MACHINE LEARNING-BASED EARLY DETECTION OF AUTISM IN CHILDREN

Dr. Rejeesh Rayaroth[1], Miliyana Reena Dsouza [2], Samruddhi H R[3], Sanyuktha Satish Shetty[4] and Shraddha Singh [5]

[1]*Assistant Professor, Computer Science and Engineering, MITE Moodabidri, India*

[2-5]*Student, Computer Science and Engineering, MITE Moodabidri, India*

Abstract: *This project aims to analyze and predict autism spectrum disorder (ASD) diagnosis using machine learning techniques. ASD is a developmental disorder that affects communication, behavior, and social interactions. Early diagnosis is crucial to provide the necessary interventions for individuals with autism. The dataset used in this study contains various features, such as age, gender, and behavioral traits, which are analyzed to identify patterns associated with ASD. Convolutional Neural Networks (CNN) is utilized for image-based data analysis, particularly for facial feature extraction, which enhances the predictive accuracy of the models. The performance of these models is evaluated based on accuracy, precision, recall, and other metrics to determine their effectiveness in real-world scenarios. Additionally, data preprocessing techniques like handling missing values and feature selection are applied to improve model performance. The project also explores the ethical considerations of using machine learning in healthcare, ensuring that the models are interpretable and reliable for medical applications. Overall, the project demonstrates the potential of AI in aiding early autism diagnosis and contributing to better healthcare outcomes.*

Keywords: *Autism Spectrum Disorder (ASD), Machine Learning, CNN, behavioral disorder, chatbot.*

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that affects an individual's ability to communicate, interact socially, and engage in repetitive behaviors. It presents in early childhood, with symptoms varying in severity, making early diagnosis essential for effective intervention and support. Traditional methods for diagnosing autism are often time-consuming, subjective, and resource-intensive, which can delay treatment for children who need early interventions.

In recent years, advancements in machine learning have provided promising opportunities to enhance the early detection of ASD. By analyzing behavioral, demographic, and other clinical data, machine learning algorithms can identify patterns that may not be immediately evident to healthcare professionals.

This project leverages data from Kaggle, featuring a dataset containing various attributes linked to ASD traits, to build predictive models for identifying children at risk of autism. Through this research, we aim to create a reliable, efficient, and scalable diagnostic tool and using Convolutional Neural Networks (CNN). These models are trained to assess the likelihood of ASD based on key indicators from the dataset. The goal is to assist healthcare providers in making informed decisions about potential ASD diagnoses, thus improving early intervention outcomes for children affected by the disorder.

2. Literature Survey

[1] Garg et al. (2024) discuss the critical need for early detection of autism spectrum disorder (ASD) to enable timely interventions and improve developmental outcomes for children. Their study explores various machine learning algorithms and methodologies employed to analyse ASD-related data, enhancing the accuracy and efficiency of diagnosis when compared to traditional methods. The research demonstrates promising results through machine learning models, suggesting their potential integration into healthcare systems to support early autism diagnosis and provide timely assistance to at-risk children.

[2] Abdelwahab et al. (2024) emphasizes the importance of early prediction of ASD in children for effective intervention and improved outcomes. The paper investigates the use of multiple machine learning algorithms and techniques to analyse data and identify patterns associated with ASD, thereby enhancing diagnostic accuracy. The authors highlight how machine learning models could transform autism diagnosis by improving accessibility to early intervention services within healthcare systems, especially benefiting children at risk.

[3] Farooq et al. (2023) propose a federated learning (FL) approach for detecting ASD in both children and adults using machine learning models. Their study achieves an accuracy rate of 98% in children and 81% in adults by processing data from four different datasets locally using Support Vector Machine (SVM) and Logistic Regression (LR) classifiers. The results are transmitted to a central server to train a meta-classifier. This FL-based model ensures data security and privacy by keeping data decentralized and transmitting only small-sized local models, making it a promising and secure approach for ASD detection.

