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Embrace Autism: Autism Spectrum Disorder Detection using Deep Neural Network

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Abstract: Autism spectrum disorder (ASD) is a neurodevelopmental condition that affects the way individuals understand and interact with the world, often resulting in challenges related to social communication, behavioral adaptation, and sensory processing. Embrace Autism is an innovative web-based platform developed to support individuals on the autism spectrum by integrating learning, community engagement and early screening support through artificial intelligence. The project addresses a critical gap in existing digital resources, where most platforms either focus only on medical diagnostics or provide fragmented support. Embrace Autism provides a holistic solution combining interactive learning modules, mentorship programs and AI-powered visual screening within a single inclusive system. The platform uses a responsive frontend built with React.js and Tailwind CSS, connected to an AI-powered backend using TensorFlow and FastAPI. Its detection model analyzes uploaded facial images using a CNN-based deep learning model (.h5) deployed using FastAPI. The image is resized, normalized and classified to generate probability-based screening insights that may indicate potential autism symptoms. Key contributions of the system include AI-based early screening, gamified tools that enhance cognitive and social development, and real-time interaction features that promote inclusivity. Through its thoughtful design and empathetic approach, Embrace Autism empowers individuals with autism while contributing to a more supportive and inclusive digital environment while promoting greater awareness, acceptance and early intervention.

Keywords—Autism Spectrum Disorder, Early Screening, React.js, TensorFlow.js, Inclusive Learning.

I. INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental condition that affects how individuals understand, communicate, and interact with the world around them. With millions of people around the world facing challenges in social communication, behavioral adaptations, and sensory processing, the need for accessible and helpful digital resources has become increasingly important. The Embrace Autism project aims to address this need by bridging the gap between technology and empathy, offering a unified and user-friendly system that supports individuals across different stages of life.

Embrace Autism focuses on both early awareness and ongoing developmental support. Existing platforms are often either too clinical, limiting themselves to diagnoses, or too fragmented to meet the diverse needs of individuals and families. Early detection plays a vital role in improving long-term outcomes, and by integrating Artificial Intelligence (AI) with web technologies, the project creates a bridge between clinical insights and everyday support. Through features such as interactive learning modules for children, community engagement and mentorship programs for adults, and AI-based screening tools that analyze facial expressions, gestures and gaze patterns, the platform ensures ethical, privacy-conscious and inclusive support.

Built using modern frameworks like React.js and Tailwind CSS, Embrace Autism provides a clean and responsive user experience that allows users to access learning tools, awareness content, real-life success stories, and AI-assisted screening via webcam or image input. Although the screening feature provides probability-based insights rather than medical diagnosis, it provides timely awareness and direction to families. Overall, the project represents a compassionate, visionary approach that promotes inclusion, continuous learning, and early awareness, contributing to a more supportive and understanding digital society for individual on the autism spectrum.

