विश्वं शास्त्रे प्रतिष्ठितम्।

PROJECT REPORT

On

NEURO NURTURER

Submitted in partial fulfilment for the award of degree

of

Master of Computer Applications

By

PARVATHY B LAL

MLM23MCA-2036

Under the Guidance of

MS. DIVYA S.B

(HOD & Associate Professor, Dept. of Computer Applications)

DEPARTMENT OF COMPUTER APPLICATIONS

MANGALAM COLLEGE OF ENGINEERING, ETTUMANOOR

(Affiliated to APJ Abdul Kalam Technological University)

NOVEMBER 2024

VISION

To become a centre of excellence in computer applications,competent in the global ecosystem with technical knowledge,innovation with a sense of social commitment.

MISSION

- To serve with state of the art ducation,foster advanced research and cultivate innovation in the field of computer applications.
- To prepare learners with knowledge skills and critical thinking to excel in the technological landscape and contribute positively to society.

Program Educational Objectives

- PEO I :Graduates will possess a solid foundation and in-depth understanding of computer applications and will be equipped to analyze real-world problems, design and create innovative solutions, and effectively man ge and maintain these solutions in their professional careers.
- PEO II: Graduates will acquire technological advancements through continued education,s lifelong learning and research, thereby making meaningful contribution to the field of computing.
- PEO III: Graduates will cultivate team spirit, leadership, communication skills, ethics, and social values, enabling them to a ply their understanding of the societal impacts of computer applications effectively.

Program Specific Outcomes

- **PSO I**: Apply advanced technologies through innovations to enhance the efficiency of design development.
- **PSO II**: Apply the principles of computing to analyze, design and implement s stainable solutions for real world challenges.

MANGALAM COLLEGE OF ENGINEERING, ETTUMANOOR

DEPARTMENT OF COMPUTER APPLICATIONS

APRIL 2025

CERTIFICATE

*This is to certify that the Project titled **"Neuro Nurturer"** is the bonafide record of the work done by **Parvathy B Lal (MLM23MCA-2036**) of Masters of Computer Applications towards the partial fulfilment of the requirement for the award of the **DEGREE OF MASTERS OF COMPUTER APPLICATIONS by APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**, during the academic year 2023-25.*

Project Guide
Ms. Divya S.B
Associate Professor
Dept. of Computer Applications

Head of the Department
Ms. Divya S.B
Associate Professor
Dept.of Computer Applications

Project Coordinator
Ms. Banu Sumayya S
Assistant Professor
Dept. of Computer Application

External Examiner

ACKNOWLEDGEMENT

I am greatly in debted to the authorities of Mangalam College of Engineering for providing the necessary facilities to successfully complete my Project on the topic “Neuro Nurturer”.

I express my sincere thanks to **Dr. Vinodh P Vijayan**, Principal, Mangalam College of Engineering for providing the facilities to complete my Project successfully.

I thank and express my solicit gratitude to **Ms. Divya S.B.,** HOD, Department of Computer Applications, Mangalam College of Engineering, for their invaluable help and support which helped me a lot in successfully completing this Project work.

I express my gratitude to my Project Co-ordinator, **Ms. Banu Sumayya S**, Assistant professor, Department of Computer Applications for the suggestions and encouragement which helped in the successful completion of our Project.

I express my gratitude to my Internal Guide, **Ms. Divya S.B.,** HOD, Department of Computer Applications for the suggestions and encouragement which helped in the successful completion of our Project.

Finally, I would like to express my heartfelt thanks to my parents who were very supportive mentally and for their encouragement to achieve my goal.

PARVATHY B LAL

(MLM23MCA-2036)

ABSTRACT

Early detection of Autism Spectrum Disorder (ASD) plays a vital role in ensuring timely intervention and support. However, traditional diagnostic methods are often time-intensive, subjective, and not easily accessible. This study introduces a novel ASD screening system that utilizes deep learning and machine learning techniques to enhance detection accuracy and accessibility. The system incorporates a dual assessment approach: users can either upload a facial image for analysis using a Convolutional Neural Network (CNN) model based on VGG19 with transfer learning or complete a multiple-choice questionnaire (MCQ), which is evaluated using a Random Forest classifier. Transfer learning enhances the CNN model's ability to recognize distinct facial patterns linked to ASD, while the questionnaire provides an objective assessment of behavioral traits associated with the condition.

Beyond diagnosis, the system integrates interactive learning modules tailored for children with ASD. These modules include letter and number recognition activities, fundamental arithmetic exercises, reading and listening tasks, and curated video content designed to promote cognitive development, creativity, and social engagement. By leveraging deep learning for facial analysis and machine learning for behavioral evaluation, this system offers a comprehensive and accessible ASD screening solution. Performance evaluations indicate that this approach improves diagnostic accuracy, reduces screening time, and enhances accessibility, making it a valuable tool for families, caregivers, and healthcare professionals.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABBREVIATION		FULL FORM
ASD	-	Autism Spectrum Disorder
AI	-	Artificial Intelligence
DFD	-	Data Flow Diagram
UI	-	User Interface
DL	-	Deep Learning
ML	-	Machine Learning
CNN	-	Convolutional Neural Network
AQ	-	Autism Spectrum Quotient
KNN	-	K-nearest Neighbors
SVM	-	Support Vector Machine
ANN	-	Artificial Neural Network
UML	-	Unified Modeling Language
NLP	-	Natural Language Processing

CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by difficulties in social communication, restricted interests, and repetitive behaviors. The severity of symptoms varies among individuals, making early detection critical for timely intervention. Studies show that early diagnosis and intervention significantly enhance cognitive, emotional, and social development, helping children build essential life skills. However, traditional ASD diagnostic methods, such as behavioral observations and standardized clinical assessments, often suffer from subjectivity, time constraints, and accessibility issues. Many families face long waiting times for evaluations, particularly in regions with limited healthcare infrastructure or a shortage of specialized professionals.

With advancements in artificial intelligence (AI) and machine learning, automated screening methods are gaining attention as a potential solution to the challenges associated with ASD diagnosis. Deep learning models, particularly Convolutional Neural Networks (CNNs), have demonstrated success in analyzing complex patterns in images, making them useful for facial recognition-based ASD screening. Research indicates that individuals with ASD exhibit subtle but distinguishable facial morphological patterns, which AI-powered models can detect with high precision. Additionally, machine learning techniques such as Random Forest classifiers can be employed to analyze behavioral traits through structured questionnaires, providing a multi-faceted approach to ASD screening.

By combining deep learning-based facial recognition with machine learning-driven behavioral analysis, this research aims to develop an automated and accessible ASD detection system. This approach not only facilitates early diagnosis but also reduces the dependency on specialists, making ASD screening more efficient and widely available. Furthermore, the integration of engagement-based learning modules provides cognitive and social development support for children diagnosed with ASD.

1.2 INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects communication, social interactions, and behavior. Early detection is crucial for timely intervention, yet traditional diagnostic methods are often time-consuming, subjective, and inaccessible, especially in underserved regions. This research proposes an AI-powered ASD screening system that integrates deep learning and machine learning to enhance detection accuracy and accessibility.

The system employs a dual assessment approach: a Convolutional Neural Network (CNN) based on VGG19 for facial image analysis and a Random Forest classifier for evaluating autism-related traits through a multiple-choice questionnaire. To further support children with ASD, the system incorporates interactive learning modules, including number and letter recognition, arithmetic exercises, reading and listening activities, and curated video content to foster cognitive and social development.

By leveraging AI-driven facial recognition and structured behavioral assessments, this solution offers a faster, cost-effective, and user-friendly alternative to traditional diagnostic methods. Designed as a web-based application, it enables parents, caregivers, and healthcare professionals to conduct preliminary ASD screenings from any location. This research aims to bridge the gap in early ASD detection by providing an accessible, automated, and engaging tool that empowers families and enhances early intervention efforts.

1.3 PROBLEM STATEMENT

Despite increased awareness and research efforts, ASD diagnosis remains a complex and time-consuming process. Traditional diagnostic approaches primarily rely on subjective behavioral assessments conducted by psychologists, pediatricians, and therapists. Standardized screening tools such as the Autism Diagnostic Observation Schedule (ADOS) and the Modified Checklist for Autism in Toddlers (M-CHAT) require trained professionals to administer, interpret, and confirm results, often leading to prolonged waiting times and delayed interventions. Additionally, in many parts of the world, there is a lack of access to specialized professionals, making early detection even more challenging.

The reliance on human interpretation introduces variability in diagnoses, as different specialists may assess symptoms differently. Furthermore, ASD presents in diverse ways, with some individuals displaying obvious signs while others exhibit subtler traits, making early identification difficult. Many children from underserved communities do not receive a diagnosis until much later, significantly limiting their chances of benefiting from early interventions that could improve their developmental trajectory.

To address these challenges, this research proposes an AI-powered ASD detection system that integrates deep learning for facial image analysis and machine learning for behavioral assessment. By automating the screening process, this system aims to provide a faster, objective, and accessible method for preliminary ASD diagnosis. Additionally, the incorporation of interactive learning activities ensures that children receive cognitive and developmental support, making the system not only a diagnostic tool but also a resource for families and caregivers.

1.4 MOTIVATION

The motivation behind this research stems from the pressing need for an accessible, efficient, and reliable ASD screening solution. Many families face significant barriers to early diagnosis, including geographical limitations, financial constraints, and a lack of awareness about ASD symptoms. The current diagnostic methods are not only time-consuming but also expensive, making them impractical for families in low-income or remote areas. The delay in diagnosis often results in missed opportunities for early intervention, which is crucial for improving social, behavioral, and cognitive outcomes in children with ASD.

Advancements in AI and machine learning provide an opportunity to revolutionize the ASD detection process. Research has shown that deep learning models can accurately analyze facial features associated with ASD, while machine learning classifiers can assess behavioral patterns through structured questionnaires. This combination presents a novel approach to early screening that is both efficient and cost-effective.

Furthermore, beyond just detection, children with ASD require continuous support to enhance their learning and social skills. Integrating interactive learning modules within the system ensures that children engage in cognitive development activities tailored to their needs. The inclusion of exercises such as letter and number recognition, arithmetic tasks, reading and listening activities, and creative video content aims to foster their cognitive abilities and social interactions.

This research is driven by the goal of democratizing access to ASD screening and intervention tools, ensuring that every child, regardless of their location or socioeconomic status, has the opportunity to receive early support. By leveraging AI-driven approaches, this system aspires to bridge the gap between technological advancements and practical healthcare solutions for ASD detection and intervention.

1.5 SCOPE

This research focuses on the development of a web-based ASD detection and support system that integrates deep learning, transfer learning, and machine learning techniques. The system is designed to serve as an early screening tool that allows users to upload facial images for analysis using a pre-trained CNN model, specifically VGG19, which has been fine-tuned through transfer learning to detect facial morphological features associated with ASD. Additionally, to provide a comprehensive evaluation, the system incorporates an MCQ-based autism screening questionnaire. The responses to the questionnaire are analyzed using a Random Forest classifier, which assesses autism-related behavioral traits based on established diagnostic criteria.

Beyond diagnosis, the system includes engagement-based learning activities to support children with ASD in developing cognitive, linguistic, and social skills. The learning modules consist of:

- Letter and number recognition exercises to improve basic literacy and numeracy skills.
- Basic arithmetic tasks to enhance problem-solving abilities.
- Reading and listening activities to aid in language development.
- Curated video content to foster creativity and social engagement.

The system is designed to be accessible and user-friendly, allowing parents, caregivers, and healthcare professionals to utilize it as a preliminary screening tool. While it does not replace clinical diagnosis, it serves as a valuable assistive technology to identify potential ASD cases early and provide children with developmental support.

CHAPTER 1

LITERATURE REVIEW

2.1 Efficient Machine Learning Models for Early-Stage Detection of Autism Spectrum Disorder(M. Bala, M. H. Ali, M. S. Satu, K. F. Hasan, M. A. Moni, 2022)

This study explores the correlation between gut microbiota composition and ASD using advanced machine learning techniques. D. Pietrucci et al. analyze microbiome data from ASD and neurotypical individuals to identify specific microbial markers that may contribute to ASD symptoms. The research applies clustering and classification algorithms to uncover patterns in gut microbiota that differentiate ASD-affected individuals from their neurotypical counterparts. This novel approach combines computational biology with artificial intelligence to advance understanding of the gut-brain axis and its potential role in neurodevelopmental disorders. A major strength of this study is that it proposes a non-invasive diagnostic method for ASD based on biological markers. Unlike traditional behavioral assessments, which may be subjective or influenced by external factors, microbiota-based diagnostics could offer a more consistent and reliable approach.

