VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

Department of Computer Engineering

Project Report on

Machine Learning Solutions for Autism Spectrum Disorder Characterization

In partial fulfillment of the Fourth Year (Semester–VII), Bachelor of Engineering (B.E.) Degree in Computer Engineering at the University of Mumbai
Academic Year 2023-2024

Project Mentor
Mrs.Veena Trivedi

Assistant Professor, Computer Engineering Department

Submitted by

Sunny Bhatia D17C 09
Divesh Chhoda D17C 14
Autharva Sawant D17C 63
Varun Chawla D17A 09

(2023-24)

VIVEKANAND EDUCATION SOCIETY'S
INSTITUTE OF TECHNOLOGY

Department of Computer Engineering

CERTIFICATE of Approval

This is to certify that ____Fourth Year Computer Engineering studying under the University of Mumbai has satisfactorily presented the project on "***Machine Learning Solutions for Autism Spectrum Disorder Characterization***" as a part of the coursework of PROJECT-I for Semester-VII under the guidance of ***Prof. Mrs. Veena Trivedi*** in the year 2023-2024.

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Date

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Internal Examiner External Examiner

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Project Mentor Head of the Department

Principal Dr. Mrs. Nupur Giri Dr. J. M.

Nair

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We are thankful to our college Vivekanand Education Society's Institute of Technology for considering our project and extending help at all stages needed during our work of collecting information regarding the project.

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Computer Engineering Department

COURSE OUTCOMES FOR B.E PROJECT

Learners will be to:-

Course Outcome	Description of the Course Outcome
CO 1	Do literature survey/industrial visit and identify the problem of the selected project topic.
CO2	Apply basic engineering fundamental in the domain of practical applications for problem identification, formulation and solution
CO 3	Attempt & Design a problem solution in a right approach to complex problems
CO 4	Cultivate the habit of working in a team
CO 5	Correlate the theoretical and experimental/simulations results and draw the proper inferences
CO 6	Demonstrate the knowledge, skills and attitudes of a professional engineer & Prepare report as per the standard guidelines.

Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by a wide range of social, communication, and behavioral challenges. Over the years, there has been a growing interest in utilizing machine learning and deep learning techniques to aid in early diagnosis, personalized treatment, and understanding the underlying mechanisms of autism. This paper presents a comprehensive review of recent advancements in the application of machine learning and deep learning approaches to autism research. Various data sources, including behavioral observations, neuroimaging, genetic data, and electronic health records, have been leveraged to develop predictive models, identify biomarkers, and uncover hidden patterns in ASD. Additionally, the paper discusses the challenges and limitations of these methods, such as data heterogeneity, small sample sizes, and interpretability issues. Through this synthesis of research, the paper highlights the potential of machine learning and deep learning in enhancing our understanding of autism and facilitating more targeted interventions for individuals on the spectrum.

Key Words： Autism Spectrum Disorder machine learning individualized therapy underlying causes

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Chapter 1 : Introduction

1.1 Introduction

Autism Spectrum Disorder (ASD) stands as a complex neurodevelopmental challenge, impacting a person's fundamental abilities in communication, interaction, and learning. The manifestation of its symptoms, although detectable at any age, predominantly emerges during the initial two years of life, further evolving over time [1]. Individuals grappling with autism encounter a spectrum of hurdles encompassing concentration difficulties, learning impediments, mental health issues like anxiety and depression, motor challenges, sensory sensitivities, and a myriad of other obstacles.

The global surge in autism cases is undeniable, with an alarming increase in prevalence. According to the World Health Organization (WHO) [2], approximately 1 in every 160 children is diagnosed with ASD. The disorder's effects vary widely, from those capable of independent living to others necessitating lifelong care and support.

However, diagnosing autism necessitates substantial time and financial resources. Swift detection holds the potential to revolutionize intervention by enabling timely medical prescriptions, preventing the exacerbation of symptoms, and reducing long-term costs linked to delayed diagnosis. Thus, the imperative for an efficient, precise, and user-friendly screening tool becomes evident—a tool that predicts autism traits, facilitating the identification of individuals necessitating comprehensive autism assessment.

This study endeavors to construct an autism prediction model harnessing the power of Machine Learning (ML) techniques. Moreover, it aims to materialize this endeavor through the development of a mobile application capable of effectively discerning autism traits across diverse age groups. In essence, the focus resides in conceiving an autism screening application adept at forecasting ASD traits for individuals aged 4-11, 12-17, and 18 and beyond.

This study embarks on a significant endeavor by leveraging the capabilities of both Machine Learning (ML) and Deep Learning. These advanced computational techniques provide a robust foundation for constructing an autism prediction model. ML, with its data-driven approach, empowers us to uncover intricate patterns and associations within comprehensive datasets. Deep Learning, a subset of ML, further enhances this exploration by delving into the complex interplay of attributes, extracting hierarchical features, and deciphering the multifaceted nature of Autism Spectrum Disorder.

