

Research Article

Evaluation of Autism Spectrum Disorder Based on the Healthcare by Using Artificial Intelligence Strategies

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The behaviors of children with autism spectrum disorder (ASD) are often erratic and difficult to predict. Most of the time, they are unable to communicate effectively in their own language. Instead, they communicate using hand gestures and pointing phrases. Because of this, it can be difficult for caregivers to grasp their patients' requirements, although early detection of the condition can make this much simpler. Assistive technology and the Internet of Things (IoT) can alleviate the absence of verbal and nonverbal communication in the community. The IoT-based solutions use machine Learning (ML) and deep learning (DL) algorithms to diagnose and enhance the lives of patients. A thorough review of ASD techniques in the setting of IoT devices is presented in this research. Identifying important trends in IoT-based health care research is the primary objective of this review. There is also a technical taxonomy for organizing the current articles on ASD algorithms and methodologies based on different factors such as AI, SS network, ML, and IoT. On the basis of criteria such as accuracy and sensitivity, the statistical and operational analyses of the examined ASD techniques are presented.

1. Introduction

Disabilities in social behavior and interaction are characteristics of ASD. According to Jon Baio [1], an estimated 1 in every 59 children is diagnosed with ASD. Special care and welfare facilities are needed by all impaired children more than by healthy youngsters [2]. In addition to limiting the lives of the sufferers, this long-term condition has a detrimental impact on their caretakers' quality of life (QoL). Patients can be monitored remotely using systems based on IoT devices, which have numerous beneficial characteristics. There have so been a number of healthcare applications leveraging IoT devices in recent years. GPS, heart rate, microphone, and ear clips [2] are some of the most common IoT sensors used in wearable devices like smartwatches and smartphones. Sensors and devices are used to identify autistic youngsters, rather than traditional techniques of diagnosis [3, 4].

To help protect youngsters from developing life-threatening disorders, several studies have been conducted during the last decade. However, there were no major breakthroughs. Hence, the most important components of assisting the patient are early diagnosis and improving the QoL of the patients. Autistic children are frequently misdiagnosed until they are two years old [4]. As a result, they are still unable to carry out their daily routines. Consequently, this article examines several IoT device techniques for children with ASD to evaluate and contrast novel ways of detecting the disorder or enhancing quality of life for individuals already diagnosed [4, 5]. The Internet of Things is using artificial intelligence, machine learning, SS network, and deep learning to identify and protect patients from physical and emotional problems [5]. Patients' vital signs are gathered by these systems, which then use various machine learning and deep learning algorithms to select the most appropriate responses. They may even be able to assist in the early

detection of ASD. There are risky behaviors that autistic children perform when they are irritated, which can impair their physical health. An alarm is sent to caretakers and doctors, informing them of the condition and requesting assistance. Every one of these IoT-based devices monitors the body's vital signs and records any changes depending on a variety of criteria (e.g., sensitivity, specificity, time, and accuracy) [6].

According to our knowledge, the ASD methods have not been extensively studied. In this work, methods for a Systematic Literature Review (SLR) are presented so that developing technologies such as wearable devices and mobiles can be utilized in ASD research. A technical taxonomy [6, 7] describes the classification of existing ASD approaches and algorithms employing IoT-based devices and ML/DL. Through the use of SS networks in the health sector, there will be an increase in communication and collaboration, with individuals sharing information about similar conditions and healthcare professionals sharing their knowledge of care and treatment. As a result, better health decisions can be made.

Our ASD methodologies are broken down into two main categories: ways to identifying and monitoring illness severity in children with ASD and programmed to improve the quality of life for children with ASD [6].

Among the SLR's significant contributions to ASD methods are the following:

- (i) Providing an overview and analysis of ASD techniques employing IoT-based devices, ML and DL algorithms, and 28 publications
- (ii) IoT-based ASD methodologies and algorithms presented in a technical taxonomy
- (iii) Technical accept such as IoT, ML, AI, and SS network used in methodologies
- (iv) Discussing and analyzing the technical aspects of each research study

The following is the structure of this paper: Section 2 presents a review of the literature, which is followed by Section 3, explaining the study strategy and methods. Section 4 presents a technical taxonomy for ASD methods, as well as a side-by-side comparison and summary for each research study that is based on the taxonomy that has been offered in the previous section. Following a review of the research papers, Section 5 gives an analytical commentary. Section 6 discusses unresolved difficulties and new obstacles associated with autism spectrum disorders (ASD) in detail. Finally, in Section 7, the study comes to a close with a conclusion.

2. Literature Review

Caregivers and families dealing with autistic children face one of the most challenging and difficult challenges. Systems that use the Internet of Things have attracted a lot of interest in recent years. ASD treatment and diagnosis have been the focus of several publications, but only a small number of

relevant studies have been presented to study ASD in the same way.

Badotra et al. [8] addressed issues in a wide range of smart devices, sensors, and systems connected to health concerns, which are closely related to our study. Internet of Things (IoT) has emerged as a modern information technology, according to [7]. One of the most interesting uses for a growing number of wearable sensors in healthcare is to store the data collected from monitoring physiological parameters like heart rate. IoT, cloud computing, and Wireless Body Area Network (WBAN) are the primary components of this technology (WBAN). IoT-powered wireless "SS networks" rely on a machine learning technique for their effectiveness since there is a lot of data that has to be intelligently managed.