[4] Yaneva et al. (2020) present a novel, non-invasive method to detect high-functioning autism in adults using eye-tracking technology. The study analyses visual processing differences during web page browsing tasks and applies machine learning classifiers to the collected data, achieving a 74% accuracy in identifying individuals with autism. The paper highlights the potential of eye-tracking technology as a cost-effective and scalable tool for autism detection in adults, underscoring its promise for broad application in clinical and nonclinical settings.

[5] Manushi Srivastav et al. (2023) This review highlights Autism spectrum disorder (ASD) is becoming increasingly common in India, bringing unique challenges for families. Many struggle with societal stigma, limited awareness, and a lack of resources, which delays diagnosis and support. Factors like advanced parental age, neonatal complications, and consanguinity increase the risk. The review emphasizes the need for inclusive education, employment opportunities, and stronger support systems. Raising awareness and addressing these issues can greatly improve the lives of individuals with ASD and their families.

3. Methodology

The methodology of this project focuses on developing a system for early detection of autism. This can be done by using image-based classification. The approach contains including a powerful backend that handles image processing and predictions also simple and user-friendly frontend for uploading images and viewing results, and a well-organized database to store and manage labeled image datasets. The backend uses a Convolutional Neural Network (CNN) to analyze features in the images and classify them. The database ensures smooth storage and retrieval of data throughout the process will be easier.

3.1. System Design and Architecture

This system architecture explains how autism in children can be detected using image data. The dataset is first improved through preprocessing steps like normalization and augmentation, which enhance its quality and diversity. The refined data is then passed into a Convolutional Neural Network (CNN) that analyzes the images to identify autism traits. The model's performance is evaluated by comparing the test accuracy with the training accuracy. If the test accuracy isn't good enough, the model is adjusted, the process is repeated. Once the accuracy meets process ensures effective detection of autism traits.