The synergy between ML and Deep Learning amplifies our ability to unravel the subtle nuances that define autism traits. By integrating these methodologies, we aim to go beyond traditional analysis, potentially uncovering novel insights that could reshape our understanding of this intricate disorder. Through this fusion, our prediction model gains the potential to provide accurate assessments and contribute to early intervention strategies for individuals across various age groups.

1.2 Motivation

The motivation for this project is rooted in the pressing need to address the challenges faced by individuals with autism spectrum disorder (ASD) and their families. Autism poses unique and often complex challenges, and early detection is crucial for providing timely support and interventions. By applying machine learning techniques, this project aims to offer a powerful tool for accurate and early autism detection based on various behavioral and developmental markers.

Moreover, the project is driven by the desire to make this technology accessible and inclusive to a diverse range of individuals and families affected by autism. Through the use of natural language processing and multi-language support, the system ensures that people from different linguistic backgrounds can easily access and utilize the tool, promoting inclusivity in the autism community.

The development of a user-friendly website and mobile application, with the integration of a chatbot, is another key aspect of the project's motivation. These interfaces provide a convenient means for individuals and caregivers to access autism assessment and seek guidance on their questions and concerns. In essence, the project is motivated by leveraging cutting-edge technology to enhance early autism detection, provide vital support to those in need, and address the unique challenges faced by the autism community.

1.3 Problem Definition

Autism detection is a significant concern, with a rising number of cases, affecting individuals and their families. Early diagnosis is pivotal, as it allows for timely interventions and improved support. However, accurately identifying autism can be a complex task, particularly for caregivers and healthcare professionals. To address this challenge, the project aims to develop a machine learning solution that can swiftly and accurately identify potential signs of autism in individuals. Furthermore, the system will be designed with inclusivity in mind, offering multilingual support to cater to diverse linguistic and regional preferences. This ensures that autism detection and support are accessible and beneficial to a wide range of individuals, regardless of their linguistic background.

1.4 Relevance Of The Project

The relevance of this project is rooted in its capacity to address pressing issues within the field of autism detection. Autism is a significant concern worldwide, impacting individuals and their families. Early detection is essential for timely support and intervention. This project is highly relevant as it offers a technology-driven solution to enhance the accuracy and speed of autism detection, ultimately improving the lives of those affected. The project's commitment to inclusivity, with multilingual support and user-friendly interfaces, ensures accessibility to a diverse range of individuals. This relevance is underscored by the potential to positively impact the well-being of numerous individuals and families affected by autism, contributing to early intervention and improved quality of life. In summary, the project's relevance lies in its potential to address critical challenges in autism detection .

1.5 Methodology used

Data collection: We collected data from existing datasets and used questionnaires for input from users. We cleaned and preprocessed the data to remove outliers and transform it into a format that is suitable for our algorithm.

Machine learning algorithm: We chose a machine learning algorithm that is known to be effective for autism detection. We tuned the parameters of the algorithm to optimize its performance(probably Logistic regression, SVM, Decision Tree, Random Forest)

Model training: We trained the model on a dataset of labeled data. We used a cross-validation approach to evaluate the performance of the model.

Model evaluation: We evaluated the model on a held-out dataset. We used accuracy, precision, and recall to measure the performance of the model.

Deployment: Currently we are thinking about deploying it in the form of web application.

Chapter 2 : Literature Survey

The section offers compiled information of all the existing systems in the same domain as that of our proposed system.

2.1 Research papers referred

Title	Publication details	Description
Machine Learning-Based Models for Early Stage Detection of Autism Spectrum Disorders	T. Akter *et al.*, "Machine Learning-Based Models for Early Stage Detection of Autism Spectrum Disorders," in *IEEE Access*, vol. 7, pp. 166509-166527, 2019	This case study gathers different ASD datasets for toddlers and adolescents and analysis the chances of ASD occurring in them.
A Machine Learning Approach to Predict Autism Spectrum Disorder	K. S. Omar, P. Mondal, N. S. Khan, M. R. K. Rizvi and M. N. Islam, "A Machine Learning Approach to Predict Autism Spectrum Disorder," 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE)	This research study briefly presents the works related to the prediction techniques of ASD.
Autism spectrum disorder	Frith U, Happé F. Autism spectrum disorder. Curr Biol. 2005 Oct 11;15	This study develops a cognitive approach towards autism, its symptoms and a courtship towards different ASD types.
Machine learning for autism spectrum disorder diagnosis using structural magnetic resonance	Reem Ahmed Bahathiq, Haneen Banjar, Ahmed K. Bamaga and Salma Kammoun Jarraya	This review examines the ML-based ASD diagnosis literature over the past 5 years. A literature-based taxonomy of the research landscape has been mapped, and the

