ANALYSING FACIAL EMOTION FOR CHILDREN WITH AUTISM

A PROJECT REPORT

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ABSTRACT

"Analysing Facial Emotions for Children with Autism" is a project that utilises computer vision and machine learning techniques to improve the emotional well-being of children with Autism Spectrum Disorder (ASD). The project captures facial expressions of children with ASD while they play a game aimed at improving their social communication skills and emotional understanding. A convolutional neural network trained on the Facial Expression Recognition dataset is used to analyse these facial expressions and detect different emotions such as happiness, sadness, anger, fear, surprise, and disgust. The results are used to provide a report that details the emotional state of the child during each task of the game. Children with ASD often struggle to express their emotions and may find it challenging to communicate their feelings effectively. By analysing the emotional state of children with ASD, the project aims to provide valuable insights into their mental health and emotional needs. This information can help doctors and caretakers to tailor interventions and treatments to the specific needs of each child, improving the effectiveness of therapy and enhancing the overall well-being of the child. The project's ultimate goal is to improve emotional understanding and communication skills of children with ASD through targeted interventions based on the analysed emotional data. The project also aims to promote the use of technology in improving the emotional well-being of children with ASD and increase awareness of the potential benefits of game-based approaches in therapy for children with ASD.

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LIST OF ABBREVIATIONS

ABBREVIATIONS / ACRONYM	DESCRIPTION
AFE	Analysing Facial Emotion
ASD	Autism Spectrum Disorder
FER	Facial Expression Recognition
CNN	Convolutional Neural Network
ERA	Emotion Recognition Assistance
DNN	Deep Neural Network
NEOB	Negative Emotion Outbursts
HFE	Human Facial Expressions
CER	Compound Emotion Recognition
CE	Compound Emotion
RNN	Recurrent Neural Network
AU	Auction Unit
UI	User Interface
UX	User Experience

CHAPTER 1

INTRODUCTION

"Analysing Facial Emotions for Children with Autism" is a project aimed at improving the emotional well-being of children with Autism Spectrum Disorder (ASD) by analysing their facial expressions and detecting their emotional state. ASD is a developmental condition that impacts behaviour, social interaction, and communication. Children with ASD often struggle to express their emotions and may find it challenging to communicate their feelings effectively. As a result, they may experience difficulties in forming and maintaining relationships, managing social interactions, and responding appropriately to social cues. The project uses OpenCV, a popular computer vision library, to capture facial expressions of children with ASD while they play a game that has been developed to improve their social communication skills and emotional understanding. A convolutional neural network (CNN) trained on the Facial Expression Recognition (FER) dataset is then used to analyse these facial expressions and detect different emotions such as happiness, sadness, anger, fear, surprise, and disgust. The results are then used to provide a report that details the emotional state of the child during each task of the game. The project aims to address a significant challenge in the treatment and care of children with ASD, namely the difficulty of assessing their emotional state accurately. Since children with ASD may have difficulties expressing their emotions verbally or through body language, caregivers and healthcare professionals may find it challenging to understand their emotional needs and tailor interventions accordingly. By using computer vision and machine learning algorithms to analyse facial expressions, the project aims to provide a more objective and accurate assessment of the child's emotional state, allowing caregivers and healthcare professionals to design more effective interventions. The ultimate goal of the project is to improve emotional understanding and communication

skills of children with ASD through targeted interventions based on the analysed emotional data. The project also aims to promote the use of technology in improving the emotional well-being of children with ASD and increase awareness of the potential benefits of game-based approaches in therapy for children with ASD. The project is significant because it addresses an important challenge in the treatment and care of children with ASD, namely the need for more objective and accurate methods of assessing emotional states. The project's focus on developing a game that improves social communication skills and emotional understanding of children with ASD is particularly noteworthy. The use of computer vision and machine learning algorithms to analyse facial expressions in real-time is also a significant contribution to the field. The project has several potential applications in the field of healthcare, particularly in the assessment and treatment of children with ASD. The use of computer vision and machine learning algorithms can be extended to other areas of healthcare, such as mental health, where objective and accurate assessments of emotional states are also important. In conclusion, "Analysing Facial Emotions for Children with Autism" is a significant project aimed at improving the emotional well-being of children with ASD by analysing their facial expressions and detecting their emotional state. By using computer vision and machine learning algorithms, the project provides a more objective and accurate assessment of the child's emotional state, allowing caregivers and healthcare professionals to design more effective interventions. The project's focus on developing a game that improves social communication skills and emotional understanding of children with ASD is particularly noteworthy, and its potential applications in the field of healthcare are significant. The project aims to promote the use of technology in improving the emotional well-being of children with ASD and increase awareness of the potential benefits of game-based approaches in therapy for children with ASD.

CHAPTER 2

LITERATURE REVIEW

2.1. Emotion Detection of Autistic Children Using Image Processing

Authors : Pooja Rani

Publisher : IEEE

Year : 2020

(Published in : 2019 Fifth International Conference on Image Information Processing)

A method for identifying human emotions using facial expressions is called facial emotion detection. A sophisticated neurobehavioral disorder is autism spectrum disorder. People with autism exhibit rude, repeated behaviour. They are not yet prepared for social interaction. These condition sufferers have difficulty identifying emotions. This study aims to identify autistic children's emotions based on the expression on their faces. Four emotions are the focus of this essay. These feelings include sadness, joy, neutrality, and anger. Image processing and machine learning techniques are used to identify the emotions of autistic youngsters. The autistic children's faces are used to extract the features using a local binary pattern. Algorithms for machine learning are used to categorise emotions. Support vector machines and other machine learning classifiers are utilised in the classification process.

2.2. An Augmentative System with Facial and Emotion Recognition for Improving Social Skills of Children with Autism Spectrum Disorders

Authors : Mohammed Alharbi, Mohammed Alharbi

Publisher : IEEE

Year : 2020

(Published in : 2020 IEEE International Systems Conference)

One in 68 children are affected by autism spectrum disorders (ASDs), a complex, widespread, and multivariate neurodevelopmental condition. Scientific studies have demonstrated the effectiveness of employing technology to help autistic youngsters develop their social and communication abilities. Children with autism are more motivated to learn while playing games when software solutions like mobile apps and multimedia are used. This paper introduces Ying, an Android mobile application that includes facial and emotion recognition. The use of this smartphone software enhances current conventional therapy strategies for helping autistic kids connect socially, such as Applied Behaviour Analysis (ABA). Ying uses a variety of computer-assisted technology to improve the verbal and social behaviour of autistic children. An experiment demonstrating the effectiveness of Ying has been carried out, and its findings

2.3. Emotional Expressions Recognize Ability in Children with Autism: Intervention Using Emotion Recognition Assistance Application

Emotional Expressions Recognize Ability in Children with Autism: Intervention Using Emotion Recognition Assistance Application

Authors : Muchamad Irvan, Ahsan Romadlon Junaidi, Dimas Arif Dewantoro, Eka Puput Puspitasari, Yuliana Pramesti, Vannicia Wahyu Ramadhani

Publisher : IEEE

Year : 2022

(Published in : 2022 8th International Conference on Education and Technology)

The foundation for acquiring social relationship skills is the capacity to recognise emotional expression. Children who suffer from autism spectrum diseases have trouble reading others' emotional cues. This study

used assistive technology based on the Emotion Recognition Assistance (ERA) android application to conduct an experiment to increase the abilities of recognising fundamental emotional expressions (angry, joyful, sad, and fearful). In the ERA application, research participants can engage in three levels of interactive activity: basic emotion recognition, context-matching for emotional expressions, and finally, imitating emotional expressions by taking photos of themselves and receiving feedback from the system on the accuracy of the expressions displayed. Wilcoxcon data analysis revealed a considerable increase in the outcomes.

2.4. Channel Deep Neural Network-based SoC for Emotion Detection of Autistic Children

Authors : Abdul Rehman Aslam, Talha Iqbal, Mahnoor Aftab, Wala Saadeh, Muhammad Awais Bin Altaf

Publisher : IEEE

Year : 2020

(Published in : 2020 IEEE Custom Integrated Circuits Conference)

It is described as an EEG-based noninvasive neurofeedback SoC for the classification of emotions in autistic children. To achieve a 30% area reduction and an overall integrated input-referred noise of 0.55 VRMS with cross-talk of -79dB, the AFE consists of two completely shared EEG-channels. With >85% accuracy, the on-sensor integration of a 4-layer Deep Neural Network (DNN) classifier allows for the classification of four emotions. The 10.13J/classification for 2 channels is consumed by the 16mm 2 SoC in 0.18um CMOS.

2.5. Channel Deep Neural Network Based SoC for Negative Emotion Outburst Detection of Autistic ChildrenChannel Deep Neural Network Based SoC for Negative Emotion Outburst Detection of Autistic Children

Authors : AbdulRehman Aslam, Muhammad AwaisBin Altaf

Publisher : IEEE

Year : 2021

(Published in : IEEE Transactions on Biomedical Circuits and Systems)

An EEG-based non-invasive 2-channel neuro-feedback SoC is presented to predict and record Autistic individuals' negative emotion outbursts (NEOB). The SoC has a deep neural network (DNN) emotion classification engine as well as a dual-channel Analogue Front-End (AFE), which is both space and power efficient. To reduce the issues with overfitting and area, the classification processor only uses two features per channel. To forecast the NEOB, a 4-layer, customised DNN classification processor is installed on the sensor. The AFE uses sampling capacitors to minimise the area by 30% and consists of two completely shared EEG channels. Additionally, it accomplishes a total integrated input-referred noise, NEF, and crosstalk of 0.55 V RMS, 2.71, and 79 dB, respectively. The 16 mm 2 SoC has a 0.18 um 1P6M, CMOS implementation and uses 10.13 J/classification for a 2-channel operation while averaging >85% accuracy in real-time testing and across several emotion databases.