Kollias et al. [9] demonstrate that children with ASD, like those with dementia and Alzheimer's, also experience forgetfulness. As a result, individuals are more likely to encounter dangerous circumstances, such as fleeing their homes. On the other hand, this technology allows children with ASD to remain in their comfort zone. Alzimio, a solution based on IoT devices, was presented to address these problems. Using a method developed by Aisuwarya Sundas et al. [10], the exact location of patients can be displayed on the smartphones of medical professionals. When patients have departed from their comfort zone, these systems may be of great assistance.

Data mining approaches like as classification, regression, and clustering were used by Farooqi et al. [11] to diagnose ASD early. For patients and their careers, early detection of ASD is critical to providing appropriate education and support. For the most accurate diagnosis, their research found that categorization algorithms are the best.

Using data mining tools, Wong et al. [12] have studied the impact of autism treatments on proper conduct. Autistic children can be predicted and better understood using this method. On the basis of these techniques, they could distinguish between what were deemed acceptable and unacceptable behaviors.

Kaur et al. [13] analyzed 45 papers that applied supervised machine learning and classification techniques to ASD. SVM, random forest, decision trees, Least Absolute Shrinkage and Selection Operator (LASSO), Neutral Network (NN), regression, Conditional Forest (CF), Nave Bayes (NB), Elastic Net regression (ENet), Random Tree, and Flex Tree were the most utilized models. A survey of 83 publications published after the year 2000 was conducted by Koumpouros and colleagues for their study. The papers committed to intervening in the treatment of ASD with wearable technology and computer power [14].

An autistic youngster can benefit from the Robota robot toy, which was used in [15] to demonstrate the potential of the AuRoRA project. An evaluation element known as Conversation Analysis (CA) was used to study the development of three children with autism. As a result, they came to understand that the youngsters are in fact interacting with the adult robot. An autistic child's joint attention was not only defined in the study, but computer and robot therapy for ASD was also highlighted.

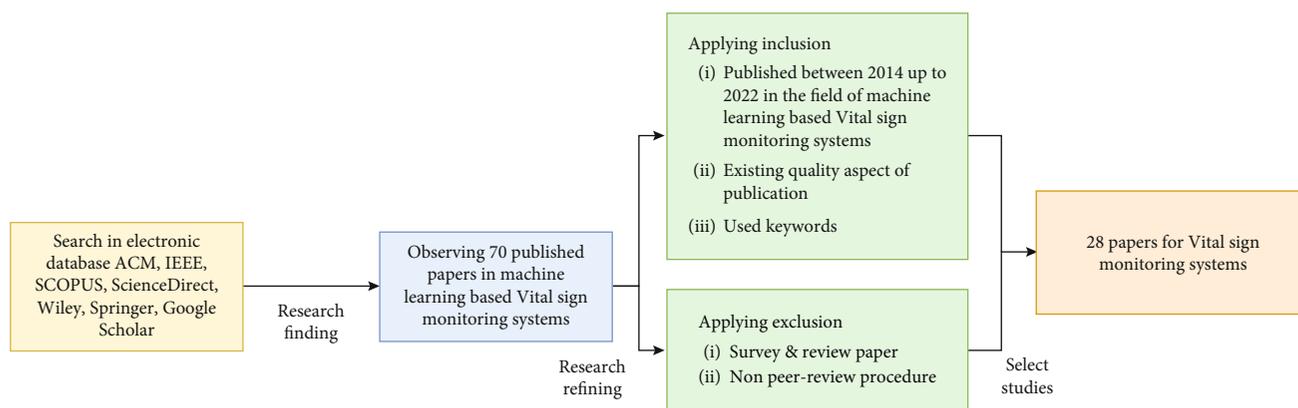


FIGURE 1: Methodology for doing research based on the SLR.

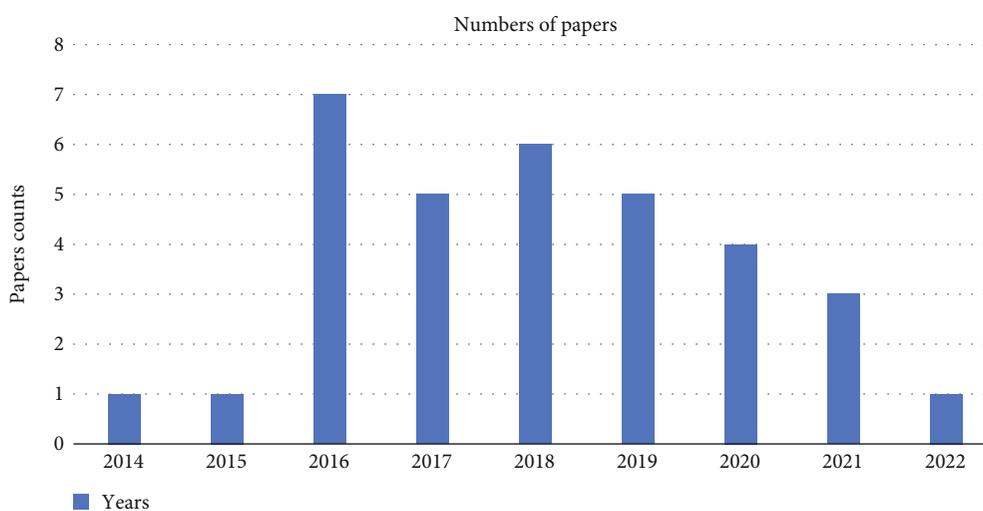


FIGURE 2: Annual publication analysis of ASD methods.

