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Survey on EEG Analytics for Early Detection of Autism Spectrum Disorder

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ABSTRACT

Predicting Cognitive Disorders such as Autism, Delirium and Dyslexia at an early stage is one of the challenges faced by health experts, who specialize in this area. Early prediction of these disorders will not only help the children to get proper treatment but also to their families who carry on their life along with these children. In order to achieve early prediction of these disorders, this research work is carried out. The primary aim of this paper work analyses improved approaches, for the early prediction of Autism and other disorders. The work is carried out using computational approaches, to determine the factors involved, in the prediction of Autism and other Cognitive Disorders such as Dyslexia and Delirium among growing children. This research work proposes three enhanced approaches, in the early prediction of Autism and other Cognitive Disorders.

Keywords---- Cognitive Disorder, Early Prediction, Developmental Disorder.

INTRODUCTION

Cognitive Disorder pervasive among children is defined as the developmental disorder of the brain or cognitive neurons where the symptoms are noticed to appear during the premature stages of the growth of a child [Susan et al. 2019].

Disorders prevalent among children are Autism, Dyslexia and Delirium which affects the brain activity and behavioral attitude. This disorder is found to occur in approximately 15 to 50 child out of every 10,000 child birth [Paul et al. 2020] and it is noticed that the disorder is more prevalent in male children rather than in female children. Cognitive Disorder can affect the processing, integrating and organizing of information and significantly impacts communication, social interaction and functional skills of a child. 'Cognitive or Brain Disorder' is a complex developmental disability that basically affects the way a person communicates, behaves and is related to people interaction. The term Cognitive Disorder is often related to children and their learning attitudes where, the condition varies among children. The complex behavioral disorder noticed among children possessing cognitive issues encompasses a variety of symptoms which are understood through social interaction disabilities, miscommunication and empathy as well as accompanied by unusual restricted, repetitive behavioral deficits [Carlos et 1 al. 2020]. As not much objective diagnostic tests for Autism is identified, a general clinical diagnosis is suggested which is based on behavior, using the Diagnostic and Statistical Manual of Mental Disorders, Text Revision as one among the standard.

MACHINE LEARNING TECHIQUES

Machine learning attempts to make computers operate like human beings and to make them learn autonomously by providing data and information in the form of observations [16]. It is the practice of using algorithms to parse data, learn from it, and then make a prediction. The acquired knowledge from available data is in the form of structural description that can be represented in different ways allowing computers to generalize to new settings. It encompasses a wide variety of techniques used for the discovery of rules, patterns and relationships in sets of data. Machines that learn are useful to humans because, with all of their processing power, they are able to find patterns quickly in unseen data. Machine learning is a tool that can be used to enhance human ability to solve problems and make informed inferences on a wide range of problems, from helping diagnose diseases to coming up with solutions for global climate change. The applications for machine learning include machine perception, computer vision, natural language processing, syntactic pattern recognition, search engines, medical diagnosis, bioinformatics, brain-machine interfaces, cheminformatics, fraud detection, stock market analysis, speech ,handwriting

computer vision, gaming, software engineering and robot locomotion. Different types of machine learning are listed below. Supervised learning: It generates a function that maps inputs to desired outputs. Unsupervised learning: It models a set of inputs and labeled examples are not available. 11 Semi-supervised learning: This method combines both examples to generate an appropriate function or classifier. Reinforcement learning: It learns to act when

provided with an observation of the world. To every action there is an influence in the environment, which provides response in the form of incentives that directs the learning algorithm. Transduction: This type of learning attempts to predict outputs based on inputs and outputs from training and test inputs.