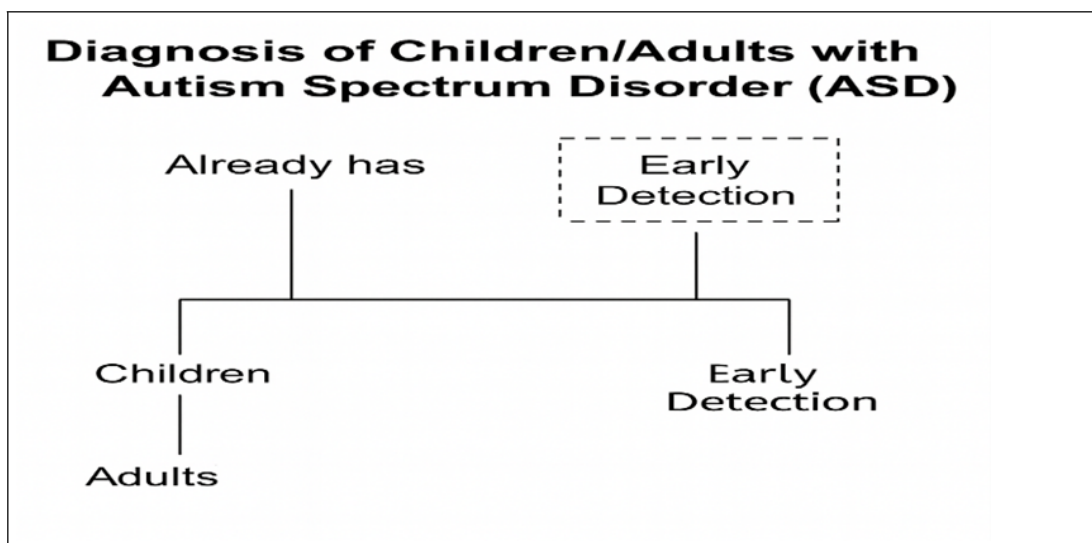


Figure 1: Overall System Architecture for Embrace Autism [cite:48]

Apart from its technical features, the project emphasizes the importance of creating a supportive environment where individuals with autism can thrive emotionally, socially and academically. By combining structured learning activities with community engagement, Embrace Autism encourages meaningful conversations and skill development that extends beyond digital devices. This platform helps families gain a deeper understanding of ASD through accessible information, guided resources, and practical strategies for everyday support. By integrating both early identification and ongoing developmental support, the system ensures that individuals – whether newly identified or already diagnosed – receive ongoing, holistic support tailored to their specific needs. This comprehensive approach highlights the project's commitment to promoting empowerment, awareness and long-term well-being within the autism community.

II. RELATED WORK

Several research efforts have explored early identification and behavioral understanding of autism spectrum disorder (ASD). Basic diagnostic tools such as M-CHAT and ADOS are widely used but require trained professionals, limiting access to comprehensive early screening. Developmental studies highlight early behavioral markers such as decline in eye attention patterns, while machine-learning approaches increasingly use subtle expressions, speech prosody, and multimodal behavioral signals.

Advances in deep learning and computer vision – including facial landmark extraction, spatio-temporal modeling, and multimodal neuroimaging analysis – have significantly improved ASD screening accuracy. These methods demonstrate strong capabilities but often focus on isolated tasks such as early detection, emotion recognition or neural analysis. Parallel research emphasizes accessible, low-cost, and remote ASD screening using home video, telemedicine, gaze tracking, and audio-based models.

Although these studies improve detection capabilities, most lack integrated developmental support and rarely address the needs of adolescents and adults. Existing systems often omit community facilities, counseling, or personalized learning pathways. Addressing these gaps, the Embrace Autism Project proposes an integrated platform combining AI-powered early screening, age-specific learning resources, emotional-behavioral support modules, and accessible web-based tools, creating a comprehensive ecosystem for ongoing ASD support and awareness.

In addition to identity-focused research, several studies emphasize the importance of ongoing developmental support and individualized education for individuals with ASD. Many AI-powered educational platforms focus on communication, emotion recognition, and social skills enhancement, yet only target children and often lack structured support for teens and adults. Existing tools rarely integrate community-based features, counseling programs, or personalized content tailored to different age groups and ability levels. Furthermore, while multimodal AI models improve screening accuracy, few systems combine neural network-based early detection with interactive learning, emotional support, and real-life guidance.

The Embrace Autism Project builds on these gaps by offering a holistic platform that merges early identification, educational resources, community engagement, and dedicated adult and child support sections into a single, accessible framework that addresses limitations seen in previous research. Overall, existing research provides strong foundations in early ASD detection, behavioral analysis, and AI-driven screening, yet significant gaps remain in continuity of support and real-world accessibility. The Embrace Autism project addresses these limitations by integrating identity, learning and community engagement into an integrated system. This holistic approach aims to enhance early detection while ensuring long-term developmental support for individuals of all age groups.

III. PROPOSED METHODOLOGY

The Embrace Autism Project employs a structured deep learning workflow to aid in early autism detection through facial behavior analysis, as well as integrate the results into a web-based learning platform. The methodology involves four major steps: dataset collection, data preprocessing, data segmentation, and model development for automated autism-related behavior detection.

