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Rule Based Cross Age Autism Detection System

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***Abstract*—**A rule based cross age autism detection system Abstract Early detection of autism spectrum disorder (ASD) is essential for early intervention. However, it is often hampered by a lack of diagnostic expertise and the cost of assessment in low-resource environments. The recently developed digital screening solutions utilize Artificial Intelligence (AI) and cloud computing; this raises privacy concerns and often function as a "black box." This article proposes a rule based cross age autism detection system which is a privacy preserving web application that undertakes initial autism screening using a combination of age appropriate behavioural questionnaires and (optional) video observation (OpenCV and MediaPipe). The system utilizes rules to analyse behavioural character-istics such as eye contact, facial expression, gaze direction, and repetitive movements rather than deep learning algorithms. The resulting information contributes towards a Behavioural Alignment Score which is presented to the user via an interactive dashboard and is also exported as a PDF. Since no computations are external to the device no data ever leaves the user, allowing a transparent assessment process and preserving the user's privacy. The proposed rule based system offers an ethical, explainable, resource efficient solution to preliminary behavioural screening that can be deployed in a variety of educational and clinical contexts and low-resource settings.

Keywords *—Autism Spectrum Disorder, Behavioural Screen-ing, Rule-Based System, Computer Vision, OpenCV, MediaPipe, Privacy-Preserving Architecture*

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition defined by difficulties in the core areas of social interaction and communication and the presence of repetitive behaviours and a restricted range of interests.

WhileASD exists on a spectrum of severity, individuals with autism may demonstrate challenges such as inattentive gaze, difficulties maintaining conversation, and sensitivity to environmental stimuli. Early detection and diagnosis can lead to early behavioural intervention and therapy which has been proven to significantly improve developmental outcomes for young children [1]. Early intervention includes behavioural therapy, educational support, and parental training.

However, diagnosing ASD traditionally relies on trained psychologists and developmental pediatricians who have experience in behavioural assessment and analysis. Access to such specialists, however, remains difficult in many low and middle income countries where shortages in training and professional healthcare services prevent many children from receiving a timely diagnosis [2]. The development of AI, ML, and computer vision technology has seen an increase in automated approaches to detect developmental and behavioural conditions such as autism [3].

Many are based on Deep Learning architectures, Machine Learning techniques such as support vector machines, and the analysis of behaviour and facial expressions from video [4], [5].

These approaches may demonstrate accuracy comparable to or exceeding human expert judgement however these typically require extensive computing resources and a reliance on cloud-based infrastructures [6]. One limitation of such approaches in a clinical context is the often opaque nature of the "black box" approach adopted in their development [7]. Such black boxes make the outputs difficult to interrogate; this hinders acceptance and adoption in a medical setting. Furthermore, the often used cloud infrastructure presents a data privacy risk, particularly in sensitive settings like early years services or in a medical setting where sensitive information relating to child development may be captured and stored remotely [8]. Consequently, there is an increase in need of such diagnostic systems where accuracy and comprehensibility does not necessarily cause excessive consumption of computing resources and which can be utilized in schools,clinics and even in remote areas where access to technology might be difficult, so to facilitate doctors.

In this work, we introduce a rule based approach to autism detection.

This system combines a traditional structured questionnaire with optional video analysis using computer vision techniques to establish a score on behaviour-based items. Unlike AI-based

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black boxes, this rule based system outputs behaviour based scores which are explainable and auditable. We ensure user privacy and system transparency by implementing all analysis on local hardware and removing any reliance on third party APIs or cloud storage.

II. Literature Review

Screening of ASD with digital technologies has been given a lot of consideration recently. Many new developed screen-ing methods use technologies of Artificial Intelligence (AI), Machine Learning (ML), and Computer Vision to evaluate behavioral patterns of the questionnaires, facial image, eye movements, speech signals, video data etc. [3,4,5]. Such methods also show relatively good performances but it needs sufficient data set, strong computation and often cloud environment [6].

A. AI and Machine Learning Approaches

Several researchers have explored the use of CNNs, SVM, Random Forests, and deep learning methods in the context of autism detection [5, 6]. This type of methods analyzes face expressions, attention direction, head pose and behaviour patterns in videos and images [4, 11]. Computer vision and deep learning methods offer acceptable classification rates but need large labeled datasets and strong hardware to work [3]. Deep learning approaches work on black-box models, where users (health providers and family caregivers) do not have access on how results are achieved. The opacity makes the systems less trustworthy in use (especially in healthcare uses) [7, 12].

B. Computer Vision-Based Screening

Several studies have lately investigated utilizing OpenCV and MediaPipe for behavioral monitoring. In that research, face landmark detection can be applied to record the orien-tation of the head, direction of view and expression of the eye as well as frequent motions without medical instruments [4,11]. The recorded videos not only act as solid evidence for observation, but also supplement the responses from self-reporting questionnaires [10, 8]. However, most of the existing video-based system processes the input videos through the cloud server, and thus brings the issue of security and privacy.