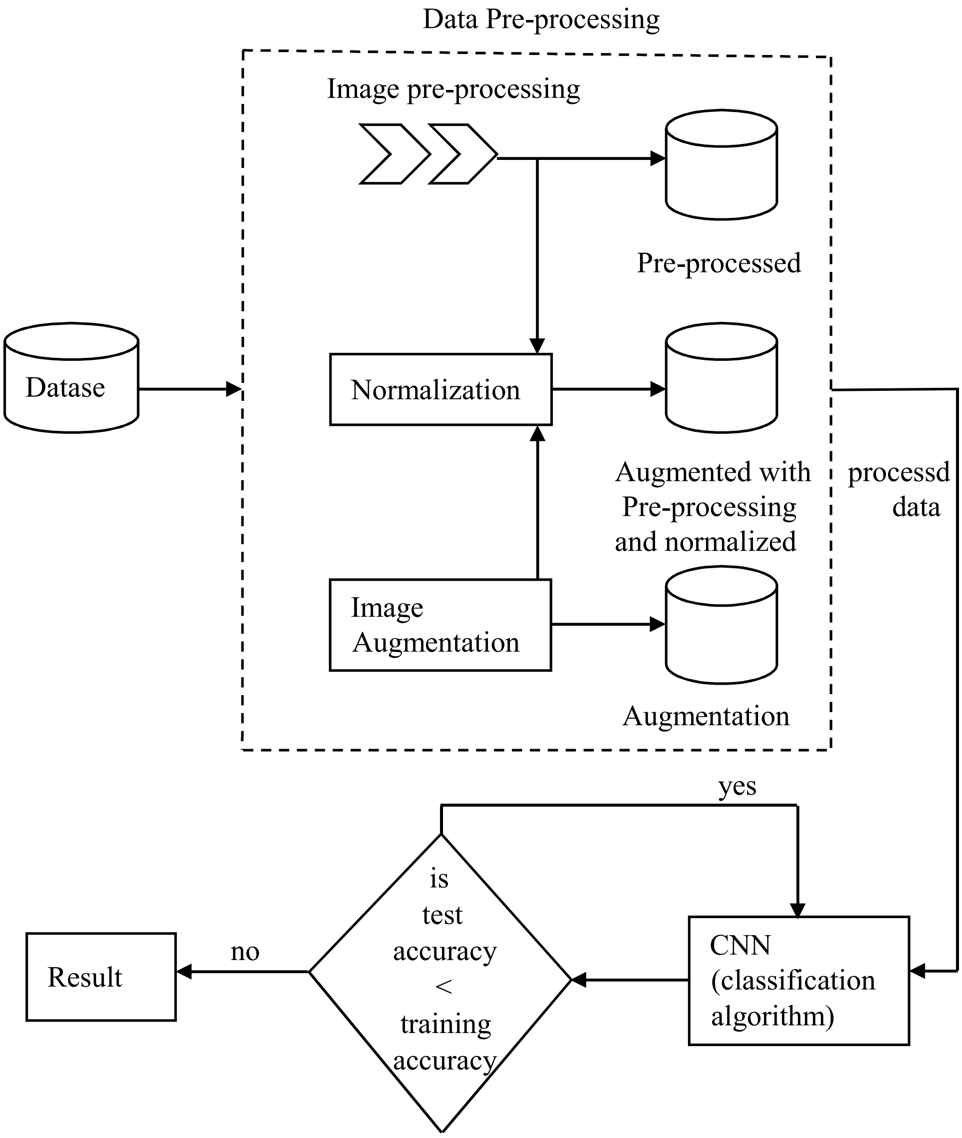

Figure 1. System Architecture

3.2. Data Preparation

The data preparation begins with gathering labeled images, which are resized to a uniform size to ensure consistency during processing. To prevent the model from overfitting to the training data, various image augmentation techniques are applied, such as rotating, flipping, and shifting. These transformations enable the model to learn generalizable features and recognize patterns in diverse scenarios. Additionally, normalization scales pixel values between 0 and 1, making it easier for the model to process and learn from the data efficiently.

3.3. Convolutional Neural Network (CNN)

This project employs a Convolutional Neural Network (CNN) to classify images as either "autistic" or "non-autistic." CNNs, known for their effectiveness in image recognition tasks, automatically learn features from images and make predictions. Convolutional Layers: The core of the CNN is its ability to learn important features from images using convolutional layers.

First Convolutional Layer: The first layer applies filters (small windows) to the input image, looking for basic features like edges or textures. It slides across the image, performing a mathematical operation to extract these features. The output of this operation is a set of feature maps that highlight where these features appear in the image.

Activation Function (ReLU): After the convolution, the model uses a ReLU activation function. This function makes the network more powerful by introducing non-linearity, allowing the model to learn more complex patterns. It also helps by turning negative values into zero, focusing on the most important parts of the image.

Additional Convolutional Layers: As the network deepens, it applies more filters to capture increasingly complex features, such as patterns, shapes, or objects. These layers are where the model starts to pick up more abstract and detailed features that are important for detecting autism.

Max-Pooling Layers: Max-pooling layers are used to simplify the information. Max-pooling helps reduce the size of the feature maps by selecting the most important information like the maximum value in each region and discarding less useful details. This helps the model focus on the most important features and reduces the computational burden, making it more efficient. It also helps prevent overfitting by abstracting the representation of the image.

Flattening: The data is in the form of multi-dimensional feature maps after convolution and max-pooling process. These feature maps are flattened into a one-dimensional vector. This step prepares the data to be passed into the fully connected layers, which will make the final classification decision.

Fully Connected Layers: Once the image features are flattened into a vector, the network passes them through one or more fully connected layers. These layers combine the features learned by the convolutional and pooling layers to make the final decision.

The neurons in these layers are connected to every other neuron in the next layer, meaning the model has access to all the features it has learned till now. These layers, the model does most of the heavy lifting in making predictions about whether the image shows signs of autism. The output from these layers is passed through a ReLU activation function, helping the model understand complex patterns in the data.

Dropout: To avoid the model from becoming too specialized on the training data which causes the problem overfitting, a dropout layer is added. During training, dropout randomly "turns off" certain neurons, forcing the network to learn to generalized data better. Improves the model's ability to work on new, that is unseen data.