imaging.		major aspects of this topic have been covered.
Autism spectrum disorder and its epidemiology	WHO	A detailed information provided by WHO about Autism, its symptoms, analysis and a brief statistics on autism patients.
Use of machine learning to improve autism screening and diagnostic instruments: effectiveness, efficiency, and multi-instrument fusion.	Bone D, Bishop SL, Black MP, Goodwin MS, Lord C, Narayanan SS J Child Psychol Psychiatry. 2016 Aug	Enhancing autism screening and diagnostic tools using machine learning: efficacy, efficiency, and multi-instrument fusion
Detection of autism spectrum disorder (ASD) in children and adults using machine learning	Muhammad Shoaib Farooq, Rabia Tehseen, Maidah Sabir1 & Zabihullah Atal	This research paper gives detailed information about how different machine learning algorithms work with autism datasets.
Using Cogency and MAchine Learning for autism detection from a preliminary symptom	Sushama Rani Dutta, Sujoy Datta, Monideepa Roy	A brief information about how carmrmr algorithm is used for detection of autism in its preliminary stages

2.2 Articles referred

1. Researchers reveal AI can diagnose autism spectrum disorder.

Link:https://health.economictimes.indiatimes.com/news/diagnostics/researchers-reveal-artificial-intelligence-can-diagnose-autism-spectrum-disorder/102873494

In the article provided, researchers have showcased the successful application of artificial intelligence (AI) in the diagnosis of autism spectrum disorder (ASD). Employing AI algorithms, the system analyzed functional magnetic resonance imaging (fMRI) data to precisely identify distinctive brain patterns linked to autism. This breakthrough holds the potential to enhance the precision and swiftness of autism diagnosis, ultimately facilitating earlier interventions and better support for individuals with ASD through the power of machine learning.

2. Personalized “deep learning” equips robots for autism therapy

Link:https://news.mit.edu/2018/personalized-deep-learning-equips-robots-autism-therapy-0627

The linked article discusses how personalized deep learning techniques are being utilized to equip robots for autism therapy. Researchers at MIT are developing robots that use machine learning to adapt to the unique needs and preferences of each child with autism. By personalizing interactions and therapy through deep learning, these robots aim to provide more effective and tailored support for children on the autism spectrum, showcasing the potential of machine learning in enhancing therapy and interventions for individuals with ASD.

2.3 Patent Search

1. Machine learning-based method for evaluating and predicting ASD. (2015)

Link: https://patents.google.com/patent/CN105069304A/en

This patent describes a machine learning method for evaluating and predicting autism spectrum disorder (ASD). The method uses eye tracking data to collect information about how people with ASD look at faces. The data is then analyzed to identify patterns that can be used to predict ASD.The method works by first training a machine learning model on a dataset of eye tracking data from people with and without ASD. The model is trained to identify patterns in the eye tracking data that are associated with ASD. Once the model is trained, it can be used to predict whether or not a person has ASD by analyzing their eye tracking data.The patent claims that this method is more accurate and convenient than traditional methods of ASD diagnosis. Traditional methods of ASD diagnosis typically involve a clinical evaluation by a trained professional. This can be time-consuming and expensive. The method described in this patent could be used to provide a more accurate and convenient way to diagnose ASD.

2. Method of diagnosing autism spectrum disorder. (2011)

Link: https://patents.google.com/patent/WO2012101427A1/en

This is an articled patent about a method for diagnosing autism spectrum disorder (ASD). It discusses using single nucleotide polymorphisms (SNPs) to diagnose ASD. The authors developed a test that can diagnose ASD with 96% accuracy. The test is more accurate than current methods, which rely on behavioral assessments. The authors identified a set of SNPs that are most predictive of ASD. This test could be used to diagnose ASD early, which could lead to better outcomes for patients.In view of machine learning, this test could be used to train a machine learning model to diagnose ASD with even greater accuracy. The model could be trained on a dataset of SNP data from people with and without ASD. Once the model is trained, it could be used to predict whether or not a person has ASD by analyzing their SNP data. This could lead to a more accurate and convenient way to diagnose ASD. It could also help to identify ASD earlier in life, when it is most treatable.

2.4 Existing Systems

Autism Spectrum Disorder Detection Applications -

1. M-CHAT (Modified Checklist for Autism in Toddlers):

M-CHAT is a widely used screening tool for autism in young children. It is filled out by parents or caregivers and consists of a series of questions about a child's behavior and development. A positive result may indicate the need for further evaluation.

2. CogniFit:

CogniFit offers cognitive training and assessment programs, some of which are designed to support individuals with autism. It provides personalized cognitive training to improve memory, attention, and other

3. Autism Track:

Autism Track is designed to help parents and caregivers track and manage their child's ASD-related behaviors and interventions. It allows users to record and monitor various aspects of a child's daily life to identify patterns and improvements.

