كلية الهندسة جامعه حلوان

جامعة حلوان
HELWAN UNIVERSITY

Autistic Assistant Robot (LEVI)

Faculty of Engineering - Helwan University

4th Year Computer and Systems Engineering Department

Supervised by: Dr. Rasha Fathy Aly Mostafa

Team Members List

Ahmed Mohammed Zaki

Bassant Magdy Salem

Youssef Hussein Ahmed

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Mohab Sherif Mahmoud

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Contributions

Team Member	Task
Ahmed Mohammed Zaki	Made contact with doctors to convince them to test the robot, as well as receiving their continuous feedback on the software and changing the software according to their feedback. **Software:** • Built the **"Games"** Section • Built the **"Education"** Section • Built the **"Entertainment"** Section **Mobile App:** • Contributed to the implementation of **"Mobile App"**
Medhat Mostafa Atya	**Software:** • Full Robot Software Design • Improved the **"Design Pattern"** of the Software. **Mobile App:** • Full Mobile App. Design • Built **Design Pattern** of the mobile app. • Contributed to the implementation of **"Mobile App"**. **Hardware:** • Delivered the **"Solidworks Design"**.

	• Followed up the updates with the **"Carpenter"**.
Youssef Hussein Ahmed	Setup all the **"Linux"** environments needed on the **"Raspberry Pi"** board. **Artificial Intelligence:** • Built the **"Emotions Classification Model"**. • Built the intelligent **"Movement and Reflexes System"** that interferes with the robot hardware. • Built the mechanism of the **"Environmental Aware"** system that interferes with the robot hardware. **Hardware:** • Followed up the updates with the **"Carpenter"**. • Assembled up all the robot **"Hardware Components"** into the robot body.
Bassant Magdy Salem	Followed up with the doctors throughout the year and carried out their feedback to the team to reach the best possible results. Met up with the doctors and recorded their **final feedback videos.** **Artificial Intelligence:** • Contributed to the **"Emotions Model"**.

	• Built the **"Chatbot Model"** including its "**Backend Server**". • Built the intelligent **"Voice System (TTS)"** that interfaces with the robot software. **Hardware:** • Followed up the updates with the **"Carpenter"**.
Muhab Sherif Mahmoud	Implemented and deployed the whole back-end logic for both mobile application and software which include setting up database and creating APIs. **Software Backend:** • Built the backend **"Server"**. • Built the backend **"Database"**. • Built the **"Middleware"** system. • Developed a **"Content management"** system for the **assets** (media). **Mobile App Backend:** • Added **authentication** system. • Added **community** system. • Implemented **communication** between members. • Managing child's **analysis**.

Abstract

Autism spectrum disorder (ASD) is a developmental disability caused by differences in the brain. ASD begins before the age of 3 years and research shows that early intervention services can greatly improve a child's development. In order to make sure the child reaches their full potential, it is very important to receive services as soon as possible. Hence the idea of our project is to shed light on autism and spread awareness about it. The common autism treatments include behavior therapy, play-based therapy, music therapy, and art therapy and our project has included all these therapies in one robot via software that is displayed on the touch screen in the robot's head.

To focus on the importance of the mental and psychological health of parents, we have built a mobile application to help parents join a community that brings together all parents of children with autism, in which they share their stories and exchange their experiences and help parents to learn a lot about autism through a chatbot which provides a service for parents by answering their questions about autism and providing them with advice on how to treat their children.

In addition, the robot sends an analysis of the child's condition while using the robot to the mobile application for the doctor and parents to see, which is very important for following up on the child and developing his skills.

Introduction

1. Problem Statement

1.1. What is Autism?

Autism is a neurodevelopmental disorder characterized by difficulties with social interaction and communication, and by restricted and repetitive behavior.

According to the DSM (Diagnostic and Statistical Manual of Mental Disorders), a child diagnosed with Autism has a problem with one of the following disorders:

- Verbal communication.
- Social interactions.
- Eye contact.

1.2. Autism Levels

There are three levels of ASD that help doctors prescribe appropriate therapies for the unique needs of their patients. These therapies can help the person with ASD make the most of their strengths and improve their social, language, and behavioral skills.

For parents of a child with ASD, knowing which level the child has can help prepare them for the types of challenges their child might face in daily life.

1.2.1. Level 1: Requires Support

A person with ASD level 1 usually is able to speak in full sentences and communicate, but has trouble engaging in back-and-forth

conversation with others. They may try to make friends, but not be very successful.

1.2.2. Level 2: Requires Substantial Support

A person diagnosed with ASD level 2 tends to speak in simple sentences and also struggles with nonverbal forms of communication.

1.2.3. Level 3: Requires Very Substantial Support

A person with ASD level 3 will have a very limited ability to speak clearly and will rarely start interactions with other people. When they do, they will do so awkwardly. Someone with Level 3 will also respond only to very direct social approaches from other people

Our Project targeted the children with autism with level 1 and level 2 only! within age from 3 to 10 years old.

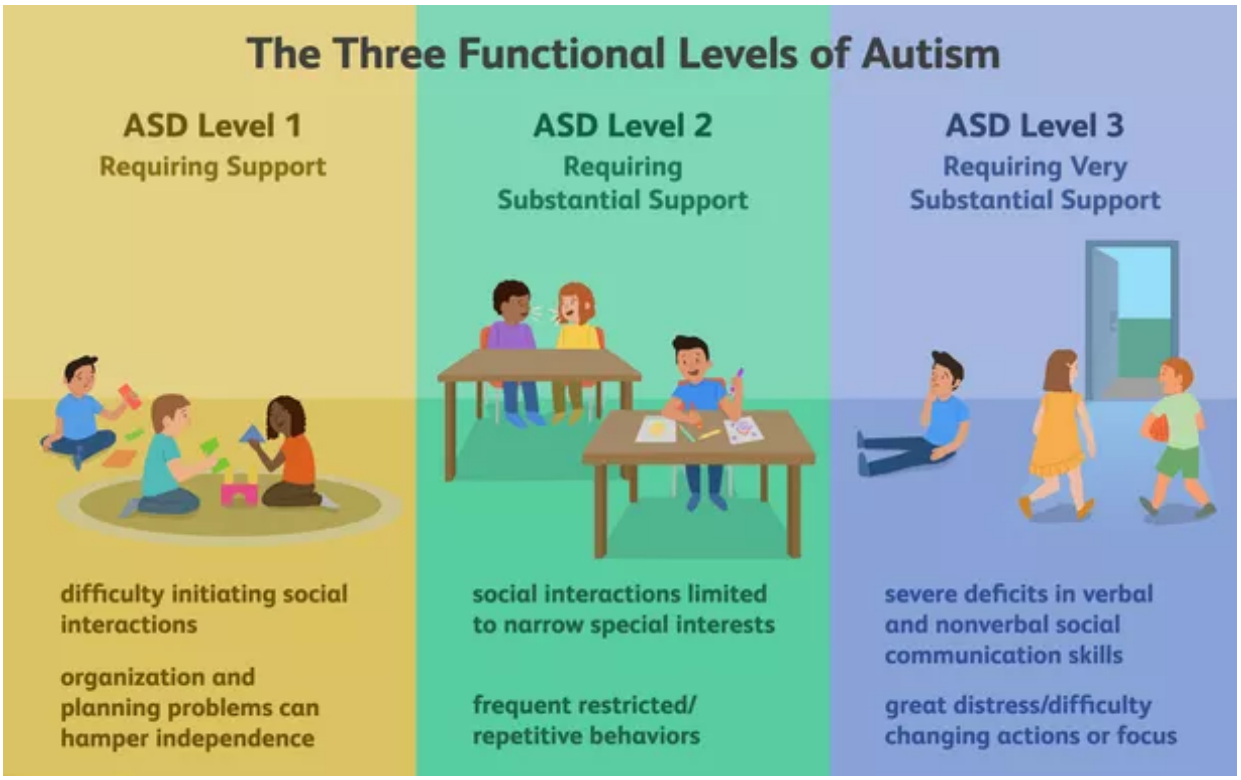


Figure 1. Autism Levels

1.3. What are the factors that cause autism?

We know that there's no one cause of autism. Research suggests that autism develops from a combination of genetic and nongenetic, or environmental, influences.

Research proved that most children are diagnosed with autism due to screens which can be either TVs, computers, mobile phones...etc, these children communicate with the screens only and have eye contact with the screen which affects their concentration with others.

1.4. Available Treatments

There is currently no one standard treatment for ASD. But there are many ways to help minimize the symptoms and maximize abilities. Children who have ASD have the best chance of using all of their abilities and skills if they receive appropriate therapies and interventions. And the common autism treatments include behavior therapy, speech-language therapy, play-based therapy, physical therapy, music therapy, and art therapy **and our project has included all these therapies in one robot.**

The techniques are applied in sessions as:

1.4.1. Behavior therapy

This treatment can help teens to develop better social and problem-solving skills, which consequently helps to improve their relationships with others. This type of therapy teaches an array of coping skills to help children manage emotional distress. This can also help the child to manage the physical symptoms, negative thoughts, and problematic behaviors that often accompany this type of distress.

1.4.2. Play therapy

According to the professional organization Play Therapy International, up to 71 percent of children referred to play therapy may experience positive change.

Play therapy can encourage the use of language or improve fine skills since children may become more creative or more verbal in their play.

Some of the potential benefits of play therapy are:

- Developing strategies and creative problem-solving skills.
- Self-respect.
- Alleviation of anxiety.
- Learning to fully experience and express feelings.
- Stronger social skills.
- Stronger family relationships.

1.4.3. Music therapy

Music therapy for autistic children was developed as a way to help these children with social interaction and communication.

For people who can't easily communicate, music therapy can be a way of communicating and interacting. Instead of using words to communicate, people can use a range of musical activities – singing, playing instruments, improvising, songwriting, and listening to music. These activities promote communication and social skills like making eye contact, sharing attention, and taking turns.

1.4.4. Art therapy

Most individuals on the autism spectrum have difficulty with social and verbal communication. Some are nonverbal, while others find it

challenging to hold a conversation and are unable to read the body language and faces of others successfully.

Art therapy allows children with ASD to use their visually-minded brains to communicate through artistic media. They can record images and visual data, express ideas, and process memories that they cannot do verbally.

Art therapy allows children with autism the chance to build communication skills in another way in a comfortable setting where they can find happiness and success.

2. Goals and Objectives

Our project has several Objectives, helping Autistic children in their life by taking care of them and helping them to learn and develop their thinking through easy ways that keep them entertained, helping parents keep their eyes on their child and follow his condition through the time and send it to his doctor, helping parents to communicate with other parents that have a child who suffers from autism, and helping the doctor to follow the child's condition and behavior, Under the supervision of **the following doctors:**

1. Prof. Dr. Mohamed Elfeky.
2. Prof. Dr. Nawal Mansour.
3. Prof. Dr. Mona Ezz Eldeen.
4. Dr. Jihan Ahmed.

We have come up with a lot of solutions, and we summarized them below:

#	Problem	Accomplishment
1	Autistic child has problems with facial expressions	Building a game that will help them to learn how to recognize different emotions.
2	Autistic child has a problem with communication	Adding social stories that can help autistic children know what to do in a given situation.
3	Autistic children have aggressive or angry behavior.	1. Building many useful games that may calm him. 2. The robot will take action and move away when the child becomes aggressive suddenly. 3. The robot will send an alert to the mobile Application to notify the parents or the doctor About the behavior of the child.

		4. Adding a music therapy section that helps him to calm down.
4	The ASD child has a huge problem with communication and difficulties with social interaction.	1. We will use art therapy by building a painting game. 2. Multi-sensory usage can help in building their feelings like listening. So, we'll use animal sounds to identify them, storytelling, and play music in our robot.
5	ASD children have a huge problem with education.	The robot will include an educational part, so the child will learn a lot of basic things such as numbers, alphabet letters, colors, animal names, emotional expressions, etc...
6	Autistic children might mimic or repeat other people's words or phrases, or words, they've heard on TV, YouTube, or videos. This is called echolalia.	We will take advantage of this problem and convert it into a solution since in the educational part, we will rely on making the robot repeats the names of animals, colors, emotional expressions, ..etc.
7	Parents of individuals with ASD often report high levels of stress and mental health problems.	Building a mobile application to guide the parents on how to deal with the difficult needs of their children and give them some incorporeal support. Also, the app will include a chatbot that will answer all of the parents' questions about autism.
8	Both parents can be busy and don't want to leave the child alone.	Building a "Watcher Mode" in the robot to monitor the child only.

3. Related Work

3.1. Telerehabilitation Service with Robot for Autism Interventions (2015)

- It wasn't easy for therapists to program special programs for their patients.
- Telerehabilitation system aims to present a website that helps therapists customize their robot scenarios
- Most therapists & parents found their online experience with the website design to be good and the content was presented well.
- The method is too complicated and takes a lot of time, also no hardware is made to implement the system.

3.2. Service Personalisation of Humanoid Robot for Autism Care(2015)

- This paper shows that social robots like Lucy with human-like characteristics (**voice, gestures, emotions, and a combination of human attributes with personalized services**) can be used in home-based environments to generate positive emotion and provide sensory enrichments to young people with ASD.
- This paper represented the outcomes of the first-ever field trial of a social robot (Lucy) with young people with autism, also the trial took **more than 3 months.**
- The trial was made on **adult people** with autism.
- The robot was improving behavior & communication while no effort on education was made.

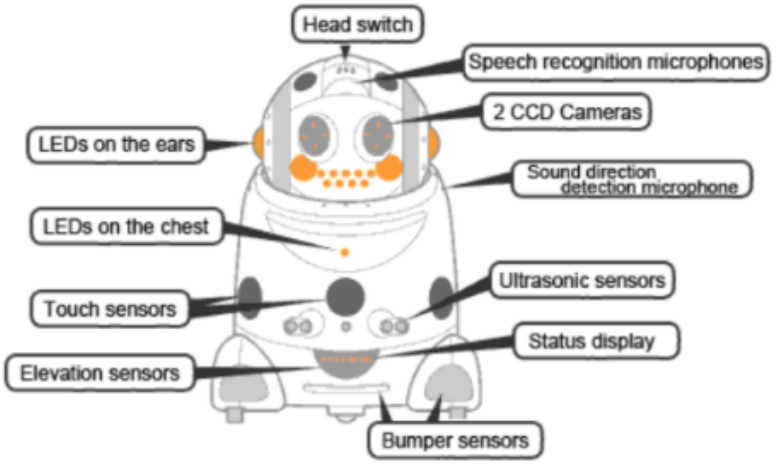


Figure 2. Lucy Robot

3.3. Socially-Assistive Robots to Enhance Learning for Secondary Students with Intellectual Disabilities and Autism(2018)

NAO	PARO
1. Beneficial for students with at least a basic level of cognition and verbal abilities. 2. It's programmed using Choregraphe to provide specific tasks. 3. For non-verbal students, was noted the potential.	1. Better suited for students in the lower end of cognition. 2. Used as a calming device to help students reduce anxiety. 3. Can't be programmed. 4. Limited to emotion regulation.

NAO

PARO

Figure 3. NAO & PARO Robots

3.4. Robot Selection in Robotic Intervention for ASD Children (2018)

- For our selection of robots, there are some features that we emphasized which include Mobility, Speech, controllable, Programmable, and Robot appearance
- The authors have decided to start our task using the RERO robot, as it has all the required criteria.
- The interaction with the child is only through voice and doesn't provide any educational means for them,

Name	Aisoy1	Milo	Romibo	Buddy	Pleo	Nao	LEGO EV3	Rero
Figure								
Mobility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Speech	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Apps	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SDK	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Shape	Pet	Humanoid	Pet	Mobile	Dinosaur	Humanoid	Anything	Anything

System Requirements

1. Enumerated Functional Requirements

REQ – x	Description
REQ – 1	Register and/or login for a single user(child).
REQ – 2	Provide games to help in the treatment.
REQ – 3	Teach how to recognize and differentiate between emotions.
REQ – 4	Teach how to differentiate between colors and eliminate the colors which have a negative effect on children.
REQ – 5	Moving away and taking action based on the child's emotion.
REQ – 6	Send an alert to the mobile application which notifies the behavior of the child.
REQ – 7	Painting games that follow art therapy.
REQ – 8	Use sounds to help them build their feelings and awareness.
REQ – 9	Educate children with various applications/games.
REQ – 10	Provide a mobile application.
REQ – 11	Watcher mode to monitor the child's behavior.
REQ – 12	Send analysis of child behavior to the mobile application.

2. Enumerated Nonfunctional Requirements

REQ – x	Description
REQ – 13	**Security**: No one can access Robot except for the registered user.
REQ – 14	**Usability**: The Robot is easily reprogrammed and used.
REQ – 15	**Support**: Communication between parents and doctors through the mobile application.
REQ – 16	**Performance:** The software should be smooth and data loaded from the backend server should load fast.

3. Functional Requirements Specification

3.1. System Stakeholders

The system Stakeholders are classified into 3 groups, there are doctors, parents, and autistic children.

3.2. Actors and Goals

The Robot will be used by children, while the mobile application will be used by parents and doctors to keep track of their children.

- **The Actor (User):** will be either a Doctor/parent or a child.
- **The carer (doctor/parent):** has multiple functions, but the main part is that they can communicate together and see the robot analysis of the ongoing session as well as control the movement of the robot through the mobile application.
- **The child:** is the main actor of the system as he is the child diagnosed with Autism, thus will interact with the robot only and from said interaction will generate a statistical report to the mobile application of the doctor.