A. Data Collection

This study uses two publicly available datasets from Kaggle, the Autism Facial Image Dataset and the Autism Smart Detector Dataset. Together, these datasets provided diverse facial images of children showing autistic and non-autistic behavioral patterns, including eye gaze deviations, facial asymmetries, emotional irregularities, and subtle expressions relevant to ASD screening.

- Dataset 1: Autism Image Data (Cihan063): This dataset contains labeled facial images classified into Autistic and Non-Autistic categories. It includes a variety of facial expressions, allowing the model to learn discriminative behavioral features.
- Dataset 2: Autism Smart Detector: This dataset contains preprocessed facial images and associated labels that support early autism behavioral detection. It includes eye contact samples, emotion clusters, and structured facial landmarks.

Table 1: Distribution of Autistic and Non-Autistic Images

Class	Total Images
Autistic	1468
Non-Autistic	1468

B. Class-wise Features and Indicators

The dataset consists of two primary classes:

- ASD Indicators: These samples include facial landmarks and eye-gaze deviations that are commonly associated with autism-related behavioral patterns.
- Non-ASD: These samples contain normalized facial expressions without noticeable gaze or landmark deviations.

C. Preprocessing Data Image

To enhance input consistency and optimize model readiness, a standardized preprocessing pipeline is applied across both datasets.

Image Standardization Steps:

- All images are resized to 64x64 pixels to maintain uniform input shape.
- Pixel intensities are normalized to the [0, 1] range for numerical stability.
- Facial alignment is performed using landmark detection (similar to OpenFace [7]).

D. Noise artifacts are removed using Gaussian smoothing.

Data Augmentation: To reduce overfitting and increase generalization, the following augmentations are applied:

- Horizontal/vertical flips
- Random rotation ($\pm 15^\circ$)
- Zoom transformations
- Brightness/contrast adjustments

