Applied Science Private University
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Graduation Project (1) Report

RAFEEQ
An Autism Support Application with Emotion-Responsive Features

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Abstract

This project addresses the critical need for personalized emotional and developmental support for children with Autism Spectrum Disorder (ASD) by leveraging advanced emotion recognition technology. The proposed application utilizes a camera to capture images of the child and applies MobileNetV3, a highly efficient and lightweight convolutional neural network, to analyze and determine their emotional state, such as happiness, anger, sadness, or surprise. Based on the detected emotion, the application provides tailored interventions, including interactive educational and recreational games, emotionally aligned media, and therapeutic exercises designed to enhance the child's cognitive, emotional, and physical well-being. The application offers several key features to maximize its usefulness. Parents and supervisors can directly customize content to suit the child's individual needs. Activity schedule alerts help families maintain daily routines, while periodic cumulative reports provide detailed insights into the child's emotional trends and developmental progress over time. These features not only support the child's growth but also empower caregivers to make informed decisions about their interventions.

This project also addresses a significant research gap in current technological solutions for ASD. While many existing tools focus on isolated aspects of support, such as basic learning activities or emotion detection, they fail to integrate real-time emotion recognition with tailored interventions in a lightweight and efficient manner. By incorporating MobileNetV3 for its state-of-the-art performance and resource efficiency, this project delivers an innovative solution that combines advanced machine learning with personalized content and progress tracking. It aspires to

improve the quality of life for children with ASD and foster meaningful engagement for both the children and their caregivers.

Chapter 1: Introduction

This project involves developing an intelligent mobile application that uses emotion recognition technology to support children with Autism Spectrum Disorder (ASD). The application aims to enhance emotional understanding and expression through real-time emotional state analysis, providing personalized interventions such as games, music, and exercises. This project seeks to bridge gaps in existing systems by offering a more interactive and tailored approach to emotional and developmental support for children with ASD. The problem is identified in terms of the current limitations and the opportunity to improve emotional and cognitive growth using advanced technologies. This chapter is structured as follows: 1.1 Description of the Current Situation and Opportunity, 1.2 Related Work, 1.3 Problem Statement (Limitations of Current Systems), 1.4 Problem Solution, 1.5 Project Objectives, 1.6 Technology and Tools Used, and 1.7 Project Plan for the Implementation. Each section provides a comprehensive overview of the project's goals and the innovative approach to supporting children with ASD.

1.1 Description of the current situation and opportunity

Children with Autism Spectrum Disorder (ASD) face unique challenges in understanding and expressing emotions, which can significantly impact their social interactions, learning, and overall quality of life. Caregivers and educators often struggle to find effective ways to engage these children, address their emotional needs, and foster developmental progress. Current solutions are either too generic, focusing on broad educational content, or lack integration of real-time emotional insights to personalize interventions.

There is a growing opportunity to leverage advancements in artificial intelligence, particularly in lightweight machine learning models like MobileNetV3, to bridge this gap. Emotion recognition technologies, combined with interactive and tailored content delivery, can provide a highly personalized and engaging experience for children with ASD. Such a solution not only supports the child’s emotional and cognitive development but also

empowers caregivers and educators with tools to better understand and respond to the child's needs.

This project identifies a clear need for an intelligent, efficient, and accessible application that integrates real-time emotion recognition with adaptive content tailored to individual children. By addressing this gap, the project aims to improve the quality of life for children with ASD, enhance their emotional and cognitive development, and support caregivers in their vital role.

1.2 Related work

Several applications have been developed to support children with Autism Spectrum Disorder (ASD), offering various educational, behavioral, and emotional interventions. While many of these applications provide valuable tools for caregivers and educators, there remains a gap in integrating advanced technologies like emotion recognition to provide real-time, personalized support for children with ASD. Below is an overview of some of the notable ASD applications:

1. **AutiSpark:** This app offers a collection of educational games aimed at children with ASD, including activities related to tracing letters, basic math, spelling, and identifying shapes and colors. Although it provides valuable learning tools, it lacks content in Arabic and does not offer emotional navigation features, such as dealing with meltdowns or stress.
2. **JADE:** JADE promotes inclusive education through technology, offering educational software and AI-based tools. One of its standout features is Jade Astea, which uses AI and eye movement tracking to assess children with suspected autism. However, it has limited language inclusivity and is available only in the US and Brazil.
3. **Learn Autism:** This app provides educational podcasts and videos with evidence-based information for parents of children with ASD, offering guidance on various stages of their children's lives. While the content is available in multiple languages, it is not interactive for children and focuses

primarily on parent education rather than providing direct support for children with ASD.

4. **The Autism Helper:** This online resource offers a variety of educational materials, courses, and tools for individuals with autism and their families. It includes professional development courses for parents and educators, but it lacks language inclusivity and does not provide sensory-based games for children.
5. **Autism 911:** Autism 911 is designed as a crisis management tool, offering immediate support and guidance during stressful situations, such as meltdowns, sensory overloads, or behavioral escalations. While it provides valuable emergency assistance, it is limited to addressing immediate crises and does not offer long-term support for broader developmental needs, such as communication or social skills. Additionally, it requires active use from caregivers, which can be challenging during stressful situations.
6. **Autism Social Video:** This app utilizes video modeling to teach social skills to children with ASD, focusing on scenarios like greetings, sharing, and conflict resolution. While it provides a broad range of social situations and allows for customization, it places more emphasis on video observation than on real-life interaction, which may limit practical application. Furthermore, it requires caregivers' supervision and does not address all possible social challenges faced by children with ASD.
7. **Autism Speech and Language:** This app focuses on speech and communication development, encouraging children with ASD to practice pronunciation, vocabulary, and conversational skills. While it provides interactive lessons and games, it lacks broader developmental tools for managing sensory processing or behavioral issues. Additionally, it relies heavily on repetition and requires caregivers' involvement for effective use.

Recent research also highlights the critical role of machine learning and explainable artificial intelligence (XAI) in improving ASD diagnostic tools,

suggesting the integration of these technologies to enhance diagnostic accuracy and interpretability. One such study by authors Jeon et al. (2024) focuses on using ML combined with XAI to improve diagnostic accuracy for ASD. By incorporating a robust data-preprocessing pipeline, including outlier removal and missing data handling, along with selecting relevant features based on clinical expertise, the study aimed to enhance both the precision and interpretability of ASD diagnostic tools. The results showed that neural networks and extreme gradient boosting models performed best, achieving high accuracy, precision, and recall. Furthermore, XAI techniques were employed to provide transparency into the models, allowing clinicians to better understand how various behavioral features contributed to predictions. This method not only improved diagnostic accuracy but also helped foster greater trust in AI-driven tools, enabling better clinical decision-making.

In the realm of educational tools, the use of augmented reality (AR) has also proven beneficial for children with ASD. A study by Hashim et al. (2022) developed an AR-based mobile application called "AReal-Vocab," aimed at helping children with mild autism acquire English vocabulary. Based on various learning theories such as behaviorism and constructivism, the app employed AR to engage children in meaningful vocabulary learning. The study demonstrated that the app successfully improved children's interest in learning, enhanced their pronunciation skills, and promoted leisure learning at home. These findings highlight the potential of AR in supporting language acquisition for children with ASD by making learning more engaging and visually stimulating.

In line with this, Mohd Z.A. Aziz et al. (2014) developed a mobile application to assist children with ASD in improving their social interactions and communication. The application was designed to be highly customizable, enabling it to adapt to the evolving needs of the child. It helped children express their needs more effectively and facilitated their communication with others. This approach not only supported the children's social integration but

also assisted parents and caregivers in understanding and addressing their children's specific needs.

The role of mobile applications in supporting the development of basic instrumental skills such as language, reading, and mathematics for children with autism has also been a subject of study. According to Gallardo-Montes et al. (2021), a comprehensive analysis of 88 apps aimed at promoting these skills revealed that most apps focused on oral language and reading, with fewer dedicated to subjects like mathematics. This gap indicates the need for more specialized apps that address a broader spectrum of developmental skills, as well as a better understanding of the age groups these apps are designed for.

Finally, Xanthopoulou et al. (2019) conducted a review of various applications available for children with ASD, categorizing them into three groups: Diagnostic Tools, Intervention Tools, and General Mobile Apps. The study assessed each app based on user feedback, download rates, ease of use, and how well they met their described goals. This classification provides valuable insights into the different types of applications available, highlighting their utility in different aspects of ASD diagnosis and intervention.

These research developments, along with existing applications, underline the importance of integrating innovative technologies to enhance the learning and diagnostic processes for children with ASD. The proposed project seeks to bridge the gap by leveraging emotion recognition and AI technologies to provide real-time personalized support.

1.3 Problem statement (limitation of current systems)

Despite the growing number of applications and technologies designed to support children with Autism Spectrum Disorder (ASD), there are several limitations that hinder their effectiveness in providing comprehensive, personalized, and real-time support. Current systems face the following challenges:

1. **Limited Personalization**: Many existing applications lack the capability to tailor content to the specific needs of each child with ASD. While some

apps provide generic educational or behavioral tools, they often fail to adjust the difficulty level, content delivery, or interventions based on the child's emotional or cognitive state. This results in a one-size-fits-all approach that may not be effective for all users.

2. **Insufficient Emotional Support:** A key challenge in supporting children with ASD is addressing their emotional and behavioral needs, especially in real-time. Most current applications do not offer emotional navigation features, such as detecting and responding to emotional triggers or meltdowns. As children with ASD often face difficulties in managing emotions, an app that can adapt and provide appropriate interventions during such moments is crucial.