2.6. Compound Emotion Recognition of Autistic Children During Meltdown Crisis Based on Deep Spatio-Temporal Analysis of Facial Geometric Features

Authors : Salma Kammoun Jarraya, Marwa Masmoudi, Mohamed Hammami

Publisher : IEEE

Year : 2020

(Published in : IEEE Access, Volume - 8)

Recognising human emotion has made a significant contribution to computer vision applications. Despite its importance, this work takes into account the safety of autistic individuals during meltdown crises by creating a new technique to alert carers using facial expression detection. Dealing with the meltdown situation has been done so with caution. Certainly, aberrant facial expressions associated with compound emotions are related to the symptoms of meltdown. Actually, scientists once believed that human facial expressions (HFE) could only express the basic seven emotions. Psychologists have described HFE as being extremely complex, as it can represent two or even more emotions known as compound or mixed emotions. There has been a little research on compound emotion (CE). In addition, there are numerous challenging tasks to identify compound emotion recognition (CER). In this study, we experimentally evaluate a collection of deep spatiotemporal geometric aspects of autistic children's microexpressions during a meltdown crisis. To do this, we compare the CER performance to several collections of microexpression characteristics in order to determine which features best distinguish autistic children's CE in meltdown crisis from normal state and which features have the best classifier performance. Using the Kinect camera in critical situations, we record films of autistic youngsters both in regular situations and during meltdowns. The experimental analysis reveals that the Recurrent Neural Network RNN with three hidden layers and Information Gain Feature Selection methods offer the best performance (85.8%) and deep spatio-temporal geometric features.

2.7. A Lightweight Convolutional Neural Network for Real-Time Facial Expression Detection

Authors : Ning Zhou, Renyu Liang, Wenqian Shi

Publisher : IEEE

Year : 2020

(Published in : IEEE Access, Volume - 9)

In order to improve the classification result, our group in this paper proposes and constructs a lightweight convolutional neural network (CNN) for real-time and bulk facial emotion detection. We build a real-time vision system to test the efficacy of our approach. Face identification is carried out by this system using multi-task cascaded convolutional networks (MTCNN), and the resulting face coordinates are transmitted to the facial emotions classification model that we first created. The task of emotion classification is thus completed. One of the cascade detection features in multi-task cascaded convolutional networks can be employed by itself to require less memory space. Global Average Pooling replaces the fully connected layer in the conventional deep convolutional neural network model in our expression categorization model. The feature map's channels are each connected to the corresponding category, somewhat removing the fully connected layer's "black box" qualities. In addition, our model combines depth-wise separable convolutions with residual modules, which drastically reduces the number of parameters and increases the model's portability. Finally, the FER-2013 dataset is used to test our model. The task of classifying facial expressions only requires 0.496GB memory, or 3.1% of the 16GB memory available. Our model's accuracy on the FER-2013 dataset reached 67%, and it can be saved in a file of 872.9 kilobytes. Additionally, it effectively detects and recognises figures that are not included in the collection.

2.8. Real-Time Facial Expression Recognition Based on Edge Computing

Authors : Jiannan Yang, Tiantian Qian, Fan Zhang, Samee U. Khan

Publisher : IEEE

Year : 2021

(Published in : IEEE Access, Volume - 9)

Many large-scale Internet of Things (IoT) information systems, including smart cities, smart medical systems, and industrial Internet systems, can now be transformed into interconnected sensor networks. If edge computing is successfully used in the IoT, it will improve sustainability, make our algorithms faster and more convenient, reduce total costs, and provide better business practices. In order to identify facial expressions, facial action unit (AU) identification examines cues regarding the movement of certain atomic muscles in the surrounding facial region. We may calculate the values of AU and then utilise classification algorithms for emotion recognition based on the facial feature points that were observed. The end user can more readily receive the identified emotions in edge devices by employing optimised and proprietary algorithms to analyse the raw image data from each camera directly. It presents difficulties for a real-time facial expression recognition system to be implemented in a distributed way while running in production due to the significant network overhead of delivering the facial action unit feature data. In order to meet this need, we created a lightweight distributed system based on edge computing utilising Raspberry Pi, and we optimised the data transfer and component distribution. To cut down on round-trip delays, front-end and back-end processing modes are separated nearby, allowing for the completion of complex computing activities and the provision of high-reliability, large-scale connection services.

2.9. Real Time Emotion Detection Using Deep Learning

Authors : Noel Jaymon, Sushma Nagdeote, Aayush Yadav, Ryan Rodrigues

Publisher : IEEE

Year : 2021

(Published in : 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies)

Facial expressions represent feelings and reveal information about a person's personality and thinking. The machine continuously completes various jobs in an effort to gain more exposure in public. Various jobs can be carried out by machines that have emotional intelligence. Machine perception necessitates that machines learn about their surroundings. Understanding facial expressions is essential for comprehending emotions as well as for finding numerous applications in the area of human-computer interaction. The model is trained on the Fer2013 dataset using the CNN Xception Architecture, the Keras library, and the Tensorflow framework.

2.10. Real-Time Facial Emotion Recognition

Authors : Devanshu Shah, Khushi Chavan, Sanket Shah, Pratik Kanani

Publisher : IEEE

Year : 2021

(Published in : 2021 2nd Global Conference for Advancement in Technology)

Being able to express emotions is a crucial quality of humans. Intimate ways of communication between people are based on emotions. With the use of a computer, it may also be possible to recognise emotions from

facial expressions. Facial emotion recognition has become more common in intelligent systems in recent years as a way to enhance human interaction. Based on human emotion, these systems continuously alter how they function. In this paper, we present a convolutional neural network (CNN)-based architecture for facial emotion identification. We employ the Facial Expression Recognition 2013 dataset (FER2013) in the implementation. We demonstrate through behavioural study how certain emotions appear to be sensitive to various facial features.

2.11. Video Games for the Treatment of Autism Spectrum Disorder

Authors : Laura Jimenez-Munoz, Inmaculada Penuelas-Calvo, Pilar Calvo-Rivera, Isaac Diaz-Olivan, Manon Moreno, Enrique Baca-Garcia & Alejandro Porras-Segovia

Publisher : Springer

Year : 2021

For kids with Autism Spectrum Disorders (ASD), playing video games is a promising area of intervention. There aren't many reviews on this subject, though. The preferred reporting items for systematic reviews and meta-analyses were adhered to in this review of research looking into the use of video games to treat ASD, and its PROSPERO protocol was registered. Databases from PubMed, PsycInfo, Embase, WebOfScience, and clinicaltrials.gov were looked up. The review covered 24 articles in all. Despite having tiny effect sizes, video game-based therapies were successful in reducing the symptoms of ASD. High rates of therapy acceptance and adherence were attained. Video games offer a viable avenue for enhancing the care of kids with ASD. One area of potential future research is the examination of commercial video games.

2.12. Emotional Understanding Skills Training Using Educational Computer Game in Children with Autism Spectrum Disorder

Authors : Stankova, Mihova, Kamenski, Mehandjiiska

Publisher : IEEE

Year : 2021

(Published in : 2021 44th International Convention on Information, Communication and Electronic Technology, MIPRO)

This study examines the effectiveness of an educational computer game application for teaching social skills to children with autism spectrum disorder (ASD) by identifying and labelling emotions. The ability model of emotional intelligence served as the foundation for the creation of the instructional computer game. The game's primary goal is to help kids with ASD learn how to name, interpret, and recognise emotions through the use of emoticons and visuals that are based on a story's premise. The e-learning platform Moodle now includes the educational computer game. The case of a child with ASD is discussed in the study, along with the outcomes of using the game repeatedly. By tracking errors, looking for more details, correct and incorrect efforts in the various game modules, as well as the amount of time needed to complete the tasks, a study of the development of the skills for recognising emotions was conducted. In order to learn more about the child's behaviour, his interest in the game, and his motivation, a survey for the parents was also used. The findings highlight the need for succinct instructions, the use of straightforward language, and the game's beneficial impact on emotion recognition.

2.13. Overview of the Literature

For kids with autism spectrum disorder (ASD), emotional literacy and communication skills are crucial, according to recent studies in the field of affective computing. Children with ASD frequently experience difficulties with emotional control, social interaction, and empathy, which can result in social isolation and poor emotional functioning.

Game-based therapies utilising computer vision and machine learning methods have recently shown potential in enhancing the emotional wellbeing of kids with ASD. These solutions make use of convolutional neural networks (CNN) and other algorithms to recognise and analyse facial expressions, accurately identifying emotional states. Children with ASD have shown to respond better to game-based interventions, which can be tailored to target particular emotional regulation and social communication difficulties.

Numerous studies have demonstrated that game-based therapies can greatly enhance the social communication and emotional functioning of kids with ASD. In one study, children with ASD who participated in a game-based training programme for emotion detection showed appreciably greater gains in this skill than those who did not get the intervention.

Machine learning algorithms have been used in conjunction with facial expression recognition (FER) datasets, such as the popular FER-2013 dataset, to precisely identify emotions from facial expressions. Both children with ASD and children who are typically developing can benefit from this strategy, according to research.

In order to gain a deeper knowledge of the emotional states of kids with ASD, computer vision and machine learning approaches have also been combined with physiological data like heart rate and skin conductance. These methods can be used to give children and carers

immediate feedback as well as to track changes in emotional states over time.

There are still restrictions on the use of technology-based therapies in children with ASD, despite the encouraging findings. Individual responses to technology-based therapy vary depending on the individual, interventions must be personalised to meet particular issues with emotional regulation and social engagement, and technology may eventually supplant social connection and human interaction.

The literature emphasises the value of communication and emotional literacy for kids with ASD, as well as the potential advantages of technology-based therapy utilising computer vision and machine learning methods. These therapies can be tailored to target particular emotional regulation and social communication issues in kids with ASD. They can accurately recognise and analyse facial expressions utilising FER datasets and algorithms like CNNs.