Final Output: The final layer is a dense layer with just one neuron, which outputs a value between 0 and 1 using a sigmoid activation function. This output represents the probability that the image belongs to the "autistic" class. Suppose, the model outputs a value greater than 0.5, it predicts the image as "autistic". If the value is less than 0.5, it predicts "non-autistic'. This makes the model suitable for a binary classification task, where the aim is to categorize the image into one of two classes whether, "autistic" or "non-autistic".

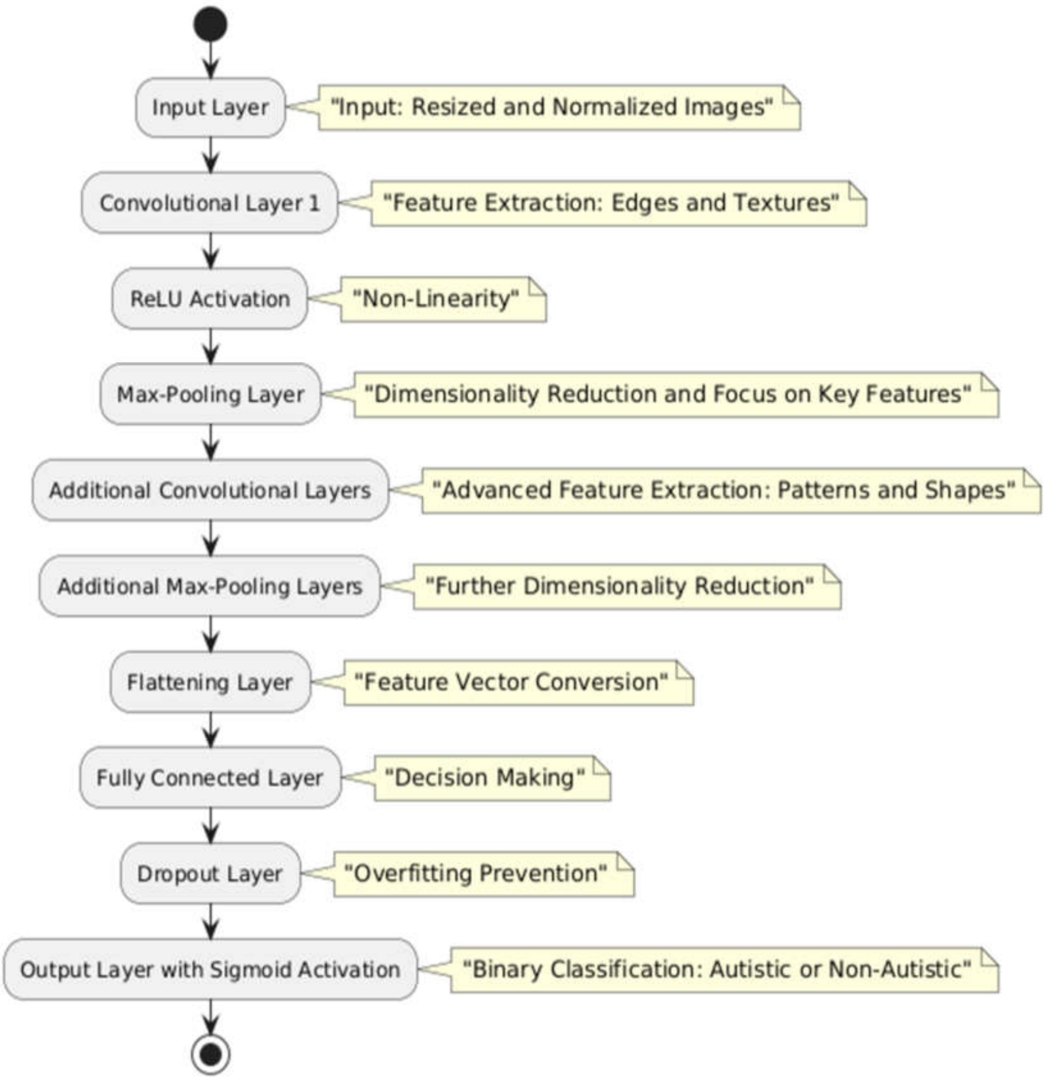

Figure 2. Convolutional Neural Network Flow Diagram

3.4. Pre-training model and Evaluation:

Training and Evaluation: The model is trained using an optimizer called Adam, which adjusts the learning rate during training to help the model learn more efficiently. The binary cross-entropy loss function is used because we're working with a binary classification problem (autistic vs non-autistic). During training, the model sees batches of images, compares its predictions to the actual labels, and adjusts its internal parameters to improve its predictions.