C. Privacy and Explainability Challenges

It is clear to see that such applications for healthcare often entail the uploading of much personal and sensitive data. When uploading behavioural videos and assessment to other servers remote from you, there are more chances for its exposure to unintended parties for illicit purposes [8,10]. In addition to that, often, prediction will often result in nothing other than a prediction score and often no details as to what behavioral indicators affected the decision making result are released. As this issue comes to rise in this area, Explainability becomes a significant necessity for medical decision support system applications [7,9,12].

D. Rule-Based Systems

Since there is a lack of explainability in the neural network model the system needs to generate a completely opaque score which makes it a very bad option in a real application with educational purpose. The rule based approaches have limited capability in detecting complicated behavioural patterns as identified by neural network approaches and have limitations when coming to computational needs, but offers a total interpretability of the result of behaviour assessment. Such techniques are most suitable in the pre-assessment of the child at educational setting, at resource constrained areas such as schools and other communities with basic computational capabilities [9, 13].

The novel Rule based Cross Age Autism Detection System described here employs structured questionnaire with automated computer vision based rules from OpenCV and Media pipe framework instead of complex neural network model.

It not only provides complete transparency on every computed aspects that leads to the outcome score, but also ensures that no processing takes place outside the user's local computer thereby maintaining user's privacy [4,8,10].

III. Proposed Methodology

Rule Based Cross Age Autism Detection System aims to perform the behavioural pre-screening in an entirely local, private and confidential web application (not dependent on the cloud). The system provides an early detection method for autistic spectrum disorders based on both subjective and objective measurements [8,10]. The application is structured into five major components and will serve an entire workflow:

1) User Authentication
   The users have to register and securely log in the system before they can start with the assessment. Authentication provides security and ensures that only a given registered individual can retrieve his previous reports from the system. This helps maintain data privacy at a higher level.
2) Behavioural Questionnaire
   The system is capable of administering different questionnaires based on the age group of the individual under assessment. Questionnaires are answered by either a parent/caregiver for a child, or by the individual himself for teens and adults [2]. The behavioural elements that are analysed based on the Questionnaire input include
   - Social interaction
   - Communication skills
   - Emotional behaviour
   - Sensory sensitivity
   - Routine adherence
   - Repetitive behaviour
3) Video-Based Behaviour Analysis
   After the questionnaire completion, the user can choose to voluntarily upload a recorded frontal view video. This video is processed on the users computer using

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Video analysis framework which provides features such as [4,11]

- Face detection
- Facial landmark extraction
- Eye contact consistency
- Gaze direction
- Head movement
- Repetitive upper body movement

4) Rule-Based Behaviour Evaluation
Rather than using a typical machine learning based algorithm to decide whether a user is having signs of autism, a purely rule-based method is applied [9,13]. All specific behavioral observed through question and the Video are allotted a certain score based on the expert definition and existing literature on Autism Disorder.
For example,
   - Reduced eye contact increases contribution to behavioural score.
   - Increased gaze aversion contributes additional score.
   - Recurring action contributes behavioural weight.
   - Questionnaire responses are mapped to behavioural domains.

   These all contributes in to the Final Behavioural Alignment Score.
5) Report Generation
The final Behavioral Alignment Score along with every behavioral details and their calculated score is summarized in an interactive dashbord and a downloadable report in the PDF format with necessary consultation and guidance are suggested to consult a doctor when there is any doubt for the ASD.

IV. System Architecture

The proposed architecture is comprised of 5 distinct layers:

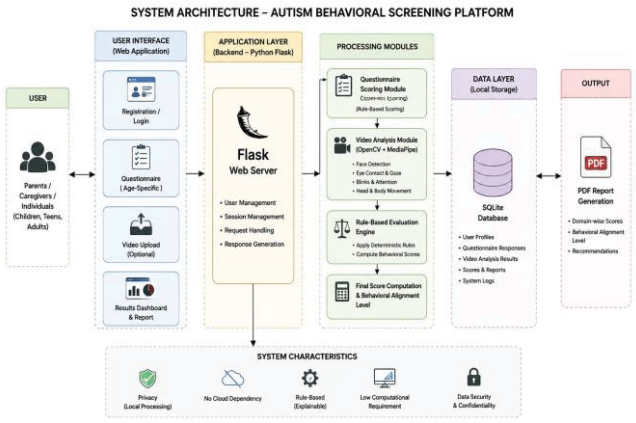


Fig. 1. Overall System Architecture

A. Frontend Layer

Front-end layer Developed using HTML, CSS, JavaScript, and Chart.js. Used for user authentication, rendering the questionnaire forms, visualising user response-based dashboard, downloading reports.

B. Backend Layer

Back-end layer Created with Flask. Responsible for han-dling API routing, user sessions, questionnaires processing, scoring, and connecting to the local SQLite database.

C. Rule-Based Video Analysis Module

Rule-based Video Analysis module Implemented using OpenCV and MediaPipe to perform behavioral tracking, such as

- Face Detection
- Facial Landmark Detection
- Eye Tracking
- Gaze Estimation
- Head Pose Detection
- Movement Analysis

Machine Learning Methods vs the Desired Methods The extracted behaviour observations are analysed via specified deterministic rules instead of using Machine Learning algorithms.