In conclusion, the research demonstrates the potential advantages of game-based therapies utilising computer vision and machine learning approaches for enhancing social communication and emotional functioning in ASD children. For a more thorough understanding of emotional states, these interventions can be integrated with physiological monitoring and virtual reality (VR) technology. They can also be customised to address particular difficulties. Individual variations in responsiveness to interventions as well as the necessity of interpersonal and social communication must also be taken into account.

CHAPTER 3

PROBLEM DESCRIPTION

Analysing Facial Emotions for Children with Autism is a project to address the emotional well-being of children with Autism Spectrum Disorder (ASD) who have difficulty in expressing their emotions and communicating effectively. The project aims to detect the emotional state of children with ASD using facial expression recognition technology and use the data to develop targeted interventions that can improve the social communication skills and emotional understanding of these children. By addressing this problem, the project can help to enhance the overall well-being of children with ASD and promote the use of technology in improving emotional health.

3.1. Background of the Project

Autism Spectrum Disorder (ASD) is a developmental disorder that affects communication, social interaction, and behaviour. Children with ASD often struggle to express their emotions and may find it challenging to communicate their feelings effectively. Analysing the emotional state of children with ASD can provide valuable insights into their mental health and emotional needs. "Analysing Facial Emotions for Children with Autism" is aimed at improving the emotional well-being of children with Autism Spectrum Disorder (ASD) by analysing their facial expressions and detecting their emotional state. Children with ASD often struggle to express their emotions and may find it challenging to communicate their feelings effectively. The project uses OpenCV to capture facial expressions of children with ASD while they play a game that has been developed to improve their social communication skills and emotional understanding.

3.2. Scope of the Project

- The project aims to improve the emotional well-being of children with ASD by analysing their facial expressions and detecting their emotional state.
- OpenCV will be used to capture facial expressions of children with ASD while they play a game that has been developed to improve their social communication skills and emotional understanding.
- A convolutional neural network (CNN) trained on the Facial Expression Recognition (FER) dataset will be used to analyse these facial expressions and detect different emotions such as happiness, sadness, anger, fear, surprise, and disgust.
- The results will be used to provide a report that details the emotional state of the child during each task of the game.

3.3. Objectives of the Project

- To improve emotional understanding and communication skills of children with ASD through targeted interventions based on analysed emotional data.
- To provide valuable insights into the mental health and emotional needs of children with ASD.
- To tailor interventions and treatments to the specific needs of each child, improving the effectiveness of therapy.
- To promote the use of technology in improving the emotional well-being of children with ASD.
- To increase awareness of the potential benefits of game-based approaches in therapy for children with ASD.

3.4. Constraints of the Projects

- Data privacy and security must be ensured when collecting and analysing sensitive data such as facial expressions and physiological data.
- The system must be user-friendly and accessible to both children with ASD and their caregivers.
- The system must accurately detect the emotional state of children with ASD and provide meaningful insights for treatment and care.
- The project must comply with relevant data protection laws.
- The system must be tested and validated with a diverse group of children with ASD and their caregivers.

3.5. Business Aspects

As a project aimed at improving the emotional well-being of children with Autism Spectrum Disorder (ASD), there are several potential business aspects to consider. One possibility is to market the game developed as part of the project as a therapeutic tool to hospitals and therapy centres specialising in ASD treatment. The emotional data collected by the project could also be used to develop personalised treatment plans for children with ASD, which could be offered as a consulting service to healthcare providers. Additionally, the technology used in the project could be adapted and licensed for use in other industries, such as mental health treatment, education, or entertainment. There may also be opportunities for collaboration with organisations focused on improving the lives of children with ASD, such as advocacy groups or research institutions. Ultimately, the potential benefits of the project extend beyond improving the emotional well-being of children with ASD to promoting awareness of the condition and advancing the use of technology in therapy and treatment.

CHAPTER 4

REQUIREMENTS

A game must be developed that can improve the social communication skills and emotional understanding of children with Autism Spectrum Disorder (ASD). A system must be developed to capture facial expressions of children with ASD while they play the game. A suitable dataset, such as the Facial Expression Recognition (FER) dataset, must be collected or obtained to train the convolutional neural network (CNN) model for facial expression recognition. A CNN model must be developed and trained on the dataset to accurately recognize different emotions such as happiness, sadness, anger, fear, surprise, and disgust. The system must be able to detect the emotional state of children in real-time during the game. A report must be generated that details the emotional state of the child during each task of the game. The system must be user-friendly and easy for caretakers and doctors to use. The system must comply with data privacy and security regulations to protect the sensitive data of the children. The system must be able to accurately recognize emotions and provide real-time feedback to the user. The system must be compatible with different devices and platforms to ensure wider accessibility.

4.1. Functional Requirements

- Facial expression capture : The system should be able to capture the facial expressions of children with autism while they play the game.
- Emotion recognition : The system should be able to recognize emotions from captured facial expressions of children with autism.
- Emotion classification : The system should be able to classify emotions of children with autism into six basic emotions - happiness, sadness, anger, fear, surprise, and disgust.

- Game development : The system should develop a game to improve the social communication skills and emotional understanding of children with autism.
- Real-time analysis : The system should analyse the facial expressions and emotional states of children with autism in real-time during the game.
- Data storage : The system should store the captured facial expressions and corresponding emotional states for further analysis.
- Reporting : The system should generate a report that details the emotional state of the child during each task of the game.
- Integration : The system should integrate the game with the emotion recognition module to facilitate real-time analysis.
- User interface : The system should provide a user-friendly interface for the caretakers and doctors to view the emotional state of children with autism.
- Scalability : The system should be scalable to support a large number of children with autism and accommodate new features and updates in the future.

4.2. Non Functional Requirements

- Performance : The system should be able to capture and analyse facial expressions in real-time with minimal latency to provide an accurate analysis of the child's emotional state.
- Usability : The game should be easy to understand and use for children with ASD, with clear instructions and an intuitive user interface. The system should also be designed to minimise errors and ensure accurate analysis of facial expressions.

- Security : The system should maintain the privacy of the children's data, ensuring that their facial expressions are not shared or accessed by unauthorised parties.
- Reliability : The system should be able to capture and analyse facial expressions consistently and accurately, without errors or downtime.
- Scalability : The system should be designed to handle a large number of users and facial expressions without performance degradation.
- Compatibility : The system should be compatible with a range of devices and operating systems commonly used by children with ASD.
- Maintainability : The system should be easy to maintain, with clear documentation and easy-to-use tools for monitoring and troubleshooting.
- Accessibility : The game and system should be accessible to children with different abilities, including those with visual or hearing impairments, by incorporating appropriate accessibility features.

4.3. Software Requirements

- OpenCV : The project requires the use of OpenCV for capturing facial expressions of children with ASD. OpenCV is an open-source computer vision library that provides tools for real-time image processing and analysis.
- Python : The project is built using Python programming language, so it requires a Python environment for implementation.

- Convolutional Neural Network (CNN) model : The project utilises a CNN model to analyse facial expressions of children with ASD. The software requirement for this is the TensorFlow machine learning framework, which provides a powerful platform for developing and training deep learning models.
- Facial Expression Recognition (FER) dataset : The project uses FER dataset for training and evaluating the CNN model. The dataset consists of over 35,000 facial images with corresponding emotion labels.
- IDE : An integrated development environment (IDE) such as PyCharm, Spyder, or Jupyter Notebook is required for developing and testing the code for the project.
- Database : The project requires a database to store the emotional data collected from the children with ASD. A suitable database system such as MySQL or SQLite can be used for this purpose.
- Game development software : The project involves the development of a game to improve social communication skills and emotional understanding of children with ASD. Suitable game development software such as Unity or Unreal Engine can be used for this purpose.
- Operating System : The project can be implemented on any operating system that supports Python and required software dependencies.

4.4. Hardware Requirements

- Computer : A computer with a minimum of 8 GB RAM and a high-performance processor is needed to run the game, capture facial expressions, and perform the emotion recognition analysis.

- Webcam : A high-resolution webcam is required to capture the facial expressions of the children accurately.
- Graphics Card A graphics card with good processing power is essential to run the game smoothly and to ensure the accuracy of the emotion recognition analysis.
- Display : A high-quality display with a high resolution and large screen size is required to provide a clear view of the game and facial expressions.
- Internet Connectivity : Internet connectivity is required to download and install necessary software updates and to access online resources such as the FER dataset.
- Storage : Sufficient storage space is required to store the game, dataset, and other necessary software components.
- Operating System : The system should run on an operating system that supports OpenCV and the required programming language and libraries.
- External Hardware : External hardware components such as microphone and speakers may be required for the game to provide audio instructions and feedback.

4.5. Specifications

- System platform : The system should be designed to run on a Windows or Linux operating system.
- Programming language : The system should be programmed in Python, and utilise OpenCV for image and video processing.
- User Interface : The system should have an intuitive and user-friendly graphical interface to make it easy for caregivers to use.

- Facial Expression Detection : The system should be able to detect facial expressions in real-time using OpenCV and a convolutional neural network (CNN) trained on the Facial Expression Recognition (FER) dataset.
- Emotion Classification : The system should classify emotions such as happiness, sadness, anger, fear, surprise, and disgust with high accuracy.
- Game Integration : The system should be able to integrate with a game specifically designed to improve the social communication skills and emotional understanding of children with ASD.
- Data Storage : The system should have the ability to store and retrieve data related to the emotional states of children during each task of the game for later analysis.
- System Performance : The system should be able to process real-time video data with a high level of accuracy and speed.
- Security : The system should implement appropriate security measures to protect sensitive data and ensure the privacy of the children using the system.
- System Compatibility : The system should be compatible with a wide range of hardware configurations and operating systems to ensure maximum accessibility.

