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An IOT Based Detection Model for the Level of Autism in a Context-Aware Health Care

Sipali Pradhan[1*], Surajit Das[2], Samaleswari Prasad Nayak[3], J.K. Mantri[4]

[1]North Orissa University, India,
[2]Utkal University, India
[3*]Silicon Institute of Technology, Bhubaneswar, India,
[4]North Orissa University, India

[*]*Corresponding Author: samaleswari.nayak@gmail.com, Tel.: +91-9658663103*

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***Abstract*—** Autism Spectrum Disorder (ASD) or simply Autism a progression of deep-rooted neuron developmental issue which is basically a brain development disorder found in the kids when they are around eighteen months. The kids suffer from communication, social interaction and repetitive behavior problems and are very difficult to identify autism on a proper way. If Autism is remained undetected in children within the age of 1 to 3 years from birth there are chances of regeneration of the symptoms manifested by the autism in the adult stage which is generally noted to be after or around the age of 60 years. Through our paper, we have proposed an IoT based detection model to get data for five symptoms using different sensors and can be transferred to the destination machine for testing using the internet from a remote location. The goal of this paper is to review the Autism Spectrum Disorder problem by generating some IF-THEN rules and build a system to identify the level of Autism using Adaptive Neuro-Fuzzy Inference System (ANFIS).

***Keywords*—** ASD, Adaptive Neuro-Fuzzy Inference System, AOI, eye tracker, IoT

I. INTRODUCTION

Autism Spectrum Disorder (ASD) draws the attention of the researcher nowadays which is a neurobehavioral disorder. It is a brain disorder, characterized based on verbal and non-verbal communication, social awareness and interactions and repetitive and restricted behavior [1]. Autism is a deep-rooted formative disability of brain that effects how they interact with others and relates with the society and it affects how they make sense of the world around them [2]. Autism is detected by the "American Psychiatric Association" as a "Pervasive Development Disorder" in 1994. It defines the symptoms appears before the age of two, which affects the development of the brain in three areas: Language Development, Social Skills and Behavioural Repertoire [3]. An expected one in 100 individuals has autism that is around 230,000 Australians and 700,000 peoples of UK. Autism influences just about four times the same number of young men than young ladies.

Autism Spectrum Disorder (ASDs) issue constitutes a gathering of complex neurodevelopmental conditions described by an impeded social correspondence profile and frequently confined or stereotypic conduct [4]. If Autism is stayed undetected in youngsters within the age of 1 to 3 years from birth there are odds of recovery of the side effects showed by the extreme ranges in the grown-up stage which is, for the most part, noted to be after or around the age of 60 years [5]. There are different types of Autism, Autism Disorder, Asperger's Syndrome, Pervasive Developmental Disorder (PDD), Rett Syndrome and Child Hood Disintegrative Disorder. So it is actually a very difficult task to identify the exact type of Autism and how much the Autism is affected the brain development. If we are able to identify the level of Autism at the proper age, the problem can be solved by different medical treatment. Crisp set generally helps to identify if there is Autism or not. But generally, a single symptom or a minimum disorder is not helping full to give the exact result. For example, a child may have a problem with his tongue, because of which he has a problem of speaking. Problem of speaking is also a most important symptom for Autism. If we can't identify the exact problem, it'll leads us to a wrong treatment for which identification of autism at the proper level is very important.

Fuzzy logic is a way to deal with modern computing, which focused on "degrees of truth" instead of the Boolean logic. Fuzzy logic system considers zero and one as great instances of truth additionally incorporates the different conditions of truth in between [5, 9]. For instance, the consequence of a correlation between two states of temperature could be not "hot" or "cold" but rather ".36 of hotness." Fuzzy logic appears to be nearer to the way human brains performs

different tasks. Human gathers information first, then structure various fractional truths which we total further into higher truths which thus, when certain limits are surpassed, results in certain further results [6]. A comparable sort of procedure is utilized as a part of artificial intelligence, neural network system and master computer or expert system. It might see fuzzy logic as the way thinking truly works and Boolean or Binary logic is essentially a special instance of it [10].