3.3. Software Diagrams

3.3.1. Use-Case Diagram

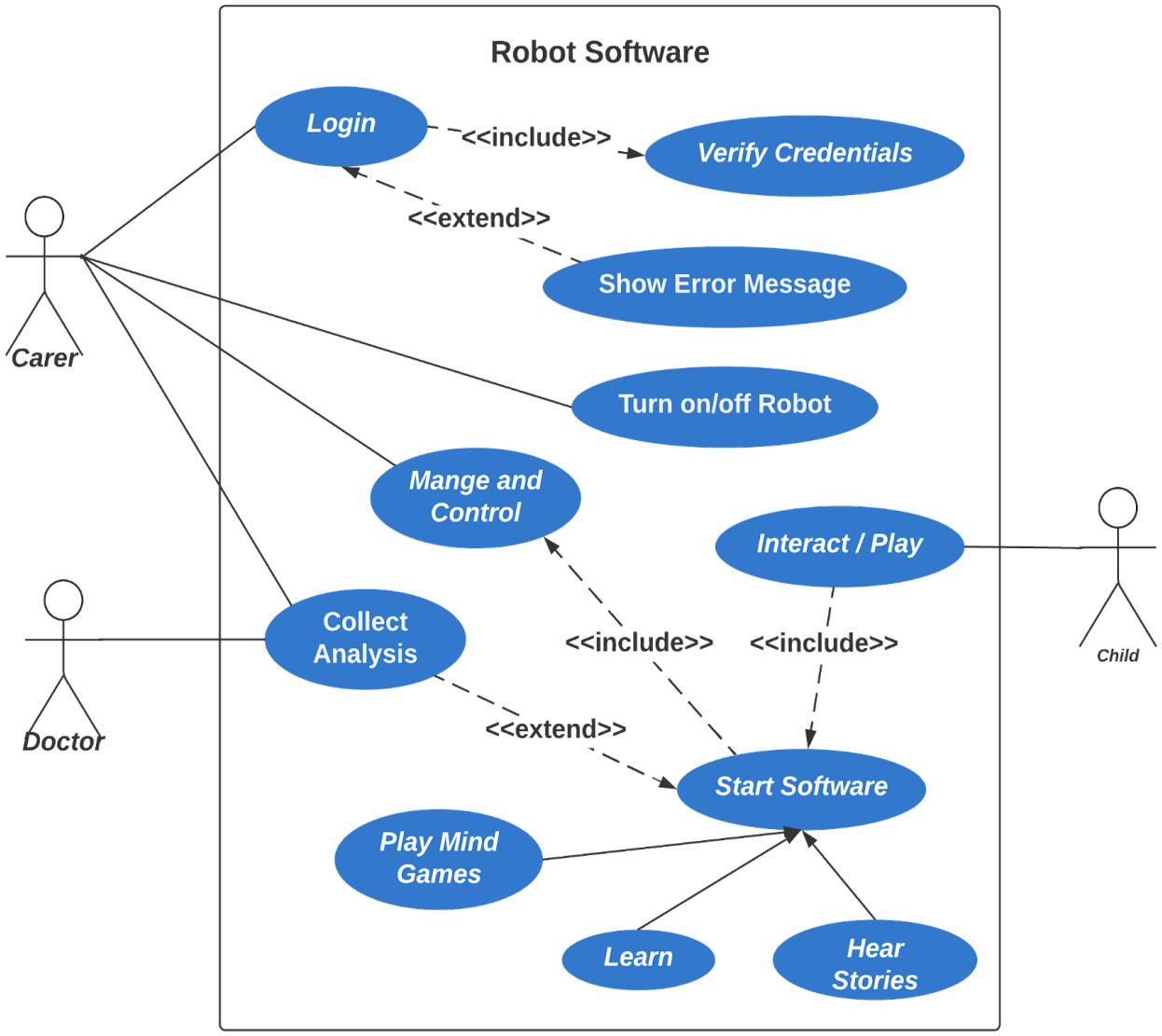


Figure 4. Use-Case Diagram

3.3.2. Entity Relationship Diagram

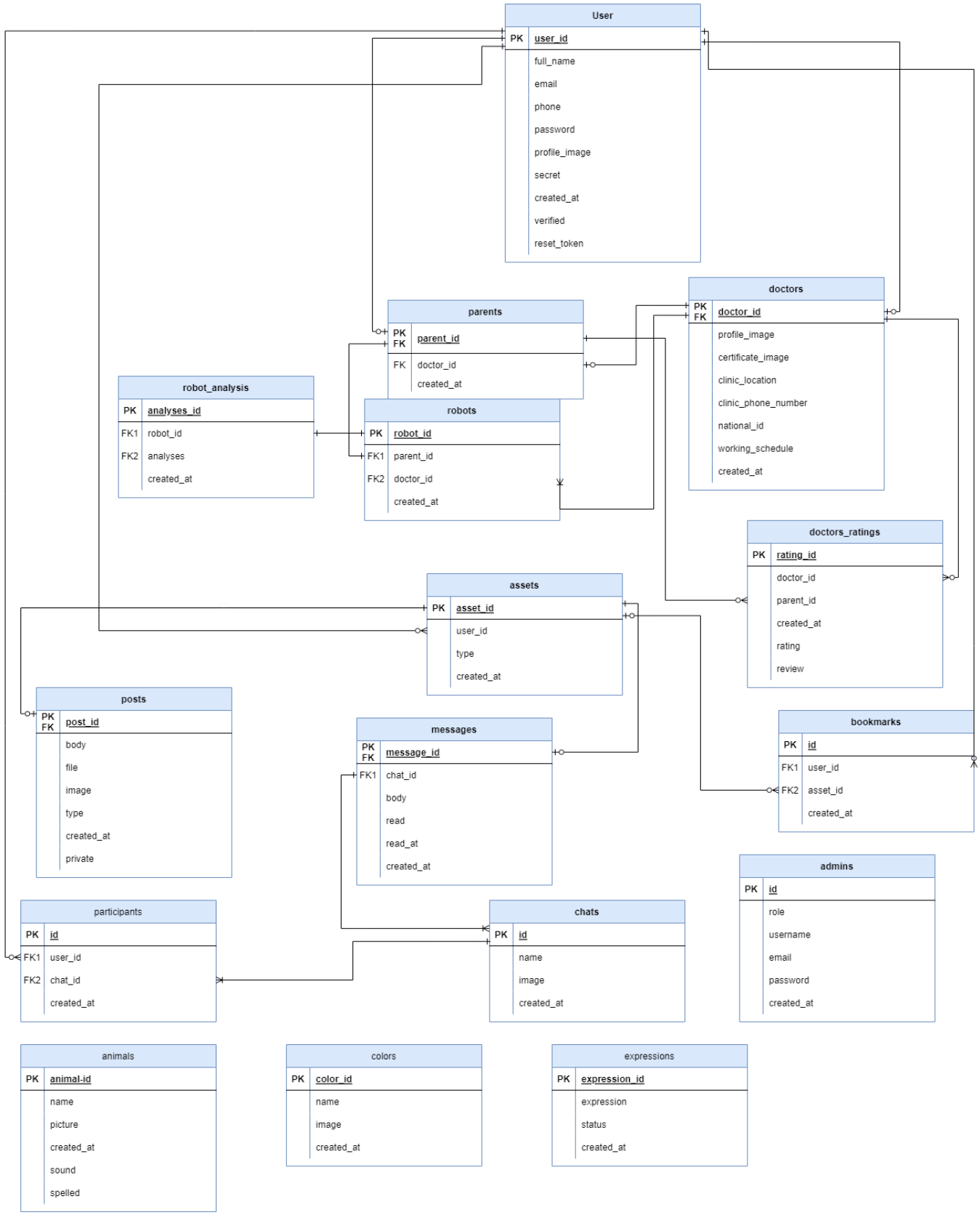


Figure 5. ER Diagram

3.3.3. Sequence Diagram

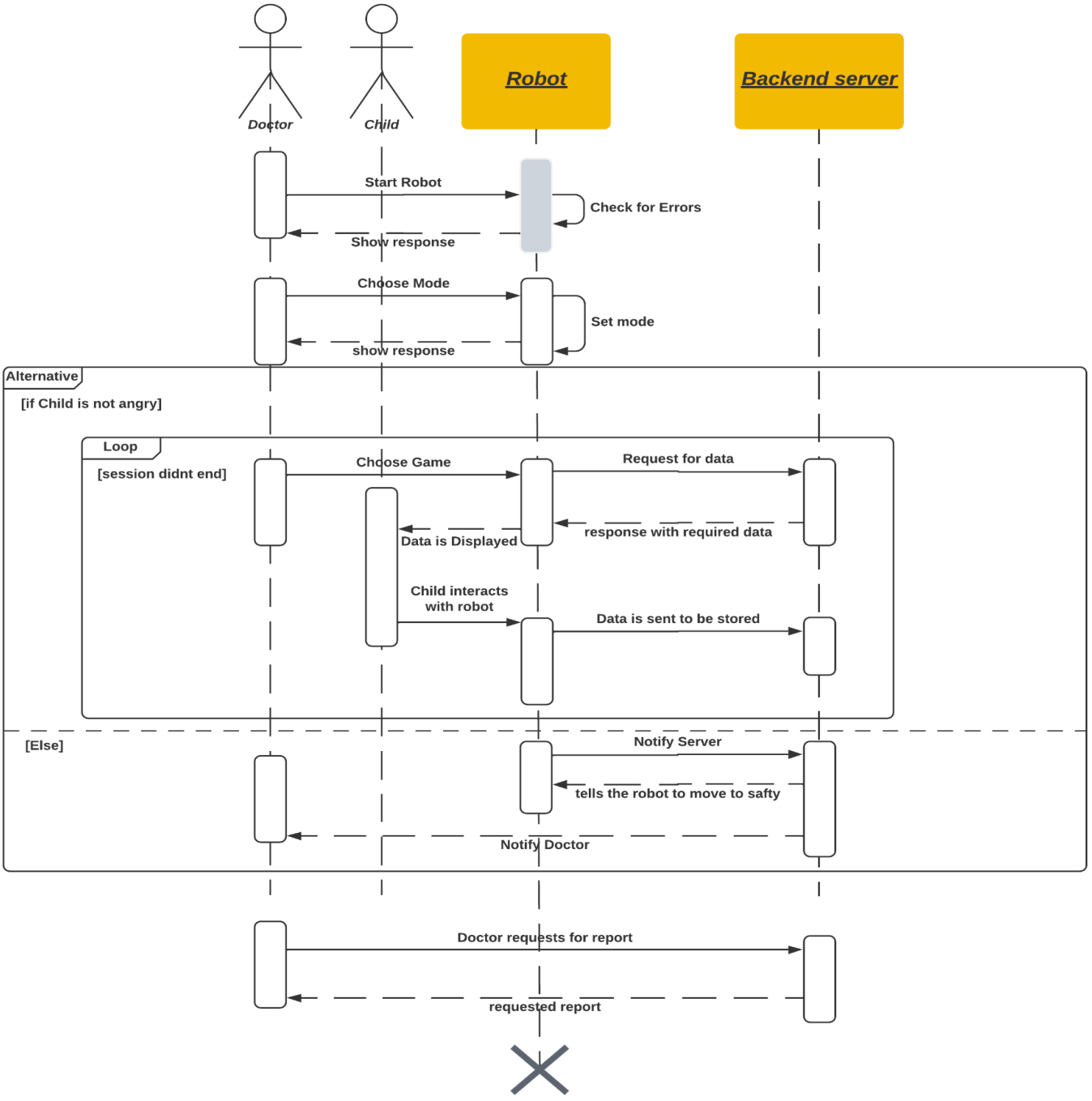


Figure 6. Sequence Diagram

3.4. Summary System Block Diagram

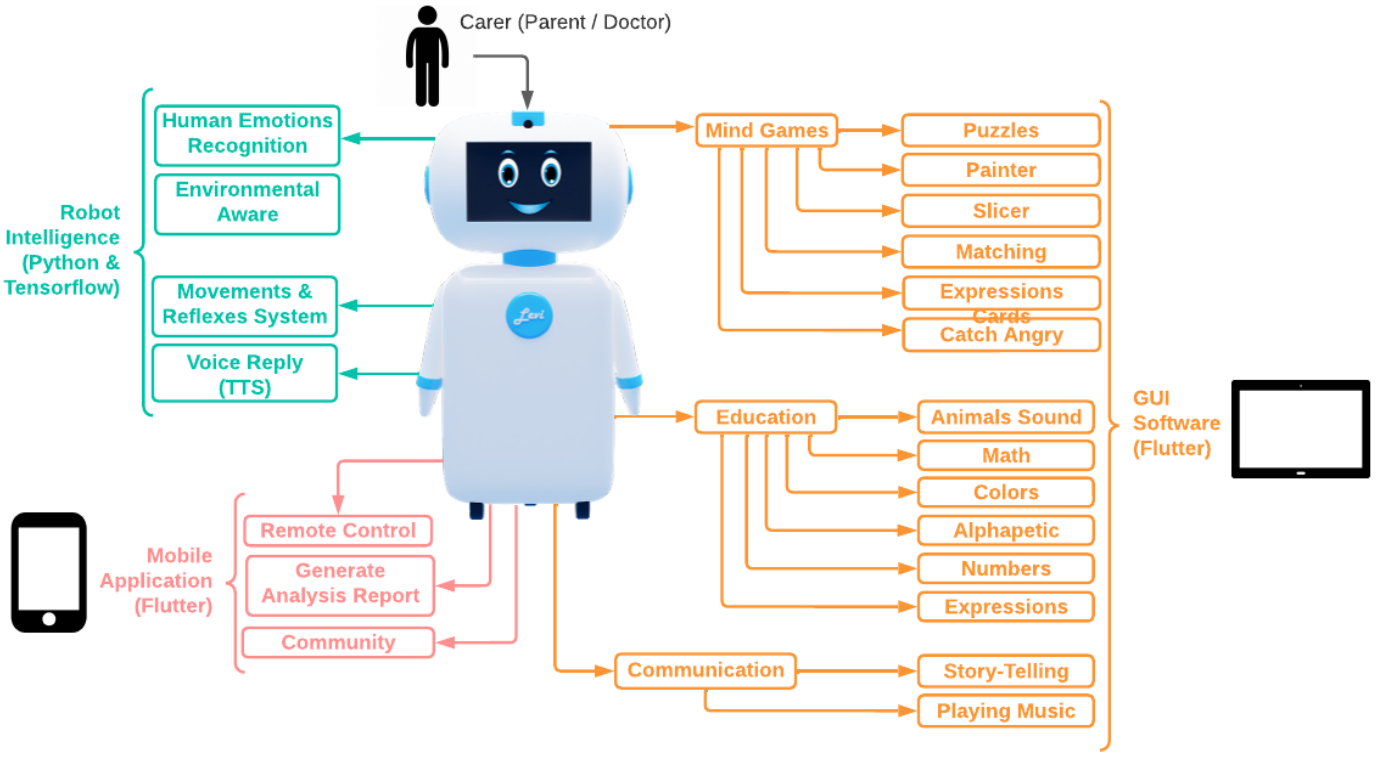


Figure 7. Summary System Block Diagram

Module 1: Software

1. Flutter

The software is written using the Flutter framework which is implemented in dart and developed and maintained by Google.

Flutter is an open-source framework to create high-quality, high-performance applications across operating systems - Android, iOS, Desktop platforms, and the Web. It provides a simple, powerful, efficient, and easy-to-understand SDK to write applications in Google's own language, Dart.

Flutter framework offers the following features to developers,

1. Modern and reactive framework.
2. Uses Dart programming language and it is very easy to learn.
3. Fast development.
4. Beautiful and fluid user interfaces.
5. Huge widget catalog.
6. Runs the same UI for multiple platforms.
7. High-performance application.

1.1. Advantages of Flutter

Flutter comes with beautiful and customizable widgets for high performance and outstanding applications. It fulfills all the customer needs and requirements.

Besides these, Flutter offers many more advantages as follows,

1. Dart has a large repository of software packages that lets you extend the capabilities of your application.
2. Developers need to write just a single code base for both applications (Android, iOS, Desktop and Web platforms).

3. Flutter may be extended to other platforms as well in the future.
4. Flutter needs less testing.
5. Because of its single code base, it is sufficient if we write automated tests once for both platforms.
6. Flutter's simplicity makes it a good candidate for fast development.
7. Its customization capability and extensibility make it even more powerful.
8. With Flutter, developers have full control over the widgets and its layout.
9. Flutter offers great developer tools, with amazing hot reload.

2. Flutter Libraries (Packages)

2.1. BLOC

A predictable state management library that helps implement the BLoC (Business Logic Component) design pattern.

State management in flutter means that the application will manage the states of the user, mostly used to rebuild the UI again when changes occur to the application (user clicked a button, data coming from server...etc).

For more information about BLOC, please refer to the reference section.

2.2. DIO

A powerful HTTP client for Dart, which supports Interceptors, Global configuration, FormData, Request Cancellation, File downloading, Timeout, etc.

This library is used to send (post) or receive (get) or even modify (put) data from the server using API calls.

For more information about DIO, please refer to the reference section.

2.3. Dart_vlc

Flutter media playback, broadcast, recording & Chromecast library. Based on libvlc.

Library used to play music and videos (media), which uses the vlc implementations of the libvlc that is a C++ library.

For more information about Dart_vlc, please refer to the reference section

3. Design Pattern (MVC)

MVC (Model-View-Controller) is a pattern in software design commonly used to implement user interfaces and data, and control logic. It emphasizes the separation between the software's business logic and display. This "separation of concerns" provides for a better division of labor and improved maintenance. Some other design patterns are based on MVC, such as MVVM(Model-View-Viewmodel), MVP (Model-View-Presenter), and MVW (Model-View-Whatever).

The three parts of the MVC software design pattern can be described as follows,

3.1. MVC Model

The model defines what data the app should contain. If the state of this data changes, then the model will usually notify the view (so the display can change as needed) and sometimes the controller (if different logic is needed to control the updated view).

The model manages data and business logic.

3.2. MVC View

The view defines how the app's data should be displayed.

The view handles layout and display.

3.3. MVC Controller

The controller contains logic that updates the model and/or views in response to input from the users of the app.

The Controller routes commands to the model and view parts.

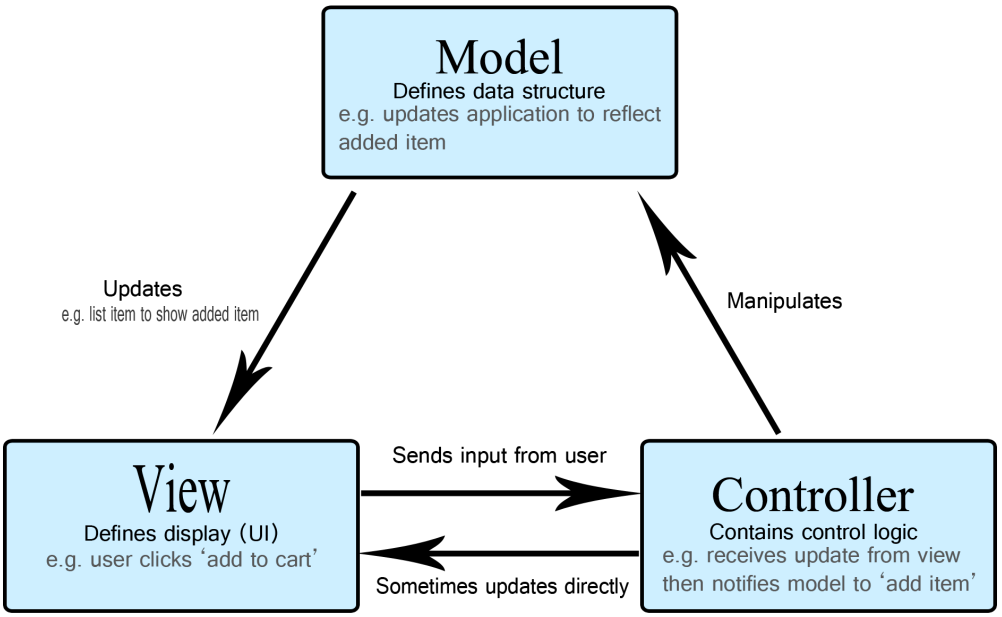


Figure 8. MVC Diagram

More can be found on the MVC design pattern in the reference section.