Advantages:

- Non-invasive diagnostic approach, reducing reliance on behavioral assessments.
- Machine learning uncovers hidden microbial patterns, potentially aiding in early ASD detection.
- Bridges computational biology and ASD research, providing new insights into the gut-brain connection.

Disadvantages:

- Microbiota variability across individuals may affect diagnostic reliability.
- Requires large-scale validation before being used as a diagnostic tool.
- Machine learning models may need retraining as new microbiome data becomes available.

2.2 Eye Tracking-Based Diagnosis and Early Detection of Autism Spectrum Disorder Using Machine Learning and Deep Learning Techniques(I. A. Ahmed, E. M. Senan, T. H. Rassem, M. A. H. Ali, H. S. A. Shatnawi, S. M. Alwazer, M. Alshahrani, 2022)

This study investigates the application of eye-tracking technology in combination with machine learning and deep learning models for the early detection of ASD. I. A. Ahmed et al. designed a system that analyzes gaze patterns, fixation behavior, and saccadic eye movements to distinguish ASD individuals from neurotypical individuals. The research employs convolutional neural networks (CNNs) and other deep learning models to automatically classify eye movement data, eliminating the need for traditional behavioral assessments. The study highlights that eye-tracking provides an objective and quantitative method to analyze social attention deficits, a core characteristic of ASD.

One of the key advantages of this approach is its potential to provide early diagnosis with minimal human intervention. Unlike traditional ASD screening, which relies on questionnaires or subjective clinical observations, this method offers an automated and data-driven alternative. The integration of deep learning techniques enhances classification accuracy by learning intricate patterns in eye-tracking data that may not be visible through manual analysis. However, the study also acknowledges the challenges of using eye-tracking technology, including the need for specialized hardware, which may limit accessibility.

Advantages:

- Objective and automated ASD screening, reducing reliance on subjective behavioral assessments.
- High classification accuracy through deep learning-based pattern recognition.
- Potential for early detection, allowing for timely interventions.

Disadvantages:

- Requires specialized eye-tracking hardware, which may limit accessibility.
- Needs further validation to ensure robustness across diverse demographics.
- Gaze behavior variations could affect classification accuracy across different populations.

2.3 A Deep Learning Approach to Predict Autism Spectrum Disorder Using Multisite Resting-State fMRI(F. Z. Subah, K. Deb, P. K. Dhar, T. Koshiba, 2021)

This study focuses on utilizing eye-tracking technology combined with machine learning for ASD detection. I. A. Ahmed et al. proposed a system that analyzes gaze patterns, saccadic eye movements, and fixation behavior to distinguish ASD individuals from neurotypical individuals. By capturing real-time eye movement data, the system identifies irregularities in visual attention and processing, which are common traits in ASD. The integration of deep learning techniques, including convolutional neural networks (CNNs), enhances classification accuracy, allowing the system to recognize subtle gaze anomalies with high precision.

The research dataset consists of eye-tracking recordings from individuals of different age groups. The authors employed feature engineering techniques to extract relevant gaze metrics, such as fixation duration, pupil dilation, and scan path efficiency. Experimental results showed that deep learning models outperformed traditional machine learning classifiers, achieving higher sensitivity and specificity in ASD diagnosis. A key advantage of this method is its objectivity, reducing reliance on subjective behavioral assessments commonly used in traditional ASD screening.

Advantages:

- Objective and automated detection of ASD traits using eye-tracking technology.
- High accuracy through deep learning-based pattern recognition, reducing diagnostic subjectivity.
- Potential for integration into non-invasive screening tools for early ASD identification.

Disadvantages:

- Requires specialized eye-tracking hardware, limiting accessibility in resource-constrained settings.
- Potential variations in gaze behavior among individuals may affect accuracy, requiring additional refinement.
- External environmental factors may influence eye-tracking data reliability.

2.4 A Deep Learning Approach to Predict Autism Spectrum Disorder Using Multisite Resting-State fMRI (F. Z. Subah, K. Deb, P. K. Dhar, T. Koshiba, 2021)

F. Z. Subah et al. introduced a deep learning model that utilizes resting-state functional MRI (fMRI) data for ASD prediction. The study demonstrates how neural activity patterns can be analyzed using convolutional and recurrent neural networks to classify ASD individuals with high precision. Resting-state fMRI captures spontaneous brain activity, providing insights into functional connectivity differences between ASD and neurotypical individuals.

The research incorporated multi-site fMRI datasets, addressing the challenge of data variability across different imaging centers. The authors employed transfer learning techniques to adapt pre-trained models for ASD classification, significantly improving performance. Their approach identified key brain regions implicated in ASD, such as the default mode network (DMN) and salience network, which showed altered connectivity patterns in ASD individuals. However, the reliance on fMRI data poses practical challenges, as MRI scans are expensive and not widely accessible for routine ASD screening. Additionally, the need for high computational power limits the feasibility of real-time analysis. Future research could explore integrating fMRI-based biomarkers with behavioral and genetic data for a more comprehensive ASD diagnostic framework.

Advantages:

- High classification accuracy through deep learning-based fMRI analysis.
- Identifies neurophysiological biomarkers linked to ASD, providing objective insights into brain function.
- Multi-site data integration improves model robustness and generalizability.

Disadvantages:

- High cost and limited accessibility of fMRI scans, restricting its widespread clinical application.
- Requires advanced computational resources for deep learning processing, making real-time diagnosis challenging.
- Data preprocessing and standardization across multiple imaging centers remain complex.

2.5 The Contribution of Machine Learning and Eye-Tracking Technology in Autism Spectrum Disorder Research: A Systematic Review (K.-F. Kollias, C. K. Syriopoulou-Delli, P. Sarigiannidis, G. F. Fragulis, 2021)

K.-F. Kollias, C. K. Syriopoulou-Delli, P. Sarigiannidis, and G. F. Fragulis conducted a systematic review to examine the role of machine learning and eye-tracking technology in Autism Spectrum Disorder (ASD) research. This study provides a comprehensive evaluation of existing literature, highlighting how these technologies contribute to the early diagnosis and assessment of ASD. The review synthesizes findings from multiple studies that utilize machine learning algorithms to analyze eye-tracking data, revealing patterns in gaze behavior, fixation duration, and saccadic movements that are distinctive in ASD individuals.

One of the key takeaways from this research is the significant role of eye-tracking in identifying atypical visual attention patterns, which are often linked to social communication deficits in ASD. The study outlines how machine learning models, such as support vector machines (SVMs), decision trees, and deep neural networks, can effectively classify ASD individuals based on these gaze characteristics. The authors emphasize that eye-tracking technology offers a non-invasive, objective alternative to traditional behavioral assessments, which are often subjective and require specialized clinical expertise.

Advantages:

- Provides an extensive review of machine learning and eye-tracking applications in ASD detection.
- Highlights the effectiveness of eye-tracking as a non-invasive diagnostic tool.
- Demonstrates how machine learning models improve classification accuracy in ASD research.

Disadvantages:

- Variability in eye-tracking data across individuals can reduce model generalizability.
- Limited availability of large-scale datasets affects machine learning performance.
- Current models require further validation in real-world clinical settings before widespread adoption.

2.6 A Machine Learning Approach to Predict Autism Spectrum Disorder (K. S. Omar, P. Mondal, N. S. Khan, M. R. K. Rizvi, M. N. Islam, 2019)

In their study, K. S. Omar, P. Mondal, N. S. Khan, M. R. K. Rizvi, and M. N. Islam explore the potential of machine learning techniques in predicting Autism Spectrum Disorder (ASD). This research, presented at the International Conference on Electrical, Computer, and Communication Engineering (ECCE), evaluates various machine learning models to identify ASD traits with greater accuracy and efficiency than traditional diagnostic methods. The study aims to address the limitations of conventional ASD screening, which often relies on subjective behavioral assessments and clinical evaluations that can be time-consuming and inconsistent.

The authors employ a dataset consisting of behavioral and demographic features relevant to ASD, such as social interaction tendencies, communication patterns, and cognitive abilities. They experiment with multiple classification algorithms, including decision trees, support vector machines (SVMs), k-nearest neighbors (KNN), and artificial neural networks (ANNs), to determine the most effective model for ASD prediction. Their findings indicate that machine learning models, particularly neural networks, exhibit high accuracy in distinguishing ASD individuals from neurotypical individuals.

Advantages:

- Provides an extensive review of machine learning and eye-tracking applications in ASD detection.
- Highlights the effectiveness of eye-tracking as a non-invasive diagnostic tool.
- Demonstrates how machine learning models improve classification accuracy in ASD research.

Disadvantages:

- Variability in eye-tracking data across individuals can reduce model generalizability.
- Limited availability of large-scale datasets affects machine learning performance.
- Current models require further validation in real-world clinical settings before widespread adoption.

CHAPTER 3

PROPOSED SYSTEM

The proposed system is an AI-driven platform designed for early screening of Autism Spectrum Disorder (ASD) by integrating machine learning and computer vision techniques. The system evaluates facial features and questionnaire responses to identify autism-related characteristics, providing an accessible and efficient screening method. Additionally, it includes an engagement-based learning module aimed at improving cognitive, linguistic, and numerical skills in autistic children. A secure data management framework is implemented to protect user privacy, allowing only authorized administrators to handle screening results and user information.

3.1. Data Collection

The system gathers input data from two primary sources: facial image analysis and questionnaire-based responses.

Facial Image Data:

- Users can upload facial images via a web-based interface.
- The model is trained using publicly available datasets such as the Kaggle Autism Dataset, Open Face, and Autism-Face Dataset to enhance prediction accuracy.
- To improve the system's reliability, clinical datasets containing confirmed ASD and non-ASD cases are incorporated.

Questionnaire-Based Data:

- Users complete the Autism Spectrum Quotient (AQ) Test, a standardized autism screening assessment designed to evaluate autism-related traits.
- Responses are processed and analyzed to detect autism-related traits.
- Data from clinical studies is utilized to refine the questionnaire model, improving prediction accuracy and minimizing false positives.

3.2. Computer Vision Module (Facial Feature Analysis & Classification)

The Computer Vision Module is responsible for extracting and analyzing facial features that may indicate ASD characteristics.

Preprocessing Stage:

- Facial images are converted to grayscale, resized, and preprocessed to standardize input.
- The system examines facial symmetry and structural features that are commonly associated with ASD.

Deep Learning Model:

- A VGG19-based Convolutional Neural Network (CNN) with transfer learning is used for feature extraction and classification.
- Data augmentation techniques enhance the model's robustness, reducing bias and improving accuracy.

Classification Process:

- A sigmoid activation function generates a probability score for ASD likelihood.
- Based on the score, individuals are classified as either ASD-positive or ASD-negative.

3.3. Questionnaire-Based Assessment

The questionnaire-based screening component utilizes machine learning techniques to assess the probability of ASD.

Data Encoding & Feature Selection:

- User responses are converted into structured datasets suitable for machine learning models.

Machine Learning Classification:

- A Random Forest classifier predicts ASD likelihood based on questionnaire responses.

- Ensemble learning techniques enhance classification accuracy while preventing overfitting.

3.4. Engagement-Based Learning Module

This module provides interactive learning activities to support cognitive and linguistic development in children with ASD.

Letter & Number Recognition:

- Image-based exercises help children recognize letters and numbers.
- Letter identification involves typing the full name of an object shown in an image.
- Number recognition tasks require users to count objects and provide the correct answer.

Basic Arithmetic Exercises:

- Children engage in addition, subtraction, multiplication, and division activities.
- A built-in verification feature provides instant feedback to ensure interactive learning.

Reading & Listening Activities:

- Image-supported exercises promote word recognition and comprehension skills.
- Audio-based learning reinforces phonetic awareness and correct pronunciation.

Video-Based Learning:

- Curated educational videos enhance social skills, creativity, and cognitive abilities.

3.5. Web Deployment & System Workflow

The system is deployed as a web-based platform, allowing users to access ASD screening and learning modules from any location.

User Interface:

- Users can upload facial images, complete screening questionnaires, and access learning resources via an intuitive dashboard.
- Administrators oversee system operations, content management, and user activities while maintaining data security.

