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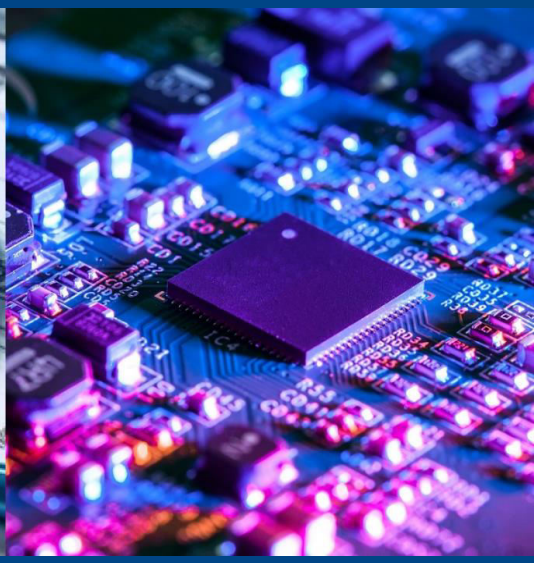

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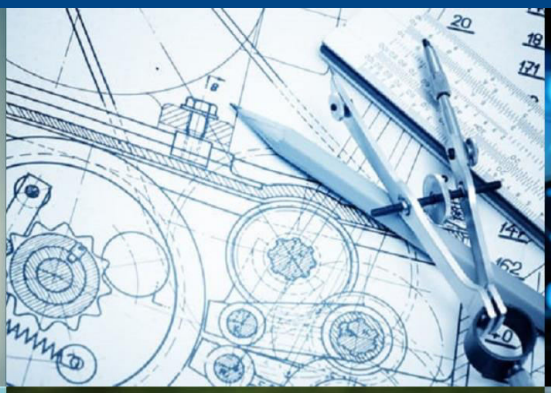

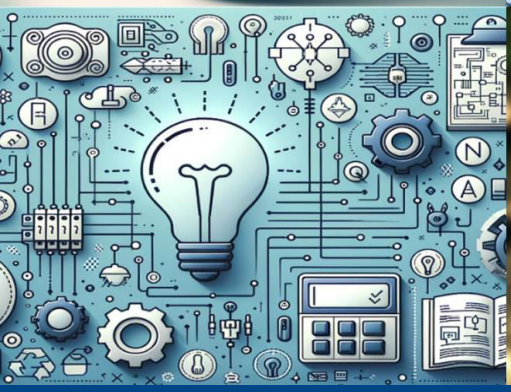

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Predicting Behavioral Challenges in Autism Spectrum Disorder in Children using Machine Learning

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ABSTRACT: Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that affects the behaviour of children. Early identification of ASD symptoms can help in timely intervention and improved support for individuals and their families. This study aims to develop a machine learning model to predict behavioral challenges in children with ASD based on survey responses. The model analyzes key behavioral traits such as eye contact, social engagement, and repetitive behaviors, while also incorporating additional factors like age and nationality to improve prediction accuracy. The output categorizes severity levels into high, medium, and low, enabling caregivers and professionals to understand the child's needs better. Furthermore, the project integrates a Generative AI module to provide personalized suggestions and support strategies based on the prediction results. To enhance accessibility, a chatbot is incorporated to answer ASD-related queries, offering parents and caregivers a reliable source of information. This project seeks to bridge the gap between early ASD detection and accessible guidance, fostering better awareness and assistance for affected individuals..

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that affects childrens behavior. Symptoms typically become noticeable through behavioral changes as early as 18 months of age. With the global prevalence of ASD on the rise, early detection and timely intervention are crucial for improving the quality of life for individuals with ASD and their families. While clinical diagnosis requires professional assessment, advancements in artificial intelligence and machine learning have provided new opportunities for identifying behavioral patterns associated with ASD more efficiently.This project focuses on developing a predictive model that analyzes key behavioral traits such as eye contact, responsiveness, and social interactions using survey-based inputs. To enhance the model's accuracy, additional demographic factors such as age, nationality, and specific symptoms are incorporated. The model categorizes individuals into three severity levels—high, medium, or low—helping caregivers, educators, and healthcare professionals better understand the potential level of support required for each child.Beyond prediction, the project integrates a Generative AI module to provide personalized recommendations based on the severity classification. These tailored suggestions aim to assist parents and educators in making informed decisions regarding therapy, intervention strategies, and daily support. Additionally, a chatbot is included to address common ASD-related concerns, offering instant, reliable information and guidance.By combining predictive analytics, AI-driven recommendations, and an interactive chatbot, this project aims to bridge the gap between early ASD detection and accessible support systems. The ultimate goal is to empower caregivers with actionable insights, raise awareness about ASD, and facilitate better-informed decision-making for the well-being of affected individuals.

