UNIVERSITY OF JEDDAH

COLLEGE OF COMPUTER SCIENCE AND ENGINEERING

REACT: RECOGNIZING EMOTION FOR AUTISTIC CHILDREN

By

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A Thesis submitted to the
Department of Software Engineering
in partial fulfillment of the
requirements for the degree of
Bachelor of Science

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ABSTRACT

REACT is an android game project, The concept of the game is to help children with autism spectrum disorder (ASD) to improve their understanding of emotions and recognizing others emotions, by providing a fun, exciting and encouraging experience to them. The project report will contain of four main chapters which are planning, problem understanding, analysis and design, in the first chapter we will cover the pre-production stage thesis consist of introduction, the problem we want to solve, the aim and objectives of the project and the project plan, while the second chapter contains the stakeholder's definition, detailed description, literature review and comparison criteria, results and feasibility study. The third and fourth chapter will describe the production stage that represents the analysis of the game application and the requirements, diagrams, architecture of the system and the GUI designs as well.

CHAPTER 1

INTRODUCTION

Autism spectrum disorder (ASD) is a lifelong developmental disability that affects how children interact and communicate with each other in this world. Autistic children often have difficulty 'reading' other children - recognizing or understanding others' feelings and intentions - and expressing their own emotions. This can make it very hard to navigate the social world. Autistic children may appear to be sensitive, confused, and lonely. According to the Centers for Disease Control and Prevention [1] (CDC), about 1% of the world's population has autism spectrum disorder – over 75,000,000 people.

"React" will help the Autistic children with their communication and how to describe their emotions and their impairment in recognizing emotional expressions that may contribute to these inappropriate or misplaced reactions and to their understanding of emotion in general. We have reviewed a study [2] that evaluated "The Transporters", an animated series designed to enhance emotion comprehension in children with ASC. Children with ASC (4–7 years old) watched The Transporters every day for four weeks. Participants were tested before and after intervention on emotional vocabulary and emotion recognition, and the participated group improved significantly with their understanding and recognition of emotions.

1.1 Project Description

"React" is an interactive Android application game that will help Autistic children with their emotional expressions and their recognition of emotions by training them to know what specific emotion should be portrayed in their faces. Through displaying a specific facial expression (for Example: Happiness) and capturing their facial expression using a phone camera and giving them points for reacting in the correct way.

1.2 Problem Statement

Autism spectrum disorder is a very complicated disorder that affects one in every 100 children[3]. These children have difficulties recognizing emotional expressions, these difficulties disrupt their communication skills and their day-to-day interactions.

1.3 Aim

The main aim of "React" is to help children with autism spectrum disorder to express their emotions and recognize other's emotional expressions by capturing their facial expression using a fun interactive game.

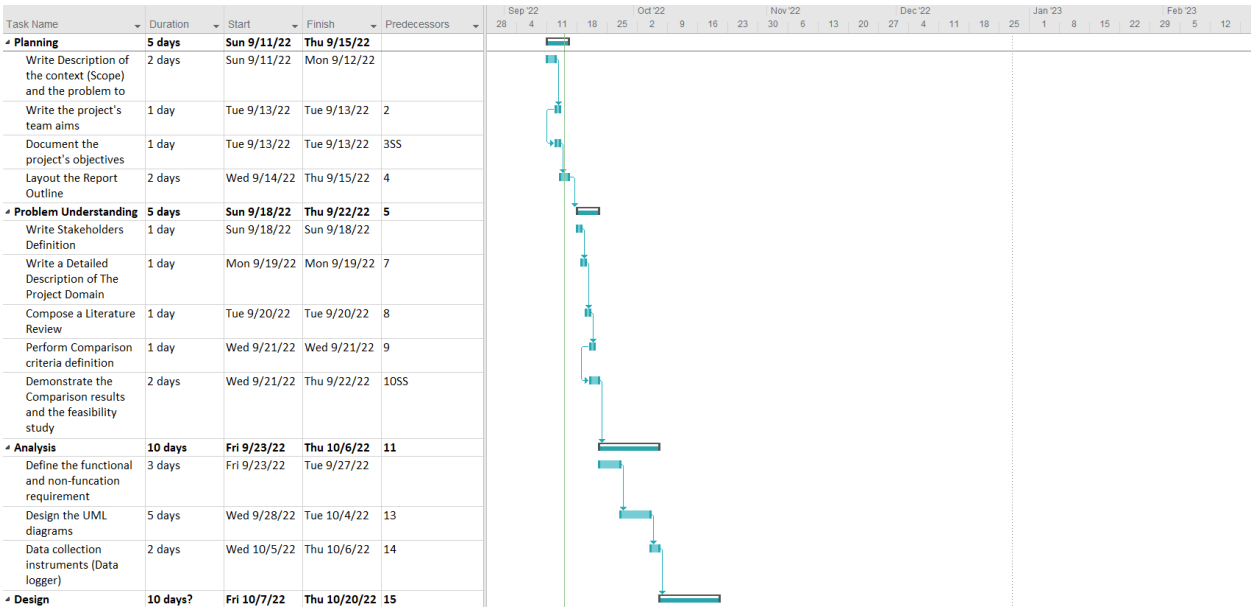
1.4 Objectives

The main objective of "React" is to develop a mobile application that assists children with autism spectrum disorder to learn and adapt themselves into the appropriate way of having a regular conversation, by using a pre-trained model and face API that will catch a person's emotion on camera.

Sub-Objectives:

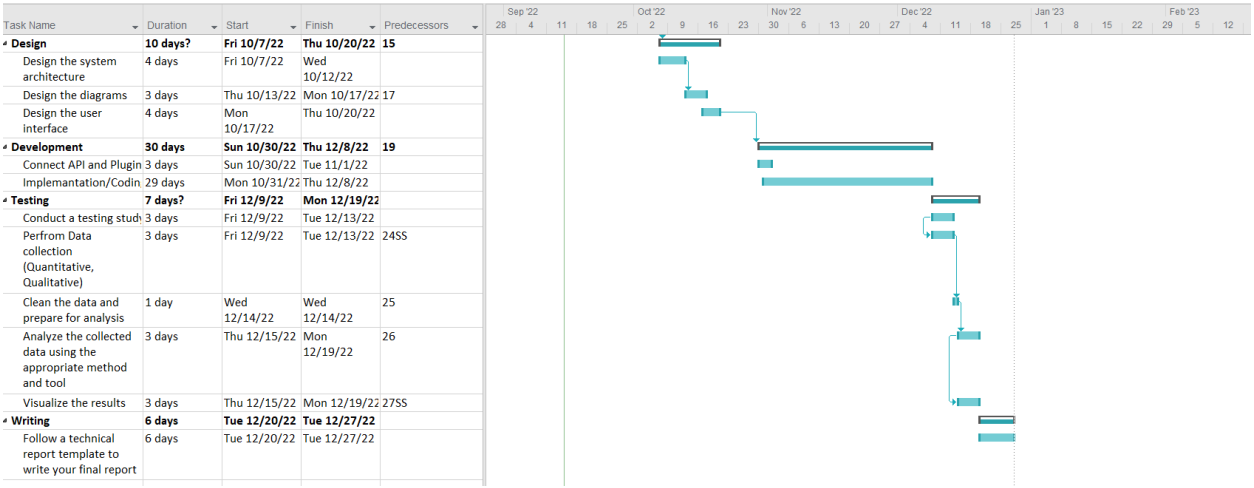
- To help children with ASD to improve their ability to correctly recognize emotions.
- To achieve users satisfaction and enjoyment through gamification mobile app.
- To encouraging children to improve their understanding of emotions by applying a score points method to represent their progression towards a better cognitive skills.

1.5 Project Plan



Task Name	Duration	Start	Finish	Predecessors
Planning	**5 days**	**Sun 9/11/22**	**Thu 9/15/22**	
Write Description of the context (Scope) and the problem to	2 days	Sun 9/11/22	Mon 9/12/22	
Write the project's team aims	1 day	Tue 9/13/22	Tue 9/13/22	2
Document the project's objectives	1 day	Tue 9/13/22	Tue 9/13/22	3SS
Layout the Report Outline	2 days	Wed 9/14/22	Thu 9/15/22	4
Problem Understanding	**5 days**	**Sun 9/18/22**	**Thu 9/22/22**	**5**
Write Stakeholders Definition	1 day	Sun 9/18/22	Sun 9/18/22	
Write a Detailed Description of The Project Domain	1 day	Mon 9/19/22	Mon 9/19/22	7
Compose a Literature Review	1 day	Tue 9/20/22	Tue 9/20/22	8
Perform Comparison criteria definition	1 day	Wed 9/21/22	Wed 9/21/22	9
Demonstrate the Comparison results and the feasibility study	2 days	Wed 9/21/22	Thu 9/22/22	10SS
Analysis	**10 days**	**Fri 9/23/22**	**Thu 10/6/22**	**11**
Define the functional and non-funcation requirement	3 days	Fri 9/23/22	Tue 9/27/22	
Design the UML diagrams	5 days	Wed 9/28/22	Tue 10/4/22	13
Data collection instruments (Data logger)	2 days	Wed 10/5/22	Thu 10/6/22	14
Design	**10 days?**	**Fri 10/7/22**	**Thu 10/20/22**	**15**

Figure 1.1: Gantt chart of the project plan 1/2



Task Name	Duration	Start	Finish	Predecessors
Design	**10 days?**	**Fri 10/7/22**	**Thu 10/20/22**	**15**
Design the system architecture	4 days	Fri 10/7/22	Wed 10/12/22	
Design the diagrams	3 days	Thu 10/13/22	Mon 10/17/22	17
Design the user interface	4 days	Mon 10/17/22	Thu 10/20/22	
Development	**30 days**	**Sun 10/30/22**	**Thu 12/8/22**	**19**
Connect API and Plugin	3 days	Sun 10/30/22	Tue 11/1/22	
Implemantation/Codin	29 days	Mon 10/31/22	Thu 12/8/22	
Testing	**7 days?**	**Fri 12/9/22**	**Mon 12/19/22**	
Conduct a testing study	3 days	Fri 12/9/22	Tue 12/13/22	
Perfrom Data collection (Quantitative, Qualitative)	3 days	Fri 12/9/22	Tue 12/13/22	24SS
Clean the data and prepare for analysis	1 day	Wed 12/14/22	Wed 12/14/22	25
Analyze the collected data using the appropriate method and tool	3 days	Thu 12/15/22	Mon 12/19/22	26
Visualize the results	3 days	Thu 12/15/22	Mon 12/19/22	27SS
Writing	**6 days**	**Tue 12/20/22**	**Tue 12/27/22**	
Follow a technical report template to write your final report	6 days	Tue 12/20/22	Tue 12/27/22	

Figure 1.2: Gantt chart of the project plan 2/2

CHAPTER 2

PROBLEM UNDERSTANDING

2.1 Stakeholders Definition

In "React" we have two types of stakeholders. Firstly, the internal stakeholders that will help develop this project throughout all the development life cycles of the mobile app.Secondly, we have the external stakeholders which are the users.

Name	Position	Internal/External	Project Role	Level of influence
Zeyad Alqahtani	Team member	Internal	Developer	High
Moayad Almutairi	Team member	Internal	Developer	High
Turki Alotibi	Team member	Internal	Developer	High
Mohammad Alahmadi	Project Supervisor	Internal	Advisor	High
Autistic Child	User	External	None	Low

Table 2.1: Stakeholders of REACT

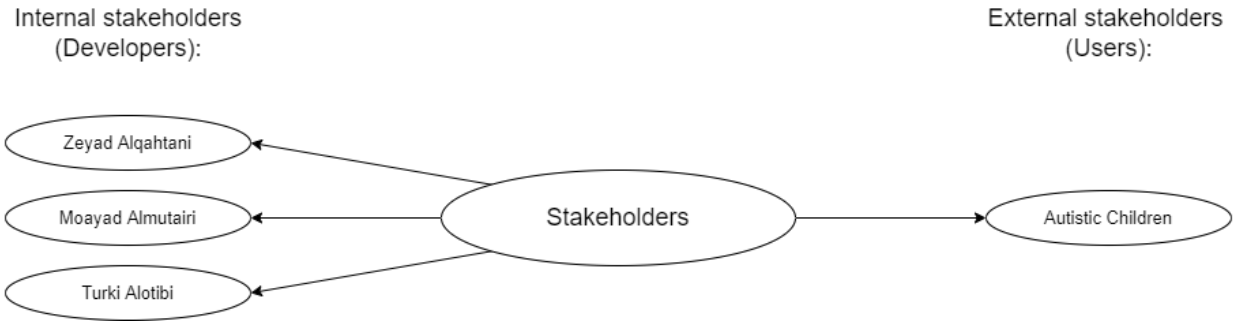


Figure 2.1: Stakeholders of REACT

2.2 Detailed Description of the Background (Project Domain)

We reviewed previous related work in the field of helping Autistic Children through gamification. Understanding how other systems work, and the technologies that was used in implementing these systems. Also, we reviewed these systems and how they are helping autistic children. Most of these games focused on the skills development and language therapy, we wanted to provide the help for the children with ASD that have difficulties recognizing emotional expressions. This problem can be improved though early learning and specially through gamification. With facial expression recognition learning techniques, we will develop this project.

2.3 Literature Review

Autism spectrum disorder (ASD) is a developmental disability caused by differences in the brain. People with ASD often have problems with social communication and interaction, and restricted or repetitive behaviors or interests. People with ASD may also have different ways of learning, moving, or paying attention. It is important to note that some people without ASD might also have some of these symptoms. But for people with ASD, these characteristics can make life very challenging [4].

Some children show signs of autism spectrum disorder in early infancy, such as reduced eye contact, lack of response to their name or indifference to caregivers. Other children may develop normally for the first few months or years of life, but then suddenly become withdrawn or aggressive or lose language skills they've already acquired. Signs usually are seen by age 2 years. Each child with autism spectrum disorder is likely to have a unique pattern of behavior and level of severity — from low functioning to high functioning. Some children with autism spectrum disorder have difficulty learning, and some have signs of lower than normal intelligence. Other children with the disorder have normal to high intelligence — they learn quickly, yet have trouble communicating and applying what they know in everyday life and adjusting to social situations. Because of the unique mixture of symptoms in each child, severity can sometimes be difficult to determine. It's generally based on the level of impairments and how they impact the ability to function[5].

Individuals with Autism Spectrum Conditions may have good technology skills and feel comfortable using devices such as a tablet or a computer for communication, an educational activity,

work related task or for entertainment. Technology allows for adaptability and can increase motivation. The portability of a hand-held device means that it can be flexibly used in a variety of circumstances for different purposes. The cost of these devices is being reduced all the time which makes it easier for more people with ASC to get access to a cool, mainstream device that can support their communication, learning and importantly, promote peer acceptance[5].

Technology can support in the following areas [5]:

- Social communication and interaction
- Memory
- Sensory processing difficulties
- Visual thinking
- Controlling emotions and choosing appropriate behaviors

Autism spectrum disorder (ASD) is a developmental disability caused by differences in the brain. People with autism often suffer from problems in social communication and interaction, so we decided to come up with an idea to help people with autism to communicate and interact with people through a program that capture a person's feelings by using the mobile camera and showing the person's feelings in an interactive and fun way to the user.

2.4 Comparison Criteria Definition

"React" is an interactive game between autistic children and the mobile app. So, to coordinate this interaction we are going to use the emotion recognition feature. So based on our mobile app's proposed features we chose webapps/apps to compare our system to. And here are the comparisons criteria and their relation to our mobile app:

- Emotion recognition: Capturing a person's state of emotion (e.g., Happiness, Sadness, Anger).
- Take a picture: Opening the camera to capture a photo of a person portraying a specific emotion.
- Mobile app availability: The availability of the system on mobile devices.
- Points scoring: Interacting with the children by giving them points based on their perception of the captured emotion.