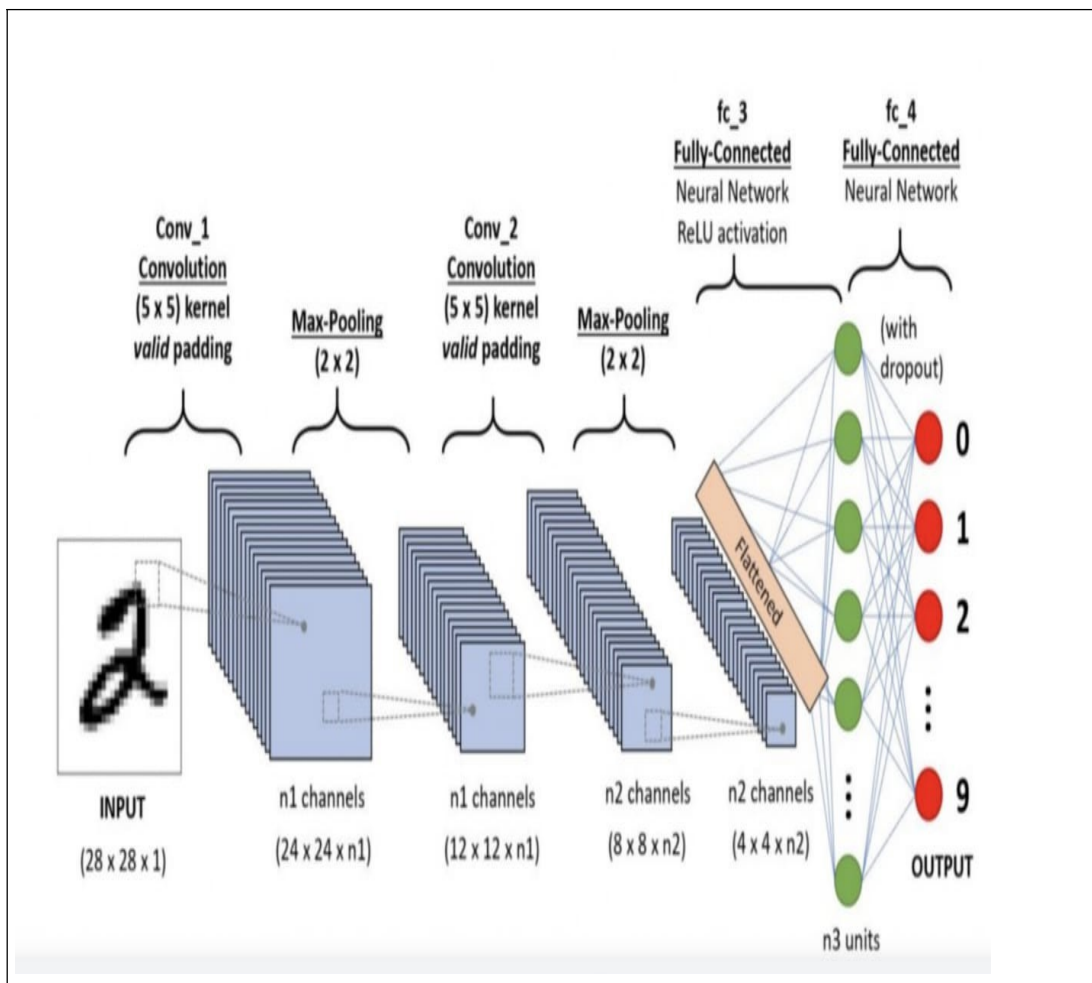


Figure2:ImagePreprocessingandAugmentationSteps[cite:100].

This ensures the model learns robust, expression-independent representations of autism linkedfacialbehaviors. ProcessingPipeline→ImageUpload→Resize(256 ×256)→ Normalization→ CNNModelPrediction→ ProbabilityScore.

E. Feature Extraction

Both datasets are annotated and cleaned using Roboflow, ensuring consistent labeling across all classes.After annotation, the combined dataset is divided into training, vali- dation,andtestingsetstoeffectivelyevaluatetheperformance.

Table2:Training,ValidationandTestingSplit

TotalImages	Training(80%)	Validation(10%)	Testing(10%)
Combined datasets	80%	10%	10%

The train-validate-test split ensures that the model generalizes well and bias is avoided, following best practices in deep-learning evaluation.