3. **Lack of Integration with Advanced Technologies:** Many existing ASD applications do not integrate advanced technologies, such as machine learning, emotion recognition, or explainable artificial intelligence (XAI), to enhance diagnostic accuracy, intervention strategies, or user experience. While machine learning has been shown to improve ASD diagnostic tools and predict outcomes, it is often not incorporated into mainstream apps. Similarly, emotion recognition features, which could provide tailored interventions based on real-time emotional analysis, are still rare in ASD apps.

4. **Limited Accessibility and Language Inclusivity:** Many of the popular ASD applications are limited by language barriers, with most apps available only in specific languages like English. This creates a significant challenge for non-English speaking families or regions with diverse linguistic needs. Furthermore, the design of many apps does not account for cultural differences or the specific needs of children from various backgrounds.

5. **Narrow Focus:** Existing applications often focus on one aspect of ASD, such as language development, social skills, or emotional regulation, but fail to offer a holistic approach. Many apps lack a comprehensive set of tools that address multiple developmental areas, including communication,

sensory processing, cognitive development, and social skills. Furthermore, few apps integrate features that support parents, caregivers, or educators in tracking and analyzing the child's progress over time.

6. **User Engagement and Retention:** While many apps provide educational content or activities for children with ASD, they often struggle to maintain user engagement over time. This can be due to the lack of interactive elements, the monotony of exercises, or the inability to adapt to the child's evolving needs. Without sustained engagement, the potential benefits of these apps may be limited.
7. **Caregiver Involvement:** Most current ASD applications require active involvement from caregivers, which can be challenging, particularly during stressful situations or when the caregiver has limited time or resources. This dependency limits the app's effectiveness and reduces its practicality in daily use.

While current systems provide valuable tools for children with ASD, their limitations in personalization, emotional support, technology integration, language inclusivity, and holistic development make it clear that there is a need for more comprehensive and adaptive solutions. Addressing these limitations is critical to improving the effectiveness of interventions and enhancing the quality of life for children with ASD.

1.4 Problem solution and Methodology

1.4.1 Problem solution

This project addresses the critical need for personalized emotional and developmental support for children with Autism Spectrum Disorder (ASD) by leveraging advanced emotion recognition technology. The proposed application utilizes a camera to capture images of the child and applies MobileNetV3, a highly efficient and lightweight convolutional neural network, to analyze and determine their emotional state, such as happiness, anger,

sadness, or surprise. Based on the detected emotion, the application provides tailored interventions, including interactive educational and recreational games, emotionally aligned media, and therapeutic exercises designed to enhance the child's cognitive, emotional, and physical well-being.

The key components of the proposed solution are as follows:

1. **Personalized Learning and Intervention:** Unlike existing applications that offer generic content, the proposed system will utilize real-time data from the child's interactions to tailor activities, difficulty levels, and interventions to meet their specific needs. By incorporating adaptive learning algorithms, the system will adjust in real-time based on the child's emotional and cognitive state, offering personalized support that is more engaging and effective.
2. **Emotion Recognition for Real-Time Support**: The system will integrate emotion recognition technology that can detect a child's emotional state using facial expressions, voice tone, and physiological indicators. This allows the system to provide immediate, context-sensitive interventions during moments of emotional distress or behavioral challenges. For example, if a child is experiencing frustration or anxiety, the system will offer calming activities, soothing sounds, or even notify caregivers for timely assistance.
3. **Machine Learning and XAI for Diagnostic and Predictive Support:** The use of machine learning algorithms will enable the system to learn from the child's behavior over time, identifying patterns in their emotional and developmental progress. Additionally, Explainable Artificial Intelligence (XAI) techniques will be implemented to make the system's decision-making process more transparent to caregivers and educators, helping them better understand the factors influencing the system's recommendations and interventions. This transparency will build trust in the system and allow for more informed decisions regarding intervention strategies.

4. **Holistic Development Approach:** The solution will address multiple areas of development, including communication, social skills, emotional regulation, cognitive skills, and behavioral management. By providing a wide range of activities—such as language learning, social interaction exercises, emotional recognition games, and cognitive training—the system will support comprehensive growth. The app will also offer features that allow caregivers to monitor progress, track improvements, and receive periodic reports on the child's development.
5. **Multi-Language and Cultural Inclusivity:** To overcome the limitations of language barriers, the system will support multiple languages, with a focus on including Arabic and other widely spoken languages. Moreover, the design and content of the app will be culturally adaptable to meet the needs of children from various backgrounds, ensuring the system's accessibility and relevance across diverse populations.
6. **Engagement and Retention Through Interactive Features:** To maintain the child's interest and encourage sustained engagement, the system will incorporate interactive and dynamic elements such as gamified learning, rewards systems, and customizable avatars. These features will keep the child engaged in a fun and stimulating way, ensuring that the intervention remains motivating and effective over time.
7. **Caregiver Empowerment and Ease of Use:** The system will be designed to minimize caregiver involvement during stressful situations. The app will offer intuitive interfaces, automated interventions, and notifications that empower caregivers to provide support without being overly dependent on them. Additionally, the system will offer educational resources and training materials for caregivers to help them understand the child's progress and best practices for intervention.

By integrating MobileNetV3, which is known for its state-of-the-art performance and resource efficiency, this solution ensures that the system operates efficiently on mobile devices without compromising accuracy. MobileNetV3's lightweight architecture enables real-time emotion detection on

devices with limited hardware resources, ensuring immediate, actionable feedback.

This project also addresses a significant research gap in current technological solutions for ASD. While many existing tools focus on isolated aspects of support, such as basic learning activities or emotion detection, they fail to integrate real-time emotion recognition with tailored interventions in a lightweight and efficient manner. The proposed solution fills this gap by combining advanced machine learning with personalized content and progress tracking, enabling a more holistic approach to managing and supporting the emotional and developmental needs of children with ASD.

Ultimately, this project aspires to improve the quality of life for children with ASD by offering real-time, personalized interventions. It also aims to foster meaningful engagement for both the children and their caregivers, supporting emotional and developmental growth while ensuring that the child's needs are met through an innovative and efficient system.

1.4.2 Methodology:

The methodology of the "Rafeeq" mobile application is based on a comprehensive, user-centered approach that combines cutting-edge emotion recognition technology with personalized interventions to enhance the development and well-being of children with Autism Spectrum Disorder (ASD). By integrating machine learning, emotion detection, and expert-driven content customization, the app provides real-time, dynamic support that meets the specific needs of each child. Below are the key components of the methodology:

1. **Emotion Recognition**

The core of "Rafeeq" is the emotion recognition system, powered by MobileNetV3, a lightweight convolutional neural network (CNN). The system

uses the camera to capture facial expressions, which are processed to detect the child's emotional state. Emotions such as happiness, sadness, anger, surprise, and more are analyzed in real-time, allowing the app to personalize the content delivered to the child.

The emotion recognition system ensures that the child receives appropriate interventions based on their current emotional state, creating a more responsive and supportive environment. The following emotional states are identified by the system:

- **Neutral:** Calm and stable emotional state.
- **Happy:** Joyful and content mood.
- **Angry:** Frustrated or upset emotional state.
- **Sad:** Low or down emotional state.
- **Fear:** Anxious or scared feelings.
- **Surprise:** Excited or shocked state.
- **Disgust:** Sensory sensitivity or aversion.
- **Contempt:** Negative or dismissive attitude.

2. Personalized Content Delivery

Based on the detected emotional state, the "Rafeeq" app delivers personalized content that helps the child engage in emotional regulation, learning, and social interaction. The content is designed to meet the child’s specific needs and adapt dynamically as the emotional state changes. This content includes:

Games: Interactive, educational games that are personalized to the child’s emotional and developmental needs. The games target social skills, communication, problem-solving, and emotional regulation. The following Table.1 outlines the interactive educational games that are personalized according to the child’s emotional state, as detected by the "Rafeeq" app. Each game is designed to address key developmental areas such as social skills, communication, problem-solving, and emotional regulation. The games are

selected based on the child's current emotional state to help foster a positive, supportive, and engaging learning environment.

Table 1: Personalized Content Delivery - Games

Emotional States	Explanation
Neutral:	Structured games like puzzles, sorting, or tracing exercises to maintain focus and calmness.
Happy:	Interactive games such as matching, sequencing, or rhythm-based activities to enhance joy and engagement.
Angry:	Calming games like guided breathing, virtual yoga, or emotion recognition activities to help manage frustration.
Sad:	Creative games like drawing or storytelling with positive narratives to provide comfort and uplift mood.
Fear:	Familiar and repetitive games to create a sense of security and reduce anxiety.
Surprise:	Exploratory games like scavenger hunts or adventure quests to channel excitement in a controlled way.
Disgust:	Educational games about hygiene or interactive simulations to explore different textures safely.
Contempt:	Cooperative games that encourage teamwork, empathy, and social interaction.

Videos: Calming or educational videos are selected to promote learning, social interaction, and emotional regulation. The following Table.2 outlines the interactive educational videos that are personalized according to the child's emotional state. Each video is designed to address key developmental areas such as social skills, communication, problem-solving, and emotional regulation. The videos are selected based on the child's current emotional state to help foster a positive, supportive, and engaging learning environment.

Table 2: Personalized Content Delivery - Videos

Emotional States	explanation
Neutral:	Educational videos, calming visuals, or simple storytelling to maintain focus and calmness.
Happy:	Upbeat videos with fun songs, playful characters, or energetic storylines to boost joy and engagement.
Angry:	Calming videos with breathing exercises, guided meditation, or emotion regulation strategies to reduce anger.
Sad:	Uplifting videos with positive narratives or heartwarming stories to provide comfort and lift the mood.
Fear:	Familiar videos with repetitive routines or characters overcoming fears to provide security and reduce anxiety
Surprise:	Adventure-themed videos or discovery-based content to channel excitement and curiosity in a controlled way.
Disgust:	Educational videos about hygiene or sensory exploration to help understand and reduce aversions to different sensations.
Contempt:	Videos emphasizing empathy, teamwork, and social interaction to encourage positive social behavior.

