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A Novel Method for Detection of Autism Spectrum Disorder using Machine Learning

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Abstract— Autism Spectrum Disorder (ASD) is a complex neurodevelopment condition that affects social interaction, communication, and behavior. Early diagnosis of ASD is crucial for providing timely interventions and support to affected individuals. In this project, we present a novel approach for the detection of ASD using machine learning techniques, implemented in Python. The Random Forest Classifier achieved remarkable results with a training accuracy score of 100% and a testing accuracy score of 99%. This indicates that the model can effectively learn from the training data and generalize well to unseen cases. The Decision Tree Classifier, while achieving a training accuracy score of 100%, maintained a testing accuracy score of 96%, showcasing robust performance. The dataset used in this project encompasses a comprehensive set of attributes, including sensory perception (A1_Score - A6_Score), cognitive abilities (A7_Score - A10_Score), age, gender, ethnicity, parental medical history (jaundice), autism diagnosis (autism), country of residence, prior app usage, and various demographic features.

Keywords— Autism Spectrum Disorder, Random Forest Classifier, Decision Tree Classifier

I. Introduction

Autism Spectrum Disorder, frequently called as ASD, is a complex neurodevelopment condition that influences how a person perceives and interacts with the world. ASD is characterized by wide range of symptoms and behaviors, and it is often described as a "spectrum" because the severity and manifestations of the disorder can vary significantly from person to person. This condition typically emerges in a early childhood and persists throughout a person's lifetime [1].

ASD is distinguished by challenges in three core areas:

Social Interaction: People with Autism Spectrum Disorder (ASD) often find it hard to pick up on social signals and respond accordingly. This can make it difficult for them to build and keep strong friendships and connections. They may struggle with the interpreting emotions, maintaining eye contact, and engaging in reciprocal conversations.

Communication: Impaired communication is a hallmark of ASD. This can manifest as delayed speech development, limited vocabulary, difficulty with non-verbal communication (such as gestures and facial expressions), and a tendency to engage in repetitive language patterns or echolalia.

Repetitive Behaviors and Interests: Individuals with ASD may exhibit repetitive or restrictive behaviors, such as intense interests in specific topics, a preference for routines and sameness, and repetitive movements or gestures. These behaviors can serve as a source of comfort or self-regulation for some individuals.

Autism Spectrum Disorder (ASD) is quite common, affecting a large number of individuals. In the United States alone, it's calculated that approximately 1 out of every 54 children is diagnosed with ASD, making it one of the most widespread neurodevelopment conditions. The condition affects individuals of all backgrounds, regardless of race, gender, or socioeconomic status. Diagnosing ASD involves a comprehensive assessment that considers a person's behavior, developmental history, and communication skills. Early diagnosis and intervention are crucial, as they

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can lead to improved outcomes and the standard of living for people with ASD [1][4].

The causes of ASD are multifactorial and still the subject of ongoing research. Genetic, environmental, and neurobiological factors are thought to have a role in the disorder's development. Despite the difficulties connected to ASD, a large number of people with the condition have distinct advantages and skills that can be harnessed and celebrated.

Understanding ASD and advancing research and interventions in this field are critical in providing support and enhancing the lives of individuals with autism. This introduction provides a broad overview of the condition [1], setting the stage for a deeper exploration of its characteristics, diagnosis, treatments, and the ongoing efforts to improve the well-being of those living with ASD.

1.2 Background

Without explicit programming, "machine learning" is a set developing algorithms for computers that can learn from examples via means of personal development. One area of artificial intelligence called machine learning, forecasts an output using data and statistical techniques so that useful insights can be obtained.

The breakthrough is the notion that a machine can autonomously learn from the data (i.e., example) to provide accurate results [3]. The field of machine learning is closely associated with Bayesian predictive modeling and data mining. After the machine receives the data as input, it uses an algorithm to generate the replies.

Creating suggestions is a typical machine learning challenge. Every movie or television show that is suggested to Netflix subscribers is based on their past usage [2]. Tech businesses are utilizing personalized recommendations and unsupervised learning to enhance user experience.

