Natural Resources for Human Health
eISSN: 2583-1194

Original Research
Received 02 May 2026
Revised 10 June 2026
Accepted 28 June 2026

Natural Resources for Human Health 2026, Vol. 6 (7s): 679–690

KEYWORDS:
CNN, Face recognition, OpenCV, Sentiment Analysis, Facial Expression Analysis, Eye movement

An Intelligent Multimodal Framework for Personalized Autism Spectrum Disorder Assessment and Therapeutic Support

Debmitra Ghosh[1*], Dr. Dharmpal Singh[2], Dr. Sumit Das[3], Subhodip Koley[4], Kallol Acharjee[5], Dipansu Mondal[6]

[1,2*]Computer Science and Engineering Department, JIS University, Kolkata, India
Email: debmitra.ghosh@jisuniversity.ac.in
[3]Department of Information Technology, JIS College of Engineering, Maulana Abdul Kalam Azad University of Technology, Kalyani, India,
[4]Department of Computer Application, JIS College of Engineering, Maulana Abdul Kalam Azad University of Technology, Kalyani, India
[5]Department of Information Technology, JIS College of Engineering, Maulana Abdul Kalam Azad University of Technology, Kalyani, India
[6]Department of Centre for Information Resource Management, University of Kalyani, Kalyani, India

ABSTRACT: The disorder of autism spectrum disorder (ASD) is a complex neurodevelopmental condition that involves various abilities and variations, such as difficulties with specific skills or repetitive tasks, as well as verbal and non-verbal communication. They cannot increase or decrease sensitivity to sensory input such as sound, touch or smell. This includes recognising the diversity of experience and ability across the spectrum and fostering an inclusive and supportive environment for people with autism. The study examines the relationship between certain behavioural signals, such as eye movements and tongue protrusions, that children show during and after exposure to vivid stimuli. The observation was made under controlled conditions of a group comprising children with ASD and developmental peers. Where their reactions to the cartoons were recorded. The analysis showed clear patterns: while typically developing children had a variety of facial expressions and actively engaged in content, children with ASD often had a limited emotional response, including a minimal or delayed response, and characteristic behaviours such as repeated eye movements (up-down). gaze) and occasional tongue protrusions. These findings highlight the potential of using subtle behavioural indicators captured by video-based assessments to aid in the early screening and detection of ASD. It faces challenges in understanding and responding to social cues, building relationships, and expressing empathy, delayed speech development, difficulties in understanding and using language, or a complete lack of non-verbal communication.

1. INTRODUCTION

Early diagnosis of autism spectrum disorder (ASD) is important to initiate early interventions that can improve the developmental outcomes of affected children. [10]. Although traditional diagnostic methods are based on behavioural assessments and clinical observations, recent studies have explored new approaches using technology and multimedia stimuli to identify early indicators of ASD. A good way is to analyse children's reactions to cartoons, simple behavioural indicators can provide important information about their social and communication skills. Children with ASD often have difficulty interpreting and responding to social cues such as facial expressions and gestures. Animated videos with attractive images and narrative elements act as a controlled stimulus that elicits different responses in children [1]. Observing how children respond or do not respond to these stimuli can provide clues about their sensory processing, emotionality and social engagement, all of which are key areas affected by ASD. This study focuses on analysing specific behaviours observed during and immediately after exposure to cartoons in children with and without ASD. The main aspect of interest is the eye movements, characterised by repeated up-down glances and the occasional tongue protrusion after video recording. These behaviours, which are often subtle and easily overlooked in everyday interactions, have been observed in clinical settings as potential signs of ASD [2]. Recent advances in video recording and analysis techniques allow these behaviours to be accurately documented and studied. By capturing and analysing such subtle signals, researchers are trying to develop objective metrics that complement traditional diagnostic tools. This approach not only improves the diagnostic process but also provides a non-invasive and child-friendly method for early screening. The challenge is to identify significant patterns between the variation of individual responses and vivid stimuli. While typically developing children can display a variety of emotional expressions and interactive behaviours in response to cartoons, children with ASD often exhibit atypical responses characterised by impaired or delayed responses and overt motor behaviours such as repetitive eye movements and tongue protrusions. The consequences of this. Research goes beyond early detection. Early identification of ASD allows [11] Access to interventions tailored to each child's unique needs. potentially mitigating the impact of developmental problems and improving long-term outcomes. In addition, the integration of video-based assessments into clinical practice can standardise diagnostic procedures, reduce diagnostic delays, and improve the accuracy of ASD diagnoses. A child with ASD does not pay attention to some live broadcasts. Let's say that when an actual online reading session takes place, different children participate in the online lesson. But when the teacher asks questions randomly, some children do not respond to his words, even after being asked twice, they do not pay attention. To facilitate recognition, we use the OpenCV library for real-time facial recognition to see their reactions after seeing the facial expression by analysing the facial emotion recognition of cartoons in real time. A normal child should be happy to see the video, but only from the perspective of the disorder, the child cannot be happy because his neurological development process is delayed. Using cartoons as a means to observe and analyse children's responses is a promising way to improve early detection and understanding of ASD. This approach emphasizes the importance of using technological azvances to improve diagnostic methods and ultimately improve the lives of people with autism.