Music: A curated selection of calming and mood-enhancing music is integrated into the app, tailored to the child's emotional state, preferences, and insights from the parent's survey and the Autism Behavior Specialist's report. The primary objective of this music is to help children relax, focus, and manage their emotions, supporting their emotional regulation throughout the day.

The following table outlines the selection of music that is personalized according to the child's emotional state. Each piece of music is carefully chosen to support key developmental areas such as social skills, communication, problem-solving, and emotional regulation. The music is specifically designed to address the child's current emotional state, promoting a positive, supportive, and engaging learning environment.

Table 3: Personalized Content Delivery - Music

Emotional States	explanation
Neutral:	Calm instrumental music or nature sounds (e.g., rain, ocean waves) to support relaxation and focus
Happy:	Upbeat, cheerful songs with lively tempos that encourage movement, clapping, or dancing.
Angry:	Soothing music with soft, steady rhythms to help calm heightened emotions, such as mellow classical pieces.
Sad:	Gentle, uplifting tunes with positive lyrics to provide comfort and promote a positive outlook.
Fear:	Soft lullabies or repetitive melodies that create a sense of safety and security, reducing anxiety.
Surprise:	Dynamic music with changes in tempo or tone to reflect excitement, but not overwhelming.
Disgust:	Light-hearted or humorous educational songs about topics like cleanliness to shift focus.
Contempt:	Songs about friendship and teamwork to promote empathy, understanding, and social connection.

3. Parental and Specialist Involvement

The app empowers parents to actively participate in their child's development by filling out surveys and providing valuable information about their child's strengths, interests, and challenges. This data helps personalize the child's experience and ensures that interventions are relevant and effective. Key aspects of parental involvement include:

- **Survey Responses:** Parents answer a set of questions that provide insight into their child's communication abilities, social interactions, and behavioral traits. These surveys allow the app to better understand the child's needs. This survey is designed to help understand the child's individual characteristics and needs by identifying strengths, preferences, and areas that require attention. The responses will help customize the content and interventions provided by the app. The Table-4 below shows the questions included in the survey, with options for the parent to answer Yes, No, or Maybe.

Table 4: Survey Responses

Questions	Yes	No	Maybe
Does your child use verbal language to communicate?			
Does your child interact with peers and adults?			
Does your child have difficulty making eye contact ?			
Does your child exhibit repetitive behaviors?			
Does your child have a strong interest in specific topics (e.g., animals, cars, numbers, or technology)? Specify please.			
Can your child express their basic needs (e.g., hunger, thirst, or tiredness) independently?			
Does your child become upset when their routine changes?			
Is your child sensitive to loud noises or certain sounds?			
Does your child react strongly to bright lights?			
Does your child feel calm or comforted when they see an avatar or character that looks like them?			

- **Gallery Uploads:** Parents can upload meaningful images or videos of their child's favorite activities, calming environments, or moments of happiness. These personalized items help provide comfort and make the child feel more connected to the app. The Table-5 below shows the questions included in the survey, with options for the parent to answer Yes, No, or Maybe.

Table 5: Personalized Content Delivery - Gallery Uploads

Emotional States	explanation
Neutral:	Upload images of the child in familiar settings (e.g., home, school), or videos of calm activities like drawing, reading, or quiet play.
Happy:	Upload images of the child smiling, playing with family, or engaging in favorite activities. Videos of celebrations, fun games, or moments of laughter are also great.
Angry:	Upload images of calming environments (e.g., nature, peaceful settings) or videos with calming sounds like ocean waves, deep breathing exercises, or guided relaxation.
Sad:	Upload images of comforting spaces, such as the child with loved ones or favorite toys. Videos showing the child engaging in relaxing activities or happy moments with family can help.
Fear:	Upload images of familiar toys, rooms, or comforting routines. Videos of calming activities like gentle music, bedtime routines, or favorite cartoons can offer security.
Surprise:	Upload images of new experiences or adventures (e.g., new toys, trips, or first-time events). Videos of the child discovering something exciting or surprising will channel their excitement.
Disgust:	Upload images of sensory experiences in a safe environment, such as trying new foods or interacting with different textures. Videos can show the child exploring new sensations with support.
Contempt:	Upload images of social interactions, like playing with friends, family, or pets. Videos of cooperative games or moments where the child works together with others can encourage empathy.

Additionally, the app involves professionals such as Autism Behavior Specialists and teachers to ensure the child receives well-rounded support.

- Autism Behavior Specialists assess the child's behavioral patterns and collaborate with parents to create tailored strategies to help manage

meltdowns, repetitive behaviors, and other challenges. They provide expert advice and design custom interventions within the app.

- Teachers customize educational activities based on the child's emotional and developmental needs. They monitor progress and collaborate with specialists to refine the child's learning experience.

4. Real-time Notifications and Progress Reports

The "Rafeeq" app includes a robust notification system that ensures parents stay informed about their child's emotional state, activity progress, and upcoming interventions. Notifications are sent in real-time, alerting parents to updates on:

- The child's mood and emotional trends
- Completed activities and games
- Reminders for daily routines and activities

These notifications help parents stay actively engaged and provide a deeper understanding of their child's emotional and developmental progress. Moreover, the app generates weekly progress reports. These reports are generated by the child's teacher and summarize the child's performance across various developmental domains, such as: Emotional regulation, Social interactions, Communication, and Academic skills. These reports give parents an overview of the child's progress and highlight areas for improvement, enabling them to refine their support strategies and collaborate with specialists to enhance the child's development.

5. Continuous Improvement and Feedback Loop

"Rafeeq" is designed to evolve and improve over time based on the feedback and data collected. The app encourages an iterative approach to content and strategy development, where:

- Data from the app's usage (e.g., emotional states, activity completion) is analyzed to continuously refine content delivery.

- Feedback from parents, specialists, and teachers helps identify areas of improvement and enhance the app's features.
- The machine learning model continuously improves as more data is gathered, ensuring that interventions become more effective and personalized as the child's needs evolve.

1.4.3 Rafeeq Model

The "Rafeeq" app utilizes a Convolutional Neural Network (CNN) model, specifically MobileNet V3, to recognize and classify the emotional states of children with autism based on their facial expressions. The model works by analyzing facial images taken by parents or caregivers, then processes them to predict the child's emotional state (e.g., happy, sad, angry, surprised, etc.). Based on the predicted emotion, the app provides personalized recommendations to support the child's emotional regulation and development.

1. **Key Steps in the Rafeeq Model:**
    - **Face Detection:** Parents or caregivers take a photo of the child's face, which is analyzed by the system. Using MobileNet V3's capabilities, the system detects key facial features, such as the eyes, nose, and mouth, and aligns them to ensure proper facial recognition.
    - **Convolutional Layers:** These layers extract essential features from the image, such as edges, textures, and facial expressions. This process allows the model to understand the child's emotional state based on visual cues from their facial expressions.
    - **Pooling Layers:** Pooling layers help reduce the complexity of the data, ensuring that variations in facial expressions—such as different angles or lighting conditions—do not affect the accuracy of the emotion recognition process. This makes the model more robust.
    - **Classification:** Once the essential features are extracted, the system classifies the child's emotional state into one of the following categories: neutral, happy, angry, sad, fear, surprise, disgust, or

contempt. This classification is key to understanding the emotional state of the child.

- **Emotion-Based Recommendations:** Based on the detected emotion, the "Rafeeq" app provides tailored interventions. For example, if the child is angry, the app may recommend calming activities like guided breathing exercises. If the child is sad, the app may suggest creative activities like drawing or storytelling to help uplift their mood.

2. Datasets Used

For training and evaluating the CNN model, the following datasets will be used:

- Autistic Children Emotions - Dr. Fatma M. Talaat [11] : This dataset contains images of children with autism showing different facial expressions (like happy, sad, angry, etc.). It's specifically useful because it focuses on the emotional expressions of children with autism, who often show emotions differently than others.
- AffectNet [12]: AffectNet is a large dataset with over 1 million facial images showing a variety of emotions like happy, sad, angry, surprised, etc.
- FER-2013 [13]: FER-2013 is another well-known dataset with over **35,000** images of facial expressions labeled into seven categories (e.g., happy, sad, angry, surprise).

These datasets contain labeled images of facial expressions, which will help the model learn and classify emotions in children, particularly those with autism.

3. Model Evaluation

After training, the model is evaluated using a held-out test set, which consists of images the model has not seen during the training phase. The model's performance on image categorization tasks can be evaluated using several key metrics:

- Accuracy: This is the percentage of test images that the CNN correctly classifies.
- Precision: Precision measures the percentage of images predicted by the CNN to belong to a specific class, and that are actually of that class.
- Recall: Recall measures the percentage of actual images of a specific class that are correctly predicted by the CNN.
- F1 Score: The F1 score is the harmonic mean of precision and recall. It is particularly useful for evaluating the performance of a model in situations where classes are imbalanced, ensuring that the model maintains a balance between precision and recall.

These evaluation metrics will help us assess the performance and reliability of the emotion detection system in the "Rafeeq" app.