3. Methodology

The comprehensive literature review technique provided by current ADS approaches [16] is used in this section. The SLR is compiling pertinent papers that identify specific research issues and questions for further investigation. Three steps are depicted in Figure 1 of the methodology: gathering, refining, and analyzing.

In March of this year, we initiated our search for pertinent articles. ScienceDirect, ACM, IEEE, Springer, Google Scholar, Wiley, and SCOPUS were also significant data sources and resources. According to a variety of inclusion and exclusion criteria, over 65 publications were analyzed to determine which studies were the most pertinent to the review literature. The use of Internet of Things devices in autism spectrum disorder (ASD) research was examined in stages from 2014 to March 2020. PICO Stone [17] utilized IoT, wearable sensors, robotics therapy, smartphones, smart watches, and the Kasper robot in an effort to employ the most pertinent keywords. Survey and review papers, as well as works written in contexts other than English or by means other than peer review, are also withdrawn. In the end, 28 articles related to IoT-based products and the diagnosis

and treatment of ASD (Figure 2) were retrieved. Below in Figure 2, ASD investigations employing IoT-based devices take an average of two years to come to fruition [18]. The chart shows 2 axes in which the y-axis indicates the number of papers counts and the x-axis represents years from 2014 to 2022.

The final selection of research yielded the following 28 studies as shown in Figures 1 and 2.

- (i) A statistical, formal, simulation-based, and implementation-based research approach has been presented
- (ii) The final version of all publications is required
- (iii) It is published on the subject of ASD

For each study research, an analysis of internal and external questions was produced to link to the technical features of the SLR technique on ASD approaches. These questions were then used to conduct the study research.

- (a) Which methods to autism spectrum disorder are being discussed and reviewed in this analysis?

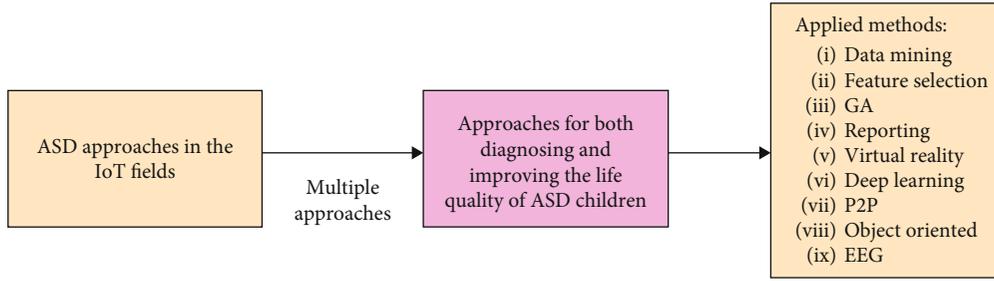


FIGURE 3: Presented taxonomy for the ASD approaches.

TABLE 1: A comparison of the approaches used for diagnosing and monitoring the degree of illness in children with autism spectrum disorder (ASD).

Ref.	Key points	Method	Characteristics of evaluation			
			Time	Specificity	Accuracy	Sensitivity
[18]	Using brain signals to focus attention on one's health using SS network	Data mining	✓	✗	✓	✗
[19]	Long-term use of wearable technologies to evaluate psychological health	Reporting	✓	✗	✓	✗
[20]	Using IoT to monitor healthcare	Feature selection	✗	✗	✓	✗
[21]	Avoid obtaining injured by autistic people who aren't at responsibility	GA	✗	✗	✓	✗
[22]	Emotional and visual indicators in a smart home	DL	✗	✗	✓	✗
[23]	Recognize the emotions of children with autism	DL	✗	✓	✓	✗
[24]	Monitoring the actions of an autistic person might be quite risky	Feature selection	✓	✗	✓	✗
[25]	Autism condition can be detected early if it is recognized using SS network	Feature selection	✓	✓	✓	✓
[26]	Autism children's situation can be properly appreciated with virtual reality therapy	Virtual reality	✓	✗	✗	✗
[27]	A reliable strategy for the early detection of autistic spectrum disorders in youngsters	Feature selection	✓	✓	✓	✓
[28]	A framework for detecting autism in children using SS network	Data mining	✗	✓	✓	✓
[29]	ML-based ASD detection	Feature selection	✓	✗	✗	✗

- (b) What techniques and processes are used in the treatment of autism spectrum disorder?
- (c) What are the ASD performance metrics?
- (d) Find out which scientific journals or conferences published based on ASD?
- (e) ASD techniques use which platforms and sensors?

DL, virtual reality, object-oriented, EEG (electroencephalography), and peer-to peer (P2P).