- Attractive to children: Since that our main targeted user are children, we are looking forward to embrace this criteria
- Friendly user experience: Since that our main targeted user are children, we are interested by this criteria

2.4.1 Systems used in the comparison

Clmtrackr:

clmtrackr[7] is an emotion-analysis tool created by a Norwegian computer scientist named Audun Øygard. "You turn on your webcam, stare into your screen, and the program will tell you what emotions you're experiencing, and in what proportions, from anger to sadness to joy"[8].

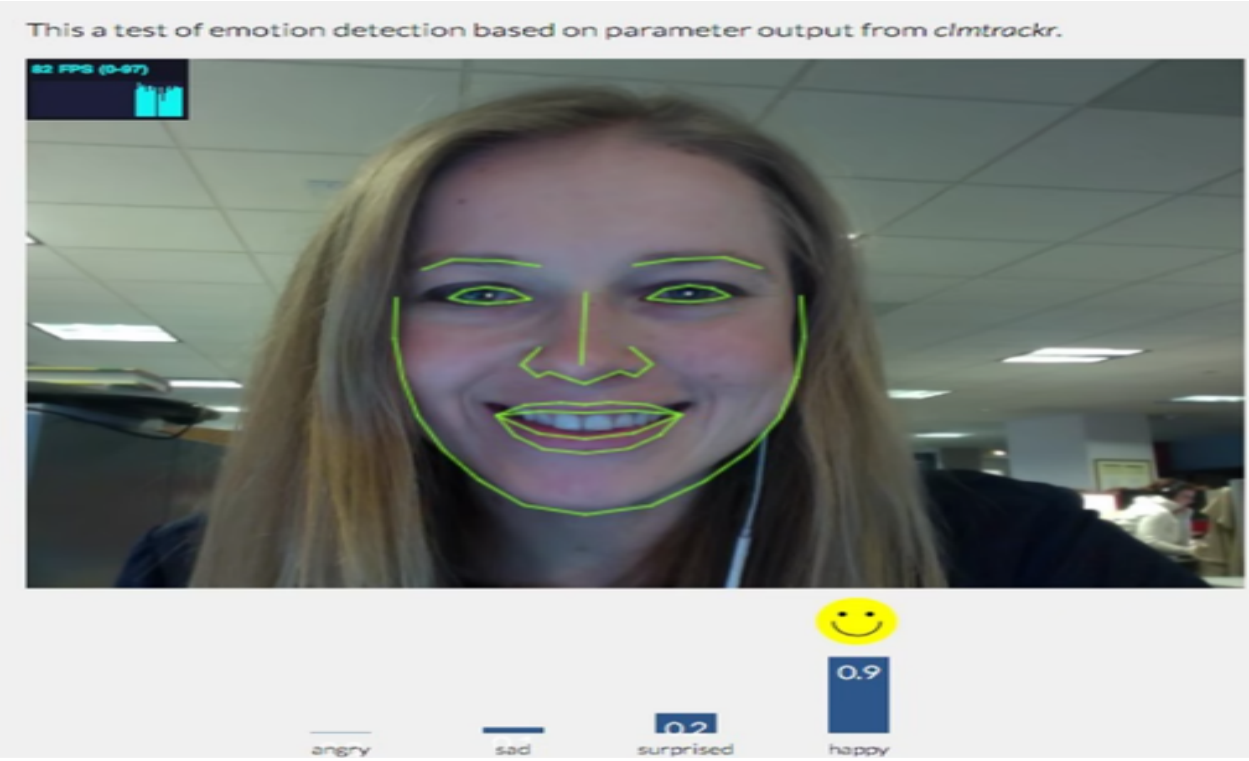


Figure 2.2: Clmtrackr main page

Remarks captured by using the system:

- The system's only job is to capture the emotion of the person's face using camera, and displaying the portrayed emotion, no further interactions is introduced
- The system's ability to catch the changing state of emotions dynamically is remarkable.

Avaz AAC:

Avaz AAC is an augmentative and alternative communication app that empowers children adults having speech-related disabilities with a voice of their own. A fully-featured speech app that also includes a training module for new AAC users caregivers.

The research-based pragmatic vocabulary consists of over 15,000 pictures (Symbolstix) with a variety of high-quality voices that a communicator regardless of their ability can tap to form sentences quickly. With a wide range of personalisation customisation options, you can make Avaz AAC your own in just a matter of minutes[9].

"Good app :) I like it. It allows children with complex communication needs to choose from an extensive list of core words and research based vocabulary to maximize their ability to communicate and it helps improve communication through interactive speech therapy sessions" – a Reviewer in the app page on app store

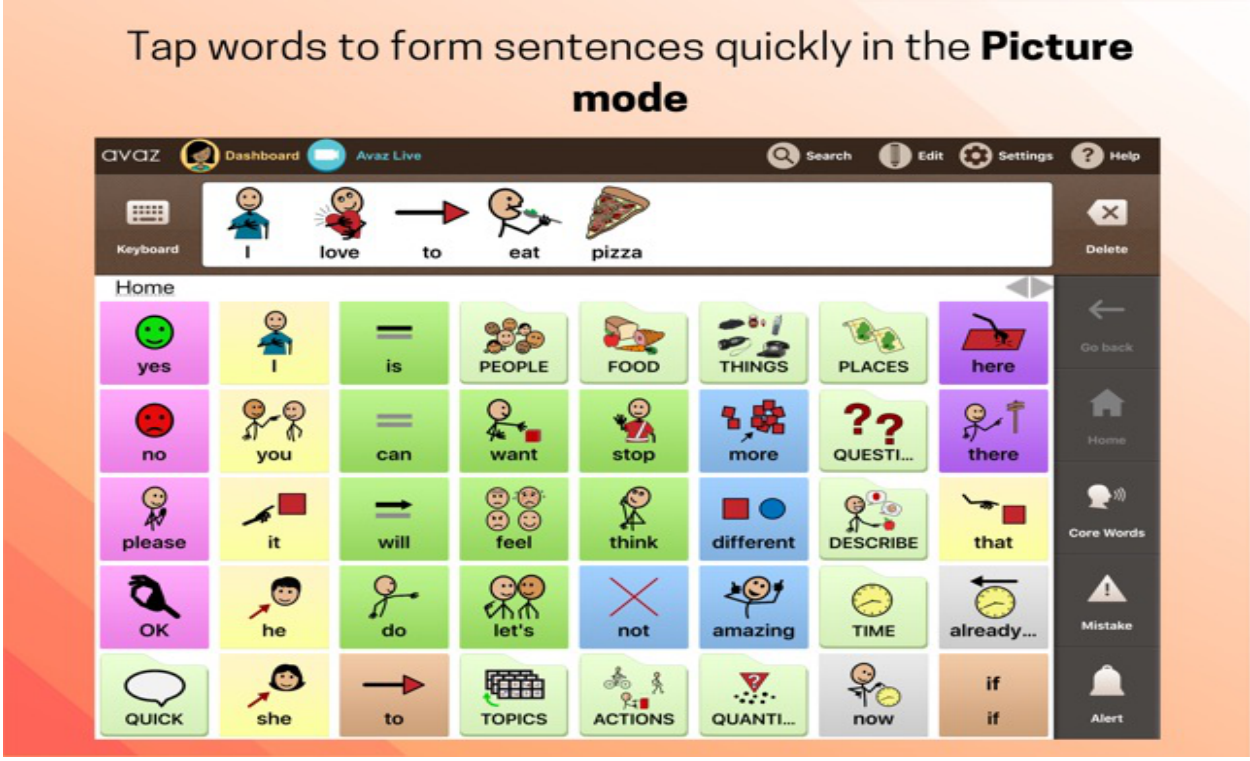


Figure 2.3: The user interface of Avaz aac that shows multiple icons that represents actual words. And a keyboard on the top of the screen. Every word that the child will type will turn into a symbol to help understand the meaning of the word

Remarks captured by using the system:

This app relates every single word that an autistic child might think of to a symbol that he can easily recognize. We want to empower the child's recognition of emotions by linking them to a real time event (e.g., people emotion), and symbolize that emotion to them onscreen to enhance their perception of that emotion.

2.5 Comparison Results

Criteria	Clmtrackr	Avaz aac	REACT
Emotion recognition	Yes	No	Yes
Take a picture	Yes	No	Yes
Mobile app availability	No	Yes	Yes
Points scoring	No	No	Yes
Attractive to children	No	Yes	Yes
Friendly user experience	No	Yes	Yes

Table 2.2: Table to compare our proposed mobile app and other related systems

2.6 Feasibility Study

2.6.1 Executive summary

In this feasibility study, we are going to discuss about "React" starting of by describing the product and the services it provides. After that, we are going to talk about the technology considerations of our project. Then, we are going to discuss about the project's existing marketplace for the product or services the organization is considering. To follow that, we are going to introduce the project's team members and their relation to the project. Also, we are going to mention the schedule of the project. Finally, we are going to share our findings after the conclusion of this study.

2.6.2 Description of products and services

We are considering a move to create and develop an Android mobile app that facilitates communication to autistic children using emotion recognition. The child opens the camera and takes an image of a parent, brother, or friend. This image will be passed to and analyzed by Deep face

API created by Microsoft azure to recognize the emotion portrayed on the person face. Finally, the child choose which symbol emphasizing the portrayed emotion is right.

2.6.3 Technology considerations

The main function of "React" is the emotion recognition feature using a photo captured by camera. The challenges that are facing us are how to connect the mobile app to the face API provided by google and pre-trained model that facilitates the recognition process. Also, if the children react to the emotion appropriately, they will be given points that encourages them to enhance their cognitive recognition.

2.6.4 Project marketplace

There are many platforms for kids and adults with developmental difficulties. Available on iOS and Android these special education apps can help with communication, social skills and even problem solving. These apps were designed for people with autism spectrum disorder (ASD), we did a research about one of these apps, "Avaz ACC" a mobile app that facilitates the communication process for children by linking the words they type in the keypad with a symbol gesturing what that word means. However, our mobile app will link the emotions portrayed by the person that is communicating to the child, to a symbol of happiness, sadness or anger. This relation between symbols and emotions will certainly be helpful to the child in terms of recognizing that emotion later on without any help, using their recollection of the symbol related. "Autism impacts on how a person understands and uses communication, as well as how a person experiences the sensory input around them. Symbols can enhance understanding and learning by displaying a visual image that can be more easily understood than spoken language and other forms of communication" [10].

2.6.5 Organization and members

"React" will be developed by a group of students as their senior project, and to fill their graduation requirements by developing a solution to real-life problem.

Team member 1: Moayad Almutairi

Team member 2: Ziyad AL Qahtani

Team member 3: Turki Alotaibi

2.6.6 Schedule

The project campaign is expected to take 3 month and 16 days from the project approval to the launch of the app. See figures 1.1-1.2

2.6.7 Findings

Based on the information introduced in this study, it came to our attention by observing the marketplace for our project, that there are apps that target people that have difficulties to establish a normal conversation. However, none of them introduced the emotion recognition feature.

CHAPTER 3

ANALYSIS

3.1 Functional & Non-Functional Requirements

3.1.1 Functional Requirements

- **Register and login:** The mobile app users shall be able to register/login in our application to be able to save their score.
- **Opening camera:** The mobile app should allow users to open their smartphone camera inside the app.
- **Facial recognition:** The mobile app shall be able to recognize and read the emotions of faces using pre-trained and face API.
- **Database:** The mobile app should be able to save the users data on a database.
- **Point scoring:** The mobile app should add a single point to the user after every correct choice they make.
- **Show result:** The mobile app show the results and scores to the user after finish playing.

3.1.2 Non-Functional Requirements

- **User Interface:** The user interface of the mobile app should be easy to use.
- **Performance:** The mobile app response time should not exceed 5s.
- **Security:** The mobile app should be secure and reliable, data should be saved and secured in the database.

3.2 Hardware Requirements

We shall have a computer with the acceptable specifications required to run Android studio IDE, also we need an android smartphone device to run and test the mobile app.

3.3 UML Diagrams

3.3.1 Class diagram

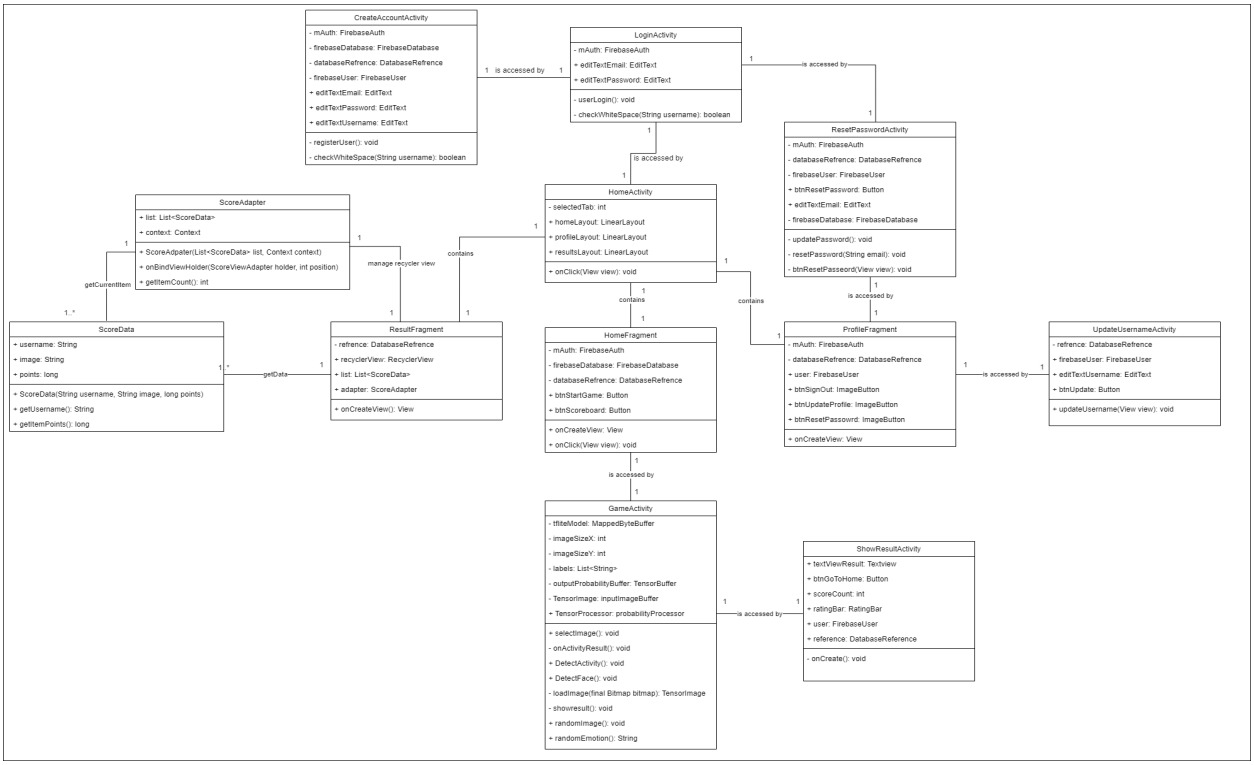


Figure 3.1: System class diagram.