4.6. Risk Factor

One potential risk factor for the project could be the accuracy of the emotion detection algorithm. If the algorithm is not able to accurately detect and analyse facial expressions, it may provide incorrect information about the emotional state of the child, leading to incorrect interventions and treatments. Another potential risk factor could be the safety and well-being of the children participating in the study. It is

important to ensure that the game and facial recognition technology do not cause any harm or distress to the children. Proper safety measures should be put in place and the children should be closely monitored during the study. Additionally, there may be ethical concerns surrounding the collection and use of sensitive personal data, such as facial expressions and emotional states, which must be carefully addressed to ensure the protection of the children's rights and privacy.

- Accuracy of facial expression recognition : The accuracy of the facial expression recognition software used in the project can impact the quality of data obtained. If the software is not accurate enough, it may provide misleading data that can affect the outcome of the project.
- Integration of hardware and software components : The project involves integrating hardware and software components such as cameras, microphones, and facial expression recognition algorithms. Any issues with integration can lead to delays or malfunctions in data collection and analysis.
- Data privacy and security : As the project involves collecting and analysing sensitive data about children with ASD, there is a risk of data breaches and privacy violations.
- Compatibility with different systems : The project involves using various software and hardware components, and compatibility issues can arise if they are not designed to work together. Any incompatibility can lead to delays and additional costs.
- Availability of technical expertise : The project requires expertise in areas such as computer vision, machine learning, and software engineering. A lack of skilled personnel or resources can lead to delays and errors in implementation.

CHAPTER 5

PROPOSED METHODOLOGY

The methodology for "Analysing Facial Emotions for Children with Autism" involves several key steps, including project planning, data collection, game development, facial expression detection, facial expression recognition, data analysis, testing and validation, and deployment. These steps are designed to ensure that the project meets its goals and objectives of improving the emotional well-being of children with ASD by analysing their facial expressions and detecting their emotional state. By following this methodology, the project can provide valuable insights into the mental health and emotional needs of children with ASD, and help doctors and caretakers to tailor interventions and treatments to the specific needs of each child.

5.1. PROJECT DEVELOPMENT

5.1.1. Project Planning

The first step in any project is planning. In this step, you will define the scope of the project, identify the goals and objectives, and create a timeline for completing the project. You will also need to define the project team, identify roles and responsibilities, and establish communication channels.

5.1.2. Data Collection

In this step, you will collect data on children with Autism Spectrum Disorder. The data will be used to train the machine learning algorithm. The data can be collected through various sources, such as public datasets, medical records, or by directly interacting with children with ASD. It is essential to ensure that the data collected is diverse and representative of the population.

5.1.3. Data Preprocessing

The collected data needs to be preprocessed before it can be analysed. This involves converting the video recordings into a format that can be inputted into the CNN. It may also involve reducing noise in the data and normalising the facial expressions to a common scale.

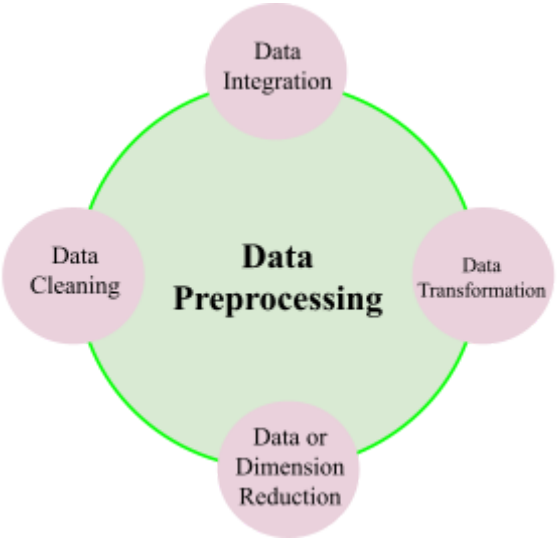

Fig. 5.1 Data Preprocessing

5.1.4. Game Development

The game development step involves creating a game that is specifically designed for children with ASD. The game should focus on improving their social communication skills and emotional understanding. The game can be designed to be played on a computer or tablet. It is essential to ensure that the game is engaging, intuitive, and user-friendly.

5.1.5. Training and Testing CNN

The next step is to train and test the CNN on the Facial Expression Recognition (FER) dataset to recognize the different emotions displayed in the facial expressions of the children with ASD. The FER dataset consists of images of facial expressions of six basic emotions: happiness, sadness, anger, fear, surprise, and disgust. The CNN will be trained on this dataset to learn the patterns and features that distinguish these different emotions.

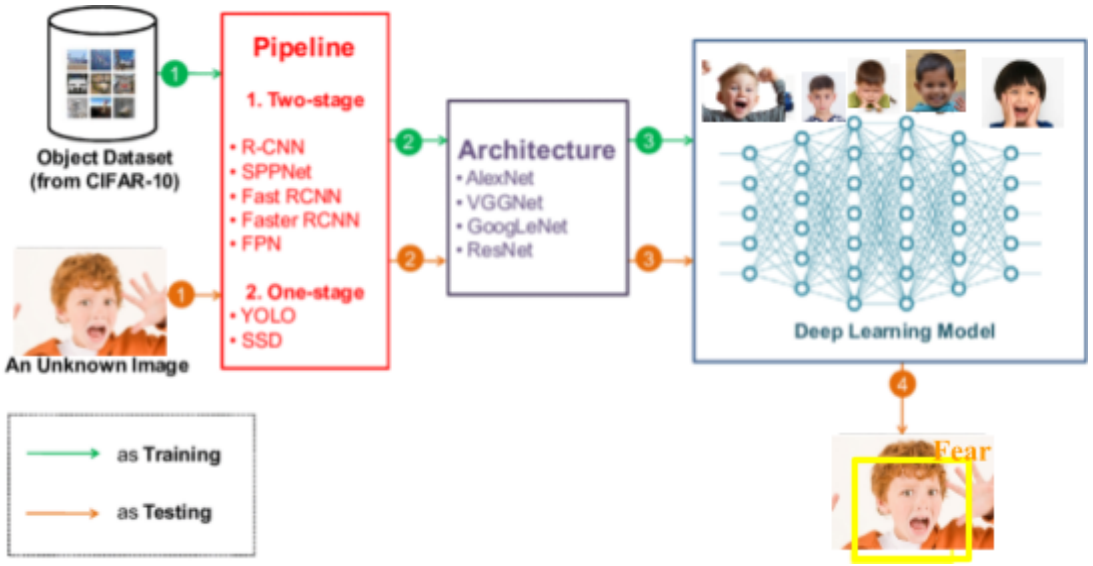

Fig. 5.2 CNN - Training and Testing

5.1.6. Facial Expression Detection

In this step, you will use OpenCV to detect facial expressions of children with ASD while they play the game. OpenCV is a computer vision library that allows for real-time facial detection and tracking. This step involves training a classifier to recognize facial expressions such as happiness, sadness, anger, fear, surprise, and disgust.

5.1.7. Facial Expression Recognition

In this step, you will use a convolutional neural network (CNN) to analyse facial expressions and detect emotions. The CNN will be trained on the Facial Expression Recognition (FER) dataset. The dataset contains over 35,000 images of facial expressions, including the six basic emotions. CNN will be trained to recognize these emotions in real-time.

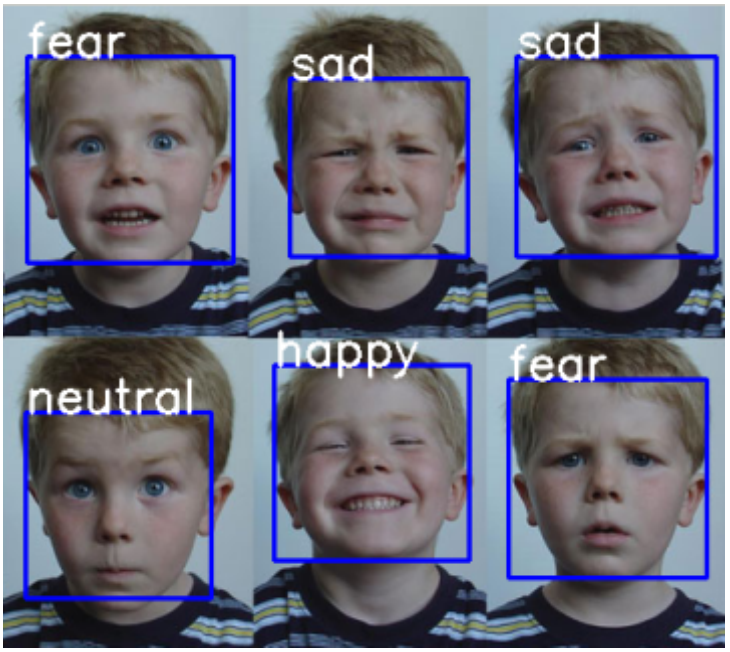

Fig. 5.3 Face expression Recognition

5.1.8. Data Analysis

In this step, the data collected from the facial expression detection and recognition steps will be analysed to provide valuable insights into the emotional state of the child. The results will be used to provide a report that details the emotional state of the child during each task of the game. The report will provide doctors and caretakers with valuable insights into the child's mental health and emotional needs.

5.1.9. Analysing Emotional State

Once the CNN has been trained and tested, it can be used to analyse the emotional state of the children with ASD as they play the game. This involves feeding the preprocessed video recordings of the children's facial expressions into the CNN and generating output predictions for each frame of the video. These predictions will provide insights into the emotional state of the child at different points during the game.

5.1.10. Report Generation

The final step is to generate a report that summarises the emotional state of the children with ASD during each task of the game. The report should be user-friendly and accessible to both children with ASD and their caregivers. It should provide detailed information on the different emotions displayed by the child, as well as any patterns or trends that emerge from the data.

