Machine Learning based Autism Grading for Clinical Decision Making

C.S.Kanimozhselvi, D.Jayaprakash

Abstract— ***Autism spectrum disorder is a pervasive developmental disorder that affects the behavioral and communication function of the children. It shows poor performance in communication, social and cognitive abilities, which are generally characterized by developmental delays and abnormal activities in their regular work. Early intervention can reduce the autism spectrum disorders. Machine learning techniques are used to detect autistic features in childhood. The prediction models are implemented as classification problem in which model is constructed by using real-time autism dataset. The proposed work is use Backpropagation and learning vector quantization with different distance measures like Euclidean Distance, Manhattan Distance, and City Block Distance to predict whether a child has autism spectrum disorder and also defines the grade of the autism. So that it can be supported for the clinical decision making. It enables automated clinical autism spectrum disorder diagnostic process using machine learning models.***

Keywords:Autism Spectrum Disorder (ASD), Backpropagation, Learning Vector Quantization (LVQ), Machine Learning (ML).

I. INTRODUCTION

Autism is a failure to create relationships with neighbors, speech delay, and problems in communication, repetitive behaviors and stereotypical activities [1]. Autism Spectrum Disorder (ASD) is a fast growing disorder in worldwide [10]. Early diagnosis of autism gives most important for autism disability recovery [13].

The traditional assessment methods includes parental interview with standard parental questionnaires and checklists of autism assessment. The result of the assessment is based on the total scores of the assessment and also clinician's experience. Machine Learning (ML) is an intelligent technique [3], [4], [14], which supports to the computers to learn problems automatically and improve their accuracy by past assessment. ML is based on the data because its decision making learn from past data. It also focuses on the computer program development. The learning process begins with observations or data, such as direct experience, follow instruction, to search for patterns in the data and make better decisions. The main goal is computer to learn decision making automatically without any support from human. ML techniques are used in many places such as Autism screening and detection, where it is not possible to develop a specific set of mechanisms for performing the task.

ASD diagnosis problems can be solved by applying classification using ML algorithms [8], [9]. Classification based models can reason with uncertainty, partial truth, imprecision and approximation [5], [7]. They have the property of storing theoretical knowledge and/or learning from past histories used for manual in inquiry. Effective diagnosis is based on previous diagnostic experience of a clinician and past history of patients and not depends on the anatomy and physiology.

Hence, it is necessary to maintain the expertise knowledge of clinician along with the symptoms and treatments given by the clinician for a particular disease/disorder. The knowledge obtained from the past experience can be utilized to handle a present situation afterwards.

The proposed work is predicting childhood autism by using ML algorithms such as Backpropagation and Learning Vector Quantization (LVQ) [12] with different distance measures to define autism grades [6]. The LVQ is implemented with Euclidean Distance, Manhattan Distance and City Block Distance [11]. These machine learning algorithms use 5 folds cross validation to estimate the skills of the model on autism data.

II. LITERATURE REVIEW

Autism grading is mostly done by a score based mechanism rather than a qualitative diagnostic mechanism. The diagnosis involves keen observation of autistic features of a child and the grading depends greatly on the observation. Autism grading is very difficult even for an expertise because of the uncertainty involved during the diagnosis. Hence, the knowledge of clinical expertise can be stored and used for grading autism children. Many researchers have applied machine learning based classification techniques to achieve this kind of task.

Omar et al proposed a system for detecting autism spectrum disorder using machine learning techniques. A model was developed by merging two machine learning algorithms namely Random Forest-CART and Random Forest-Id3. The system is used to detect autism by determining a set of conditions and it is useful to clinicians to make a decision about autism of a child's earlier age [2].