1.5 Project objectives

This project aims to address the critical need for personalized and effective emotional and developmental support for children with Autism Spectrum Disorder (ASD). By leveraging cutting-edge emotion recognition technology, the proposed system seeks to provide real-time, adaptive interventions tailored to the emotional and developmental state of each child. The objectives outlined below detail the key features and capabilities of the system:

1. **Personalized Learning and Intervention:** The system will adjust activities, difficulty levels, and interventions based on the child's emotional and developmental state, ensuring that the support is tailored to meet their specific needs.
2. **Emotion Recognition for Real-Time Support:** By utilizing emotion recognition technology, the system will detect the child's emotional state (such as happiness, sadness, or frustration) and provide immediate, context-sensitive interventions, helping to manage emotional distress or behavioral challenges effectively.

3. **Machine Learning and Explainable AI (XAI) Integration**: The system will utilize machine learning algorithms to track the child's progress over time, with XAI techniques offering transparency into the system's decision-making process to help caregivers understand the rationale behind the recommended interventions.
4. **Holistic Development Approach:** The system will support various aspects of the child's development, including communication, social skills, emotional regulation, and cognitive skills, offering a comprehensive set of activities and exercises to foster well-rounded growth.
5. **Multi-Language and Cultural Inclusivity:** To ensure accessibility, the system will support multiple languages, with a focus on Arabic, and will be adaptable to accommodate different cultural backgrounds, making it relevant and effective for diverse populations.
6. **Engagement and Retention Through Interactive Features:** The system will include gamified learning, customizable avatars, and reward systems to keep children engaged and motivated, ensuring sustained interest and participation in the interventions.
7. **Caregiver Empowerment and Easy-to-Use Interface:** The system will provide intuitive interfaces and automated features that reduce caregiver involvement during stressful situations, while also offering detailed, easy-to-understand reports on the child's emotional trends and developmental progress.

By addressing these objectives, this project aims to significantly improve the quality of life for children with ASD, enhancing their emotional and developmental progress while empowering caregivers with the tools they need to support and track the child's journey.

1.6 Technology and tools used

This project integrates a variety of advanced technologies and tools to deliver an effective and personalized solution for children with Autism Spectrum

Disorder (ASD). The core technologies utilized in the development of the application include Flutter, Firebase, Application Programming Interfaces (APIs), and Machine Learning with Python. Below is a detailed explanation of each technology and how it contributes to the project's functionality.

1. **Flutter with Dart:**
    - Flutter is an open-source UI framework developed by Google for building natively compiled applications for mobile, web, and desktop. For this project, Flutter will be used to build the mobile application that serves children with ASD by delivering interactive and engaging interventions.
    - Dart is the programming language used alongside Flutter. It is well-suited for building high-performance, fast applications with smooth user interfaces. This is critical for creating an intuitive and child-friendly app that engages users and provides a seamless experience.
2. **Firebase:**
    - Firebase is a cloud-based platform that offers various services for app development, including real-time database management, user authentication, and cloud storage. For this project, Firebase will be used to handle the back-end processes.
    - Firebase Realtime Database will store and sync data, such as user profiles, emotional trends, and activity schedules, in real time. This ensures that caregivers can access up-to-date information about the child’s progress and interventions.
    - Firebase Authentication will enable secure login for users (parents and caregivers), ensuring privacy and safety of the data.
    - Firebase Cloud Functions will be used to automate tasks such as sending notifications about activity schedules and emotional progress, keeping caregivers informed without requiring manual input.

3. Application Programming Interfaces (APIs):

Various APIs will be integrated into the system to enhance its functionality and support dynamic content delivery. For example:

- Emotion Recognition API will provide the capability to detect a child's emotional state through facial expressions captured by the camera. This will allow the system to offer tailored interventions in real time.
- Push Notification APIs will enable the application to send alerts to caregivers regarding important updates, such as activity reminders or emotional trends, thus enhancing caregiver engagement.

4. Machine Learning with Python and MobileNetV3:

- Python is the primary programming language used for implementing machine learning algorithms. Python's rich set of libraries and frameworks makes it an ideal choice for processing and analyzing the data.
- MobileNetV3 is a lightweight and highly efficient convolutional neural network (CNN) model, which will be used for emotion recognition. It will analyze images from the child's camera feed to determine their emotional state (e.g., happiness, sadness, anger, surprise, etc.).
- TensorFlow is the library that will be used to implement the MobileNetV3 model. TensorFlow provides tools for building, training, and deploying machine learning models, ensuring accurate and real-time emotion recognition.
- OpenCV (Open Source Computer Vision Library) will be used for image pre-processing and facial feature extraction, enabling the system to analyze and interpret the child's facial expressions and other indicators of emotional states.

By combining these technologies, the project aims to create an application that delivers personalized and real-time interventions for children with ASD. The integration of Flutter ensures an engaging and user-friendly interface, while

Firebase handles data management and real-time synchronization. The use of APIs extends the functionality, and Python with MobileNetV3 ensures efficient and accurate emotion recognition, allowing the system to offer customized, context-sensitive interventions.

1.7 Project plan for GP2 (Gantt chart, PERT chart)

The following section outlines the project plan for the second phase (GP2), which includes the detailed breakdown of tasks, milestones, and timelines. To visualize and manage the project efficiently, the Gantt Chart and PERT Chart will be used as primary tools for scheduling, resource allocation, and tracking the project's progress.

Gantt Chart

The Gantt chart below Fig.1 provides a timeline view of the tasks and their respective deadlines. It serves as a roadmap for the project, outlining the sequential and overlapping activities necessary to achieve the objectives by May 15, 2025.

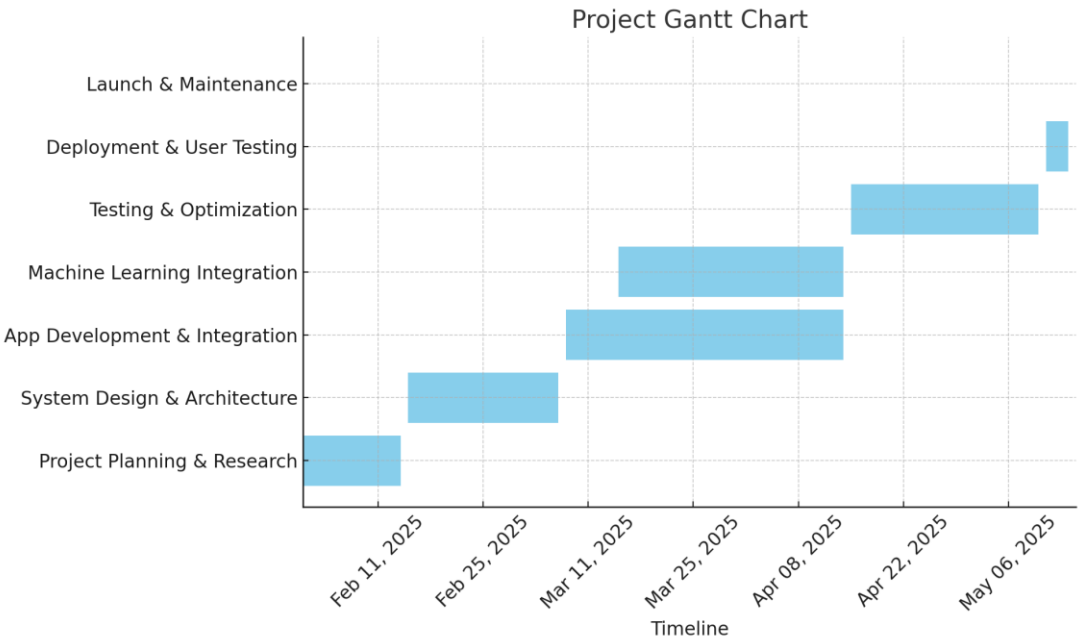

Figure 1: Project Gantt Chart

Chapter 2: Requirements and Analysis

2.1 Software Process Model

The project follows the Spiral Development Model, selected for its iterative and evolving approach, which is particularly beneficial for addressing the complex and evolving needs of children with Autism Spectrum Disorder (ASD). The model allows for the incorporation of feedback at every stage, ensuring the application remains aligned with user needs and continually improves in terms of usability, accuracy, and functionality.

Each cycle within the Spiral Development Model includes the following stages:

Planning:

The planning phase focuses on defining the application's requirements, drawing from various stakeholders, including parents, teachers, caregivers, and specialists in the field of autism. Key goals during this phase include understanding the unique needs of children with ASD and determining the best methods for integrating advanced emotion recognition technology. The requirements gathered in this phase will guide the design and development of the application's core features, such as real-time emotion detection and personalized interventions.

Risk Analysis:

In this phase, the project team identifies and mitigates potential risks. For a project like this, key concerns include ensuring the usability of the application for children with autism, who may have diverse cognitive and emotional responses. There is also a significant focus on data privacy and security, especially considering the sensitive nature of data related to children's emotional states. Addressing these challenges early in the process helps ensure the application remains both effective and secure.

Development and Prototyping:

This phase involves building the core features of the application, including the emotion recognition system powered by MobileNetV3, and the development of personalized activities and interventions. MobileNetV3 is integrated to analyze the child's emotional state based on real-time image input from the camera, determining if the child is happy, sad, angry, or surprised. Once the emotion is detected, the application tailor's interventions, such as personalized educational games, therapeutic exercises, and emotionally aligned media. Prototypes will be tested, and feedback will be gathered to refine and improve these features through each iteration. This phase ensures that the application remains lightweight and responsive, catering to the child's emotional needs efficiently.

Testing and Evaluation:

Once the prototype is developed, it undergoes rigorous testing with real users, including children with ASD, their parents, and caregivers. User feedback is collected during this phase to evaluate the effectiveness of the emotion detection and personalized interventions. Key evaluation criteria include the accuracy of emotion recognition, the appropriateness of suggested activities, the application's ease of use, and its overall impact on the child's development. Periodic evaluations will provide insights into the child's emotional trends and developmental progress. The testing phase helps identify any gaps or improvements needed, leading to a more refined application in subsequent iterations. Additionally, the results from this phase will inform future updates to the application, ensuring it remains relevant and beneficial to users.