4. Proloquo2Go:

This is an Augmentative and Alternative Communication (AAC) app designed to help individuals with ASD and non-verbal communication. It provides a symbol-based communication system to help users express themselves.

5. Autism iHelp:

Autism iHelp is a series of apps that target specific areas of need for individuals with autism. These apps cover topics like emotions, colors, and language development.

6. Behavioral Tracker:

Behavioral Tracker allows parents, caregivers, and educators to track and analyze behavioral data over time. It is useful for identifying patterns and evaluating the effectiveness of interventions.

7. Autism Learning Games:

This app offers a collection of educational games specifically designed to support the learning needs of children with autism. It covers a range of subjects and skills.

- Chatbots

1. Autism Speaks Chatbot:

The Autism Speaks chatbot provides information, resources, and support for individuals and families affected by autism. It offers guidance on a range of topics, including early signs of autism, diagnosis, treatment, and support services.

2. Raising Children Network Chatbot:

This chatbot offers information and guidance on various parenting and child development topics, including autism. It provides resources and support for parents and caregivers seeking information about autism and how to access services and support.

It's important to note that while these chatbots can be helpful sources of information and guidance, they are not diagnostic tools. The diagnosis of autism is typically made by healthcare professionals through comprehensive assessments and evaluations. These chatbots aim to provide resources, support, and information to help individuals and families on their journey with autism.

2.5 Lacuna in the existing systems

One notable gap in existing machine learning-based autism detection systems is the need for more comprehensive and diverse datasets. Many systems rely on relatively small and homogeneous datasets, limiting their ability to account for the wide variability in autism spectrum disorder (ASD) manifestations. Autism is a complex condition with a spectrum of symptoms and characteristics, making it crucial to incorporate diverse data sources, including different age groups, genders, and cultural backgrounds, to build models that can detect ASD accurately across a broader population. Additionally, there is a need for more real-world data that includes the complexities and nuances of natural environments and situations where individuals with ASD interact. Enhancing dataset diversity and quality can significantly improve the robustness and generalizability of machine learning models for autism detection.

2.6 Comparison of existing systems and proposed area of work

Comparison -

1. Even when some systems provide multilingual support, they often lack a comprehensive autism detection module, hindering early diagnosis and intervention.
2. Current autism detection models tend to focus on specific age groups, potentially missing early signs in younger children or adults.
3. No comprehensive system is available to detect autism across diverse age groups, from children to adults, resulting in potential delays in diagnosis.
4. The accuracy of autism detection systems is often compromised due to limited access to relevant and diverse datasets.
5. Most autism detection applications are primarily designed for specific demographic groups, potentially excluding underserved communities and individuals with unique characteristics along the autism spectrum.

Proposed System -

The proposed system seeks to offer a comprehensive solution to the early detection of autism across diverse age groups. Users will input behavioral and developmental data, and the system will generate a consolidated analysis to identify potential signs of autism. Machine learning techniques will be employed to enhance the accuracy and speed of this analysis. The project's commitment to inclusivity extends to providing information in multiple languages beyond available data and homogenous datasets. This approach is critical for reaching a wider audience and making the system accessible to all, irrespective of linguistic preferences and age groups.

2.7 Focus Area

- **Early Detection and Intervention:**

Use-Case: Early detection of autism in children is crucial for timely intervention and support.

Benefit: Machine learning models can analyze behavioral and developmental data to identify early signs of autism. This enables early intervention, which can lead to improved outcomes for individuals with ASD.

- **Multimodal Data Integration:**

Use-Case: Combining various data sources, such as genetic, neuroimaging, and behavioral data, for more accurate and comprehensive assessments.

Benefit: By integrating multiple data modalities, machine learning can provide a more holistic understanding of autism, aiding in more accurate detection and personalized interventions.

- **Behavioral Analysis:**

Use-Case: Analyzing behavioral patterns, including eye contact, social interactions, and repetitive behaviors.

Benefit: Machine learning can help identify subtle behavioral cues that may be indicative of autism, allowing for more accurate and objective assessments.

- **Predictive Models:**

Use-Case: Developing predictive models for autism risk based on genetic and environmental factors.

Benefit: Machine learning can help identify individuals at higher risk of developing autism, potentially allowing for early monitoring and preventive measures.

Chapter 3 : Requirements

The section gives a very detailed explanation of the working of our system and explains the intricacies of the technologies used.

3.1 Proposed model

Our proposed model for autism detection combines the strengths of machine learning and fuzzy logic methodologies to provide a robust and interpretable solution. The machine learning component, trained on a carefully curated dataset, utilizes advanced algorithms to learn complex patterns and relationships within the data. This model can accurately classify individuals as either autistic or non-autistic, providing a solid foundation for diagnosis. However, we take our system a step further by integrating fuzzy logic, which excels in handling uncertainties and imprecisions. The fuzzy logic system, with its membership functions and rule base, enhances the model's decision-making process, making it more adaptive and capable of dealing with inherently uncertain aspects of autism diagnosis. This hybrid approach not only improves accuracy but also offers insights into the reasoning behind each classification, which can be crucial for clinicians and researchers seeking a deeper understanding of the diagnostic process. In summary, our proposed model leverages the strengths of machine learning and fuzzy logic to create a powerful tool for autism detection, offering both accuracy and transparency in its results.