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* Correspondence Author
Dr.C.S.Kanimozhiselvi*, Computer Science and Engineering, Kongu Engineering College, Perunduari, Erode, Tamil Nadu, India. (Email: kec.kanimozhi@gmail.com)
Mr.D.Jayaprakash, Computer Science and Engineering, Kongu Engineering College, Perunduari, Erode, Tamil Nadu, India. (Email: jayassoft@gmail.com)

Kanimozhiselvi C S et al described the childhood autism screening and grading using Possibilistic-Linear Vector Quantization (Po-LVQ). This system defined the autism grades based on the autistic features such as Normal, mild to moderate, moderate to severe and severe. The results of the algorithm are compared with the LVQ and other ML models. Based on the comparison Po-LVQ grading system provides highest accuracy of 95% and also provides support to the uncertain diagnosis situations [6].

Bone et al studied the best-practices to be followed in machine learning based autism research, and focused few areas for interdisciplinary research involving AI and behavioral science [3].

Artificial Neural network based classification support for autism is studied by many researchers in 1990s. A neural network with back propagation learning is built on 138 training instances is an interesting work. The researchers have collected the data from an autism assessment instrument called Autism Behavior interview was one among them. In comparison with the traditional Discriminant function analysis, neural networks performed superior with the classification ability on 85% vs. 92% basis during generalization testing [4].

A. Pratap et al describes that artificial intelligence based autism grading technique is an useful decision making technique which simulated the human expertise by making use of the knowledge obtained from previous case histories and solutions. The artificial intelligence models can help in dealing with uncertainty, approximation and partial truth. They explored the use of few some soft computing models for measuring the predictive accuracy of autism grading [5].

III. PROPOSED SYSTEM

The input data fetched through a diagnostic tool. This tool tries to gather the minor and major symptoms from the parental interview. The design of the architecture framework is shown in Fig.1. In the proposed work, CARS based data of

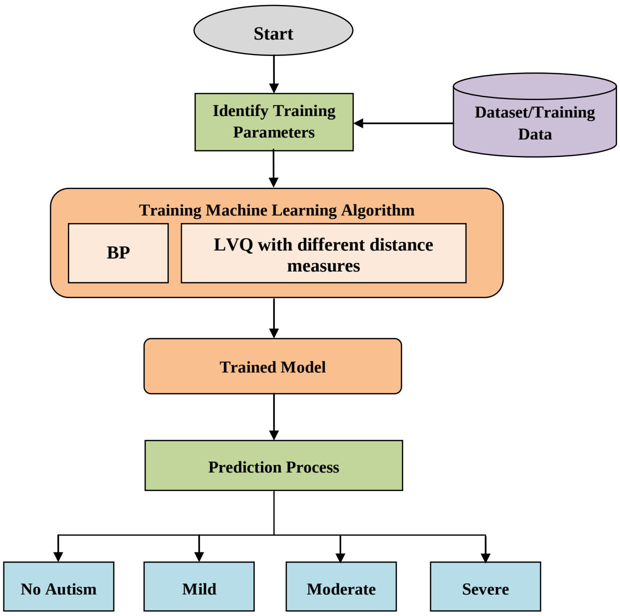

Fig. 1 Proposed Flow Diagram

autistic children is collected from clinicians. The collected data is then applied to classification techniques and the autism grade is obtained which is then verified with the ground truth in the dataset. The predictive accuracy of the soft computing model is then measured.

A. Data Collection

Secondary CARS data containing 182 instances are collected from clinicians where 32 instances have no autism, 43 instances are mild, 25 instances are moderate and 82 records are severe. The autism dataset classification diagram is shown in Fig. 2.

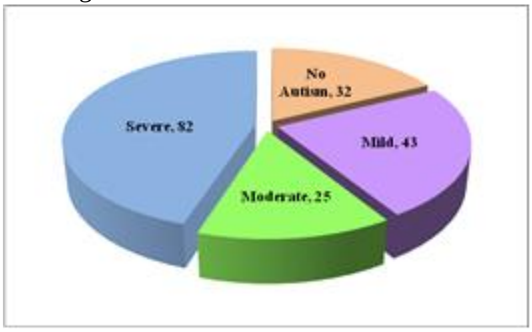

Fig.2 Autism Dataset Classification Details

B. Classification Models

Classification models are built by learning from a given data input and the assigned ground truth against the data. The Back propagation and LVQ with Euclidean Distance, Manhattan Distance and City Block Distance vector algorithms are used to identify the best suitable model in the autism dataset.