The brain that does all of the education is machine learning. Machine learning is comparable to human learning. People pick up lessons from their experiences. Our ability to foresee it gets easier as we get more knowledge. By comparison, our chances of success are lower in an unknown scenario than in a known one. The similar method is used to train machines. The machine sees an illustration to help produce an accurate forecast. The machine can determine the result when we offer it another example that is similar. But much like a human, the machine finds it difficult to forecast if it is fed an example that hasn't been seen before.

Inference and learning are the main goals of machine learning. Initially, the machine gains knowledge by spotting trends. The data was used to make this discovery. Selecting the right data to feed the machine is an essential skill for a data scientist [3]. A list is a feature vector of characteristics that are employed to address an issue. A vector of features can be conceptualized as a portion of the data that is utilized to address an issue.

1.8 Problem Statement.

ASD is a complex neurodevelopment illness defined by repetitive activities, communication, difficulty with social interaction. Early diagnosis of ASD is essential for starting effective interventions on time, which can greatly enhance the quality of life and developmental outcomes for those with the disorder. However, the subjective nature, length of time, and need for specialized clinical skill of traditional diagnostic procedures for ASD can cause delays in diagnosis and unpredictability in the results of the diagnostic process.

The current diagnostic practices face several key challenges:

Subjectivity and Variability: Diagnoses are often based on clinical observations and subjective assessments, which can vary between clinicians

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and result in inconsistent diagnoses.

Resource Intensity: Comprehensive assessments involve lengthy procedures and multiple visits, which can be burdensome for families and strain healthcare resources.

Limited Access: Specialized diagnostic services may be inaccessible to individuals in remote or underserved areas, leading to disparities in early detection and intervention opportunities.

Research Objectives:

The primary aim of this thesis is to develop and evaluate machine learning (ML) models for the identification of Autism Spectrum Disorder (ASD) to improve the accuracy, efficiency, and accessibility of ASD diagnosis. The specific objectives are:

- **Identify and Preprocess Relevant Datasets:** Collect and prepare diverse datasets, including behavioral, neuroimaging, and genetic data, that are essential for ASD detection. Proper preprocessing ensures data quality and suitability for model training.
- **Develop Accurate ML Models:** Create ML models that can accurately detect ASD using the preprocessed datasets. This involves selecting suitable algorithms and fine-tuning their parameters to optimize performance.
- **Evaluate Model Performance:** Assess the models' performance using appropriate metrics, such as accuracy, sensitivity, and specificity, and validate their effectiveness by comparing them with traditional diagnostic methods.
- **Integrate Multiple Data Sources:** Investigate the combination of different types of data to enhance the robustness and accuracy of the diagnostic models. This integration aims to provide a more comprehensive and reliable approach to ASD detection.
- **Address Ethical and Practical Challenges:** Consider the ethical implications and practical issues related to deploying ML-based diagnostic tools in clinical settings. This includes ensuring patient privacy, minimizing biases, and developing guidelines for the responsible use of these tools.

II. Literature Survey

The proposed system for the identification of the ASD presents an innovative approach that addresses several key limitations observed in the existing system. This system makes use of Python-based machine learning models, including the Random Forest Classifier and the Decision Tree Classifier, to increase the precision and robustness of ASD detection. The recommended approach makes use of two distinct ML algorithms: the Random Forest Classifier and the Decision Tree Classifier. Several decision trees can be combined using the ensemble learning technique Random Forest to produce a very stable and accurate model. In contrast, the Decision Tree algorithm offers a straightforward and efficient method for classifying data.

The dataset used in the proposed system contains 704 records with the 21 features. These features encompass a wide range of the attributes, including medical history, demographics, cognitive abilities, sensory perception. Notably, the dataset is more extensive than that used in the earlier system, ensuring a more comprehensive analysis [37].