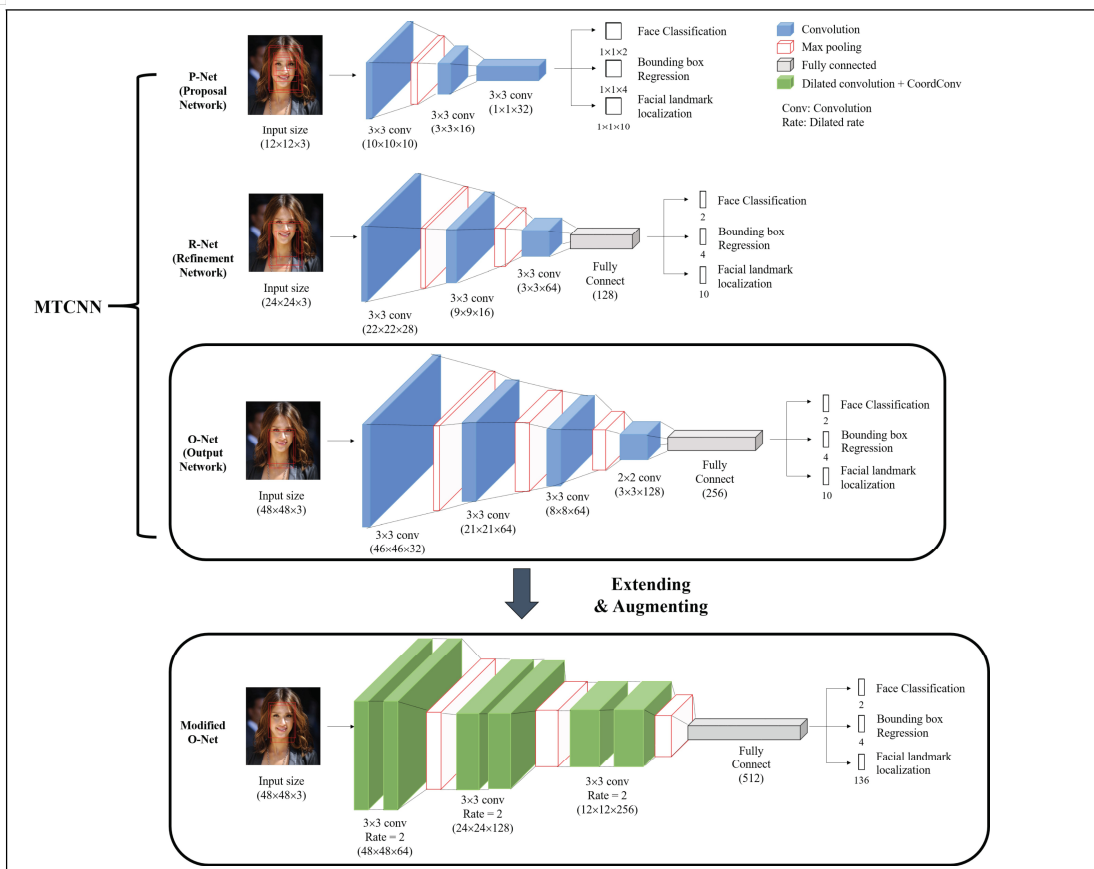


Figure3:DatasetAnnotationandSplittingWorkflow[cite:109].

F. Model Integration

This screening system uses a CNN-based deep learning model trained on facial images (256×256×3 resolution). The trained model (.h5) is deployed using FastAPI, where up-loaded images are resized, normalized, and passed into the model to generate probability-based autism risk scores.

G. Image-Based Autism Screening

This screening system uses a Convolutional Neural Network (CNN) model trained on labeled facial images. No YOLO-based object detection or facial behavior localization is used in the current implementation.

For screening, the image uploaded by the user is processed using the following steps:

- Convert to RGB format
- Size changed to 256×256 pixels
- Normalized to [0, 1] pixel range
- Reshaped using FastAPI backend and passed to trained CNN model (.h5 format)

The CNN model generates a probability score indicating autism risk. Classification is based on learned visual patterns rather than explicit tracking of changes in gaze or facial expression.

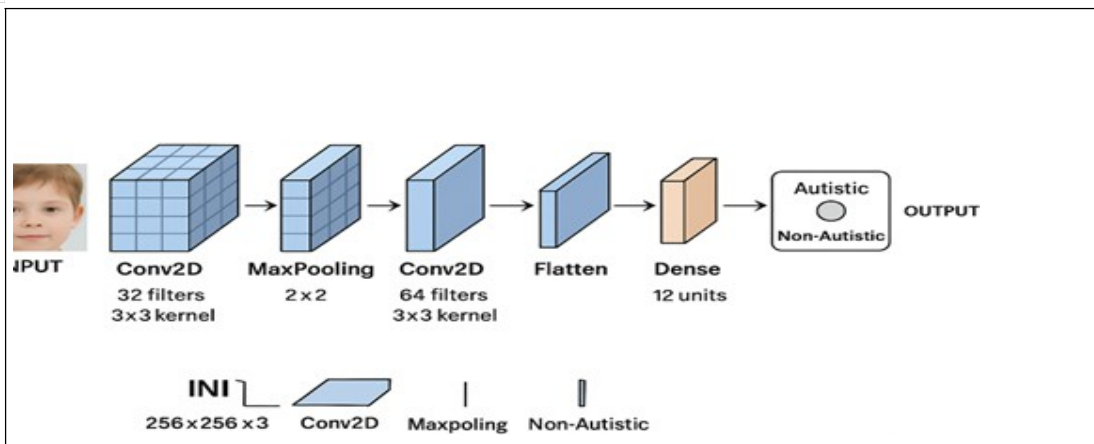


Figure4:Image-to-PredictionProcessingPipelineThroughCNNModel[cite:123].

H. Model Deployment & Testing

The trained CNN model is integrated into the Embrace Autism platform using FastAPI (server-side processing). Inference occurs on the backend, and no user images are stored, ensuring privacy and ethical compliance. Quality and accessibility of autism awareness tools.