3.5. Frontend Development (HTML, CSS, JAVA SCRIPT)

The frontend of the application is designed with a combination of HTML, CSS, and Bootstrap to create a clean, responsive, and visually appealing interface. It includes an interactive dashboard where users can upload images for analysis or view their results, with cards and background images adding to the polished look. A chatbot is built right into the interface to assist users, and JavaScript makes it come to life by handling interactions, like opening and closing the chatbot window and enabling real-time conversations. JavaScript also ensures smooth transitions and responsive behavior, making the application easy to use and engaging across different devices. The result is a user-friendly experience that feels modern and intuitive.

3.6. Backend Development (Flask)

The application's backend is built using Flask, providing a solid and dependable structure. It efficiently manages user authentication, enabling secure registration, login, and session handling through Flask-Login and bcrypt for encrypted password storage. It also supports file uploads, ensuring proper validation for a smooth user experience. A TensorFlow model is integrated to analyze the uploaded images and deliver precise predictions. The database is managed using SQLAlchemy, which ensures data organization and reliability. All these components work together to deliver a seamless, secure, and efficient platform for users.

3.7. Database Management (SQLite)

SQLite is incredibly useful in this project as it helps store and manage data efficiently. For example, it securely saves user login and signup details, making authentication smooth and reliable. It also keeps track of uploaded files and their details, such as image paths and related results, without needing a complicated setup. When a user checks their results, SQLite ensures the data is quickly retrieved and displayed. Its simplicity allows it to work perfectly with the backend, making data storage and retrieval seamless. Being lightweight and portable, it fits well into this project's scale, ensuring everything runs reliably and without extra hassle.

3.8. Chatbot

The chatbot in this project makes user interaction simple and efficient. It's always accessible via a floating button (🗨) in the corner, ready to help without disrupting what users are doing. When opened, it greets users with a friendly message and provides options like "Parent" or "Guardian" to guide them based on their role. Its chat interface is easy to use, featuring a scrollable conversation area and a text box for queries. The design is discreet and only appears when needed. Built with straightforward JavaScript, it's easy to expand if needed. Overall, the chatbot offers quick, personalized support, making the dashboard easier to navigate and more user-friendly.

4. Proposed System

The proposed system is a web application designed to detect autism in its early stages in children. It features a user-friendly interface that allows parents and guardians to easily assess their child for potential signs of autism. This system aims to raise awareness about autism spectrum disorder (ASD), which is commonly observed in children, and provides a valuable tool for early detection. By enabling early identification, the system helps families seek timely intervention and support, potentially improving the outcomes for children with autism. It also empowers parents with information, offering them a proactive way to understand and address their child's needs. The platform strives to make autism detection more accessible and efficient, creating a positive impact on children's developmental journeys.

4.1. User Interface

The user interface of this application is designed to be simple and easy to navigate. It offers a smooth experience where parents and guardians can easily sign up, log in, upload images of their children, and view the results. The pages are clean and user-friendly, with notifications to guide users through each step. Whether it's uploading an image for analysis or viewing the results, the interface ensures users don't feel overwhelmed and can interact with the system effortlessly.

4.2. Backend

At the core of the application is Flask, a lightweight framework that takes care of handling the requests and routing. When users log in, upload images, or check results, the backend processes these actions and communicates with the TensorFlow model to make predictions. It also manages user authentication, ensuring that only registered users can access the system. The backend also handles errors gracefully, providing clear feedback through notifications, so users know exactly what's happening during their interactions.