2. RELATED WORKS

Integrating multimedia stimuli, particularly cartoon videos, into the diagnostic assessment holds promise for identifying early behavioural indicators of ASD. These studies highlight the importance of using technology and empirical research to develop sensitive and objective tools [12] that support early intervention and improve To address the complex issues surrounding autism spectrum disorder, it is crucial to encourage collaboration among clinicians, researchers, and technologists in researching and collaborating on outcomes. ASD and intervention. Attempts have been made to integrate video-based assessments into clinical diagnostic methods for ASD. Muratori et al. (2017) [21]. Investigated the utility of video analysis in improving diagnostic accuracy by capturing and quantifying behavioural indicators characteristic of ASD, such as delayed or deficient responses to social cues and stereotypic behaviour. Their findings highlight the potential of multimedia stimuli as standardised tools to improve the objectivity and reliability of ASD diagnoses. Comparative studies of children with ASD and typically developing peers have provided valuable information about patterns of response to vivid stimuli. Conducted a longitudinal study that examined how children's emotional reactions and interactive behaviour developed over time when exposed to cartoons. They found that while typically developing children exhibited a variety of emotional expressions and interactive behaviours, children with ASD often exhibited limited emotional responsiveness and repetitive motor behaviours such as tongue sticking out after videotaping. Advances in technology have made it possible to develop automatic tools to analyse children's responses to multimedia stimuli. Goodwin et al. (2018) [23] developed a software tool that uses machine learning algorithms to identify subtle facial expressions and behavioural signs suggestive of ASD in video recordings. Their approach aims to provide objective measures that complement traditional diagnostic methods and facilitate early intervention strategies. Research has also focused on analysing certain behaviours, such as eye movements and nonverbal cues, during and after video recording. Jones et al. (2016) [24] conducted a study that used eye- tracking technology to monitor the gaze patterns of children with ASD while watching animated series. They found that children with ASD exhibited typical gaze behaviours, including repetitive up-and-down eye movements, which could be signs of the disorder. Studies have shown that observing children's reactions to animated videos can provide valuable information about their social and communication skills, which are often impaired in ASD. For example, Bhat et al. (2011) examined how children with and without ASD reacted to social and non-social videos. They found that children with ASD showed less attention to social stimuli and showed fewer emotional reactions compared to typically developing children. This study highlights the potential of video-based assessments to reveal early behavioural differences associated with ASD. Researchers have used video stimuli, including cartoons, to observe and analyse how children with ASD interact and respond compared to typically developing children. Chita-Tedmark (2016) [26] investigated how children with ASD attend vivid social scenes compared to non-social scenes. They found that children with ASD showed less interest in social relationships depicted in cartoons and showed fewer facial expressions and gestures compared to their neurotypical peers. This study highlights the potential of using animated stimuli to assess social and communication skills, which are critical areas affected by ASD. Eye-tracking technology has helped study eye patterns and visual attention in children with ASD during video presentations. Fletcher-Watson et al. (2009) investigated eye movements and control in children with ASD while viewing dynamic social scenes. They found differences in gaze fixations and saccadic movements, with children on the spectrum often showing atypical patterns, such as prolonged fixations on objects rather than faces. This study highlights the use of eye movement analysis as a sensitive marker to detect social perception difficulties associated with ASD. Automated tools that can analyse facial expressions and respond to visual stimuli are now attainable due to advancements in computer vision and machine learning. During the 2009-2017 study period, 1 in 6 children (ages 3-17) reported that their child's parents had a developmental disability. Diseases including autism, ADHD, blindness and cerebral palsy were listed [25]. Their research demonstrated the potential of using video-based assessments to measure emotional expression and identify ASD diagnosis symptoms.

3. CHALLENGES

Inattention to animations, abnormal eye movements and tongue sticking out are symptoms of ASD [13]. Children with ASD have difficulty participating in activities that their peers enjoy, which affects their interactions and play. Therefore, abnormal eye movements hinder the development of non-verbal communication skills necessary for social interaction [14]. Defects captured on live video increase the accuracy of autism prediction. This is also done by learning different types of humour because it helps to understand the life style. Children with ASD may exhibit repetitive behaviours and have limited interests that interfere with many tasks. These challenges are significant, and early intervention and appropriate support can significantly improve outcomes for children with ASD.