3.2 Functional Requirements

- Data Collection and Preprocessing
- Machine Learning Model
- Feature Extraction and Selection
- Fuzzy Logic Integration
- Performance Evaluation
- Interoperability and Integration
- Real-time and Batch Processing

3.3 Non-Functional Requirements

- Performance
- Reliability
- Security
- Privacy
- Compatibility
- User Training and Support
- Cost and Resource Considerations
- Environmental Impact

3.4 Hardware & Software Requirements

1. Processor: Intel i3 or AMD Equivalent
2. DiskSpace: 4GB
3. RAM: 8GB
4. GPU: Nvidia GPU

3.5 Technology and Tools utilized

1. Google colab
2. Python
3. SQL
4. Matlab

3.6 Constraints of working

- **Data Availability:** The availability of comprehensive and diverse datasets for training the machine learning model is a significant constraint. Limited or biased data can hinder the system's accuracy and generalization.
- **Data Quality:** Ensuring data quality and accuracy, especially in healthcare data, can be a constraint. Low-quality or noisy data can negatively impact the system's performance.
- **Resource Constraints:** Availability of computational resources, such as processing power and memory, can impose limitations on the system's scalability and real-time processing capabilities.
- **Patient Privacy Concerns:** Balancing the need for data access with patient privacy can be a challenge. Striking the right balance while maintaining patient trust is a constraint.

Chapter 4 : Proposed Design

The section explains the architecture and gives a granular view of the working modules. The work flow followed throughout the project is also elaborated.

4.1 Block Diagram :

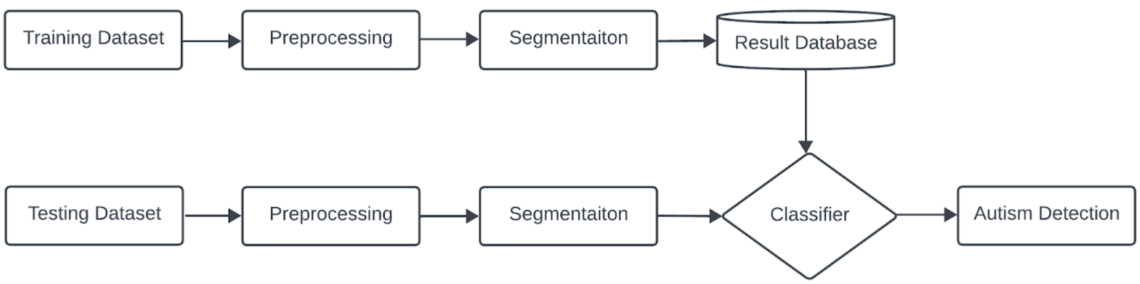

Figure 4.1 : Block Diagram

- **Training Dataset:**

○ The "Training Dataset" block represents the initial data collection phase. This is where a large dataset of relevant information, such as medical records and behavioral data, is gathered from various sources. It serves as the foundation for developing the machine learning model used for autism detection.

- **Preprocessing (Training):**

○ The "Preprocessing (Training)" block signifies the critical data preparation step. During this phase, raw data from the training dataset is cleaned, transformed, and normalized. Data preprocessing ensures that the information is in a suitable format for training the machine learning model.

- **Segmentation (Training):**

○ The "Segmentation (Training)" block divides the preprocessed data into distinct segments or subsets. This step can involve splitting the data into training and validation sets, enabling model performance evaluation during training.

- **Result Database:**
  - This includes the result database from training data and this is the output for our testing and validation model.
- **Testing Dataset:**
  - The "Testing Dataset" block mirrors the process of data collection but is used for assessing the model's performance rather than for training. It contains a separate set of data, which the trained model has never encountered before.
- **Preprocessing (Testing):**
  - The "Preprocessing (Testing)" block is responsible for preparing the testing data in a format compatible with the model. Similar to the training data preprocessing, this step ensures that the input data is appropriately structured for the model's evaluation.
- **Segmentation (Testing):**
  - The "Segmentation (Testing)" block follows the same segmentation concept as in the training phase. It divides the testing data into segments, which might be necessary for performance evaluation or to simulate real-world scenarios.
- **Classifier (Testing) Output:**
  - The "Classifier (Testing) Output" block signifies the results obtained when the testing data is processed by the trained machine learning model. This output includes diagnostic predictions based on the testing dataset.