C. Backpropagation Algorithm

The back propagation algorithm is a multilayered feed forward network. It is a supervised learning network which takes the CARS based data with the actual grade assigned by the clinician for creating the training set. The network has 15 input neurons and 4 output neuron. The network is initialized with random weights. One weight for each input connection and additional weight for the bias. Initially calculates the activation of a neuron from 15 inputs. The input data are taken from training set, like the case of hidden layer. In the output layer, the hidden layer may contain outputs from each neuron. The neuron activation is calculated as the weighted sum of the inputs. Neuron activation is calculated as the weighted sum of the inputs. The process is through each layer of our network calculating the outputs for each neuron. The final output is the grade like no autism, mild, moderate and severe.

D. LVQ Algorithm

The Learning Vector Quantization (LVQ) algorithm makes predictions by finding the best match among a set of patterns. Initially, four vectors to represent each grade are initialized randomly as reference vectors from the training dataset. This learning algorithm shows one training record at a time to find the best matching unit among the codebook vectors and moves it closer to the training record. The codebook vectors are initialized to randomly selected values from the training dataset. Each of the training record is then compared with the reference vectors. When the two vectors are of same class, then they are moved closer or moved further according to the distance.

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Hence, the distance between a training record and each of the reference record is measured using different distance measures. The measures used are Euclidean distance, Manhattan distance and city block distance.

The Euclidean distance d is

$$d = \sqrt{\sum_{i=1}^{k}(x_i - y_i)^2}$$

Where x_i is the training vector and y_i is the reference vector.

The Manhattan distance of the LVQ is

$$d = \sum_{i=1}^{k}|x_i - y_i|$$

The city block distance represents absolute differences between two training vectors. It is represented as Minkowski distance with λ=1.

$$d_{ij} = \sum_{k=1}^{n}|x_{jk} - x_{jk}|$$

To test a case and assign a class, the distance to the test case and each of the reference vectors is first measured. The distances are then sorted. After that, the first or most similar reference vector is selected and the corresponding class is the grade for the new test case.

IV. RESULTS AND DISCUSSIONS

The proposed techniques can be applied to ASD screening and diagnosis. By using the real-time autism dataset, training and testing of Backpropagation and LVQ with Euclidean distance, Manhattan distance, City Block Distance is performed for the ASD diagnosis. In this process dataset is split into training and test sets with 5 fold cross validation split. Performance analysis is done by calculating the accuracy, precision and recall.

A. Accuracy

The graphical representation of all four algorithms prediction accuracy is shown in Fig. 3. From this graph, it is inferred that the LVQ with City Block distance algorithm has the highest accuracy of 100% in No autism, 96% in mild, 77 has moderate and 93 in severe class. LVQ with Manhattan distance performs fairly better than city block measure for Moderate and severe cases with 96% and 100% respectively. Backpropagation algorithm performs equally well except for moderate cases.

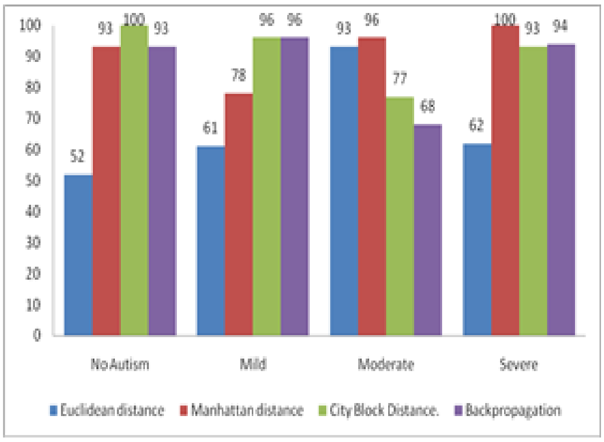

Fig.3 Accuracy Measure of ASD Prediction

B. Precision

Learning Vector Quantization with City Block distance algorithm has the highest precision for Mild and Moderate instances. Learning Vector Quantization with Manhattan distance algorithm has the highest precision for severe instances. Back Propagation algorithm has the highest precision for no autism instances. Refer the Fig. 4 for graphical representation of precision.

