Artificial Intelligence in Autism Diagnosis & Therapy
Recent Trends and Future Innovations

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Abstract : There has been an increase in use of Artificial Intelligence or AI in our daily lives. Our phones, gadgets, cars, even homes have become 'smart' with AI intervention. No wonder then that AI will be having applications in healthcare and diagnostics. As an emerging technology AI has promise in making life easier. AI systems are used as diagnostic tool and office assistance by clinicians and technicians. The reliability and accuracy of AI diagnoses has made ripples in psychology and psychoanalysis. AI can be used to create programs to think and reason like humans and perform tasks on its own. A computer system develops its intelligence and evolves just like the human brain via machine learning. Using Fuzzy logic and available database AI is becoming a powerful and effective tool to diagnose, and suggest therapy to patients. Autism is a developmental disorder that is complex in origin, development and rehabilitation. The autistic brain is Neurodivergent, so its perception, learning, and thinking are different. Along with that there are some physical, genetic, neurological aspects that are typical in most autistics. The diagnosis of autism is very challenging because of the difference in individual persons with autism, and early intervention and therapy, as early as two years, is needed because the neuralplasticity is lost as the children grow up. The impairment of speech, language, expression, social interaction happens in persons with autism. AI, VR, ML enabled devices and applications can be developed to speed up the diagnosis and therapy and help them get through daily life activities with the help of such devices and apps. This article deals with the current manual processes of autism diagnosis and therapy in brief and then explores the emerging technology of AI and its application in Autism diagnosis and therapy, with a discussion on the future of AI in the Autism sector.

Index Terms - **AI, Artificial Intelligence, Autism, ASD, Mental Health, Psychology, Robotics**

I. INTRODUCTION

AI or Artificial Intelligence term was coined by John McCarthy of Stanford University in 1955. LISP (List Processing) is the computer language invented by McCarthy, that is still used for most AI programming. In his own words, "a system which is to evolve intelligence of human order" is what AI is (1960). There are three types of Ais. First type is a program dedicated for one task, known as Narrow AI. Alexa, Siri are examples of Narrow AI. Second type of AI, known as General AI is able to perform human level task, of course it is in developing stage, an example is Fuzitsubuilt K supercomputer. The third type is Super AI, and is supposed to perform more than human capacity, evolve on its own. unfortunately, such AI is still restricted to the pages of science fiction books, and imagination of sci-fi movie-makers.

AI is an upcoming trend in health. Mental health is an evolving area of AI. In the 1960s Lotfi Zadeh of University of California, Berkley, used Fuzzy logic that is something in between YES/NO based decisions to develop AI for mental illness diagnosis. This resembles human reasoning while coming to a conclusion about the state of mind and body of a patient. In the Boolean system truth value, 1.0 represents the absolute truth value and 0.0 represents the absolute false value. But in the fuzzy system, there is no logic for the absolute truth and absolute false value. But in fuzzy logic, there is an intermediate value too present which is partially true and partially false (Figure 1). In recent times AI is used in psychology as an efficient tool and has proven to be very valuable resource, both as in office assistance and assessment. Apart from monitoring vitals that help assessing the physical state of a patient, AI enables assessment of mental state by facial mapping, microexpression analysis, blood flow to face and body by infrared imaging. Optical sensing by assessing even the minutest of eye movement and Vocal analysis are also done by previewing speech characteristics like tone & pitch of voice of the patient. All these are recorded to very precise and minute details. Even breath analysis for possible substance abuse can be done through AI (Luxton, 2014). AI has been proven to be a good assessment tool for coma and trauma patients, as well as infants, whose non-verbal distress can be addressed (Hardesty, 2012). A major number of people in the Autism Spectrum, are unable to express their needs, thoughts, distress, due to neural impairment in the speech, language and communication. This is a study of the diagnostic and therapeutic use of Artificial Intelligence of AI in Autism, and explores the possibility of generating help and hope in ASD individuals and their families.
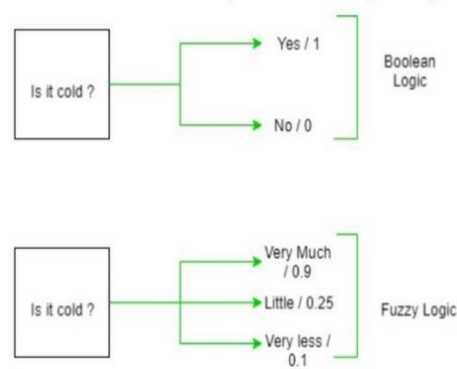
Figure 1: Fuzzy logic and Boolean Logic

What is Autism?