4. Software Block Diagram

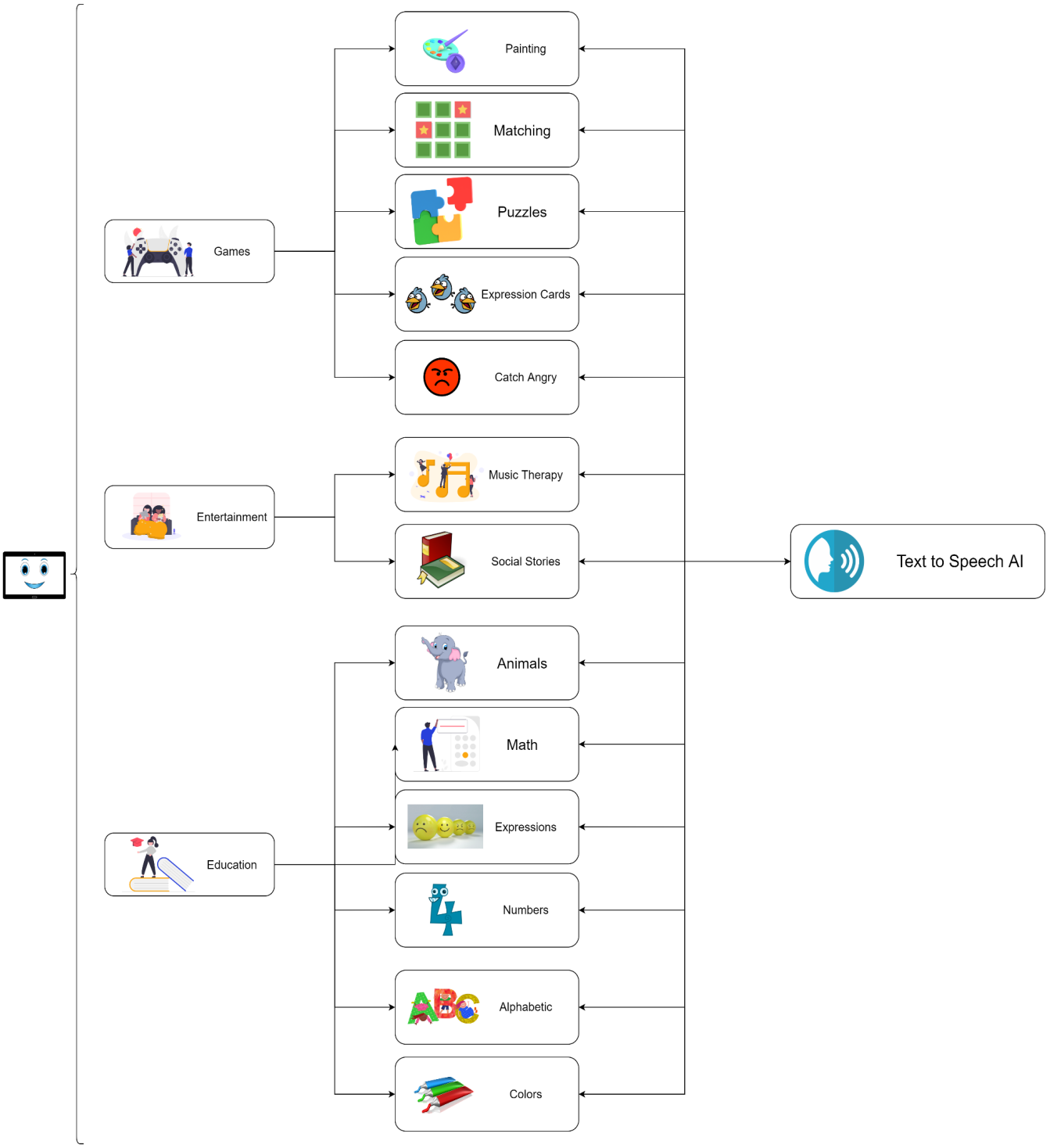


Figure 9. Software Block Diagram

5. Games

Games improve the children with ASD skills, these games have been carefully chosen and monitored from the doctors that's responsible for treating autism, these games include:

5.1. Puzzles

Description,

The children will reconstruct a picture with different levels of difficulty when it's complete and applause is made so that the child is motivated.

Reason of Choice,

Puzzles are highly appealing to children with autism. They offer opportunities to help children develop problem-solving skills, and provide visual stimulation. Oftentimes children with autism think in pictures rather than words, so puzzles offer them a creative outlet for grounding.

5.2. Catch Angry Face

Description,

Faces (happy and angry faces) will be thrown on the screen so that the child and child will tap on the wrong face (angry face), this will make the child's expressions be happier and angry free.

Reason of Choice,

This game is to help children with autism understand emotions, visual support is most commonly used as a tool, and is also highly effective.

5.3. Matching

Description,

A simple matching between 2 sets of data, using drag & drop the child will start to match these data.

Reason of Choice,

The matching game helps children to learn how to identify objects that are alike or the same. This helps to prepare children to identify objects that are different and eventually move on to sorting items

5.4. Expression Cards

Description,

A game that teaches children different expressions and what are good and bad expressions.

Reason of Choice,

A great visual aid for children, these emotion cards can be used to help young children with ASD to understand different emotions and how to behave towards their classmates or anyone.

The emotion cards also teach the children what are good and bad expressions which is important because they have difficulty distinguishing between them.

6. Education

Educational approach for the doctor to choose from, instead of using the pen and paper the doctors use to treat the autism children, we converted these techniques from paper techniques to a software code that performs exactly as the doctor's treatment sessions for the autism children, also we carefully picked what to put in this section to make the child feel that the normal sessions he previously had are the same as the new sessions he is having when using our robot, this service has the following sections:

6.1. Alphabetic

Description,

Using an educational video that teaches the alphabet with a simple song.

6.2. Animals

Description,

Uses various pictures and sounds of the animals to teach the child about animals as well as how to say the animal, these animals are displayed as rotating cards.

6.3. Colors

Description,

Uses various pictures of objects which view a certain color to teach the child about colors as well as how to say the color, these colors are displayed as rotating cards.

6.4. Math

Description,

Simple math equations using only 2 operators and generating the operands and operators randomly, when the child chooses the correct answer the robot will say that right, excellent ..etc, while on a wrong answer it says try again..etc

6.5. Numbers

Description,

Using an educational video that teaches the numbers with a simple song.

6.6. Expressions

Description,

Using various pictures of people expressing their feelings teaching the child about expressions as well as what a specific expression is called, these expressions are displayed as rotating cards.

6.7. Reason of choice Education Activities

School is rarely a good environment for children with autism. And that can be a serious problem in the first years. The researchers proved that Visual strategies help students learn effective communication, appropriate social interaction, and positive behavior. So, we used visual education to help the child to learn about numbers, letters, animals, colors..etc. As children with autism are great visual learners.

7. Communication

Communication section is divided into 2 parts, the first one is music which will allow the child to play music games many children like to hear calming music when children start to be nervous or afraid, and the second part is storytelling which will show the children different situations and to help autistic children what to do in a given situation.

7.1. Music listening

Description,

Calm and steady music that is used to make the child feel less nervous.

7.2. Playing music

Description,

A piano-like game that contains some buttons which produce different sounds whenever pressed.

Reason of Choice,

To improve responses in autistic children. Studies reveal that autistic kids respond much more frequently than usual during music lessons. Music helps them to enjoy the process of expressing themselves.

7.3. Social stories

Description,

Multiple situations which will teach the children how to act at each one, these stories are displayed as rotating cards.

Reason of Choice,

To help autistic children not only know what to do in a given situation but also help them gain a better understanding of how others feel and why they should respond with specific behavior.

8. Software Snapshots Sample

8.1. Splash Screen

Splash screen displays when the software runs on the robot.

Figure 10. Splash Screen Snapshot

8.2. Home Screen

The home screen (background animated) displays after the end of the splash screen, which may lead to three sections as follows,

8.2.1. Home Screen: Games Snapshot

Figure 11. Home Screen: Games Snapshot

8.2.2. Home Screen: Education Snapshot

Figure 12. Home Screen: Education Snapshot

8.2.3. Home Screen: Communication Snapshot

Figure 13. Home Screen: Communication Snapshot

8.2.4. Games Screen Snapshot

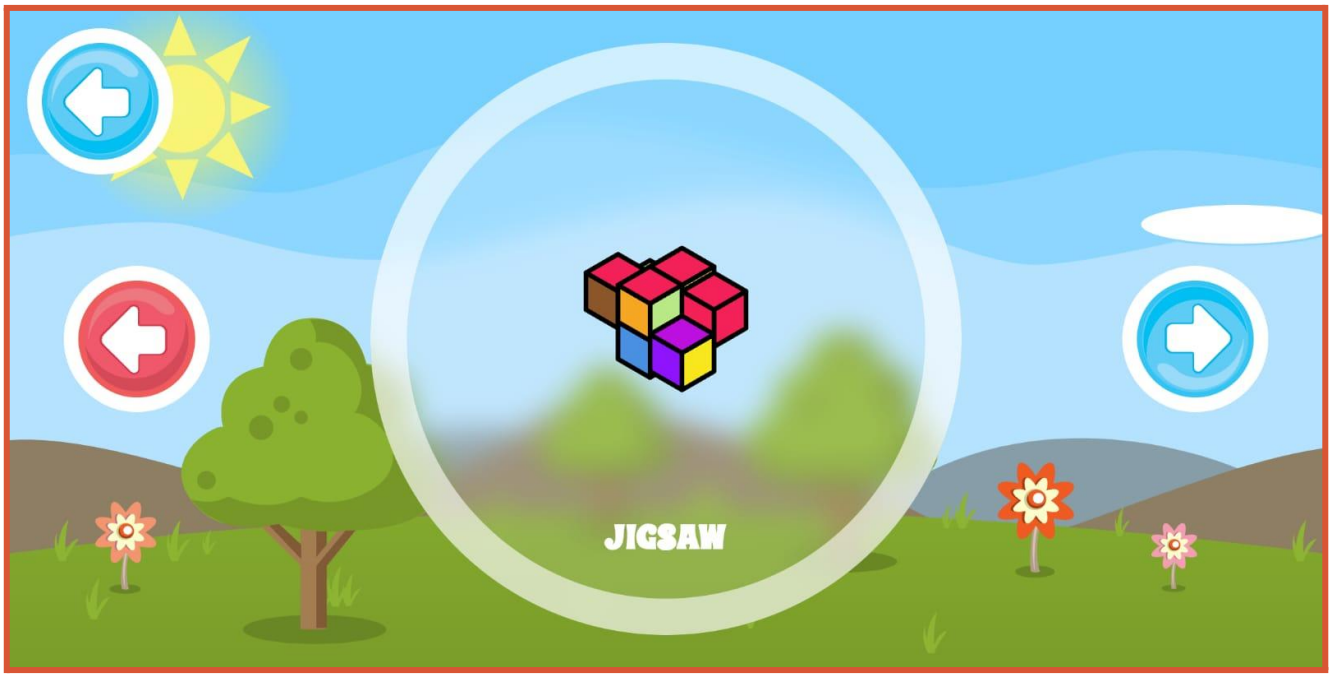


Figure 14. Games Screen Snapshot

8.3. Entertainment Screen Snapshot

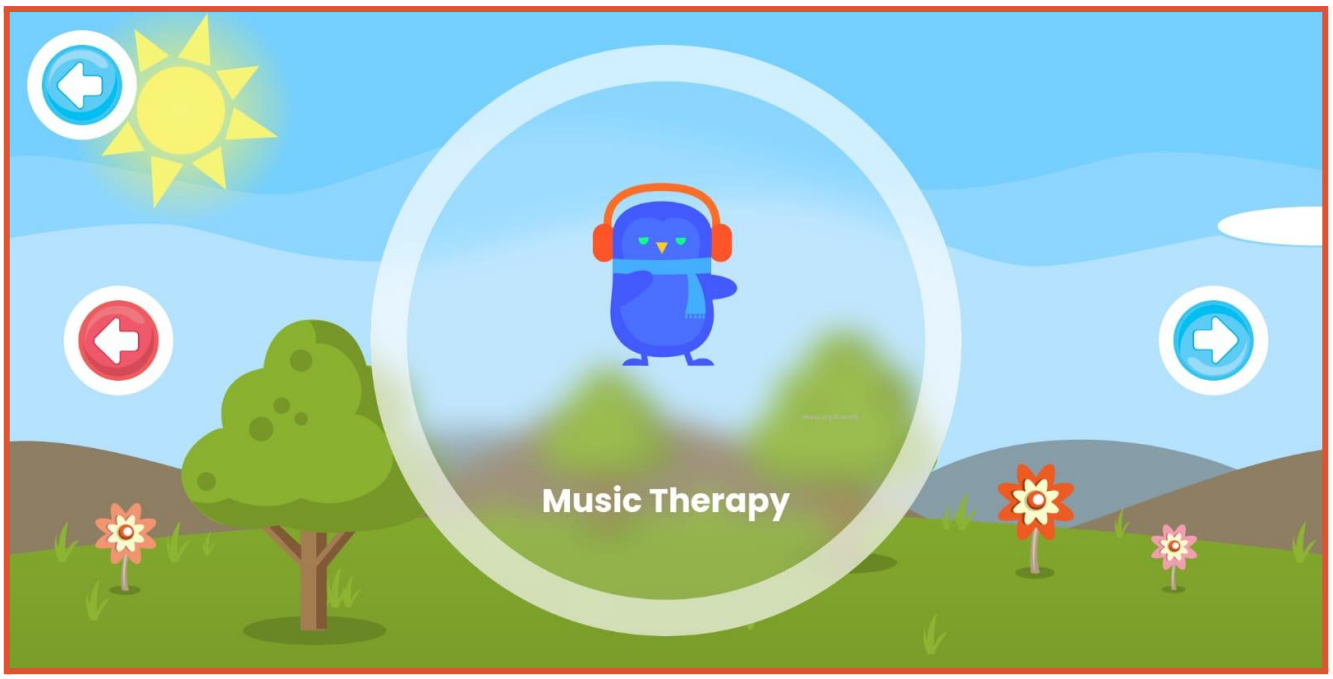


Figure 15. Entertainment Screen Snapshot

8.4. Education Screen Snapshot

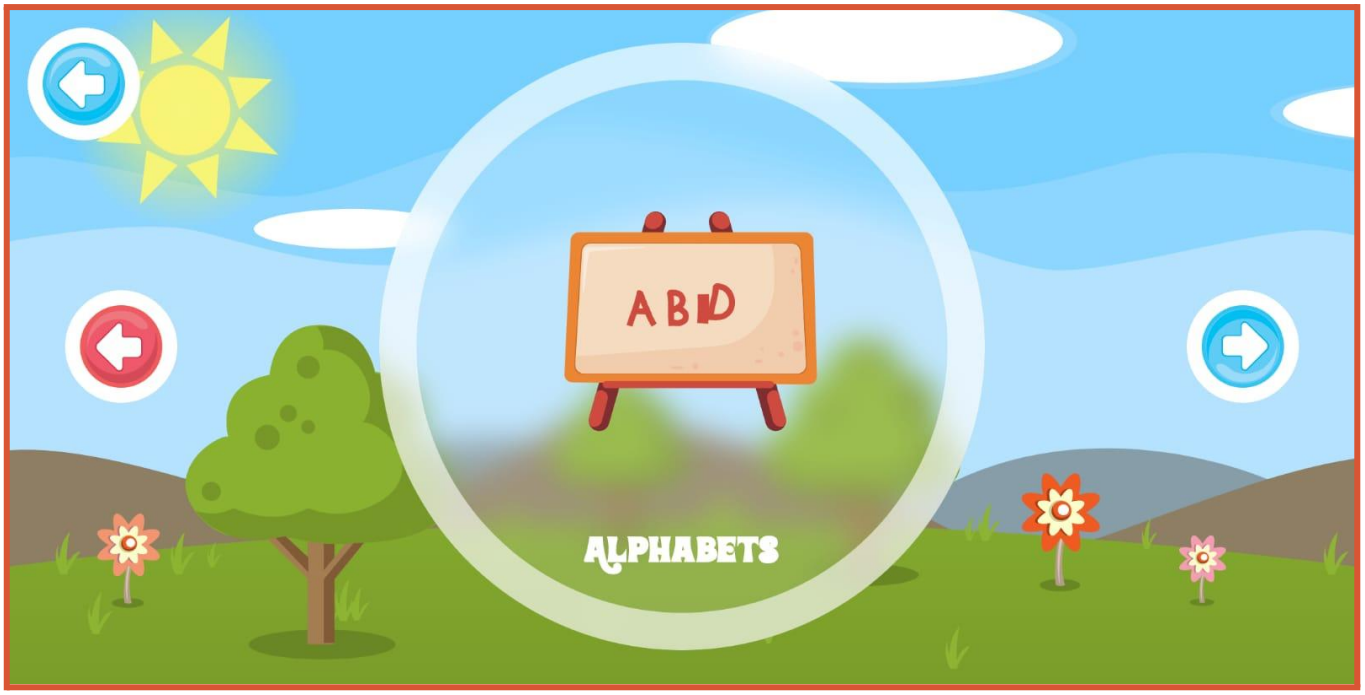


Figure 16. Education Screen Snapshot

Module 2: Artificial Intelligence

1. Emotional Intelligence

1.1. ASD Child Environment

It's important for an ASD child carer to watch the mood of the ASD child all the time, which may appear in his physical and mental reactions in different situations.

One of the best ways that the Robot can achieve this process is to keep tracking the facial expressions of the ASD child to record an analysis of how the child interacts with the surrounding environment that naturally includes the Robot and its various activities.

1.2. Emotions Recognition Ability

In order to give the Robot the intelligence to recognize various human emotions (facial expressions) to keep tracking the ASD child's mood during his interactions with the Robot and its activities, we had to build an "Emotions Classification Deep Learning Model".

1.3. Deep Learning

Deep learning is a subset of machine learning, which is essentially a neural network with three or more layers. These neural networks attempt to simulate the behavior of the human brain—albeit far from matching its ability—allowing it to “learn” from large amounts of data.

Deep Learning tools rely on predictive modeling and statistics, which helps data scientists collect, interpret, and analyze massive amounts of data. These tools help seamlessly to detect objects, classify images, translate languages, recognize speech, and make decisions accordingly.

Top 7 Deep Learning Tools:

1. ConvNetJS
2. Torch and PyTorch
3. Tensorflow & Keras
4. H20.ai
5. Neural Designer
6. DeepLearningKit
7. Microsoft Cognitive Toolkit

1.4. TensorFlow and Keras

To build our model, we used Tensorflow & Keras. TensorFlow is an end-to-end open-source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries, and community resources that lets developers easily build and deploy ML-powered applications.

Keras is a deep learning API written in Python, running on top of the machine learning platform TensorFlow. It was developed with a focus on enabling fast experimentation. Being able to go from idea to result as fast as possible is key to doing good research.

Figure 17. Tensorflow & Keras Logos

1.5. Model Build

The problem of human emotions classification requires building a "Convolution Neural Network" (CNN) model as the input of the problem is three-dimensional (image, video frame, or camera frame).

There are various famous Convolution Neural Networks (CNN) model architectures that developers are able to use to build their models according to their problem needs.

Some famous CNN Model Architectures:

1. DenseNet
2. EfficientNet (V1,2,3)
3. MobileNet (V1,2,3)
4. Vgg16
5. Vgg19
6. NASNet-A
7. RegNet
8. ResNet

1.6. VGG16 Architecture

VGG16 is a convolutional neural network (CNN) model proposed by K. Simonyan and A. Zisserman from the University of Oxford in the paper “Very Deep Convolutional Networks for Large-Scale Image Recognition”. The model achieves 92.7% top-5 test accuracy in ImageNet, which is a dataset of over 14 million images belonging to 1000 classes. It was one of the famous models submitted to ILSVRC-2014.

VGG16 is considered to be one of the excellent vision model architecture to date. The most unique thing about VGG16 is that instead of having a large number of hyper-parameter they focused on having convolution layers of a [3x3] filter with a stride [1] and always used the same

padding and max pool layer of [2x2] filter of stride [2]. It follows this arrangement of convolution and max pool layers consistently throughout the whole architecture. In the end, it has [2] FC (fully connected layers) followed by a softmax for output. The 16 in VGG16 refers to it having 16 layers that have weights. This network is a pretty large network and it has about 138 million (approx) parameters.