3.3.2 Use case diagrams

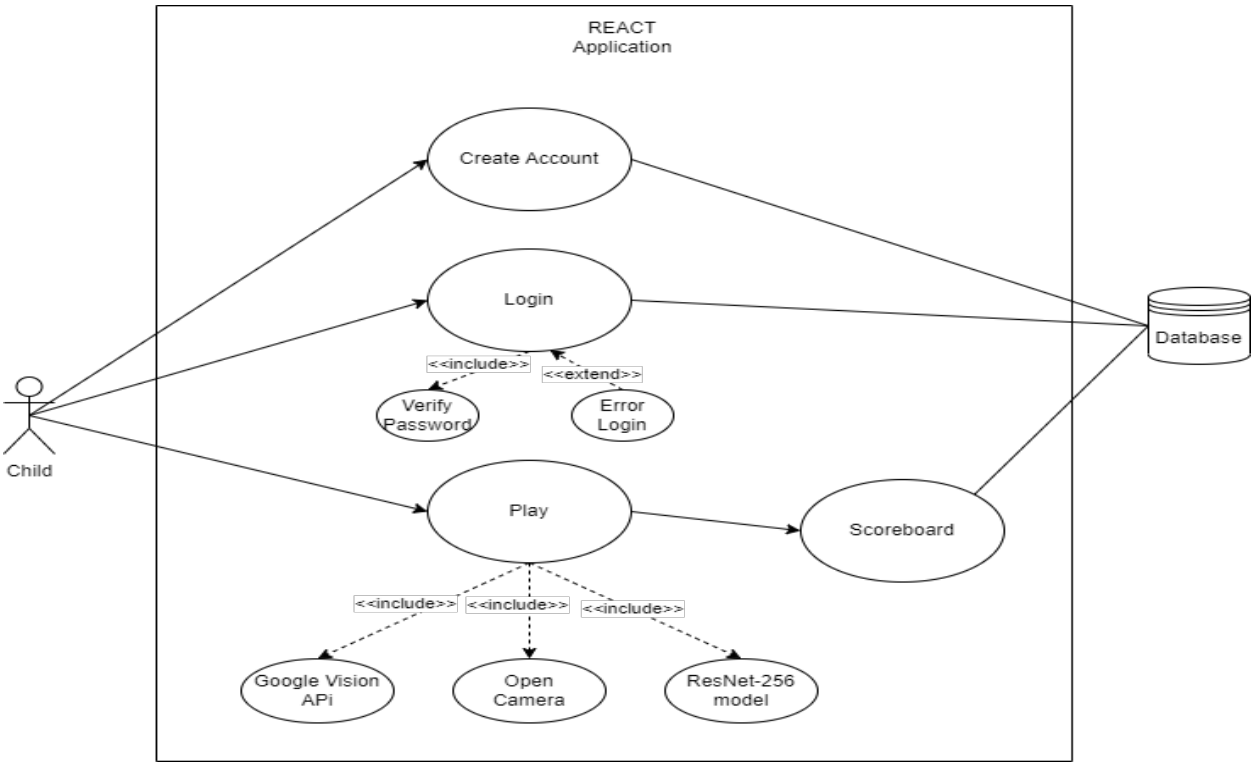


Figure 3.2: System use case that includes the main actors and functions of React.

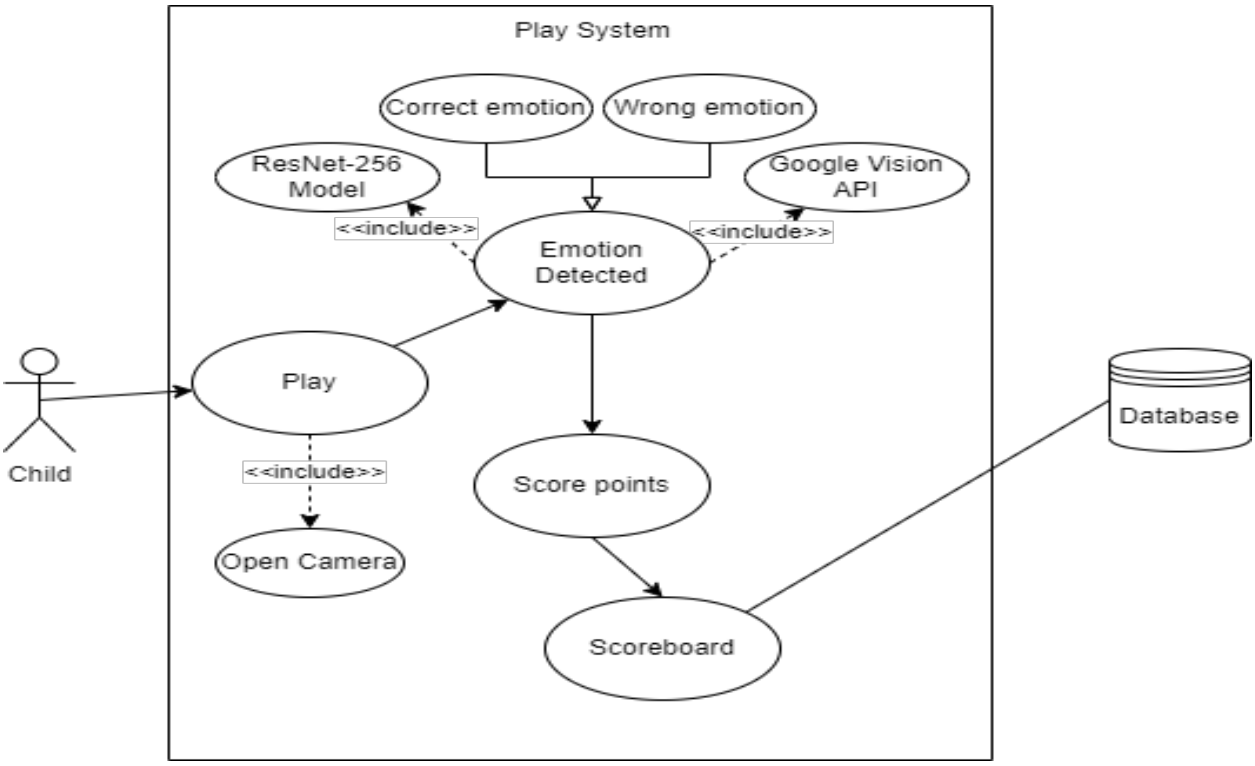


Figure 3.3: System use case that includes the main actors used in the scoring functions.

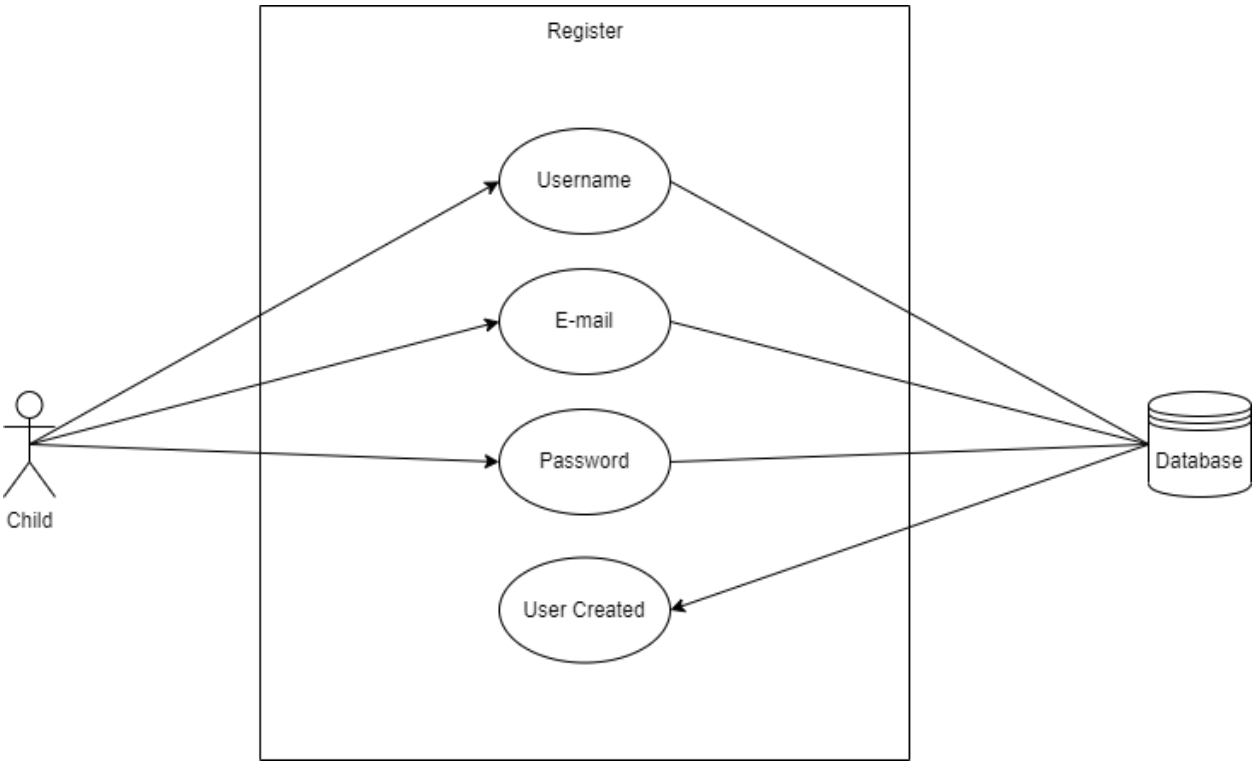


Figure 3.4: System use case that includes the main actors used in the registration functions.

3.3.3 Sequence diagrams

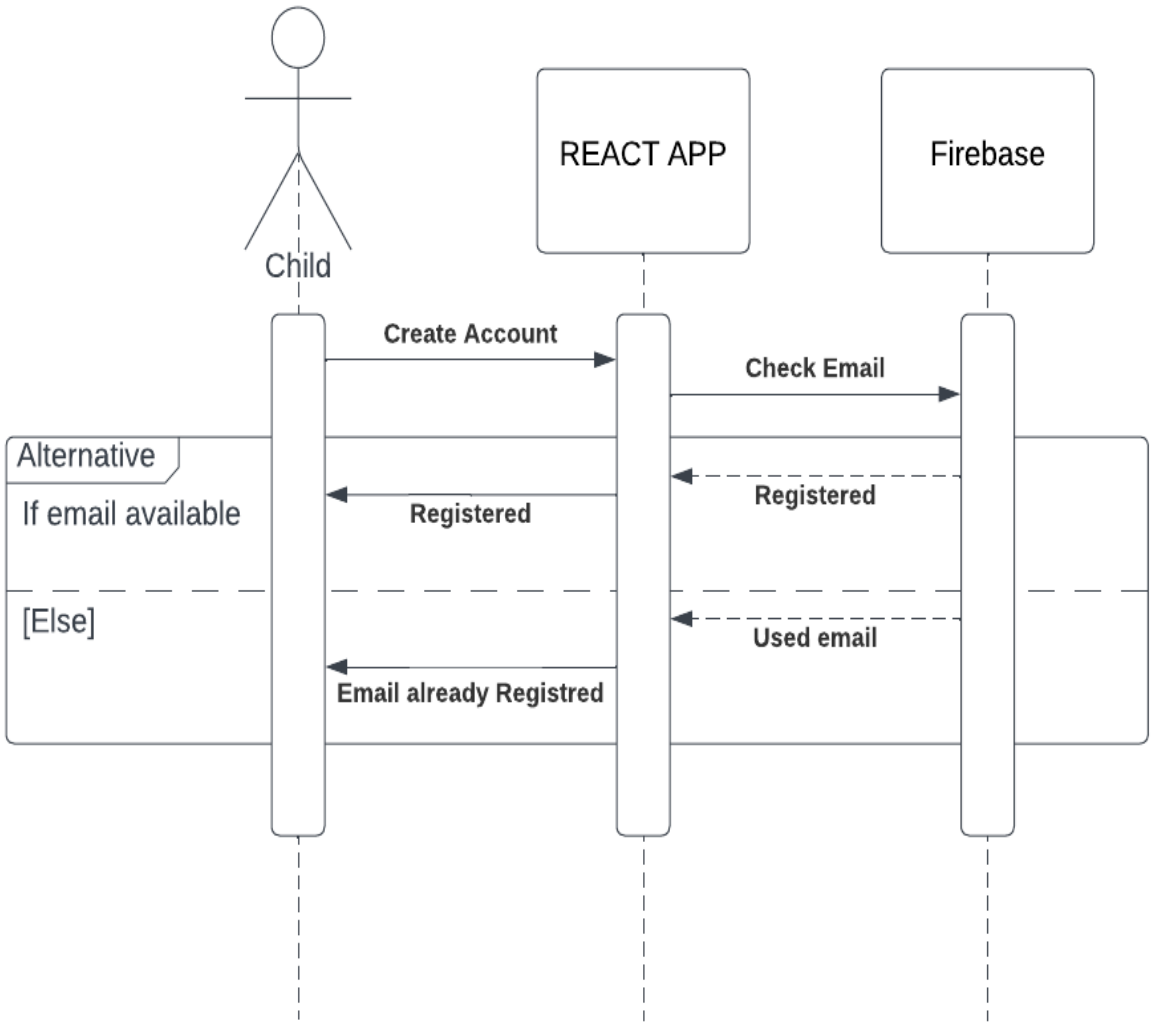


Figure 3.5: System sequence diagram that shows the process interaction of registration.

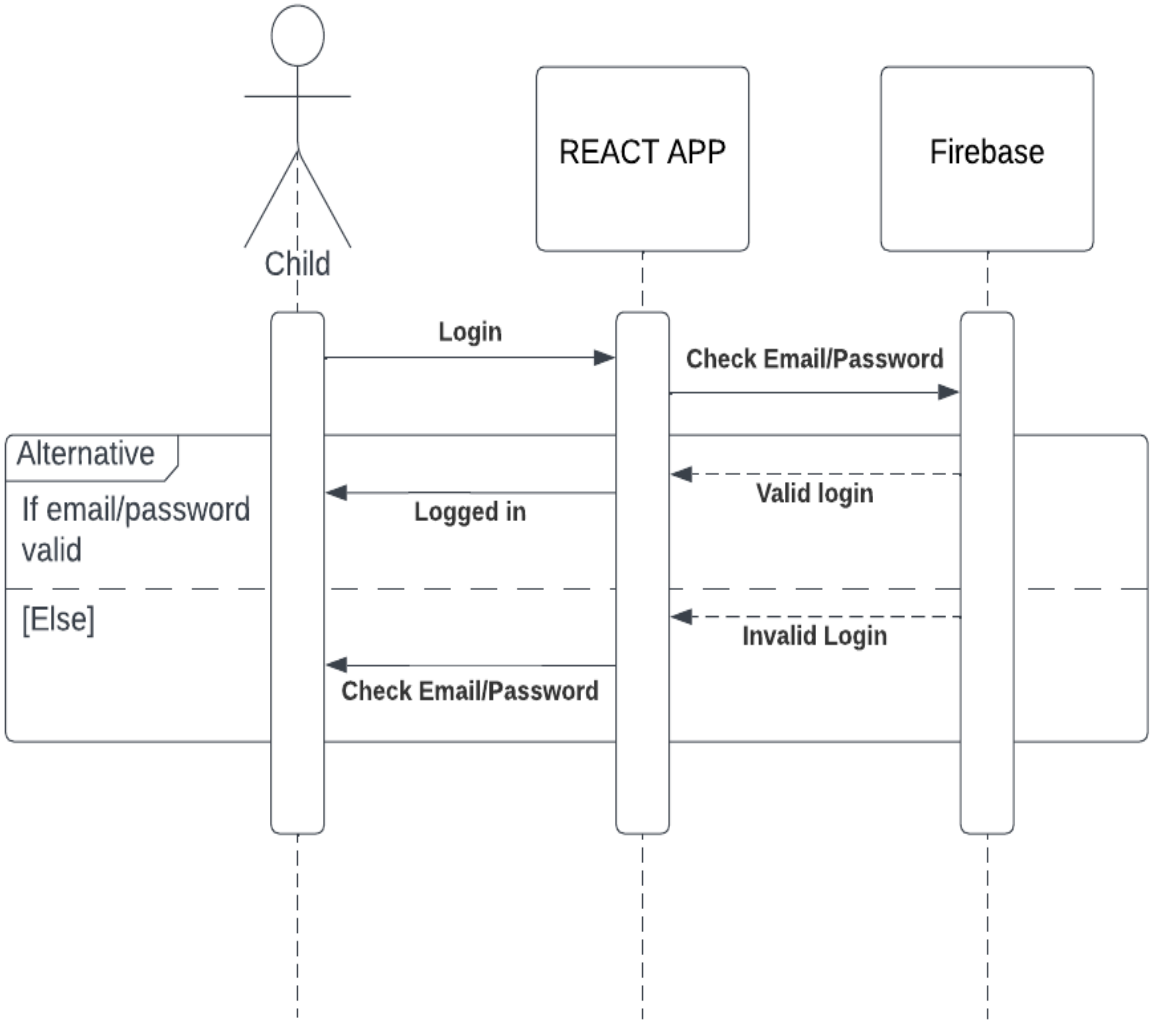


Figure 3.6: System sequence diagram that shows the process interaction of login.