Backend Processing:

The system architecture is built using XAMPP with:

- Apache as the web server.
- MySQL for database management.
- PHP to handle backend operations and facilitate communication with Python, which runs the ASD detection models.
- A secure database is implemented to store user data and screening results.

System Optimization:

- The system is designed to run efficiently on standard computers without requiring GPU acceleration.
- Periodic model retraining is performed to integrate new data and continuously improve ASD detection accuracy.

The proposed system aims to provide a comprehensive and accessible approach to early Autism Spectrum Disorder (ASD) detection and intervention. By integrating computer vision, deep learning, and machine learning techniques, the system enhances accuracy in ASD identification while ensuring data security and user privacy. Additionally, the engagement-based learning module offers interactive exercises to support cognitive and social development in children with autism. With a user-friendly web interface and optimized backend processing, the platform ensures seamless functionality without requiring high-end computational resources. Regular updates and model retraining further improve the system’s accuracy and adaptability, making it a reliable tool for early ASD screening and personalized learning support.

CHAPTER 4

METHODOLOGY

The methodology outlines a systematic approach to the design, development, and deployment of the proposed autism screening and interactive learning system. The system integrates deep learning-based facial analysis, machine learning-driven questionnaire assessments, and engagement-based learning activities to create a comprehensive and effective ASD detection and support tool. The methodology is structured into multiple stages, including data collection, preprocessing, model development, system implementation, evaluation, and security considerations.

4.1 Data Collection

Accurate autism detection requires diverse and reliable datasets for both facial recognition-based screening and questionnaire-based assessment. The system gathers data from two primary sources:

Facial Image Data:

- Users upload facial images through the platform for ASD screening.
- The deep learning model is trained using publicly available datasets such as:
    - Kaggle Autism Dataset – Contains labeled images of individuals with and without ASD.
    - OpenFace Dataset – Provides extensive facial analysis data to enhance model robustness.
    - Autism-Face Dataset – Includes clinically validated images to ensure medical relevance.
- Additional real-world clinical datasets containing confirmed ASD and non-ASD cases are used to refine model performance and improve generalizability.
- The system aims to mitigate dataset bias by ensuring diversity across different ethnicities, age groups, and genders.

Questionnaire-Based Data:

- Users complete the Autism Spectrum Quotient (AQ) Test, a well-established autism screening questionnaire designed for individuals of different age groups.
- The test evaluates social, cognitive, and behavioral traits associated with ASD.

- Responses are collected, structured, and analyzed using machine learning techniques to determine ASD likelihood.
- To enhance reliability, data from existing clinical studies and expert-reviewed research is incorporated into the system to fine-tune the questionnaire-based classification model.
- The system ensures that irrelevant or misleading responses are filtered to prevent inaccuracies in assessment.

4.2 Data Preprocessing

Before feeding data into the system's deep learning and machine learning models, preprocessing steps are applied to enhance accuracy and efficiency.

Facial Image Preprocessing:

- Facial images undergo multiple transformations to standardize input data:
    - Grayscale Conversion – Reduces complexity while retaining essential facial features.
    - Resizing and Normalization – Ensures uniform input dimensions across different image resolutions.
    - Facial Feature Extraction – Identifies key facial markers potentially associated with ASD characteristics.
- Data augmentation techniques, including rotation, flipping, and noise addition, are applied to increase dataset diversity and improve model robustness.
- Outlier detection mechanisms filter out low-quality images that could negatively impact prediction accuracy.

Questionnaire Data Preprocessing:

- Questionnaire responses are converted into structured numerical data suitable for machine learning analysis.
- Feature selection techniques identify the most significant responses correlated with ASD diagnosis.

- Handling Missing Data: If users leave responses incomplete, imputation techniques are applied to minimize the impact of missing values.
- Data balancing methods ensure that the training set does not introduce bias toward ASD-positive or ASD-negative cases.

4.3 Model Development

The system integrates a hybrid approach combining deep learning for facial analysis and machine learning for questionnaire-based screening.

Computer Vision-Based Model:

- A VGG19-based Convolutional Neural Network (CNN) with transfer learning is used for ASD facial feature classification.
- The model is trained on labeled ASD and non-ASD facial datasets, learning patterns associated with autism-related traits.
- Key steps in the classification process:
  - Feature Extraction: Identifies unique facial structures.
  - Probability Score Generation: Assigns ASD likelihood based on facial features.
  - Softmax Activation Function**:** Categorizes individuals as ASD-positive or ASD-negative.
- Transfer learning techniques allow the system to leverage pre-trained models for enhanced efficiency and accuracy.

Questionnaire-Based Classification:

- A Random Forest Classifier is implemented to process questionnaire responses.
- The model learns behavioral patterns indicative of ASD through supervised learning techniques.
- Ensemble learning is used to improve classification accuracy while minimizing false positives and false negatives.
- The system continuously updates its model by incorporating new user data, enhancing its predictive performance over time.

4.4 System Implementation

The proposed system is deployed as a web-based platform that integrates autism screening and engagement-based learning modules.

Frontend Development:

- The user interface (UI) is designed for accessibility and ease of use.
- Users can:
  - Upload facial images.
  - Complete the AQ test questionnaire.
  - Access personalized learning modules.
- The dashboard provides intuitive navigation and real-time results display.

Backend Development:

- The system is built on the XAMPP stack, incorporating:
  - Apache – Web server for hosting the application.
  - MySQL – Database management system for storing screening results and user data.
  - PHP – Handles backend operations, enabling seamless communication between the database and frontend.
  - Python – Executes deep learning models for ASD detection.
- A secure database architecture ensures encrypted storage of user data, preventing unauthorized access.

4.5 System Evaluation

The system undergoes rigorous testing and evaluation to ensure reliability, accuracy, and security.

Model Performance Evaluation:

- The CNN-based ASD screening model is tested using validation datasets and evaluated using key metrics:
  - Accuracy: Measures overall correctness of ASD predictions.
  - Precision & Recall: Assesses the model's ability to differentiate ASD-positive cases from non-ASD cases.
  - F1-Score: Balances precision and recall for optimal classification performance.

- The questionnaire-based classifier is validated using cross-validation techniques to ensure its consistency in predicting ASD likelihood.

User Experience & System Usability:

- A group of test users (caregivers, educators, and professionals) assess the platform's usability and interface design.
- Feedback is collected and used to refine system responsiveness, accessibility, and user interaction.

4.6 Security & Ethical Considerations

Given the sensitivity of ASD screening, the system incorporates strict security and ethical guidelines.

Data Encryption & Privacy Protection:

- Facial images and questionnaire responses are encrypted before storage.
- User access control mechanisms restrict unauthorized data access.
- The system complies with data privacy regulations to ensure ethical handling of personal information.

AI Fairness & Bias Mitigation:

- The model is trained on diverse datasets to prevent racial, gender, or age biases.
- Regular audits ensure fairness and accuracy in ASD predictions.

Ethical AI Usage:

- The system does not provide a definitive autism diagnosis but rather an initial screening to guide further clinical evaluation.
- Users are encouraged to consult healthcare professionals for comprehensive ASD assessment.

To further improve the system's effectiveness and adaptability, future enhancements will focus on expanding dataset diversity, refining deep learning models, and integrating additional behavioral assessments. The inclusion of real-time facial expression analysis and gaze tracking could enhance screening accuracy by identifying subtle behavioral markers associated with ASD. Moreover, incorporating natural language processing (NLP) techniques for speech and language analysis could provide deeper insights into communication patterns in autistic individuals.

CHAPTER 5

SYSTEM ARCHITECTURE

The ASD Detection System architecture is designed to facilitate accurate and efficient autism screening while providing interactive learning support for children. The system integrates facial recognition-based screening, questionnaire-based assessment, and an engagement-based learning platform, ensuring a comprehensive approach to early autism detection. Built on a web-based framework, the system ensures accessibility, security, and scalability for caregivers, healthcare professionals, and educators. The modular design allows for seamless integration of screening results and learning activities, making it an all-in-one solution for ASD assessment and support.

5.1 Data Acquisition Module

The system collects input data from users through two primary sources: facial image submissions and structured questionnaire responses. This dual-input approach enhances diagnostic accuracy by combining behavioral indicators with facial feature analysis.

- **Facial Image Collection:** Users submit high-quality facial images through the platform, ensuring optimal input for the deep learning model. The system provides guidelines on image clarity, facial positioning, and lighting conditions to improve detection accuracy.
- **Questionnaire-Based Assessment:** Users complete a standardized screening questionnaire, such as the Autism Spectrum Quotient (AQ) test, which evaluates behavioral traits linked to ASD. Responses are stored securely for further analysis.

This module ensures the seamless capture of relevant data while maintaining user privacy and compliance with ethical guidelines.

5.2 Data Preprocessing

Once the data is collected, it undergoes preprocessing to enhance model performance and ensure consistent input quality.

- **Facial Image Processing:** Images are converted to grayscale, resized, and normalized to standard dimensions, reducing computational complexity and improving feature extraction. Feature selection techniques highlight key facial markers linked to ASD traits.
- **Questionnaire Data Processing:** Responses undergo feature encoding and normalization before being fed into the machine learning model. Outlier detection and data validation techniques are employed to handle inconsistent or missing responses.

These preprocessing steps enhance the system's robustness, allowing it to function effectively across different environmental and user-specific conditions.

5.3 ASD Screening Module

The core of the system's diagnostic capability lies in its dual-layer ASD screening approach, combining facial recognition with behavioral analysis for improved accuracy.

Facial Recognition-Based Screening:

- The processed facial image is analyzed using a Convolutional Neural Network (CNN) model (VGG19 with transfer learning) to extract distinguishing features associated with ASD.
- The model generates a probability score indicating the likelihood of ASD based on predefined facial markers.
- The decision-making process is optimized to minimize false positives by refining detection thresholds.

Questionnaire-Based Screening:

- The system applies a Random Forest classifier to analyze questionnaire responses and identify ASD-related behavioral patterns.
- A predictive ASD probability score is assigned based on established screening criteria.
- The final assessment combines insights from both screening techniques to enhance diagnostic accuracy.

This integrated approach ensures a comprehensive screening process, leveraging both facial recognition and behavioral data for a more reliable assessment.

5.4 Machine Learning Model

The ASD detection system is powered by two primary machine learning models, each serving a distinct function:

- **VGG19 with Transfer Learning (Facial Recognition Model):** The deep learning model is pre-trained on large-scale image datasets and fine-tuned using ASD-specific facial image datasets. This enables the system to detect subtle facial features linked to autism traits.
- **Random Forest Classifier (Questionnaire-Based Model):** This model is trained on historical ASD screening data to recognize behavioral indicators predictive of ASD. By analyzing multiple decision trees, it enhances classification accuracy and reduces overfitting.

The models undergo periodic retraining with new data, ensuring adaptability to evolving diagnostic patterns and improving long-term performance.

5.5 Learning & Engagement Module

Beyond screening, the system provides an interactive learning platform tailored for children with ASD. The engagement module incorporates multiple learning activities, including:

- **Letter & Number Recognition:** Image-based exercises that help children associate objects with letters and numbers.
- **Basic Arithmetic Exercises:** Addition, subtraction, multiplication, and division activities that provide real-time feedback.
- **Reading & Listening Activities:** Text-to-speech and visual storytelling exercises that enhance comprehension and language skills.
- **Video-Based Learning:** Curated educational videos designed to improve cognitive skills, social awareness, and creativity.

This module promotes interactive learning, ensuring an engaging and personalized experience for children with ASD.

5.6 User Interface & Accessibility

The system is designed with a user-friendly interface, ensuring ease of navigation for both caregivers and children. Key interface components include:

- **Screening Dashboard:** Users can view test results, screening progress, and assessment summaries in an intuitive layout.
- **Learning Dashboard:** Provides access to interactive activities, progress tracking, and customizable learning paths.
- **Admin Panel:** Allows system administrators to manage users, update learning materials, and oversee data security.

Accessibility features such as text-to-speech support, color contrast adjustments, and voice-guided navigation ensure inclusivity for users with diverse needs.

5.7 Security & Ethical Considerations

Given the sensitive nature of ASD screening, the system implements robust security measures to protect user data.

- **Data Encryption:** All stored data, including facial images and questionnaire responses, is encrypted to prevent unauthorized access.
- **Privacy Policies:** User screening results remain confidential, accessible only to the respective user.
- **AI Fairness & Bias Mitigation:** The deep learning model is trained on diverse datasets to minimize bias and ensure fair assessments across different demographic groups.