Precision is given by the relation:

$$\text{Precision} = \frac{T_P}{T_P + F_P}$$

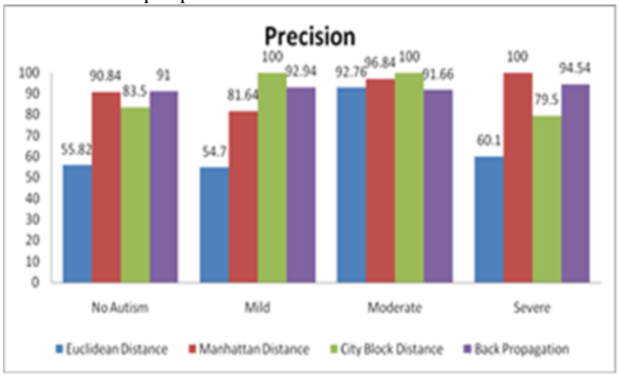

Fig.4 Precision Measures for the ASD grade prediction

C. Recall

Learning Vector Quantization with City Block distance has the highest recall for no autism instances. Back Propagation algorithm has the highest recall for mild and severe instances. Learning Vector Quantization with Manhattan distance has the maximum recall for moderate instances. The results are shown in Fig. 5.

The recall is given by the relation:

$$\text{Recall} = \frac{T_P}{T_P + F_N}$$

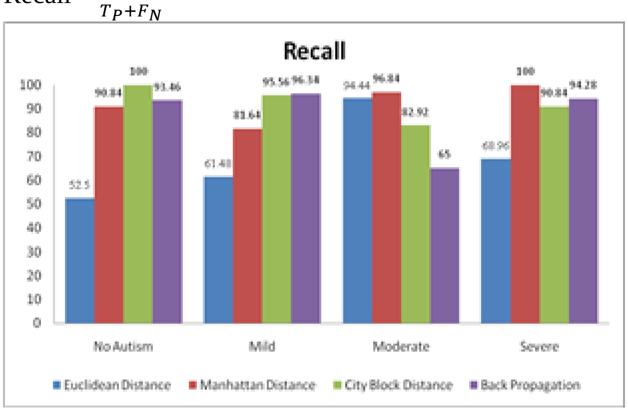

Fig.5 Recall Measures for the ASD grade prediction

V. CONCLUSION

Autism grading is very critical to clinician due to its uncertainty nature. Machine learning algorithms can be applied to solve this problem. In this work, few classification models are built using machine learning algorithms such as Backpropagation and Learning Vector Quantization with Euclidean distance, Manhattan distance, City Block Distance. Real-world clinical dataset and is used to predict and verify the autism grades. In this study, Learning Vector Quantization with Manhattan distance algorithm provides the greatest accuracy.

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AUTHORS PROFILE

Dr. C. S. Kanimozhi Selvi is a professor in the Department of Computer Science and Engineering of Kongu Engineering College, Perundurai, Erode, Tamil Nadu, India. She holds a Ph.D. in Computer Science (2011) from Anna University, Chennai. She is at the teaching profession for more than 20 years and more than 10 years research experience. Her areas of academic interest include data mining, Machine Learning and Deep Learning. She has published more than 40 articles in international journals and more than 30 papers in international and national conferences.

D.Jayaprakash is a Junior Research Fellow in the Department of Computer Science and Engineering of Kongu Engineering College, Perundurai, Erode, Tamil Nadu, India. He received his Bachelor's degree in Computer Science and Engineering in 2006 from Anna University and a Master's degree in Computer Science and Engineering from Anna University in 2013. Now, he is pursuing his Ph.D in Computer Science and Engineering at Anna University, Chennai. He has published 8 articles in international journals and 12 papers in international and national conferences. His current research interest is machine learning and healthcares.