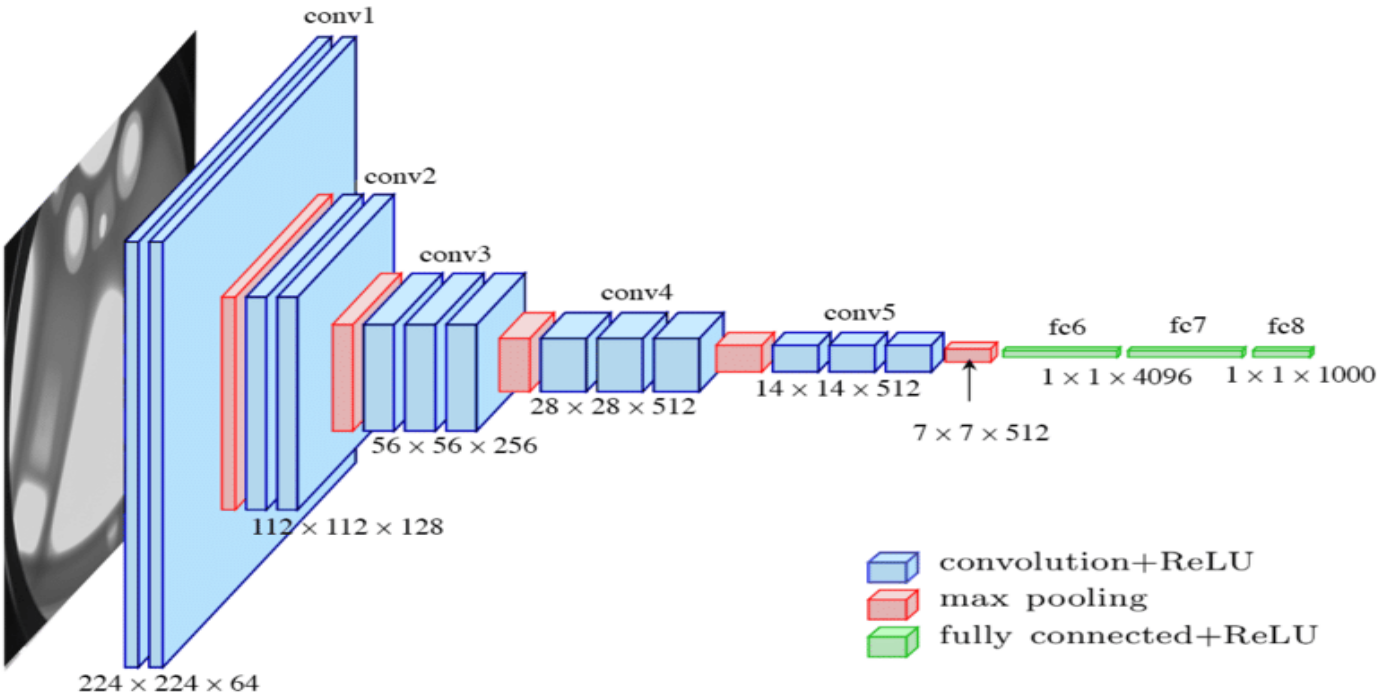


Figure 18. VGG16 Model Architecture

1.7. Emotions Classification Dataset

Emotions Classification enables machines to recognize various emotions. The technique that helps machines and computers to be capable of detecting, expressing, and understanding emotions is known as emotional intelligence. In order to understand and classify emotions, the first and foremost requirement for machine learning models is the availability of a dataset.

Below here, we are listing down the top eight datasets, in no particular order, that is available for emotions classification.

1. AffectNet

2. FER-2013
3. Ascertain
4. Dreamer
5. Extended Cohn-Kanade Dataset (CK+)
6. EMOTIC
7. Google Facial Expression Comparison Dataset
8. K-EmoCon

Unfortunately, It's not possible to get access to one of these datasets unless you're a researcher for some university. Even if, you get access to a dataset, you still face the problem of the very large size of these datasets.

These datasets have very large sizes (ex, affect-net size is 120GB) so it is nearly impossible to train a CNN model based on one of these datasets with the computational resources of your personal computer.

To overcome these problems, we resorted to this list of solutions:

1. Using only a sample of datasets.
2. Using online platforms that offer high computational resources available to use, such as
    a. Google Colab
    b. IBM Watson Studio
    c. AWS Amazon SageMaker

In the end, It was decided to use a sample of the Fer-2013 dataset with the following specifications:

1. This Fer-2013 dataset sample is available on Kaggle.com
2. The data consists of [48x48] pixel grayscale images of faces.
3. The data is available in (.csv) format
4. The data consists of 3 columns as follows,

a. **emotion:** index of emotion in current image
b. **pixels:** pixels values of current image
c. **usage:** current image belongs to one usage category of the following (Training, PublicTest, or PrivateTest)

5. The data cover seven emotions categories distributed as follows,

[Index]=	Emotion Category	Count
[0] =	Angry	4953
[1] =	Disgust	547
[2] =	Fear	5121
[3] =	Happy	8989
[4] =	Sad	6077
[5] =	Surprise	4002
[6] =	Neutral	6198

6. The faces have been automatically registered so that the face is more or less centered and occupies about the same amount of space in each image.

7. The data is split for usage as follows,

Split	Count
a. Training	28709
b. PublicTest (Valid)	3589
c. PrivateTest (Test)	3589

1.8. Emotions Classification Model

Now, we have chosen the CNN architecture of our model (VGG16). In addition to, providing a suitable dataset (Fer2013 Sample). Also, we have access to an online platform that offers computational resources that is fast enough to train our model (Google Colab).

Sum up all these sections together to finally build our "Emotion Classification Model" through the following steps:

1. Before training, we dropped unnecessary emotions categories such as,

[Index]=	Emotion Category	Count
[1] =	Disgust	547
[5] =	Surprise	4002

2. After that, we fix the data indices to be as follows,

[Index]=	Emotion Category	Count
[0] =	Angry	4953
[1] =	Fear	5121
[2] =	Happy	8989
[3] =	Sad	6077
[4] =	Neutral	6198

3. Extract `x_train, x_val, x_test, y_train, y_val, y_test`

4. Visualize sample of data,

Figure 19. Fer-2013 Dataset Sample

5. Convert `y_train, y_val, y_test` from simple categorical data (integer number from 0 to 4 represents the current emotion) to one-hot encoded categorical data (array of size equal to the number of categories, each element represent the state [0 or 1] of the emotion that corresponds certain index meaning the array has zero values for all elements except for the element that its index corresponds to current emotion).

6. Preprocess training data through,
    a. Normalization (rescale to 1/255)
    b. Data Augmentation (Horizontal Flip, Random Rotation by 10, Width Shift by 0.1, and Height Shift by 0.1)

7. Implement the VGG16 CNN model architecture.

8. Create a model instance then start training with the following specifications,
    a. Adam Optimizer (learning rate = 0.01)
    b. Categorical Cross-Entropy Loss
    c. Accuracy Metrics.
    d. Fitting to 60 Total Epochs.

9. Visualize Training Analysis through the epochs,

a. 20 Epochs

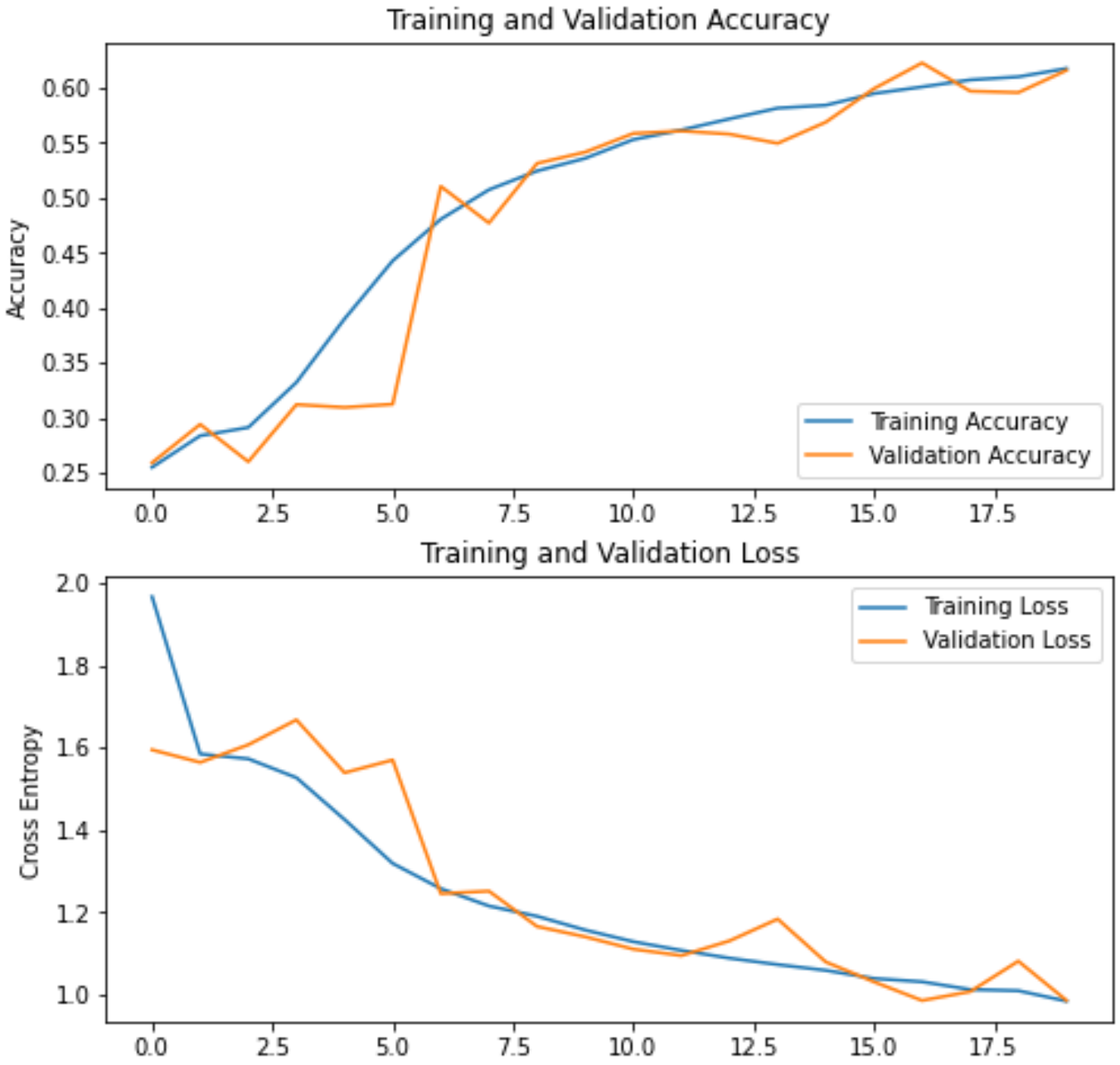


Figure 20. Model Training/Validation Loss & Accuracy through 20 epochs

b. 50 Epochs

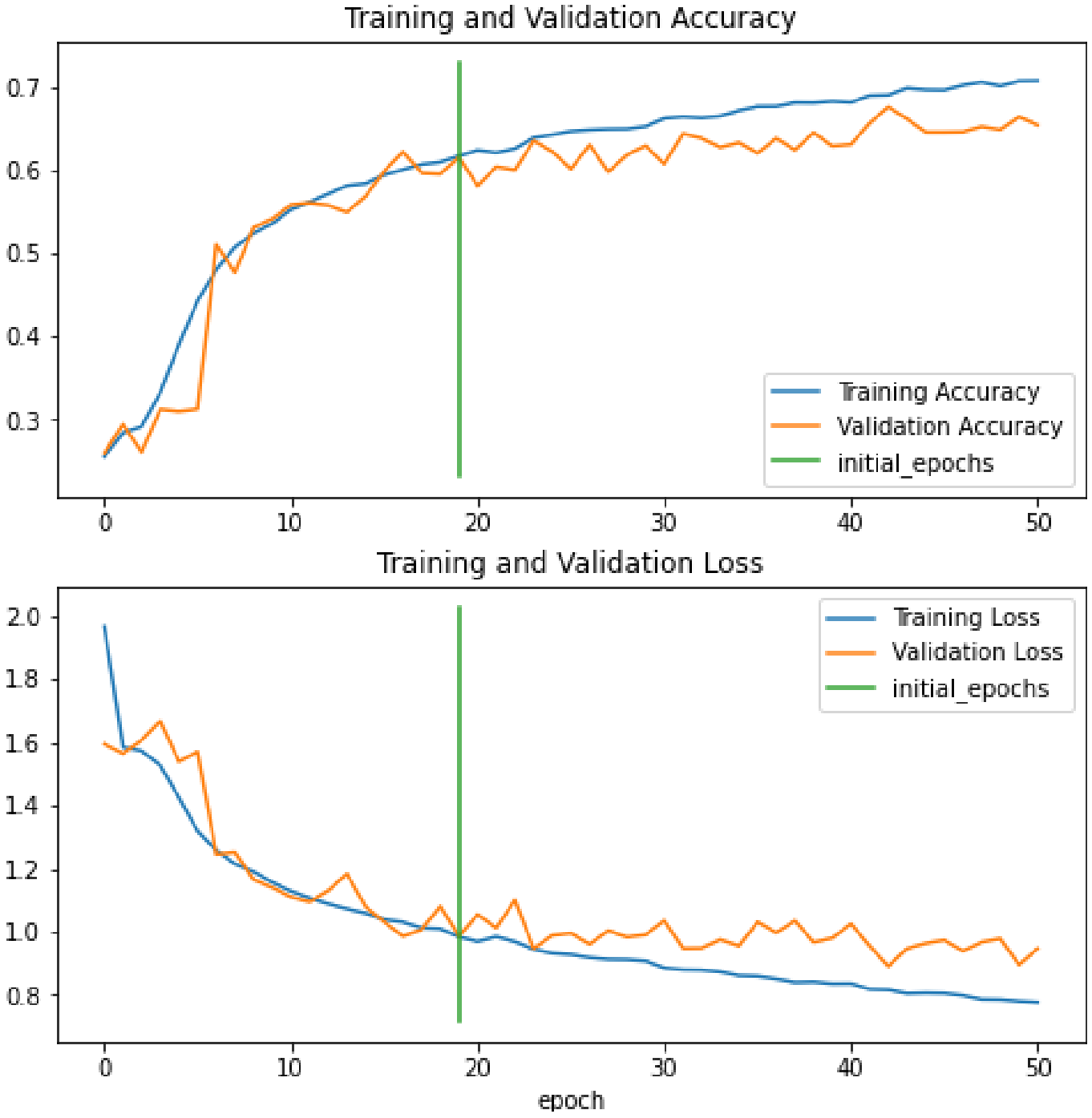


Figure 21. Model Training/Validation Loss & Accuracy through 50 epochs

c. 60 Epochs

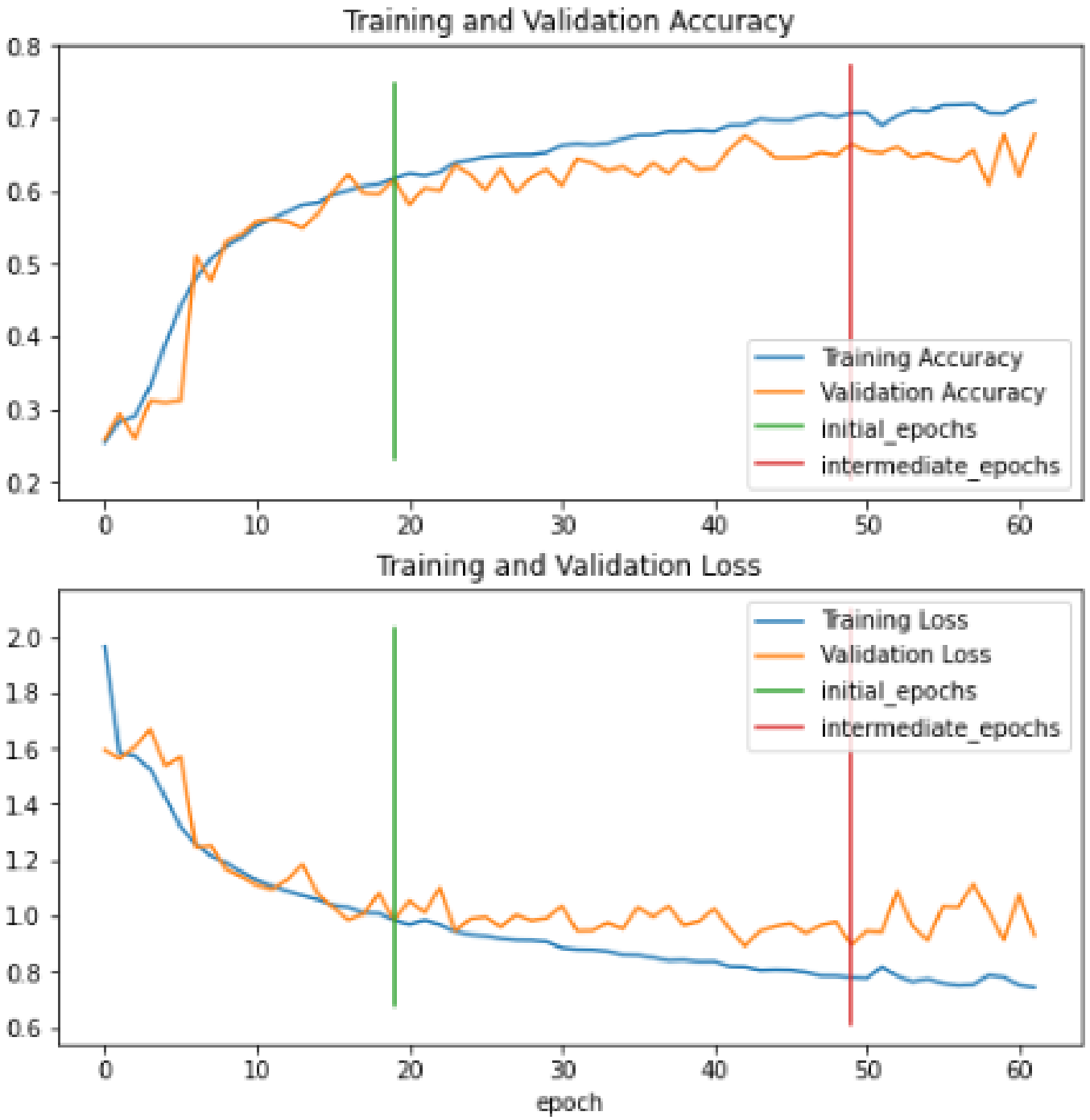


Figure 22. Model Training/Validation Loss & Accuracy through 60 epochs

10. Finally, our model achieved the following results,
    1. **Training** Accuracy = **[0.73]**
    2. **Validation** Accuracy = **[0.68]**
    3. **Testing** Accuracy = **[0.7]**

1.9. Model Inference

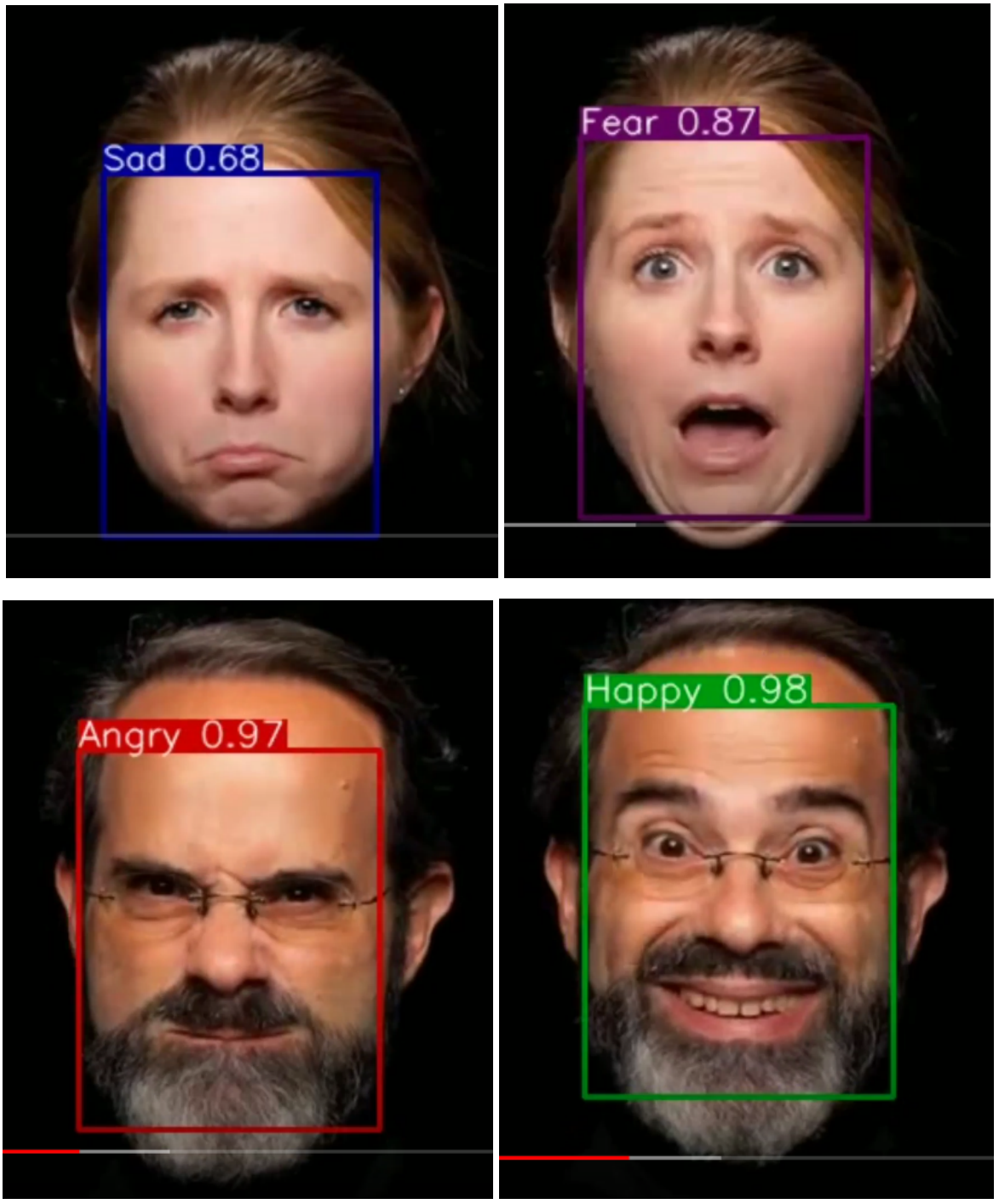


Figure 23. Emotions Classification Model Inference

2. Environmental Aware

The robot needs to be aware of the environment that surrounds him to be able to understand the child's behaviors and also to be able to take corresponding actions based on these behaviors.