By prioritizing ethical considerations, the system fosters trust and ensures responsible AI deployment in ASD detection.

Overall System Workflow

The ASD Detection System follows a structured workflow to provide seamless autism screening and personalized learning experiences, ensuring accuracy, efficiency, and user engagement. The process begins with User Registration & Input Submission, where users upload facial images and complete the Autism Spectrum Quotient (AQ) test, a validated questionnaire designed to assess behavioral traits linked to ASD. Once the data is collected, it undergoes a Preprocessing phase, where facial images are transformed, enhanced, and standardized to ensure uniformity, while questionnaire responses are cleaned and formatted for accurate analysis. The Feature Extraction & Analysis module then identifies key facial markers and behavioral traits associated with ASD, utilizing advanced deep learning techniques to analyze subtle patterns that may not be easily detectable by the human eye.

Following this, the system moves to the Probability Score Calculation phase, where a Convolutional Neural Network (CNN) model and a Random Forest classifier process the extracted features to generate an ASD likelihood score. These machine learning models, trained on diverse datasets, assess both facial and behavioral indicators to enhance the screening accuracy. Once the probability score is determined, the system proceeds to Result Generation & User Feedback, where a comprehensive report is generated. This report provides insights into the screening results, helping parents, caregivers, or professionals understand the findings and make informed decisions regarding further assessments or interventions.

For individuals identified with ASD traits, the Engagement Module Activation ensures that personalized learning activities are recommended to support cognitive and behavioral development. These activities are tailored to the child's specific needs, fostering skill enhancement and early intervention strategies. Additionally, the Continuous Model Improvement phase ensures that as more screening data is collected, the machine learning models are refined and updated, improving detection accuracy over time. This adaptive learning approach allows the system to evolve, making it increasingly precise in identifying ASD indicators across diverse populations.

By integrating AI-driven facial analysis, behavioral assessment, and interactive learning support, the ASD Detection System functions as a holistic diagnostic and developmental platform.

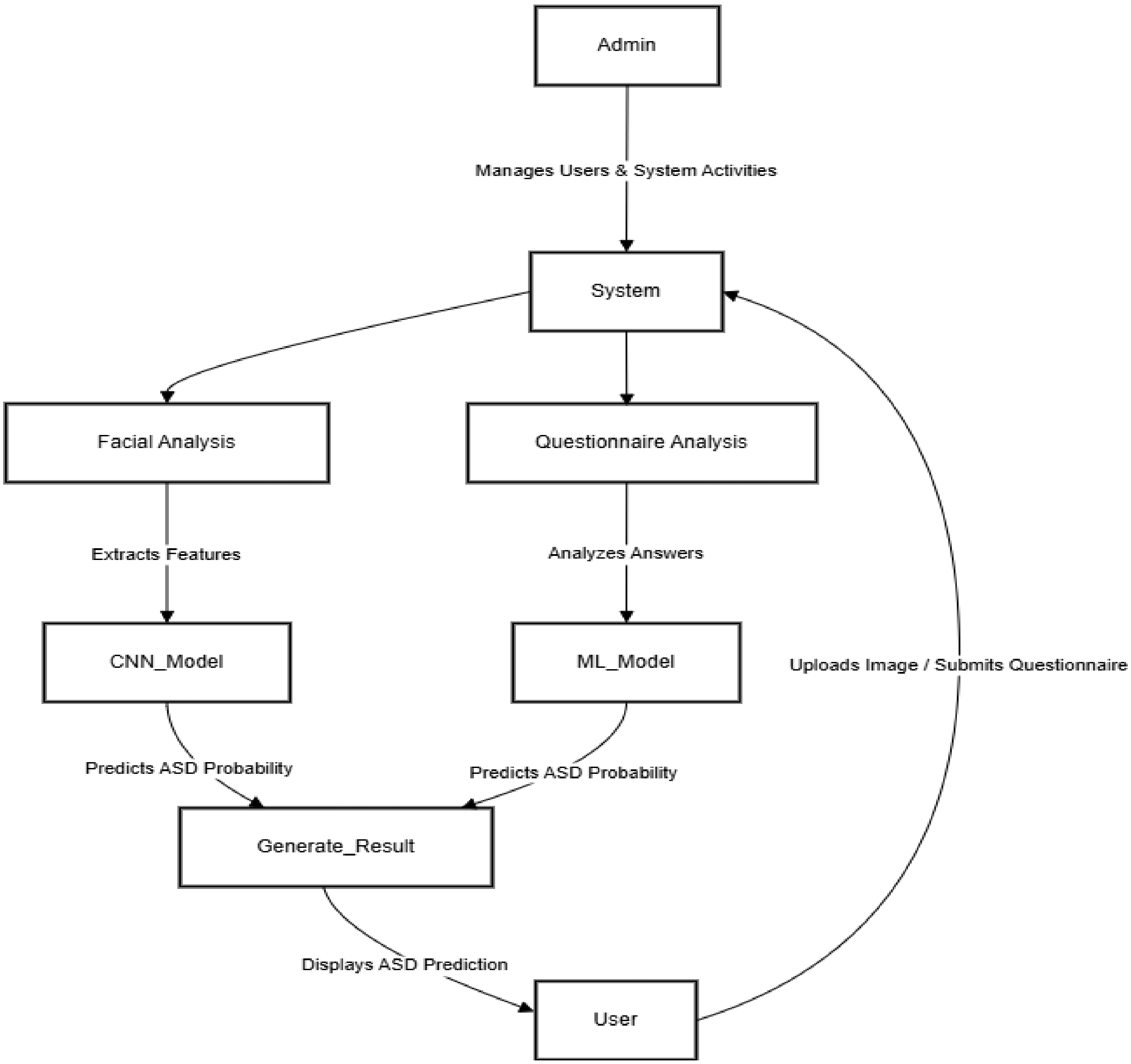


Fig: 1- Architecture Diagram

CHAPTER 6

MODULES

The ASD Detection System consists of multiple modules, each designed to ensure smooth operation, user engagement, and accurate autism screening. These modules work together to provide a seamless learning and diagnostic experience, integrating AI-driven autism detection with educational content.

6.1 Admin Module

The Admin Module is responsible for managing the system's content, overseeing user activities, and ensuring smooth operation. This module is primarily designed for administrators, including health professionals, who can manage platform content and user data.

- **User Authentication**: Admins can securely log into the system using a registered username and password.
- **Health Professional Access**: The system allows healthcare professionals to manage platform content and oversee screening activities.
- **Content Management**: Admins can upload and manage reading materials designed to help children improve their reading skills.
- **Listening Content Management**: Admins can add and organize listening materials, linking them with multiple-choice questions (MCQs) for assessments.
- **Guardian Management**: Admins have access to the details of guardians who register on the system, enabling better tracking and monitoring.
- **Content Review**: Admins can review, modify, and remove reading and listening materials as needed to maintain content quality and relevance.

6.2 User Module

The User Module enables individuals, including children, parents, and caregivers, to interact with the system for learning and autism detection. This module provides a user-friendly interface for seamless engagement and diagnosis.

- **User Registration**: Users can sign up by providing basic information such as name, email, phone number, and password.
- **User Authentication**: Secure login is available for users to access personalized features.
- **Content Access**: Users can engage with reading materials within a specified time frame, promoting structured learning.
- **Listening & Assessment**: Users can listen to provided audio content and complete MCQ-based assessments to enhance cognitive skills.
- **Autism Prediction**: The system allows users to upload facial images for ASD detection, leveraging deep learning models to analyze facial markers.
- **Result Interpretation**: If ASD traits are detected, the system provides a detailed report, offering insights and recommendations for further evaluation or intervention.

6.3 Screening & Detection Module

The **Screening & Detection Module** is the core component responsible for processing user inputs and performing autism detection using AI-driven techniques.

- **Image Preprocessing**: Uploaded images are cleaned, resized, and enhanced to ensure consistency before analysis.
- **Feature Extraction**: The system identifies key facial markers associated with ASD, analyzing structural and expression-based features.
- **Machine Learning Model Application**: A combination of Convolutional Neural Networks (CNN) and Random Forest classifiers process extracted features to generate a probability score indicating ASD likelihood.
- **Result Generation**: The system provides a comprehensive report outlining detection results, including confidence levels and relevant insights.

6.4 Learning & Engagement Module

This module is designed to support children who are identified with ASD traits by offering personalized learning experiences.

- **Personalized Learning Paths**: Based on screening results, the system suggests learning activities tailored to the child's needs.
- **Reading Support**: The module provides structured reading exercises to help children improve their comprehension skills.
- **Listening Activities**: Engaging auditory exercises help enhance cognitive and communication abilities.
- **Progress Monitoring**: The system tracks user engagement and progress, allowing

6.4 Report & Analytics Module

The Report & Analytics Module is designed to provide insights into screening outcomes, learning engagement, and system performance.

- **Guardian Insights**: Parents and caregivers can access personalized insights related to their child's engagement with the learning materials and system interactions. This helps them understand behavioral patterns and track learning activities.
- **Performance Metrics**: The system analyzes key factors such as engagement levels, response times to assessments, and activity participation. These insights help improve the learning experience and ensure the system operates effectively.
- **System Optimization**: Data collected from learning activities and screenings contribute to refining the AI model. Over time, this enhances the system's ability to provide more accurate and reliable autism screening and learning support.

By integrating these interconnected modules, the ASD Detection System ensures a comprehensive approach to early autism screening and intervention, supporting both diagnosis and developmental growth.

CHAPTER 7

DIAGRAMS

Introduction

The design phase is an essential part of any system development process, where creative and structured methodologies are employed to define the architecture and workflows of the system. A well-executed design ensures the system's effectiveness, efficiency, and ability to meet its intended objectives. In software engineering, system design plays a crucial role by outlining the architectural components necessary to realize the physical implementation of the software.

For the Personalized Learning Platform using Artificial Intelligence, the design process focused on maximizing performance, accuracy, and user experience. The following diagrams illustrate the structural and functional aspects of the system, including data flow, user interactions, and system components. Each diagram offers a detailed view of how different modules interact with one another, contributing to the overall functionality of the platform.

7.1 DFD (Data Flow Diagram)

DFD is the abbreviation for Data Flow Diagram. The flow of data in a system or process is represented by a Data Flow Diagram (DFD). It also gives insight into the inputs and outputs of each entity and the process itself. Data Flow Diagram (DFD) does not have a control flow and no loops or decision rules are present. Specific operations, depending on the type of data, can be explained by a flowchart. It is a graphical tool, useful for communicating with users, managers and other personnel. it is useful for analyzing existing as well as proposed systems.

Components of Data Flow Diagram

Following are the components of the data flow diagram that are used to represent source, destination, storage and flow of data:

- **External Entity:** External entity also known as Terminator, Actor, is the component of Data flow Diagram (DFD) that stands outside of the system and communicates with the system. It can be, for example, organizations like banks, groups of people like customers or different departments of the same organization, which is not a part of the model system and is an external entity. Modeled systems also communicate with terminator.

- **Process:** Input to output transformation in a system takes place because of process function.

The symbols of a process are rectangular with rounded corners, oval, rectangle or a circle. The process is named a short sentence, in one word or a phrase to express its essence

- **Data Flow:** Data flow describes the information transferring between different parts of the systems. The arrow symbol is the symbol of data flow. A relatable name should be given to the flow to determine the information which is being moved. Data flow also represents material along with information that is being moved. Material shifts are modeled in systems that are not merely informative. A given flow should only transfer a single type of information. The direction of flow is represented by the arrow which can also be bidirectional.