D. Database Layer

SQLite stores

- User information
- Questionnaire responses
- Behaviour scores
- Assessment history
- Generated reports

The behavioural data will not be shared externally as all data will remain on the locally stored machine.

V. Implementation

A. Hardware and Software Requirements

The proposed Rule Based Cross Age Autism Detection System has been designed to works on a regular consumer's hardware. The minimum hardware requirements are Intel Core i3 processor, 4 GB RAM, webcam, and approximately Disk Space of 500 MB.

The software environment consists of:

- Python 3.8 or above
- Flask Framework
- OpenCV
- MediaPipe
- SQLite Database
- HTML
- CSS
- JavaScript
- Chart.js
- ReportLab

The application runs entirely on the local device.

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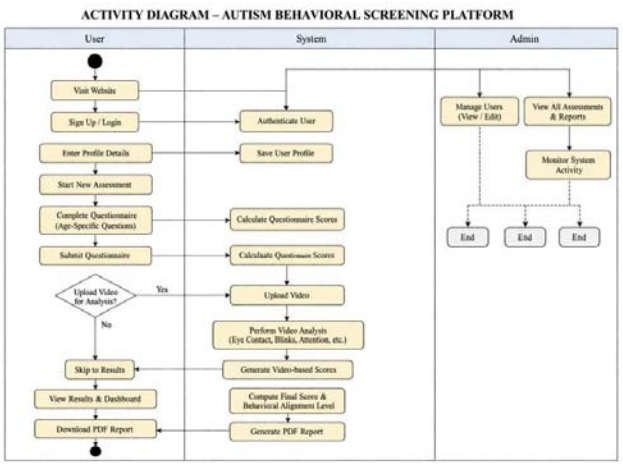


Fig. 2. Activity Diagram of the Proposed System

B. System Workflow

The complete workflow of the proposed system is illustrated in Fig. 2.

The operational flow is summarized below:

1) User Registration and Login
   User Registers or Log-in to the systems.
2) Questionnaire Assessment
   Depending on the age groups selected Questionnaire are loaded on the run time.
3) Optional Video Upload
   The user will uplaod the frontal video which should not exceed 10 to 60 Seconds
4) Behaviour Analysis
   Behaviour Analysis - OpenCV along with Mediapipe detect face landmark s the, user gaze directly, constancy of contact with others, the repetitions on mannerism.
5) Rule Evaluation
   Deterministic rules evaluta e the observed behaviors.
6) Behavioural Alignment Score Calculation
   It will calculate and derive an aggregate score based on the answers and observe behaviors
7) Dashboard Generation
   display the real-time dashboards via the use of charts through Charts.js.
8) PDF Report Generation
   generates an individualised detail assessment using ReportLab .

VI. Results and Discussion

This prototype proof of concept shows how behavioral assessment using questionnaires can be combined with rule-based computer vision [4,9].

The decisions on every behavioral classification are understandable because they come from deterministic pre-defined rules, unlike deep-learning [9,13].

The behavior's assessment comes with an easily inter-pretable Behavioral Alignment Score to the users instead of black-box prediction [7].

TABLE I
Behavioural Alignment Score Classification

Level	Score Range	Interpretation
Low	< 0.70	There were not any detectable autistic symptoms in behaviour.
Moderate	0.70–1.30	Significant matching of behaviours found. Professional advice is recommended.
High	> 1.30	High behavioural alignment with features of ASD. Clinical assessment is strongly recommended.

The proposed approach provides several advantages:

- Complete privacy as processing is done locally.
- Explainable decision making based on rules.
- Low computational requirements.
- No dependency on cloud.
- Easy deployment in educational institutions.
- Suitable for low-resource environments.

VII. Limitations and Future Scope

Despite clear behavioural screening there are other drawbacks on the proposed platform. The system is meant for behavioural assessment, not for medical diagnosis. The accuracy of observations depends on the quality of web camera, illumination, position of user and resolution of the video. Despite clear behavioural screening there are other drawbacks on the proposed platform.

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Future enhancements include:

- Real-time webcam analysis
- Mobile application deployment
- Multi-language support
- More flexible behavioural rule engine
- Explainable AI integration
- Clinical testing with large datasets

VIII. Conclusion

This paper introduced a Rule Based Cross Age Autism Detection System based on specific questionnaires that were adapted for age in conjunction with computer vision assessment using OpenCV and MediaPipe. This system deviates from conventional automated screening solutions that utilize AI in that it processes everything local, employs a set of behavioral rules to provide the user with results that are deterministic and understandable. Not only does it protect user privacy with the automatic creation of the Behavioral Alignment Score and the resultant PDF report for easy understanding, but it also makes a clear-valued,ethical, resource-efficient pre-screening application that will further the use of such programs to foster an increase of diagnosis rates and the rate of diagnosis with young age.

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