By adopting this model, the project ensures continuous improvement of the application, allowing it to evolve based on real-world usage and feedback. The integration of MobileNetV3 and tailored interventions offers a comprehensive solution to the current gap in ASD technological support, aiming to enhance the quality of life for children with ASD while providing caregivers with the tools to monitor and improve emotional and developmental progress.

2.2 System scope with explanation

This project focuses on developing a mobile application to support children with Autism Spectrum Disorder (ASD) by providing personalized interventions

based on real-time emotion recognition. The app will enhance emotional regulation, cognitive development, and social interaction, while facilitating collaboration between parents, teachers, and specialists. The following outlines the key elements of the project scope:

1. Goals and Deliverables:

The main goal of the project is to create a mobile application that will:

- Support Emotional Regulation: By using emotion detection, the app will help children with ASD recognize and manage their emotions.
- Provide Personalized Activities: Activities such as games, music, and videos will be tailored based on the child's emotional state and developmental needs.
- Enable Parental Involvement: Parents will be empowered with tools to monitor their child's emotional states and progress, providing a clearer view of their development.
- Foster Collaboration Among Stakeholders: Teachers and specialists will collaborate to provide tailored learning and behavioral strategies for each child.

2. Features and Functions:

- Emotion Detection: The application will use facial recognition technology to assess the child's emotional state (e.g., happy, sad, angry, neutral) in real time. This will serve as the basis for delivering activities tailored to the child's emotional needs at any given moment.
- Personalized Content: Based on the detected emotional state and the child's developmental stage, the app will offer dynamic content, including:

  Games: Educational games designed to support emotional and cognitive development.

  Music: Emotionally aligned music to soothe or engage the child.

Videos: Short, tailored videos that reflect the child's emotional state and learning needs. Machine learning algorithms will personalize these content recommendations and continuously adapt to the child's preferences and progress.

- **Static Gallery:** Parents will have the ability to upload personalized content, such as images, videos, and audio clips, that are meaningful and comforting to the child. This feature enables a customized experience that can help the child feel more secure and engaged.
- Parental Tools: The application will provide a comprehensive set of tools for parents:

  Child Profile Survey: Allows parents to input their child's preferences and needs.

  Real-time Notifications: Parents will receive alerts based on the child's emotional state, helping them stay informed about their child's well-being.

  Weekly Progress Reports: The app will generate reports, based on input from teachers and specialists, that track the child's emotional trends, cognitive progress, and behavioral development. These reports will be visualized through easy-to-read charts, helping parents monitor the child's progress over time.

- **Specialist Support:** Teachers and Autism Behavior Specialists will be integrated into the app, allowing them to provide personalized learning and behavioral strategies. These interventions will be tailored to the child's unique needs, and specialists will be able to track the child's progress and adjust strategies as necessary. This feature will ensure a collaborative approach to the child's development, ensuring consistency in care and learning.

3. **Tasks and Deadlines:**

The project will be carried out in phases, with each phase focusing on specific goals and deliverables. The following phases will guide the development:

Phase 1: Requirement Analysis and Planning (1 month)

- Gather input from parents, teachers, and specialists.
- Define the emotional states to be detected and outline the structure of personalized content.
- Prepare the child profiling survey and tools for parental involvement.

Phase 2: Development of Emotion Detection and Machine Learning Algorithms (2 months)

- Implement facial recognition technology for emotion detection.
- Develop machine learning algorithms for personalized content recommendations.
- Integrate emotion detection with content delivery systems.

Phase 3: User Interface and Experience Design (2 months)

- Design a user-friendly interface for children, parents, and specialists.
- Create engaging and age-appropriate activities and content.
- Ensure the interface is accessible and suitable for children with ASD.

Phase 4: Specialist Collaboration and Integration (1 month)

- Work with teachers and Autism Behavior Specialists to integrate personalized learning and behavioral strategies.
- Implement feedback mechanisms for specialists to adjust strategies based on the child's progress.

Phase 5: Testing, Refinement, and Launch (2 months)

- Conduct testing with users (children, parents, and specialists).
- Refine the app based on feedback.

- Prepare for the official launch of the app.

4. Costs

The costs of the project will include the following key components:

Emotion Detection Technology: The costs of implementing facial recognition technology and training machine learning models for emotion detection and personalized content.

Content Development: The costs associated with creating personalized games, music, and videos that are tailored to the emotional states and developmental needs of children with ASD.

Software Development: Costs for developing the app's user interface, integrating features for parental involvement, and building the backend infrastructure to support real-time notifications, progress reports, and specialist collaboration.

Testing and Quality Assurance: Expenses related to user testing, collecting feedback from parents, children, and specialists, and refining the app to meet the requirements.

Deployment and Maintenance: Costs associated with launching the app on mobile platforms, as well as ongoing maintenance and updates to improve functionality and add new features.

2.3 List of Functional Requirements and Non-Functional Requirements

Functional and non-functional requirements are essential for defining the expected behaviors, capabilities, and constraints of the system. Functional requirements specify what the system must do, while non-functional requirements address how well the system must perform under certain conditions.

1. **Functional Requirements:**

- **Emotion Recognition:** The app shall utilize facial recognition technology and machine learning algorithms to accurately detect and analyze the child's emotional state, such as happiness, sadness, anger, or neutrality. This real-time analysis will guide the delivery of personalized interventions and activities based on the child's current emotional state.
- **Content Personalization:** The app shall provide personalized content, including games, music, and videos, tailored to the child's emotional state, developmental needs, and preferences. These preferences will be identified through an initial survey, ongoing feedback, and reports provided by specialists and parents. The app shall continuously adapt to the child's evolving needs over time.
- **Static Gallery:** Parents shall be able to upload personalized content, such as images, videos, and audio files, to a dedicated gallery within the app. This content will be accessible to the child through a specific gallery tab and can be used to provide emotional comfort or engage the child in therapeutic activities.
- **Specialist Collaboration:** Teachers and Autism Behavior Specialists shall be able to provide customized learning modules, behavioral strategies, and support through the app. These interventions will be integrated into the child's daily activities, ensuring that the child's educational and emotional needs are being met consistently. The system shall allow specialists to track the child's progress and adjust strategies accordingly.
- **Parental Tools:** The app shall offer the following tools to parents for better monitoring and support of the child's development:
- **Surveys:** A tool to collect information about the child's preferences, behavioral patterns, and learning needs, which will inform personalized content recommendations.

- **Real-time Notifications:** The system shall notify parents about the child's emotional state in real-time and provide alerts when new activities are available or progress milestones are reached.
- **Weekly Progress Reports:** The app shall generate weekly progress reports, including insights from teachers and specialists. These reports will highlight the child's emotional trends, developmental progress, and areas requiring attention. Reports will be visualized in an accessible chart format for easy interpretation.

2. **Non-Functional Requirements:**

- **Performance:** The system must be able to process and deliver personalized content (games, videos, music) in real-time with minimal latency. The emotion recognition and content delivery must operate smoothly without delays to ensure the child's emotional needs are addressed immediately.
- Usability: The app shall be designed with a user-friendly interface that ensures ease of navigation, especially for children with ASD. The interface should be intuitive and simple, with large icons, minimal text, and clear visual cues to help children navigate independently or with minimal guidance.
- **Reliability:** The app must provide consistent, reliable performance. This includes delivering accurate emotion detection and personalized content recommendations, ensuring that the system remains operational without frequent crashes or technical issues.
- **Scalability**: The app should be scalable to handle a growing user base, with the capacity to support multiple users (children, parents, and specialists) simultaneously. The system must maintain high performance even as the number of users increases, ensuring a seamless experience for all.
- **Security:** The app must adhere to the highest standards of data privacy and security. This includes encrypting sensitive information such as

emotional analysis data, personal content uploaded by parents, and any other personal data. The app shall comply with relevant privacy laws and regulations, such as GDPR or COPPA, to protect the privacy and security of the child's data.

- **Accessibility:** The app shall meet accessibility standards to accommodate children with varying levels of ability and sensory preferences. This includes providing features like adjustable text size, color contrast settings, voice commands, and other sensory-friendly options to support children with different disabilities.
- **Maintainability:** The system must be designed to allow for easy updates, bug fixes, and enhancements. The app should be maintainable and flexible to accommodate changes based on user feedback, new feature requests, or improvements in technology.
- **Compatibility:** The app should be compatible across a range of devices and operating systems, including but not limited to iOS and Android platforms. It should function smoothly on both smartphones and tablets, with responsive design to adjust to various screen sizes.

2.4 Use Case Diagram with Use Cases descriptions

The mobile application designed for children with Autism Spectrum Disorder (ASD) aims to provide a personalized and adaptive environment that supports emotional regulation, learning, and social interaction. Through the use of facial recognition and machine learning algorithms, the application detects the child's emotional state (e.g., happy, sad, angry, neutral) and dynamically adapts content such as games, videos, and music to meet their specific needs.

Parents, teachers, and Autism Behavior Specialists work together to ensure the app provides comprehensive support. Parents play a vital role by completing surveys to profile their child's preferences, uploading meaningful content for the child, and receiving notifications and weekly progress reports. If necessary,

parents can also request additional support from teachers or specialists. Teachers and specialists customize educational activities and behavioral strategies to enhance the child's development.