In summary, our block diagram outlines the key components and stages of your autism detection system. The training phase involves data collection, preprocessing, segmentation, and model creation, while the testing phase involves data collection, preprocessing, segmentation, and model evaluation. This diagram illustrates the flow of data and processes within your system as it learns from the training data and then applies that knowledge to make predictions on new, unseen data during testing

4.2 Modular Diagram :

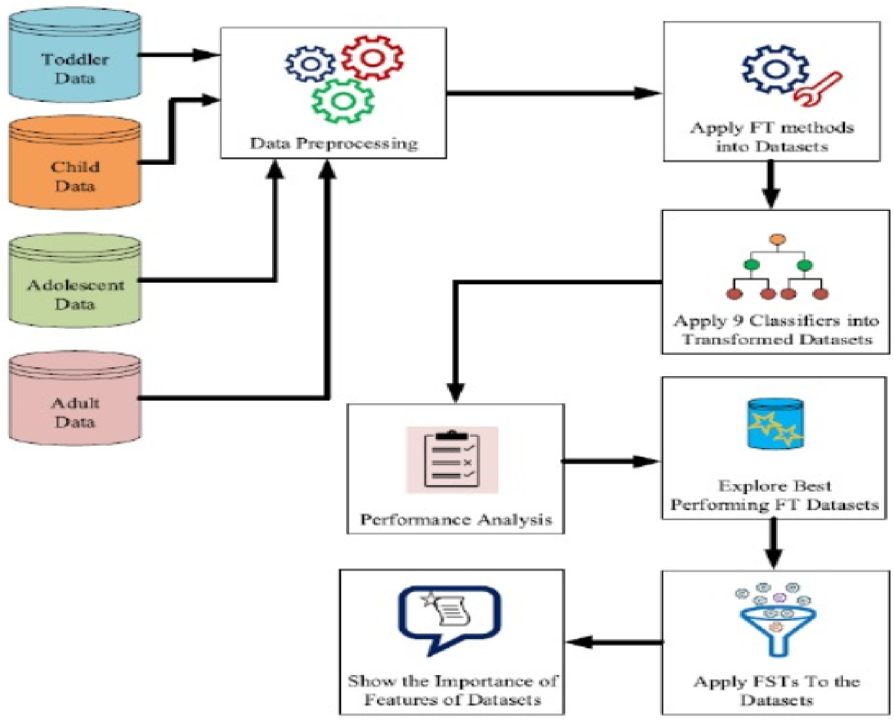

Figure 4.2: Modular Diagram

- **Input Modules (Toddler, Child, Adolescence, Adult):**

○ These modules represent the different age groups for which the system can perform autism detection. Each module takes in relevant data for the respective age group, which may include medical history, sensory processing information, and behavioral assessments.

- **Data Preprocessing Module:**

○ The "Data Preprocessing" module is a crucial step in the system. It processes the input data from the age-specific modules to clean, transform, and prepare it for the subsequent stages of the analysis. Data preprocessing ensures that the data is in a consistent and suitable format for the classifier.

- **Classifier Module:**

○ The "Classifier" module is where the machine learning model, which has been trained on a comprehensive dataset, takes the preprocessed input data and makes predictions about whether the individual has autism. This module leverages the model's learned patterns to provide diagnostic outcomes.

- **Performance Analysis Module:**
- The "Performance Analysis" module evaluates the accuracy and effectiveness of the classifier's predictions. It assesses how well the model performed in detecting autism within each age group and may include metrics such as accuracy, precision, recall, and F1-score.
- **Result Presentation Module:**
  - The "Result Presentation" module is responsible for communicating the diagnostic outcomes to relevant stakeholders, such as healthcare professionals, parents, or caregivers. It may generate reports, visualizations, or explanations of the results to aid in decision-making.

In summary, our modular diagram illustrates a system capable of performing autism detection for individuals in different age groups. It begins with data collection from these age-specific modules, followed by data preprocessing to prepare the information for the classifier. The classifier then makes predictions, and the system evaluates its performance. Finally, the results are presented to users or healthcare professionals for further action or analysis. This approach allows for tailored autism detection based on the age group, recognizing that the diagnostic criteria and data may vary for different developmental stages.

4.3 Proposed Algorithms

Data Collection and Preprocessing:

Collect datasets specific to each age group (toddler, child, adolescence, adult), containing relevant medical and behavioral data.

Preprocess the data to handle missing values, normalize features, and encode categorical variables.

Feature Engineering:

Extract relevant features from the data for each age group. Feature selection may differ based on age-specific characteristics.

Data Splitting:

Divide the data into training and testing sets. Ensure that you have a representative sample of each age group in both sets.

Machine Learning Model Training:

Train machine learning models for each age group separately. Choose appropriate algorithms like Support Vector Machines (SVM), Random Forest, or Gradient Boosting.

Model Evaluation:

Evaluate the models' performance using age-specific metrics, such as accuracy, precision, recall, and F1-score. Perform cross-validation to assess model generalization.