Autism is the hidden epidemic, slowly spreading like cancer over the past 50 years. Currently 1 in 44 children fall in the spectrum (CDC, 2022). Autism or Autism Spectrum Disorder (ASD) is a complex neurological disorder that cause developmental disability of different levels, sometimes significantly hampering social behavior, language, speech, and communication. The statistics of autism prevalence is rising rapidly at an alarming rate worldwide. The boys are 4 times more affected than girls. There are more than thousand genes responsible for ASD. The disability is caused by differences in brain, its perception, and function (DSM-5, 2013).

People with the disorder have a differently wired brain and hence perceive, behave, learn, communicate, in a way different from what most people do. Autistics are now put under the umbrella of differently wired people, called Neurodivergent individuals, a term getting relevance throughout the education and societal systems. Autism is not easy to understand, as they say, if one sees an autistic person, one sees one autistic person. Such is the level and magnitude of the 'spectrum'.

ASD is a lifelong disability of varying degrees in persons having this condition. Typically, autism diagnosis occurs at the age of 30 months to three years in children. But now even younger children, as young as 9 months, can be diagnosed by looking for developmental delays in milestones. (CDC, 2022). Sometimes regression is seen in children who gained skills and developmental milestones till two years.

Maintaining relationships, friendships, even jobs become difficult in adults who manage to overcome the condition to some extent to function independently. Such people are labelled as High functioning. Based on their ability to adjust, communicate, learn, speak, and functioning in society and school, autistics are often categorized or labelled into subgroups. There are five major types of autism which include Asperger's syndrome, Rett syndrome, childhood disintegrative disorder, Kanner's syndrome, and pervasive developmental disorder – not otherwise specified. All these have a multitude of problems and different types and levels of disability. Based on the levels of learning and performing at school they are sometimes categorized as High or Low Functioning, Verbal or Non-verbal etc. However, the labels are in itself inadequate in understanding an individual in the spectrum. The WHO and CDC statistics reveal that the number of children diagnosed with each passing year is alarmingly increasing. The rise from 1 in 150 in 2000 to 1 in 44 in 2018 (Figure 2) is in itself reason enough for the healthcare sector to be concerned.

Identified Prevalence of Autism Spectrum Disorder

ADDM Network 2000-2018 Combining Data from All Sites

Surveillance Year	Birth Year	Number of ADDM Sites Reporting	Combined Prevalence per 1,000 Children (Range Across ADDM Sites)	This is about 1 in X children...
2000	1992	6	6.7 (4.5-9.9)	1 in 150
2002	1994	14	6.6 (3.3-10.6)	1 in 150
2004	1996	8	8.0 (4.6-9.8)	1 in 125
2006	1998	11	9.0 (4.2-12.1)	1 in 110
2008	2000	14	11.3 (4.8-21.2)	1 in 88
2010	2002	11	14.7 (5.7-21.9)	1 in 68
2012	2004	11	14.5 (8.2-24.6)	1 in 69
2014	2006	11	16.8 (13.1-29.3)	1 in 59
2016	2008	11	18.5 (18.0-19.1)	1 in 54
2018	2010	11	23.0 (16.5-38.9)	1 in 44

Figure 2: A collection of information from peer-reviewed autism prevalence studies from CDC website.

II. MANUAL DIAGNOSTIC & THERAPEUTIC TECHNIQUES IN AUTISM

The people on the spectrum have some signs and symptoms with which they are diagnosed by healthcare professionals. The presence and absence of these signs and symptoms are scored manually to find results pertaining to the severity of the condition. The people in spectrum struggle with social communication, interaction, understanding societal norms. Sometimes they have limited interest and have repetitive behavior. Learning, expressing (motor movement), cognition, concentration, can be impaired, making it challenging to carry out simple tasks in daily life and may cause them to need lifelong support system.

2.1 Diagnosis of Autism

The Centre for Disease Control (CDC) has very specific guidelines and methods to diagnose Autism Spectrum Disorder (ASD). According to the website children of 18 months onwards, sometimes at 9 months onwards are diagnosed by the following steps:

a) Developmental Monitoring: Health workers look for developmental milestones, or delays in those milestones in infants and toddlers. They look for gross and fine motor skills by the way the children hold things, walk, run, jump, etc. Loose or stiff muscles, restricted movement of limbs, level of voluntary movements. Speech and language delays are also scored (Figure 3).

b) Developmental Screening: Periodical follow ups at 9, 18,30 months are done to look for progression or regression of developmental milestones.

c) Developmental Diagnosis: Involves physiological testing and genetic testing for the condition and offer genetic counselling.