4.3. Database

The application stores user information securely in a SQLite database. When a user signs up, their username and password (safely hashed using Bcrypt) are stored in the database. SQLAlchemy helps manage the database smoothly, ensuring that user accounts are created, updated, and validated without any hassle. The database ensures that all sensitive information is well protected and keeps track of each user’s credentials for secure access to the system.

4.4. Efficiency or Accuracy

The application leverages a pre-trained deep learning model to analyze uploaded images and predict if autism is detected. It works efficiently by processing images quickly, ensuring that users get their results without unnecessary delays. While the system strives to be accurate, the effectiveness of the predictions depends on the quality of the trained model and the images provided. With further improvements and more data, the accuracy of the model could be enhanced, offering even more reliable results for users.

4.5. Privacy

Privacy is a top priority for this application. The system ensures that user passwords are securely stored using hashing techniques, so even if the database were to be compromised, the passwords would remain safe. The app only collects necessary information, such as usernames and hashed passwords, and doesn't track or store any personal data related to the images or any other details. Users are always notified through clear messages, so they have full control over their data and are informed about what’s happening with it.

4.6. Chatbot

The chatbot in this project makes it easier for users to get help whenever they need it. It provides quick guidance through the steps of uploading images and checking results, offering a friendly and interactive experience. By asking whether the user is a parent or guardian, it tailors the support to their specific needs. Ultimately, the chatbot makes the entire process smoother, more engaging, and user-friendly.