II. LITERATURE REVIEW

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by social, communication, and behavioral challenges. Early diagnosis and intervention are critical for managing ASD symptoms effectively. Traditional diagnostic tools such as the Autism Diagnostic Observation Schedule (ADOS) and the Autism Spectrum Quotient (AQ) have been widely used, relying on behavioral indicators such as poor eye contact, repetitive behaviors, and restricted interests **(Baron-Cohen et al., 2001; Lord et al., 2020**). However, manual assessments are time-consuming, subjective, and require specialized expertise. Recent advancements in machine learning and artificial intelligence (AI) have led to

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the development of predictive models for ASD diagnosis and severity assessment, enabling faster and more objective evaluations.

Machine Learning in ASD Prediction

Several researchers have explored the use of machine learning algorithms to predict ASD using behavioral and demographic data**. Thabtah et al. (2019**) applied decision trees, support vector machines (SVM), and deep learning models to classify ASD cases, achieving high accuracy in early detection. Similarly, **Duda et al. (2017)** used machine learning to analyze social behavior patterns, reporting over 85% classification accuracy. Additionally, natural language processing (NLP) has been used to analyze speech and text patterns in individuals with ASD, providing insights into communication deficits **(Bone et al., 2015**).

Relevance to Current Research:

The current study builds upon this work by incorporating additional behavioral factors such as eye contact, repetitive movements, and social engagement to enhance ASD severity prediction. By leveraging machine learning, the model aims to improve diagnostic accuracy and early detection rates.

Expanding Input Variables for Better Prediction

Existing ASD prediction models often rely on limited datasets, focusing primarily on behavioral responses and demographic information**. Anzulewicz et al. (2016**) introduced motor pattern analysis using touchscreen interactions as predictive markers for ASD, demonstrating promising results. **Jaswal & Akhtar (2018**) examined environmental factors such as parental education and early childhood interventions, highlighting their impact on ASD severity.

Relevance to Current Research:

The current research expands on these findings by integrating additional input variables, including nationality, age, and early childhood symptoms. This comprehensive approach enhances the predictive power of the model, making it more adaptable across diverse populations.

Integration of AI for Personalized Recommendations

Recent advancements in AI have enabled the development of intelligent systems that provide personalized recommendations for ASD management. AI-driven chatbots and recommendation systems have been implemented to assist parents in understanding and addressing their child's behavioral challenges (**Shic et al., 2017**). Deep learning models have also been used to analyze facial expressions, eye-tracking data, and physiological responses, further refining ASD diagnosis (**Liu et al., 2020**).

Relevance to Current Research:

This study incorporates AI-driven recommendations based on ASD severity levels. By analyzing survey responses, the system provides tailored suggestions for behavioral interventions, bridging the gap between diagnosis and actionable support for parents.

Digital Health and Chatbot Integration for ASD Support

With the rise of telemedicine and digital health solutions, chatbot-based systems have been explored to assist caregivers and professionals in ASD diagnosis and management. Research by **Kumazaki et al. (2019)** demonstrated the effectiveness of AI chatbots in engaging ASD individuals and providing therapeutic guidance. Additionally, virtual assistants have been developed to answer common ASD-related questions, improving access to information for parents and caregivers.

Relevance to Current Research:

This study aims to develop a chatbot that answers ASD-related queries based on a dataset of frequently asked questions. The integration of a chatbot into the ASD prediction website enhances user experience, providing instant responses and educational resources to parents.

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No.	Paper Title	Author Name	Key Points	Remark
1	Machine Learning for Autism Detection	Thabtah et al., 2019	Used decision trees, SVM, and deep learning for ASD classification. Achieved high accuracy in early detection.	Enhances predictive accuracy using machine learning models.
2	Behavior-Based ASD Prediction Using AI	Duda et al., 2017	Analyzed social behavior patterns, achieving over 85% classification accuracy.	Used to protect data confidentiality by assisting deletion of related content, where the user is presented with files that should be securely deleted together.
3	Motor Patterns as ASD Predictors	Anzulewicz et al., 2016	Used touchscreen interactions as predictive markers for ASD.	Virtual machines that are present on a physical system or running on a portable storage device can be detected or analyzed.
4	AI-Driven Chatbots for ASD Support	Kumazaki et al., 2019	Developed chatbots for ASD diagnosis and support.	Use less computational power and processing time.