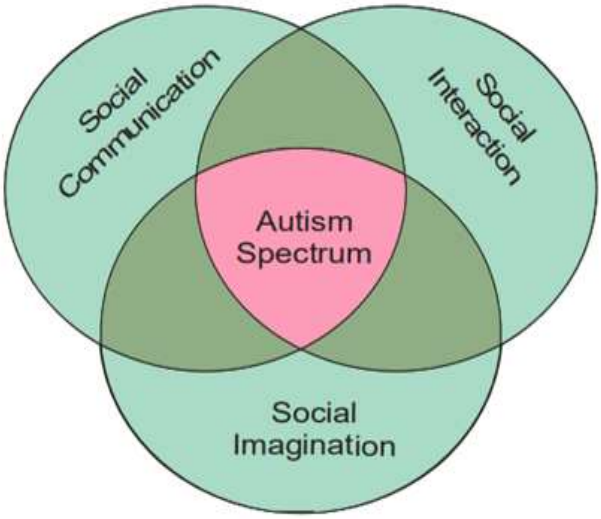

Fig. 1.1 ASD – Autism Spectrum Disorder and relation with Social aspects

RELATED WORKS

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problems and make informed inferences on a wide range of problems, from helping diagnose diseases to coming up with solutions for global climate change. The applications for machine learning include machine perception, computer vision, natural language processing, syntactic pattern recognition, search engines, medical diagnosis, bioinformatics, brain-machine interfaces, cheminformatics, fraud detection, stock market analysis, speech and handwriting recognition, object recognition in computer vision, gaming, software engineering and robot locomotion. Different types of machine learning are listed below. Supervised learning: It generates a function that maps inputs to desired outputs. Unsupervised learning: It models a set of inputs and labeled examples are not available. 11 Semi-supervised learning: This method combines both examples to generate an appropriate function or classifier. Reinforcement learning: It learns to act when provided with an observation of the world. To every action there is an influence in the environment, which provides response in the form of incentives that directs the learning algorithm. Transduction: This type of learning attempts to predict outputs based on inputs and outputs from training and test inputs. Data Driven Approach Orly et al. (2020) have brought together the health systems of public children and their gene data for studying diseases like Autism and Dyslexia. The behavioral attributes of the children and the Prediction of these disorders at an early age are done with the help of the data obtained from their gene. The authors also summarize on the developments related to the aspects of disease surveillance system for studying children behavior and related zoonotic disease for pathogen biology as well as to identify opportunities for future research on disorder forecasts. 34 The study carried out by sally et al. (2021), MoCA(Montreal Cognitive Assessment) approach possesses a sensitivity of 59% while the specificity of 81% for identifying cognitive impairment is maintained using a score cut point of 26.10 value. The sensitivity can be improved to 83% with a cut point of 28, but such changes will decrease specificity. Symptomatic patients show an improved accuracy rate may be in addition to other tests.

Attributes	Description	Fuzzy Measure
Language	Communication Skills	Mild, Moderate, Severe
Social Activity	Social skills	Mild, Moderate, Severe
Behaviour	Behavioural Level	Mild, Moderate, Severe
Levels of Autism	Disorder Level	Very High, High, Medium, Low

Fuzzy Attributes for Autism Disorder

Multiple Autism theories are proposed [Gnanathusharan, Peter, 2019] which suggests genetic issues (many genes have been linked to ASD), inclusion to perinatal and environmental factors, stress, infections, vaccines, influence of various chemicals, etc.

Analysis of ASD theories by Wlodzislaw et al (2021) proves that none of the ASD theories have predictive knowledge as power, but suggests genetic correlations. Autism may be a large set of disorders with diverse mechanisms, like intellectual disability that may be due to many reasons. More than 90 gene mutations have been tested [Li et al. 2014, Judith, 2019] which are linked to only about 27% of all the cases, where each single gene mutation is correlated very weakly with Autism.

Machine Learning based behavioral analytics emphasis the need to develop accurate prediction models for detecting the risk of autism faster than the traditional diagnostic methods. Quality of prediction rely on the accuracy of the supplied dataset and the machine learning model. To improve accuracy of prediction, dimensionality reduction with feature selection is applied to eliminate noisy features from a dataset. In this work an ASD diagnosis dataset with 21 features obtained from UCI machine learning repository is experimented with swarm intelligence based binary firefly feature selection wrapper. [Vaishali R, Sasikala R, 2019]

Autism Spectrum Disorder (ASD) is a group of neurodevelopmental disabilities that are not curable but may be ameliorated by early interventions. Here, [Tania Akteri, 2019] the feature transformations resulting in the best classifications was sine function for toddler and Z-score for children and adolescent datasets. After these analyses, several feature selection techniques were used with these Z-score-transformed datasets to identify the significant ASD risk factors for the toddler, child, adolescent, and adult subjects. The results of these analytical approaches indicate that, when appropriately optimized, machine learning methods can provide good predictions of ASD status. This suggests that it may possible to apply these models for the detection of ASD in its early stages. Santos et al. (2019) have emphasized on the atypical communication of ASD. In this work the acoustic – prosodic analysis of the pre-verbal vocalization of 18 months old babies are executed. The children who have the high-risk of having ASD were diagnosed and children with low-risk also developed controls. Many acoustic-prosodic components were mined and trained with SVM and Neural Networks classifiers.97% of accuracy was obtained.