The dataset includes features related to the diagnosis of Autism Spectrum Disorder (ASD), such as sensory perception (A1_Score - A6_Score), cognitive abilities (A7_Score - A10_Score), demographic information (age, gender, ethnicity), medical history (jaundice), history of autism diagnosis (autism), place of residence, prior app usage, and other demographic attributes (Age_desc, Relation). An evaluation of people that is more comprehensive is made possible by this vast feature set [37].

The accuracy results of the suggested system have been very good. The Random Forest Classifier demonstrated its exceptional capacity to learn from the data and generalize by achieving a testing accuracy score of 99% and a training accuracy score of 100%. The Decision Tree Classifier demonstrated strong performance as it attained a testing accuracy score of 96% while retaining a training accuracy score of 100%.

The results of the suggested system have important therapeutic implications since they may help with the early identification of ASD and prompt intervention. It is essential to diagnose ASD children early on in order to support them and enhance their quality of life. [13]. The system's high accuracy underscores its potential in enhancing the diagnostic process for ASD.

In conclusion, the proposed system for ASD detection offers a promising approach to overcoming the limitations of the earlier system. It harnesses the power of Python-based machine learning models, a comprehensive dataset, and a rich feature set to achieve remarkable accuracy in diagnosing ASD. These aspects collectively position the proposed system as a useful tool for healthcare professionals working with ASD [38].

III. Challenges & Gape Analysis

- The existing system for the identification of ASD was developed using the Ada Boost (AB) machine learning algorithm and attained a remarkable accuracy percentage of 97.95%. This system represented a significant milestone in the application of machine learning to ASD diagnosis [1].
- The existing system harnessed the power of the Ada Boost (AB) algorithm, which is a popular ensemble learning technique. Ada Boost combines multiple weak learners to create an accurate and strong model. It excels in enhancing classification accuracy by focusing on the instances that were previously misclassified in an iterative manner.
- A standout feature of the earlier system was its exceptional accuracy rate of 97.95%. This high accuracy indicated that the Ada Boost model performed exceptionally well in distinguishing between individuals with ASD and those without. Such accuracy is particularly promising in the field of healthcare, where the reliability of diagnostic tools is of paramount importance.
- **Data Dependency:** The high accuracy achieved by the existing system may have been heavily dependent on the specific dataset used for the training and the testing. Machine learning models, including Ada Boost, can be sensitive to the quality and representativeness of the training data. Therefore, the model's performance may not be as reliable when applied to different or larger datasets.
- **Overfitting Risk:** Achieving a very high accuracy rate, such as 97.95%, can sometimes indicate a risk of overfitting. Over fit models may perform exceptionally well on the training data but may not generalize effectively to unseen data. This means that the model may be too customized to the peculiarities of the training set and might not perform as well on real-world cases.
- **Limited Transparency:** Ada Boost, like other ensemble methods, is not as interpretable as some simpler models like decision trees. Understanding the reasons behind the predictions made by the model can be challenging, which is a potential disadvantage, especially in healthcare applications where interpretability is crucial.

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- **Computationally Intensive:** Ada Boost typically requires more computational resources and time compared to simpler algorithms due to its iterative nature. This increased computational demand may not be suitable for real-time or resource-constrained applications.

Proposed System:

- The suggested structure for the identification of the ASD presents an innovative approach that addresses several key limitations observed in the existing system. Python-based machine learning models, namely the Random Forest Classifier and the Decision Tree Classifier, are integrated into this system, to achieve enhanced accuracy and robustness in ASD diagnosis.
- The Decision Tree Classifier and the Random Forest Classifier are two different machine learning algorithms that are used in the suggested system. Using an ensemble learning technique called Random Forest, When many decision trees are merged, it produces a very stable and accurate model. In contrast, the Decision Tree algorithm provides an easy-to-use and effective way to categorize data.
- The dataset used in the proposed system contains the 704 records with the 21 features. These characteristics include a broad spectrum, such as demography, medical history, cognitive ability, and sensory perception. Notably, the dataset is more extensive than that used in the earlier system, ensuring a more comprehensive analysis.
- The features in the dataset cover various aspects related to ASD diagnosis, including the following: country of residence, previous app usage, medical history (jaundice), history of autism diagnosis (autism), sensory perception (A1_Score - A6_Score), cognitive abilities (A7_Score - A10_Score), and other demographic attributes (Age_desc, Relation). This rich feature set allows for a more holistic assessment of individuals [38].
- The precision of the suggested system has shown remarkable outcomes. The Random Forest Classifier demonstrated its exceptional capacity to learn from the data and generalize by achieving a testing accuracy score of 99% and a training accuracy score of 100%. The Decision Tree Classifier demonstrated strong performance as it attained a testing accuracy score of 96% while retaining a training accuracy score of 100%.
- The results of the suggested approach have important therapeutic implications since they can help with the early identification of ASD and prompt intervention. It is crucial to diagnose ASDs early in order to support those who are affected and enhance their quality of life. The system's high accuracy underscores its potential in enhancing the diagnostic process for ASD.
- In conclusion, the proposed system for ASD detection offers a promising approach to overcoming the limitations of the earlier system. It harnesses the power of Python-based machine learning models, a comprehensive dataset, and a rich feature set to achieve remarkable accuracy in diagnosing ASD. These aspects collectively position the proposed system as a valuable tool for healthcare professionals working with ASD.

Advantages of Proposed System:

- **High Accuracy:** The suggested method has shown to be incredibly accurate in

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identifying ASD. While the Decision Tree Classifier continued to retain a 100% training accuracy score and a 96% testing accuracy score, the Random Forest Classifier attained both 100% training accuracy and 99% testing accuracy. These high accuracy rates play a critical role in guaranteeing accurate and precise diagnosis of ASD.

- **Robust Generalization:** The capacity of the system to achieve excellent precision in both training and the testing dataset indicate that it may be successfully applied to new, unseen cases. This robust generalization is vital in real-world clinical settings where patients may present with diverse characteristics and histories.
- **Rich Feature Set:** The proposed system utilizes a dataset with 21 comprehensive features, including sensory perception, cognitive abilities, demographics, medical history, and more. This rich feature set allows for a holistic assessment of individuals and improves the model's ability to capture complex relationships between variables.
- **Early Diagnosis:** Early detection of ASD is critical for timely intervention and support. The high accuracy of the proposed system facilitates early diagnosis, enabling healthcare professionals to provide the necessary care and assistance to individuals with ASD at an early stage of development.
- **Diverse Demographic Consideration:** The dataset used in the proposed system includes various demographic attributes such as age, gender, ethnicity, and country of residence. This consideration of diversity is essential in ensuring that the system can be applied across different populations and demographic groups.
- **Interpretability:** Decision trees, one of the models used in the system, are inherently more interpretable than complex models. This provides clinicians with insights into how the model is making its predictions, aiding in the understanding of the diagnostic process.
- **Clinical Relevance:** The proposed system's findings have direct clinical relevance and real-world implications. It can help medical practitioners diagnose and treat ASD patients more intelligently, which will eventually improve the quality of life for those who have the disorder.
- **Flexible Application:** Python-based machine learning models are highly versatile and can be readily adapted to various healthcare settings. The flexibility of the proposed system allows it to be integrated into different clinical environments.
- **Continuous Learning Potential:** Machine learning models like those in the proposed system can be updated and improved as new data and knowledge become available. This adaptability supports ongoing advancements in ASD diagnosis.

IV System requirement

Hardware requirement

1.	System	Pentiumi3Processor
2.	Hard Disk	500 GB.
3.	Monitor	15’’ LED
4.	Input Devices	Keyboard, Mouse
5.	RAM	8 GB

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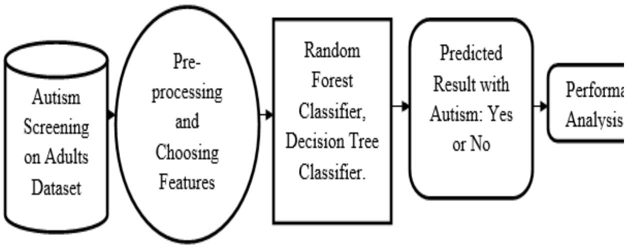
Software requirement

1.	Operating system	Windows 10 Pro.
2.	Coding Language	Python.
3.	Web Framework	Flask.
4.	Frontend	HTML, CSS, JavaScript.