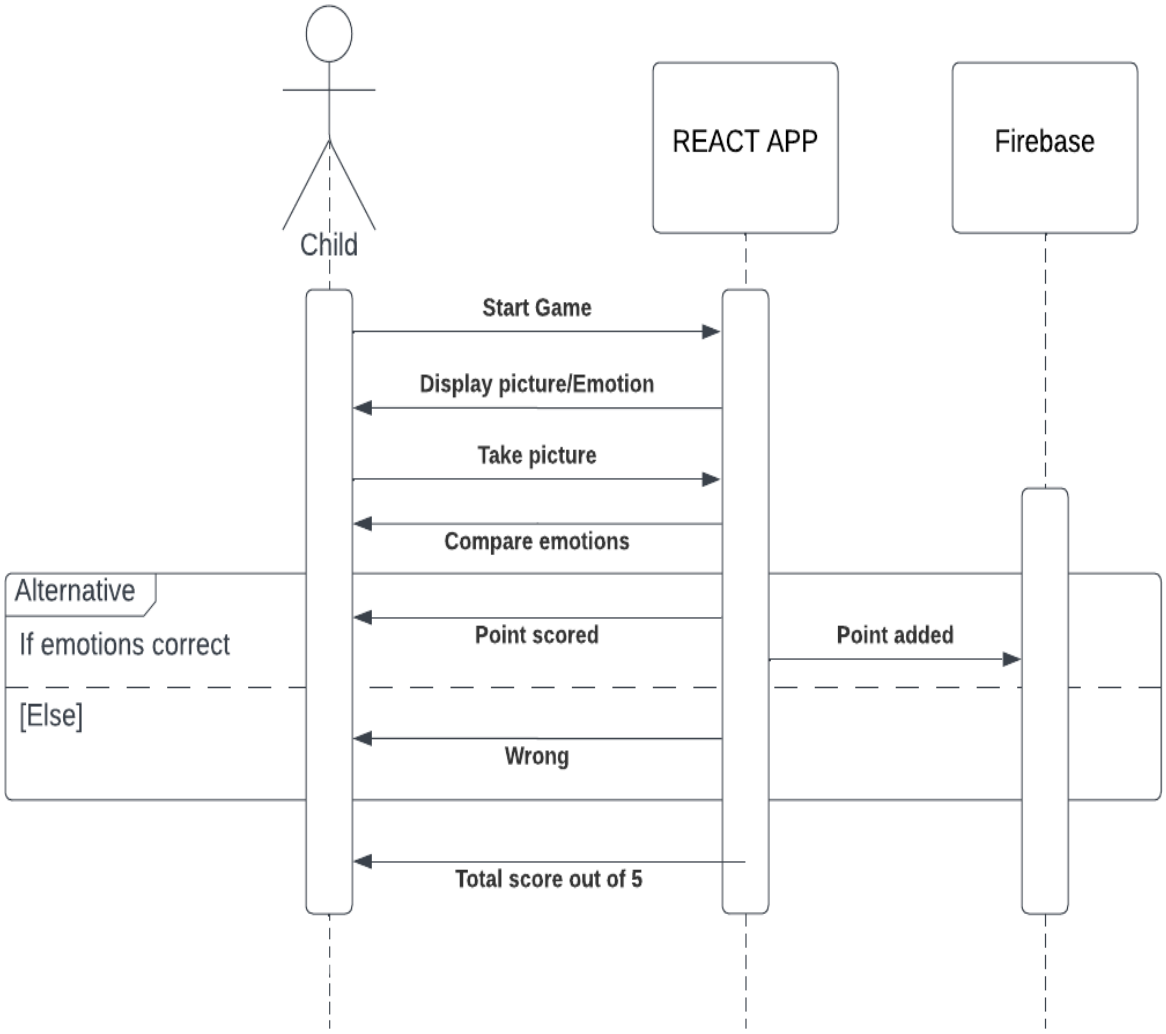


Figure 3.7: System sequence diagram that shows the process interaction of the game.

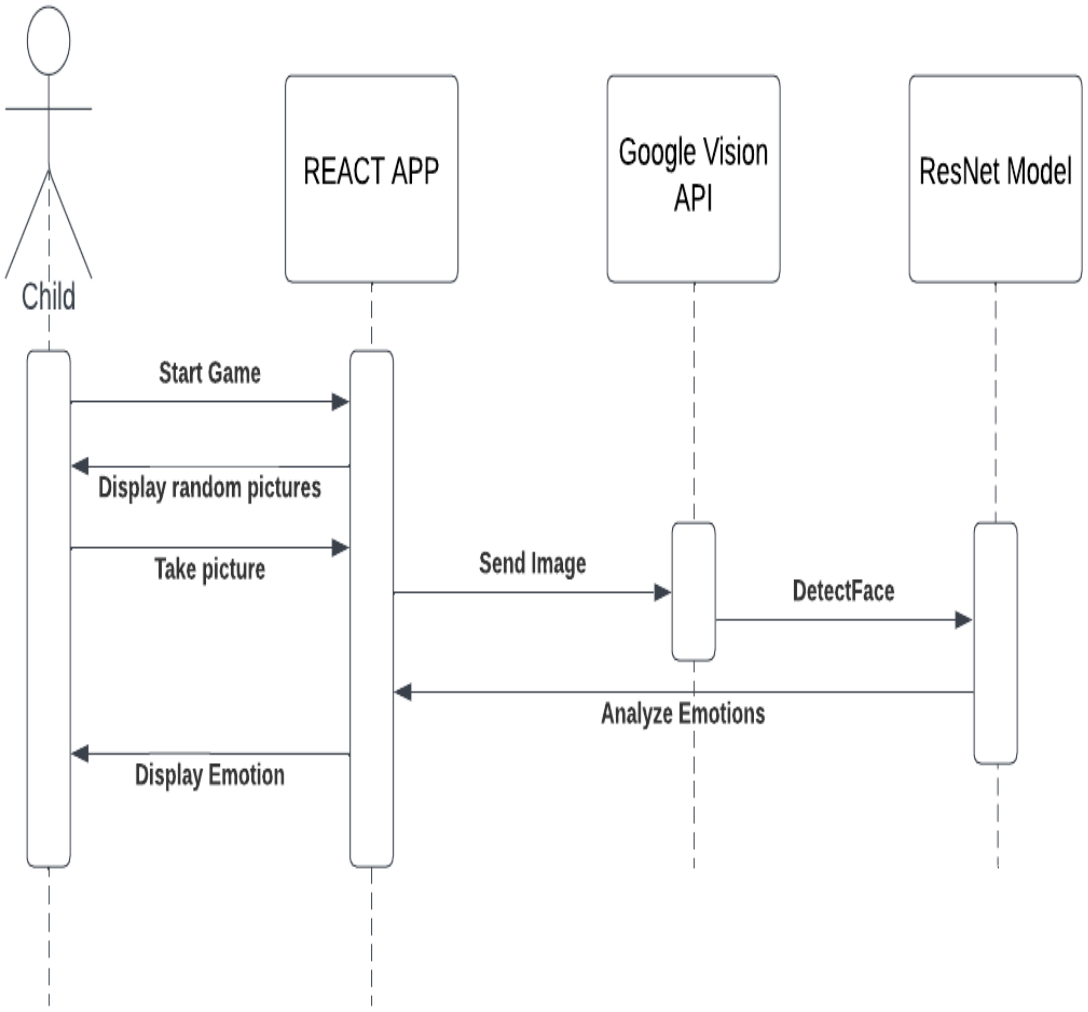


Figure 3.8: System sequence diagram that shows the process interaction of the emotion detection.

3.3.4 Activity diagram

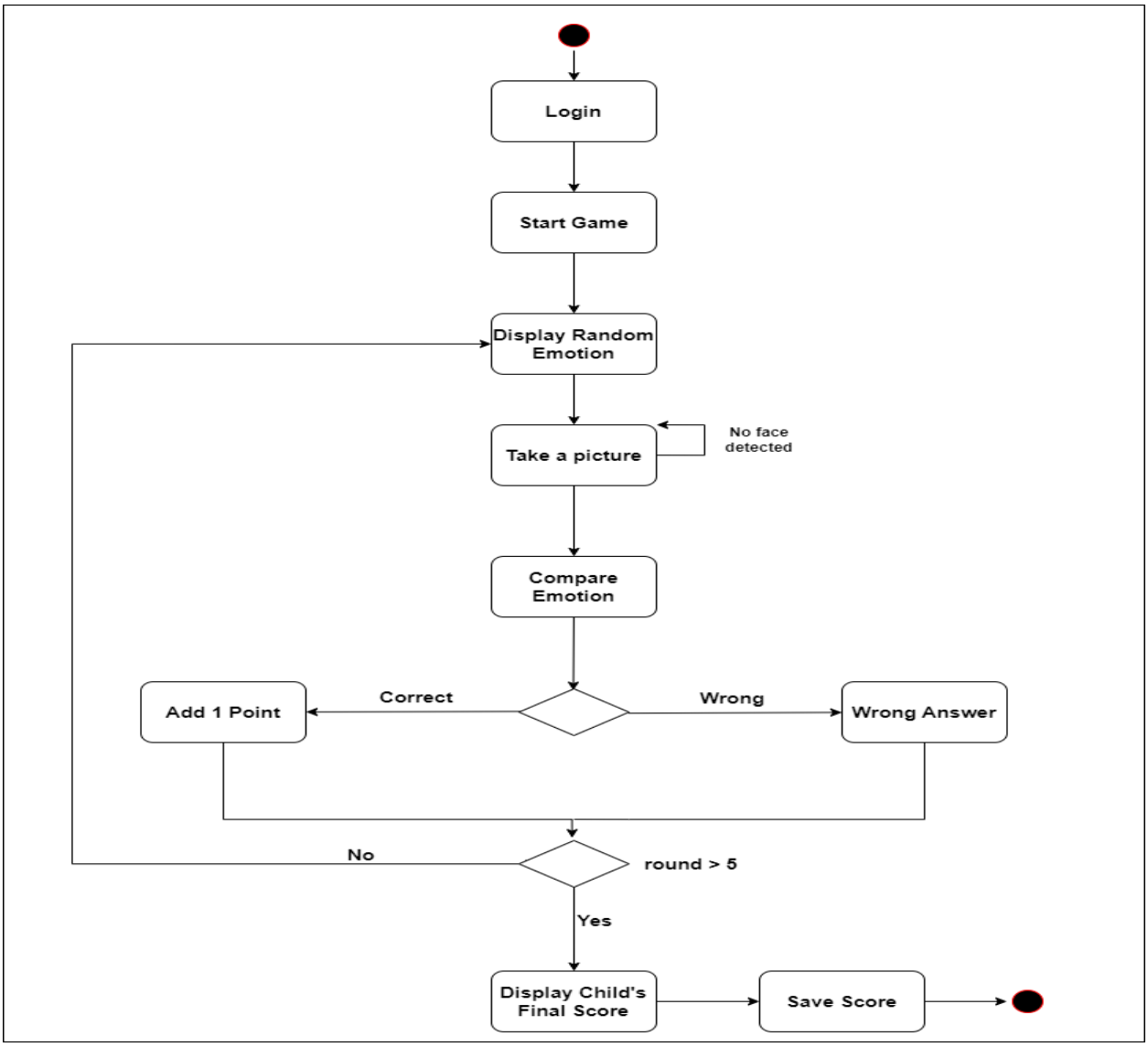


Figure 3.9: System Activity diagram that shows the workflow of React.

3.3.5 State machine diagram

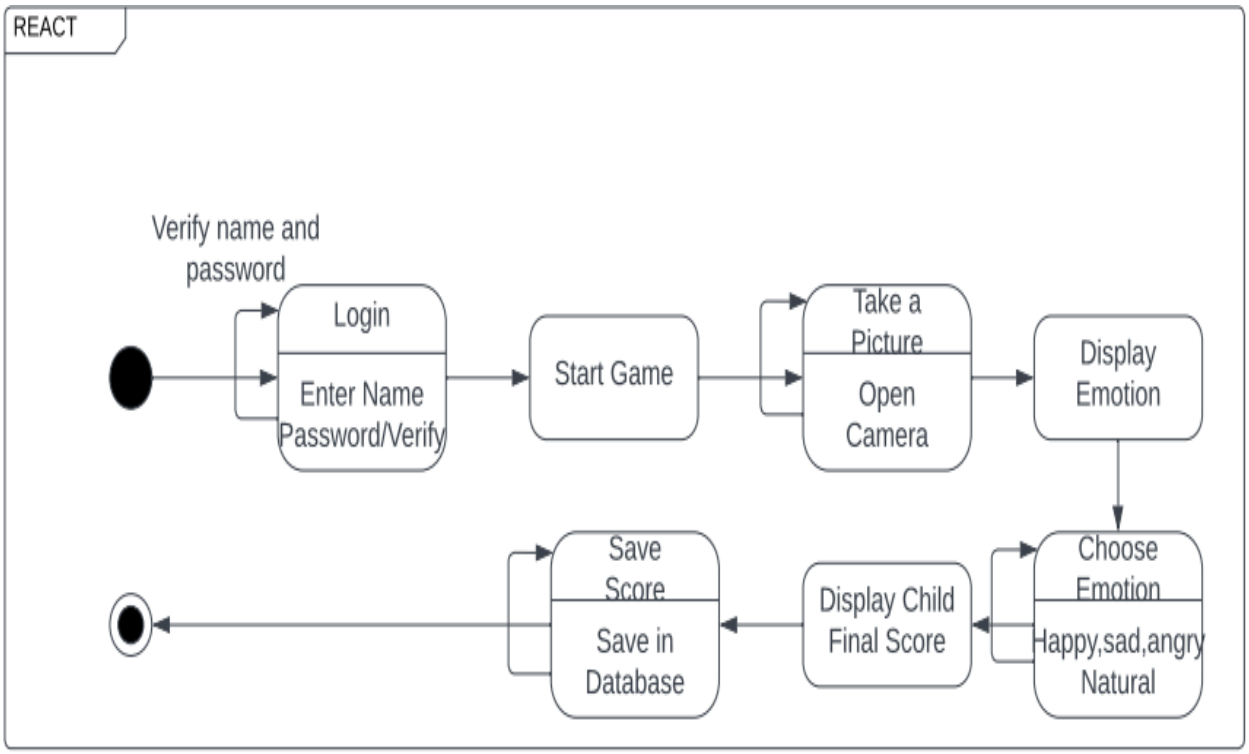


Figure 3.10: System State-machine diagram that shows the different states of React.

3.4 Data Collection Instruments (Data Logger)

In order to collect data of a delicate matter like autism spectrum disorder, and collect the real-life experience that affects the daily lives of children diagnosed with the spectrum, using a way that is going to assist us in understanding the issue they are having even more, in order to help us implement the mobile app in a way that addresses the issue effectively. We had to collect data using observations to a reliable source. A person that diagnose and treat people with ASD, and know what it does to children affected by it. The following observations made by watching videos of people talking about the spectrum.

How To Teach Your Child with Autism to Recognize Emotions – By Autism Recovery Network [11]

For children on the spectrum, they often encounter problems communicating with others due to their inability to recognize emotions and facial expressions. Comprehending what others might

be feeling can be a great challenge to them. Hence, teaching your child how to recognize emotions is essential as it helps them to regulate their own behaviors and behave in a socially appropriate manner to form meaningful social connections with others.

Emotion charts and emotional thermometers:

Use of emotional thermometers helps the child in:

- Identifying feelings
- Communicating feelings

Also, it enhance their emotional self-regulation and reduces the challenging behaviors.