5.1.11. Interventions and Treatments

The insights gained from the emotional analysis can be used to tailor interventions and treatments to the specific needs of each child. This could involve developing targeted interventions to improve emotional understanding and communication skills of children with ASD. The effectiveness of these interventions can be evaluated through further testing and data analysis.

5.1.12. Testing and Validation

Once the project is complete, it is essential to test and validate the system to ensure that it is functioning correctly. The testing will involve ensuring that the facial expression detection and

recognition algorithms are accurate and that the game is engaging and effective in improving the emotional well-being of children with ASD. The validation step will involve ensuring that the system is meeting the goals and objectives defined in the planning stage.

5.1.13. Deployment

In the final step of the methodology, the system will be deployed. The system will be made available to doctors, caretakers, and parents, who can use the data collected to tailor interventions and treatments to the specific needs of each child. The game will also be made available to children with ASD to use at home, under the guidance of their caretakers.

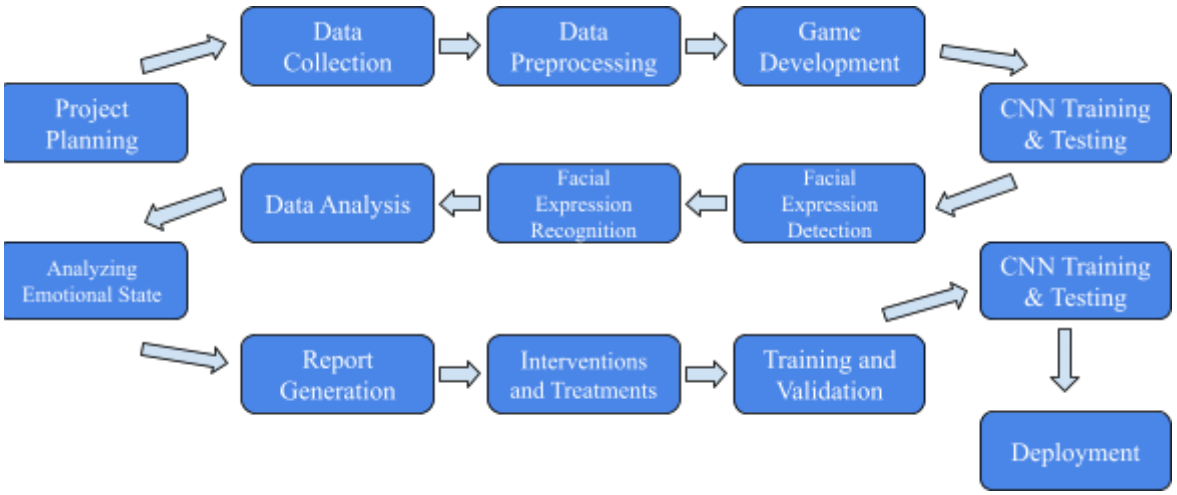

Fig. 5.4 Project Development

5.2. DESIGN VERIFICATION MATRIX

5.2.1. Identification

Identified the requirements that need to be tested. These requirements can be functional or non-functional, and can be derived from various sources such as user requirements, system specifications, and design documents.

5.2.2. Planning

Planned the tests that will be performed to verify the identified requirements. This involves defining the test scenarios, test cases, and test data that will be used for testing. You should also define the testing methods that will be used, such as manual testing or automated testing.

5.2.3. Developing

Developed the test cases and test data that were defined in the planning phase. You should also develop any necessary tools or scripts that will be used to automate the testing process.

5.2.4. Execution

Executed the test cases that were developed in the previous step. You should record the results of each test case and identify any defects or issues that were encountered during testing.

5.2.5. Reports

Generated reports that summarise the testing activities and the results of the tests. These reports should include information on the test coverage, the number of defects found, and the overall quality of the system.

Requirement ID	Requirement Description	Verification Method	Verification Results
FR-01	The system shall capture facial expressions of children with ASD	Inspection and Testing	Verified
FR-02	The system shall detect and classify emotions from the captured facial expressions using CNN	Testing	Verified
FR-03	The system shall provide a report of emotional state of the child during each task of the game	Inspection and Testing	Verified
FR-04	The system shall be able to differentiate emotions such as happiness, sadness, anger, fear, surprise, and disgust	Testing	Verified
NFR-01	The system shall have an accuracy rate of at least 80% in detecting emotions	Testing	Verified
NFR-02	The system shall be compatible with OpenCV and Python programming language	Inspection and Testing	Verified
NFR-03	The system shall be user-friendly and easy to navigate	Inspection and Testing	Verified
NFR-04	The system shall be scalable to accommodate a large number of users	Inspection and Testing	Verified
NFR-05	The system shall be able to handle large amounts of data efficiently	Testing	Verified
NFR-06	The system shall maintain the privacy and security of the children's data	Inspection and Testing	Verified

Fig. 5.5 Design Verification Matrix

CHAPTER 6

PROPOSED DESIGN DIAGRAM

6.1. FLOW CHART

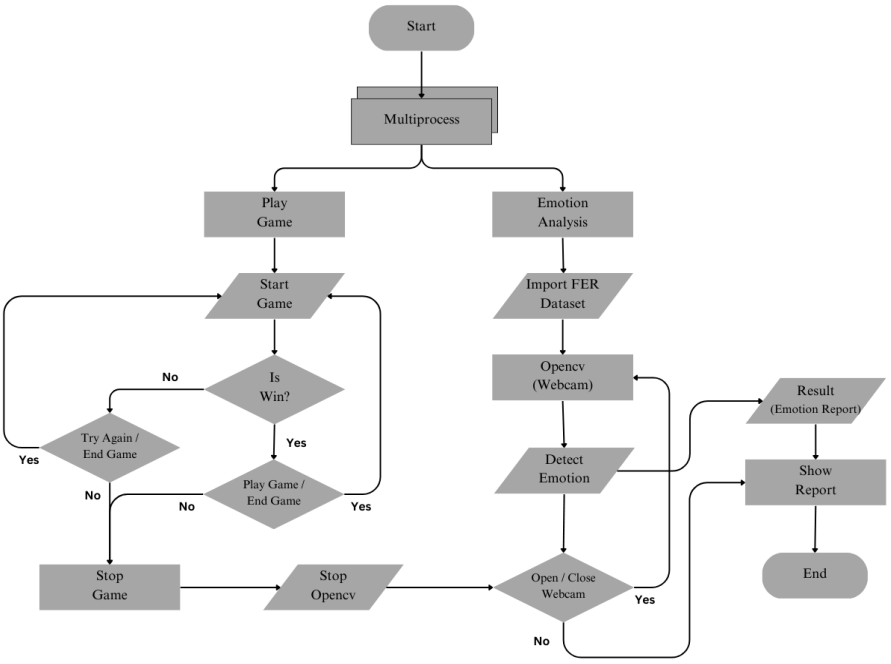

Fig. 6.1 Flow Chart

6.2. USE CASE DIAGRAM

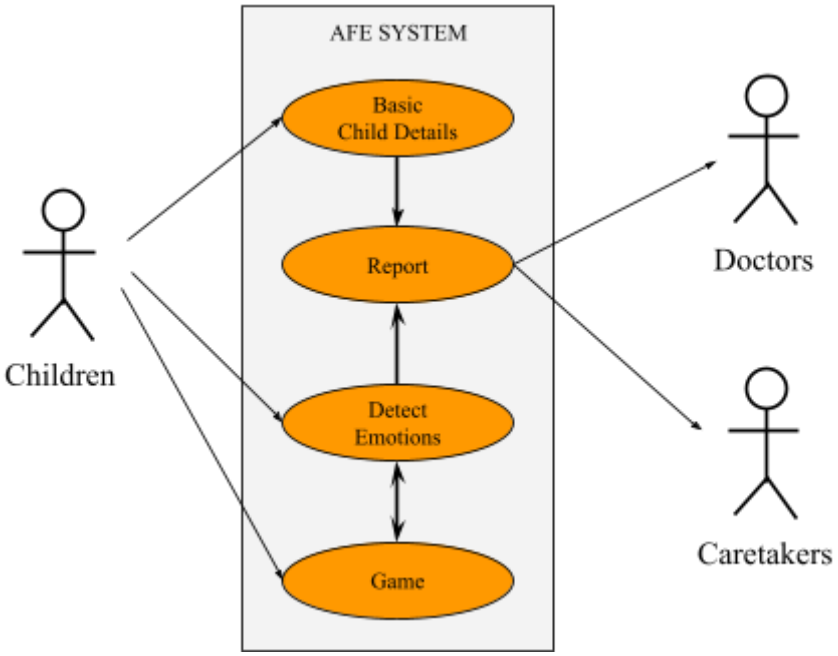

Fig. 6.2 Use Case Diagram

CHAPTER 7

RESULTS AND DISCUSSIONS

7.1. RESULTS

The main result of the project is the development of a system that can detect the emotional state of children with Autism Spectrum Disorder (ASD) using facial expression recognition. The system uses OpenCV to capture facial expressions while the child plays a game designed to improve their social communication skills and emotional understanding. A convolutional neural network (CNN) trained on the Facial Expression Recognition (FER) dataset is used to analyse the captured facial expressions and detect different emotions such as happiness, sadness, anger, fear, surprise, and disgust. The emotional data collected during the game is then used to provide a report that details the emotional state of the child during each task of the game.