3.1 EYE CONTACT IS A SIGNIFICANT FACTOR IN THE DEVELOPMENT OF AUTISM:

Eye movement analysis focuses on several key parameters, including gaze direction, fixation duration, saccades, and pupillary response. People with autism often have different eye movement patterns compared to neurotypical people. For example, they may spend less time looking at faces and more time focusing on objects or details in the background. This difference in viewing behaviour can be an important indicator of the social and communication difficulties that are the core features of autism [3]. Gaze direction is a critical parameter in eye movement analysis. Studies have shown that autistic people avoid direct eye contact and may become distressed after being stared at by others. This can lead to challenges in understanding social cues and social interaction [15]. By analysing the direction and duration of gaze, researchers [16] were able to identify patterns that indicate autism. For example, children with autism may have less time to look at people's eyes and mouths, which are key areas for interpreting emotions and needs. Time or time spent looking at a particular point is another important metric. Neurotypical individuals usually have a balanced distribution of fixations in different regions of the scene. In contrast, individuals with autism may have a longer focus on certain objects or regions, suggesting a tendency to focus intensely on certain details while ignoring others [17]. This atypical fixation pattern can disrupt the ability to gather comprehensive information about the environment, making social interaction and communication difficult. Saccades, rapid eye movements between fixation points, are also different in people with autism. Research suggests that autistic individuals may exhibit atypical saccadic patterns [4], such as fewer or slower saccades when scanning a scene. This can affect their ability to process visual information quickly and efficiently, causing challenges in interpreting complex social situations. Analysis of saccade patterns can provide valuable information about differences in visual processing associated with autism [18]. Autism detection through eye movement analysis has become an important research area that leverages machine [19] learning and computer vision advances. Eye movements, an important indicator of cognitive and social engagement, provide important insights into the behavioural patterns of individuals with autism. Through the examination of these movements, scientists strive to create diagnostic tools that are both efficient and non-invasive. Autism spectrum disorder (ASD) [20] is characterized by difficulties with social interaction, communication and repetitive behaviour. Early diagnosis is critical to implementing effective intervention strategies, and eye movement analysis has shown promise in identifying atypical gaze patterns associated with autism. People with ASD often have different eye movements, such as reduced eye contact, different fixation patterns and unusual eye movements, which can indicate their condition. Detecting eye movements in autism involves several important steps, starting with data collection. This step involves the collection of extensive video recordings of individuals with or without autism performing various tasks or viewing stimuli. High-resolution cameras and eye-tracking devices are used to record precise eye movements, providing detailed information about gaze direction, fixation duration and saccadic movements.

3.2 AUTISM WITH TONGUE PROTRUSIONS:

The presence of numerous social, communication, and behavioural issues is a characteristic of Autism Spectrum Disorder (ASD) Early diagnosis of autism is important to provide timely interventions that can improve developmental outcomes. An emerging area of research focuses on analysing non-verbal behaviours such as tongue sticking out to detect early signs of autism. Tongue thrusting and tongue thrusting are simple but important behaviours that indicate developmental differences. Research has shown that children with autism may have atypical tongue protrusion compared to their neurotypical peers. These differences may be related to problems with motor control, sensory processing and social interaction. People with autism often have impaired motor control, resulting in atypical movements and gestures. Tongue protrusions that require fine motor control may occur more often or in different contexts in children with autism. These differences may be small but they can be detected by careful observation and analysis. For example, an autistic child may stick out his tongue during tasks that require concentration or when overloaded with sensory stimuli, which highlights the link between motor control and sensory processing in autism. Sensory processing differences are a hallmark of autism and affect how people perceive and respond to sensory information. Tongue protrusions may be a response to sensory overload or a self-stimulatory behaviour used to regulate sensory input. In social contexts, autistic children may use tongue protrusion to cope with overwhelming stimuli or to seek sensory feedback. This behaviour can act as a calming mechanism to help the person control their sensory environment. Social interaction challenges are another key feature of autism, and tongue protrusions can be a sign of these difficulties. Non-verbal communication such as facial expressions and gestures play a vital role in social interaction. Children with autism often have difficulty interpreting and using non-verbal cues. Protruding parts of the tongue during social interactions may reflect difficulties in understanding social norms and expectations. For example, a child with autism may stick out their tongue to express discomfort or lack of understanding due to social anxiety or embarrassment. Analysing tongue protrusions for autism requires observing the frequency, context, and associated behaviour of tongue protrusions. These findings can be recorded and analysed to identify patterns that distinguish autistic children from their neurotypical peers. For example, if a child often sticks out their tongue during social interactions, this may indicate difficulties in social interaction. Similarly, tongue protrusions during tasks that require concentration or in a sensory environment may highlight problems related to motor control and sensory processing.

3.3 CARTOON VIDEO HELPS TO ANALYSE FACIAL EXPRESSION:

Autism detection using cartoon videos involves assessment of attention level, a method that uses visual engagement and response patterns instead of conventional diagnostic methods. This approach takes advantage of the inherent attraction that children, including children with ASD, have for animated content that can reveal valuable information about their cognitive processes and social interaction skills. It explores how cartoon videos technological implications and ethical considerations of this innovative diagnostic tool. Some of the challenges are —

- Cartoon videos as diagnostic tools: Cartoons are probably a part of every child. They have the happiest moments with this comic. However, out of 100 children, 99% of the children answered, but 1% still did not express themselves.
- Technological innovations: Advances in technology (e.g. eye tracking software, artificial intelligence algorithm) increase the use of cartoons in diagnosis by extracting the features of real-time video expressions.

The aim is to illustrate how cartoon videos offer a unique and promising way to detect autism using attention level assessment. It highlights both the opportunities and challenges associated with this approach.