The Environmental Aware system is built using the native python programming language.

Figure 24. Python Logo

The Environmental Aware system can be split into 2 sections of work as follows,

2.1. Recording Session Analysis

The time the child shall spend with the robot will be split into sessions, each session has the following details:

1. Start time.
2. End time.
3. Duration of 1 hour.
4. Activities made through the session:
    - 4.1. Puzzle Game
    - 4.2. Slicing Game
    - 4.3. Painter Mode
    - 4.4. Matching Game
    - 4.5. Animals Classification Lesson.
    - 4.6. Catch Angry Face Game
    - 4.7. Alphabets Lesson.

4.8. Colors Matching Lesson.
4.9. Maths Exercise.
4.10. Numbers Lesson.
4.11. Music Therapy Mode.
4.12. Listening to Music.
4.13. Play Music.
4.14. Listening to Story.

5. The child's emotional reaction to each activity and how these activities affect his mood and behavior during the session.

All these session details shall be written and saved locally as a (.json) file, then it will be posted to a database server that can store it and provides access to doctors or parents through the mobile application.

2.2. Intelligent Reflexes

To keep itself viable, the robot should be able to take certain actions based on the situation that found itself in.
Here is a list of actions that the robot is capable of taking and their corresponding situations,

Situation	Action
The child suddenly became angry!	The robot takes 2 steps backward.
The child seems sad.	The robot plays some joyful music.
The child looks fear of something.	The robot plays a relaxing voice.
The child has made a positive behavior such as winning a certain game, solving a puzzle, or finished listening to a story, music, etc...	The robot provides its support through positive lines to speak, such as Well Done, Great Job, You have Made It!, etc...

Also, the robot can be remote-controlled from the mobile app through the Bluetooth module integrated into the Raspberry Pi board.

3. Levi Chatbot

3.1. Objective

Parents of children with autism spectrum disorders (ASD) often report high levels of stress and mental health problems, associated with the challenges of caring for children with complex needs. The big challenges parents face are how to know more about ASD, deal with their child when behaving unusually, and help their child to get better in communication and their life.

The Levi Chatbot provides answers about ASD and offers some strategies and tips that can minimize this, such as:

- Teach the child about inappropriate behaviors as occasions arise, and show them what a better reaction looks like.
- Make an effort to catch them doing something good, and reward the child when they act appropriately or learn a new skill.
- Pay attention to the child's sensory sensitivities and Figure out what sights, sounds, smells, and movements.
- Use social stories, social stories can be a useful way of explaining how to manage anger.

The researchers also said that this can reduce stress for both parent and child, and it may turn a situation around.

3.2. Levi Chatbot Dataset

We created a custom dataset in JSON format. We defined a few simple intents and a bunch of messages that correspond to those intents and also map some responses according to each intent tag, this data contains the most important questions about autism that parents of

children with ASD need to know, as well as it contains tips about how parents can deal with children with ASD, Here is a sample of our data:

```
  {"tag": "4",
   "patterns": ["How you could help me?", "What you can do?",
    "What support is offered" ],
   "responses": ["I can guide you through your journey with your awesome
      child, and in knowing more about Autism, giving you useful tips"],
   "context_set": ""
},
  {"tag": "5",
   "patterns": ["What is Autism", "What is autism spectrum disorder"],
   "responses": ["Autism refers to a broad range of conditions characterized by
      challenges with social skills, repetitive behaviors, speech"],
   "context_set": ""
},
  {"tag": "6",
   "patterns": ["How is autism diagnosed", "Is there a test for autism"],
   "responses": ["There is no blood test to diagnose autism spectrum
     disorder. A diagnosis is made based on behaviors. In order to be
     diagnosed with autism, an individual must display deficits in social
     communication, and show restrictive and repetitive behavior" ],
   "context_set": ""
},
```

3.3. Natural Language Processing (NLP)

3.3.1. What is NLP?

Natural language processing (NLP) refers to the branch of computer science—and more specifically, the branch of artificial intelligence or AI—concerned with giving computers the ability to understand the text and spoken words in much the same way human beings can.

NLP drives computer programs that translate text from one language to another, respond to spoken commands, and summarize large volumes of text rapidly—even in real-time.

3.3.2. NLP tools and approaches

The Python programming language provides a wide range of tools and libraries for attacking specific NLP tasks. Many of these are found in the Natural Language Toolkit, or NLTK, an open-source collection of libraries, programs, and education resources for building NLP programs.

The **Natural Language Toolkit (NLTK)** includes libraries for many of the NLP tasks listed above, plus libraries for subtasks, such as sentence parsing, stemming and lemmatization, and tokenization.

3.4. Processing Data

When working with text data, we need to perform various preprocessing on the data before we make a machine learning or a deep learning model.

Tokenizing is the process of breaking the whole text into small parts like words. Here we iterated through the patterns and tokenized the sentence using `nltk.word_tokenize()` function and appended each word in the words list. We also create a list of classes for our tags. Then, we lemmatized each word and removed duplicate words from the list.

Lemmatizing is the process of converting a word into its lemma form and then we stemmed each word to convert each word to its root e.g. playing to play.

Stemming is a natural language processing technique that lowers inflection in words to their root forms, hence aiding in the preprocessing of text, words, and documents for text normalization and we used the `LancasterStemmer()` which is NLTK that implements the Lancaster stemming technique.

Lancaster Stemmer is straightforward, although it often produces results with excessive stemming. Over-stemming renders stems non-linguistic or meaningless.

3.5. Model Build

Keras model is a data structure about how we stack our neural network layers. We can stack our neural network layers mainly in three different ways

- Sequential.
- Functional.
- Subclass.

We used the **Keras sequential API** that allows you to create models layer-by-layer for most problems. It is limited in that it does not allow you to create models that share layers or have multiple inputs or outputs.

Sequential models are the machine learning models that have a linear stack of layers embedded with Keras where each layer has one input with Keras extended with tensor and similarly one output tensor. Sequential data includes text streams, audio clips, video clips, time-series data, etc. So, We used The sequential API because we are dealing with text data streams.

3.6. Sequential Model Architecture

Before we talk about the model details, we need to understand some concepts in deep learning

Dense Layer is a Neural Network that has a deep connection, meaning that each neuron in the dense layer receives input from all neurons of its previous layer.

Activation function in a neural network defines how the weighted sum of the input is transformed into an output from a node or nodes in a layer of the network. Activation functions serve two primary purposes:

- Help a model account for interaction effects.
- Help a model account for non-linear effects.

The softmax activation function is a mathematical function that converts a vector of numbers into a vector of probabilities which means that its output is a vector of values that sum to 1.0 and it is as follows

$$f = \frac{e^{x}}{sum(e^{x})}$$

Where x is a vector of outputs and e is a mathematical constant that is the base of the natural logarithm.

Rectified linear activation function, or ReLU is the most common activation function used for hidden layers because it is both simple and effective, The function returns 0 if it receives any negative input, but for any positive value x it returns that value back. So it can be written as $f = max(0, x)$, graphically it looks like the following figure

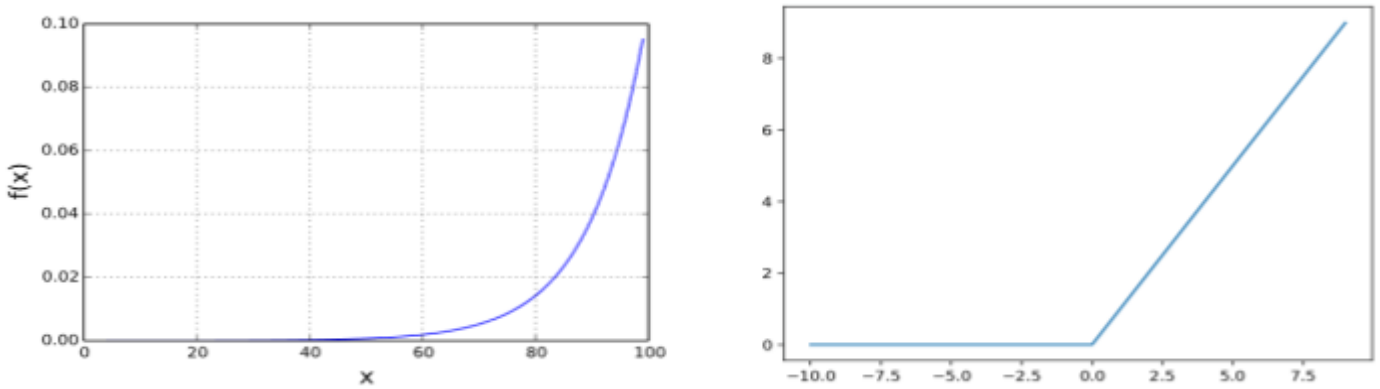


Figure 25. Softmax Vs ReLU Activations

Now, let us talk about our model structure that consists of 3 Dense layers. The first dense layer has **128 neurons** with **RELU** activation function. The second layer has **64 neurons** with also the **RELU** activation

function. The third layer which is the output layer has **128 neurons** with a **softmax** activation function which as discussed before the activation is 'softmax'. Softmax makes the output sum up to 1 so the output can be interpreted as probabilities. The model will then make its prediction based on which option has the highest probability. The following figure illustrated the model structure.

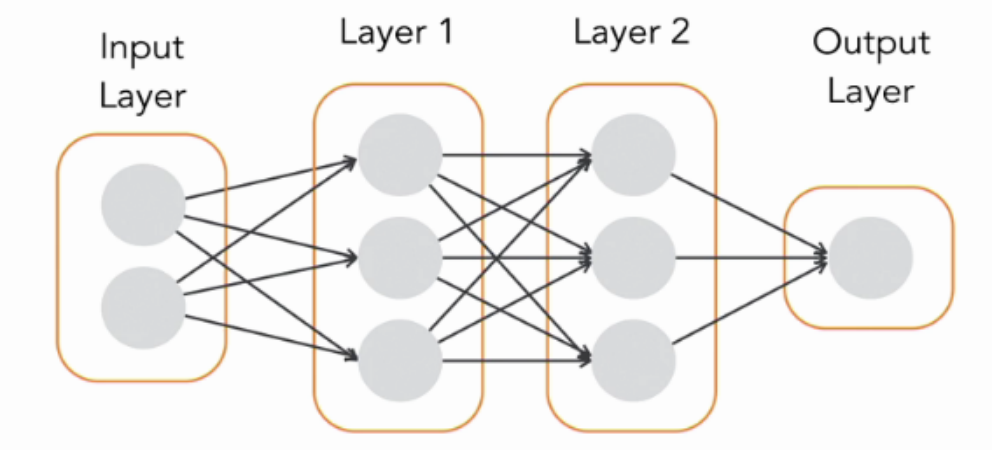


Figure 26. Model structure

After using `model.summary()` method that prints a useful summary of the model, which includes the Name and type of all layers in the model, the Output shape for each layer, ..etc.

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 128)               12544

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 64)                8256

 dropout_1 (Dropout)         (None, 64)                0

 dense_2 (Dense)             (None, 18)                1170

=================================================================
Total params: 21,970
Trainable params: 21,970
Non-trainable params: 0
```

Figure 27. Model Layers summary

3.7. Compiling Model

Next, we need to compile our model. Compiling the model takes three parameters: optimizer, loss, and metrics. The optimizer controls the learning rate. We used **'SGD'** as our optimizer. Stochastic gradient descent (SGD) with Nesterov accelerated gradient gives good results for this model with `learning_rate = 0.01`.

The learning rate determines how fast the optimal weights for the model are calculated. A smaller learning rate may lead to more accurate weights up to a certain point, but the time it takes to compute the weights will be longer. We used **'categorical_crossentropy'** for our loss function.

3.7.1. SGD Algorithm

SGD is a simple modification to the standard gradient descent where the weight matrix W is updated for a smaller batch of datasets instead of updating at the end of every epoch.

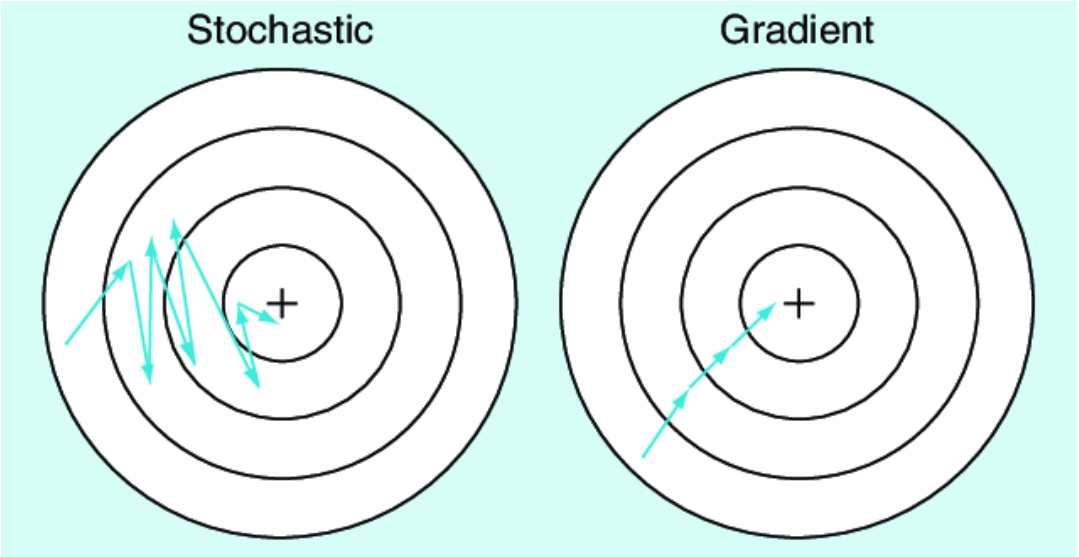


Figure 28. SGD Algorithm

The word ‘stochastic‘ means a system or process linked with a random probability. Hence, in Stochastic Gradient Descent, a few samples are selected randomly instead of the whole data set for each iteration.

Suppose, you have a million samples in your dataset.

In SGD, only one sample from the dataset is chosen at random for each iteration, and the path taken by the algorithm to reach the minima is usually noisier than your typical Gradient Descent algorithm. But that doesn’t matter all that much because the path taken by the algorithm does not matter, as long as we reach the minimum and with a significantly shorter training time.

3.7.2. Why we used SGD optimizer

In text classification based on SGD, The researchers reviewed the effectiveness of different learning approaches in text data and compared the performance of different SGD classifiers on four categories of newsgroup datasets. They proposed a plain stochastic gradient descent learning routine without mentioning the loss function, penalties, and other parameters' effect on the classification results in their designed experiment.

3.8. Model Training

To train, we will use the `fit()` function on our model with the following parameters: training data `np.array(train_x)`, target data `np.array(train_y)`, and the number of epochs.

3.9. Model Evaluation

After the first 50 epochs and after the 200 epochs, the model accuracy plots would be as shown in the following figures between 95% and 99%

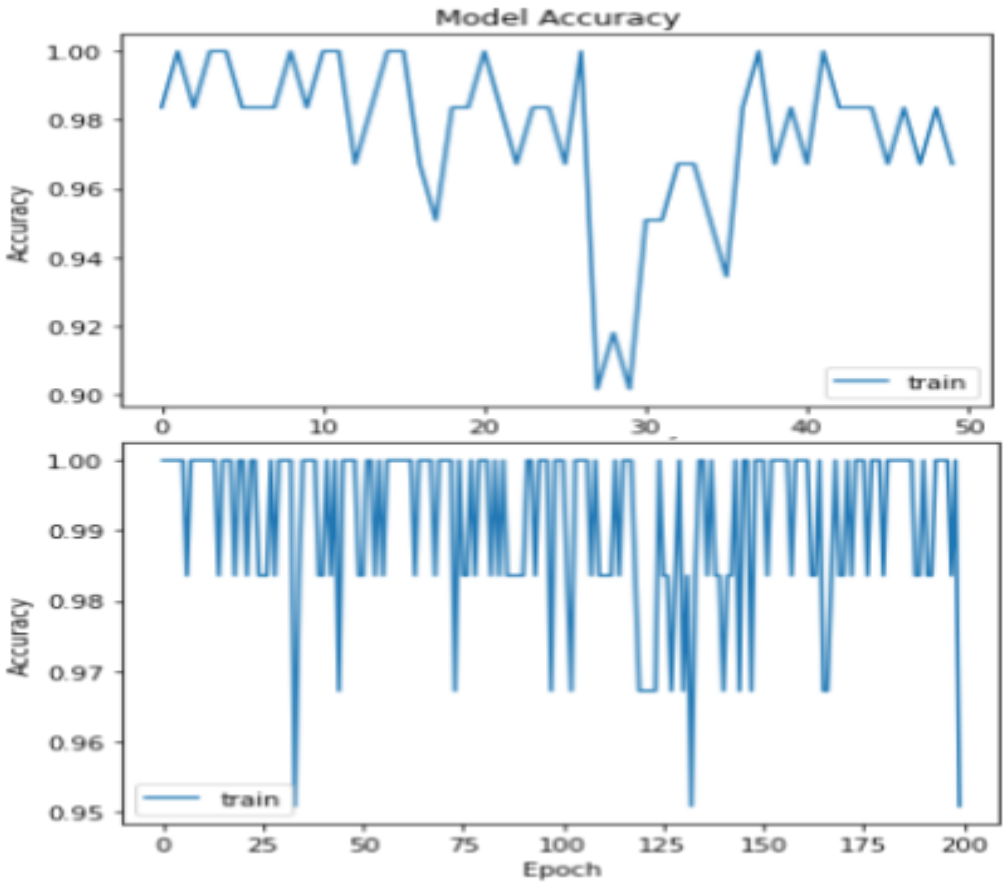


Figure 29. Levi chatbot Model Accuracy Plots

3.10. Model Inference

3.10.1. Bag of words

A bag-of-words, or BoW for short, is a way of extracting features from the text for use in modeling. A bag-of-words is a representation of text that describes the occurrence of words within a document. It involves two things:

- A vocabulary of known words.
- A measure of the presence of known words.

It is called a “bag” of words because any information about the order or structure of words in the document is discarded. The model is only concerned with whether known words occur in the document, not where in the document.

3.10.2. Testing Levi Chatbot Model

We can test the Levi chatbot by `response()` method that was discussed before. The following figures show different outputs for the method and it works well.