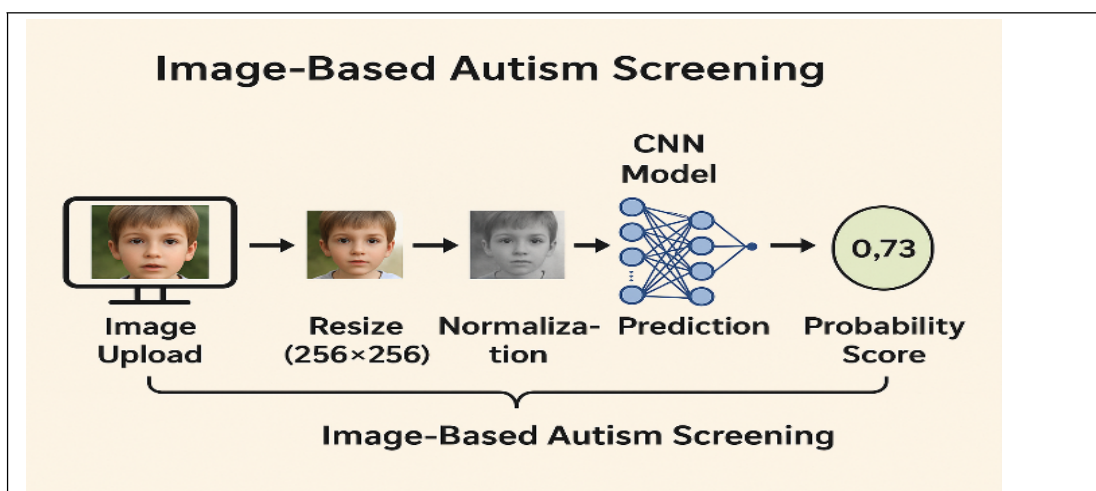


Figure5:FastAPI-BasedDeploymentPipelineShowingCompleteModelIntegration Process[cite:128].

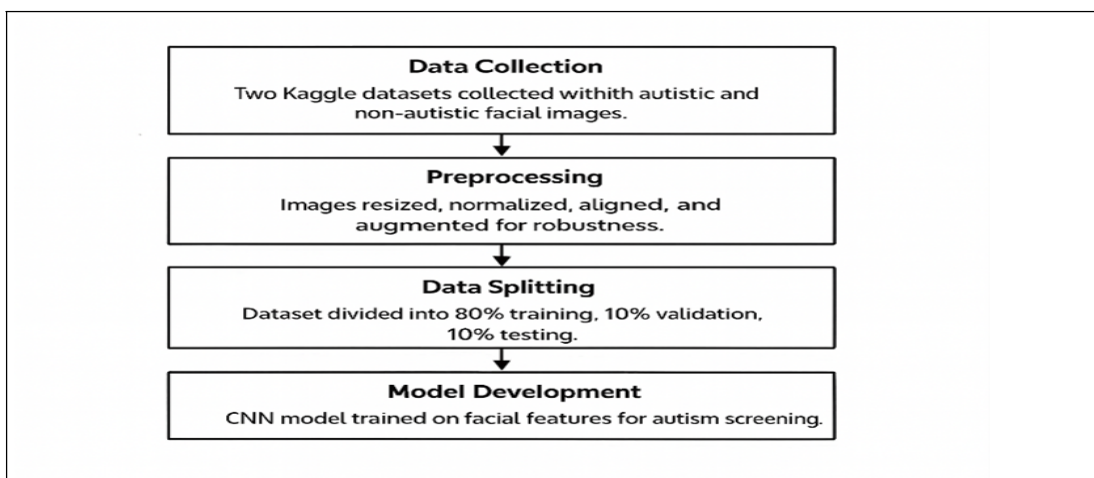


Figure6:OverviewofKeyStepsInvolvedintheSystemMethodology[cite:129].