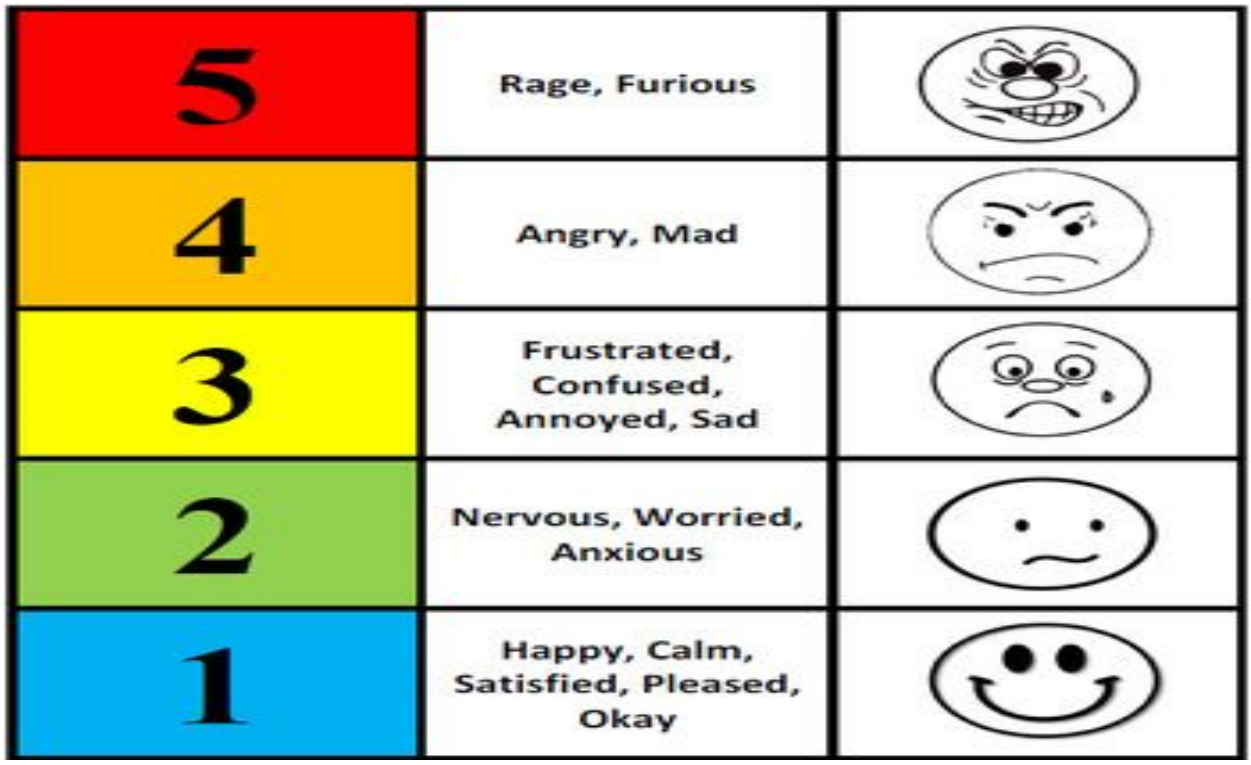


Figure 3.11: An emotional thermometer that ranks specific emotions to different numbers. The child uses the thermometer with the help of a guider to understand their current emotional feelings

Provide visual cues:

Children of autism spectrum disorder are great visual learners. The can understand photo cards that show faces and body languages that are usually associated with a specific emotion

Figure 3.12: A guider that assist a child in recognizing emotions using face cards [11].

3.4.1 Findings:

We can use the concepts of emotional thermometer and provide visual cues digitally in our mobile app, After the child opens the camera and takes a picture of the person playing with the child, the face detector well capture the person's emotion. Then, an emotional thermometer that includes the three main emotions – Happy, content and sad emotion – will be displayed to the child. Then, the child will click on the emotion that seems right to them.

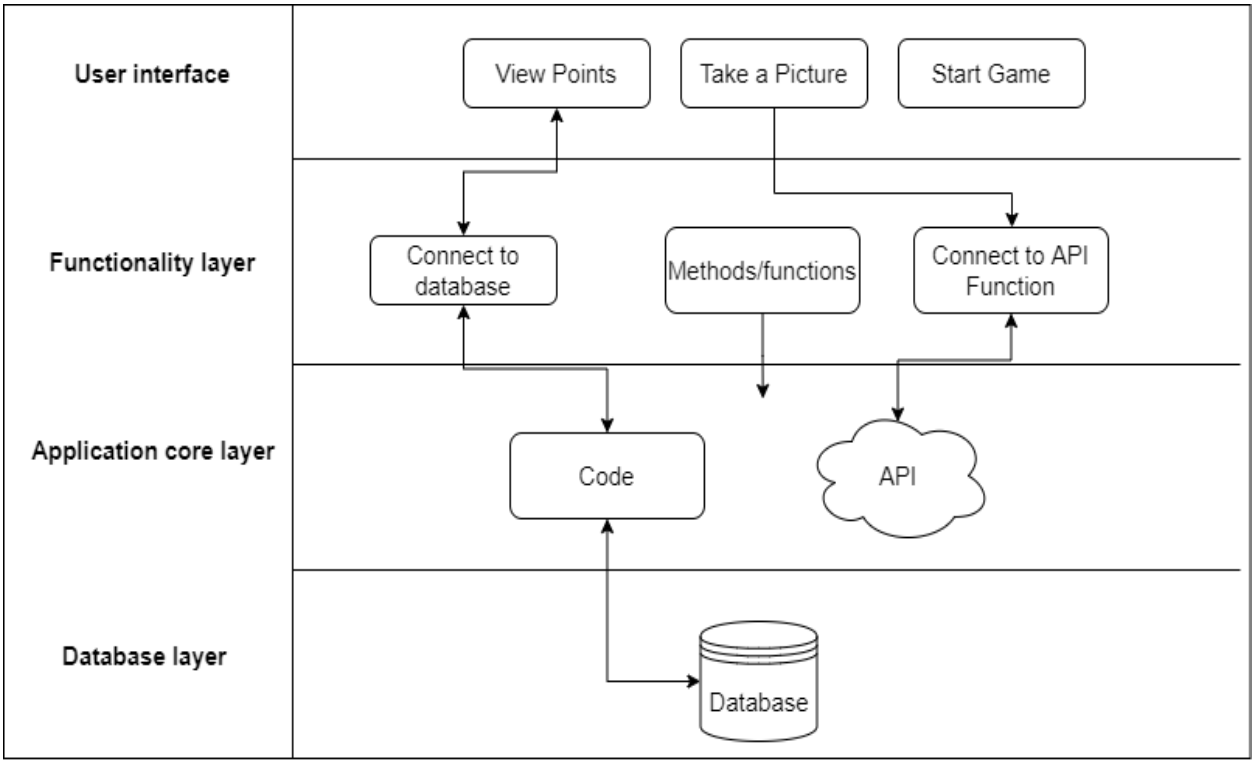
CHAPTER 4

DESIGN

4.1 System Architecture

"React" is an interactive game for children with ASD (autism spectrum disorder). The proposed system consists of an Android application, and must have a network connection to connect to the google vision API used for analyzing the photos uploaded by the child and detecting the face. Also, to store the points scored by the child we need a date.

We used the layered architecture to describe the system's flow of data:



4.2 User Interface Design

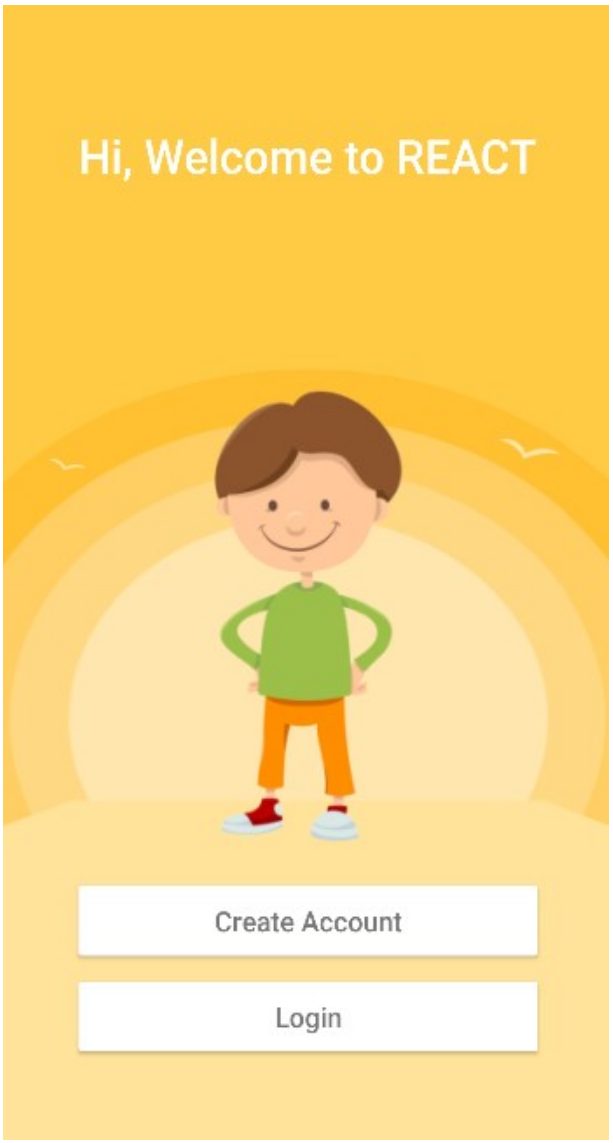


Figure 4.1: First page of REACT.

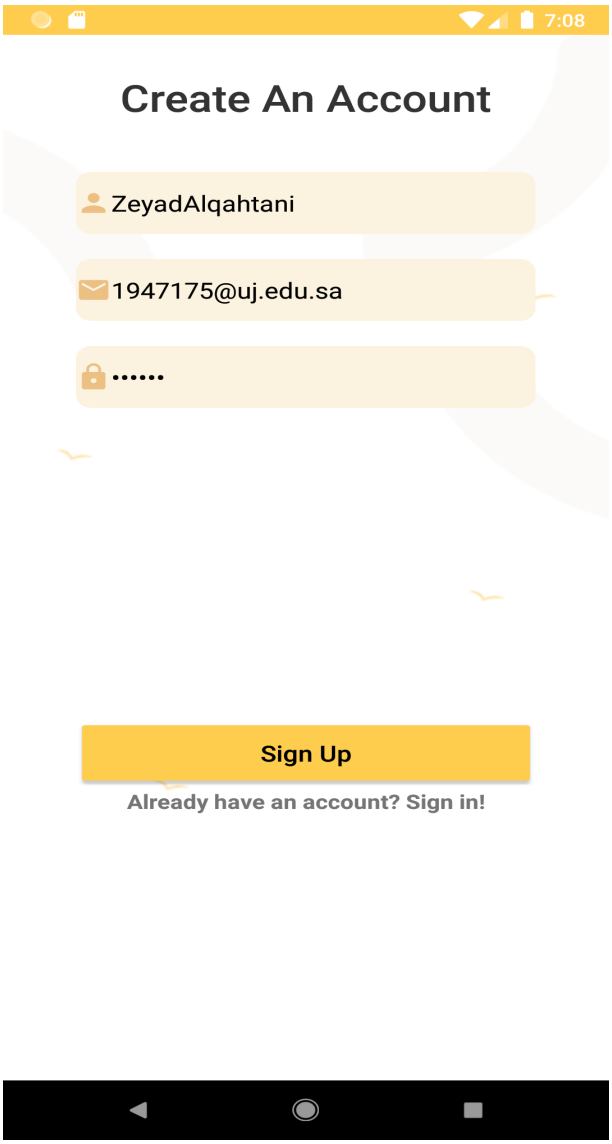


Figure 4.2: Sign up page of REACT.

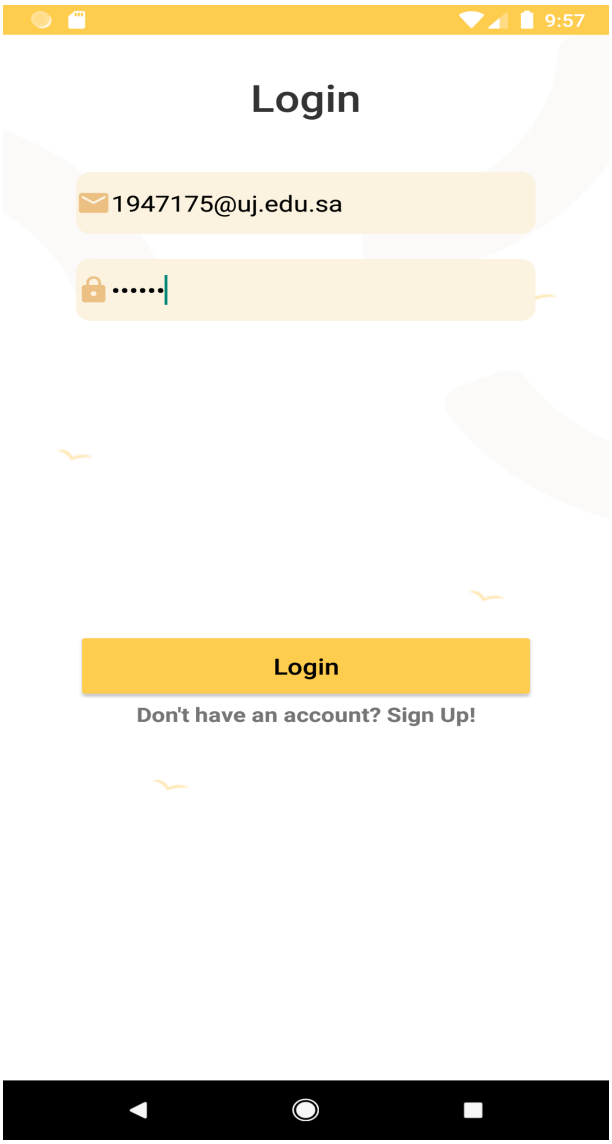


Figure 4.3: Login page of REACT.

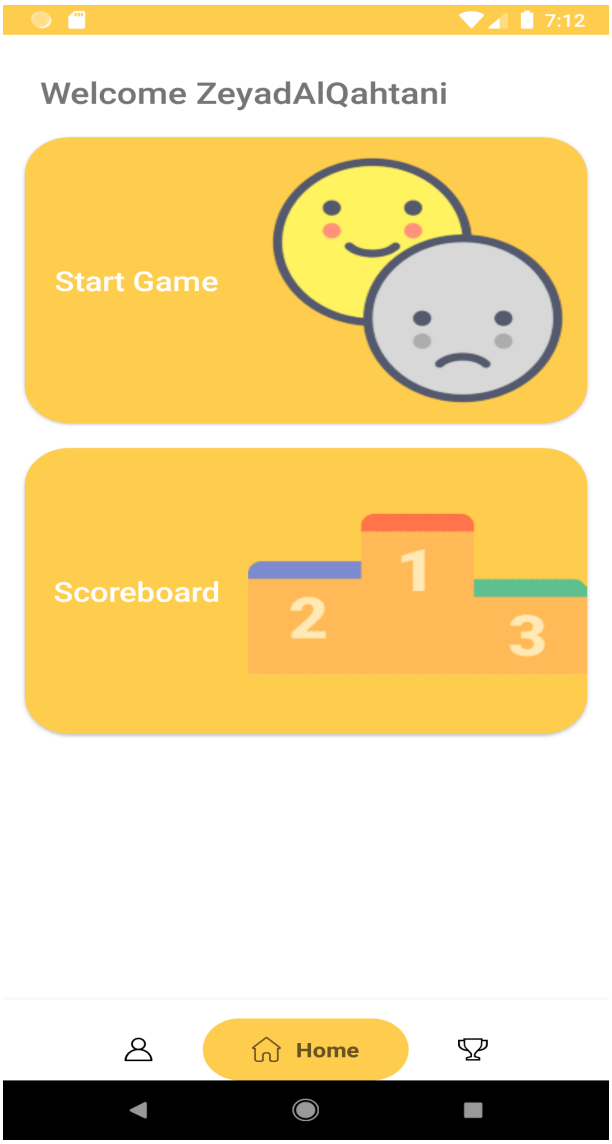


Figure 4.4: Home page of REACT.