5. Results

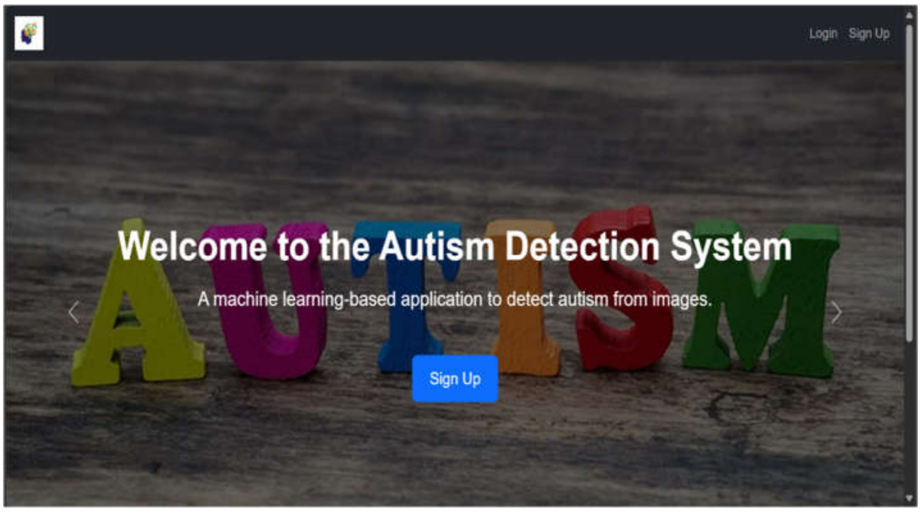

Figure 1. Home Page

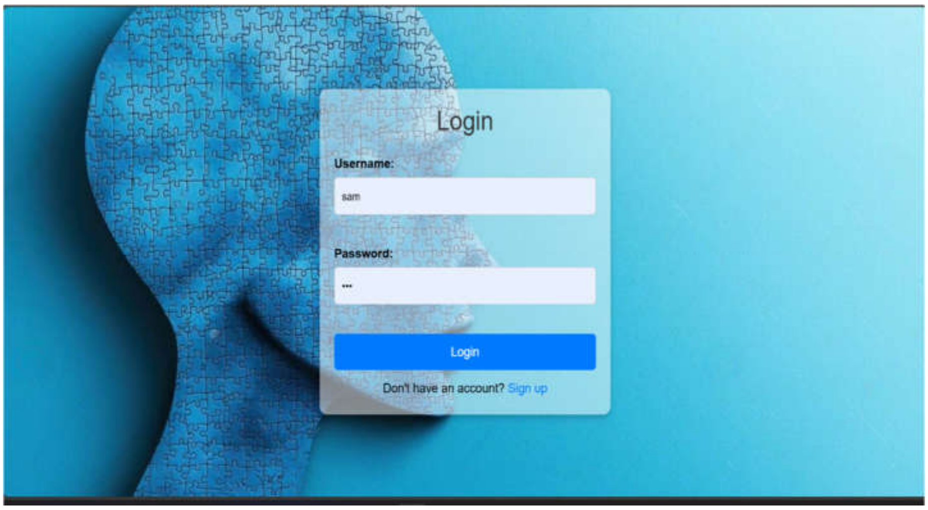

Figure 2. Login Page

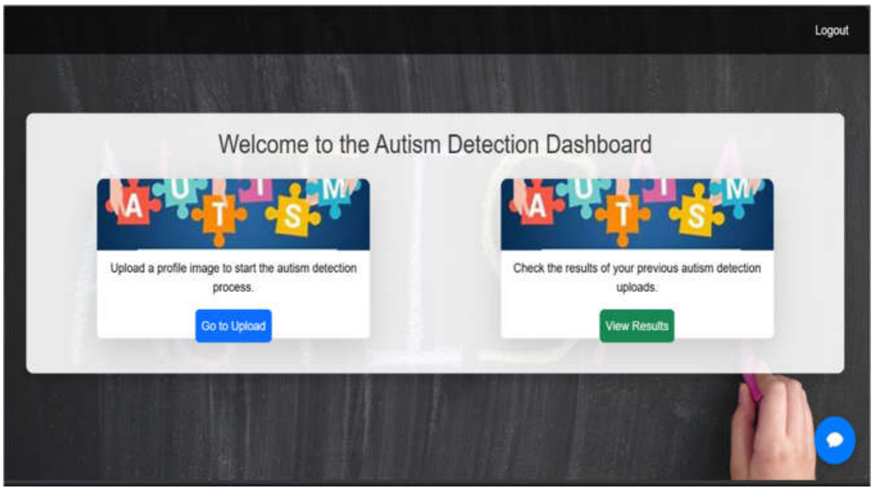

Figure 3. Dashboard Page

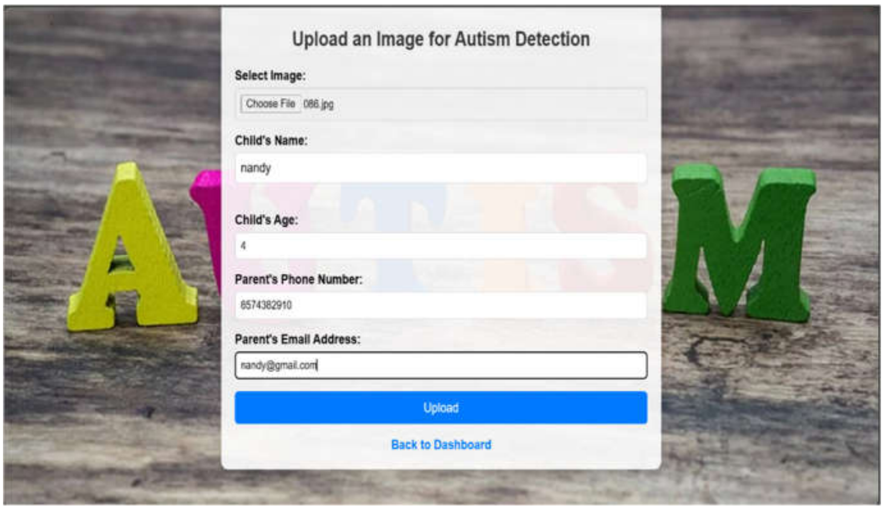

Figure 4. Upload Page

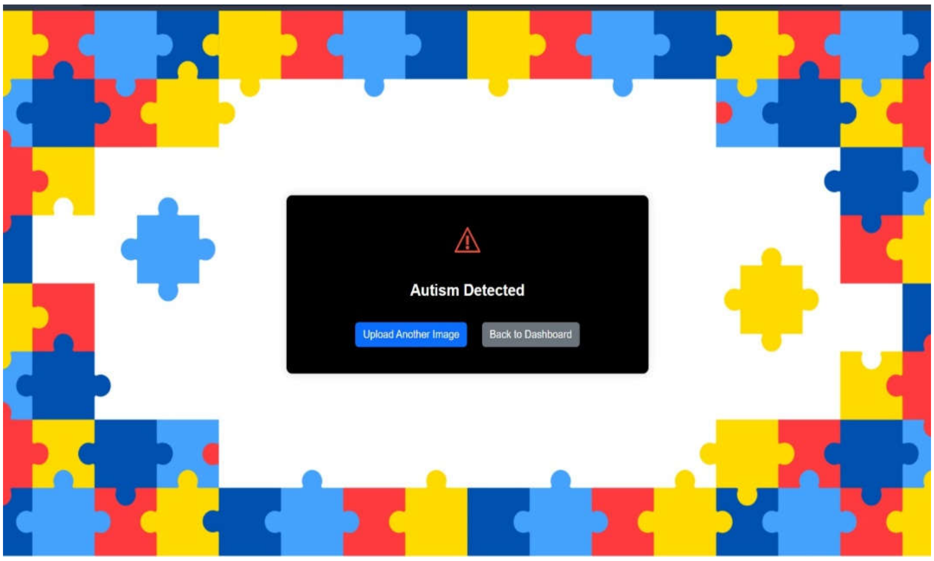

Figure 5. Result Page

6. Future work

The proposed system for Autism detection in early stages in children shows easy detection of autism in children. Also, future improvements and further work can be done to improve the system efficiency and user interaction.

6.1. Parental Support Community

The system can include online support groups, which connect parents and guardians of children with autism, providing a platform to share experiences, offer advice, and support each other. This feature fosters a sense of community and reduces isolation, as parents can interact with others facing similar challenges. Additionally, expert advice can be offered by allowing users to schedule live consultations with medical professionals or therapists through video or text chat. This ensures that parents have access to expert guidance when they need it most, addressing specific concerns in real-time.

6.2. Integration with Therapy or Intervention Tools

The system can also integrate with behavioral therapy tracking, such as Applied Behavior Analysis (ABA), to monitor a child's progress over time. This feature would allow parents to track therapy milestones, session logs, and provide a visual representation of the child's developmental journey. To further support children's therapy, a gamified therapy feature could be implemented, where interactive games and exercises aligned with therapeutic methods encourage children to participate. These games would make therapy more enjoyable and engaging while helping children develop essential skills in a fun, interactive manner.

6.3. Parenting Tips and Personalized Recommendations