II. RELATED WORK

Different symptoms of Autism are chosen as contexts to successfully implement the system. Autism Spectrum Disorder (ASD) is described by social-connection issues, verbal and nonverbal communication issues and repetitive behavior issue [3, 5, 10]. Problems with Eye-to-eye staring, outward appearances, inability to build up fellowship, absence of sympathy, prefer to be alone are the different symptoms for social Interaction and reaction. Verbal and nonverbal communication can be detected by the issues like, poor speech, difficulty in understanding the others point of view. Inappropriate gameplay, self-injury, Stereotypy is redundant development are the different major indication for repetitive behavior issue. Among these entire symptoms eye contact and alone preference for social interaction are the major issues and key points to identify Autism. Autism is viewed with the way of paradigm shift, evolving from a lifelong condition with a very poor diagnosis to one in which maximum collection and neuroplasticity are required, especially appropriate interventions are provided only when condition is detected early [7]. The major challenge is to delete the gap between research and the implementation of evidence-based work out. Reductions in Purkinje cell number are a challenging task for autism [8]. It is not known whether the glutamate decarboxylase (GAD) changes also occur in different cells at the level of transcription. Using various studies the solution can be found out, for which through this article we have proposed an IoT based solution to find the level of autism in real time.

III. PROPOSED MODEL

So for our work we choose poor eye contact, poor speech, inappropriate gameplay, self-injury and alone preference are choose symptoms. For achieving the required scenarios we have used five symptoms as the context for the system.

The assumed data can be collected using different eye trackers to detect the eye gaze patterns. These trackers are classified into three classes: desktop-based trackers, head-mounted trackers and tracking glasses. In desktop-based eye tracking system a subject with ASD has to sit steady and look through a camera [4, 9, 11]. The camera takes pictures of the subject face. Then the pictures are analyzed based on the area of interest (AOI) to detect the focus of the ASD affected person. Head-mounted trackers are placed around the forehead or on a cap that was worn by the patient. HATCAM, a head-mounted eye tracker placed on a hat, which records the eye direction with respect to head orientation. Image of both the eyes passes through a calibration algorithm to measure the gaze behavior. Another head-mounted eye tracker called WearCamplaced on the forehead of the subject which record videos of the eye position based on different object positions. Later on the videos are analyzed to monitor the subject's focus. Tracking glasses basically uses point-of-views cameras to collect videos of the patient's eye and face. Though the accuracy of the desktop-based eye tracker is more, it is used in most of the cases [12].

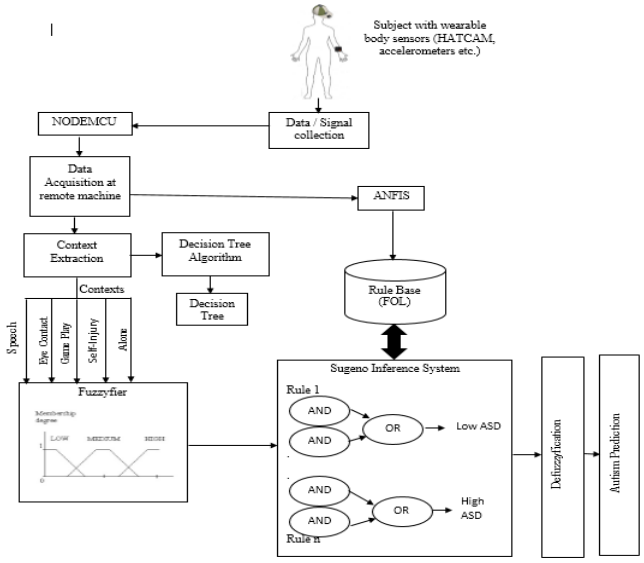

Figure 1: Model Architecture

IV. METHODOLOGIES

Different methodologies can be followed to get the level of autism of a child through different steps.

A. Context-Aware Healthcare using IoT

Context is any data which is utilized to portray the current circumstance of a substance [5]. Also, context-aware computing is the utilization of connection to get important data and/or instructions to the client, where relevancy depends on the specific assignment of the client. Context modeling is a key element in context-aware frameworks to give context to intelligent system through required sensor [3, 9]. With the coordination of Context-awareness, for healthcare we have provided the new proposed an adequate framework. Sometimes the different symptoms of a disease can be used as context to implement medical devices. Here a patient's required data can be collected and used through sensor for different contexts to describe the current situation of the patient.