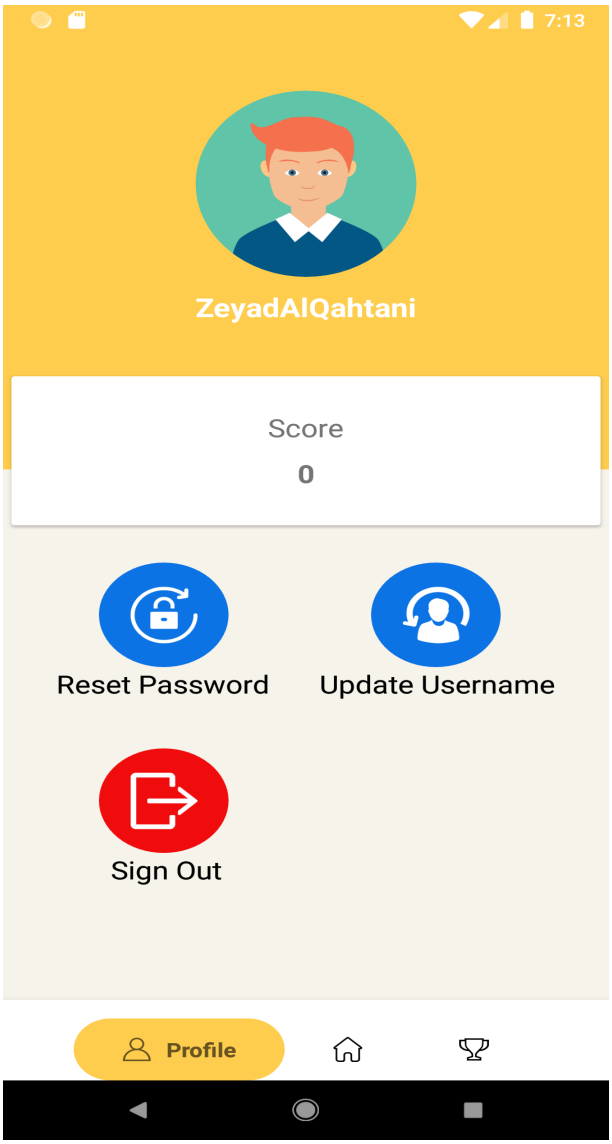


Figure 4.5: Profile page of User.

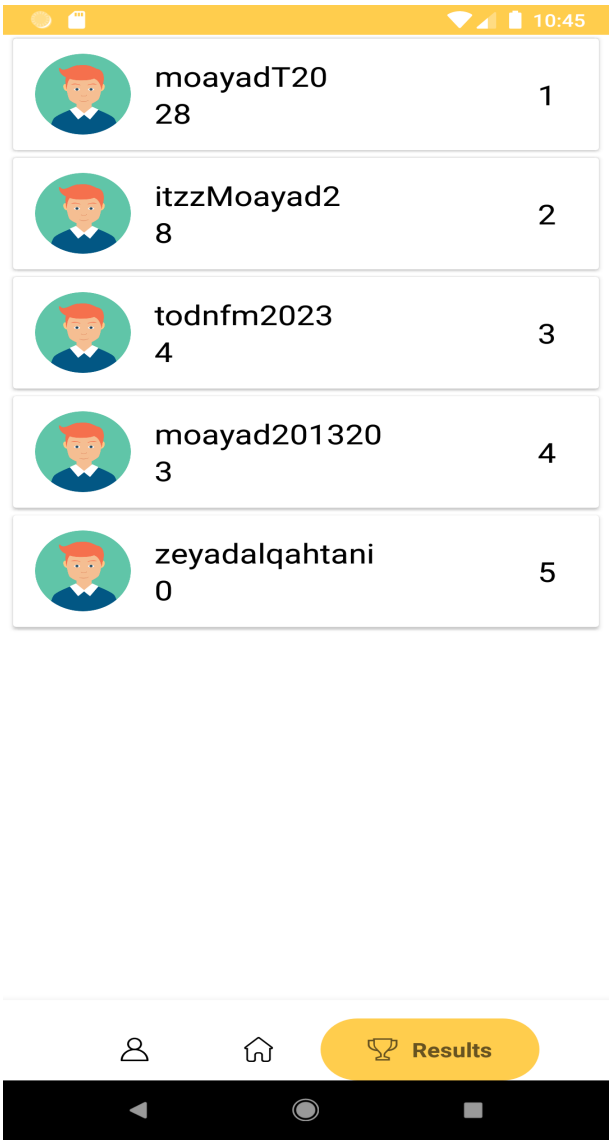


Figure 4.6: Result page of REACT.

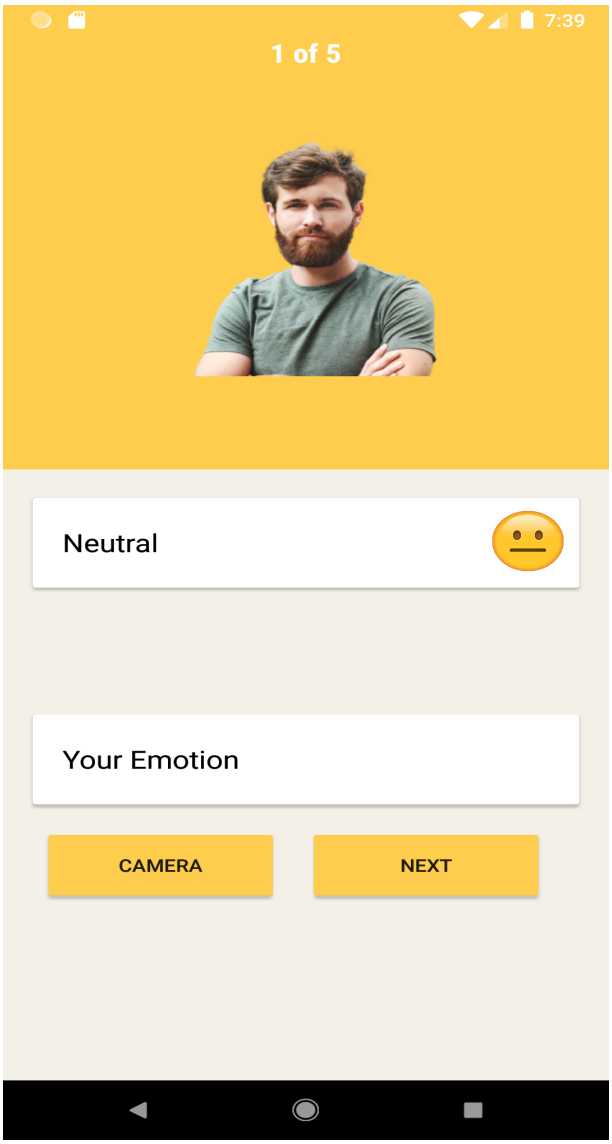


Figure 4.7: Game page and the first emotions displayed randomly to the user.

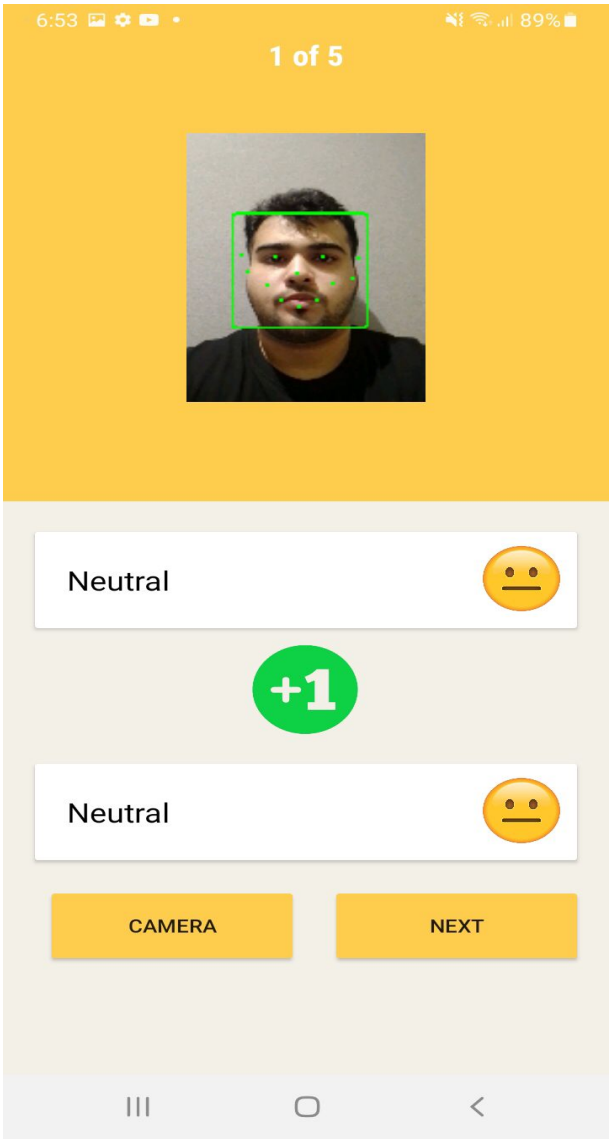


Figure 4.8: Compare emotion page. In case the child copied the emotion correctly, the application will display a 1+ massage with the color green.

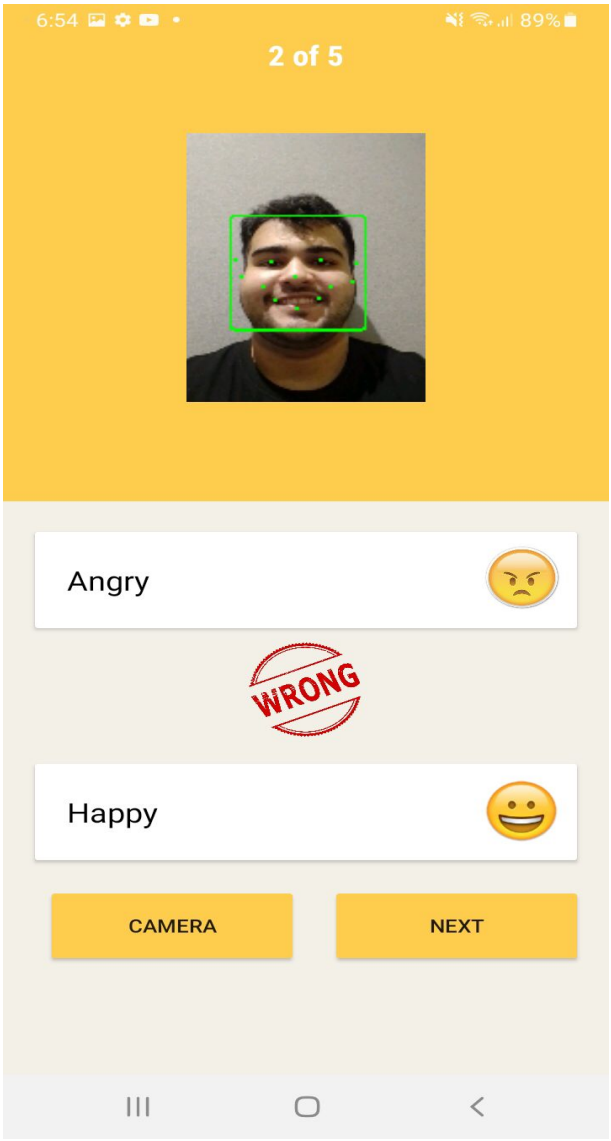


Figure 4.9: Compare emotion page. In case the child copied the wrong emotion, the application will display a wrong massage with the red green.

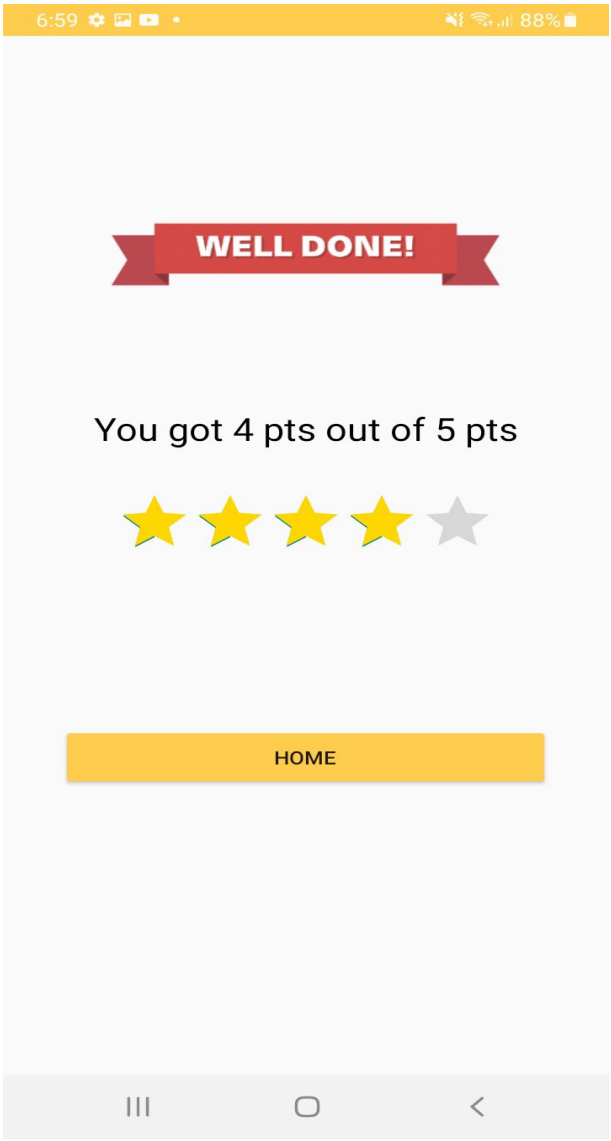


Figure 4.10: After completing the 5 rounds,a result page containing the score of the child out of 5 if it was a high score.

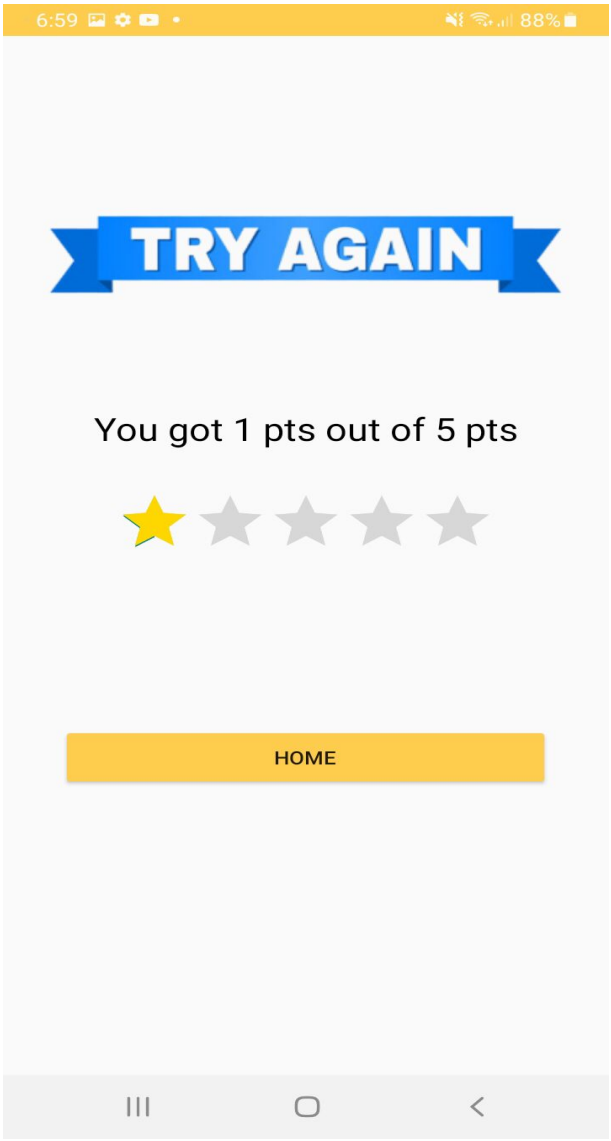


Figure 4.11: After completing the 5 rounds,a result page containing the score of the child out of 5 if it was a low score

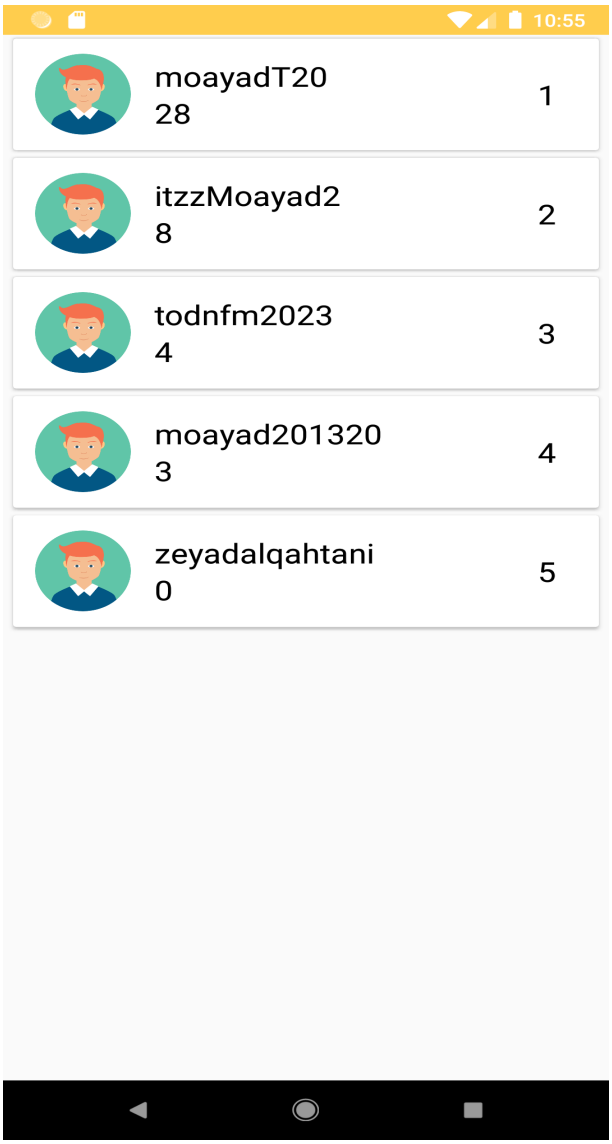


Figure 4.12: scoreboard page shows the score of children and their ranking.