```
response('what is autism')
```

```
Autism refers to a broad range of conditions characterized by challenges with social skills, repetitive behaviors, speech
```

```
response('What is the cause of autism')
```

```
this time, there is no evidence that specific chemicals in the environment, immunization practices or dietary differences cause autism.
```

```
response('How can I help my child')
```

```
Create a private space in your home where your child can relax
```

```
response('tips')
```

```
If you are observant and aware, you can learn to pick up on the nonverbal cues that children with ASD use to communicate
```

Figure 30. Testing Levi Chatbot Response

4. Text-To-Speech

4.1. Objective

Among emerging techniques used in the treatment and education of people with autism, multisensory approaches are among the most popular, incorporated into a wide range of therapy plans and special education programs.

Most children with autism are visual learners. For this reason, visual teaching methods are often incorporated into a multisensory approach to learning., and augmentative picture communication cards can make this same verbal-visual connection. So, we needed the robot to speak in

order to teach the child a lot of important basic things such as the alphabet, numbers, colors, and animal names.

4.2. Technologies and Tools

4.2.1. Pyttsx

pyttsx is a cross-platform text-to-speech (TTS) library that is platform-independent and It is compatible with both Python 2 and 3.

4.2.2. why Pyttsx

It works offline, unlike other text-to-speech libraries. Rather than saving the text as an audio file, pyttsx actually speaks it there. This makes it more reliable to use for voice-based projects.

4.2.3. Pyttsx Usage

An application invokes the `pyttsx3.init()` factory function to get a reference to a `pyttsx3.Engine` instance. During construction, the engine initializes a `pyttsx3.driver.DriverProxy` object that is responsible for loading a speech engine driver implementation from the `pyttsx3.drivers` module. After construction, an application uses the engine object to register and unregister event callbacks; produce and stop speech; get and set speech engine properties.

Figure 31. Text-to-speech conversion using pyttsx3

Module 3: Hardware

1. Mechanical Design

In the field of mechanical design, various 3D design software can be used to deliver a well-described robot design carrying all the required details for electronic components.

Examples of 3D mechanical design software:

1. AutoCAD
2. Solidworks
3. CATIA
4. Unigraphics NX

2. SolidWorks

To deliver our design, we used SolidWorks.

Figure 32. Solidworks Logo

SolidWorks is an original 3D design software based on the Windows system. With its easy-to-use and friendly interface, SolidWorks can fully automatically capture design intent and guide design changes during the entire product design work. In the assembly design of SolidWorks, it can directly refer to the existing parts to generate new parts.

Final SolidWorks design that is delivered:

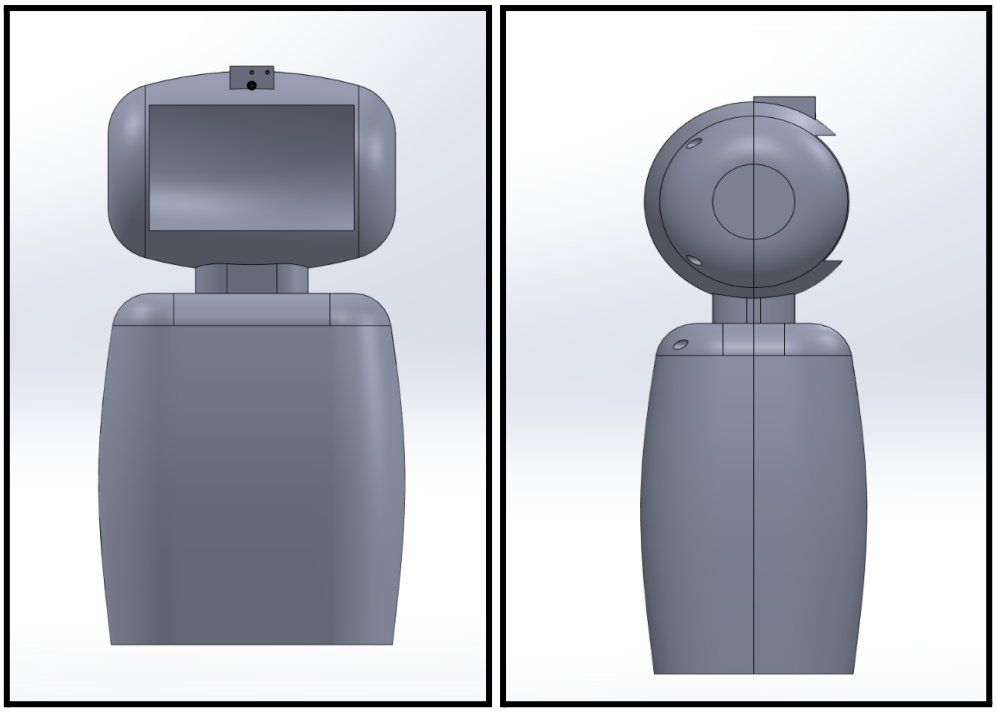


Figure 33. Solidworks Design

3. 3D Printing

The next step, after the SolidWorks design is ready, is to print the design through a 3D printer.

3D printing or additive manufacturing is making three-dimensional solid objects from a digital file.

This process has high accuracy and efficiency, so naturally, it would have high manufacturing costs. In addition to, using high-cost materials.

It costs [3 LE] to produce a [1 gram] using 3D printing.

It was found that the empty robot design (no components inside) weights [4 kilograms], which means it would cost [12,000 LE] to produce the whole robot design, and that number is not affordable by the project budget regardless of the cost of the other components that passed [6000 LE].

To overcome the 3D printing high-cost issue, we had to resort to another process to produce the robot design. This process is to use wood to build the robot body with a hand of a professional carpenter.

[Figure 38.] shows an approximate design of the robot body that was provided to the carpenter:

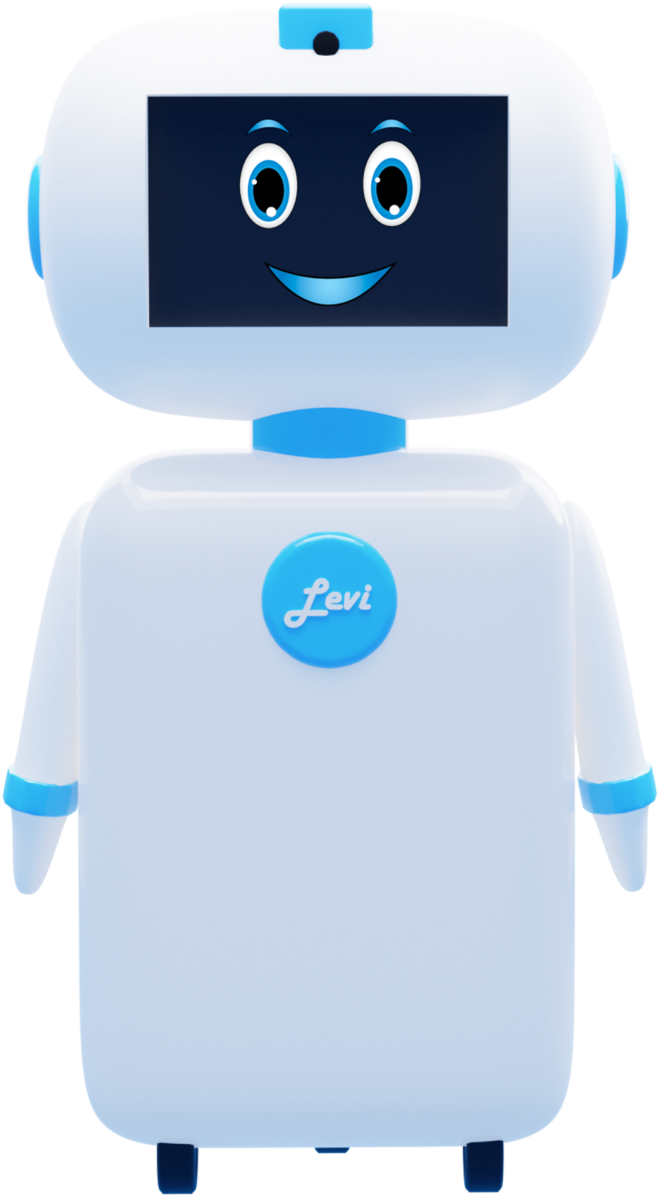


Figure 34. Robot Body Design

4. Hardware Block Diagram

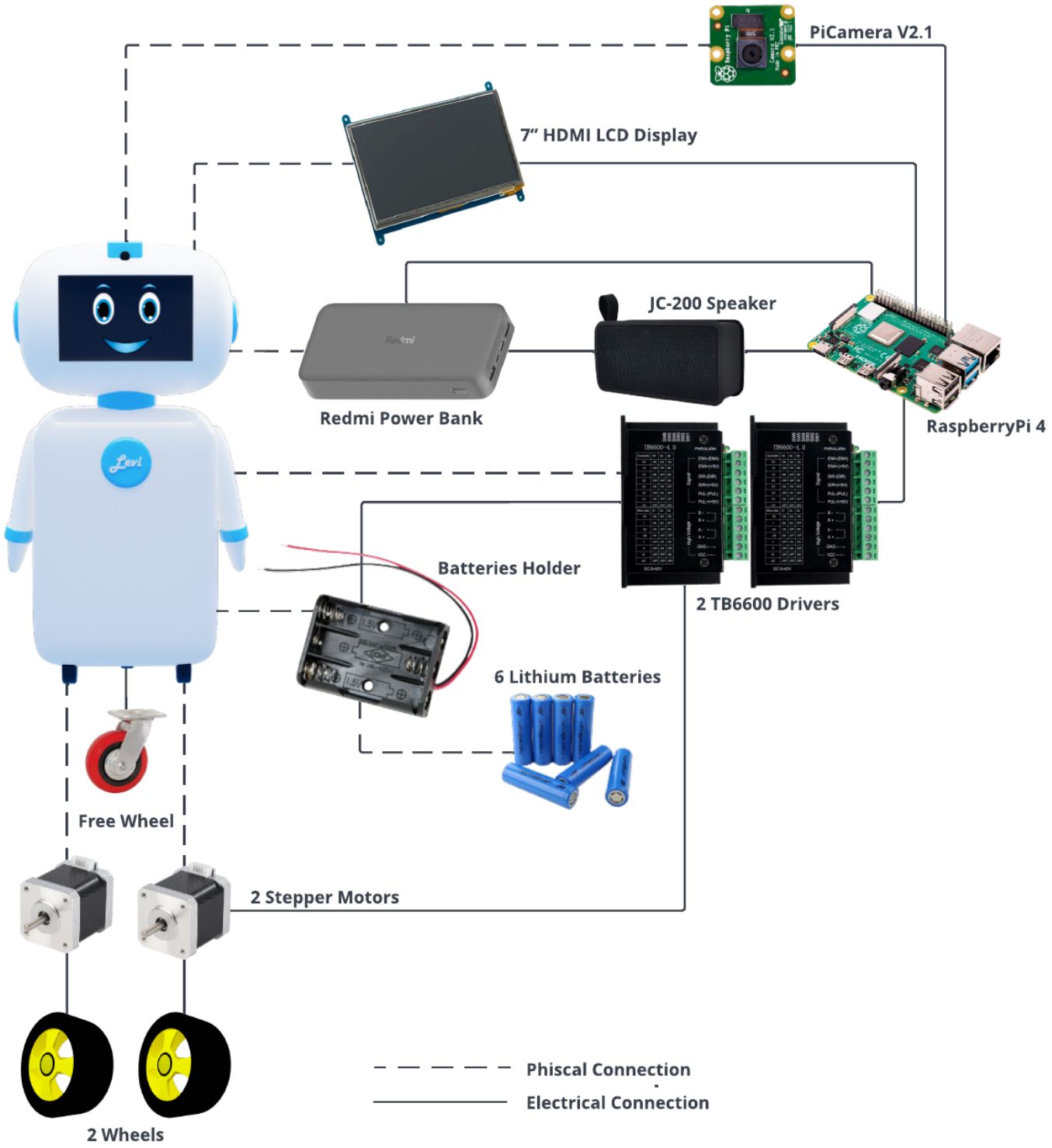


Figure 35. Hardware Block Diagram

5. Hardware Components

5.1. Raspberry Pi 4 [Model B]

Raspberry Pi is the most critical component of hardware that represents the embedded system or the mind of the robot.

The raspberry pi comes in two models, they are model A and model B. The main difference between model A and model B is the USB port. Model A board will consume less power and that does not include an Ethernet port. But, the model B board includes an Ethernet port and is designed in china.

Raspberry Pi contains the essential parts of any embedded system. In addition to
such as

1. CPU.
2. GPU.
3. RAM.
4. GPIO Pins.
5. UART.
6. Mass Storage (SD Flash Memory Card).

Raspberry Pi also provides so many interfaces for external devices that came up very useful to use during the robot build, such as

1. WiFi Module.
2. Bluetooth Module.
3. Camera Support.
4. HDMI LCD Screen Support.
5. Audio Support.
6. LAN Cable Support.
7. USB 2 Cable Support.

8. USB 3 Cable Support.
9. Power Source (Type C Port)

There are various Raspberry Pi versions with various specifications that were available to choose from for our robot requirements, such as

1. Pi Zero / Pi Zero W
2. Pi 1 Model (A/A+/B/B+)
3. Pi 2 Model (A/B)
4. Pi 3 Model (A/A+/B/B+)
5. **Pi 4 Model (A/B).**
6. Pi 400.

We choose the best version that is available in Egypt that is the **Raspberry Pi 4 Model B**. It came with the following specifications:

1. Broadcom BCM2711, Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
2. 8GB LPDDR4-3200 SDRAM.
3. 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
4. Micro-SD card slot for loading operating system and data storage

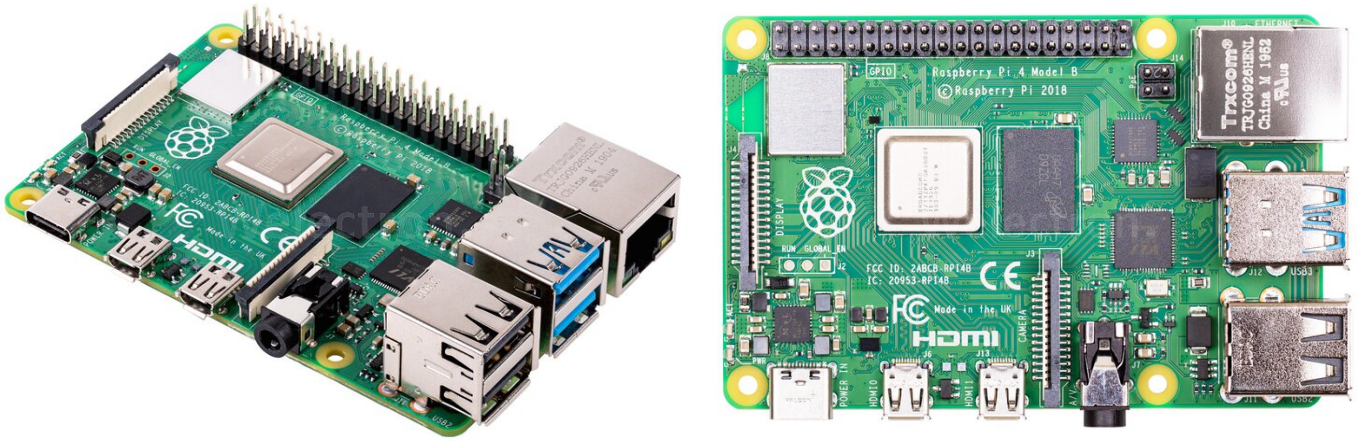


Figure 36. Raspberry Pi 4 Model B

5.2. Raspberry Pi Camera V2

The camera is the essential part of the robot's vision that the robot should be aware of the surrounding environment and physical interactions.

There were 3 available Raspberry Pi cameras to choose between that are,

1. Pi Camera v1 (5 Megapixels).
2. Pi Camera v2 (8 Megapixels)
3. HQ Camera (12.3 Megapixels).

We choose the Pi Camera v2 to use as the HQ Camera is not available in Egypt. It came with the following specifications:

1. Resolution: 8 Megapixels.
2. Video modes: 1080p30, 720p60 and 640 × 480p60/90
3. Sensor Resolution: 3280 × 2464 pixels

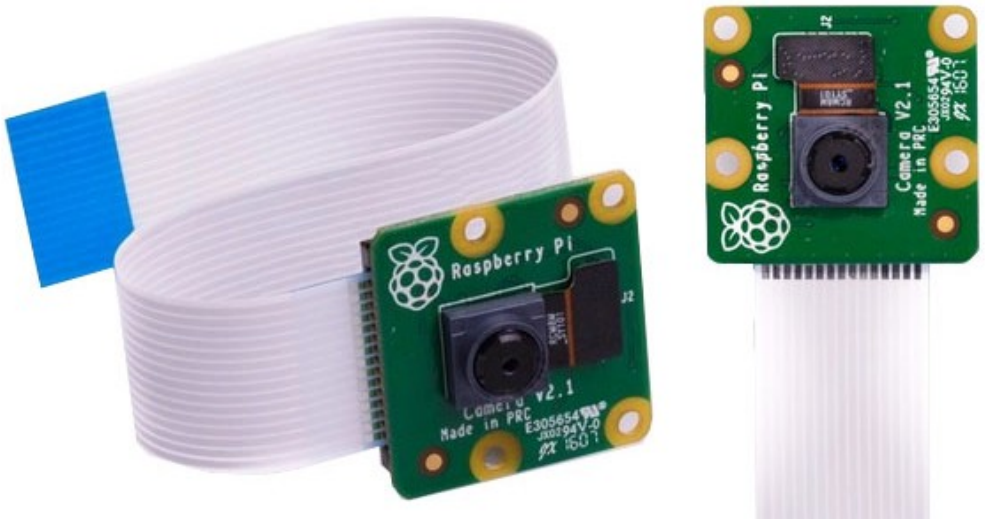


Figure 37. Raspberry Pi Camera V2

5.3. Raspberry HDMI LCD Touch Screen [7 Inches]

The robot would naturally have a display component to show its software application and to be able to interact with the user through touch, mouse, keyboard, or whatever accessory is connected.

Since the raspberry pi provides an HDMI port, any HDMI screen with any size, resolution, etc.. should be able to be attached to the raspberry pi and work as its display component.

Although any HDMI can be attached to the raspberry pi, there are HDMI screens that were designed to work efficiently with the raspberry pi, such as the one we choose, Raspberry Pi 7" HDMI LCD Display [1024*600]

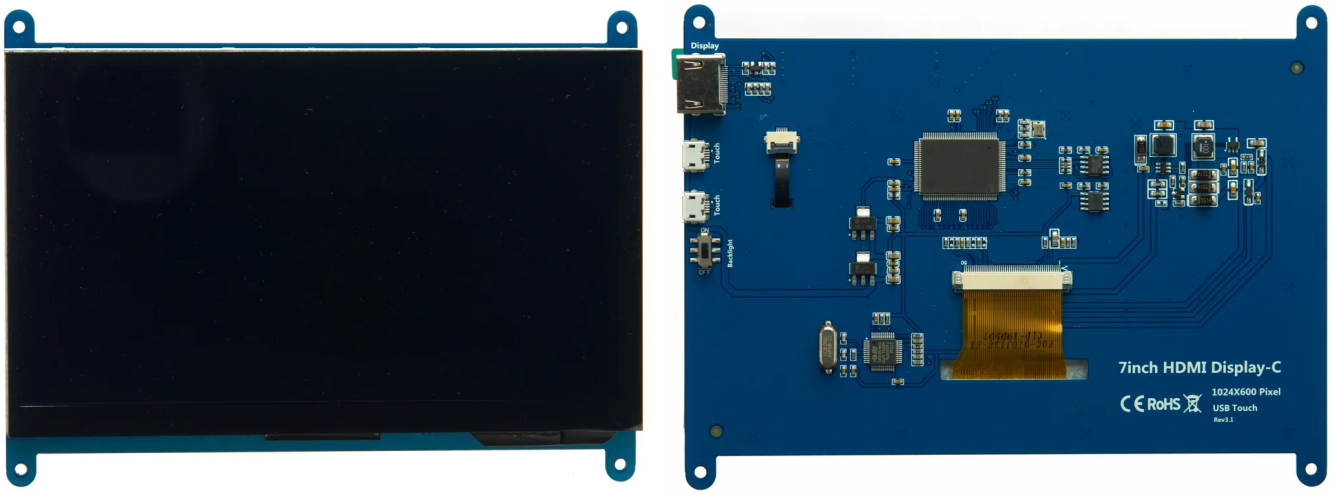


Figure 38. Raspberry Pi 7" HDMI LCD Display

5.4. Redmi Power Bank [20,000mAh]

The robot mandatorily needs an independent power source with a large enough capacity.

There were various options to choose from but in the end, we finally stick with this Redmi power bank with specifications as follows,

1. High capacity of [20,000 mAh]
2. Two input ports [USB-C & Micro-USB]

3. Lithium-ion polymer battery.

Figure 39. Redmi Power Bank [20,000mAh]

5.5. JC-200 Sound Speaker

A simple sound speaker is required to output the robot voice and software sound/voice interactions.

There were various options to choose from but in the end, we finally stick with this JC-200 speaker with specifications as follows,

1. Bluetooth Module.
2. Transmission Distance: 10m
3. Battery Capacity: 400mAh
4. Charging Time: 2-4 hours.

Figure 40. JC-200 speaker

5.6. NEMA 17 Stepper Motors

Naturally, The robot should be able to move, manually or when it has to take certain actions based on the situation.

For robot movement, we choose to use the NEMA 17hs4401 stepper motors.

Electrical Specification:

1. Motor Type: Bipolar Stepper
2. Step Angle: 1.8 deg.
3. Holding Torque: 40N.cm (56oz.in)
4. Rated Current/phase: 1.7A

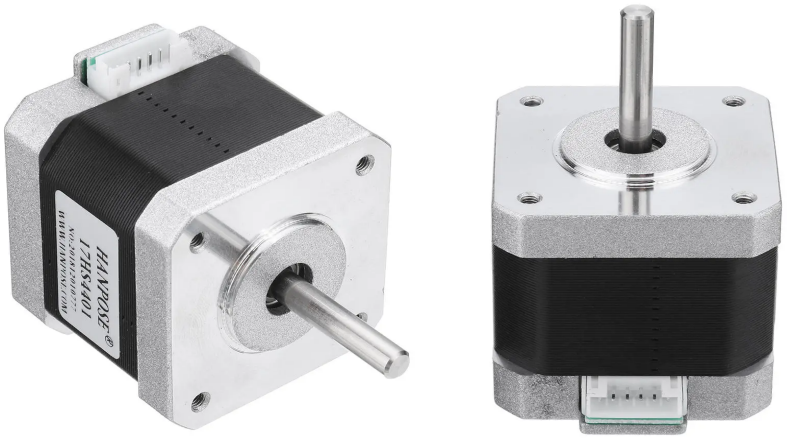


Figure 41. NEMA 17hs4401 Stepper Motor

5.7. Two Wheels + Free Wheel

Robot also needs 2 wheels to attach to the stepper motors. In addition to a freewheel to balance the movement.

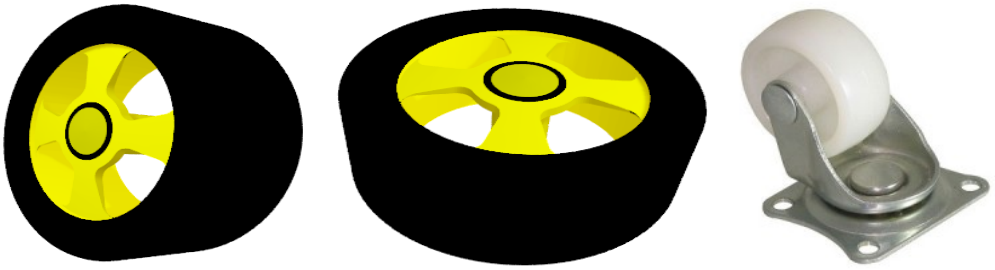


Figure 42. Two Wheels + Free Wheel

5.8. TB6600 Stepper Motor Drivers

To control the steps, microsteps, volts, amps, coils, etc... of a stepper motor, a TB6600 driver is required.

TB6600 Specifications:

1. Input Supply Voltage: 9 ~ 42 VDC
2. Supply Current: 0 to 5 Amp
3. Max. Output Current: 3.3 to 24 Amp
4. Max Power Output: 160 W
5. Micro Step: 1, 2A, 2B, 8, 16, 320

Figure 43. TB6600 Stepper Motor Drivers

5.9. Two Lithium Batteries [n=3] Holders = 6 Batteries

Since the TB6600 driver required a high input supply voltage (9 ~ 42 VDC) and high supply current (0 to 5 Amp) that cannot be supported by the Redmi power bank, we resort to using 6 lithium batteries to provides the electrical input requirements of the TB6600 drivers.

Figure 44. Two Lithium Batteries [n=3] Holders = 6 Batteries

6. Robot Parts Costs

#	Part	Cost
1	Robot Body	2000 LE
2	Raspberry Pi 4 [8GB RAM] + Case + Charger	2150 LE
3	Raspberry Pi Camera V2	850 LE
4	Raspberry Pi LCD HDMI Touch Screen [7 Inch]	1350 LE
5	Memory Card [64 GB]	130 LE
6	Camera Cable [Long]	30 LE
7	Sound Speaker	200 LE
8	2 Nema 17 Stepper Motors [1 = 250 LE]	500 LE
9	2 TB6600 Stepper Motor Drivers [1 = 250 LE]	500 LE
10	Redmi Power Bank [20000mA]	420 LE
11	2 Wheels + Shaft	170 LE
12	Free Wheel	25 LE
Total Robot Cost		**8325 LE**

Module 4: Backend

1. What is Backend?

Backend development languages handle web application 'behind-the-scenes' functionality. The code connects the web to a database, manages user connections, and runs the web application. Backend development collaborates with front-end development to deliver the final product to the end-user.