B. Decision Tree

Decision tree fabricates classification or regression models as a tree structure [6]. It is used to separates a dataset into smaller subsets while in the meantime a related decision tree is incrementally created. Through result it has been represented with decision node and leaf node. A decision node has two or more branches. Leaf node speaks to a classification or choice. The highest choice hub in a tree which compares to the best indicator called root hub. Decision trees can deal with both all out and numerical information. In simple words, a decision tree is flow charts like tree structure where each intermediate node denotes a test condition on a specific attribute, each branch represent the result of the test condition and leaf node represent the class name or class distribution.

C. ANFIS

ANFIS or Adoptive Neuro-Fuzzy Inference System is a derivation framework based on some neural network and fuzzy logic technique which is being utilized on a given dataset [5]. The tool compartment function ANFIS builds a fuzzy deduction framework (FIS) and its membership function parameters of the fuzzy inference system are balanced by utilizing either a back-propagation calculation alone or by combing with least-squares technique. This permits our fuzzy frameworks to gain from the information we are demonstrating. By default ANFIS generates a Sugeno Model for fuzzy derivation with a standard structure for the proposed model:

If x is A and y is B then z = f(x,y)

V. EXPERIMENTAL RESULT

From the literature review of Autism, it has been realized with the conclusion that no single symptom is enough to identify the level of Autism for an affected child. But two or more than two symptoms are considered effective to identify the Autism. By the help of eye tracker sensor, movement trackers, human-robot like KASPAR can be used to provide different types of touch and polysomnography where data can be collected from different AOI and through decision tree we are able to classify the level of autism [12]. Data has been fade to the ANFIS to generate the rule base. We choose trapezoidal membership function for its best performance and simplicity. To tune the membership function back-propagation is used along with least square technique. In brief the hybrid method is used to set the membership value. For decision tree we have used ID3 algorithm to classify the data. Based on the selected context autism has been classified into three different levels such as “low”, “medium” and “high”.

For implementation we have used MATLAB tool by considering the data set and the ANFIS Model of FUZZY toolbox to generate the record. Whenever the patient provides or the user needs some information from the patient it will use the head-mounted eye tracker sensor to collect data from different regions. Through NODEMCU the data can be collected and can be transmitted to the destination machine for intra-network communication. For internetworking communication the GSM module can be used with Arduino device. Once data is collected can be given as input to the Fuzzy logic-based system for validation and finding the level of autism.

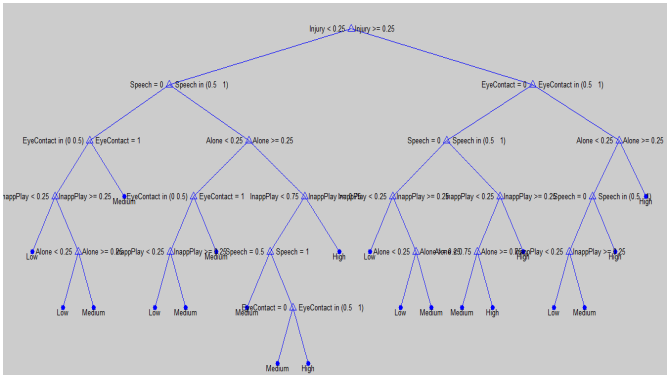

Figure 2: Decision Tree

Decision tree is dividing the crisp range [0, 1] into three continuous sequence, as [0, 0.25]; [0.26, 0.5]; [0.51, 1]. As per the system design we can relate these three sequence with three class levels as, Low [0, 0.25]; Medium [0.26, 0.5]; and High [0.51, 1].But on the other hand the fuzzy logic system does not classify the data but gives some values based on the IF-THEN rules. From the comparison table it can be observed that the decision tree shows only the class level whereas the fuzzy logic based system shows some values from where the level of Autism can be understood. Decision tree only shows the class level but from the fuzzy logic based system seriousness of the Autism more accurately can be observed.