CHAPTER 5

DEVELOPMENT

In this chapter, we will describe the development phase in REACT application project. We also defined what API and Model we have used to detect facial expression and emotions of the users and how we complete the development phase of the project.

5.1 AI model and API

As one of the most important directions in the field of technology is human emotion recognition based on facial expressions and the researches in the area of human-computer interaction(HCI), got us in these technology that helped us to reach the goal of helping children with autism spectrum disorder to know how to understand emotions.

In REACT application project we used two main technology to complete our program:

- Google Vision API
- ResNet Model

5.1.1 Google Vision API

First the Google Vision API allows developers to integrate vision detection features within applications, including many features the API offers, for example Detect objects, read printed and handwritten text and face and landmark detection, which that we used in our project.

5.1.2 ResNet Model

In detecting the emotion of the user, we have used TensorFlow lit. which is a mobile library for deploying models on mobile. We have used a pre-trained model using TensorFlow python framework and used in android application where the basic language is java.

The pre-trained model is ResNet-256 model that we used in REACT application the ResNet-256 model are called Residual Networks. Which is a special type of Convolutional Neural Network (CNN) that is used for tasks like Image Recognition. ResNet was first introduced in 2015 by

Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun in their paper – "Deep Residual Learning for Image Recognition". The number at the end specifies the number of layers in the network or how deep the networks are, we have used a 256 layered. ResNet can be designed with any depth using the basic building blocks of a ResNet.

The Resnet-256 model used a dataset that collected from Facial expression recognition challenge[12] in Kaggle to train the model for the emotion recognition that contain many 48x48 pixel faces expressing that include these emotions: happy, angry, neutral, sad and surprised.

5.1.3 Why ResNet-256 model?

ResNet-256 model compared to other models that are publicly available, it solve the vanishing gradient problem using identity mapping and has a high classification accuracy in showing the correct emotions.

5.1.4 How Google Vision API and ResNet-256 model will work on REACT application?

In the following figure the sequence diagram will show the process of facial and emotion detection happen.

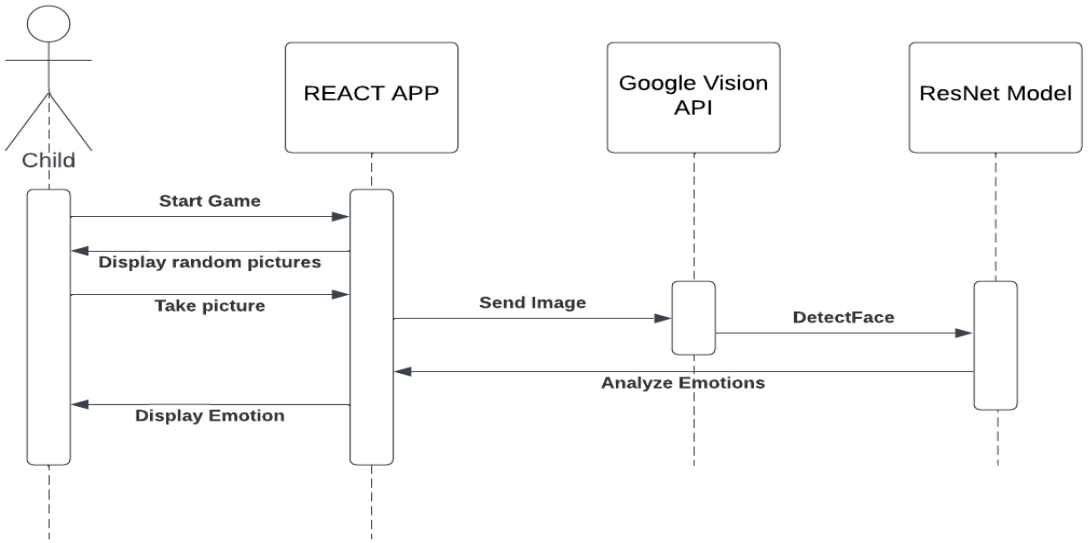


Figure 5.1: Sequence diagram of emotion analyze process

5.2 Data collection instruments (Data logger)

In REACT project our main goal is to help children with autism spectrum disorder to recognize and understand their emotions and others as well. But how we will implement these features in our mobile application, we used observation from reading articles, studies and viewing projects that used the emotion detection technology, and see what is the most accurate way to detect user emotions and what they used to achieve this goal.

Facial expression recognition via ResNet-50 Model[13]

Emotion is at the core of all human interaction, and thus as technology is becoming increasingly pervasive in daily life, emotion recognition is becoming increasingly relevant as well.Many Researches has been done on detecting facial expressions from images using machine learning models, and in this research they found out that many methods and models that been used by scholars in facial and emotion expression recognition have the problem that the original emotional information is easy to be lost. In addition, the generalization and robustness of these network models are also poor and has an accuracy of facial expression recognition is not high. So the ResNet model is by far the best model for image classification and it is one of the most efficient Neural Network Architectures, as they help in maintaining a low error rate much deeper in the network and has a high accuracy rate in detecting emotions.

A practical study about the Google Vision API[14]

In everyday life there are many problems that can be solved through computer vision solutions, like the Facial recognition detection and image classification can be solved with some of the market solutions that are available to public at a low-cost. Google Vision API is a great example of low-cost solutions and services that is publicly available to use and easy to implement.

This is some of Google Vision API services:

- Landmark Detection
- Face Detection
- Label Detection
- Logo Detection

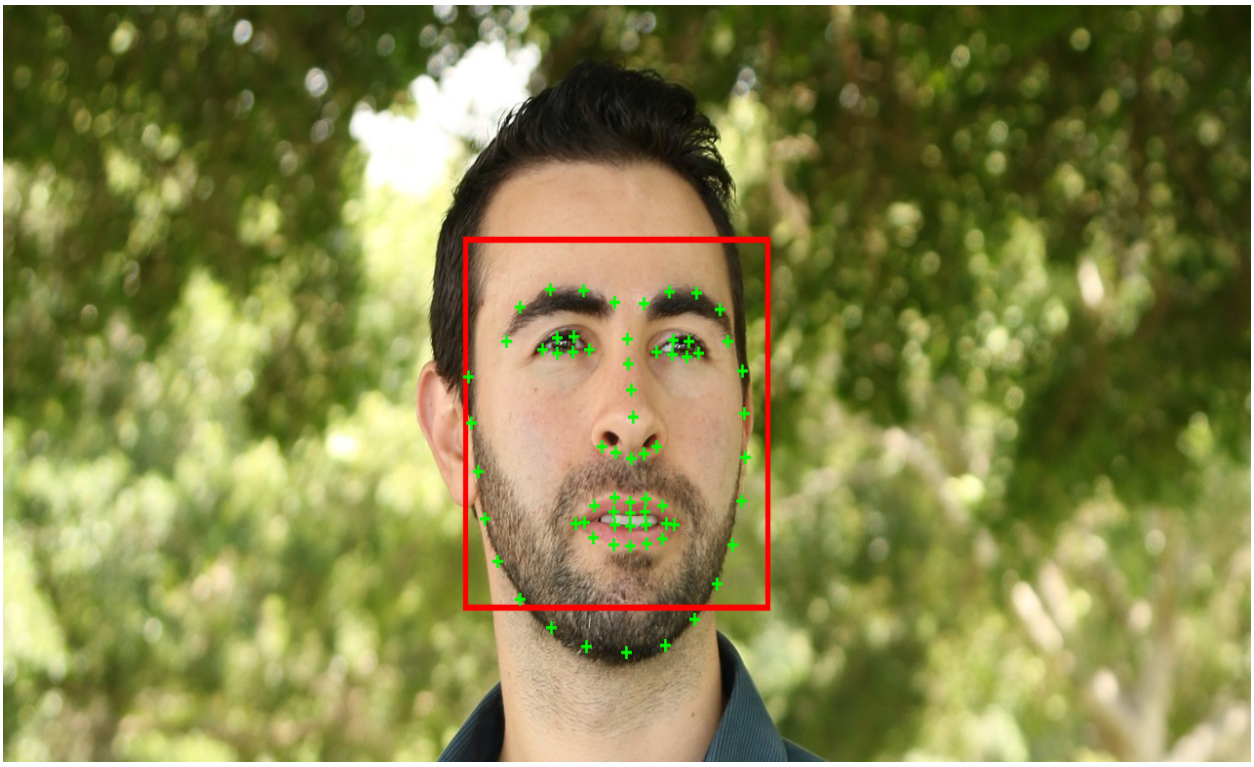


Figure 5.2: Facial landmark detection

5.2.1 Findings:

Many Studies has been done on detecting facial expressions and emotions recognition from images using machine learning AI, and we have chosen these technology and learned how to implement them on REACT app. We have combined the two technology, the ResNet model for emotion recognition and Google Vision API for face detection, in order to help children with autism spectrum disorder with their emotion recognition.

5.3 Firebase

Firebase is a Backend-as-a-Service (Baas). It provides developers with a variety of tools and services to help them develop quality apps, grow their user base, and earn profit. It is built on Google's infrastructure. Firebase is categorized as a NoSQL database program, which stores data in JSON-like documents.[15]

We used Firebase in our project for two main procedures:

- Storing data in Realtime database
- Authentication

5.3.1 Firebase Realtime database

Realtime Database is a feature provided by Firebase, Store and sync data with our NoSQL cloud database. Data is synced across all clients in realtime, and remains available when your app goes offline[16].

The Realtime Database is a NoSQL database and as such has different optimizations and functionality compared to a relational database. The Realtime Database API is designed to only allow operations that can be executed quickly. This enables you to build a great realtime experience that can serve millions of users without compromising on responsiveness[16].

In React, we store the user's email, username, points. Whilst password is stored securely by Firebase authentication.

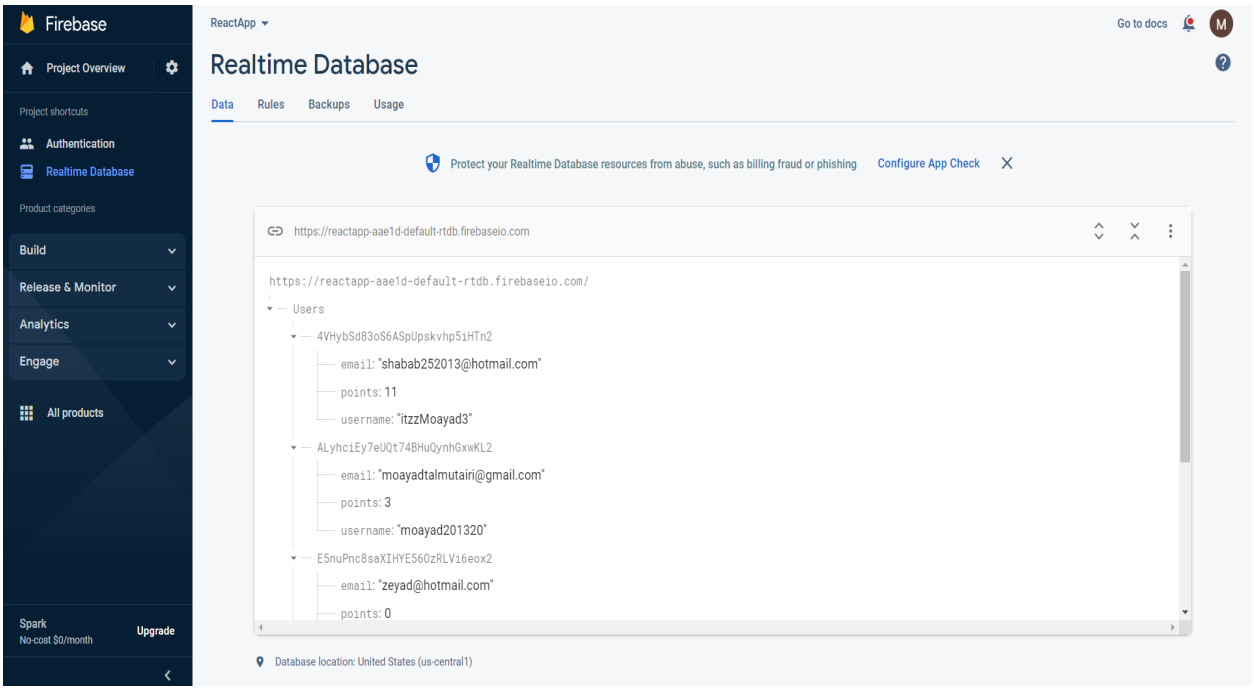


Figure 5.3: User interface of Firebase, and React's realtime database, showing the structure of the data in the realtime database. Each user has an email, points, and an username

5.3.2 Firebase Authentication

Firebase Authentication provides backend services, easy-to-use SDKs, and ready-made UI libraries to authenticate users to your app. It supports authentication using passwords, phone numbers, popular federated identity providers like Google, Facebook and Twitter, and more[17].

In React, when user register their accounts, their Email and password would be stored securely in Firebase Authentication. Also it would generate an user ID that would be linked to distinct users.