The system uses machine learning to automate emotional analysis and content recommendations, ensuring real-time personalization. The notification system provides parents with updates on their child's emotional states and daily activities. This collaborative and dynamic approach ensures that the app effectively addresses the developmental, emotional, and social needs of children with ASD, fostering a seamless and impactful support system.

The use case diagram illustrates the interactions between the key actors—child, parents, teachers, specialists, and the system. It outlines how each actor engages with the system's core functionalities, such as detecting emotions, delivering personalized content (games, music, videos), and tracking progress. The diagram visually represents the flow of actions and relationships between users and the system, emphasizing how personalized interventions and collaborative efforts contribute to the child's emotional and developmental support.

Use Case Descriptions

1. **Emotion Recognition**

- Description: The system uses facial recognition and machine learning algorithms to detect the child's emotional state in real-time. This triggers the system to provide personalized content, such as games, music, or videos, based on the detected emotion.
- Actors Involved: Child, System
- Outcome: The system accurately identifies the child's emotional state and delivers appropriate content to address their emotional needs.

2. **Personalized Content Delivery**

- Description: Based on the child's emotional state and preferences, the system delivers tailored content (games, music, videos) to support emotional regulation and cognitive development.
- Actors Involved: Child, System
- Outcome: The child engages with content that is dynamically adjusted to their emotional state and developmental needs.

3. **Survey Completion**

- Description: Parents complete surveys to profile their child's preferences, behavior, and developmental needs. This data is used to customize the app's content recommendations.
- Actors Involved: Parents, System
- Outcome: The system collects important data to personalize the content and activities for the child.

4. **Upload Personalized Content**

- Description: Parents upload photos, videos, and other meaningful content to the child's personalized gallery, which can be accessed through the app.
- Actors Involved: Parents, System
- Outcome: The child can view personalized content that provides emotional comfort or engagement.

5. **Receive Notifications**

- Description: The notification system sends real-time alerts to parents about the child's emotional state, progress, and activities.

- Actors Involved: Parents, Notification System
- Outcome: Parents stay informed and are alerted to key events, such as progress reports or the need to engage in specific activities.

6. Request Specialist Support

- Description: Parents can request support from teachers or Autism Behavior Specialists if they need additional assistance with the child's development.
- Actors Involved: Parents, Teachers, Autism Behavior Specialists
- Outcome: Parents receive expert advice or interventions that are tailored to the child's needs.

7. Tailor Educational Activities

- Description: Teachers customize learning activities based on the child's progress and emotional state, ensuring that the activities are appropriate for the child's developmental level.
- Actors Involved: Teachers, System
- Outcome: The child engages in learning activities that align with their emotional and cognitive abilities.

8. Monitor Child's Development

- Description: Teachers and specialists monitor the child's development, using data from the app and feedback from parents to adjust learning strategies and behavioral interventions.
- Actors Involved: Teachers, System
- Outcome: Teachers and specialists can make informed decisions about the child's development and tailor activities accordingly.

9. Provide Behavioral Strategies

- Description: Autism Behavior Specialists offer customized strategies to address specific behavioral challenges, which are then integrated into the app's functionality.
- Actors Involved: Autism Behavior Specialists, System
- Outcome: The child receives personalized behavioral strategies that are aimed at improving emotional regulation and behavior.

10. Generate Progress Reports

- Description: The system generates periodic progress reports detailing the child's emotional states, activities, and developmental milestones.
- Actors Involved: Parents, Teachers, System
- Outcome: Parents receive comprehensive reports that provide insights into the child's emotional and developmental progress.

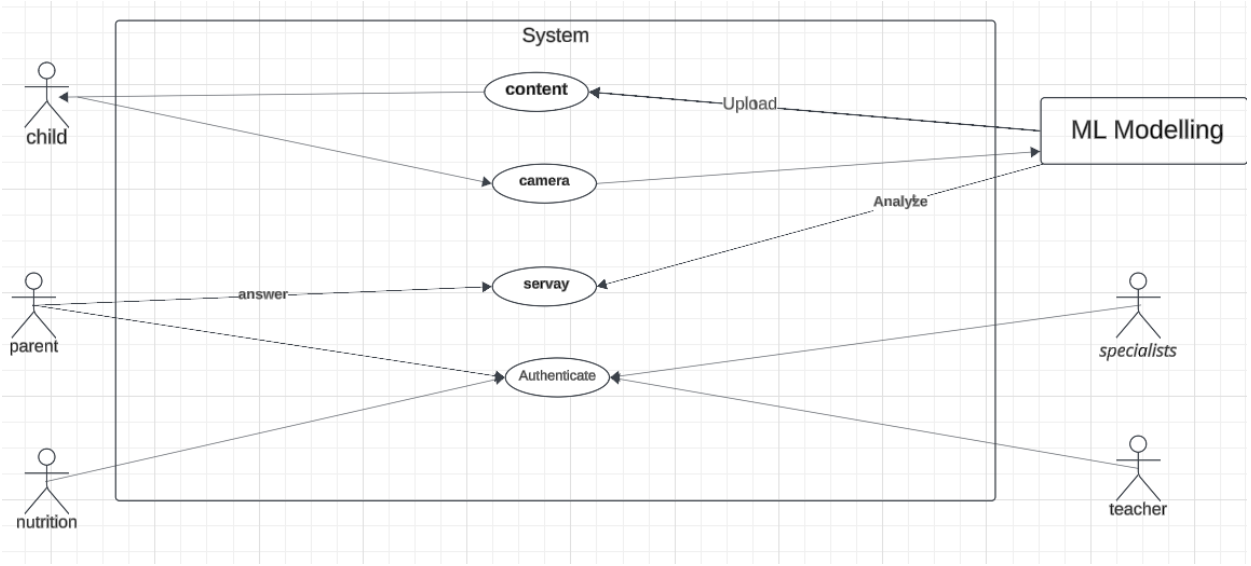

Figure 2-A: Project Use Case

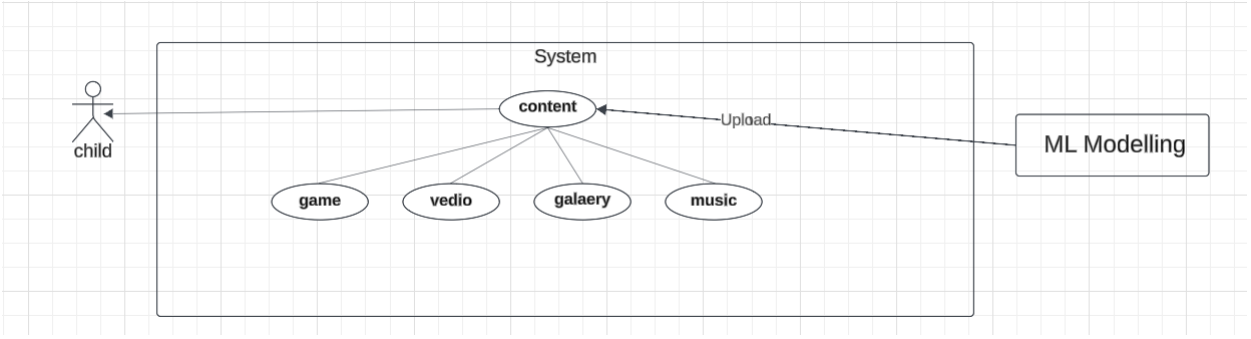

Figure 2-B: Project Use Case

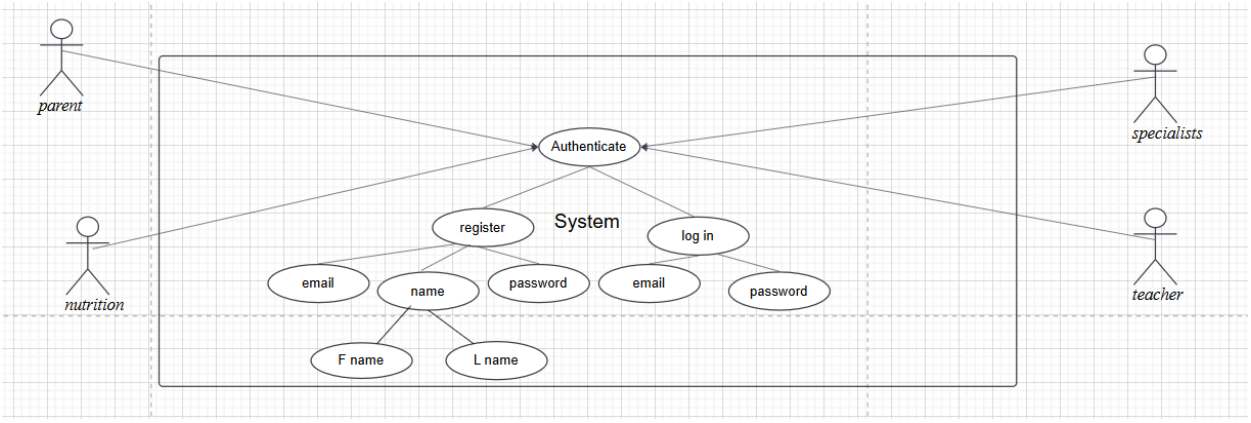

Figure 2-C: Project Use Case

Chapter 3: Design

3.1 Conceptual Class Diagram

The "Rafeeq" app is designed with a modular and object-oriented architecture. Below are the detailed components and relationships from the class diagram:.