4. WORKFLOW DIAGRAM OF MODEL

Workflow diagram and visual representation of our model is shown below in fig 1–

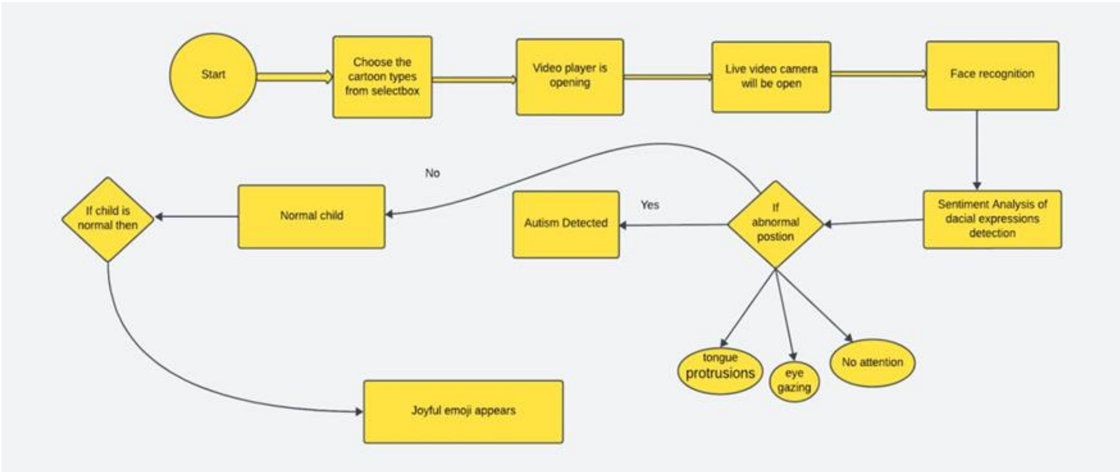

Fig: 1 Workflow diagram and visual representation of the model.

Comparative Study:

Overview of Existing Approaches

- **Face Detection**: Convolutional Neural Networks (CNN) and Multi-Task Contraction Network(MTCNN), for example, are currently used for accurate real-time face recognition. These approaches are mature and widely used in a variety of environments.
- **Emotion Detection**: The first method is to analyse facial expressions using deep learning methods (CNN, RNN or hybrid models). Popular datasets such as FER, CK+ and others have improved the accuracy of emotion recognition.
- **Autism Detection**: Current research relies on behavioural assessments (such as the ADOS-2) and clinical observations. Recently, automated systems are emerging where facial expressions, eye tracking and speech signals are evaluated using artificial intelligence.

Current Limitations

- **Face Detection**: High-performance models require large amounts of label data and high computing power, which limits real-time applications in low-resource settings.
- **Emotion Detection**: Accurately understanding emotions can be difficult, especially for children, because emotional expression can vary greatly across ages, cultures, and individual behaviour patterns.
- **Autism Detection**: Most of the current models focus on static features, such as eye contact or eye muscle movement. However, they often ignore the physiological aspect (i.e. how the child's response

Proposed Novelty

- **Dynamic Emotional Response Tracking**: Instead of drawing ideas from snapshots or photos of graphs, you can build a system that tracks emotional changes over time by watching a series of animations. This dynamic analysis can capture periodic responses to emotional cues in cartoons, such as happiness, surprise, or sadness, and further explain the emotional response. Internal.
- **Multi-modal Approach**: Instead of relying solely on facial expressions, integrate additional modalities, such as **eye gaze tracking** (to observe attention shifts), **voice analysis** (if possible), and **gesture analysis**. This holistic view of emotional expression will increase detection accuracy.

- **Cartoon-Based Stimuli Customization**: Match cartoon stimuli with emotional or social situations designed to elicit responses that children with autism experience (e.g. social connectedness, empathy). You can create videos that focus on autistic behaviour and have a stronger foundation for identifying autistic behaviour.
- **Neurodevelopmental Profiles**: Exploring the use of deep learning to create emotional neurodevelopmental information. By analyzing the child's reaction to the various emotions in the cartoons, the student can compare the responses to developmental patterns.
- **Cross-cultural and Age-specific Calibration**: Include a comparative analysis of emotional responses across different age groups and cultures to increase generalizability. This will strengthen the paper's relevance across diverse populations.

Comparison with Previous Work

- **Face Detection**: Compare the accuracy and efficiency of your facial recognition system with advanced techniques such as MTCNN and Face Net. Highlight the improvement in processing time, and stability in low light conditions or the area of blocking.
- **Emotion Detection**: Show how your dynamic emotional response tracking outperforms models that focus on static facial expressions. Highlight the importance of emotion evolution and the novel insights this approach brings to the autism detection domain.
- **Autism Detection**: Emphasize the benefits of using dynamic responses to stimuli over traditional one- time assessments. Show how incorporating emotional changes can facilitate early, non-invasive screening for autism and potentially reduce the age of intervention.

Personalized Emotional Feedback Loop: Imagine a system that provides real-time alarm adjustments, with the ability to monitor child emotions through feedback. This is an opportunity for the autism spectrum and healing process.

Ethical and Data Privacy Considerations: Given the sensitive nature of working with children, consider a comprehensive section on ethical considerations, confidentiality and the importance of consent. Demonstrate how your system can optimize data collection and processing for greater utility in sensitive environments.