Along with these principles there are certain scoring methods to assess the level of severity of disability in ASD:

Autism Diagnosis Interview – Revised (ADI-R): A clinical diagnostic instrument for assessing autism in children and adults. It is a structured and systematic interview that is conducted with the parents of possible autistics. It can be used for 24 month old children, to score for reciprocation of social interaction (responding to name, social smile, eye contact etc.), communication and language (word

and sentence level, carrying out simple commands, asking for things), and patterns of behavior (repetitiveness, echolalia, obsession). The revised ADI-R is a very reliable and consistent instrument to determine whether a patient or child has autism.

Autism Diagnostic Observation Schedule – Generic (ADOS-G): This is a set of structured and semi-structured tasks, lasting for half an hour to one hour time. The tasks are based on social and communication behavior. Adults and children suspected of having autism are tested for a diagnosis with ADOS-G. There are four modules which are age specific, of which module 1 is for children with limited speech.

Childhood Autism Rating Scale (CARS): It is a rating system whose score decides where in the spectrum a child falls. During childhood the score might keep changing. It is also a behavior rating scale. It consists of 14 domains of autism behavior assessment, and a 15th based on general impression of autism, 1- 4 is the rating scale of each domain, the higher the score higher are the levels of impairment. As low as 15 and as high as 60 could be the score. Scores below 30 indicate the child does not belong to the spectrum, 30- 36.5 means mild to moderate autism, and 37- 60 score indicates severe autism (Schopler et al. 1988)

Gilliam Autism Rating Scale – Second Edition (GARS-2): It is used in schools to assess whether a child needs special education. 42 item norm referenced screening instrument that can be used by educators in schools who find behavioral discrepancies in students. It can be applied to ages 3 to 22.
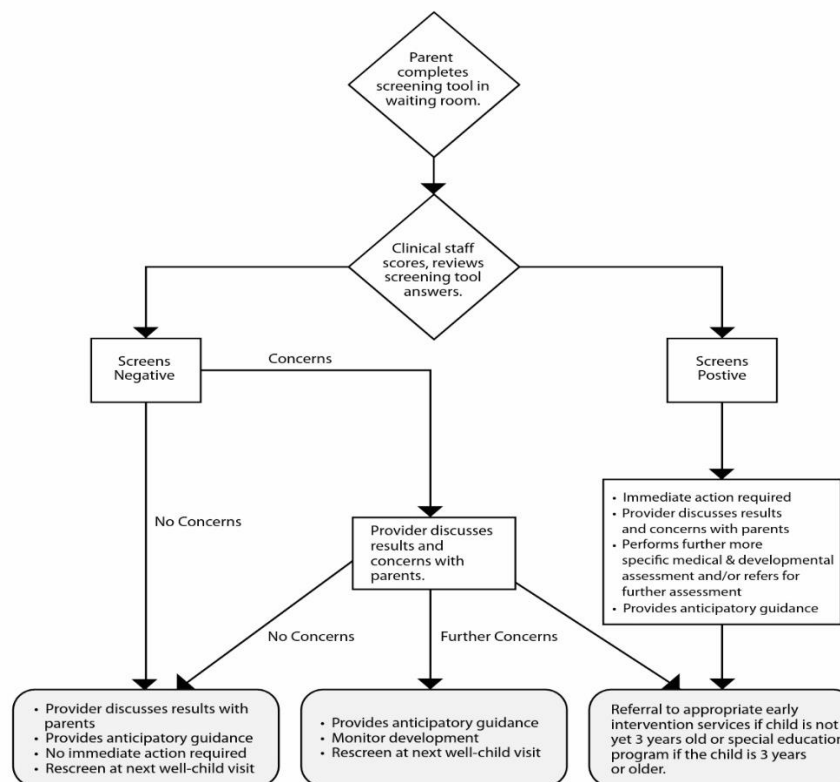

Figure 3. Flowchart for developmental screening in children, CDC.

2.2 Current Therapies in Autism offered manually

The triad of impairment in autism spectrum disorder or ASD, viz., speech & language, communication, and social interaction, calls for multilevel therapies, just like multilevel diagnosis. These therapies are planned in accordance to the level of disability of a diagnosed patient and are extremely customized. Most important therapies ate those that can reduce the debilitating symptoms of the syndrome, thereby increasing the quality of life and finding out the best way for the individual to learn coping with daily life activities and education (Hyman et al, 2020).