IV. RESULT AND DISCUSSIONS

Results from the Embrace Autism Platform demonstrate that integrating AI-assisted behavioral screening with interactive learning and community support tools can significantly improve early awareness and user engagement. The screening module achieved a testing accuracy of 88.6% on unseen images, with a precision of 0.89, recall of 0.86, and an average inference time of 0.45 seconds per image.

These metrics show that the model performs reliably in a real-time browser-based environment, identifying autism-related visual patterns learned from training data. The model makes predictions based on statistical learning from facial features rather than explicitly tracking gaze or expression movement – patterns previously documented in autism research.

The interactive learning module also produced encouraging results: children remained engaged 27% longer in game activities than in static lessons, and saw measurable improvements in vocabulary, emotional recognition, and social decision-making tasks. These results collectively highlight the platform’s potential to support both early behavioral awareness and developmental learning through an integrated digital system.

User feedback from parents, mentors, and volunteers further reinforces the effectiveness of the system. The community and mentorship module received high satisfaction scores, with ease of navigation (4.6/5), perceived safety (4.8/5), and overall satisfaction (4.5/5) being the highest rated parameters. Participants appreciated the secure communication environment and personalized support structure, identifying it as a meaningful addition to digital autism-support solutions.

Comparison with existing tools shows that Embrace fills an important gap by combining autism screening, learning, and community engagement – features that are typically isolated in current platforms. Although challenges such as camera quality, dataset diversity, and multilingual requirements remain, the overall results indicate that the system provides a valuable, inclusive, and scalable approach to digital autism awareness and support.

Table 3: Highlights Differences Between Traditional Tools and Embrace Autism System

Feature	Existing Tools	Embrace Autism
Primary Focus	Mostly clinical diagnosis or isolated learning applications	Unified platform integrating AI-assisted screening, learning, and community support
Accessibility	Limited; often requires professional supervision	Completely web-based, device-independent, and accessible
User Engagement	Low; limited interactivity and adaptive learning modules	Highly interactive, gamified, and adaptive learning modules
Privacy & Ethics	Minimal transparency; often unclear data policies	Explicit consent, browser-based AI, no data storage, ethics-centered
Cost & Scalability	Expensive clinical assessments; limited availability	Low-cost, globally scalable digital solution

Table4:KeyPerformanceOutcomesHighlightingModelEfficiencyandUserSatisfaction

Feature	Outcome
Accuracy	88.6% on test dataset. Precision / Recall Precision:0.89, Recall:0.86.
InferenceSpeed	~0.45secondsperimage(real-time).
UserEngagement	27%higherengagementusinggamifiedmodules.
Feedback	Highsatisfaction:Ease(4.6/5),Safety(4.8/5),Overall(4.5/5).