4. ASD Approaches

Autism is an incurable condition that requires the sufferer to deal with it for the rest of their lives. If you can foresee immediately that the therapeutic procedures should be used, you can act swiftly to implement them. In this part, there is a lot of attention paid to ASD research. The publications need to be studied more thoroughly in order to improve ASD treatment approaches. According to Figure 3, our study methodologies included two elements in the following subsections: ways for diagnosing and assessing the severity of ASD for children and programmed for enhancing the quality of life of children with ASD. Following studies used a variety of ways to achieve these objectives, including data mining, feature selection, genetic algorithms, reporting on

4.1. *Children with ASD May Be Diagnosed and Their Condition Severity Measured Using a Variety of Different Methods.* Forecasting and monitoring are two of ASD's thorniest problems. The educational and health assistance sectors are impacted by the impact of autism's unique way of seeing the world. With IoT services, the sickness is anticipated in 2- or 3-year-old children in mild and severe ranges; however the approach has been hastened.

The individuals will benefit from this enhancement in the quality of educational and health services. Table 1 shows the fundamental concept, implemented technique, platforms and sensors, and the evaluation elements that were examined.

Wearable sensors that scan brainwaves have been proposed by Sundhara Kumar and Bairavi [18] as a framework for autonomous monitoring of health issues. Caregivers of autistic persons received regular updates on the progress of their loved ones. When a patient's health is in jeopardy, a health description is communicated to their careers and physicians via sensors that monitor brain activity. Predicting the illness is more accurate with brain data.

Yang et al. [19] presented wearable technology based on social sensing, privacy audio feature merging, environment sensing, and behavior tracking. To evaluate voice quality and information without storing unprocessed audio data, the wellbeing monitoring platform developed privacy audio wellbeing capabilities. In their case study, they utilized Android smartphones and servers to create an application that explains the long-term relationship between physical and psychological data. It may also be evaluated on actual humans in clinical trials. Krishna and Sampath [20] have also presented an IoT system for monitoring important patient metrics and health situations. This information is transmitted to the cloud server via a smartphone or other device. Using cloud computing and the collected metrics, such as heart rate, oxygen saturation percentage, and body temperature, we can determine the health status of a user. A programmed laptop or smartphone can be used to display the data from the user's mobile phone.

A Service-Oriented Architecture (SOA) for persons with an autistic condition was developed by Eshetu et al. [21]. In the proposed wearable sensors, autistic persons and their environment may be monitored for their physiological state. Using readily accessible and inexpensive devices such as smartphones, cameras, and other wireless items, Mano et al. [22] developed an Internet of Things therapeutic system for the home use of handicapped patients and the elderly. For the treatment of patients, they made use of image processing and embedded computers and aided in the development of a health-conscious household. Accuracy and cognitive theory emphasize were outlined by the authors. For Parkinson's sufferers as well as children with ASD, this therapy may be able to enhance facial expression. Some of the behaviors and reactions of autistic children, such as voice pitch, communication without words, and complex techniques, have been reported by Lavanya et al. [23].

An IoT system that uses a wristwatch to identify autistic children's stereotyped behaviors was introduced by Amiri et al. [24]. For children with autism, weeping, flapping of the hands, and painting are frequent behaviors. The accelerometer in the wristwatch is designed to recognize these three common reactions. Sensors are used to collect data, which is subsequently sent to the cloud for processing. Parents, clinicians, and caregivers will benefit from this technology since the process changes decision trees and improves their correctness. When it comes to early detection, Moradi et al. [25] used a smart toy automobile. In the toy car, the SVM algorithm was used to tell between healthy children and autistic youngsters. So far, this method has the highest level of accuracy, sensitivity, and specificity, based on the results of their experimentation. An autistic child's emotional, attentional, and social ties can be reinforced in a therapy-based virtual world that has several levels. Attracting attention with color lights and loud noises first, the atmosphere focuses on boosting social ties and engagement by allowing people to touch each other, as well as throw a ball at each other. When it comes to choosing a decision, this is it! Autistic children's terror, frustration, and eagerness may all be predicted with virtual reality therapy [26].

Using linear or nonlinear EEG variable selection, Abdol-zadegan et al. [27] developed a robust technique for early identification of children with ASD using EEG data description and analysis. MI, SVM, GA, and K -nearest neighbor were all important factors in the feature selection process (KNN). In terms of KNN and SVM, they came out on top. Deep neural network and hybrid classifications were not supported by the suggested technique.

Data analysis and machine learning techniques were used by Shankar et al. [28] to create a paradigm for diagnosing autism in babies. Their structure also made extensive use of SVM-based training of data models and of data analysis in general. It was able to attain an accuracy of 89% but will need to be improved using DL and biomedical imaging in order to be more efficient. Praveena et al. [29] used ML algorithms to diagnose ASD early enough to provide the most effective treatment for the condition. They used the UCI dataset to test their own method. The technique can be used in conjunction with other diagnostic tools for autism spectrum disorder, such as EEG and MRI scans. For SVM and DL algorithms, in particular, an intelligence detective needs to be constructed.

4.2. Children with ASD May Be Diagnosed and Their Condition Severity Measured Using a Variety of Different Methods. ASD is a serious problem that has to be addressed. Few studies have looked at some significant factors related to the quality of life for children with autism spectrum disorder. Table 2 gives more information on these studies.