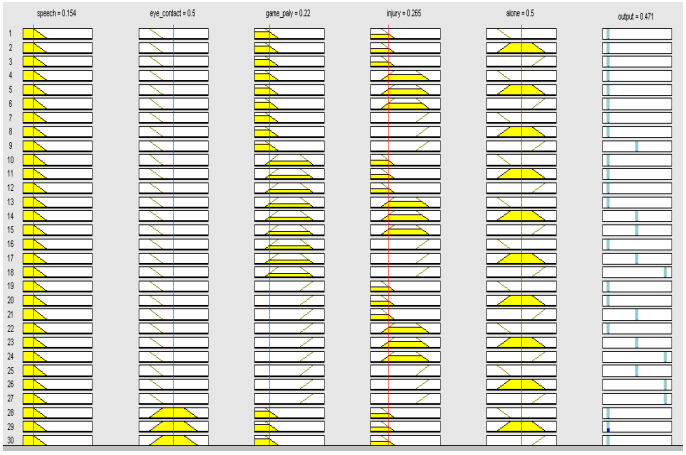

Figure 3: Fuzzy Logic based System

Table 1: Comparison of Results for different symptom

Speech	Eye Contact	Inappropriate Play	Self Injury	Alone	FIS Result	Decision Tree result
0.0338	0.0564	0.101	0.108	0.0709	0	Low
0.169	0.117	0.0131	0.19	0.19	0.00195	Low
0.259	0.252	0.168	0.22	0.235	0.171	Low
0.274	0.312	0.175	0.257	0.198	0.269	Medium
0.117	0.207	0.087	0.28	0.302	0.281	Medium
0.199	0.207	0.175	0.429	0.369	0.324	Medium
0.237	0.169	0.25	0.31	0.332	0.403	Medium
0.365	0.252	0.131	0.34	0.302	0.612	High
0.417	0.44	0.34	0.295	0.31	0.961	High
0.756	0.771	0.787	0.825	0.884	1	high

On the above table for the two tuples (0.368, .0252, .0131, 0.34, 0.612) and (0.756, 0.771, 0.787, 0.825, 0.884) decision tree shows High for both of them but from the result of fuzzy logic system we can understand that the seriousness of first tuple is closer to the "medium" level whereas the seriousness of second one is extremely "high". So it is preferable to use fuzzy system over decision tree to identify the level of autism.

VI. CONCLUSION

As the detection of autism is very difficult but is necessary to identify Autism in the early ages for betterment of human being. Through this paper we can achieve our main goal to collect data through sensors and can transfer to destination machine to create a fuzzy inference system that will predict the level of Autism. We have used the information and focused on five most important symptoms as: poor speech, self-injury and eye contact, inappropriate game play and alone preference and chosen the same five as our context to create the system. We use Adaptive Neuro Fuzzy Inference System (ANFIS) fuzzy tool box of matlab to build the fuzzy inference system. Also we have implemented the decision tree (ID3) algorithm to determine the class level. Finally we extract the system result that predicts the level of Autism and compare the result of both fuzzy logic based system and decision tree. For the extension of this work we can use different sensors as proposed to collect data in real time and classify the level of autism in more number of classes and add some more classes like very low or extremely high. Also we can provide some online interface to resolve online queries regarding the problem of autism and can allow the patient not to sit steady and can move freely.

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Authors Profile

Sipali Pradhan is a Ph.D research scholar in the Department of Computer Science and Applications, North Orissa University, Baripada, Odisha. She has completed M.Tech in Computer Science and Engineering from Utkal University after completing B.Tech in Electronics and Communication Engineering from Biju Pattnaik University of Technology Odisha. Her research interest includes Internet of Things and its application in Healthcare.

Mr. S Das pursued Bachelor of Science from Vidyasagar University, West Bengal, India in 2014, Master of Science (CS) from VIT University, Vellore, Tamil Nadu, India in 2016 and Master in Technology (CSE) from Utkal University, Odisha in 2018. He is currently working as Assistant Professor in Department of Computer Science and Engineering, Konark

Institute of Science and Technology, Odisha. His main research work focuses on Internet of Things.

Samaleswari Prasad Nayak has pursued his MTech in computer science and continuing his PhD in Utkal University. He is working as an Assistant Professor in department of CSE at Silicon Institute of Technology, Bhubaneswar, Odisha. His area of specializations are Wireless Sensor Network, Mobile computing and Internet of Things. His main research work focuces on Health monitoring using Internet of Things.

Dr.Jibendu Kumar Mantri is Associate Professor and Head of the Department of Computer Application, North Orissa University, Baripada, Odisha. He obtained M.Sc & MPhil in Mathematics and M.Tech and Ph.D in Computer Science. His area of specializations are Artificial Intelligence, Business Process Reengineering and Computer Security.