Fig: 2- DFD- Level-0

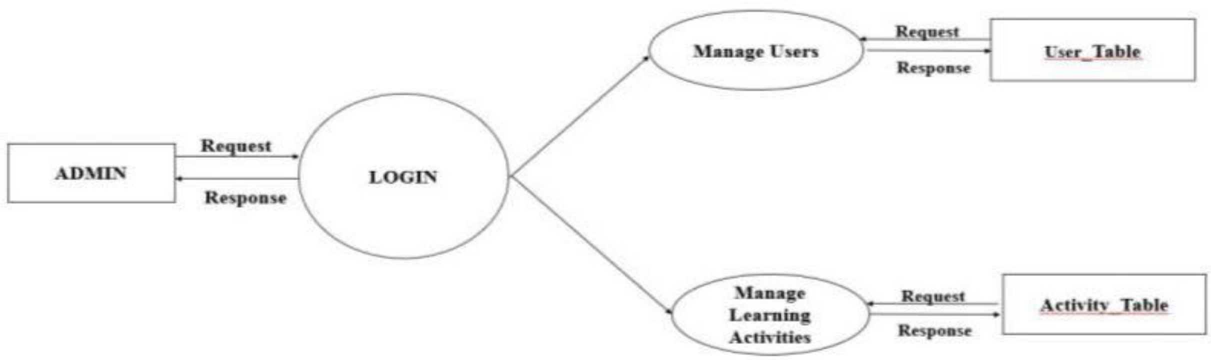


Fig: 2.1-DFD- Level-1 Admin

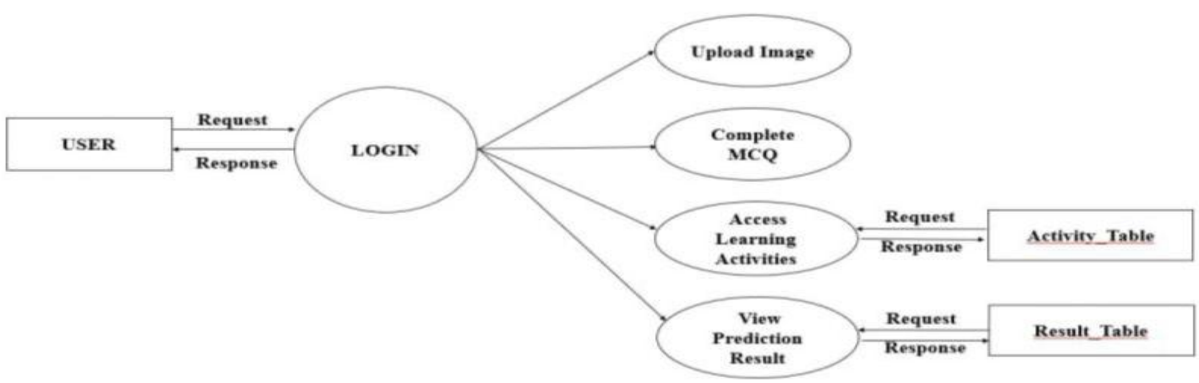


Fig:2.2- DFD- Level-1 User

7.2 Activity Diagram

The UML activity diagram is a graphical tool used to represent the control flow of a system, rather than its implementation details. It models both sequential and concurrent activities, providing a visual representation of the workflow between them. The activity diagram highlights the order and condition of flow, and can represent sequential, branched, or concurrent flows using elements such as forks and joins. Essentially, it is an object-oriented flowchart that represents a set of actions or operations to model the behavioral aspect of a system.

Components of an Activity Diagram

a)Activities - The categorization of behavior into one or more actions is termed as an activity.In other words, it can be said that an activity is a network of nodes that are connected by edges.

b)Activity partition/swim lane - The swim lane is used to cluster all the related activities in one column or one row. It can be either vertical or horizontal. It used to add modularity to the activity diagram.

c)Forks - Forks and join nodes generate the concurrent flow inside the activity. A fork node consists of one inward edge and several outward edges. It is the same as that of various decision parameters.

d) Join Nodes - Join nodes are the opposite of fork nodes. A Logical AND operation is performed on all of the inward edges as it synchronizes the flow of input across one single output (outward) edge.

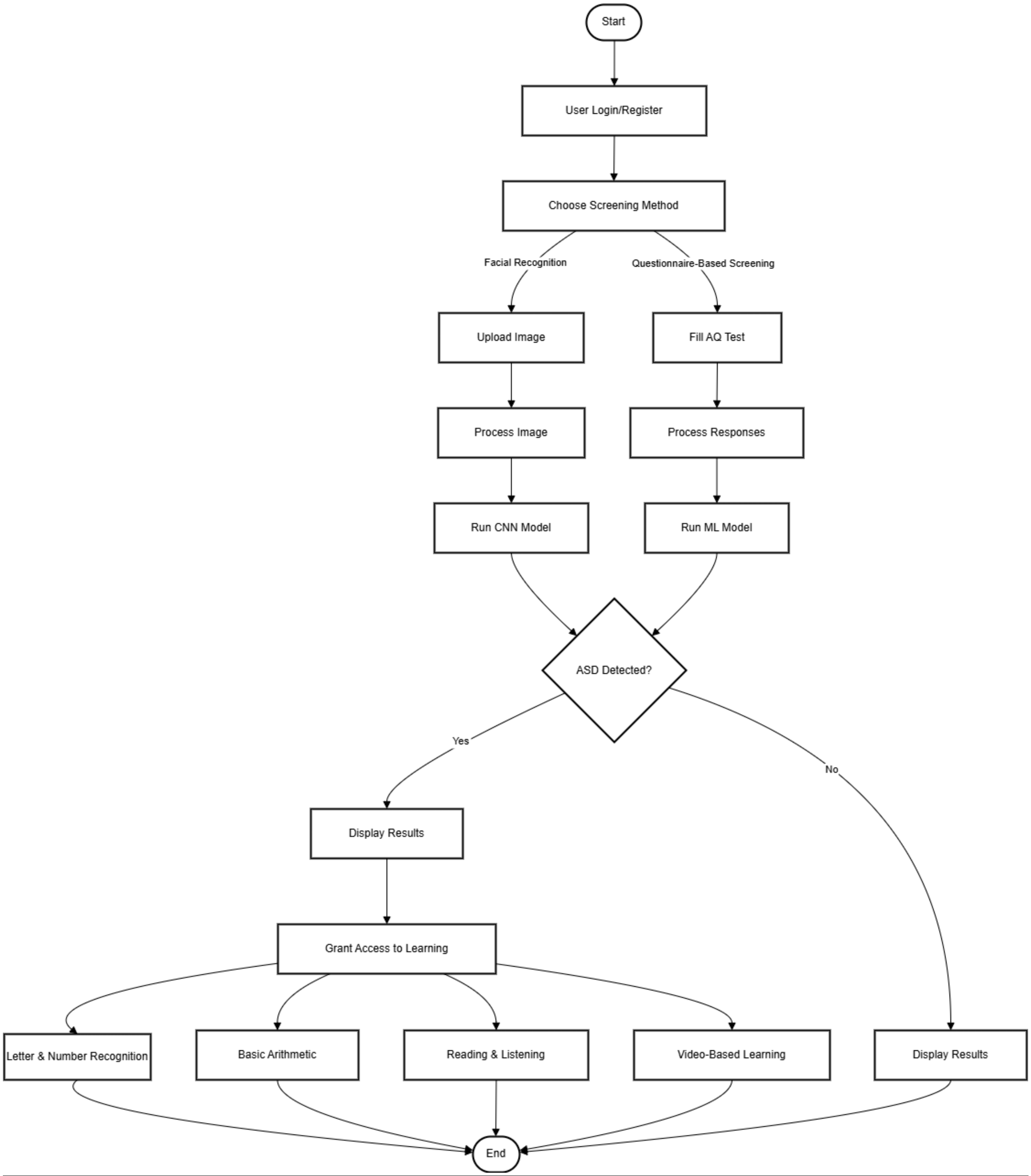


Fig:3- Activity Diagram

7.3 Class Diagram

The class diagram provides a static representation of an application, showing the types of objects present in the system and their relationships. A class is made up of its objects and may inherit from other classes. This diagram serves to visualize, describe, and document various aspects of the system, as well as to construct executable software code. It displays attributes, classes, functions, and relationships to provide an overview of the software system. Each of these elements is placed in a separate compartment, making it easier for software developers to work with. Because it comprises classes, interfaces, associations, collaborations, and constraints, it is classified as a structural diagram.

Components of a Class Diagram

The class diagram is made up of three sections:

- **Upper Section:** The upper section encompasses the name of the class. A class is a representation of similar objects that share the same relationships, attributes, operations, and semantics. This section serves as the identifier for the class, making it easier to understand its purpose within the overall system. Naming conventions often reflect the class's role or function, enhancing clarity for developers.
- **Middle Section:** The middle section constitutes the attributes, which describe the qualities of the class. Attributes are the data elements that define the characteristics of the objects instantiated from the class. This section can include visibility indicators (public, private, protected) to specify access control, guiding how the attributes can be manipulated and accessed by other classes or objects.
- **Lower Section:** The lower section contains methods or operations. The methods are represented in the form of a list, where each method is written on a single line. This demonstrates how a class interacts with data, providing the functionality required to manipulate the attributes. Each method typically includes its name, return type, and parameters, which clarify how it can be invoked and what outputs it can produce. Additionally, documenting methods in this manner helps in understanding the responsibilities of the class and how it contributes to the overall system behavior.

Relationships

In UML, relationships are of three types:

- **Dependency:** A dependency is a semantic relationship between two or more classes where a change in one class causes changes in another class. It forms a weaker relationship, indicating that one class relies on another to function properly. In design, understanding dependencies helps to manage code complexity and reduce the risk of cascading changes that can affect the overall system.

- **Generalization:** A generalization is a relationship between a parent class (superclass) and a child class (subclass). In this, the child class is inherited from the parent class, allowing it to acquire the properties and behaviors of the superclass. This relationship promotes code reusability and establishes a hierarchy that can be useful for organizing similar classes and managing shared functionality.

- **Association:** Association describes a static or physical connection between two or more objects, depicting how many objects are involved in the relationship. It can be one-to-one, one-to-many, or many-to-many, reflecting the multiplicity of the interaction. Additionally, associations can be bi-directional or uni-directional, depending on whether one or both classes are aware of the relationship between them.

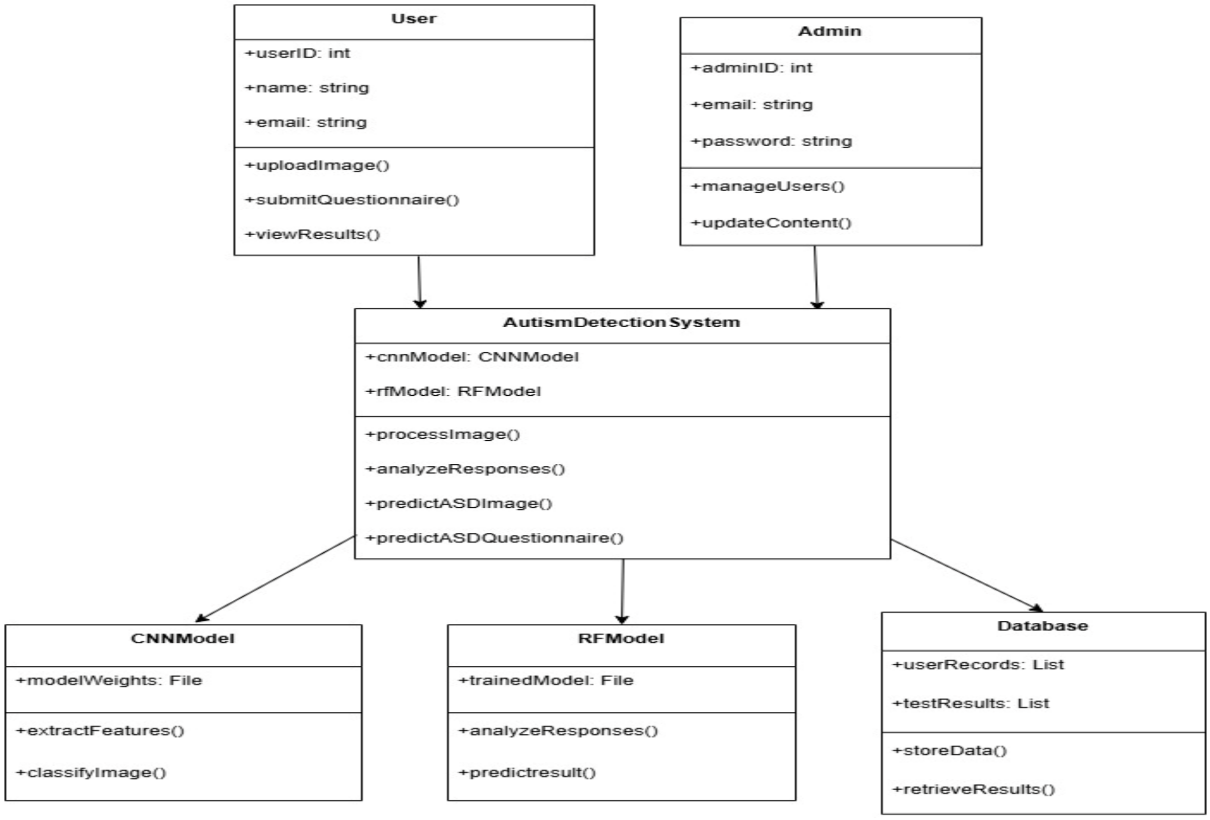


Fig:4- Class Diagram

7.4 Use Case Diagram

A use case diagram is a visual representation of the interactions that take place among the components of a system. Use case methodology is utilized in system analysis to define, explain, and structure system requirements. The term "system" refers to something that is either being developed or already in operation. UML, a commonly used notation for modeling real-world objects and systems, incorporates use case diagrams.

use case diagram contains four components:

• The boundary defines the system of interest in relation to the world around it, visually representing what is included within the system and what lies outside.