An IoT system was described by Alam et al. [30]. ASD symptoms and indicators are gathered by ubiquitous sensor nodes in the Belief Rule Base (BRB) in order to categorize different autistic kid kinds. They monitored their heart rate, social contact, and other activities with a variety of devices. Rule weight and patient believe level are the system's criteria. Sensors and IoT systems can, however, be used to increase their accuracy. For children with autism, Rahman and Bhuiyan [31] developed an individual need platform that assessed physiological signals and utilized data gathered and converged from applications. The wearable system's design featured an array of sensors, multiple integrated wearable sensors, and medical servers to detect the health state of autistic children. Sensors and other embedded devices are used in the multimodal intelligent mode to enhance patients' day-to-day activities. Wearable features that are comfortable for laboratory usage cannot be employed in the workplace or for everyday activities. A wearable gadget developed by Shi et al. [32] is also being used in classrooms to study the interaction and behavior of children with ASD. Obsessive-compulsive disorder (ASD) sufferers can improve their social skills with the use of technology. Using this strategy, teachers receive the best feedback and responses, which improves classroom involvement.

A fuzzy assistive approach developed by Sumi et al. [33] decreases the amount of dependence on the user. In order to restore order, the system gathers data from numerous sensors and transmits it to the aiding personnel. If a child is damaged or hurt, helpers will be alerted instantly thanks to wearing sensors. Using the ASD's facial expressions and

TABLE 2: Approaches for increasing quality of life for children with autism spectrum disorder (ASD).

Ref.	Key points	Method	Characteristics of evaluation			
			Time	Specificity	Accuracy	Sensitivity
[30]	Autism spectrum disorder assessment in children using SS network	Data mining	✓	✗	✓	✗
[31]	IoT sensors detect autism-related special needs in youngsters	Data mining	✓	✗	✗	✗
[32]	Providing instructors of autistic children with the greatest possible feedback	Data mining	✓	✗	✓	✗
[33]	Removing the autistic learner from reliance on others' help and support	Data mining	✓	✗	✓	✗
[34]	ASD's ability to recognize and express emotion	Data mining	✗	✗	✓	✗
[35]	Acknowledging the necessity of ASD via PECS	Data mining	✓	✗	✗	✗
[36]	Using robots to train autistic children and enhance their talents using SS network	Genetic algorithm	✓	✗	✓	✗
[37]	The recommended technological treatment for ADD/ADHD in parents using SS network	Reporting	✓	✗	✓	✗
[38]	Investigating the ways in which intelligent items assist autistic individuals	Feature selection	✓	✗	✗	✗
[39]	Intelligent technology has enabled autistic children to perform previously inaccessible tasks	Object- oriented	✗	✗	✓	✗
[40]	In order to improve the autistic patient's heuristic detection issue,	P2P	✓	✗	✗	✓
[41]	Students' social and communication skills will be improved thanks to the robot Kasper to detect ASD	P2P	✓	✗	✗	✗
[42]	To assess the effectiveness of human and robot-based treatment for children with autism spectrum disorder (ASD)	Reporting	✗	✗	✗	✗
[43]	To develop an IoT-based assistive device for people with autism spectrum disorder (ASD)	Reporting	✓	✗	✓	✓

body movements, Tang [34] has developed an IoT-based approach for understanding emotions. It is a difficult challenge for neurotypical people, thus they evaluated various sensors to add emotion labels to emotion API and system training prediction emotion. For those with ASD, an image exchange communication system developed by Tang and Winoto [35] has been shown to assist them in expressing themselves as well as aiding their families, caretakers, and teachers in using the system. As a result of data gathered by sensing instruments, autistic people's descriptions are automatically sent to their aides if social communication is in a poor state. However, the sensors now in use do not provide adequate coverage for all of the potentially lethal scenarios.

The effects of geofencing the safe zone and activity identification in illnesses including Alzheimer's autism, and dementia were also demonstrated by Kollias et al. [9], who created a smartphone app. IoT-based software, Azimo, should be able to run on a variety of various devices. The authors developed an Android app by analyzing activity detection algorithms and enhancing accuracy and efficiency with the least amount of delay. An instructional platform was developed by Liu et al. [36]. The researchers created a robot that can mimic ASD and vice versa. As a teacher, coach, etc., the robot is requested to mimic the autistic child's activities in order to better understand them. Improves social communication and imitation abilities in autistic children, as well as behavior analysis and feedback to caregivers, using motor learning techniques. However, by engaging in more complicated dialogues, it is possible to increase DL and neural language processing.

The energy route and life balance of IoT devices were highlighted as a solution by Einarson et al. [37]. The prototype systems are impacted by the IoT's common and underlying structure. Based on the detection of the stress, they propose to improve the participation activities of the targeted end-users and link the gadgets. Using IoT, Badotra and Panda [38] have developed a smart object-oriented gadget that has a direct influence on enhancing the quality of life of autistic persons. They used platforms and intelligent objects to categorize the various kinds of autism. There are three main kinds of beneficial technologies and objects: social interaction enhancers, learning supporters, and behavior deterrents. This categorization aids in the eradication of the particular requirements of each and every autistic and impaired person [44].

An IoT and P2P-based method to improve the quality of life (QoL) of autistic children has been reported by Sula et al. [39]. Gadgets and technology like cellphones, laptops, and touch screen tablets thrill children with autism. Children are forced to consider the consequences of their actions, feelings, and desires as a result of the introduction of smart gadgets into their lives. Autistic children's focus and quality of life are considered to improve with the development of abilities such as mathematics, language, and socialization. For students diagnosed with ASD, Badotra and Panda [40] provided an environment. IoT and P2P with diverse visual systems, such as photos, realistic drawings, objects, and written phrases, are all part of their strategy. There were a few variations in the study offered in order to improve and expand on their earlier work. For example, they analyzed the pros and downsides of several arithmetic aids for autistic pupils.