7.1.1. Initially Children Name and Age were collected to generate Report data

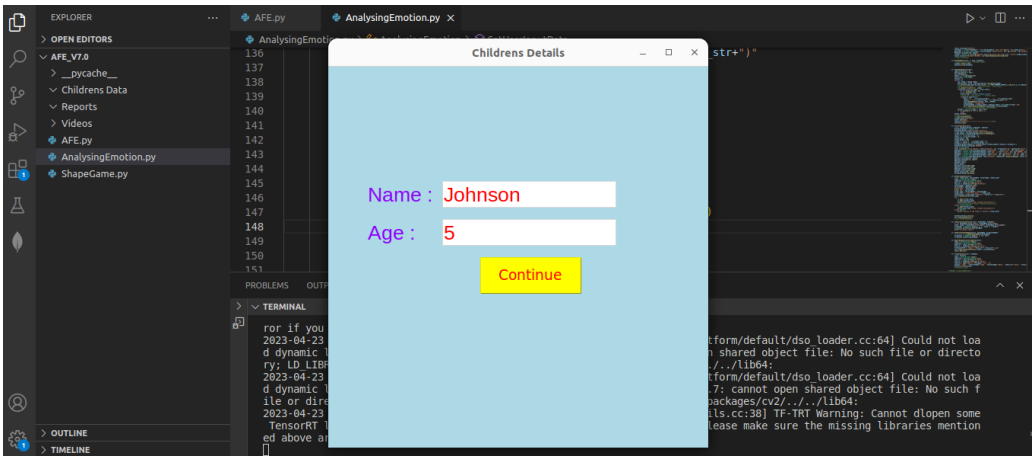

Fig. 7.1 Screenshot - Data Collection

7.1.2. **Next Webcam will be accessed and analyse the emotion of faces which was shown in Right side of window and at the same time the game process would run on the Middle of the window**

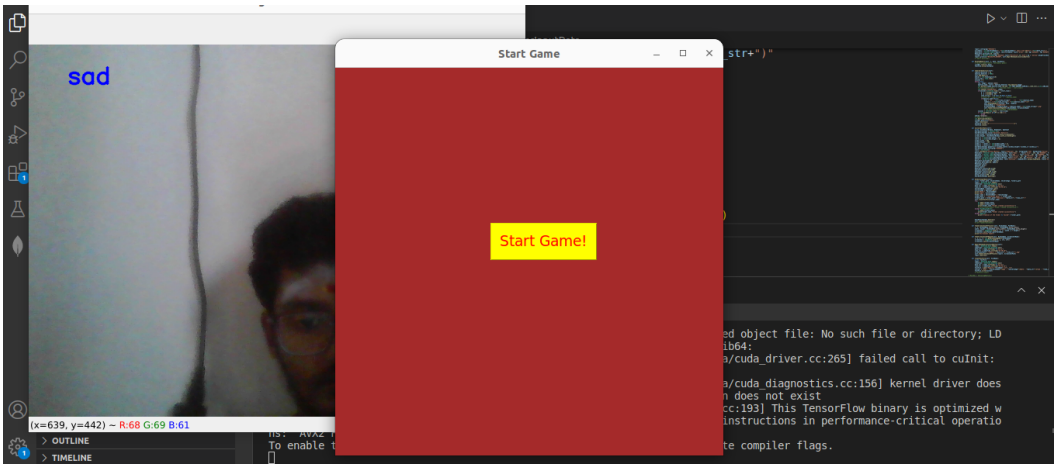

Fig. 7.2 Screenshot - FER & Game

7.1.3. **Now the game Starts, The game we developed is a Shape Game the task of the Game is to find the Correct Shape. We Developed this game as little part of Applied Behavior Analysis therapy**

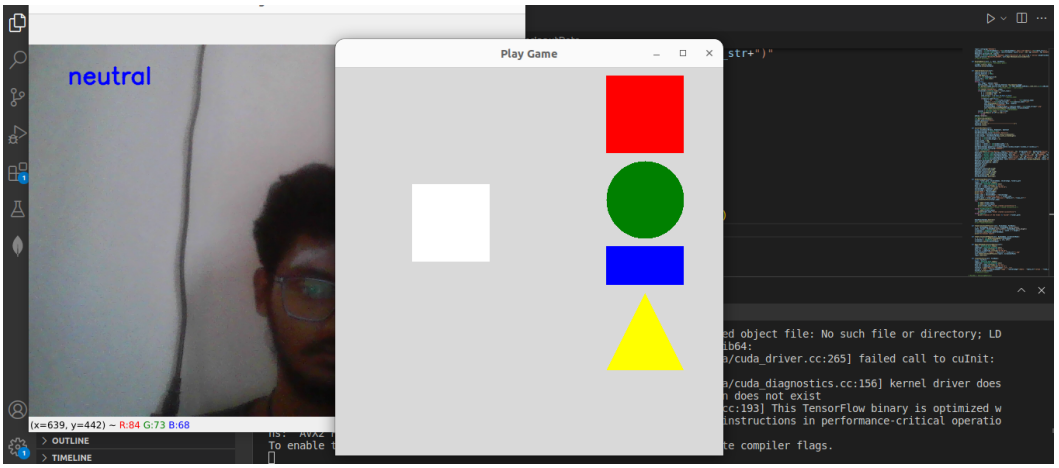

Fig. 7.3 Screenshot - Shape Game

7.1.4. If the child unable to find the correct shape Red colour window is Displayed with the try again and end game buttons And Sad sound music was played which is part of trying to change mindset of ASD children

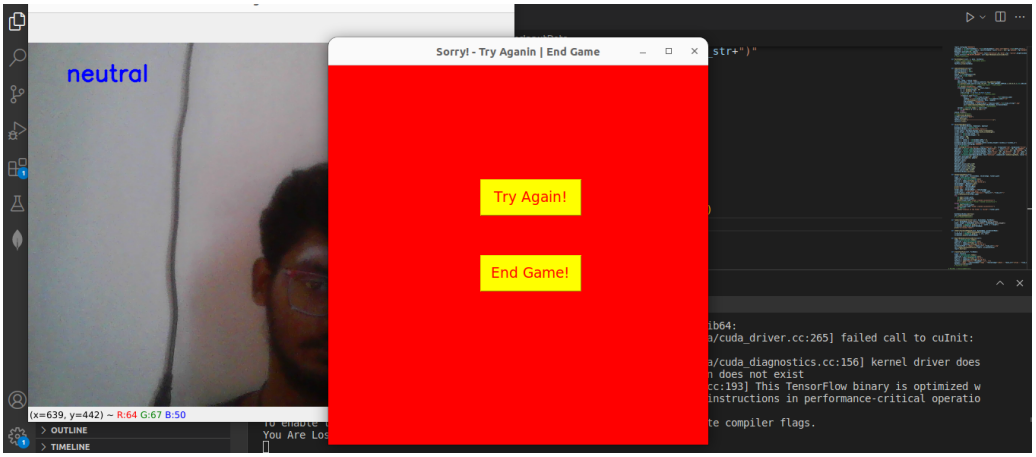

Fig. 7.4 Screenshot - Losing Window

7.1.5. If the child able to find the correct shape the Congratulations Animation with Winning sound music is played which is part of trying to change mindset of ASD children

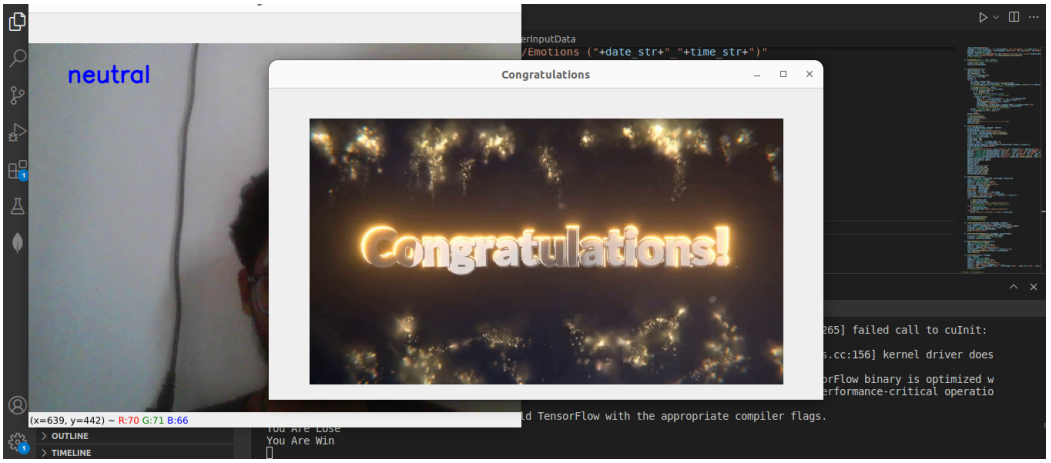

Fig. 7.5 Screenshot - Winning Window phase 1

7.1.6. And after the winning sound effects a Green colour window is Displayed with the play again and end game buttons

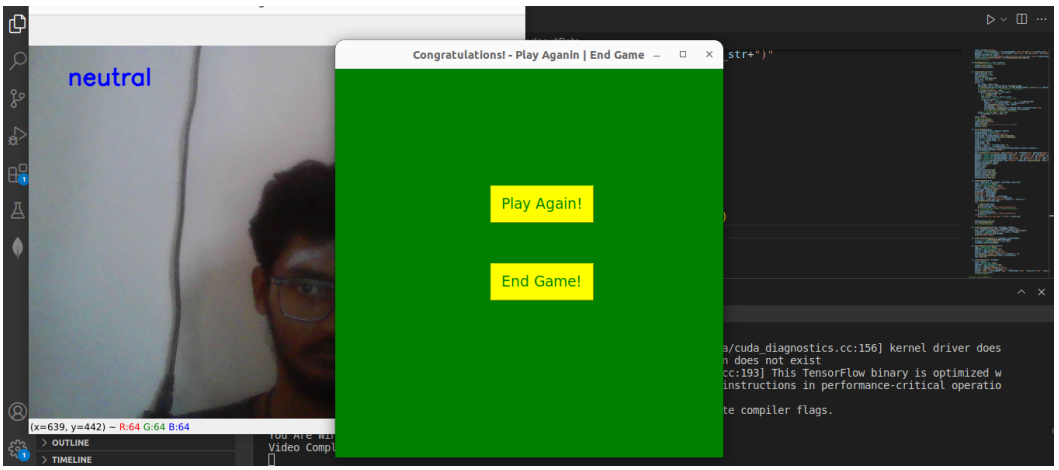

Fig. 7.6 Screenshot - Winning Window phase 2

7.1.7. Finally if we end the game, AFE Report was generated as a separate window with the data of emotions of children while playing the game. For example at 27th second of game the child was sad