- Actors are individuals or external systems that interact with the system, defined according to their roles.
- Use cases describe the specific interactions or functionalities provided by the system to the actors.
- Relationships illustrate how actors are connected to use cases, showing the interactions between them.

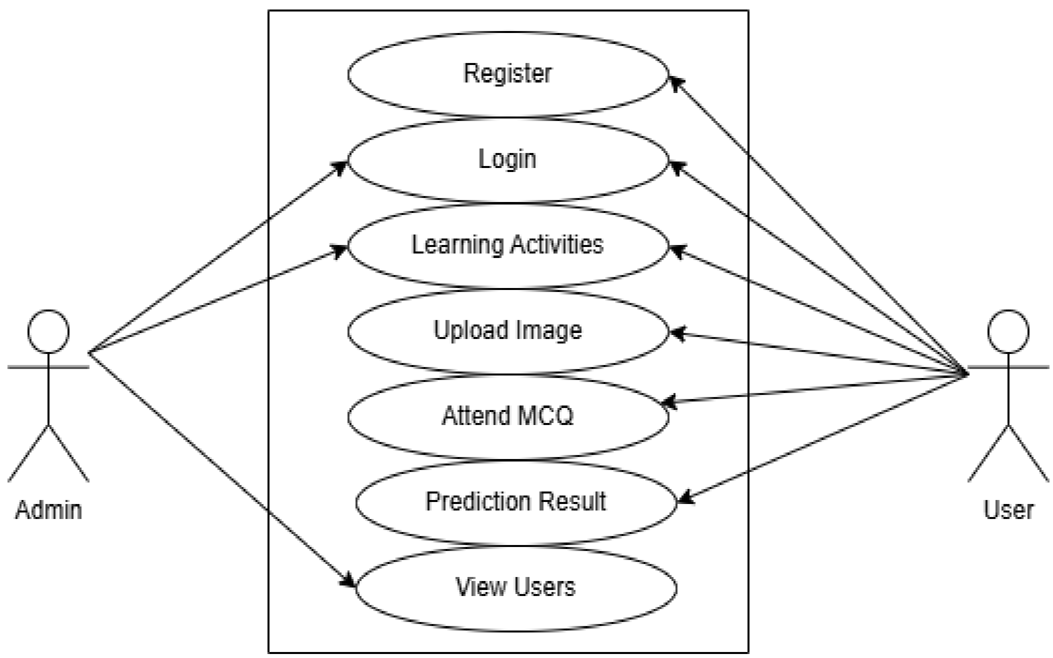


Fig:5 - Use Case Diagram

CHAPTER 8

TESTING

The testing phase plays a crucial role in ensuring that the ASD detection system functions as expected for different users, including parents, caregivers, and healthcare professionals. It is essential to maintain high accuracy, usability, and security while validating the system's performance across various conditions. The testing process involves multiple stages, each designed to assess different aspects of the system, including individual components, module interactions, performance under diverse conditions, and real-world usability.

8.1 Types of Testing

1. Unit Testing

Unit testing focuses on verifying the functionality of each individual module in isolation. The key modules tested include:

- **Facial Feature Analysis Module:**
    - Ensures that the CNN model with transfer learning using VGG19 accurately extracts facial features associated with ASD.
    - Verifies that the system correctly processes images of children under varying conditions such as lighting differences, occlusions, and facial expressions.
- **Questionnaire Processing Module:**
    - Validates that the Random Forest model correctly classifies responses to ASD-related questions.
    - Ensures that incomplete or ambiguous responses do not lead to incorrect classifications.
- **User Interface (UI) Components:**
    - Checks that the web application provides smooth and intuitive interactions for different users.
    - Verifies form submissions, image uploads, and the display of results.
- **Learning & Activity Modules:**

  - Ensures that additional activities like letter and number recognition, basic mathematical exercises, and video-based learning are functioning properly.
  - Validates that the system correctly tracks user engagement with these activities.

2.Integration Testing

Once individual modules are verified, integration testing ensures that all components work together seamlessly. This phase evaluates:

- **Data Flow Between Modules:**
  - Verifies that facial images are correctly processed and fed into the CNN model.
  - Checks whether questionnaire responses are properly analyzed and integrated into the final classification.
- **Inter-module Communication:**
  - Confirms that results from both the facial analysis and questionnaire-based assessment are accurately combined for a final ASD probability score.
  - Ensures that different components, such as the ASD detection module, learning activities, and user dashboards, function cohesively.
- **Edge Case Handling:**
  - Tests system behavior with low-quality or unclear facial images to check robustness.
  - Evaluates the handling of partial or incorrect questionnaire submissions.

3.PerformanceTesting

Performance testing is essential to assess the system's effectiveness under real-world conditions. It evaluates:

- **Facial Recognition Under Various Conditions:**
  - Tests images with different lighting, angles, facial expressions, and partial occlusions.
  - Ensures that the CNN model maintains reliable performance across diverse datasets.

- **Questionnaire-Based Classification Across Demographics:**
  - Analyzes responses from different age groups, backgrounds, and cognitive abilities.
  - Ensures consistency in classification, minimizing biases or misinterpretations.
- **System Response Time:**
  - Measures the time taken for image processing, feature extraction, questionnaire evaluation, and final result generation.
  - Ensures minimal delay in providing ASD probability scores and recommendations.
- **Accuracy and Error Rate Analysis:**
  - Evaluates false positive and false negative rates to minimize incorrect classifications.
  - Identifies areas for improving model performance, such as refining feature extraction or dataset expansion.

4.Real-TimeTesting

The final phase involves evaluating the system in real-world scenarios with actual users. This phase includes:

- **Live Testing with Parents, Caregivers, and Healthcare Professionals:**
  - Observes user interactions to ensure the system is intuitive and easy to use.
  - Collects feedback to refine the UI, result interpretation, and usability.
- **Testing in Realistic Settings:**
  - Evaluates performance in different environments, such as homes, clinics, and schools.
  - Ensures that users can upload images and complete questionnaires without technical issues.
- **Behavioral Observation Analysis:**
  - Assesses how children respond to engagement activities (letter and number recognition, reading/listening tasks, and video content).
  - Monitors user engagement patterns to improve learning module effectiveness.
- **Error and Accuracy Refinement:**
  - Reviews system performance based on real-time feedback to adjust thresholds, improve detection algorithms, and enhance overall reliability.

CHAPTER 9

ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

1. Early Detection for Timely Intervention:

The system enables early identification of Autism Spectrum Disorder (ASD) in children by analyzing facial features and behavioral patterns. By detecting ASD-related traits at an early stage, the system helps parents, caregivers, and healthcare professionals intervene sooner, allowing for early therapy, personalized learning plans, and better long-term developmental outcomes.

2. Dual-Method Screening for Higher Accuracy:

By combining facial feature analysis (CNN with transfer learning using VGG19) and questionnaire-based assessment (Random Forest model), the system offers a comprehensive approach to ASD detection. This hybrid method improves classification accuracy, reducing the chances of false positives and false negatives compared to using a single approach.

3. Accessible and Cost-Effective:

As a web-based solution, the system is easily accessible from anywhere, eliminating the need for expensive clinical visits for initial ASD screenings. Parents and caregivers can use the platform at their convenience, making ASD detection more widely available, especially in remote or underserved areas where specialized healthcare services may be limited.

4. Cognitive and Learning Support:

Beyond detection, the system provides engaging activities such as letter and number recognition, reading and listening exercises, and mathematical problem-solving to assess cognitive abilities and learning patterns. Additionally, carefully selected video content fosters creativity, social engagement, and skill development in children with ASD.

DISADVANTAGES:

1. **Dependence on Image Quality:**

   The accuracy of facial feature analysis depends on the clarity of the images provided. Low-resolution images, poor lighting conditions, or facial obstructions (such as hair or accessories) may affect the model's ability to correctly identify ASD-related facial patterns. Ensuring high-quality image inputs is essential for reliable detection.

2. **Computational Resources:**

   Processing facial images and running deep learning models require significant computational power. As the system scales up, incorporating real-time video analysis for behavioral assessment may demand higher processing capacity, cloud-based infrastructure, or dedicated servers. This could increase the overall cost of deployment, particularly for large-scale use.

3. **Variability in Behavioral Assessment:**

   While the questionnaire-based evaluation provides a structured approach to assessing ASD-related traits, responses may sometimes be subjective. Differences in how parents or caregivers interpret questions can introduce variability in results. Refining the questionnaire with clinically validated questions and continuous improvement through real-world testing can help enhance accuracy.

4. **Environmental and External Factors:**

   Factors such as different facial expressions, emotional states, or cultural variations in facial features may influence the accuracy of facial analysis. Additionally, children's cooperation during image capture can impact the quality of inputs. In some cases, supplementary behavioral tests or professional clinical assessments may be necessary for a more definitive diagnosis.

CHAPTER 11

RESULTS AND CONCLUSIONS

Results:

This study demonstrates the effectiveness of integrating deep learning and machine learning techniques for early Autism Spectrum Disorder (ASD) detection. By utilizing Convolutional Neural Networks (CNN) with transfer learning using VGG19 for facial image analysis and Random Forest for questionnaire-based assessment, the system ensures a structured and accurate screening process. This dual-method approach enhances objectivity compared to traditional ASD diagnostic methods, which often rely on subjective evaluations.

Additionally, the system incorporates interactive learning activities to support cognitive and social development in autistic children. Features such as letter and number recognition, arithmetic exercises, reading and listening assessments, and carefully curated video content provide an engaging environment for skill enhancement. These activities serve not only as a means of assessing cognitive abilities but also as an educational tool to aid in learning and development.

The evaluation results indicate that the proposed system enhances diagnostic efficiency, reducing the dependency on subjective assessments. By integrating facial feature analysis and questionnaire-based screening, the system minimizes the risk of misclassification and ensures a more comprehensive ASD detection process. The inclusion of interactive learning features further distinguishes the platform from conventional screening tools, offering an additional educational and developmental component.

Preliminary testing results suggest that the engagement-based activities encourage user participation and may contribute to cognitive and linguistic skill development over time. The web-based interface enhances accessibility, enabling parents, caregivers, and healthcare professionals to conduct ASD screenings conveniently. By allowing active participation in the screening process, the system fosters early awareness and promotes timely interventions.

Future improvements, such as expanding the dataset to include more diverse facial features and refining model training, could enhance the system's adaptability across different age groups and demographic backgrounds. Additionally, incorporating real-time behavioral analysis through video processing could further refine the assessment process, making it even more accurate and adaptive to individual cases.

Conclusion:

In conclusion, this study highlights the potential of AI-driven ASD detection systems in improving early diagnosis, enhancing accessibility, and supporting developmental learning for autistic children. By integrating deep learning-based facial analysis with machine learning-driven behavioral assessments, the proposed system provides a more efficient, objective, and scalable alternative to traditional ASD screening methods.

The inclusion of engagement-based learning activities adds significant value by offering a dual-purpose platform that supports both ASD detection and cognitive development. This feature sets the system apart, ensuring that it is not just a diagnostic tool but also a supportive learning resource for children with ASD.

The findings indicate that AI-powered ASD screening tools can help bridge the gap between early detection and timely intervention. The system's automated nature reduces dependence on specialized healthcare professionals, making early diagnosis more accessible to a wider population, including underserved communities.

Future advancements, such as enhancing model accuracy through larger, more diverse datasets, integrating real-time video-based behavioral tracking, and expanding screening capabilities to mobile applications, could further improve system performance and usability. Additionally, incorporating speech analysis and advanced behavioral tracking could enhance diagnostic precision by providing a multi-modal approach to ASD assessment.