Karakosta et al. [41] used the Kaspar robot to treat seven kids with ASD at an elementary school in Greece. Unprompted imitation, patients' interpersonal and communication skills, prompted speech, and attention were studied to see if employing Kaspar had any effect on them. Patients' teachers were astonished to find that their treatment had a good effect on their speaking and communication abilities. Eye gazing, attentiveness, imitation, and gesture recognition prompted and unprompted were some of the characteristics they used to assess their performance [45, 46]. A group of 23 autistic youngsters were divided into two groups: one for human teachers and one for robots. They then compared the development and identification of novel gestural gestures using these two serving techniques. In the end, the input obtained by the two teams was identical. To put it another way, the structure of a child's lesson can have a substantial influence on the gestural learning of children with autism spectrum disorder (ASD).

Regarding hypersensitive individuals with autism spectrum disorder, Khullar et al. [43] have proposed an IoT companion that can recognize and control the patient's environment. Sensory information is detected and retrieved by electrical sensors in their suggested method. 93percent of respondents of caregivers agree with the technique, but VR, ML, and DL algorithms can make it smarter. [42] provides a robot-based engagement method for kindergarten students with autism to strengthen their narrative abilities. NAO was used to facilitate communication and gestures amongst patients who spoke Chinese [47–49]. According to the researchers' findings, children are better able than physicians to conduct constructive conversations with robots. However, the study's results did not show a significant improvement in the participants' motions [50, 51].

5. Discussion

Technical and comparative analyses of current ASD methods are presented here. Some technical and statistical replies to the problems posed in Section 1 were as follows.

5.1. Which Methods to ASD Are Being Discussed and Reviewed in This Analysis? Figure 4 shows the proportion of current ASD treatment options. It is clear that the majority of publications focus on enhancing the quality of life for children with autism spectrum disorders. There are 16 studies using this method for the diagnosis of autistic condition. On the other hand, a total of 12 publications examined all possible methods for diagnosing and measuring illness severity. Autism is a life-long illness with no known treatment, so finding ways to improve the quality of life for those who are affected by it is a compelling reason to continue research in this area.

Additionally, parents or caregivers identify autism and its severity at the earliest age of 3 and provide treatment remedies. Early detection of autism has numerous advantages, though [52, 53].

5.2. What Techniques and Processes Are Used in the Treatment of Autism Spectrum Disorders? According to Figure 5, data mining approaches are the most popular

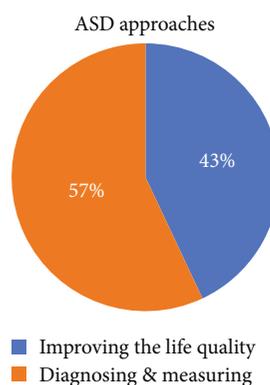


FIGURE 4: A variety of ASD treatment methods in the published literature.

which is further described as in 2 axes in which the y-axis indicates the number of papers counts and the x-axis represents different approaches used in ASD. Pattern-recognition algorithms are the primary way of extracting useful information from big datasets. Data mining and the healthcare sector have produced effective early identification methods and other health service technologies regarding clinical and diagnostic data. Also, the mining algorithms include characterization, generalization, clustering, classification, evolution, association, data visualization, pattern matching, and metarule-guided extraction. This study found that data mining technologies are most commonly utilized to improve the quality of life for children with autism spectrum disorders (ASD). It can, however, only be used with wearable sensors and smart devices that collect information. It is important to point out that such technology lacks sufficient intelligence approaches. Since it is a controlled setting, it is utilized instead of being used in the actual world.

In this study, the second and third most popular techniques of feature selection and reporting are discussed. It is possible to minimize dimensionality by picking a subset of the features input variables using feature selection technique such as GA or other approaches. Papers that used robots to improve patients' quality of life were the source of the reporting methodologies. It is used to compare the impressions of human and machine treatment. Since they have enough speed, but still require additional development, they are a viable option.

In addition, recent publications have featured GA, DL, and P2P approaches that provide a variety of services for individuals with ASD by utilizing AI. The approaches are fast enough, but the precision is not high enough to be useful for parallel computation done with IoT devices [54].

