomarkers and features, such as early circumference enlargement and volume overgrowth of the brain, that can be used as the input to machine learning models for detection of brain disorders[18] .table1 showing the algorithms used with the eye tool

Author	method	algorithm	accuracy	limitations
Gorriz et al. 2019 [19]	sMRI.	SVM	66.16	To reveal the predictive feature of WM and GM
Heinsfeld et a 2018 [20]	fMRI	DNA	70	To reveal the predictive feature of whole-brain functional connectivity abnormalities
Rubbina, et al 2019[21]	n hybrid brain imaging	CRF	92.5	Examination of the use of structural and functional features together with deep learning application for ASD diagnosis and comparison with functional connectivity
(Rakic et al., 2020 ´[22]	sMRI+ fMRI	MLP	85	There is a discrepancy between the results and reality The separation

				between training, validation and testing was generated randomly, and finally, some details of the original implementations were not available

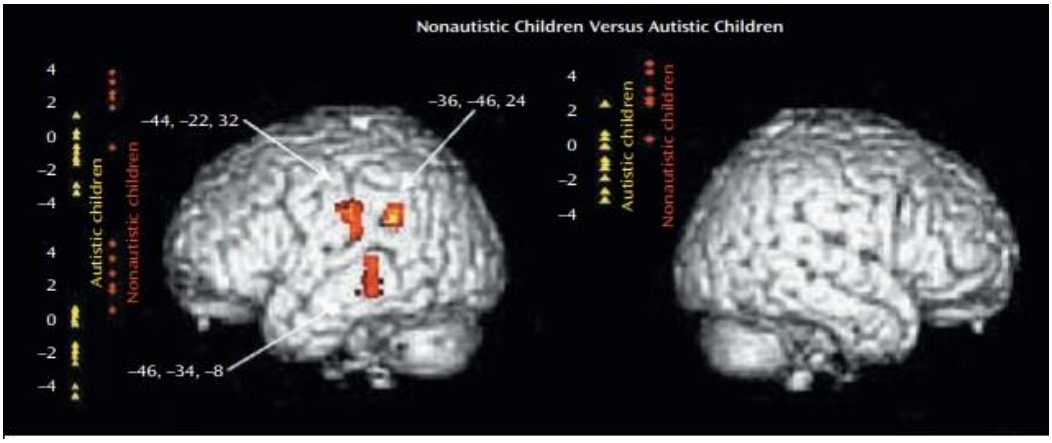


Figure (2) MRI of a child with autism [23]

3- **face Expressions**

A machine learning algorithm uses facial scanning patterns to identify children with autism spectrum disorder. A machine learning approach involves detecting facial expressions and recognizing the emotions of ASD children. Facial expressions are taken from different angles and with varying environmental lighting. Using the image data set, autistic people have difficulty expressing their feelings. And then, by capturing facial images, the different facial expressions of children with autism can help solve this problem through rapid developments in machine learning (ML) algorithms for complex computations and different image processing. Recent studies have addressed the proposal of a machine learning solution to measure potential ASD risk based on face scanning patterns in a face recognition task. In particular, we used a data-driven approach to extract features from face scanning data and a machine learning algorithm to do the classification. The predictive value of this machine learning model was evaluated for accuracy, specificity, and sensitivity. In this case, the youngster sits on the caregiver's lap while watching short films shown on a smart tablet, with the built-in camera recording the child's facial expressions. Computer vision analysis was utilized to predict head position and facial emotions by automatically detecting and tracking facial elements (positive, neutral, and everything else). Expression and movement of the face When compared to children without autism spectrum disorder, who have a wide range of expressions, children with autism spectrum disorder show neutral expressions more frequently. Non-autistic children had a strong desire for all other expressions and frequently displayed large brows and an open mouth, both of which are indicators of involvement and attentiveness. Studies demonstrate that using a tablet-based assessment to compute facial movements and expressions can reveal variations in emotional expression, which is an early fundamental component of autism spectrum disorder.[24]

Table (2) showing the algorithms used with the face tool

Author	algorithm	accuracy	limitations
Wenbo Liu,et al. 2016[25]	SVM	88.51%.	This technique is not accurate because facial features change, so it must be combined with another technique
D. Zhao, 2018[26].	random forest	72%	Facial expressions contain a large amount of noise generated By means of muscle movement and multimodal stimulation
Kang, (2020)[27]	SVM+ mRMR	72.50%	The sample consisted of children aged from 3 to 6, and no younger patients were included.