By continuously refining AI models and incorporating user feedback, the system can adapt to different populations and accommodate variations in ASD symptom presentation. The integration of artificial intelligence in ASD detection and learning support has the potential to revolutionize early intervention efforts, promoting inclusive, timely, and accessible healthcare solutions.

Output:

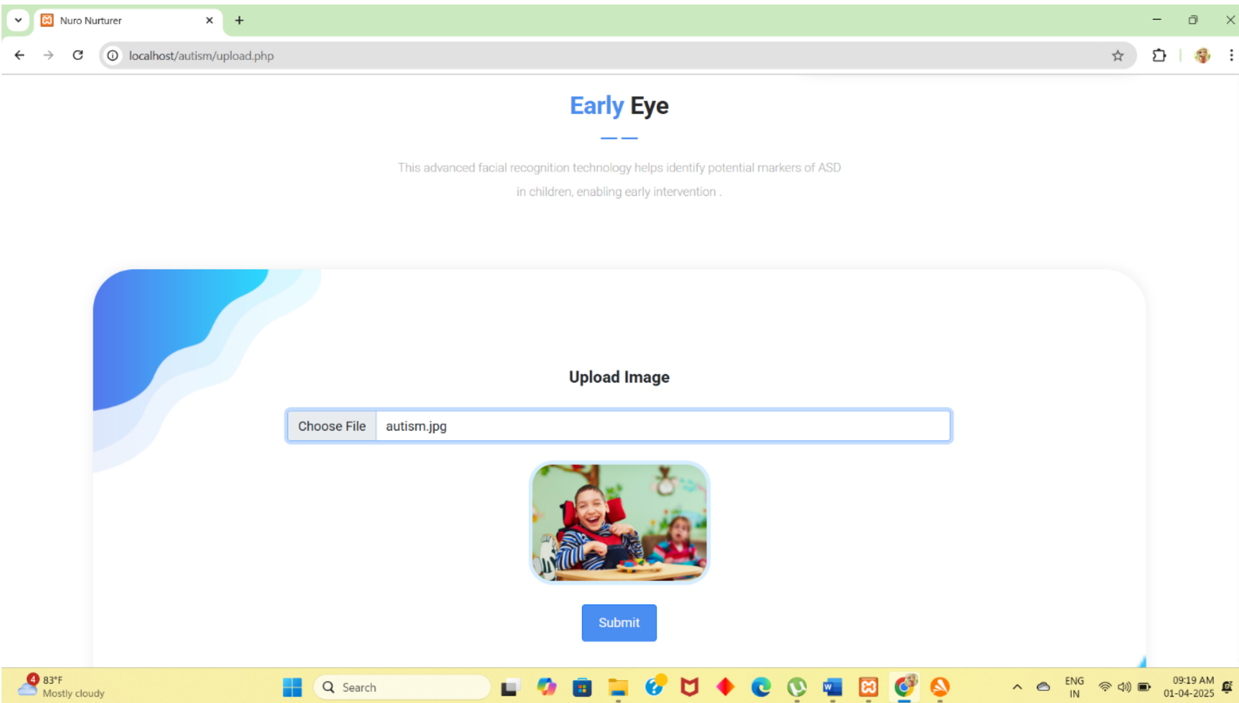


Fig:6- Facial Analysis

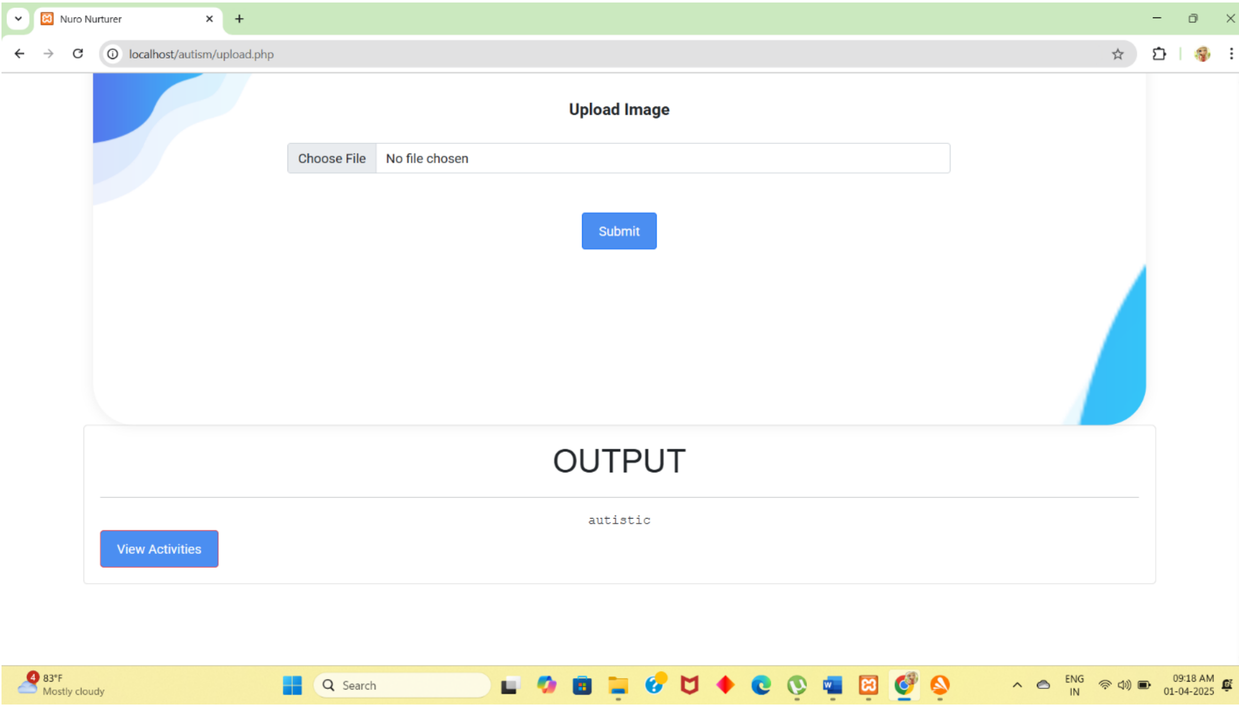


Fig:6.1- Autistic

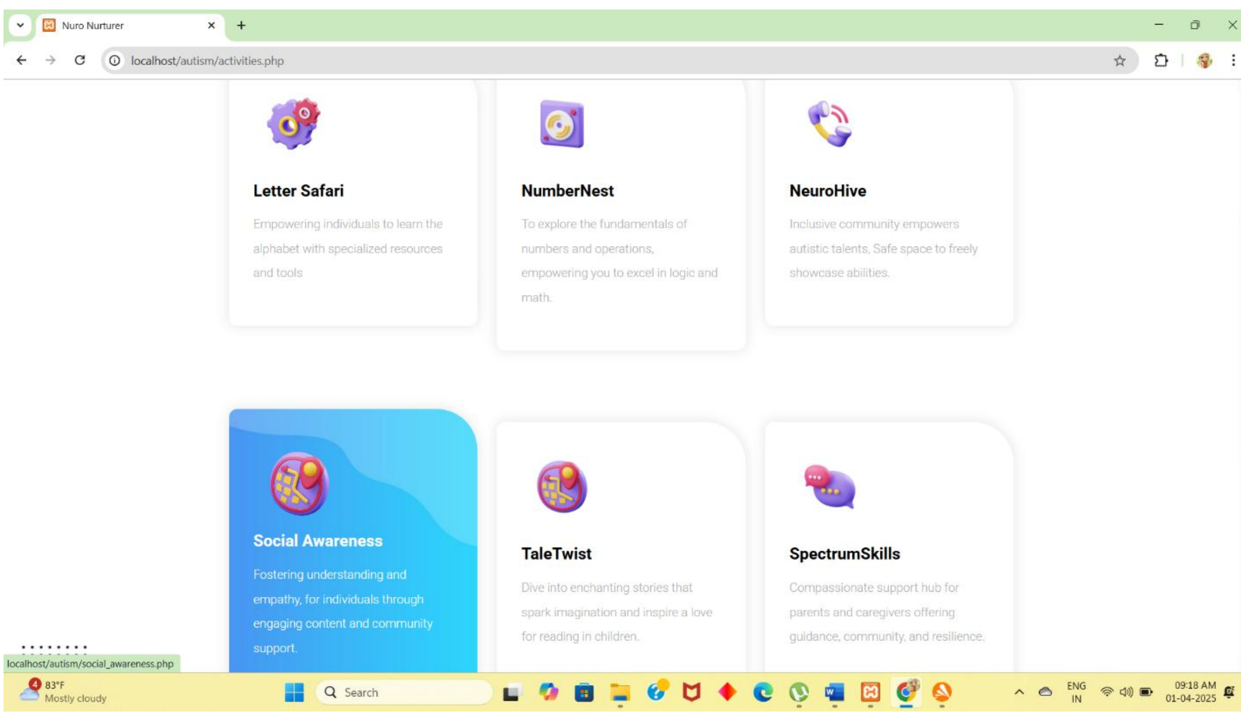


Fig:6.2- Learning Activities

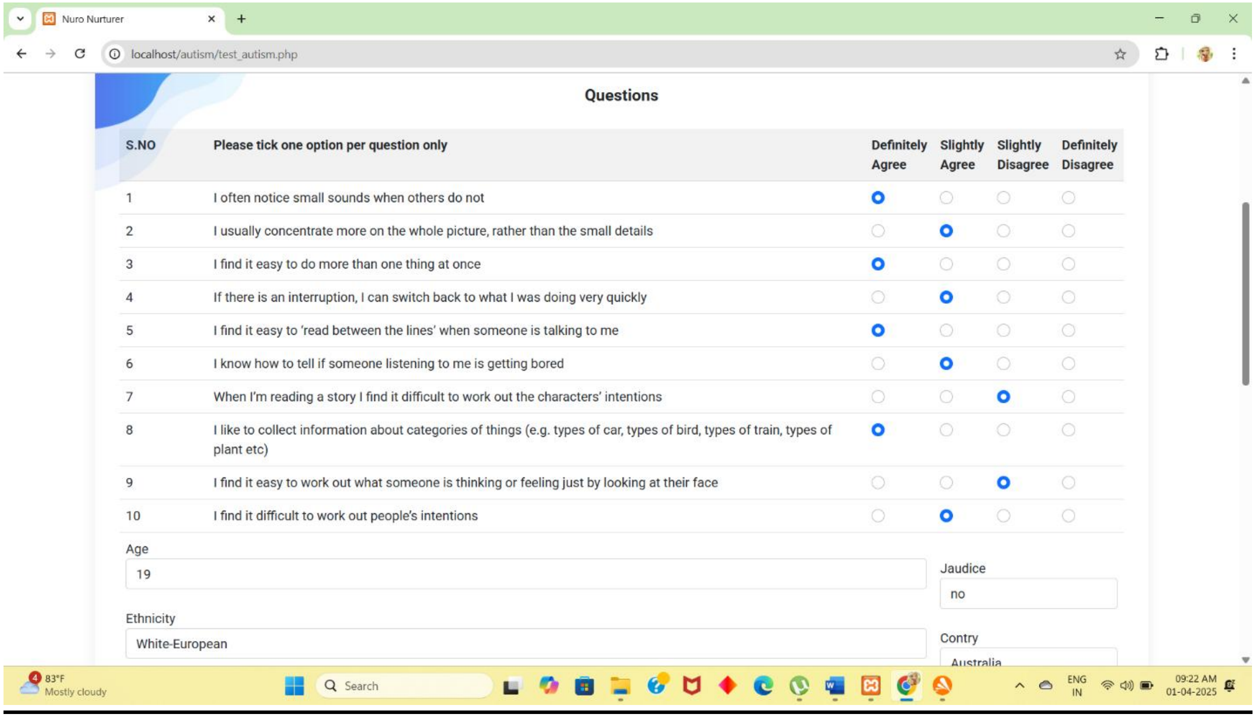


Fig:6.3- Questionnaire Analysis

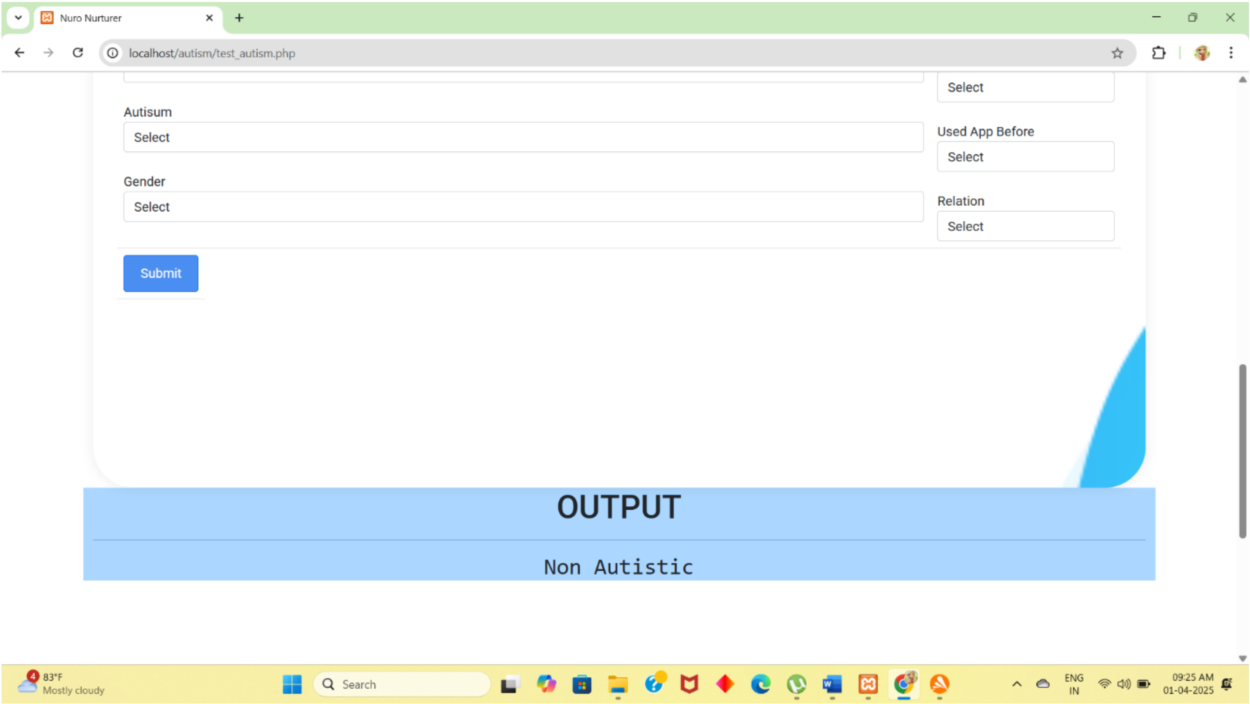


Fig:6.4- Non Autistic

CHAPTER 12

APPENDICES

upload.php

```
<?php
include("header.php");
?>
<div id="pricing" class="pricing-tables">
  <div class="container">
    <div class="row">
      <div class="col-lg-8 offset-lg-2">
        <div class="section-heading">
          <h4><em>Early</em> Eye</h4>
          <img src="assets/images/heading-line-dec.png" alt="">
          <p>This advanced facial recognition technology helps identify potential markers of ASD
            in children, enabling early intervention .</p>
        </div>
      </div>
<div class="col-lg-12">
  <div class="pricing-item-pro">
    <h4>Upload Image</h4>
    <form id="imageUploadForm" method="post" enctype="multipart/form-data">
      <div class="row">
      <div class="col-lg-8 offset-lg-2">
```

```
        <input type="file" name="uploadedfile" id="imageInput" class="form-control"
accept="image/*" onchange="previewImage(event)" placeholder="Username">

       </div>

      </div>

      <br>

      <div id="imagePreview" style="display: none;"></div>

      <br>

      <input type="submit" name="submit" value="Submit" class="btn btn-primary">

    </form>

    <br><br><br><br>

  </div>

</div>

<script>

  function previewImage(event) {

    var reader = new FileReader();

    reader.onload = function() {

      var output = document.getElementById('imagePreview');

      output.style.display = 'block';

      output.innerHTML = '<img src="' + reader.result + '" style="max-width:224px; max-
height:224px; border: 5px solid #D5EEFF; border-radius: 30px;">';

    };

    reader.readAsDataURL(event.target.files[0]);

  }

</script>
```

```
<?php
set_time_limit(0);
include('connection.php');
$target_path="test/test.png";
$target_path = $target_path;
if(move_uploaded_file($_FILES['uploadedfile']['tmp_name'], $target_path)) {
  echo "<br>";
  //$python = `python averaging_predictor.py`;
  //echo "<pre>".$python."</pre>";
  $python1 = "C:\\Users\\lalps\\AppData\\Local\\Programs\\Python\\Python38\\python.exe";
  $file = "C:\\xampp\\htdocs\\autism\\averaging_predictor.py";
  $python=exec($python1 . " " . $file);
  //echo $python;
  echo "<div class='col-lg-12 col-md-12 well' style='background-color:white; padding:
20px; border: 1px solid #ddd; border-radius: 5px;'>
  <center><h1 style='margin-bottom: 20px; font-family: Arial, sans-
serif;'>OUTPUT</h1><hr>
  <pre style='font-family: Courier, monospace; font-size:
16px;'>".$python."</pre></center>";
  if($python=='autistic')
  {
    echo "<a href='activities.php' class='btn btn-danger'>View Activities</a>";
    $date=date('Y-m-d');
```

```
          mysqli_query($con,"insert into result(user_id,result,date) Values
('$_SESSION[uid]','$python','$date')");

         }

         echo"</div>";

        }

        ?>

      </div>

    </div>

  </div>

  <?php
include("footer.php");
?>
```

detection.php

```
<?php
include('header.php');
include('connection.php');
?>

  <!-- ***** Header Area End ***** -->

  <div id="services" class="services section">

    <div class="container">

      <div class="row">

        <div class="col-lg-8 offset-lg-2">
```

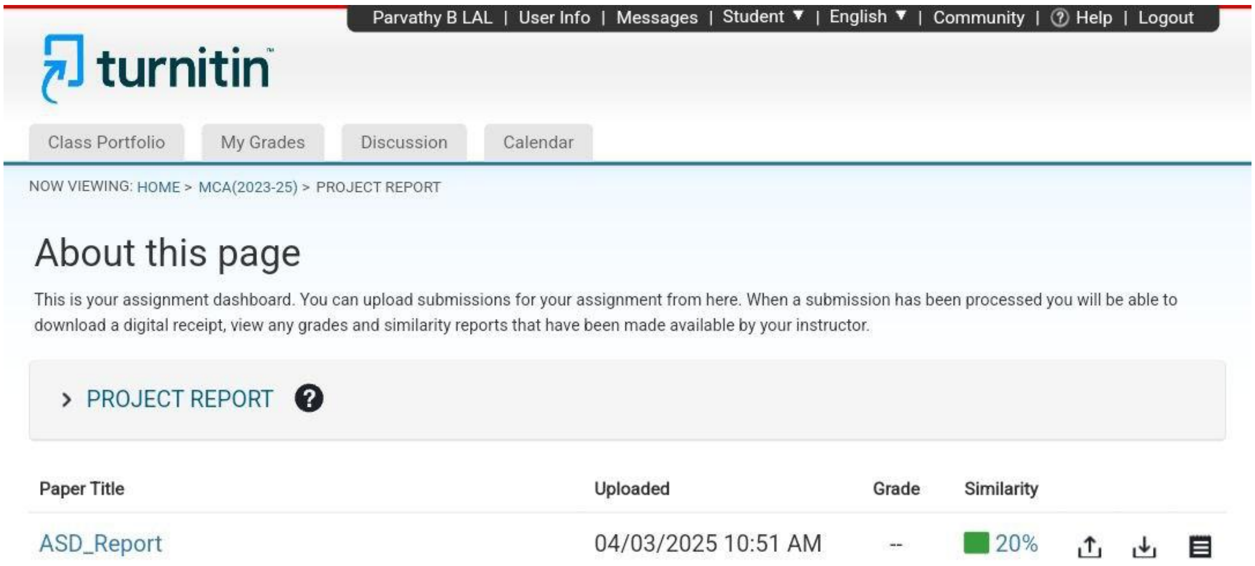
```
        <div class="section-heading  wow  fadeInDown"  data-wow-duration="1s"  data-wow-delay="0.5s">