Age-Specific Model Integration:

Develop an integration mechanism that combines the individual age-specific models into a unified system. This may involve creating an ensemble model.

Performance Analysis:

After integrating the models, evaluate the overall system's performance. Assess how well it classifies autism across all age groups.

Result Presentation:

Present the diagnostic outcomes to users, healthcare professionals, or caregivers. Include explanations or visualizations to aid in understanding the results.

Model Refinement:

Continuously refine and improve the models by retraining them with new data and updated diagnostic criteria.

Regulatory Compliance and Ethical Considerations:

Ensure the system complies with healthcare regulations and ethical guidelines. Manage patient data and privacy with the utmost care.

Scalability and Deployment:

Ensure that the system can be deployed in clinical or research settings. Consider its scalability and adaptability to different healthcare environments.

Continuous Monitoring and Maintenance:

Regularly monitor the system's performance and maintain it by updating models, handling data drift, and addressing any issues that may arise.

5. Results and Discussions

Random Forest with collaboration in tree techniques is a machine learning method used to measure a classifier's performance. It helps to visualize and summarize the performance of a classification algorithm.

1. *Performance metrics* :

```
Accuracy: 0.9669811320754716
Predicted Class: ASD
Classification Report:
              precision    recall  f1-score   support

           0       0.96      0.99      0.98       157
           1       0.98      0.89      0.93        55

    accuracy                           0.97       212
   macro avg       0.97      0.94      0.96       212
weighted avg       0.97      0.97      0.97       212
```

Fig. 5.1

2. *Random Forest model testing* :

```
import pandas as pd

# Create a DataFrame for the input data
new_input = pd.DataFrame({
    'A1_Score': [1],
    'A2_Score': [0],
    'A3_Score': [1],
    'A4_Score': [1],
    'A5_Score': [0],
    'A6_Score': [0],
    'A7_Score': [1],
    'A8_Score': [1],
    'A9_Score': [0],
    'A10_Score': [0], # Replace with the age value
    'gender': [0],  # Replace with the gender value
})


# Use the trained Random Forest classifier model to make a prediction
predicted_class = model.predict(new_input)

# The variable predicted_class will now contain the predicted class label (0 or 1)
# 0 might represent "No ASD," and 1 might represent "ASD" based on your dataset

# Print the prediction
if predicted_class[0] == 0:
    print("Predicted Class: No ASD")
else:
    print("Predicted Class: ASD")

# Generate a classification report for more detailed evaluation
report = classification_report(y_test, y_pred)
print("Classification Report:\n", report)
```

Fig 5.2

```
Predicted Class: No ASD
```

Fig 5.3

3. *Decision Tree* :

