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Soft Computing Models for the Predictive Grading of Childhood Autism- A Comparative Study

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***Abstract*: Artificial intelligence technique is a problem solving method, by simulating human intelligence where reasoning is done from previous problems and their solutions. Soft computing consists of artificial intelligence based models that can deal with uncertainty, partial truth, imprecision and approximation. This article discusses about the performance of some soft computing models for the predictive grading of childhood autism. Now a day's, childhood autism is a common neuro-psychological developmental problem among children. Early and accurate intervention is needed for the correct grading of this disorder. Result demonstrates that soft computing techniques provide acceptable prediction accuracy in autism grading by dealing with the uncertainty and imprecision.**

***Index Terms*: soft computing, autism, naïve bayes model, neural network, classifier combination model.**

I. INTRODUCTION

The ability to learn and reason from cases where past experiences are reused to recognize the salient features in a problem and its solution, is the fundamental to natural human intelligence. Artificial intelligence based automated systems also has the property of storing theoretical knowledge and learn from case histories that are used for manual investigation. For example, medical diagnosis not fully based on the theory of anatomy and physiology but also depends on previous case histories and practical experience with other patients and its treatments. Thus diagnostic cases along with its salient features and solutions are recorded for building large case bases to simulate domain expertise. Then a similarity based mapping is built for how that experience can be applied for the present situation.

A. About Childhood Autism –Clinical Features and Diagnosis Method

Autism is a form of childhood psychosis with an onset within the first 30 months of age and may proceed to adulthood depending on its grade or severity.It is characterized by a delay in multiple developmental functional skills that include: social, language and behavior. Hence it is considered as a communicative and cognitive disorder which affecting the communication and socialization in children.The diagnosis is totally depending on the qualitative features or symptoms shown by a child, and other quantitative tests are of little importance. The main clinical symptoms are:

1) Lack of responsiveness to other human beings
2) Difficulty in developing social relationships
3) Compulsive behavior with resistance to change in environment
4) Repetitive acts with restlessness
5) Language disorders like muteness, echolalia etc
6) General intellectual retardation

Generally a parent notices any delay in their child's communication skill prior to the age of three which prompts them to consult a developmental pediatrician. Now the suspicion about autism arises for the first time by the clinician due to the impairments in certain functional areas of the child. The child is then recommended for an assessment test using any of the autism rating tools. These tools are normally a questionnaire or a checklist regarding autistic features and each question is followed by certain choices with assigned numerical scores. Thus clinician fills the questionnaire based on direct observation and parental interview of the suspected child. Finally, scores of entire questions are added up to calculate a total score'T'. The different grades of childhood autism are: Normal, Mild, Moderate and Severe. Each grade is associated with a threshold limit of that grade. The obtained total score's' is compared with these thresholds and the child will be graded with anyone. Examples of certain threshold limits are as shown in table 1.

Table 1

Total Score 'T'	*Grade 'G'*
T< 30	Normal
T= {30..,.33}	Mild
T= {33..,36}	Moderate
T>36	Severe

B. Challenges in Diagnosis and Need of a Decision Support Model.

The assessment is merely dependent on the qualitative features present in a child. Accuracy in diagnosis of this disorder in an infant or toddler depends on the expertise of a clinician. Hence it is considered as challenging decision making problem in psychology in terms of accuracy. Even though assessment is completed using any tools, accurate grading about the strength of the disorder without any uncertainty is needed for future treatments including therapies. An expert clinician can easily spot an autistic child or grade its severity. But clinicians who are lacking expertise or in their initial career stage, totally depend on diagnostic tools and may find difficulty in correctly grade the disorder. Thus their diagnosis ends up in an uncertain grading or they will recommend for a second opinion.

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Another suggested difficulty is, if the total scores 'T'= 32 then the child will be labeled as 'Mild to Moderate' because 33 is the threshold that separates Mild and Moderate. Similar is the case of T=34 or 35. In majority of cases, clinicians upon any uncertainty can be able to grade either as 'Normal', 'Mild to Moderate', 'Moderate to Severe' and 'Severe'. Here the grades: Mild to Moderate and Moderate to Severe can be considered as uncertain grading or otherwise overlapped grades. These are the needs of an automated decision support system.

II. PROBLEM DEFINITION, OBJECTIVES AND RELATED WORKS

This section describes about the research objective and related works in this domain.

A. Problem Definition

The intention of this research is to study the application of certain soft computing techniques in developing autism assessment support systems for grading childhood autistic disorder with good accuracy and certainty.