ABOUT PROJECT INSTANCES:

4.1 APP INSTANCES:

The figure 2 shows Working procedure of the app**.**

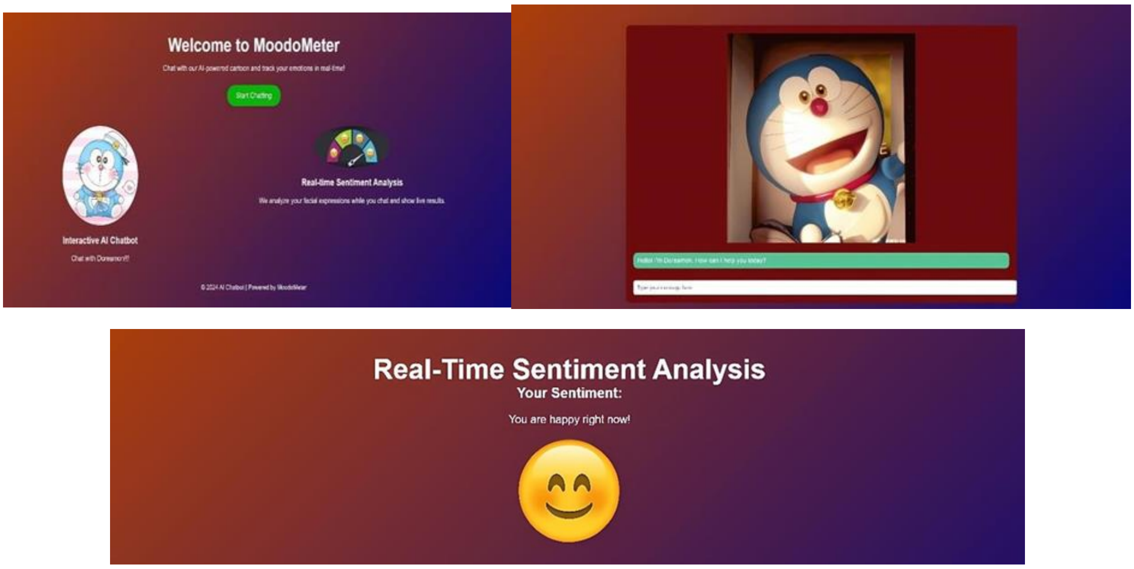

Figure 2: Snapshots of the app.

5. METHODOLOGY

Acquired to identify Autism Spectrum Disorder (ASD)involves a comprehensive evaluation that includes observing the child's behaviour, taking a developmental history, and providing various assessments. The behaviours you mention - lack of interest in the cartoon, atypical eye movements and tongue sticking out – may be part of this assessment, but they alone cannot determine an ASD diagnosis.

USED LIBRARY: Tensorflow, Keras, Streamlight, Scikit-learn, Numpy, Pandas, Matplotlib, Seaborn, OpenCv

USED PLATFORM: Jupyter Notebook, Vscode.

DATASET:

a) We have our dataset that uses facial expression and gaze data carefully. We source cartoon videos and make sure they are kid-friendly and have a variety of content.

b) We collect images of the facial expressions of both typically developing children and children diagnosed with autism as they watch these videos.

c) Tagging each image with the appropriate child diagnosis (autism or typically developing) and other relevant information (eg age, gender). Of.

5.1 DATA PREPROCESSING:

Standardize image size after data pre-processing to maintain consistency. Set the pixel values to the same range, usually 0-1. If necessary, supplement the data using transformations such as rotation or translation to increase the diversity and robustness of the dataset. Next, we convert indicators such as sex and gender into numerical values using standard coding techniques. This step is important for feeding data to machine learning models that require numerical integration. Then the data sets are divided into three separate sets: training, validation and test sets. The training set is used to train the model, the validation set helps to adjust the metadata of the model, and the test set evaluates the performance of the model with null data. This distribution ensures that the model is broad and works well with new data. Figure 3 shows various data visualization techniques. The figure 3 shows distribution of dataset.