Thierry Chaminade et al. (2021) have investigated on the social interactions of human that involves the neural bases or with a robot using fMRI. The use of new tools like robots can be successful only when the perception of interaction with artificial and natural agents both in adults with the disorder and without the disorder is understood properly. The participants were made to play the game chifumi(stone-paper-scissors) in its computerized version believing that they are playing live with a human or robot with Artificial Intelligence or a random generator.

According to the ASD problem starts with childhood and continues to keep going on into adolescence and adulthood. Propelled with the rise in use of machine learning techniques in the research dimensions of medical diagnosis, in this paper there is an attempt to explore the possibility to use Naïve Bayes, Support Vector Machine, Logistic Regression, KNN, Neural Network and Convolutional Neural Network for predicting and analysis of ASD problems in a child, adolescents, and adults. The proposed techniques are evaluated on publicly available three different non-clinically ASD datasets. First dataset related to ASD screening in children has 292 instances and 21 attributes. Second dataset related to ASD screening adult subjects contains a total of 704 instances and 21 attributes. Third dataset related to ASD screening in Adolescent subjects comprises of 104 instances and 21 attributes. After applying various machine learning techniques and handling missing values, results strongly suggest that CNN based prediction models work better on all these datasets with higher accuracy of 99.53%, 98.30%, 96.88% for Autistic Spectrum Disorder, [Suman raj, Sarfaraz Masood, 2019]

The study showed that the brain network was more activated when interacting with the human rather than a robot which implies that interacting with human is more appealing than with artificial agents. The posterior temporal sulcus in autistic patients was activated when playing with human. Prud' hommeaux et al. (2019) analyzes on the difficulties for classification of non-standardized text of machine learning techniques. Language errors are identified that are related to atypical language in ASD and 36 a method for replicating these words is also proposed. The Dataset encompasses the transcribed data used in the clinical diagnostic tool for the diagnosis of Autistic children with language disorder. Methods for the automatic extraction of lexical and syntactic features are also proposed based on the child's speech. The identification of syntactic and semantic errors is done and diagnosis is made based on classification. The classifier that is proposed has achieved better results to augment the diagnosis of neurodevelopment and on the analysis of atypical language.

Role of Computational Approaches

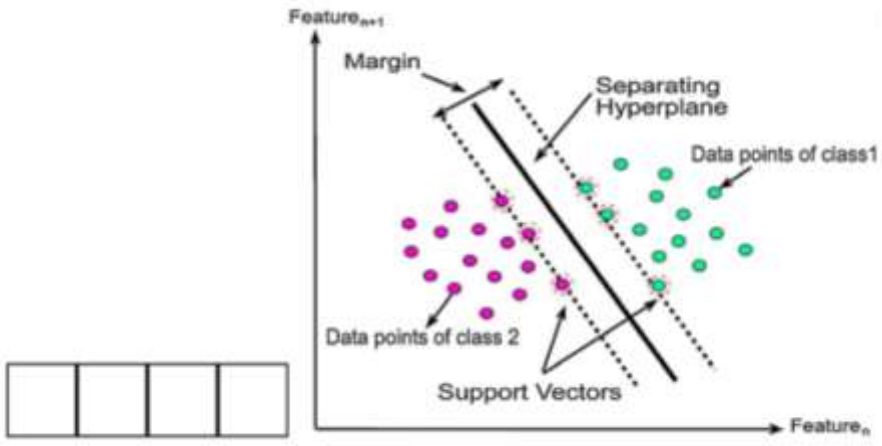
Analysis on child behavior for a Cognitive Disorder can be suggested in terms of classification or predictive rule analytics being applied on training data to form the model. To improve the model, accuracy in predicting the disorder and its life time plays a major role; hence the test data is employed over computational approaches such that the accuracy of the model can be analyzed. ASD is measured by impairments in social functioning and language 40 and by the presence of restricted interests and repetitive behaviors. People with Autism also have a learning disability; hence even persons with average intelligence may be identified to possess Autism.