1. **System**
   - Description: The central hub of the application, coordinating the interaction among its modules (e.g., nutrition, specialists, teacher).
   - Relationships: Acts as the parent class for the Nutrition, Specialists, and Teacher modules, enabling shared functionality across these components.
2. **Parent**
   - Attributes:
     - String parentID: A unique identifier for each parent user.
     - String name: The name of the parent.
   - Description: Represents the caregiver or guardian who supervises their child and interacts with the app on their behalf.
   - Relationships:
     - Aggregated with Child: A parent can manage one or more children.
     - Aggregated with Survey: Parents can provide input through surveys to complement emotion analysis.
3. **Child**
   - Attributes:
     - String name: The name of the child.
   - Methods:
     - uploadContent(): A method for uploading content (e.g., images or videos) for analysis by the app.
   - Description: Represents the child whose emotions and behaviors are analyzed and supported through the app.
   - Relationships:

- Aggregated with Parent: Each child is supervised by a parent or guardian.

4. **Camera**
   - Attributes:
     - faceID: A unique identifier for the detected face during emotion analysis.
     - Methods:
     - AnalyzeEmotion(): Captures images and analyzes emotions using the machine learning model.
   - Description: Handles image capture and processing for emotion detection.
   - Relationships:
     - Aggregated with Child: Captures the child's image for emotion analysis.
5. **ML Modeling**
   - Attributes:
     - AnalyzeEmotion: The function that classifies emotions using MobileNet V3.
     - UploadContent: Handles the input of training data for model updates.
   - Description: The core module for machine learning, responsible for emotion detection and analysis based on input images.
   - Relationships:
     - Aggregated with Camera: Processes data captured by the camera.
6. **Survey**
   - Attributes:
     - String question: Represents questions provided in the survey for parents to answer.
   - Description: A feature for collecting contextual information from parents about their child's emotional state or behavior.
   - Relationships:

- Aggregated with Parent: Parents can fill out surveys to provide insights into their child's emotions.

7. **Nutrition**
   - Attributes:
     - String nutritionID: A unique identifier for nutrition-related advice or modules.
   - Description: Provides tailored nutritional advice or guidance for children based on their emotional or physical needs.
   - Relationships:
     - Inherits from System: Represents a module of the system.
8. **Specialists**
   - Attributes:
     - String specialistsID: A unique identifier for specialists (e.g., therapists or counselors) involved in the app.
   - Description: Represents experts available through the app to provide professional advice and support to parents and children.
   - Relationships:
     - Inherits from System: Represents a module of the system.
9. **Teacher**
   - Attributes:
     - String teacherID: A unique identifier for teachers or educational advisors in the app.
   - Description: Provides educational content and guidance tailored to the child's needs.
   - Relationships:
     - Inherits from System: Represents a module of the system.

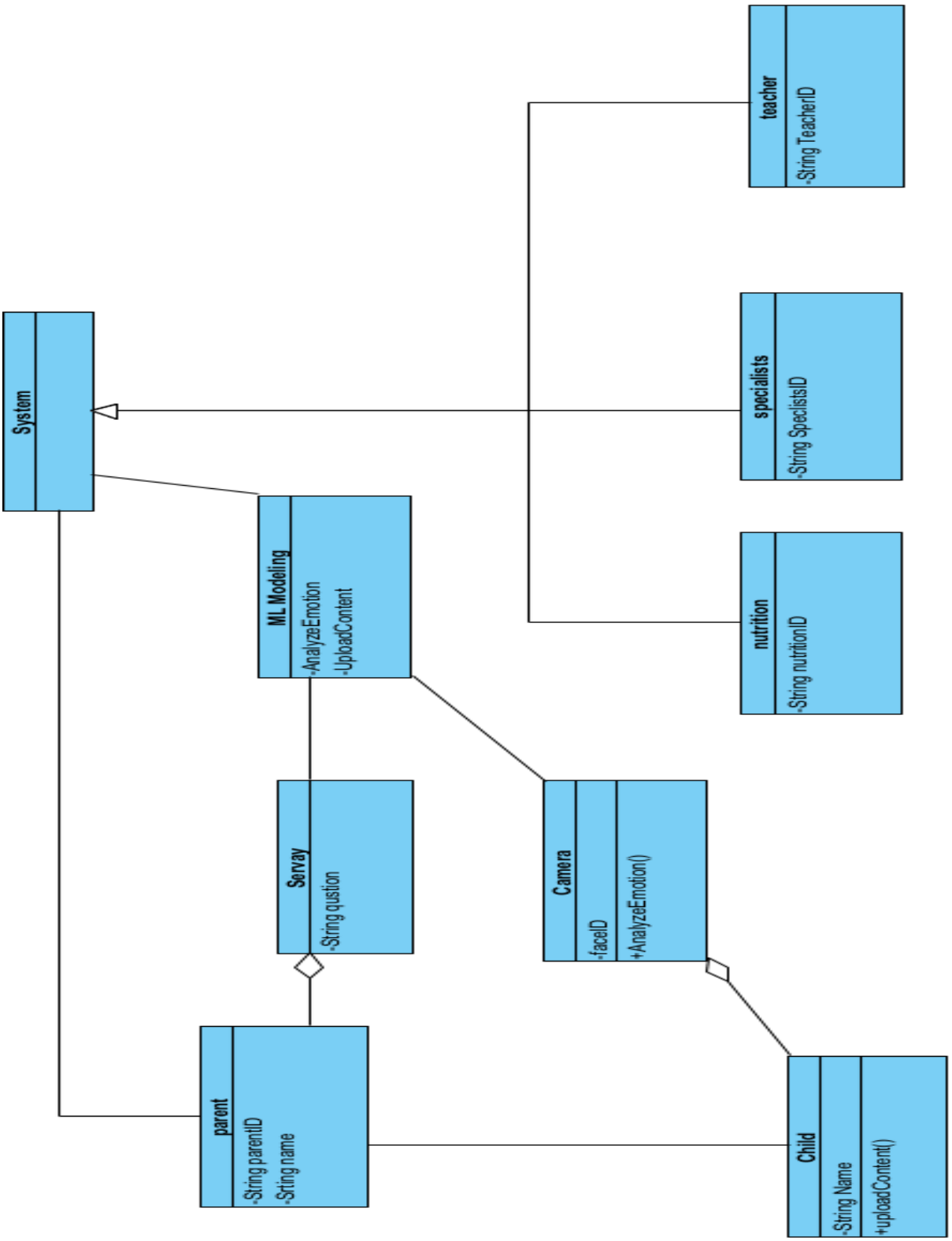

Figure 3: Project Conceptual Class Diagram

2.5 Provisional Database ER Diagram

The system design for the "Rafeeq" application illustrates the relationships between its core components and their interactions. This modular structure ensures that the application effectively meets its objective of recognizing and addressing the emotional and behavioral needs of children with autism.

1. **Main Components**
   - System: The central component that manages all interactions between users and functionalities. It connects various modules, ensuring seamless communication and operation.
   - **Parent:**
     - Role: The primary caregiver who manages the child's activities within the application.
     - Features:
       - Log In: Securely access the application.
       - Email: Used for authentication and communication.
       - Password: Ensures account security.
       - Responsible for uploading content, requesting analyses, and monitoring the child's progress.
   - **Child**
     - Role: Represents the child whose emotions and behaviors are monitored and analyzed.
     - The parent oversees the child's activities and interactions with the system.
   - **Specialist**
     - Role: Professionals, such as therapists and psychologists, who provide support and guidance for the child.
     - Features:
       - Log In: Access the application securely.
       - Info: View or input detailed insights about the child's emotional or behavioral state.

- **Nutritionist**
  - Role: Focused on providing dietary recommendations and nutritional advice for the child.
  - Features:
    - Log In: Secure access to the system.
    - Info: Share or access nutrition-related data and insights.
- **Teacher**
  - Role: Educators who provide tailored educational content and track the child's learning progress.
  - Features:
    - Log In: Secure access to their module.
    - Info: Provide or retrieve child-specific educational material.
- **ML Modeling**
  - Role: Handles the application's core machine learning functionality, which includes emotion detection and data analysis.
  - Features:
    - Analyze: Processes data (e.g., facial expressions) to detect emotions.
    - Upload Data: Allows parents or specialists to contribute new data for improving the model's accuracy.
- **Camera**
  - Role: Captures facial expressions in real-time to analyze the child's emotional state.
  - Works closely with the ML Modeling module for emotion recognition.
- **Request**
  - Role: Manages all user-initiated requests, such as analysis requests, service queries, and consultation requests.
  - Acts as an intermediary between the system and the user.

2. **Key Features**
   - Login Functionality: Available for all primary users (parents, specialists, nutritionists, teachers) to ensure secure and role-based access.

- Role-Specific Information Management: Specialists, nutritionists, and teachers have dedicated modules to manage and view child-related data relevant to their expertise.

- Emotion Recognition: Powered by the ML Modeling and Camera modules, enabling real-time detection and analysis of the child's emotions.

- Parent-Centric Design: The parent plays a pivotal role in managing the child's profile, uploading data, and interacting with specialists, nutritionists, and teachers.

3. **Relationships and Data Flow**
   - **Parent ↔ System**
     Parents access the system to upload content, manage activities, and request analyses.
   - **Child ↔ System**
     The child interacts indirectly with the system through the parent or via features like the Camera and ML Modeling modules.
   - **Specialist, Nutritionist, Teacher ↔ System**
     These users interact with the system to provide tailored guidance or access relevant child-related data.
   - **ML Modeling ↔ Camera**
     The Camera captures real-time data, which is processed by the ML Modeling module for emotion analysis.
   - **Request ↔ System Components**
     Handles all actions initiated by users, ensuring efficient processing and response.