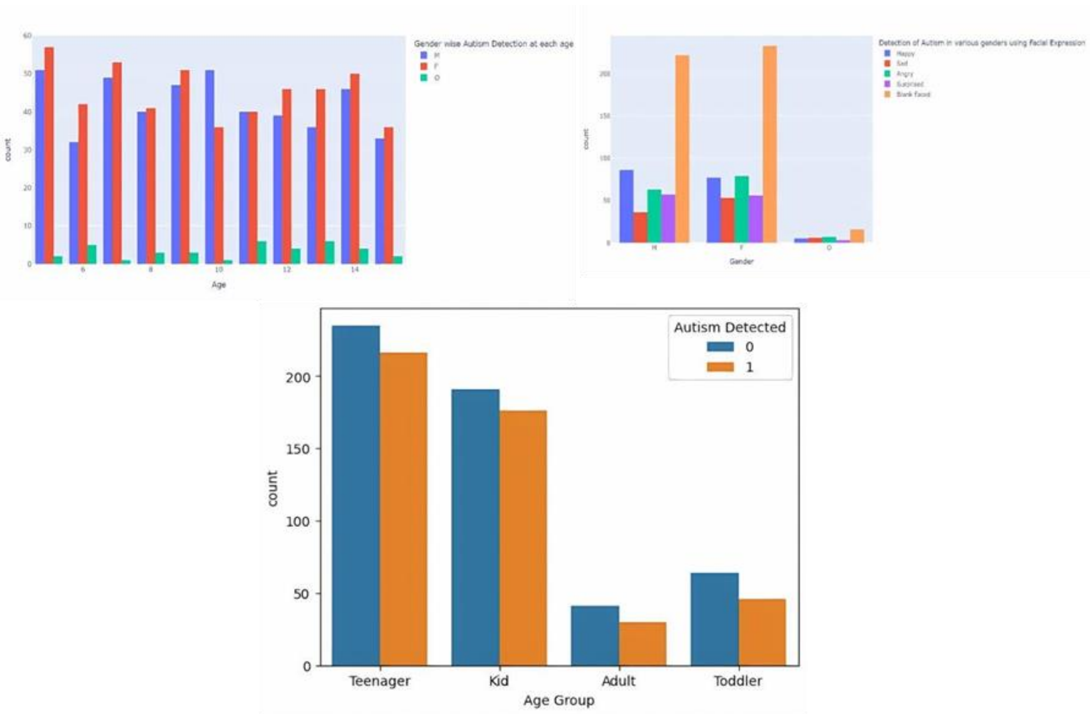

Fig: 3 Shows various data visualization techniques.

5.3 MODEL SELECTION:

We use CNN (Convolutional Neural Network) for image recognition and RNN (Recurrent Neural Network) for better feedback and their combination as Convolutional Recurrent Networks (CRN Models that contain temporary data (video) are a good choice for studying sequences of images. Break down the data as a training, validation and testing set.

5.4 ALGORITHMS:

The Convolutional Recurrent Network (CRN) is a powerful deep learning architecture that integrates Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) for tasks requiring both spatial and temporal data processing. It is well-suited for domains such as video analysis, speech recognition, and other spatiotemporal sequence analysis.

Here is a reformulation of the CRN model algorithm with mathematical explanations:

5.4.1 CNN Layer: Spatial Feature Extraction

The CNN layer extracts spatial features from the input data. Assume the input is a 3D tensor X of dimensions (T, H, W), where:

- T represents the number of time steps or frames,
- H is the height of each frame,
- W is the width of each frame.

Convolution Operation:

For each time step t, a 2D convolution operation is performed on the corresponding input frame X_t, as follows:

$X'_t = f(W_c * X_t + b_c)$

Where:

- X_t is the input tensor at time step t,
- W_c and b_c are the convolutional filter weights and biases,
- f is an activation function (such as ReLU),
- represents the convolution operation,
- X'_t is the output feature map at time step t.

5.4.2 Pooling Layer: Dimensionality Reduction

To reduce the spatial dimensions of the feature maps and retain important features, a pooling operation (like max pooling) is applied. This reduces computational complexity while preserving key information.

Pooling Operation:

For each time step t, the pooling operation is applied to the convolutional output X'_t:

$X''_t = pool(X'_t)$

Where:

- X''_t is the reduced (pooled) feature map at time step t,
- pool represents the pooling function, typically max or average pooling.

5.4.3 RNN Layer: Temporal Feature Learning

The RNN layer, often implemented using LSTM or GRU, captures temporal dependencies between feature maps across time steps. The pooled feature maps from the CNN layer are processed as a sequence $\{X''_1, X''_2, ..., X''_T\}$.

LSTM Operation (Example):

The LSTM processes the sequence of pooled feature maps. At each time step t, the following equations govern

the LSTM cell operations:

$$i_t = \sigma (W_i X''_t + U_i h_{t-1} + b_i)$$

$$f_t = \sigma (W_f X''_t + U_f h_{t-1} + b_f)$$

$$o_t = \sigma (W_o X''_t + U_o h_{t-1} + b_o)$$

$$\tilde{c}_t = \tanh (W_c X''_t + U_c h_{t-1} + b_c)$$

$$c_t = f_t \odot c_{t-1} + i_t \odot \tilde{c}_t$$

$$h_t = o_t \odot \tanh(c_t)$$

Where:

- i_t, f_t, o_t are the input, forget, and output gate activations at time step t,
- $\tilde{c}_t$ is the candidate cell state,
- c_t is the cell state at time step t,
- h_t is the hidden state at time step t,
- σ is the sigmoid function,
- tanh is the hyperbolic tangent function,
- $\odot$ denotes element-wise multiplication,
- W_i, W_f, W_o, W_c and U_i, U_f, U_o, U_c are weight matrices,
- b_i, b_f, b_o, b_c are biased terms.

5.4.4 Fully Connected (FC) Layer: Final Prediction

After the RNN processes the temporal sequence, the hidden state at the final time step, h_T, is passed through a fully connected layer to produce the final prediction, whether it is for classification or regression.

Fully Connected Operation:

The output is computed as:

$$y = f (W_{fc} h_T + b_{fc})$$

Where:

- W_{fc} and b_{fc} are the weight matrix and bias for the fully connected layer,
- f is an activation function, typically softmax for classification tasks or linear for regression,

- h_T is the final hidden state from the RNN layer,
- y is the final output.