A combination of therapies to improve health, education, expression, adjustment is applied in institutionally as well as at home. So, a group of professionals with multiple specializations, teachers, caregivers, and parents all need to work in unison.

The following major categories of therapies and treatments are provided currently:

DEVELOPMENTAL: this therapy is targeted for 2-12 years old children who fall in the spectrum. This focus on the developmental skill, like language skills, physical skills (fine & gross motor), etc. The most applied developmental therapies are speech and language therapy. Use of speech & language is often limited in ASD children, so, it is very important for them to learn to communicate. Use of verbal or sign language is also used for this (Ospina et al, 2008).

BEHAVIORAL: ABA or Applied Behavior Analysis is one of the popular behavioral therapies, using Discrete Trial Training (DTT) and Pivotal Response Training (PRT), they try to improve the skills and extract desired responses from the patients through step-by-step instructions. ABA follows a 'manding' principle, where rewards are given after performing each step correctly. ABA is set up in a clinic setting while PRT is mainly in a natural setting, where a 'pivotal' skill is improved to improve other skills. Initiation of communication is one such example (Ospina et al, 2008).

SENSORY: The ASD patients are having a different and complex CNS functioning. This leads to them having sensory dysfunction like more and/or less sensitivity in vision, hearing, olfaction, taste, touch, vestibular, proprioception, interoception. In fact, these are

symptoms of autism according to DSM-5 (2013). So, sensory integration therapy was introduced to help people with autism overcome sensory overload or under-reactivity and function better in a given environment. (AAP, 2019)

OCCUPATIONAL: Due to sensory dysfunction autistics have a hard time fulfilling tasks and simple activities. Occupational Therapy or OT, helps individuals with autism to participate and function in a meaningful way. OT intervention from an early age can help people with autism function purposefully throughout their life by providing personalized OT plans (Burmin et al, 2015).

COGNITIVE: Autism can have some comorbidities like OCD, ADHD, schizophrenia associated with it. Most have anxiety alongside the condition. These are treated with Cognitive therapy to modify their beliefs and behavior into positive ones (Danial and Wood, 2013).

EDUCATIONAL: At classroom much of the therapy can be imparted via teaching and learning to school age children. Education is a powerful tool for opening the mind to infinite options. TEACCH or Treatment and Education of Autistic and Related Communication-Handicapped Children is one such approach. ASD children are visual learners, so TEACCH uses visual cues to make them to learn to express their needs (Schopler et al, 2004).

PSYCHOLOGICAL: Living with Autism is a difficult challenge for a person having this condition, the family members too have to face everyday challenges. This leads to anxiety and depression in many patients. Psychological analysis and interventions have proven to help in those cases (Cooper et al, 2018).

SOCIAL: Human beings are social beings, if one thing could be done for the autistic community, it is to accept them as they are in the society without judgements and isolation. For that society has to be made aware and autistics are to be prepared for social conditioning. Social Story is one such approach, where a situation is narrated to the ASD person, before exposing them to that situation. Social gatherings, ceremonies, shopping expeditions, play, are some examples (Carol Gray, 2022).

PHARMACOLOGICAL: Autism is a condition, not a disease, so there is no cure for it. However, there are some associated physiological and psychological issues in various orders found in persons with autism, that can be ameliorated with the help of FDA approved therapeutic drugs. This can in turn relieve the patients of discomforts and help them focus on their rehabilitation (Kumar et al, 2012).

ALTERNATIVES: also, known as CAM or CAT. Since there is no cure for autism, alternative therapies like yoga, meditation, reiki, acupressure, can help. Homeopathy and Ayurveda have also proven to help with certain symptoms associated with autism. Stem cell therapy is another therapy, but has limited results (Gupta, 2004).

III. USE OF ARTIFICIAL INTELLIGENCE IN AUTISM

The diagnosis for autism in an individual is done by studying, screening, and monitoring of developmental, behavioral, cognitive observations. Artificial Intelligence and Machine Learning can used to teach machine to draw conclusions based on set data fed to it for analyzing traits of Autism Spectrum Disorder or ASD (Deo, 2015).