Artificial Neural Network

ANN plays a predominant role in prediction analysis or supporting decision making strategies. The child's behavioral inputs varying with age, activities and region are considered as variables requested for identifying a disorder. These patterns are given to the ANN network through the 'input layer' which communicates with one or more 'hidden layers'. The hidden layers then link to an 'output layer' in identifying various classifications of disorders. Most ANNs adopt 'Learning rule' that modifies the weights of the connections in step with the input patterns and finally the decision support solution.

Support Vector Machine

In classification approaches, Support Vector Machine (SVM) is a supervised learning model with associated learning algorithms that analyze data and acknowledge the patterns used mainly for classification and regression analysis. A SVM training algorithm builds the model that assigns new examples into one class or the other, creating it a non-probabilistic binary linear classifier. An SVM model could be a representation of the examples as points in space and it is mapped so that the examples of the separate categories are divided by a transparent gap that is as wide as possible.



Fuzzy and Logical Analysis

Fuzzy logic has been applied to several fields, from control approach to automated approach. Fuzzy logic deals with reasoning model where approximation is primary instead of fixed and exact. Fuzzy logic variables could have a truth value that ranges in degree between the binary values 0 and 1. Fuzzy logic is extended to handle the conception of partial truth in Autism child data.

Decision Tree and Weighted Decision Tree are two major approaches adopted for decision making in Autism Dataset where the children's behavior variables and related tuples such as age, region, IQ level are generated as a decision making tree format.

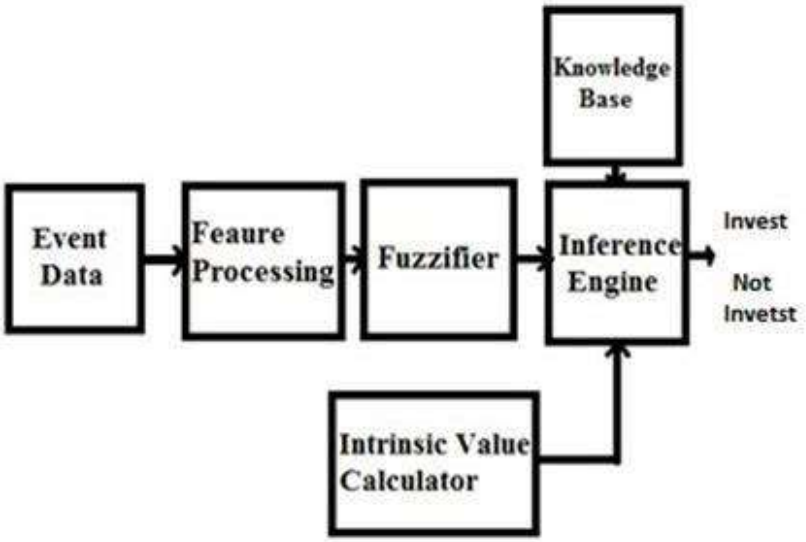


Fig 1. Fuzzy Relational model.

Swam Intelligence

The Swarm supportive mining algorithms play a vital role in the Prediction of Cognitive Disorders and its related applications [Arvinder, Shivangi, 2019] which pertains to knowledge extraction and consistent update of disorder information. Swam Intelligence based algorithms such as Ant Colony Optimization, Bee Hive Foraging Behavior and Fishes swarm intelligence, support in adaptive decision making for large Dataset. Swarm intelligence is highly adaptive to large and consistent Dataset, where global optima are achieved.

6. CONCLUTION

Autism and Delirium shows complex behavioral disorder which are noticed among children possessing cognitive issues. Various symptoms encompasses on the different types of Autism being understood through disabilities of social interaction, anguishes, miscommunication, empathy as well as accompanied by unusual restricted, repetitive behavioral deficits. The phenomenon of Cognitive Disorder being prevalent among growing children is Autism, Dyslexia, and Delirium, which partially affects the activity of the brain and also the child's behavioral attitude. Such rate of disorders being Pervasive among growing children is high and hence being defined as Developmental Disorder of the brain which damages the cognitive neurons where the symptoms are noticed to appear during the early growth stages of a child.

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