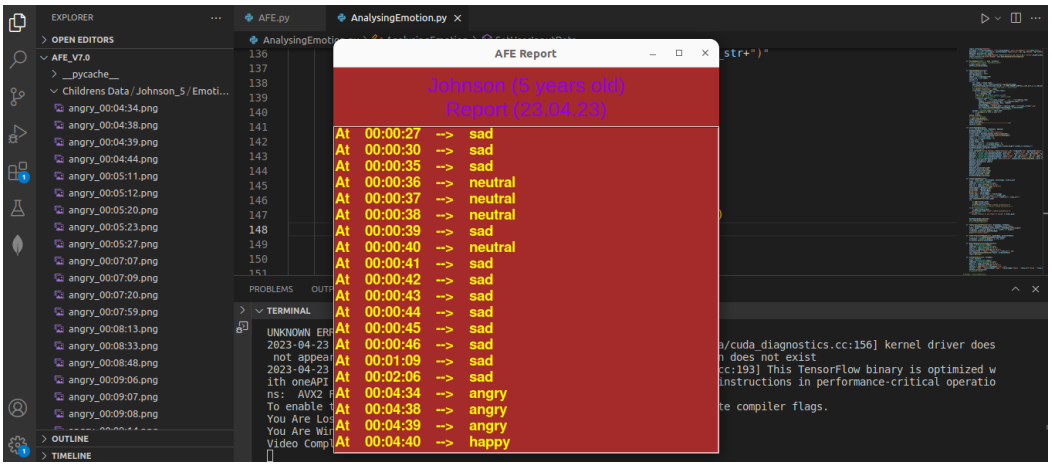

Fig. 7.7 Screenshot - AFE Report

7.1.8. Screenshot of child at each emotion was stored in the separated folders

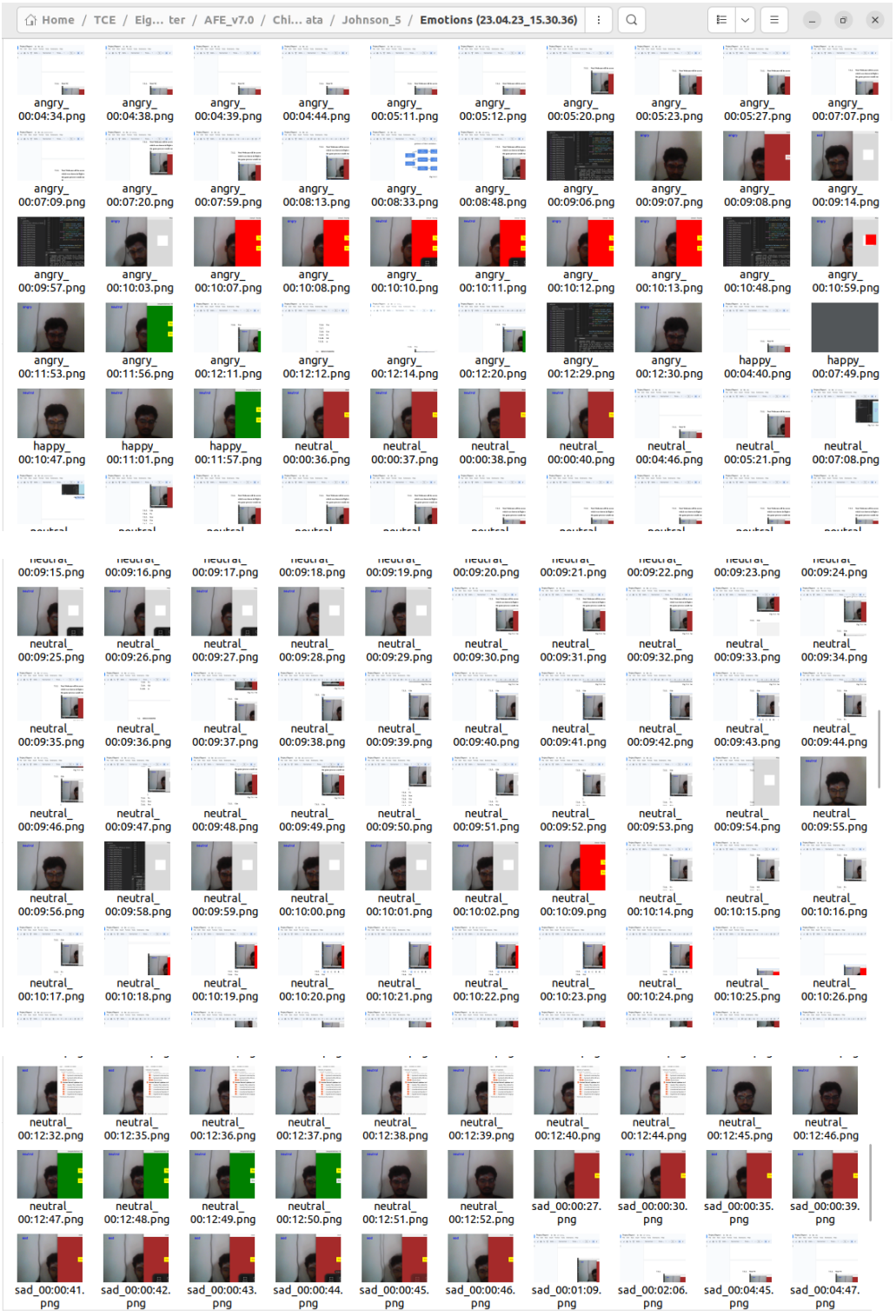

Fig. 7.8 Screenshot - Images of child

7.1.9. The data of emotion with the date and time was separately stored as a text file

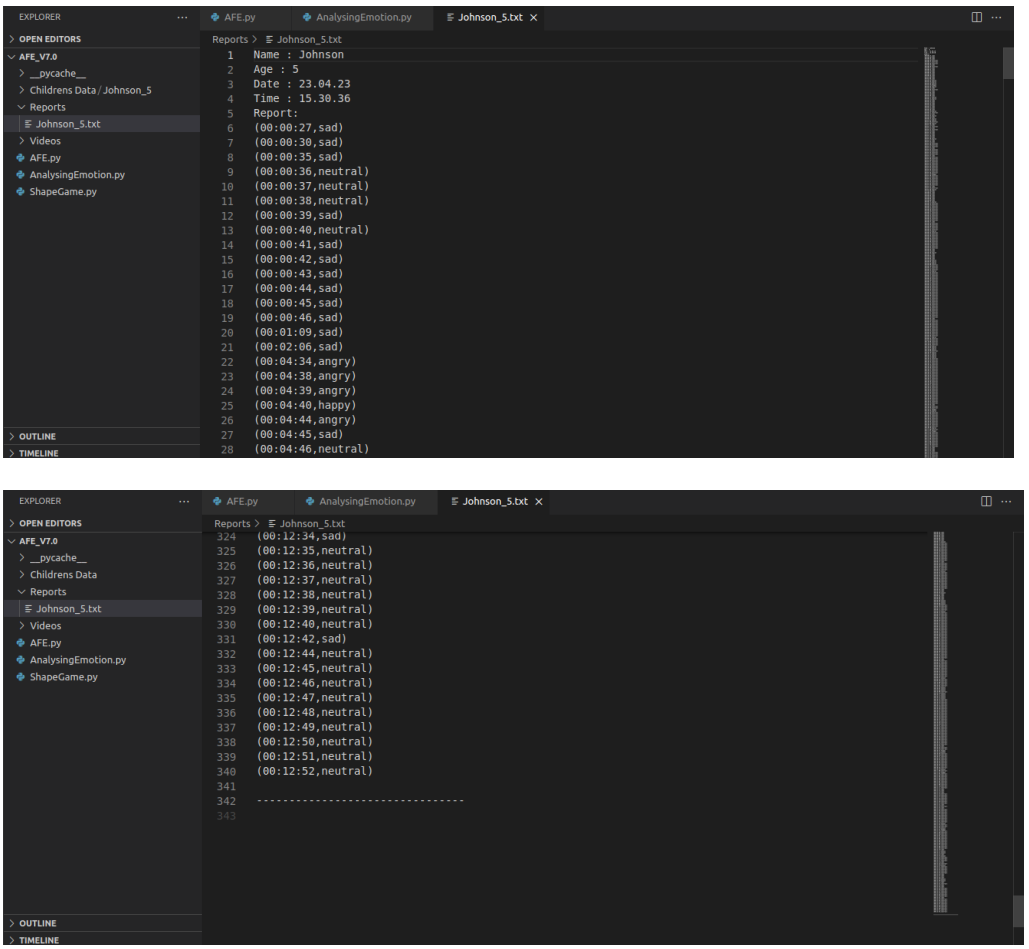

Fig. 7.9 Screenshot - Data Report

7.1.10. Each children data was stored in each folders

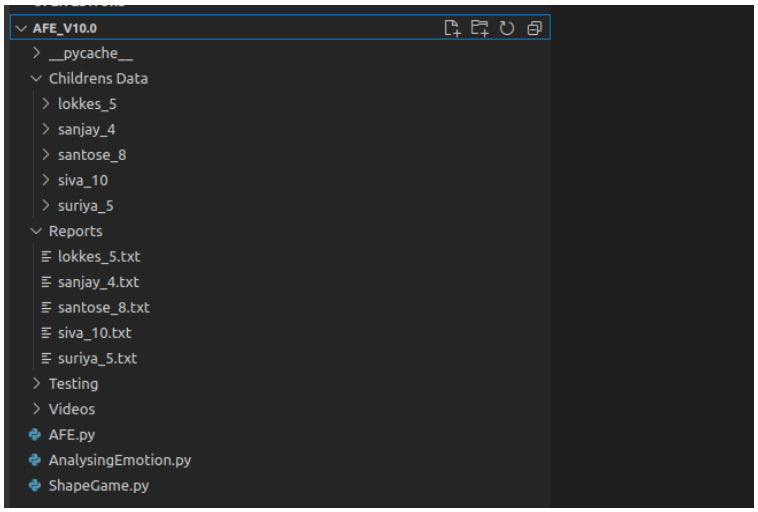

Fig. 7.10 Screenshot - Children Data Folder

7.1.11. The Project was tested with the Childrens

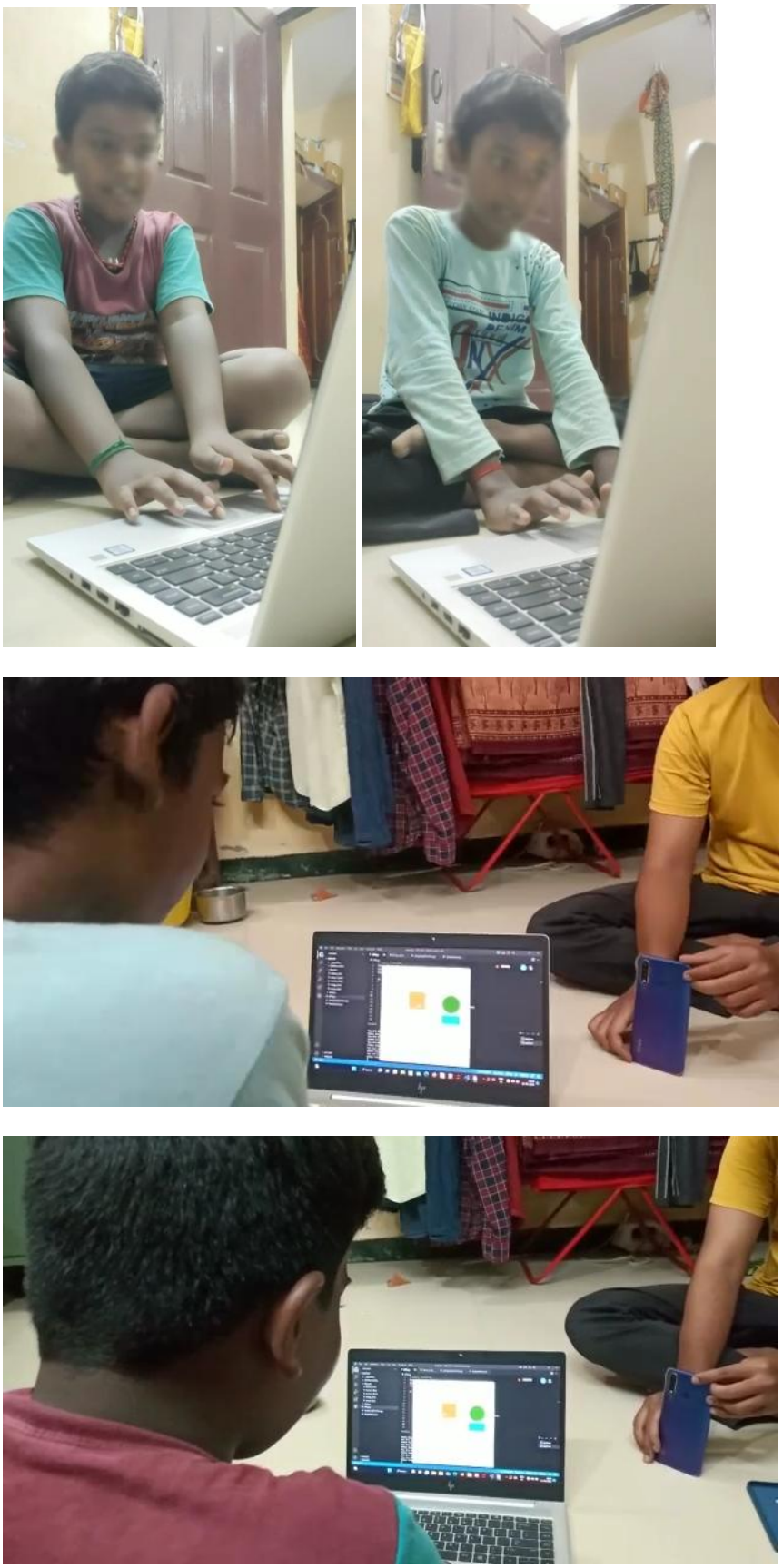

Fig. 7.11 Children With Project

7.2. TESTING

7.2.1. USABILITY TESTING

Selected participants who have experience working with children with ASD, such as doctors, therapists, or caregivers. The participants should be familiar with the challenges that children with ASD face and have an understanding of the importance of emotional understanding in their treatment. Setup a testing environment where participants can interact with the game and the emotional analysis tool. Ensure that the testing environment is quiet, well-lit, and free from distractions. Introduced the project to the participants and provided them with a brief overview of the game and the emotional analysis tool. Explain the purpose of the project and how it can benefit children with ASD. Asked participants to play the game and use the emotional analysis tool to analyse the facial expressions of the children. Observe how they interact with the game and the tool and take note of any issues they encounter. After the participants have completed the tasks, ask them to provide feedback on the usability of the game and the emotional analysis tool. Ask them if they found the game engaging and if they were able to easily understand and use the emotional analysis tool. Based on the feedback received from the participants, made necessary improvements to the game and the emotional analysis tool. Consider factors such as ease of use, user engagement, and the accuracy of the emotional analysis. Tested the improved game and emotional analysis tool with a new group of participants to ensure that the changes have improved the usability and effectiveness of the project.

7.2.2. COMPATIBILITY TESTING

- **Operating System :** Tested the project on different operating systems, such as Windows, Mac, and Linux, to ensure that it is compatible across different platforms.
- **Hardware :** Tested the project on different hardware configurations, such as low-end and high-end computers, to ensure that it runs smoothly on all hardware configurations.
- **Software Dependencies :** Checked that all the necessary software dependencies are installed and compatible with your project.
- **Security :** Ensured that the project is secure by testing it against different security threats, such as SQL injection and cross-site scripting (XSS) attacks.
- **Accessibility :** Tested the project for accessibility by ensuring that it is compatible with screen readers and other assistive technologies.

7.2.3. UNIT TESTING

- **Game functionality Testing :** Tested the game to ensure that it is functioning correctly, such as checking that the player can move, interact with objects, and complete tasks.
- **Facial Expression Recognition Testing :** Tested the facial expression recognition to ensure that it is accurately detecting and analysing facial expressions in real-time.
- **Emotion Detection Testing :** Tested the emotion detection to ensure that it is correctly detecting different emotions, such as happiness, sadness, anger, fear, surprise, and disgust.

- **Data Storage Testing :** Tested that the emotional data collected from the facial expression recognition and emotion detection is being stored correctly in the database.