3.1 Artificial Intelligence in Diagnosis of Autism

As a diagnostic tool, Artificial Intelligence can help in different ways. Since, the numbers of people in the spectrum are ever increasing, there is a dearth of trained healthcare professionals. AI can be a very important tool for speeding and enabling diagnoses. The behavioral information can be gathered, stored, analyzed by AI and if needed sharing those data with other AI programs, for an effective and accurate diagnosis can be done. Data Analysis is a very important part played by AI, especially of the physical health parameters that are associated with autistics, or to analyze how the patient is feeling while getting diagnosed. The signs and symptoms of physical, physiological, neurological, all together can be corelated with the data provided in the interview with the patient or his/her parents. Moreover, AI can serve as an assistant to the clinician, replacing a human, thereby providing an effective and excellent source of information and support. In fact, AI algorithm can be set for it to suggest the best therapy to be chosen for a particular patient. The following techniques can be used to screen ASD with AI:

a) Genetic Screening: The first thing AI algorithm can be taught is to look for biomarkers or genes that are present in certain sure cases of autism. There are many biomarkers that are clear indication of underlying risk of occurrence of autism. Presence of certain metabolic, methylation related, immunological biomarkers (Table 1) are indication of a genetic basis of diagnosing ASD (Goldani, et al, 2014). Apart from that, Fragile -X is a sure shot genetic marker of autism in some people. The reports from blood, urine, DNA can be fed to database to screen autism.

b) Neurological Screening: The number of genetically earmarked ASD individuals are very low, so, additionally, neurological screening can be used for further diagnosis. Neuroimaging, fMRI, EEG, can also segregate or diagnose some of the cases. There are some neurological anomalies seen in most autistic individuals. The fMRI show that autistic brain has decreased cerebellum size, decreased volume of hippocampus and amygdala, decreased volume in caudate nucleus. While the lobes of cerebrum and ventricles increase in size. So, the brain functions typically associated with ASD can be very easily screened by AI, from available database (Mahajan and Mostofsky, 2015).

c) Behavioral Screening: It is very difficult to analyze behavior in an autistic individual, especially children and nonverbals. Moreover, the behaviors keep changing during lifetime. So, it might be difficult for AI to capture such changes. So, AI should be used as an office assistant and could help score the severity with fuzzy logic.

Table 1: Biomarkers in ASD
Created from the work of Goldani et al (2014)

Sl.No	Biomarker type	Names
1	Genetic	Neurexin 1 (NRXN1) deletion, 7q11.23 duplication, 15q11-13 duplication, 16p11.2 duplication and deletion, SHANK 3, SHANK 2, SNC2A, CHD8, DYRKIA, POG2, GRIN2B, KATNAL2, CNTN4 deletion, CNTNAP2, 5p14.1, CDH10, CDH9, MTHFR 677>T, SEMA5A, TAS2R1, 2q22.1, 3p26.3, 4q12, 14q23, NLGN4
2	Oxidative Stress	Glutathione - reduced/oxidised, Methionine, Cysteine, Organic acid test - alpha hydroxybutyrate, pyroglutamate and sulfate, Plasma F2t-isoprostanes (F2-IsoPs), Urine8-OHdG, Transferrin, Ceruloplasmin, Plasma 3-chlortyrosine (3CT), 3-Nitrotyrosine (3NT)
3	Mitochondrial Function	Lactate, Pyruvate, Lactate/Pyruvate ratio, Carnitine (free and total), Alanine, Quantitative plasma amio acids, Ubiquinone, Ammonia, CD, AST/ALT, CO2, Creatine kinase, Aspartate aminotransferase, Serum creatine kinase
4	Methylation	S-adenosylmethionine (SAM)/S-adenosylhomocysteine (SAH), Homocysteine, MTFHR
5	Immunological	TGF-beta, CCL 2, CCL 5, IGM, IgG, Th1/Th2, Neopterin, S110B protein, Anti ganglioside M1 antibodies, Antineronal antibodies, Serum anti-nuclear antibodies, BDNF
6	Others	Glutamate, GABA, BDNF, RBC fatty acids

3.2 Artificial Intelligence in in Autism: Therapies, Learning and Support

Recently it is found that Artificial Intelligence can be fed logic to assist clinicians to accurately diagnose ASD in children that are less than 6 years of age. Scientists have started to explore the possibility to develop applications (apps) and devices to help persons with autism to communicate and live an independent life. Information and Communication Technology (ICT) based classrooms are a must in educational institutes of higher studies, but this ICT enabled classroom and/or home environment can help ASD individuals significantly to carry out their daily life activities.