V System Design

System Architecture



VI Results and Discussion

- **Data Collection:**

We have constructed the system to obtain the input dataset in the first module of A Framework for Early-Stage Machine Learning-Based Autism Spectrum Disorder Identification. The initial stage in developing a machine learning model is gathering data, which is accomplished through the data collection process. This is a crucial stage that will have a cascading effect on the model's quality; the more and better data we collect, the more capable our model will be. There are various methods for gathering the data, including manual interventions and online scraping. Our dataset may be found in the model folder of the project. The standard dataset repository Kaggle is the source from which all researchers refer to this popular dataset. The dataset consists of numerical data. The dataset contains 704 unique data points. The dataset consists of 21 columns.

The proposed system exhibits exceptional accuracy, with the Random Forest Classifier achieving a training accuracy score of the 100% and a testing accuracy score of 99%, while the Decision Tree Classifier maintains a training accuracy of 100% and a testing accuracy of 96%. These results underscore the system's capability to distinguish between individuals with ASD and those without, with high precision.

A key strength of the proposed system lies in its rich feature set, which encompasses sensory perception, cognitive abilities, demographics, medical history, and other relevant attributes. This comprehensive approach allows for a more holistic assessment of individuals, enabling the model to capture complex relationships between variables.

Early diagnosis of ASD is of paramount importance for timely intervention and support. The proposed system facilitates early detection, which can significantly improve the quality of life for affected individuals [24][26]. Furthermore, the system's consideration of diverse demographic attributes ensures its applicability across different populations and demographic groups.

The interpretability of the Decision Tree Classifier provides healthcare professionals with insights into how the model makes decisions, enhancing their understanding of the diagnostic process.

In conclusion, the proposed system marks a significant advancement within the domain of healthcare and machine learning for ASD detection. Its high accuracy, robust generalization, rich feature set, early diagnosis capabilities, interpretability, and clinical relevance collectively position it as a valuable tool for healthcare professionals working with individuals on the autism spectrum. This project exemplifies the potential of machine learning in improving the diagnosis of complex neurodevelopment

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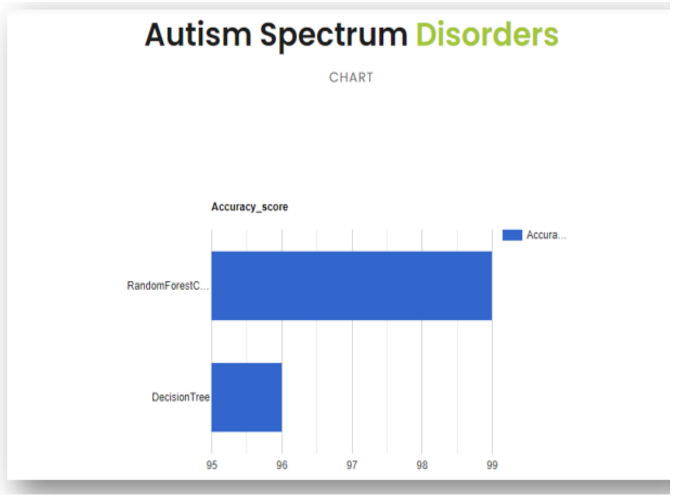
conditions and contributes to the broader goal of enhancing the standard of living for people with ASD.

Confusion matrix of RFC



VII. CONCLUSION

In summary, future work should focus on expanding and refining the system's dataset, improving feature engineering, exploring advanced algorithms, enhancing interpretability, conducting validation studies, addressing ethical considerations, enabling continuous learning, developing user-friendly interfaces, integrating with healthcare systems, and fostering collaboration with stakeholders. These efforts will contribute to the ongoing advancement of ASD diagnosis and support for individuals with autism.

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