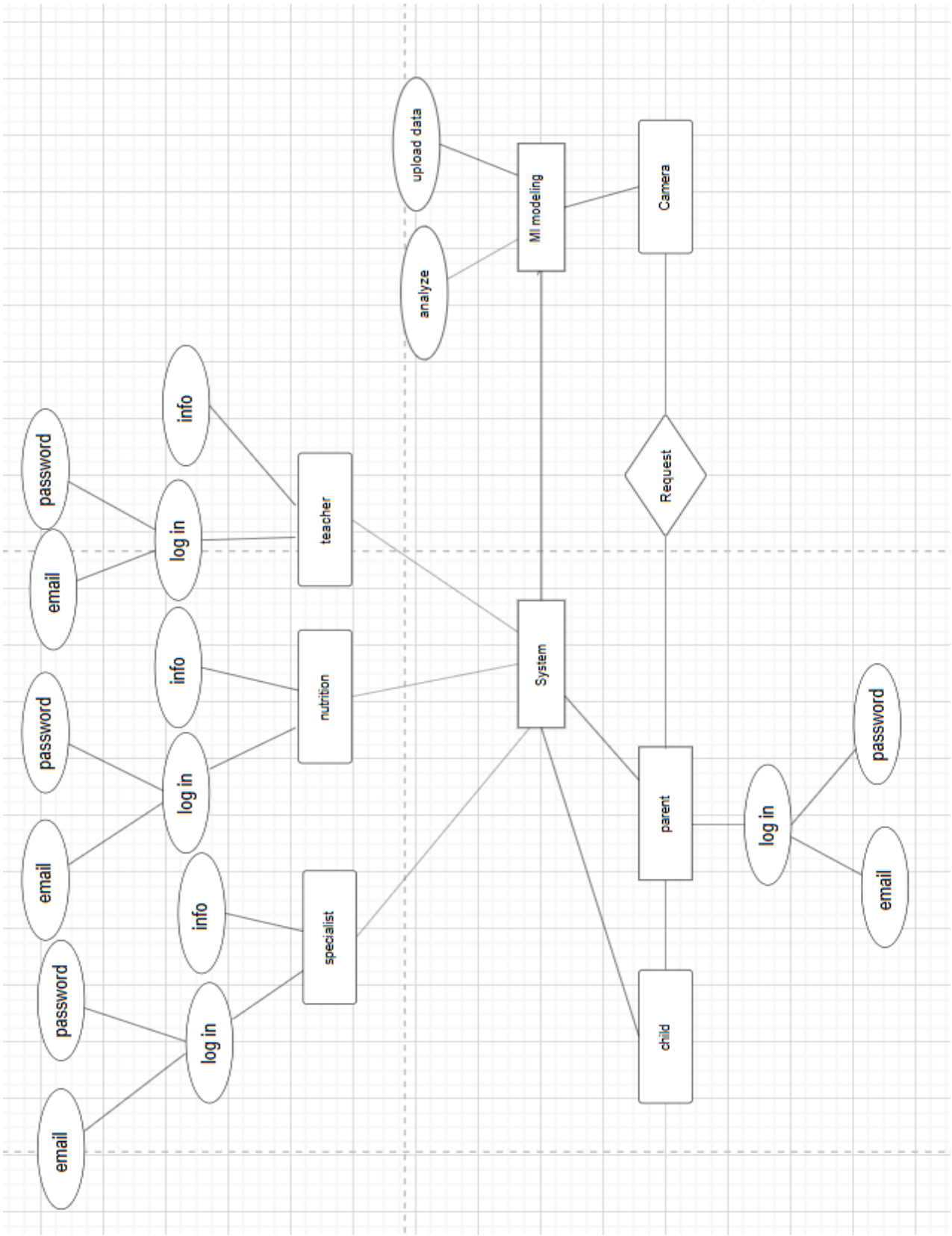

Figure 5: Project Provisional Database ER Diagram

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Appendix

Convolutional Neural Network (CNN) and Its Relation to Our Project

1. What is a Convolutional Neural Network (CNN)?

A Convolutional Neural Network (CNN) is a specialized deep learning algorithm primarily used for processing structured data in grid-like arrangements, such as images. CNNs are widely employed in tasks like image classification, object detection, facial recognition, and medical image analysis. In addition to image-related applications, CNNs are also used in natural language processing and recommendation engines, where they identify patterns and features in large datasets.

CNNs are designed to mimic the way the human brain processes visual information, learning hierarchies of features that range from simple patterns like edges to more complex shapes and objects. Their architecture enables them to excel in detecting spatial hierarchies and relationships between data points, making them ideal for tasks requiring high accuracy and pattern recognition.

2. How Does a Convolutional Neural Network Work?

CNNs function by ingesting and processing data in a grid-like format, breaking down information into smaller, more manageable pieces. They pass this data through multiple layers, each designed to extract specific features and perform unique tasks. The workflow can be broken down as follows:

- **Convolutional Layers**

  These layers are the core building blocks of CNNs. They apply convolutional filters (kernels) to the input image to detect essential features like edges, textures, and patterns. Each filter slides over the input data, performing a mathematical operation (dot product) to generate feature maps.

Key Properties:

- Preserve spatial relationships between pixels.
- Enable the detection of localized patterns in images.
- Multiple filters are used to extract a wide range of features.

- **Pooling Layers**

Pooling layers downsample the spatial dimensions of the feature maps, reducing the computational load and number of parameters in the network. This step helps retain the most critical features while ignoring redundant or insignificant information.

Types of Pooling:

- Max Pooling: Selects the maximum value from a group of neighboring pixels.
- Average Pooling: Calculates the average value of the selected region.
- Global Pooling: Reduces the spatial dimensions to a single value.

- **Fully Connected Layers**

These layers connect every neuron in one layer to every neuron in the next. They act as the decision-making part of the CNN, using the features learned by previous layers to classify input data.

Key Functions:

- Aggregate features from convolutional and pooling layers.
- Map extracted features to specific classes or outputs.

3. CNN Training and Evaluation

- **Training**

  CNNs are trained using a supervised learning approach, where the model learns to map inputs (e.g., images) to outputs (e.g., labels) by minimizing a loss function. The training process involves:

  – Forward Propagation: Passing input data through the network to generate predictions.

  – Loss Calculation: Measuring the difference between predicted and actual outputs using a loss function (e.g., categorical cross-entropy).

  – Backward Propagation: Adjusting the weights and biases of the network using optimization algorithms like stochastic gradient descent (SGD) or Adam.

  – Iteration: Repeating the above steps over multiple epochs until the model converges.

- **Evaluation**

  After training, CNNs are evaluated on unseen test data using metrics such as:

  – Accuracy: Percentage of correctly classified test samples.

  – Precision: Ratio of true positives to the sum of true positives and false positives.

  – Recall: Ratio of true positives to the sum of true positives and false negatives.

  – F1 Score: Harmonic mean of precision and recall, particularly useful for imbalanced datasets.

4. Popular CNN Models

Several CNN architectures have been developed, each optimized for specific tasks:

- **LeNet:** The first successful CNN, designed for handwritten digit recognition.
- **AlexNet**: Introduced deeper networks with ReLU activations and dropout for regularization.
- **ResNet:** Addressed the vanishing gradient problem using residual connections.
- **GoogleNet:** Utilized Inception modules for efficient computation.
- **MobileNet:** Lightweight and efficient, designed for mobile applications.

5. What is MobileNet?

MobileNet is a family of CNN architectures optimized for mobile and embedded applications. It is computationally efficient and suitable for devices with limited resources. MobileNet achieves efficiency through depthwise separable convolutions, which break down the convolution process into two parts:

- **Depthwise Convolution:** Applies a single filter to each input channel, preserving spatial relationships.
- **Pointwise Convolution:** Combines the results of depthwise convolutions using a 1x1 filter, reducing computational complexity.

6. MobileNet V3

MobileNet V3 builds on previous iterations, introducing advancements like:

- **Squeeze-and-Excitation Block**s: Improve feature selection by weighting channel importance.

- **Swish Activation Function:** Enhances gradient flow and model accuracy.
- **NAS Search:** Uses neural architecture search for optimal design.

In our project, we chose MobileNet V3 for its balance of performance and efficiency, making it ideal for mobile-based emotion detection tasks.

7. How is CNN Related to Our Project?

Our project uses CNNs to detect and predict children's emotions based on facial expressions. The process involves:

- **Face Detection:** Using image preprocessing techniques, the system identifies and aligns facial landmarks (eyes, nose, mouth, etc.).
- **Feature Extraction:**
  - **Convolutional Layers:** Extract fine details like edges, textures, and contours.
  - **Pooling Layers:** Downsample the data, retaining critical features while reducing computational load.
- **Emotion Classification:**
  - The CNN classifies facial expressions into predefined categories (neutral, happy, angry, sad, fear, surprise, disgust, contempt).
- **Emotion Prediction:**
  - Based on the classified emotion, the application suggests tailored recommendations, such as games, music, videos, or activities to enhance the child's well-being.
  - Recommendations Based on Emotional States

For each detected emotion, our application provides tailored recommendations:

- **Neutral:** Sorting and tracing games, calm instrumental music, and guided breathing exercises.
- **Happy:** Matching foods, upbeat songs, animated stories, and dancing activities.
- **Angry:** Hangman, soothing music, yoga, and stress-relief exercises.
- **Sad:** Puzzles, uplifting tunes, motivational videos, and crafting activities.
- **Fear:** Matching numbers, lullabies, reassuring animations, and storytelling.
- **Surprise:** Fun games, dynamic tunes, scavenger hunts, and "what happens next?" videos.
- **Disgust:** Sorting tasks, humorous videos, and sensory play activities.
- **Contempt:** Teamwork games, empathy-building songs, and group challenges.

This personalized approach ensures emotional engagement, fostering holistic development and well-being for children with autism. Parents can also customize recommendations to align with their child’s preferences and needs.