Autism diagnosis can take time, but the wait for getting therapy could be more and challenging. This wait can diminish the chances of early intervention while the brain is still flexible or Neuroplastic. For therapeutic purpose AI, MI (Machine Learning) and VR (Virtual Reality) based applications and devices can be very useful. One such example is Canvas Dx. Improvement in certain areas like social, educational, and communication can be brought about by AI. We will discuss how AI can help or enhance therapy in those areas, that were enumerated in the manual therapeutic section. While the robotics, ML, and VR devices are costly options at times, most of the device based applications are freely available or of low cost and are easy to use.

AI in therapy based on the current manual ways:

DEVELOPMENTAL INTERVENTION OF AI: The understanding and gauging of facial emotions and expressions is difficult for children in the spectrum. Developing app, based on face recognition to learn the state of mind or emotion of a face on mobile or laptop screen is a very good way to teach children during their developmental phase. There is a mobile gaming App having 67% accuracy. It uses CAFE or Child Affective Facial Expression (Washington et al, 2022). Speech, hearing, and language disorders have over 40 free resources in the internet. Such apps also help in developmental intervention to some extent.

BEHAVIORAL INTERVENTION BY AI: this is done along with cognitive therapy. Machine Learning or ML can perform human like reward system to seek the most appropriate behavior from a patient or child in therapy. ABA can be taught to robots in order to increase the time and personnel, required for huge number of newly diagnosed children. The neutral face and voice of robots can be soothing to the children on the spectrum, creating a relaxed mindset and more receptive towards performing activities and behavioral modification. CBT and ABA can be applied together in AI intervention effectively. Any out of ordinary behavior by an autistic could be a way of communication. AI can be used to assess such behaviors and reason for that (Washington et al, 2022).

SENSORY INTEGRATION WITH AI: Sensory integration focuses primarily on tactile, vestibular, and proprioception, along with vision, auditory, olfaction, taste, to some extent. Virtual Reality (VR), can be a good and effective tool for integration of senses in autistics, this is called Virtual Reality- Tangible Interaction of Senses (VR-TIS). Measurement of coordination ability, social skills training, SIT, can be done and therapy be provided accordingly, improvement after therapy could also be recorded. The results were very promising for children in one such set up (Jung et al, 2006).

OCCUPATIONAL THERAPY AND AI: One of the best outcome of AI intervention perhaps is in OT. Robotics, Human-Machine Intervention play a big role in AI enabled OT. Children with Autism can be interested to play with electronic devices and machines. Robotics has a new emerging application in Autism therapy called Robot-Assisted Autism Therapy or RAAT. It uses Anthropomorphic and zoomorphic robots. This therapy can encourage a child to talk or carry out simple tasks. This type of robot can be taught to play with children thereby developing motor skills (Szymona et al, 2021).

COGNITIVE BEHAVIORAL THERAPY BY AI: A very well handled therapy by AI is CBT. The children and adults belonging to the spectrum often feel isolated from the greater society due to their differently wired brains. This may lead to stress triggering anxiety, depresssion, schizophrenia. AI induced ML can help those individuals by being a friend as well as a therapist, resulting in reduced stress, anxiety and such symptoms. The sense of isolation and helplessness can be reduced to some extent too (Sideraki and Drigas, 2021).

EDUCATIONAL PROGRESS WITH AI: From ML TO VR, Apps, Devices to Robots, Artificial Intelligence can do wonders in terms of education in ASD. A simple app with TRUE/FALSE or YES/NO, can help educators and caregivers understand the level of learning and progress in a child. A letter board, a laptop, and a robot together can be of great help to educate autistics, especially the otherwise less expressive section of the spectrum often labelled wrongly as 'Non' or 'Low' Functional. Some very simple and easy available AI apps are available for iOS and Andriod devices (Sideraki and Drigas, 2021).

PSYCHOANALYSIS AND PSYCHOMETRY WITH AI: Autism is a complex disorder of the body and brain, sometimes with comorbidities like ADHD, anxiety and depression, sleep problems, bipolar disorder, GI issues, eating disorders, immunedefficiency

and epilepsy. Naturally, the work of a psychologist becomes difficult, and proper therapy delivered in time becomes challenging. AI can help in such cases. Cognoa ASD, an AI enabled mobile app is one such app. It has online portal for video analysis, where caregivers and parents can upload videos of the autistic person in question for analysis by AI, and to derive a solution for help. The wait time and resources to visit a psychologist are saved (de Mello and de Souza, 2019).