        <h4><em>Early</em>Eye</h4>
        <p> Revolutionizing Autism Detection: Using advanced AI, our platform analyzes facial images and questionnaire responses
        to identify potential signs of autism early on, enabling timely intervention and support.</p>
        <img src="assets/images/heading-line-dec.png" alt="">
      </div>
    </div>
  </div>
  <div class="container">
    <div class="row justify-content-center"> <!-- Added justify-content-center class here -->
      <div class="col-lg-3">
        <a href="upload.php"style="color: black;">
          <div class="service-item second-service_uploadimg">
          <div class="icon"></div>
            <h4>Upload Image</h4>
            <p> Facial feature analysis for early autism detection.</p>
            <div class="text-button"></div>
          </div>
        </a>
      </div>

      <div class="col-lg-3">
```

```
      <a href="test_autism.php" style="color: black;">
       <div class="service-item second-service_question">
       <div class="icon"></div>
        <h4>Attend the Test</h4>
        <p> Identifying autism through questionnaire analysis.</p>
        <div class="text-button"></div>
       </div>
      </a>
     </div>
    </div>
   </div>
  </div>
 </div>
<?php
include('footer.php');
?>
```

CHAPTER 13

REFERENCES

1. M. Bala, M. H. Ali, M. S. Satu, K. F. Hasan, and M. A. Moni, “Efficient machine learning models for early-stage detection of autism spectrum disorder,” *Algorithms*, vol. 15, no. 5, p. 166, May 2022.
2. D. Pietrucci, A. Teofani, M. Milanesi, B. Fosso, L. Putignani, F. Messina, G. Pesole, A. Desideri, and G. Chillemi, “Machine learning data analysis highlights the role of gut microbiota in autism spectrum disorders,” *Biomedicines*, vol. 10, no. 8, p. 2028, Aug. 2022.
3. A. Ahmed, E. M. Senan, T. H. Rassem, M. A. H. Ali, H. S. A. Shatnawi, S. M. Alwazer, and M. Alshahrani, “Eye tracking-based diagnosis and early detection of autism spectrum disorder using machine learning and deep learning techniques,” *Electronics*, vol. 11, no. 4, p. 530, Feb. 2022.
4. F. Z. Subah, K. Deb, P. K. Dhar, and T. Koshiba, “A deep learning approach to predict autism spectrum disorder using multisite resting-state fMRI,” *Appl. Sci.*, vol. 11, no. 8, p. 3636, Apr. 2021.
5. K.-F. Kollias, C. K. Syriopoulou-Delli, P. Sarigiannidis, and G. F. Fragulis, “The contribution of machine learning and eye-tracking technology in autism spectrum disorder research: A systematic review,” *Electronics*, vol. 10, no. 23, p. 2982, Nov. 2021.
6. 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,” in Proc. Int. Conf. Electr., Comput. Commun. Eng. (ECCE), Feb. 2019, pp. 1–6.


Parvathy B LAL | User Info | Messages | Student ▼ | English ▼ | Community | ? Help | Logout
turnitin
Class Portfolio
My Grades
Discussion
Calendar
NOW VIEWING: HOME > MCA(2023-25) > PROJECT REPORT
About this page
This is your assignment dashboard. You can upload submissions for your assignment from here. When a submission has been processed you will be able to download a digital receipt, view any grades and similarity reports that have been made available by your instructor.
PROJECT REPORT
Paper Title
Uploaded
Grade
Similarity
ASD_Report
04/03/2025 10:51 AM
--
20%

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Parvathy B LAL
Assignment title:	PROJECT REPORT
Submission title:	ASD_Report
File name:	ASD_Report.docx
File size:	2.3M
Page count:	62
Word count:	10,633
Character count:	69,203
Submission date:	03-Apr-2025 05:21AM (UTC+0000)
Submission ID:	2633718752

PROJECT REPORT

On

NEURO NURTURER

Submitted in partial fulfilment for the award of degree

of

Master of Computer Applications

By

PARVATHY B LAL

MLM23MCA-2036

Under the Guidance of

MS. DIVYA S.B

(HOD & Associate Professor, Dept. of Computer Applications)

DEPARTMENT OF COMPUTER APPLICATIONS

MANGALAM COLLEGE OF ENGINEERING, ETTUMANOOR

(Affiliated to APJ Abdul Kalam Technological University)

NOVEMBER 2024