An application generally has two parts. The frontend and the backend. Many people fail to understand the concepts due to a lack of clarity. So, let's take an analogy, suppose you are sitting in a car and the basic things that you can see and use are the brakes, clutch, accelerator, gear, etc. These are called the frontend components through which you can interact with the car. But, when you use any of these, there is a series of actions happening behind the scenes which you are not aware of. This is known as the backend. In the same way in any Web App, you are able to interact with the frontend but the processing of your request is done at the backend. Backend is basically the server-side architecture of the web.

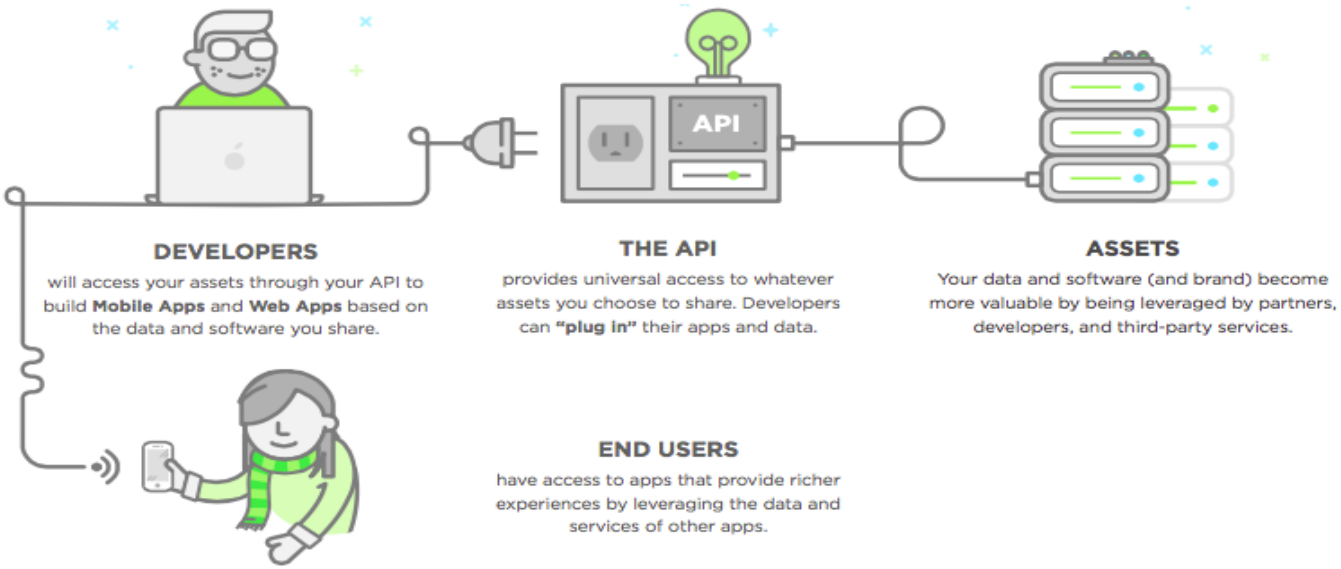


Figure 45. Backend Cycle

Robot system backend is split into two parts:

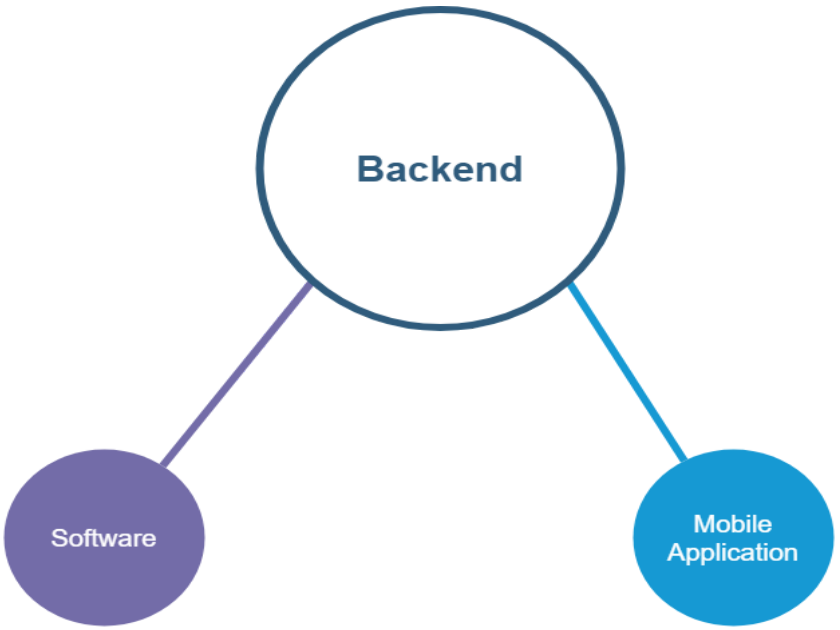


Figure 46. Robot System Backend

1.1. Software System Backend

It's responsible for managing data by the CRUD operations that exist to access and modify the data of the software. Software data like assets are stored on the server to be easier for adding/deleting or changing their content of it. Simply all this is done on the server and can be controlled remotely that is the case.

1.2. Mobile Application Backend

All mobile application services are done by the backend server, which includes every detail that exists in the mobile application, from the connection between parent and robot passing to the connection with parents/doctors. The entire community is managed and handled over the server.

2. Components of a Backend

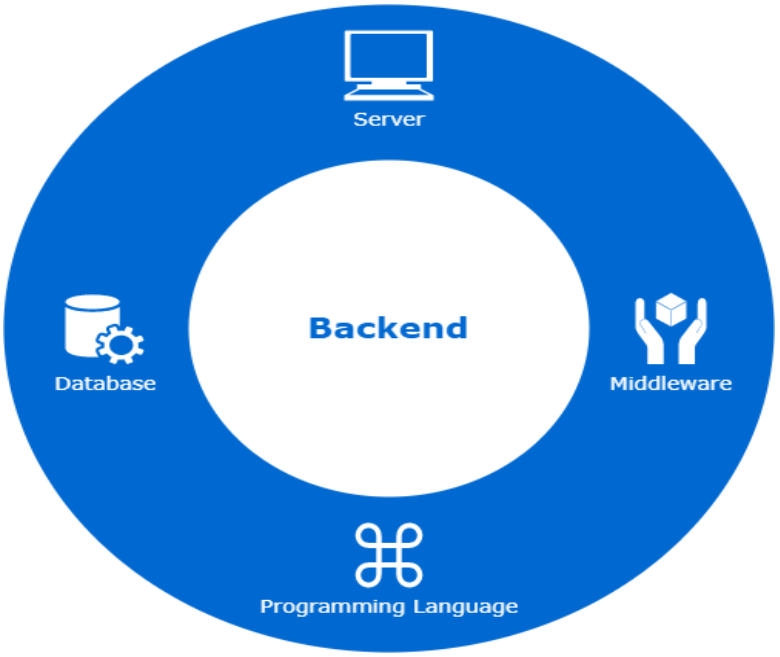


Figure 47. Backend Components

2.1. Server

Server is the place where the backend is stored and run. These are high-powered computers that provide resources that the backend needs i.e. file storage space, processing power, security and encryption, databases, and other web services.

2.2. Database

Database is the brain of any Website that makes it dynamic. If you are searching for anything on a website be it a profile on any social media or any product on an E-commerce website it is the role of a database to take the query and fetch the required data to the user.

2.3. Middleware

Middleware is any software (Server-side) that facilitates the connection between the frontend and the backend. It acts as a medium that takes

requests from the user and provides it to the backend and then facilitates the user with a response given by the backend.

2.4. Programming Languages and Frameworks

There is a variety of languages available in which the backend can be coded however, the language is chosen based upon the usage because of the difference in their performance, memory usage, compatibility, etc.

3. Environment used for Robot Backend

[Figure 48] shows the components of the environment that was chosen to use to build our Robot Backend system.

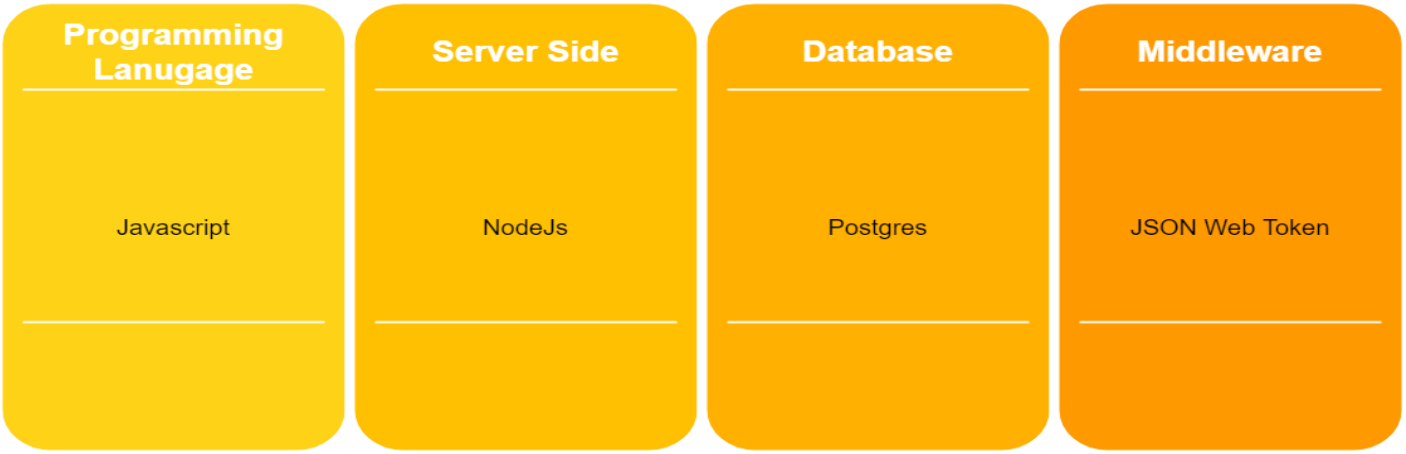


Figure 48. Robot Backend Environment

3.1. JavaScript

JavaScript is a very powerful client-side scripting language. JavaScript is used mainly for enhancing the interaction of a user with the webpage. In other words, you can make your webpage more lively and interactive, with the help of JavaScript. JavaScript is also being used widely in game development and Mobile application development.

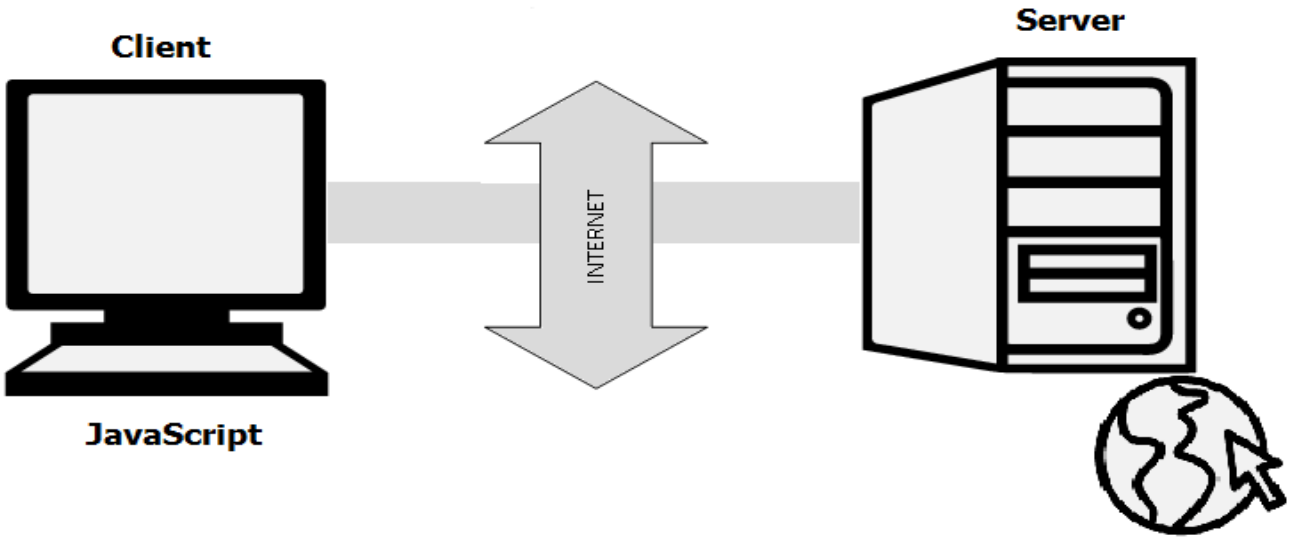


Figure 49. JavaScript Client-Server

3.2. Node.js

Node.js is a server-side, packaged software that contains predefined processes to accomplish specific tasks.

As a server-side runtime, every Node.js process is executed on a server; essentially working on the backend aspect of an application to manage data. For instance, if you wanted to store some data in a file or a database, you'd need to employ the use of a server-side language or application. Node.js is labeled as a JavaScript run-time environment because it uses JavaScript to conduct backend processes.

3.3. How Node.js Works?

Node.js is built on the V8 JavaScript engine, which is used to compile and execute JavaScript source code. So when you execute a JS script using Node.js, that code is initially passed to the V8 JavaScript engine. The V8 JavaScript engine then compiles the script and passes the result of the compilation back to Node.js where it can be used in the application.

3.4. REST APIs

REST stands for Representational State Transfer. It is a set of protocols that describe how communication should take place between the computers and other applications across the network. To have a clear understanding let's take the car example again. Suppose you want to drive a car so you know that you have to use the accelerator, clutch, etc. to drive it. In the same way, suppose a Web App wants to communicate to a Web Server. So, a Rest API uses GET, POST, PUT, and DELETE methods to communicate. Therefore, we can conclude that REST is an architectural style for designing network applications. It uses simple HTTP methods to communicate between clients and servers. But it should be noted that HTTP and REST are not the same.

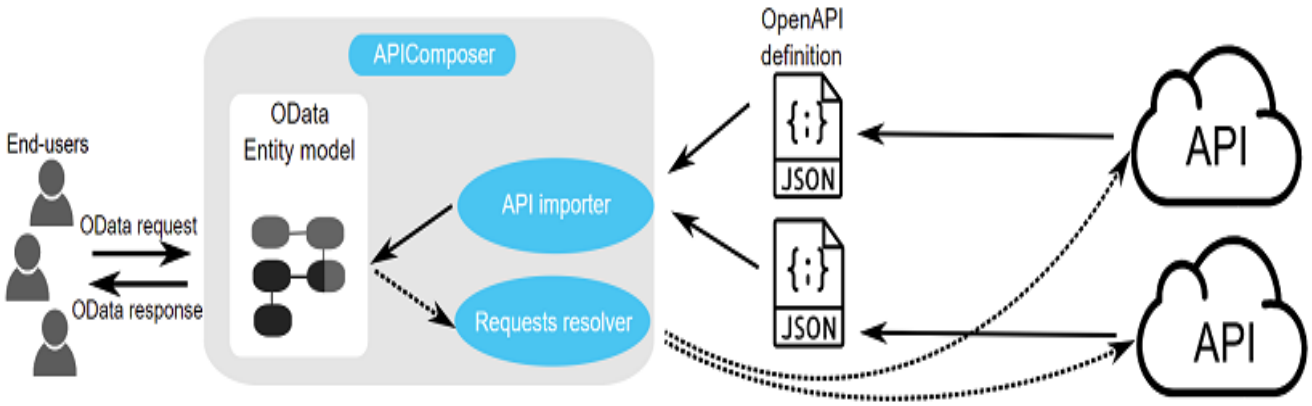


Figure 50. Rest APIs Network

REST API is known to us as a state of rules that developers follow when they create their API. One such rule says that we should be able to attain a specification when we link to a specific URL. This URL is a locator that when browsed generates a request and the specification it gets is called a response.

3.5. REST API Request

[Figure 51] shows REST API main parts,

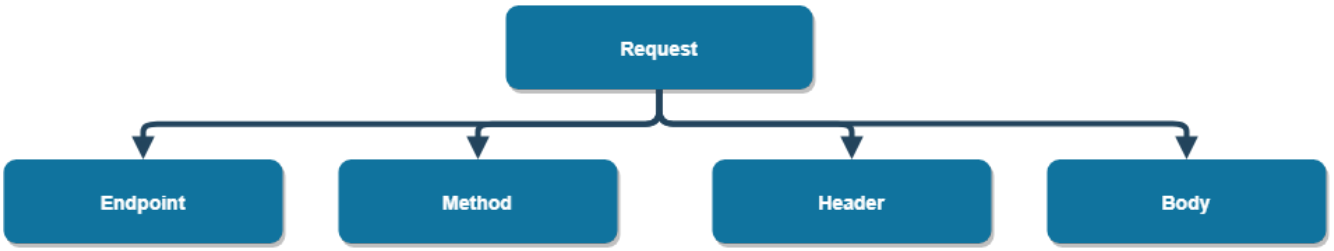


Figure 51. REST API Main Parts

3.5.1. Endpoint

The end point or the route is the URL we have requested for is structured as follows:

root- endpoint/?

This is usually the starting point of the API we are requesting from, and the corresponding path determines the resource you're requesting for. For eg: https://api.github.com, https://api.twitter.com

Let us assume we want to get a list of repos from a Github account of a user, through the Github API. Github documentation asks us to use the following path:

/ users / : username/ repos

Colons (:) on a path denotes a variable, these variables are replaced with their values. Eg. :username :username is replaced with the username of my Github account Developer Abhirupa. So, in order to avail all my repos from GitHub, the endpoint/ route will be:

https://api.github.com/users/DeveloperAbhirupa/repos

The final part of an endpoint is the query parameter. The query parameter allows us to modify our request with key-value pairs. They start with a '?' and each parameter pair is separated with an '&'.

3.5.2. Method

The method defines the type of request that is sent to the server. There are 5 types of methods:

- **GET:** GET request is used to obtain a resource from a server. On performing a GET request, the server looks for the data that has been requested and sends it back to us
- **POST:** A POST request creates a fresh entry onto the database and reverts back to us telling us whether the reaction of the entry has been successful or not.
- **PUT/PATCH:** These requests are used to update resources on the server.
- **DELETE:** This request deletes a resource from the server.

3.5.3. Headers

Header are used to provide information to both the client and the server and used for authentication, and also, may hold content about the body. It is a component of a network packet, sent by either the browser or a client, requesting for a specific resource.

An HTTP request header allows us to access the website. When we try to access a particular website, the HTTP request header is generated an correspondingly sent to the webiste, containing information mostly in the form of plain text, about the request made by the user. In response to the request, the web server sends back an HTTP.

3.5.4. Body

The data or the body consists of the message we want to send to the server.

3.6. PostgreSQL

Figure 52. PostgreSQL Logo

PostgreSQL is an open-source relational database management system (DBMS) developed by a worldwide team of volunteers. PostgreSQL is not controlled by any corporation or other private entity and the source code is available free of charge. PostgreSQL is an advanced, enterprise-class, and open-source relational database system. PostgreSQL supports both SQL (relational) and JSON (non-relational) querying.

3.7. JSON Web Token

JSON Web Token (JWT) is an open standard (RFC 7519) that defines self-contained way for securely transmitting information between parties as a JSON object. This information can be verified and trusted because it is digitally signed. JWTs can be signed using a secret with the HMAC algorithm or a public/private key pair using RSA or ECDSA.

Although JWTs can be encrypted to also provide secrecy between parties, we will focus on signed tokens. Signed tokens can verify the integrity of the claims contained within it, while encrypted tokens hide those claims from other parties. When tokens are signed using public/private key pairs, the signature also certifies that only the party holding the private key is the one that signed it.

4. Design Pattern Used: MVC Architecture

The MVC architecture pattern turns complex application development into a much more manageable process. That's why it's used on the backend.

MVC stands for model-view-controller. Here's what each of those components means:

- Model: The backend that contains all the data logic
- View: The frontend or graphical user interface (GUI)
- Controller: The brains of the application that controls how data is displayed

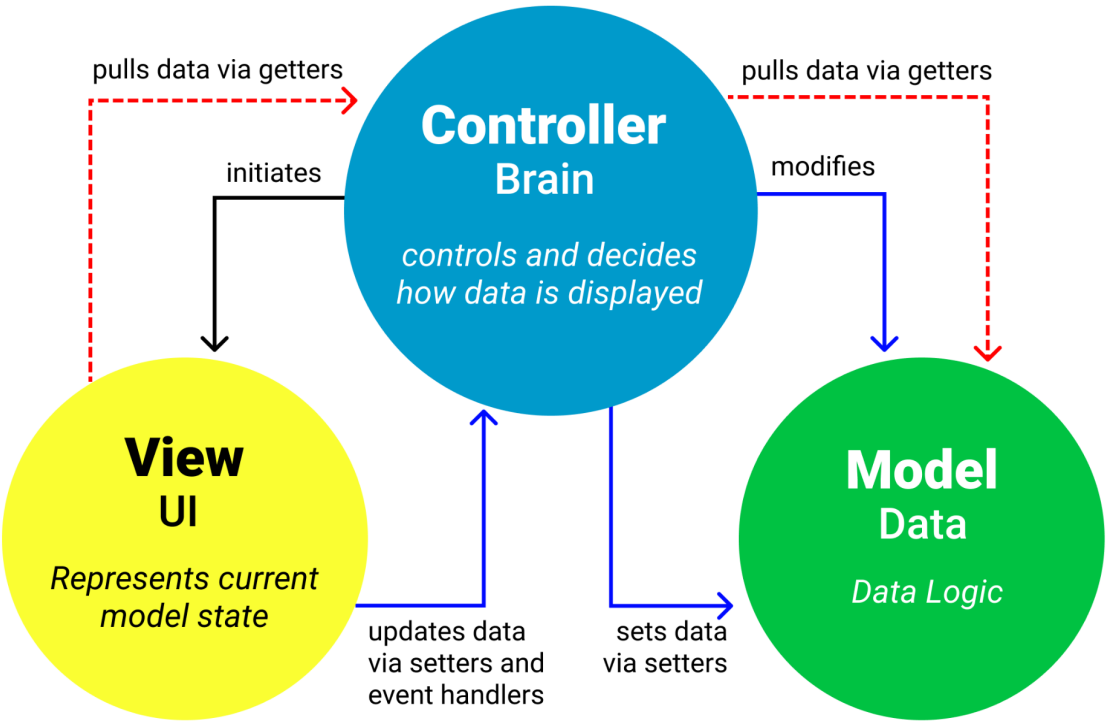


Figure 53. MVC Architecture Pattern

The MVC pattern helps you break up the frontend and backend code into separate components. This way, it's much easier to manage and make changes to either side without them interfering with each other.

5. Server Deployment

Server is deployed via Heroku which is a cloud platform as a service (PaaS) supporting several programming languages. One of the first cloud platforms, Heroku has been in development since June 2007, when it supported only the Ruby programming language, but now supports Java, Node.js, Scala, Clojure, Python, PHP, and Go. For this reason, Heroku is said to be a polyglot platform as it has features for a developer to build, run and scale applications in a similar manner across most languages.

5.1. Server Upload and Running:

The server is running on https://levi-robot1.herokuapp.com/