6. MODEL EVALUATION

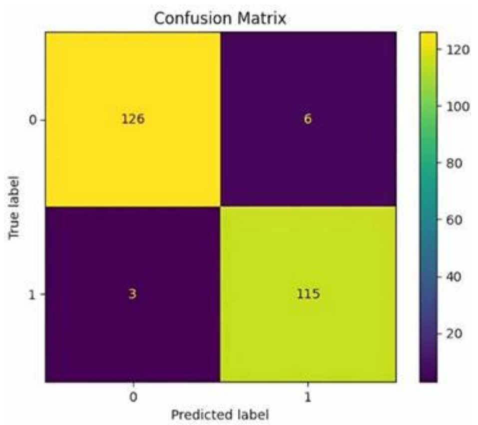

Fig: 8

7. RESULT AND DISCUSSION:

We see that if a child shows indifference to the video, shows atypical eye movements (like up-down) or behaviours like tongue-sticking, this can prompt caregivers and educators to consider the possibility of ASD. These behaviours may indicate problems with social interaction, communication, and sensory processing that are characteristic of ASD. It is important to emphasise that although these behaviours may be concerning, they are not, by themselves, definitive indicators of ASD. ASD is a complex neurodevelopmental disorder that requires thorough evaluation by trained professionals [5]. This assessment usually involves observing the child's behaviour in various contexts, gathering a developmental history from caregivers, and conducting standardised screening tests and clinical assessments. Behavioural observations play a crucial role in the diagnostic process. A child's lack of interest in a cartoon video may be due to difficulty engaging in age-appropriate activities or understanding social cues that would normally generate interest. Atypical eye movements, such as repetitive up- and-down movements, may indicate challenges in maintaining typical visual attention or processing sensory stimuli normally. Similarly, behaviours such as tongue protrusion may be due to sensory seeking or motor coordination problems, highlighting potential sensory processing differences associated with ASD. Caregivers and trainers who notice these behaviours must approach them with sensitivity and awareness.[6] Early recognition and intervention can significantly affect a child's development and well-being. By recognizing these potential signs, caregivers can initiate timely assessments and interventions tailored to the child's specific needs. Understanding these behaviours in the broader context of ASD helps create a supportive environment for the child. It encourages caregivers and teachers to seek guidance from health professionals who specialise in developmental disabilities. Working with a multidisciplinary team ensures a holistic approach to assessment and intervention planning that addresses various aspects of child development, including social skills, communication skills, sensory sensitivity and behavioural problems [7]. Recognizing and acknowledging behaviours such as indifference to a cartoon, atypical eye movements, or unusual behaviours such as tongue sticking out can be early indicators of potential developmental problems, including ASD. However, a thorough evaluation by qualified professionals is necessary to confirm the diagnosis and create an individualised intervention and support plan. Early identification and intervention are critical to optimising outcomes for children with ASD, emphasising the importance of awareness, proactive assessment, and collaboration between caregivers, educators, and healthcare providers.

8. CONCLUSION

Observing a child's reaction to a cartoon, such as lack of interest, atypical eye movements (such as up and down), or tongue thrusting, may raise concerns that may indicate autism spectrum disorder (ASD) [8]. However, these behaviours alone do not definitively diagnose ASD. Diagnosis requires a thorough professional evaluation that includes behavioural observations, developmental history, standard screening tests, and clinical evaluations. ASD is characterised by several challenges, including difficulties with social interaction, communication and sensory processing. Early identification and intervention are critical to improving outcomes, as tailored support can help children with ASD develop skills and navigate everyday life more effectively.[9] It is important for caregivers and educators to be alert for potential signs, seek professional help when concerns arise, and work with a multidisciplinary team to provide appropriate support and interventions based on a child's unique needs and strengths.

- Competing Interests: N/A

- Funding Information: N/A

- Data Availability Statement: N/A

- Research Involving Human and /or Animals: N/A

- Informed Consent: N/A

REFERENCES

[1] APA, Diagnostic and Statistical Manual of Mental Disorders, 5th ed. Washington, DC: American Psychiatric Association, 2022.

[2] K. Bottema-Beutel, S. K. Kapp, J. N. Lester, N. J. Sasson, and B. N. Hand, "Avoiding ableist language: Suggestions for autism researchers," Autism in adulthood, vol. 3, no. 1, pp. 18–29, 2021.

[3] E. A. Fuller and A. P. Kaiser, "The effects of early intervention on social communication outcomes for children with autism spectrum disorder: A meta-analysis," Journal of Autism and Developmental Disorders, vol. 50, pp. 1683–1700, 2020.

[4] A. S. Nahmias, M. Pellecchia, A. C. Stahmer, and D. S. Mandell, "Effectiveness of community-based early intervention for children with autism spectrum disorder: A meta-analysis," Journal of Child Psychology and Psychiatry, vol. 60, no. 11, pp. 1200–1209, 2019.

[5] M. can't Hof, C. Tisseur, I. van Berckelear-Onnes, A. van Nieuwenhuyzen, A. M. Daniels, M. Deen, H. W. Hoek, and W. A. Ester, "Age at autism spectrum disorder diagnosis: A systematic review and metaanalysis from 2012 to 2019," Autism, vol. 25, no. 4, pp. 862–873, 2021.

[6] D. L. Robins, D. Fein, and M. Barton, "M-chat-r/f: The modified checklist for autism in toddlers, revised with follow-up," Online, 2009, available at: https://www.mchatscreen.com/.