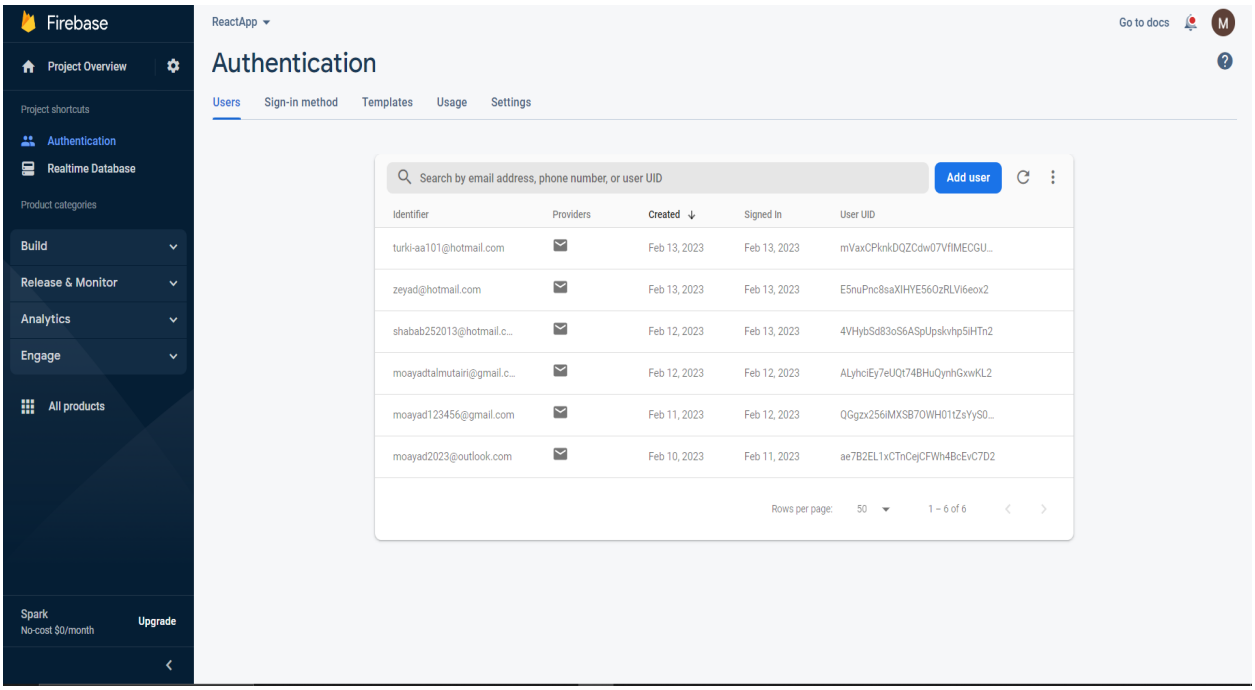


Figure 5.4: User interface of Firebase, and React's authentication page, showing all the users that registered in our app, with a unique UID

5.4 Implementation and Coding

5.4.1 Android studio

We used Android studio development tools to write the code of React, The language in which we wrote the code with is Java

Android Studio is the official Integrated Development Environment (IDE) for Android app development. Based on the powerful code editor and developer tools from IntelliJ IDEA , Android Studio offers even more features that enhance your productivity when building Android apps[18].

Functionality	Code Snippet
Registration	

```
mAuth.createUserWithEmailAndPassword(email,
    password).addOnCompleteListener(new
    OnCompleteListener<AuthResult>() {
@Override
public void onComplete(@NonNull Task<AuthResult>
    task) {
progressBar.setVisibility(View.GONE);
if(task.isSuccessful()){

    HashMap<String,Object> hashMap = new HashMap
    <>();
    hashMap.put("username", username);
    hashMap.put("email", email);
    hashMap.put("points", 0);
    firebaseUser = FirebaseAuth.getInstance().
    getCurrentUser();
    databaseReference.child("Users")
        .child(firebaseUser.getUid())
        .setValue(hashMap);

    UserProfileChangeRequest profileUpdates = new
    UserProfileChangeRequest.Builder()
    .setDisplayName(username).build();

    firebaseUser.updateProfile(profileUpdates);
    Intent intent = new Intent(
    CreateAccountActivity.this, LoginActivity.
    class);
    intent.addFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP
    );
    tartActivity(intent);
}else{
    if (task.getException() instanceof
    FirebaseAuthUserCollisionException){
            editTextEmail.setError("Email already
    registered");
            editTextEmail.requestFocus();
            }else{
                Toast.makeText(
    getApplicationContext(), task.getException().
    getMessage(), Toast.LENGTH_SHORT).show();
             }
        }
     }
});
```

Table 5.1: Code snippet of the registration function

Functionality	Code Snippet
Login	

```
private void userLogin(){
        String email = editTextEmail.getText().
    toString().trim();
        String password = editTextPassword.getText
    ().toString().trim();
        if(email.isEmpty()){
            editTextEmail.setError("Email is
    required");
            editTextEmail.requestFocus();
            return;
        }
        if(!Patterns.EMAIL_ADDRESS.matcher(email).
    matches()){
            editTextEmail.setError("Please input a
     valid email");
            editTextEmail.requestFocus();
            return;
        }
        if(password.isEmpty()){
            editTextPassword.setError("Password is
     required");
            editTextPassword.requestFocus();
            return;
        }
        if(password.length() < 6){
            editTextPassword.setError("Minimum
    length of password should be 6");
            editTextPassword.requestFocus();
            return;
        }
        progressBar.setVisibility(View.VISIBLE);
        mAuth.signInWithEmailAndPassword(email,
    password).addOnCompleteListener(new
    OnCompleteListener<AuthResult>() {
```

Table 5.2: Code snippet of the login function

Functionality	Code Snippet
Loading an image to TensorImage	

```
private TensorImage loadImage(final Bitmap bitmap)
    {
        // Loads bitmap into a TensorImage.
        Bitmap bitmap01 = bitmap.copy(Bitmap.
    Config.ARGB_8888,true);
        inputImageBuffer.load(bitmap01);

        // Creates processor for the TensorImage.
        int cropSize = Math.min(bitmap.getWidth(),
     bitmap.getHeight());
        // TODO(b/143564309): Fuse ops inside
    ImageProcessor.
        ImageProcessor imageProcessor =
                new ImageProcessor.Builder()
                        .add(new
    ResizeWithCropOrPadOp(cropSize, cropSize))
                        .add(new ResizeOp(
    imageSizeX, imageSizeY, ResizeOp.ResizeMethod.
    NEAREST_NEIGHBOR))
                        .add(
    getPreprocessNormalizeOp())
                        .build();
        return imageProcessor.process(
    inputImageBuffer);
    }
```

Table 5.3: Code snippet of the Loading image to TensorImage function

Functionality	Code Snippet
Detect face	

```
if(faceresult==1) {
    faceresult = 0;
     bitmaaap = Bitmap.createBitmap(newBitmap, (
    int) face.getPosition().x, (int) face.
    getPosition().y, (int) face.getWidth(), (int)
    face.getHeight());

    int imageTensorIndex = 0;
    int[] imageShape = tflite.getInputTensor(
    imageTensorIndex).shape(); // {1, height,
    width, 3}
    imageSizeY = imageShape[1];
    imageSizeX = imageShape[2];
    DataType imageDataType = tflite.getInputTensor
    (imageTensorIndex).dataType();

    int probabilityTensorIndex = 0;
    int[] probabilityShape =
    tflite.getOutputTensor(probabilityTensorIndex)
    .shape(); // {1, NUM_CLASSES}
    DataType probabilityDataType = tflite.
    getOutputTensor(probabilityTensorIndex).
    dataType();

    inputImageBuffer = new TensorImage(
    imageDataType);
    outputProbabilityBuffer = TensorBuffer.
    createFixedSize(probabilityShape,
    probabilityDataType);
    probabilityProcessor = new TensorProcessor.
    Builder().add(getPostprocessNormalizeOp()).
    build();

    if (bitmaaap != null) {
        inputImageBuffer = loadImage(bitmaaap);

        tflite.run(inputImageBuffer.getBuffer(),
    outputProbabilityBuffer.getBuffer().rewind());

        showresult();

                }

                progressDialog.dismiss();

            }
```

Table 5.4: Code snippet of the detect face function

Functionality	Code Snippet
Showing result	

```
private void showresult(){
    Map<String, Float> labeledProbability =
    new TensorLabel(labels, probabilityProcessor.
    process(outputProbabilityBuffer))
    .getMapWithFloatValue();
    Map.Entry<String, Float> maxEntry = null;
    for (Map.Entry<String, Float> entry :
    labeledProbability.entrySet())
    {if (maxEntry == null || entry.getValue().
    compareTo(maxEntry.getValue()) > 0)
        {maxEntry = entry;}}
    String stringResult;
    if ( maxEntry.getKey().equals(requiredEmotion)
    ) {
        scoreCount = scoreCount + 1;
        stringResult = "Correct";}
    else{
        stringResult = "Wrong";}
textViewEmotion.setText(maxEntry.getKey());
    if (stringResult.equals("Correct"){
    circleImageViewResult.setImageResource(R.
    mipmap.correct);}
    else if (stringResult.equals("Wrong")){
circleImageViewResult.setImageResource(R.mipmap.
    wrong);}
    if (maxEntry.getKey().equalsIgnoreCase("Angry"
    )){        circleImageViewEmotion.
    setImageResource(R.mipmap.angryemoji);}
    else if (maxEntry.getKey().equalsIgnoreCase("
    Happy")){circleImageViewEmotion.
    setImageResource(R.mipmap.happyemoji);}else if
     (maxEntry.getKey().equalsIgnoreCase("Sad")){
        circleImageViewEmotion.setImageResource(R.
    mipmap.sademoji);}
    else if (maxEntry.getKey().equalsIgnoreCase("
    Surprised")){
        circleImageViewEmotion.setImageResource(R.
    mipmap.surprisedemoji);}
    else if (maxEntry.getKey().equalsIgnoreCase("
    Neutral")){
        circleImageViewEmotion.setImageResource(R.
    mipmap.neutralemoji);}
    }
```

Table 5.5: Code snippet of the show result function

CHAPTER 6

TESTING AND ANALYSIS

6.1 About the testing study

We conducted the testing study using the black box approach, where we test the functionality of the system and the system behavior under several inputs. Black box testing gives abstraction from code and focuses on testing effort on the software system behavior.

6.2 Data collection (Quantitative, Qualitative)

We made test cases regarding the following aspects (Registration, Login, Emotion detection, Scoring system, Scoreboard) The test cases will produce results concerning the following aspects:

Registration:

- Input Validation
- Successful/Failed Registration

Login:

- Input Validation
- Successful/Failed Login

Emotion Detection:

- We tested the emotion detection mechanism used in the app and its output in comparison with the emotion that the user submitted.
  - User makes a happy face = React should return “Happy”
  - User makes a sad face = React should return “Sad”
  - User makes an angry face = React should return “Angry”
  - User makes a surprised face = React should return “Surprised”
  - User makes no emotion = React should return “Neutral”
  - User’s picture does not include a face = React should return “No Face detected”

Scoring System:

- User makes the right emotion = User should get 1 point
- User makes the wrong emotion = app should notify the user that the emotion is wrong
- User makes the wrong emotion on every round = The overall score should be 0 out of 5
- User makes the right emotion 2 times out of 5 = The overall score should be 2 out of 5
- User makes the right emotion 5 times out of 5 = The overall score should be 5 out of 5

Scoreboard:

- After creating a new user
  - Opening the scoreboard without yet playing the first round should show that the user score is 0
  - Opening the scoreboard after scoring 5pts should show that the user score is 5pts
  - Opening the scoreboard after scoring 2pts should show that the user score is 7pts

6.3 Test cases and Results

6.3.1 Registration test cases

Test Case No.	Test Case Description	Expected Results	Outcome (Pass / Fail / Other (Comments))
TC001	User taps on SIGN UP button on main screen.	User should be taken to the Registration screen.	Pass
TC002	User leaves all fields blank on Registration screen and taps SIGN UP button.	User should be displayed with a message: "Username is required".	Pass
TC003	User enters Username with whitespaces and leaves email and password empty.	User should be displayed with a message: "Username must not have whitespaces".	Pass
TC004	User enters Username and leaves all other fields blank on Registration screen and taps SIGN UP button.	User should be displayed with a message: "Email is required".	Pass
TC005	User enters Username, Email and leaves Password field blank, and taps SIGN UP button.	User should be displayed with a message "Password is required."	Pass
TC006	User enter Username and an Email that is already used.	User should be displayed with a message "Email already registered".	Pass

Figure 6.1: Test cases regarding the functionalities of the registration process (1/2).

TC007	User enters First Name, Email and a password that is less than 6 characters and taps SIGN UP button.	Password should be displayed with asterisks **** in password field. User should be displayed with a message: "Minimum length of password should be 6.".	Pass
TC008	User enters information in all required fields and taps SIGN UP button.	User registration completed successfully , User should be taken to the Login screen.	Pass

Figure 6.2: Test cases regarding the functionalities of the registration process (2/2).

6.3.2 Login

Test Case No.	Test Case Description	Expected Results	Outcome (Pass / Fail / Other (Comments))
TC09	User leaves all fields blank on Login screen and taps Login.	User should be displayed with a message "Email is required".	Pass
TC010	User enters an invalid email and taps Login.	User should be displayed with a message "Please enter valid email".	Pass
TC011	User enters a valid username (email) and leaves password blank and taps Login.	User should be displayed with a message: "Password is required".	Pass
TC012	User enters valid username and password.	Application should hide the password by masking with **** on the password field.	Pass
TC013	User enters valid username and a wrong password and taps Login.	User should be displayed with a message "Invalid username/password".	Pass
TC014	User enters a valid username and a valid password.	User should be taken to home screen.	Pass

Figure 6.3: Test cases regarding the functionalities of the login process.

6.3.3 Emotion detection

Test Case No.	Test Case Description	Expected Results	Outcome (Pass / Fail / Other (Comments))
TC015	The user presses the camera button to take the picture	The camera should open, and user can take a picture	PASS
TC016	The user takes a picture of a happy emotion	React should display "Happy"	PASS
TC017	The user takes a picture of a sad emotion	React should display "Sad"	PASS
TC018	The user takes a picture of angry person	React should display "Angry"	PASS
TC019	The user takes a picture of a surprised emotion	React should display "Surprised"	PASS
TC020	The user takes a picture of a neutral emotion	React should display "Neutral"	PASS

Figure 6.4: Test cases regarding the functionalities of the Emotion detection process.

Emotion	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Success rate
Happy	1	1	1	1	1	100%
Sad	1	1	1	1	1	100%
Angry	1	1	0	1	1	80%
Surprised	1	1	1	1	0	80%
Neutral	1	1	1	1	1	100%

Figure 6.5: Test cases regarding the functionalities of the Emotion detection process, This test case showcase the accuracy of ResNet model to capture the right emotion.

6.3.4 Scoring System

Test Case No.	Test Case Description	Expected Results	Outcome (Pass / Fail / Other (Comments))
TC021	The user makes the right emotion	React should give the user a single point	PASS
TC022	The user makes the wrong emotion	React should notify the that the emotion is wrong	PASS
TC023	The user makes the wrong emotion on every round	React should display the overall result to be 0 out of 5	PASS
TC024	The user makes the right emotion 2 times out of 5	React should display the overall result to be 2 out of 5	PASS
TC025	The user makes the right emotion 5 times out of 5	React should display the overall result to be 5 out of 5	PASS

Figure 6.6: Test cases regarding the functionalities of the Scoring process.

6.3.5 Scoreboard

Test Case No.	Test Case Description	Expected Results	Outcome (Pass / Fail / Other (Comments))
TC026	After creation of a new user. The user open the scoreboard without yet playing the first game	The user's score should be 0 on the scoreboard	PASS
TC027	After creation of a new user. The user opens the scoreboard after playing a game in which he got 2pts out of 5pts	The user's score should be 2 on the scoreboard	PASS
TC028	The user opens a second a game and scores 5pts out 5pts	The user's score should be 7 on the scoreboard	PASS

Figure 6.7: Test cases regarding the scoreboard page.

6.3.6 Findings

After conducting several test cases regarding the registration and login. It came to our attention that Firebase offers secure and reliable way to store and authenticate data.
Also regarding The emotion detection, it came to our attention that ResNet model provides accurate results of displaying the user's emotion.

CHAPTER 7

LIMITATION, FUTURE WORK, AND CONCLUSION

7.1 Conclusion

React is an application for autistic children, it provides a fun game for children to teach them how to react and understand emotions. Children with autism spectrum disorder have difficulties in comprehending emotions. Through active practice with an app that provides visual cues that links images of real people with an emoji describing the emotion, the child intellectual behavior toward emotions will improve.

In conclusion, after successfully developing React, and the intellectual properties that it provides. We can say that we met the project objectives, and used our research regarding ASD to aid us in building a fun and easy to use app.

7.2 Future Work

After finishing this paper, we see that future work should cover the following area

- Improving people incapabilities through mobile development
- Emotion detection using ResNet models
- Collaborate with an Autism treatment center.

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