H

S

F

A

Lip corner puller – H

Lip corner depressor- S

Jaw drop-F

Figure (3) The Facial Expressions used in the diagnosis
(H = Happiness; S = Sadness; F = Fear; and A = Anger)[28]

4. **Kinematic analysis**

Children with autism have motor impairments such as hand flutter, body movement, abnormal walking, rocking, and turning, which are common to most children with this form of autism. Research has demonstrated that the dynamics of head movement (displacement and velocity) are greater in autistic children than in non-autistic children, providing a quantitative basis for clinical reports.

Differences in head movement are evident in lateral movement (yaw and roll) but not vertical movement (pitch) and are specific to a social rather than a social situation. When presented with social stimuli, children with autism had higher levels of head movement and moved their heads more quickly than children without autism. Children may use head movement to modify their perception of social scenes [29], and this suggests that a child with autism can be diagnosed by head shaking. Movement problems are currently considered to be associated features that support a diagnosis of ASD, as recent studies have revealed that investigation into the nature of motor problems in ASD may bring a new perspective in diagnostic and treatment approaches.[30.]

Table (3) showing the algorithms used with the Kinematic analysis tool

author	algorithm	Accuracy	limitations
ZHONG ZHAO,et al .2019[31]	KNN	%88.37	The method of diagnosis is objective and automated
Ge, et al. 2019[32]	AdaBoost	97%	It is necessary to achieve a real-time response, but it leads to decreases the accuracy of the system
Suman Raj,et al 2019.[33]	CNN	99.53%	Performance is limited

Figure (4) The tilting test can be used as an early indicator for possible autism At 6–8 months a typically developed infant maintains hisher head vertical as the body is being tilted (A–C). A negative response is evident when the infant carries the head in line with the rest of the tilted body (D) [34]

5- Speech and language disorders

Many children with autism spectrum disorder have trouble understanding speech and language, resulting in delays in learning to speak (beyond the age of two) or a complete lack of communication. Speak with an odd rhythm or pitch, or with an unusual tone of voice. repeating words or phrases over and over again with no intention of making a connection. Having difficulty initiating or maintaining a conversation? Communication issues when it comes to needs or wants It doesn't grasp simple inquiries or words. As a result, we find that autistic children who can communicate say things that have no meaning or are unrelated to their dialogues with others. A child might for example count from one to five repeatedly during a non-numerical discourse. Or, in the case of echolocation, the youngster may repeatedly repeat the phrases he or she has heard. When a child repeats what someone has just said, it is called an instant echo. might respond to a question by asking another one. The toddler repeats the phrases he heard earlier in the echo delay. . Some autistic youngsters speak loudly, sing a tune, or speak in a robotic manner. Other children may initiate a conversation by using common phrases. even when speaking with family or friends. Others continue to repeat what they have heard[35] .

6-Integration of more than one technology is a modern method currently used to diagnose autism spectrum disorder is a combination of

two technologies such as EEG with eye tracking data or merging facial features with eye tracking data and this method gives a more reliable diagnosis of autism spectrum disorder compared to other methods.[36]

6-Discussion

Various types of technologies have been used to diagnose and screen children with autism spectrum disorder and to try to predict the behavior of these children in the future. Research indicates that children with autism can be distinguished from an early age using modern smart techniques in ML and access to good results in the future. Its accuracy has not yet been proven.

7-Conclusions

The research dealt with providing new techniques for machine learning to diagnose autism, reducing the time of diagnosis, and revealing the expected future behavior of children. This research provides a benefit to doctors, parents, and those interested in this category.

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