5.3. What Are the ASD Performance Metrics? The research papers have been reviewed based on various quality characteristics such as sensitivity, accuracy, reaction and specificity time in the ASD approaches, as depicted in Figure 6. According to our findings, the reaction speed and efficiency were the most important attribute aspects in Internet of Things-based autism spectrum disorder detection devices and systems. In general, we discussed four procedures and

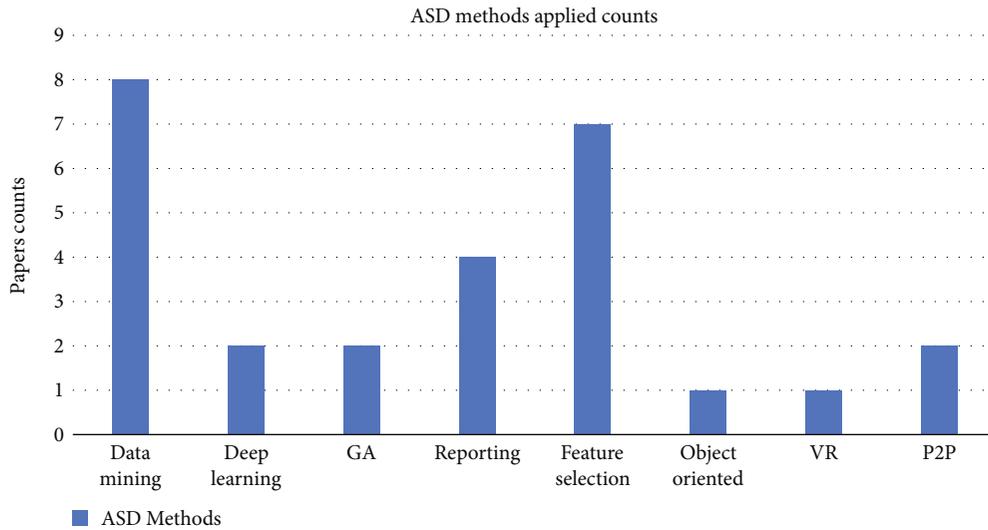


FIGURE 5: The proportion of procedures employed in ASD approaches that have been published in the literature.

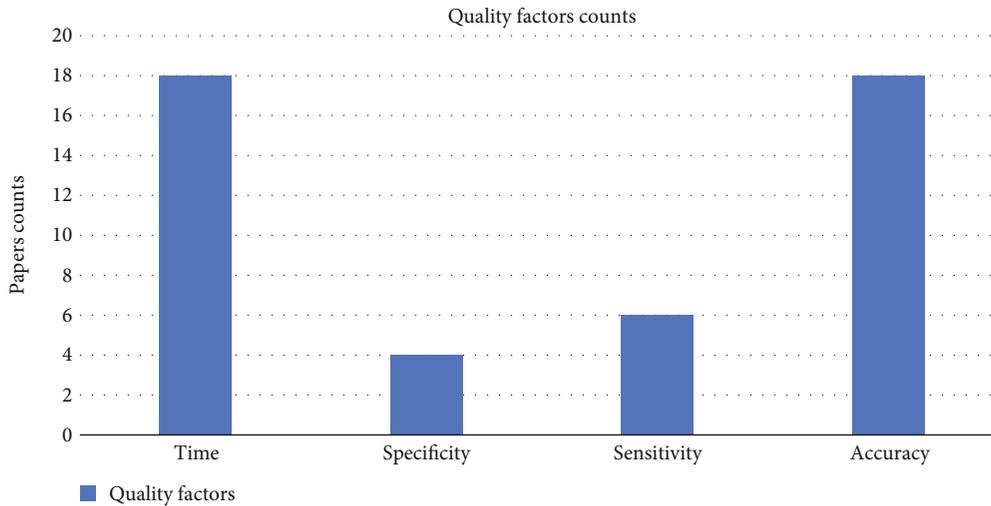


FIGURE 6: Quality elements in ASD approaches are compared and contrasted.

fundamental factors in the *x*-axis; however, other essential aspects, such as CCR, reliability, and processing speed, might be examined as well with respect to their counts in the *y*-axis.

5.4. *Find Out Which Scientific Journals or Conferences Are Published Based on ASD.* As per Figure 7 and the application of SLR techniques on the Asperger syndrome investigations, IEEE has published 11 articles out of a total of 28 research work that were selected. As a result, IEEE has the maximum number of publications that have been evaluated. The chart shows 2 axes in which the *y*-axis indicates the number of publishers papers counts and the *y*-axis represents different publisher names.

5.5. *ASD Techniques Use Which Platforms and Sensors?* Figure 8 illustrates how several research projects use a range of platforms and sensors to put ASD concepts into practice. Smart belts, heart rate variability (HRV), and pulse oximetry

are just a few of the current technologies and sensors that go under the umbrella term “wearable sensors.” The pie chart shows different platforms and sensor comparison in ASD methods.

6. Open Issues

This research indicates that creating IoT-based strategies for children with ASD faces several unresolved concerns and different experiences. The following are some of the concerns that have not been fully addressed so far:

- (i) Object-oriented segmentation strategy aid reduces the particular demands of children with autism in the diagnosis and measurement of illness severity for those with ASD
- (ii) Using various automatons to improve the quality of life for children with autism spectrum disorder is