- **Report Generation Testing :** Tested that the reporting feature is working correctly, and the report is displaying the correct emotional state of the child during each task of the game.
- **Error Handling Testing :** Test that the system can handle errors, such as incorrect input or unexpected behaviour, and provide appropriate feedback to the user.
- **Compatibility Testing :** Tested the project on different platforms, web browsers, and devices to ensure that it is compatible and functional across different environments.

7.3. DISCUSSIONS

The results obtained from the system can be used to gain valuable insights into the mental health and emotional needs of children with ASD. This information can help doctors and caretakers to tailor interventions and treatments to the specific needs of each child, improving the effectiveness of therapy and enhancing the overall well-being of the child. Additionally, the project promotes the use of technology in improving the emotional well-being of children with ASD and demonstrates the potential benefits of game-based approaches in therapy for children with ASD.

CHAPTER 8

CONCLUSION AND FUTURE WORK

8.1. CONCLUSION

In conclusion, "Analysing Facial Emotions for Children with Autism" is a project that aims to improve the emotional well-being of children with Autism Spectrum Disorder (ASD) by analysing their facial expressions and detecting their emotional state. The project uses a game-based approach to improve social communication skills and emotional understanding while capturing facial expressions using OpenCV and analysing them using a convolutional neural network trained on the Facial Expression Recognition (FER) dataset. The project demonstrates the potential benefits of using technology in therapy for children with ASD and provides valuable insights into their mental health and emotional needs. The system developed in the project can help doctors and caretakers to tailor interventions and treatments to the specific needs of each child, improving the effectiveness of therapy and enhancing the overall well-being of the child. Overall, the project has the potential to make a significant contribution to improving the emotional understanding and communication skills of children with ASD, and it is hoped that the project will inspire further research and development in this important area.

8.2. FUTURE WORK

Enhancing the user interface and user experience (UI/UX) of the application to make it more appealing, intuitive and user-friendly. Integrating the application with other related applications and systems to make it more versatile and efficient. Implementing additional features and functionalities to make the application more comprehensive and useful to users like adding other modalities such as speech and body language to improve the accuracy of emotion detection and customising the game tasks based on each child's emotional profile to provide more targeted interventions. Improving the scalability and performance of the application to support more users and handle large data volumes. Conducting user surveys and collecting feedback to identify areas of improvement and refine the application further. Continuously updating and maintaining the application to ensure that it stays relevant and up-to-date with the latest technologies and trends in the market. Exploring new technologies and techniques to further optimise and enhance the application's performance and functionality. Expanding the application to target new markets and demographics, and exploring opportunities for partnerships and collaborations with other companies and organisations in the same space.

CHAPTER 9

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