B. Objectives

The main objective of this research article is to highlight the application of certain soft computing techniques for grading childhood autism that deals with uncertainty. Other sub objectives are to explain about the materials and methods:

1) *Data Collection and organization to create a dataset*
2) *Probabilistic reasoning method for initial screening of autism*
3) *Connectionist based grading similar to conventional tool based approach*
4) *Dealing uncertainty in neural network models using a classifier combination approach*

C. Related Works

One of the main challenges in psychological diagnosis is, the dependenancy of assessments on qualitative features. Representation of the degree of qualitative symptoms is a sub challenge of it. Since machine learning mechanisms have gained vast importance recently and there are upcoming applications of it in the field of psychology. Some of the machine learning techniques have already applied for autism diagnosis and obtained good results also. A feed forward back propagation neural network trained a sample size of 138 have gained a classification accuracy of 95% [1]. Another study was an implementation of a feed forward back propagation neural network integrated with fuzzy logic. This system was trained with a sample size of 40 and obtained an accuracy of around 85-90%[2]. MLP neural network and logistic regression models were compared after raining with a sample size of 638, which has shown an accuracy of not less than 92%[3]. Fuzzy cognitive maps were also applied for autism identification , by inputing 23 features and 3 output classes[4].

III. KNOWLEDGE ENGINEERING

A. Data structuring and Representation

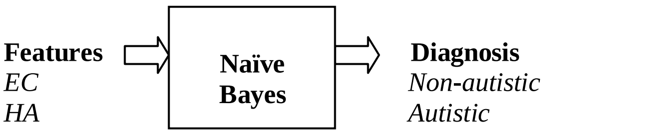
Problem solving systems needs an efficient knowledge elicitation method for building a knowledge base by collecting enough and accurate information regarding the problem("mike Green well"). Proper functioning of knowledge base depends on data collection and analysis from two or more domain experts. Hence a group elicitation method has been used during the data collection phase of this research. This was for the efficient acquision of data and the expert group includes: Speech therapist, psychologist and neurologist. The knowledge engineer communicates with each domain expert and records their opinion until no new contributions are forth coming [5]. The study has been carried out with data of children in age group 2-3 years. Previously diagnosed CARS score of 100 cases are stored to form a medical database in order to keep track of all reported symptoms along with its diagnosis grade. These case details are separated into two main fields: Symptoms and Grade. The Symptom field indicates the strength of the qualitative symptom present in the child and the Grade field contains the diagnosed grade based on the occurred symptom present in the child. The Symptom field is divided into 16 atomic symptom fields and thus the dataset can be viewed as a 100×17 matrix: 100 cases, 16 symptoms, 1 grade.

IV. SOFT COMPUTING APPROACHES

Four different soft computing models have been implemented and tested. This section describes about the implemented different soft computing model.

A. Probabilistic Reasoning

Probability inference has been applied on decision making systems for the past few years. The main goal of this model was to study the application of probabilistic inference for the initial screening of childhood autism. In probabilistic inference, knowledge is represented using statistical measures as evidence and belief. The study has been carried out by implementing a naïve Bayesian classification model which is a two class classifier model where grades are labeled as: Non –autistic i.e. Normal and Autistic. Naïve bayes classifier applies Bayes rule for finding the most probable grade based on the symptoms given.



During the knowledge acquisition phase, domain experts helped to find the most commonly seeing 12 symptoms. A case history with 45 real cases from the global dataset was created for the calculation of complex probabilities[5]. According to Naïve bayes classification, the class with highest posterior probability has to be selected. Consider 'S' being a set of symptoms 'Gi' being 'ith' grade, the posterior probability for the grade'Gi' can be found as:

$$P\left(\frac{Gi}{S}\right) = \frac{P\left(\frac{S}{Gi}\right) \times P(Gi)}{P(S)} \quad (1)$$

Where

$P\left(\frac{Gi}{S}\right)$= probability of being in Grade'i' with 'S',

$P(S)$= Evidence

$P\left(\frac{S}{Gi}\right)$ =Class likelihood of 'Gi'.

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$P(Gi)$=Prior probability of ‘Gi’.
According to Maximum A Posteriori Hypothesis and Maximum Likelihood hypothesis, Eqn(1) is reduced and naïve bayes selects Gi based on:

$$P\left(\frac{Gi}{S}\right) = \arg\max\left\{P\left(\frac{S}{G1}\right),\ P\left(\frac{S}{G2}\right)\right\} \qquad (2)$$

Thus Naïve bayes classifier infers that the set of symptoms ‘S’ belongs to Grade G1 iff $P\left(\frac{G1}{S}\right) > P\left(\frac{G2}{S}\right)$.