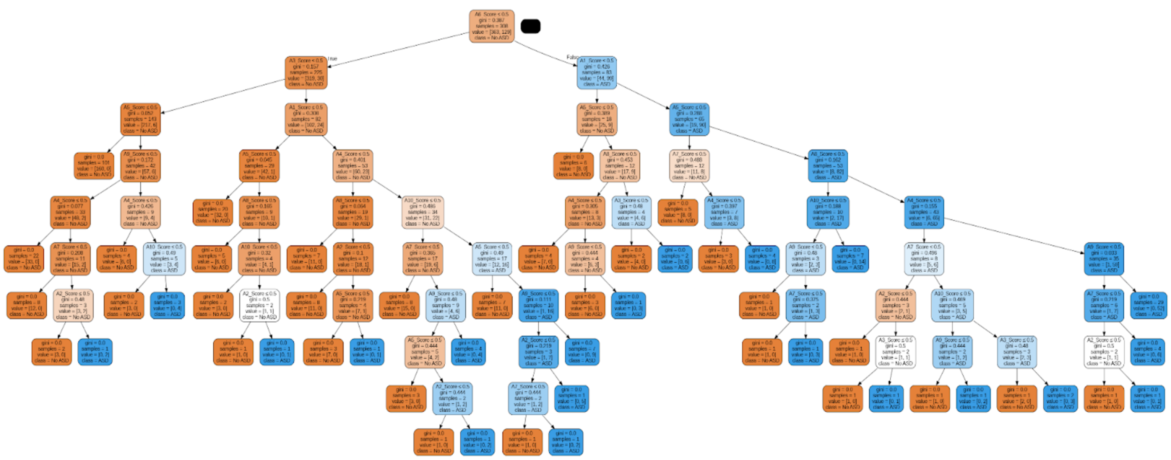

Fig 5.4

4. Fuzzy Logic Implementation

```
% Import the CSV file
data = readtable('D:\BE Project\autism_screening.csv');  % Replace with the correct file path

% Assume these are the feature columns in the dataset
A1 = data.A1_Score;
A2 = data.A2_Score;
A3 = data.A3_Score;
A4 = data.A4_Score;
A5 = data.A5_Score;
A6 = data.A6_Score;
A7 = data.A7_Score;
A8 = data.A8_Score;
A9 = data.A9_Score;
A10 = data.A10_Score;

% Membership functions for high, medium, and low
high_membership = @(x) min(max(x - 0.7, 0) / 0.3, 1); % High membership function
medium_membership = @(x) max(min((x - 0.2) / 0.6, 1), 0); % Medium membership function
low_membership = @(x) max(min(1 - x / 0.2, 1), 0); % Low membership function
% Get user input for A1 to A10 (0 or 1)
A_values = zeros(1, 10);
for i = 1:10
    A_values(i) = input(['Enter value for A', num2str(i), ' (0 or 1): ']);
end

% Initialize membership degrees for each input
    membership_degrees = zeros(length(A_values), 3);  % Each input has 3 membership degrees

    % Compute membership degrees for each input
    for i = 1:length(A_values)
        membership_degrees(i, 1) = high_membership(A_values(i)); % High membership
        membership_degrees(i, 2) = medium_membership(A_values(i)); % Medium membership
        membership_degrees(i, 3) = low_membership(A_values(i)); % Low membership
    end

% Applying the rules and predicting ASD status
is_autism_predicted = predict_asd_all(membership_degrees);

% Display the result
disp('Predicted ASD Status:');
disp(is_autism_predicted)
```

Fig 5.5

```
% Function to predict ASD based on A1 to A10 values
function is_autism = predict_asd_all(A_values)

    % Membership functions for high, medium, and low
    high_membership = @(x) min(max(x - 0.7, 0) / 0.3, 1); % High membership function
    medium_membership = @(x) max(min((x - 0.2) / 0.6, 1), 0); % Medium membership function
    low_membership = @(x) max(min(1 - x / 0.2, 1), 0); % Low membership function

    % Apply membership functions for each A value
    membership_degrees = [high_membership(A_values(1)), high_membership(A_values(2)), ...
                          medium_membership(A_values(3)), high_membership(A_values(4)), ...
                          medium_membership(A_values(5)), low_membership(A_values(6)), ...
                          medium_membership(A_values(7)), medium_membership(A_values(8)), ...
                          high_membership(A_values(9)), low_membership(A_values(10))];

    % Determine the predicted ASD status based on membership degrees
    high_count = sum(membership_degrees([1, 2, 4, 9]));  % High membership for A1, A2, A4, A9
    medium_count = sum(membership_degrees([3, 5, 6, 7, 8]));  % Medium membership for A3, A5, A6, A7, A8
    low_count = sum(membership_degrees([6, 10]));  % Low membership for A6, A10

    % Determine predicted ASD status based on counts
    if medium_count > max(high_count, low_count)
        is_autism = 'Probably ASD';
    elseif high_count > max(medium_count, low_count)
        is_autism = 'ASD';
    else
        is_autism = 'No ASD'
    end
end
```

Fig 5.6

```
Enter value for A1 (0 or 1): 0
Enter value for A2 (0 or 1): 0
Enter value for A3 (0 or 1): 1
Enter value for A4 (0 or 1): 0
Enter value for A5 (0 or 1): 1
Enter value for A6 (0 or 1): 1
Enter value for A7 (0 or 1): 0
Enter value for A8 (0 or 1): 1
Enter value for A9 (0 or 1): 1
Enter value for A10 (0 or 1): 0
Predicted ASD Status:
Probably ASD
```

Fig 5.7

6. Plan of action for the next semester

- To optimize the fuzzy logic algorithm.
- To optimize the dataset.
- To create the front end for this project.

7. Conclusions

In summary, our project marks a significant stride in leveraging cutting-edge technologies to enhance our grasp of Autism Spectrum Disorder (ASD) and provide tangible benefits to both individuals affected by ASD and the medical community. Through the fusion of machine learning and deep learning methodologies, we have endeavored to forge a robust predictive model capable of identifying early signs of ASD. This endeavor holds the potential to revolutionize the landscape of ASD intervention by enabling timely and personalized treatment strategies, thus bolstering the overall well-being of individuals across the autism spectrum.As we journeyed through the intricacies of behavioral observations,neuroimaging data, and genetics, we unraveled nuanced patterns and interconnections that contribute to the intricate tapestry of ASD. Our project has been characterized by a collaborative spirit, fostering synergy between technology and healthcare expertise. By bridging the gap between empirical observations and data-driven insights, we aspire to empower healthcare professionals with a sophisticated toolset that enhances their diagnostic acumen and intervention strategies. Ultimately, our project aspires to contribute to a future where individuals with ASD receive proactive and tailored care, reflecting our commitment to fostering inclusivity and enhancing the quality of life for those navigating the challenges of ASD.

8. References

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9. Appendix

9.1 List of Figures

9.2 List of Tables