SOCIAL INTERACTION WITH THE HELP OF AI: RAAT like intervention can again be used for social interaction and integration. For a person to live in a society the first thing he or she needs to undestand the situation and the mood of person in front. Secondly, it is very important to understand one's own mood. AI apps can replace PECS like visual cues which are used by the educators and caregivers manually. Sky is the limit for social therapy and intervention in ASD people where AI is involved. VR or virtual reality could be a great tool to be developed in preparing autistics for social situations where there are crowds or new setting. Social story is an in thing for giving an idea about social functions and new situations to autistic individuals who want a predictive environment. Such social stories can be custom made via apps available for Tabs and smartphones. One such app iKatha, is available for Indians in iOS, Apple Play store. Then of course friendly, zoomorphic robots are sometimes used as robotic pets, to soothe and keep company, and even play with children on the spectrum (Dautenhahn and Werry, 2004) .

PHARMACOLOGY AND AI: Autism is not curable but comorbidities need to be ameliorated. The psychologists and psychiatrists need to be extremely careful in issuing prescription drugs. Use of AI enabled therapy room to record the minute details of facial twitch, any physical disturbances, vitals, every single change can be analyzed by AI system fed with preprogrammed logic. Such physical and mental attributes together can be taken into consideration while prescribing accurate and safe drugs. This might prevent contraindications, side effects, and help with proper diagnosis and cure (Kalyane, 2020).

ALTERNATIVE POSSIBILITIES OF AI: AI induced ANN or Artificial Neural Network, Data mining, and multivariate analysis can more-or-less predict the paths to be taken for alternative therapies (Song et al, 2021). A detailed study of alternative therapy by Chu et al (2022) showed, with the help of AI in acupuncture, tongue and lip diagnoses, Ayurveda, music therapy, pulse diagnosis etc. were having potential, but large-scale clinical trial in this field is needed to establish the use of AI.

3.3 Artificial Neural Network, Brain-Computer Interface & The Future

As the name suggests, the ANN or Artificial Neural Network takes after the human neural network to observe, analyze, and respond just like neurons do. It is modelled after the human brain and uses the computational network of an 'input' and then passing through several pathways to achieve a particular 'output'. The neuron like things here are called nodes, that are interconnected to each other (Figure 4).
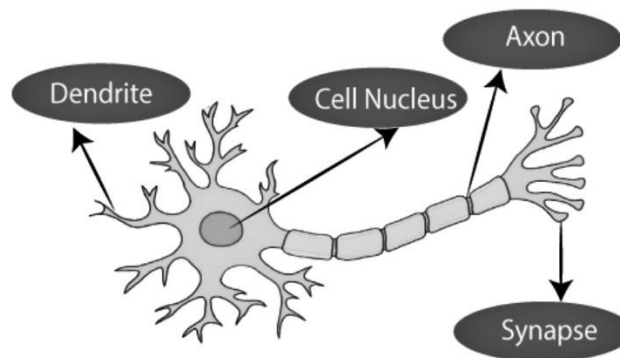

Figure 4: Human Neuron

Mimicking the network of neurons that comprise the human brain, computers will try to understand a situation and take decisions in a human like manner. In human brain neurons the output of one neuron can become the input of a second neuron, thereby creating a network that goes through multiple decision makings before finally carrying out a desirable outcome (Javatpoint online database, 2022). Such multidimensional goals can be set for the machines to learn in an ANN run program. Infact, most of the autistic brains have exceptionally more neural networks that do not diminish with time like the neurotypical's brain, and is one of the reasons for dysfunction.

Modelling on that complexity the ANN has three layers. Input Layer that accepts different inputs as per the program. Hidden Layer that is a complicated layer in between input and output layer that does all the calculations, permutations, and combinations. Finally, Output Layer, the final resultant that is most acceptable after computing the weighted sum of all inputs in the hidden layer (Figure 5).
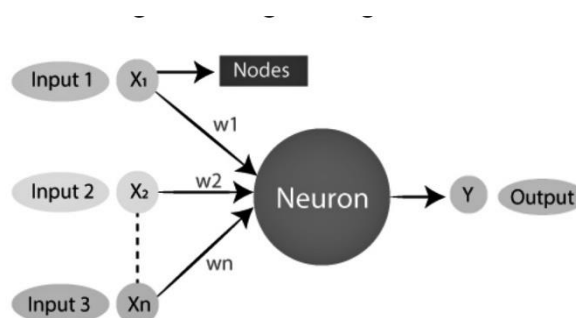

Figure 5: Artificial Neural Network (ANN)

ANN's best advantage is parallel processing, storing the data on the whole network, memory distribution, capability to work with incomplete knowledge, and fault tolerance. But, end of the day its ML by AI, there are certain areas where it still cannot function as human brain, one such problem arises with hardware dependency. However, the simple and lesser complex tasks can be brought about that can help persons with severe Autism.