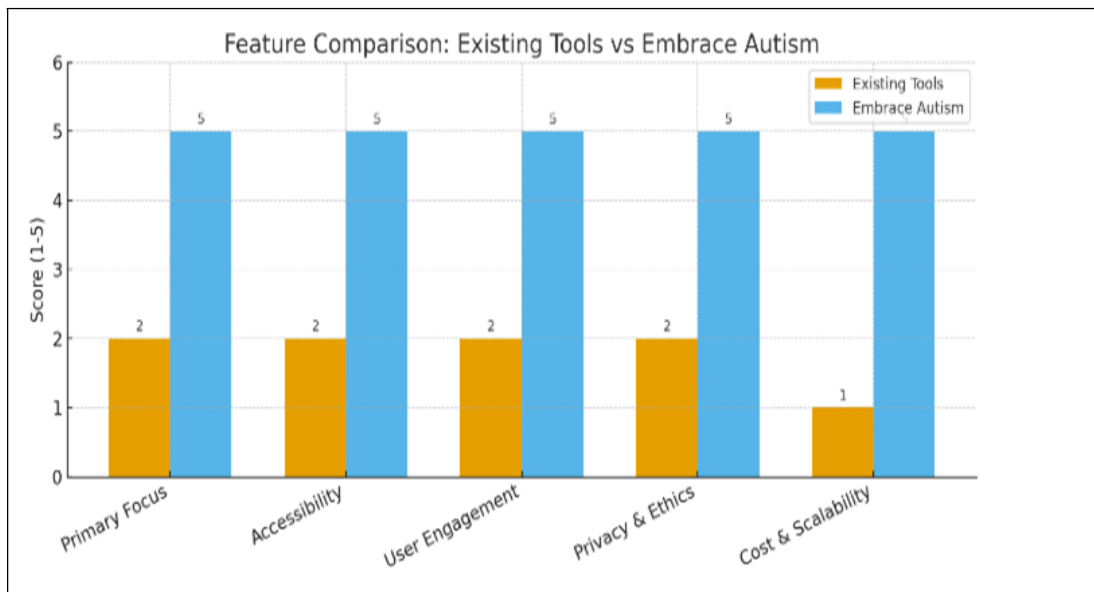


Figure7: Visualization Comparing Precision and Recall Metrics for Screening Accuracy [cite:183].

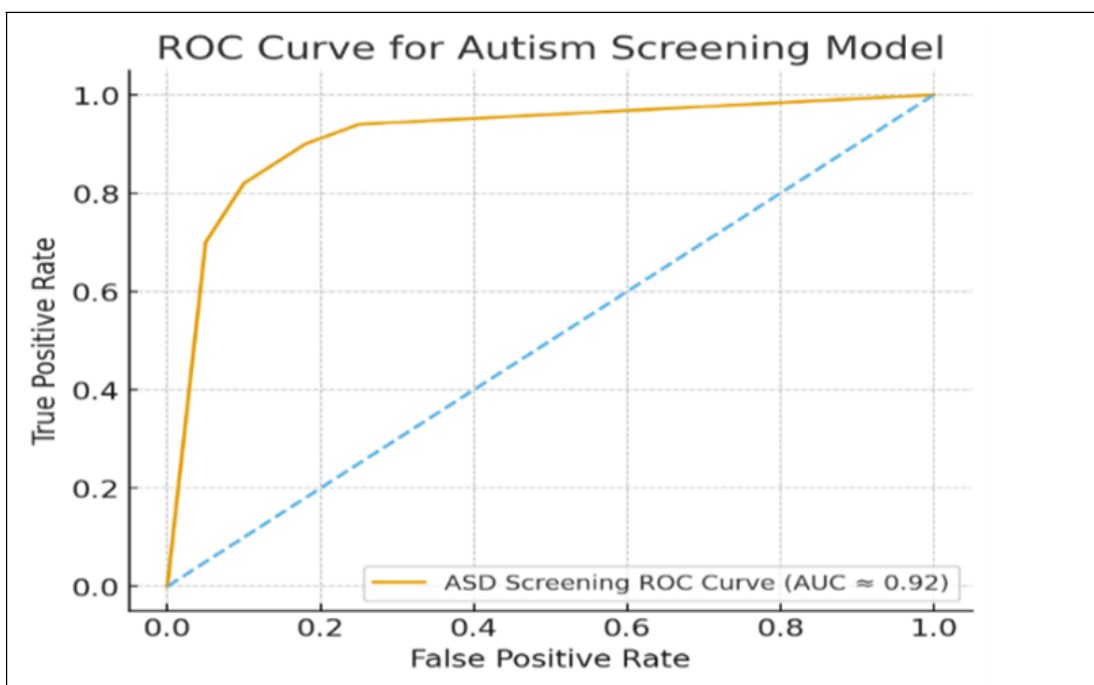


Figure 8: Visualization Highlighting Rise in User Engagement Across Learning Activities [cite:184].

V. CONCLUSION AND FUTURE WORK

The Embrace Autism Project successfully integrates a CNN-based screening model with a web platform to promote autism awareness and digital support. The model (h5) is deployed using FastAPI and evaluates the uploaded facial images to generate a probability-based risk score. Although this system does not provide medical diagnosis, it does support early awareness and direction. Future enhancements include expanding the dataset, integrating real-time webcam analysis using TensorFlow.js, incorporating multimodal behavioral analysis (speech, motion tracking), and collaborating with medical professionals to improve reliability and ethical impact.

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