[7] K. Supekar, C. de Los Angeles, S. Ryali, K. Cao, T. Ma, and V. Menon, "Deep learning identifies robust gender differences in functional brain organization and their dissociable links to clinical symptoms in autism," The British Journal of Psychiatry, vol. 220, no. 4, pp. 202–209, 2022.

[8] F. Cilia, R. Carette, M. Elbattah, G. Dequen, J.-L. Guerin, J. Bosche, ´ L. Vandromme, B. Le Driant et al., "Computer-aided screening of autism spectrum disorder: Eye-tracking study using data visualization and deep learning," JMIR human factors, vol. 8, no. 4, p. e27706, 2021.

[9] J. T. Megerian, S. Dey, R. D. Melmed, D. L. Coury, M. Lerner, C. J. Nicholls, K. Sohl, R. Rouhbakhsh, A. Narasimhan, J. Romain et al., "Evaluation of an artificial intelligence-based medical device for diagnosis of autism spectrum disorder," NPJ digital medicine, vol. 5, no. 1, p. 57, 2022.

[10] W. Jones and A. Klin, "Attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism," Nature, vol. 504, no. 7480, pp. 427–431, 2013.

[11] P. Mundy and J. Bullen, "The bidirectional social-cognitive mechanisms of the social-attention symptoms of autism," Frontiers in Psychiatry, vol. 12, p. 752274, 2022.

[12] OpenAI, "Gpt-4 technical report," 2023.

[13] C. Li, C. Wong, S. Zhang, N. Usuyama, H. Liu, J. Yang, T. Naumann, H. Poon, and J. Gao, "Llava-med: Training a large language-and-vision assistant for biomedicine in one day," arXiv preprint arXiv:2306.00890, 2023.

[14] E. Billing, T. Belpaeme, H. Cai, H.-L. Cao, A. Ciocan, C. Costescu,D. David, R. Homewood, D. Hernandez Garcia, P. Gomez Esteban ´ et al., “The dream dataset: Supporting a data-driven study of autism spectrum disorder and robot enhanced therapy,” PloS one, vol. 15, no. 8, p. e0236939, 2020.

[15] J. Rehg, G. Abowd, A. Rozga, M. Romero, M. Clements, S. Sclaroff, I. Essa, O. Ousley, Y. Li, C. Kim et al., “Decoding children’s social behaviour,” in Proceedings of the IEEE conference on computer vision and pattern recognition, 2013, pp. 3414–3421.

[16] G. Riva, E. Riva et al., “De-enigma: Multimodal human-robot interaction for teaching and expanding social imagination in autistic children,” Cyberpsychology, behaviour and social networking, vol. 23, no. 11, pp. 806– 807, 2020.

[17] A. Zunino, P. Morerio, A. Cavallo, C. Ansuini, J. Podda, F. Battaglia, E. Veneselli, C. Becchio, and V. Murino, “Video gesture analysis for autism spectrum disorder detection,” in 2018 24th international conference on pattern recognition (ICPR). IEEE, 2018, pp. 3421–3426.

[18] P. Pandey, A. Prathosh, M. Kohli, and J. Pritchard, “Guided weak supervision for action recognition with scarce data to assess skills of children with autism,” in Proceedings of the AAAI Conference on Artificial Intelligence, 2020, pp. 463–470.

[19] M. Del Coco, M. Leo, P. Carcagno`ı, F. Fama, L. Spadaro, L. Ruta, G. Pioggia, and C. Distante, “Study of mechanisms of social interaction stimulation in autism spectrum disorder by an assisted humanoid robot,” IEEE Transactions on Cognitive and Developmental Systems, vol. 10, no. 4, pp. 993–1004, 2017.

[20] G. Dawson, K. Campbell, J. Hashemi, S. J. Lippmann, V. Smith, K. Carpenter, H. Egger, S. Espinosa, S. Vermeer, J. Baker et al., “Atypical postural control can be detected via computer vision analysis in toddlers with autism spectrum disorder,” Scientific reports, vol. 8, no. 1, p. 17008, 2018.

[21] Kamran M (2019) ICTs in learning: multimedia learning in the classroom. Glob Media J Pak Ed 12(1):77– 94

[22] Logan H, Cumming T, Wong S (2020) Sustaining the work-related wellbeing of early childhood educators: perspectives from key stakeholders in early childhood organisations. Int J Early Child 52(1):95–113

[23] Sudarsana IK (2018) Quality improvement of early childhood education through the utilization of multimedia. J Penjaminan Mutu 4(2):174–183

[24] Li H, Yang W, Chen JJ (2016) From ‘Cinderella’to ‘Beloved Princess’: the evolution of early childhood education policy in China. Int J Child Care Educ Policy 10:1–17

[25] Zablotsky, B., Black, L.I., Maenner, M.J. et al.: Prevalence and trends of developmental disabilities among children in the United States 2009–2017. Pediatrics 144(4), e20190811 (2019)

[26] Chita-Tegmark, Meia, et al. "Investigating social attention in autism using interactive technologies: a systematic review and meta-analysis." International Journal of Human-Computer Studies 87 (2016): 1-19.