III. METHODOLOGY OF PROPOSED SURVEY

3.1. Data Collection

3.1.1. Source of Data

The study will utilize:

- **Publicly Available ASD Datasets**: Datasets from repositories such as the UCI Machine Learning Repository, Kaggle, and autism research institutions.
- **Survey-Based Data Collection**: A structured questionnaire will be designed to collect responses from parents and caregivers regarding a child's behavioral traits, including:
  - **Eye Contact** (e.g., frequency and duration of eye contact).
  - **Repetitive Behaviors** (e.g., hand-flapping, echolalia).
  - **Social Interaction** (e.g., ability to respond to names, engagement in group activities).
  - **Communication Patterns** (e.g., delayed speech, unusual tone of voice).
  - **Demographic Details** (e.g., age, nationality, parental education level).

1.2. Inclusion Criteria

- Children aged **2 to 12 years** diagnosed or suspected of ASD.
- Parents/caregivers willing to participate and provide behavioral data.

3.2. Data Preprocessing

3.2.1. Data Cleaning

- **Handling Missing Values**: Missing responses will be imputed using statistical methods such as mean/mode imputation.
- **Removing Duplicates**: Duplicate records will be eliminated.

3.2.2. Feature Engineering

- **Encoding Categorical Variables**: Responses (e.g., "Often," "Rarely") will be converted into numerical values using label encoding.
- **Feature Scaling**: Normalization or standardization will be applied to ensure consistent data distribution.

3.2.3. Balancing the Dataset

- If the dataset is imbalanced (e.g., more mild cases than severe cases), oversampling (SMOTE) or undersampling techniques will be applied.

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3.3. Model Development

3.3.1. Machine Learning Algorithms

Several supervised learning models will be trained and evaluated:

- **Logistic Regression** (Baseline model).
- **Random Forest Classifier** (Handles non-linearity and feature importance).
- **Support Vector Machine (SVM)** (Effective for small, high-dimensional datasets).
- **Deep Learning (Neural Networks)** (For complex patterns in large datasets).

3.2. Model Training and Testing

- **Train-Test Split**: Data will be split into **80% training and 20% testing**.
- **Cross-Validation**: **K-Fold Cross-Validation** (k=5) will be applied to improve model generalizability.
- **Evaluation Metrics**:
  - Accuracy
  - Precision
  - Recall
  - F1-Score
  - ROC-AUC Score (to measure classification performance).

3.4. Integration of AI-Driven Recommendations

3.4.1. Severity Classification

- The model will classify ASD severity into **High, Medium, and Low** based on behavioral scores.

3.4.2. Personalized Recommendations

- An **AI-based recommendation system** will generate personalized interventions based on severity levels:
  - **Low Severity**: Suggest behavioral therapy, social skills training.
  - **Medium Severity**: Recommend speech therapy, sensory integration therapy.
  - **High Severity**: Suggest specialized ASD intervention programs and professional consultations.

3.5. Development of ASD Chatbot

3.5.1. Chatbot Architecture

- The chatbot will be developed using **Natural Language Processing (NLP)** with **Dialogflow or Rasa**.
- It will provide:
  - **Answers to ASD-related questions** (e.g., symptoms, interventions, therapy options).
  - **Guidance based on model predictions** (e.g., next steps after severity assessment).

3.5.2. Knowledge Base for Chatbot

- The chatbot will be trained using:
  - **Research-based ASD FAQs** (compiled from authoritative sources).
  - **Parents' common concerns** extracted from ASD forums and research.

3.6. Deployment and Testing

3.6.1. Web Application Development

- The model and chatbot will be integrated into a user-friendly web platform.
- **Technologies Used**:
  - **Frontend**: React.js or Astro
  - **Backend**: Node.js with Express
  - **Database**: PostgreSQL for storing user inputs and predictions

6.2. Performance Evaluation

- The deployed model's performance will be evaluated through **user feedback surveys**.
- The chatbot's response accuracy will be tested using a **dataset of ASD-related queries**.

7. Ethical Considerations

- **Informed Consent**: Participants will be informed about data usage.
- **Data Privacy**: User data will be anonymized and stored securely.
- **Bias Mitigation**: The dataset will be checked for biases to ensure fairness in predictions.

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IV. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a novel approach to predicting behavioral challenges in children with Autism Spectrum Disorder (ASD) using machine learning. The approach analyzes survey responses related to behavioral traits and classifies ASD severity into high, medium, or low levels. Additionally, we integrate an AI-driven recommendation system to provide personalized intervention strategies based on the predicted severity. A chatbot is also incorporated to assist caregivers by answering ASD-related queries and providing relevant guidance. The proposed system enhances early detection and intervention planning, making ASD management more accessible and efficient. Our future work includes expanding the dataset to improve model accuracy and generalizability. We also plan to integrate real-time behavioral analysis using computer vision techniques and wearable sensors to enhance prediction reliability. Furthermore, we aim to refine the chatbot's capabilities with advanced natural language processing (NLP) techniques and develop a mobile-friendly application for seamless access to ASD support resources.

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