B. Neural Network Model

Artificial Neural Network (ANN) is a data processing system built with interconnected neurons which are the processing elements to solve a problem. These neurons have a layers structure which is inspired by biological nervous system. It is analogous to human brain in gathering knowledge through a learning process, called training and can infer a new test sample also. Hence a trained ANN can act like an expert specific to a problem in a domain. The process of learning through sample inputs and output is called supervised learning, where the training in which target output is not known is called unsupervised learning. But ANN can find the relationship between input and outputs thereby generalize from this previous experience. Since they can process and generalize complex information, they are well suitable for classification and prediction problems. In this research work, applications of unsupervised neural networks for autism grading are implemented. Similar to the conventional diagnosis, total score is considered and applied to unsupervised an model. Thus a Self Organization Feature Map (SOM) neural network model is designed 1-0-4 neuron layers with ‘total score’ as input and 4 grades as output. For a comparative study, other unsupervised clustering methods like K-means algorithm, Fuzzy C Means(FCM) algorithm and Learning vector quantization neural network were also implemented [6]. But in order to find the relationship with all autistic features a 16-0-4 competitive neural network was also implemented for this study. The four output grades are: Normal. Mild-Moderate, Moderate- Severe and Severe. The 16 input attributes and its semantics are as give in Table 2.

Table 2. Autistic symptoms and its attribute names

Attribute Name	*Symptom*
NCR	Poor Name Call response
SA	Solo Play
JA	Poor Joint Attention
EC	Poor Eye Contact
DD	Developmental delay
VMS	Vocal-Motor Stereo types
EF	Excessive Fear
TT	Temper Tantrums
AD	Attention Deficit
HA	Hyper Activity
PC	Poor Comprehension
BS	Brain Seizures
ER	Poor Emotional Response
SI	Injurious to self or others
OS	Spinning objects or self
TOT	Total of attributes

C. Classifier Combination

Accuracy in classification can be improved by using multiple classifiers for a joint decision, called classifier combination. The output from individual classifiers is either fused to get a joint decision, or output of one classifier is again judged or reviewed by another classifier for supporting it. The formal architecture contains either homogeneous or heterogeneous classifiers arranged in parallel and the latter contains classifiers in serial. In our implemented model a neural network and fuzzy systems are the constituent classifiers where the predicted output or grade of a trained neural network is checked by a rule based classifier for the presence of enough facts of the neural network prediction. Suppose the neural network predicts that a test case belongs to grade ‘Severe’, and then the rule based fuzzy system checks for the class contribution of ‘Severe’ in the severity of disorder. Here rule based fuzzy system is designed with Takagi –Sugeno Kang type rule, say:
Ri: If $X(x_1, x_2 \ldots x_n)$ = Ai then Y=f(X) where x_i is individual input, f(X) is a function that maps input to output ‘Y’.

V. RESULTS ANALYSISS

This section describes about the experimental results of different soft computing models on the problem under study. A comparison between the models with respect to accuracy is shown in Table 3.

A. Result of Probablistic Approach

For a test sample of size 40, the observed results were similar to the expected output thereby giving a classification accuracy of almost cent percentage. For a given test case,
Posterior Probability of class ‘Autistic’= 0.96
Posterior Probability of class ‘Normal’= 0.04
Then according to Naïve Bayesian theory, the class ‘Autistic’ is having the maximum probability and hence the child is graded as autistic[5]. The result shows that Naïve Bayesian model can used as a good classifier to screen the presence of the disorder or not.

B. Neural Network Approach

Unsupervised clustering based neural networks of one input type and 16 input types were tested. The single input type SOM behaves like a conventional diagnosis method. The cluster centre of each grade is trained with total score and upon testing SOM also gives cent percent accuracy. But single input type LVQ was able to give an accuracy of average 93% . Other single input type unsupervised clustering methods like K-means and FCM were performed with 93 and 96 percentage of accuracy[6].

Table 3. Comparison of soft computing approaches

Model	*Test sample*	*Inputs*	*Grades*	*Accuracy Rate*
Naïve Bayes	40	12	2	1
SOM	30	1	4	1
LVQ				0.93
K-Means				0.93
FCM				0.96
Neural Fuzzy	100	16	4	0.98

C. Classifier Combination Approach

Here the accuracy of competitive neural networks were improved and increased to 98% by combining it with fuzzy system.

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The predicted grade of neural network is either agreed or disagreed by a fuzzy classifier and a joint decision will be taken upon giving a test sample. This result shows that classifier combination soft computing approach can give better accuracy than individual machine learning models

VI. CONCLUSION AND FUTURE WORK

The aim of this paper is to highlight the application of soft computing models in the predictive grading of autistic disorder in toddlers. A case study was done by collecting using judgment sampling methods and prepared it for training and testing different machine learning models. Since there is no bench mark dataset for this problem, the models are compared with the prepared data set. Experimental results show that soft computing approaches can be used for embedding expertise by implemented as decision making systems. The implemented and tested techniques performed with good accuracy and can be used for screening and unique grading of this disorder.

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