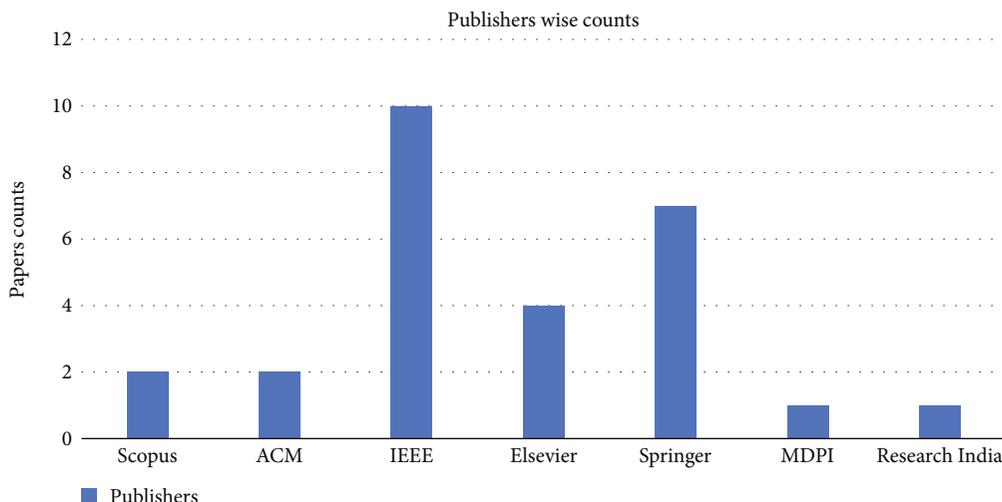


FIGURE 7: Some ASD articles are already being published by some publications.

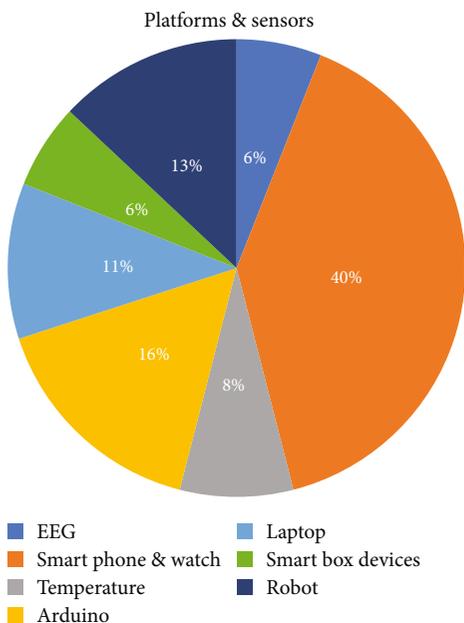


FIGURE 8: Sensor and platform comparison in ASD methods.

one of the most unanswered questions in the approach towards this end. It is a method for learning autistic children how to imitate gestures and simultaneously speak

- (iii) To anticipate and assess autistic behavior, wearable gadgets are employed in all classifications of techniques (EMG, pulse oximeters, GSR, and GPS). Sensors may be integrated into any gadget or worn as a separate outfit
- (iv) DL is a significant unanswered issue in the field of autism spectrum disorder diagnosis, and it may be used to a range of approaches, including multi-side databases and brain imaging

Additionally, the ASD that integrates Internet of Things-based devices raises a variety of challenges, including the following:

- (i) Integrity: the integrity of all information must be preserved during the transmission process between devices and arrive at its final destination intact and secure
- (ii) Availability: availability ensures that the approved portion has access to all IoT-based healthcare services, including global, local, and cloud-based services, when required due to different attacks
- (iii) Self-healing: it is vital for IoT-based networks to have self-healing capabilities because of the risk of medical equipment failing. Additional devices for interaction should therefore be able to provide a minimal level of security

7. Conclusion

Patients with ASD benefit greatly from the adoption of IoT devices with SS network consist. One of the most difficult aspects of treating autism in children is finding the correct IoT solutions. Sensors, platforms, and methodologies in ASD can have a significant influence on the children, and this is often the case. There were 28 articles included in this review that looked at various methods to ASD published between 2014 and 2020. In both 2016 and 2018, the number of articles published was close to the previous year's total. The most papers are published in the IEEE journal, with a percentage of 51%. Selected 28 studies were divided into two groups: those that focused on diagnosing patients and those that supported efforts to enhance the QoL of such patients. Nearly 43% of respondents thought of studies examining new methods for diagnosing and assessing the severity of ASD in children, while 57% thought about ways to enhance the quality of life for such youngsters. Additionally, all of the selected methodologies were evaluated in

terms of accuracy, sensitivity, specificity, and time, among other variables. There has been a comparative examination of ASD and IoT-based devices based on the case studies offered. Most research studies are aimed at enhancing the QoL of autistic children, according to the findings. New ASD techniques and gadgets for autistic persons will benefit from research into IoT-based variations on traditional ASD approaches such as AL, ML, and SS network.

To keep classic ASD techniques safe, IoT-based devices are becoming more and more common. Also, several studies have shown that children with ASD prefer robots over people for assistance. NAO's eye contact attention is steadier than in a traditional classroom for youngsters with ASD [47]. In addition, IoT solutions cut caregiving and support expenses and are simple to use, in contrast to traditional methods of protecting patients.

Emotions, on the other hand, can have an impact on the effectiveness of human-based therapy in ways that sensors and robots cannot. Robotic behavior should resemble that of humans in order to prepare for the unpredictability of our reality. In order to accomplish the goal, robots or other technologies that interact with people will need to incorporate emotional and cognitive computing. These are some of the limitations of this review: When searching for research, we used the terms "autism spectrum disorder," "internet of things," and "autism in the internet of things" (non-English speakers).

Journals, chapter books, and thesis were not included in this investigation. Research on IoT-based ASD methods has been addressed and published in different languages (we think).

Data Availability

Data is not supported by this research.

Conflicts of Interest

The authors do not have any conflict of interest with anyone.

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