Another way ANN, ML algorithm is used in Brain Computer/Machine Interface (BCI/BMI). The BMI/BCI are implants or chips that are inserted into specific areas of the brain and can decode EEG or Electro Encephalo Gram signals to control robotic limbs, or robots to function. In other words, thoughts are converted into actions. BMIs cause Intra-Cortical Microstimulation or ICMS of the somatosensory cortex, and since children with autism have a reduced somatosensory activity, these implants can help with that (Marco et al, 2012).

The user's cognitive or motor thoughts in EEG are decoded successfully and recorded via a non-invasive electrode and processed to reproduce noise free EEG signals. Then time-frequency analysis helps to extract the signals from EEG. These extracted signals are fed to ANN as inputs and finally desired output or response can be achieved by the machine/robotic hardware. BMIs are mainly aimed to help persons with severe motor disabilities, coma patients, paralysis, spinal injuries etc. (Buvaneash and Stalin, 2018). One such chip, implanted in a Macaque monkey, has been successfully shown to control motor activities and playing computer games via mind when taught to do so. So, this opens up a new horizon in ASD therapy in persons with severe issues with body control. However, the brains of ASD individuals being wired differently, full understanding of the workings of those brains are needed before suggesting an implant.

IV. DISCUSSION

A proper diagnosis of Autism, detailed analysis of the patient's status in relation to their level of disability and position in the spectrum is in itself extremely challenging. Multiple therapies of variable levels, sometimes end up in trial & error at the expense of the person's or child's comfort and resources of the parents. It takes years to develop a suitable diagnosis or therapy method that works, only to find a dearth of human resource to learn, implement and trained enough to impart therapy and education properly (ANI News, 2019; Medindia, 2014; Lipinski et al, 2022). With the autism rate alarmingly increasing over the past two decades (CDC, 2020), there is a pressure on the healthcare sector to provide accurate diagnosis and suggest customized therapies that are cost and time effective. The scenario is even more pathetic in underdeveloped and developing countries. Even though there is not enough food to put in every plate, modernization and technology has put smart phones in every hand. This opportunity of easy availability of smart devices, needs to be exploited.

It was often inferred that the nonverbal section of the spectrum lack intellect, but current studies show that it's a very misunderstood section. The first nonverbal autistic person incidentally graduated from the same State of US that invented AI, California! The most overlooked and underestimated population/section within the spectrum are the non-verbal, non-speaking individuals. Sometimes categorized as low-functioning and having low IQ, they are often diagnosed incorrectly and are left out of proper therapy, intervention, and rehabilitation, just because they don't have a 'voice' (National Autism Resources, 2021). But gone are those days when non-speaking meant non-thinking. The intervention of Assistive and Augmentative Communication (AAC) by different Operating Systems, already has put out a loud 'voice' out there for the world to see and hear the minds of nonverbals. Recorded Speech devices like GoTalk Communication Aid, BIGmack, Electronic tablet speech application with programs like ProLoQuo2Go for devices like iPads, Lenovo Tabs, or Dell Venues, can be helpful. The use of social media platform like Facebook, Twitter, and blogs, have shown a new path to understanding of how an autistic brain thinks and how an autistic's body acts (Thabtah, 2017).

There are some lacunae in the AI induced therapy in autism and research. There is a lack of participatory interventions that are remotely delivered with the help of AI. Individual goals should be included in AI interventions. And, finally a lack of custom-made AI intervention for an individual and his environment. Since, no two persons diagnosed with ASD are similar, and there is no bias in cast, creed, culture, country when autism occurs, saving the male female ratio of prevalence, extremely personalized treatment plan and action needs to be taken while choosing AI intervention for Autistics.

With new ideas in ASD therapies coming up every second day, it is highly confusing to keep up with what's good for a particular person or family. AI as we studied, can speed up the diagnosis and even suggest best therapies suitable for the situation. AI can also help ASD individuals find their way with society, education, communication, and live a fulfilling life. So, it is important to study and explore the options AI offers in terms of ASD intervention. Moreover, WHO is working on providing AI-powered predictive care to the patients by the next decade. The predictive analysis will assist the patient to understand the risk of a certain disease to which he/she can be prone to and suggest preventive measures based on individual lifestyle, eating habits, age, and medical history. Many countries are developing AI-enabled robotic nurses who can care for the patients more efficiently than the human and will also minimize the rate of human error. So, persons with severe disability in Autism have a future that's probably going to be better than their predecessors.

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