A key feature could be the delivery of daily tips to parents, providing personalized advice on managing behaviors associated with autism. These tips could include social skills exercises, communication techniques, or sensory-friendly activities designed to assist parents in handling daily challenges. Additionally, the system could offer activity suggestions tailored to a child's specific needs. These recommendations might include relaxation exercises, social interaction games, or cognitive development tasks, chosen based on the child's symptoms and requirements.

6.4. Location-Based Support Services

The system could also provide location-based support services, helping parents find nearby autism specialists, therapy centers, or support groups using GPS functionality. A map displaying these locations would make it easier for parents to access relevant services and find the help they need. Furthermore, parents could receive event notifications about autism-related events, conferences, or workshops in their area. This feature would help keep families informed about educational opportunities, support networks, and autism-related activities available in their community.

6.5 Multimedia Learning Resources

To further support parents and guardians, the system could offer a library of educational videos explaining autism spectrum disorder, early detection signs, and strategies for managing symptoms. These videos would provide essential information to help parents better understand autism and how to support their child. In addition, the platform could offer interactive courses or webinars for parents, providing them with an opportunity to learn more about autism, available treatments, and effective strategies for supporting their child's development.

These are some future work that can even improve our aim to spread awareness as in current generation autism is seen in the children at the early stages. However this due to combination of genetic, where certain genes associated with brain development being linked to an increased risk of ASD. Also, environmental factors such as prenatal exposure to certain chemicals, infections, or complications during pregnancy, may also contribute, though these factors alone are not enough to cause autism. So early detection can help to socialize the autistic child and also giving therapy.

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