```
2022-07-02T23:45:32.987221+00:00 heroku[web.1]: State changed from
down to starting
2022-07-02T23:45:35.522855+00:00 heroku[web.1]: Starting process with
command `node src/index.js`
2022-07-02T23:45:37.831918+00:00 app[web.1]: starting app on:
http://localhost:24945
2022-07-02T23:45:38.307387+00:00 heroku[web.1]: State changed from
starting to up
```

Here is an example of a response for getting a post by ID (https://levi-robot1.herokuapp.com/api/posts/36) [GET]


```
{   "status": "success",
    "code": 200,
    "message": "Post fetched successfully",
    "data": { "user_id": 500,
              "profile_image":
"https://res.cloudinary.com/dqhxoyoqc/image/upload/v1656788443/Cloud
inaryDemo/naidr36tku29anpzhzzv.png",
        "full_name": "mohab",
        "post_id": 36,
        "body": "New Post from clouding",
        "created_at": "2022-07-02T18:59:20.998Z"
    }
}
```

6. Levi Chatbot backend

6.1. Flask

Flask is a micro web framework written in Python and used in the backend. it does not require particular tools or libraries. Applications that use the Flask framework include **Pinterest** and **LinkedIn**.

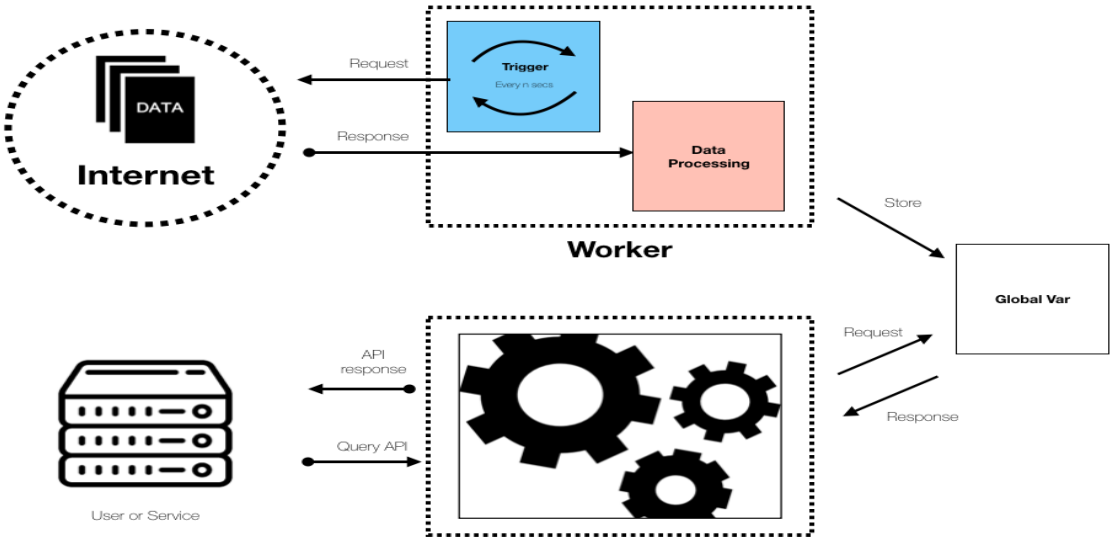


Figure 54. Working with Flask Framework

6.2. Post Request

In web services, POST requests are used to send data to the API server to create or update a resource. The data sent to the server is stored in the request body of the HTTP request.

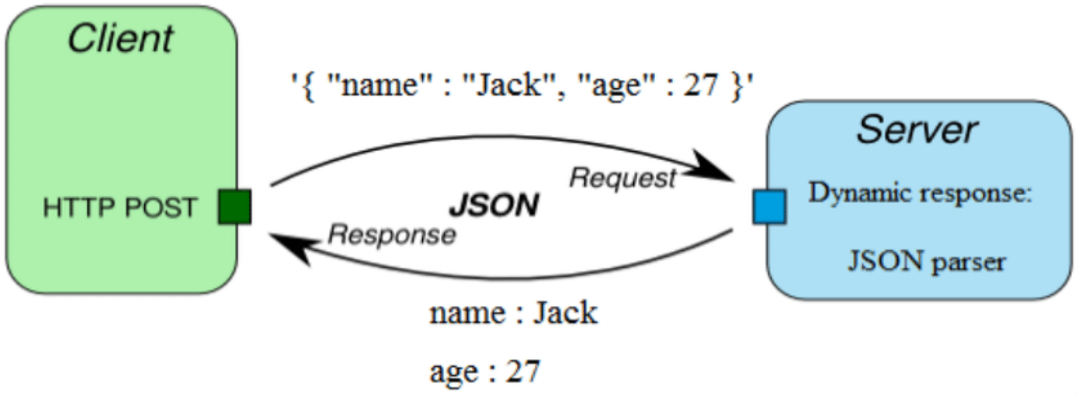


Figure 55. POST Request Example

6.3. Levi Chatbot API

We used the Flask framework which is discussed previously to create the Levi chatbot backend, The scenario will be as follows, the user of the chatbot will send his message and it will be sent as a POST request to the server in JSON format and the model will output the response through server and sent it to the user.

6.4. Testing Levi chatbot API

After deploying the server via Heroku, we tested it on Postman as follows which the server is running on [https://levi-chatbot.herokuapp.com/]

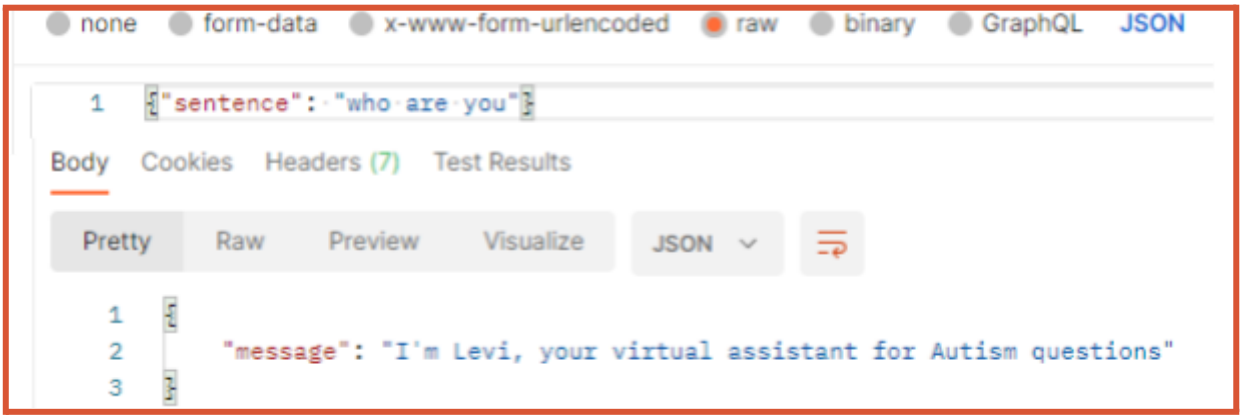


Figure 56. Levi Chatbot API Testing

Module 5: Mobile Application

1. App Plan

In our project, we want a way for both parents and doctors to communicate with each other and also to make it easy for the doctor to follow up on his patient's conditions. so, we made this application for these main features.

In the planning for this application, we started with the basic concept that we want for this app which is how to make a better way for the doctor to see the analysis of the child from his robot and also how to make a better way for both parents and doctors to communicate with each other.

We followed some steps to make this mobile application:

The first step, we identified the problems that we want to solve with our app. and the way that we decide to solve each problem.

1.1. Parent Perspective

Problem	Solution
We want the parent to communicate with the doctor easily	We decided to make a community to make it easy for the parent to deal with the doctor and also to communicate with other parents that have children with autism.
We want the parent to set the alarm for his child sessions	We decided to make an alarm page so the parent can set an alarm to his child sessions.
We want the parent to control the robot movement.	We decided to make a section called robot controller which helps the parent to control the robot movement using bluetooth which can

	connect easily with the robot and send commands to it and also receive data from it.
If the parent doesn't know how to deal with his child	We decided to make a chatbot for the parent so he can easily ask for some tips to deal with his child and it will help him.

1.2. Doctor Perspective

Problem	Solution
A way for the doctor to follow up with the child.	We decided to make an easy way for the doctor to follow up with the child by linking the doctor with the parent that is already linked with the robot, so the doctor can see the analysis of the child directly in his phone.
We want the doctor to communicate with the parents easily	We decided to make a community to make it easy for the doctor to communicate with the parents.

In the second step, we made the software diagrams that help us to determine each and every part in the app like [flowchart].

After this step, we start with the UI & UX of the app. To start with this step we used an Adobe xd [A program made by Adobe that helps to make wireframes and UI designs for mobile apps, web apps, and desktop apps].

Figure 57. Adobe xd Logo

After finishing the UI, We started to code this UI, and then we built the business logic for each page in the app and also connected with the APIs, all of this using Flutter Framework.

2. Mobile Application Architecture Diagram

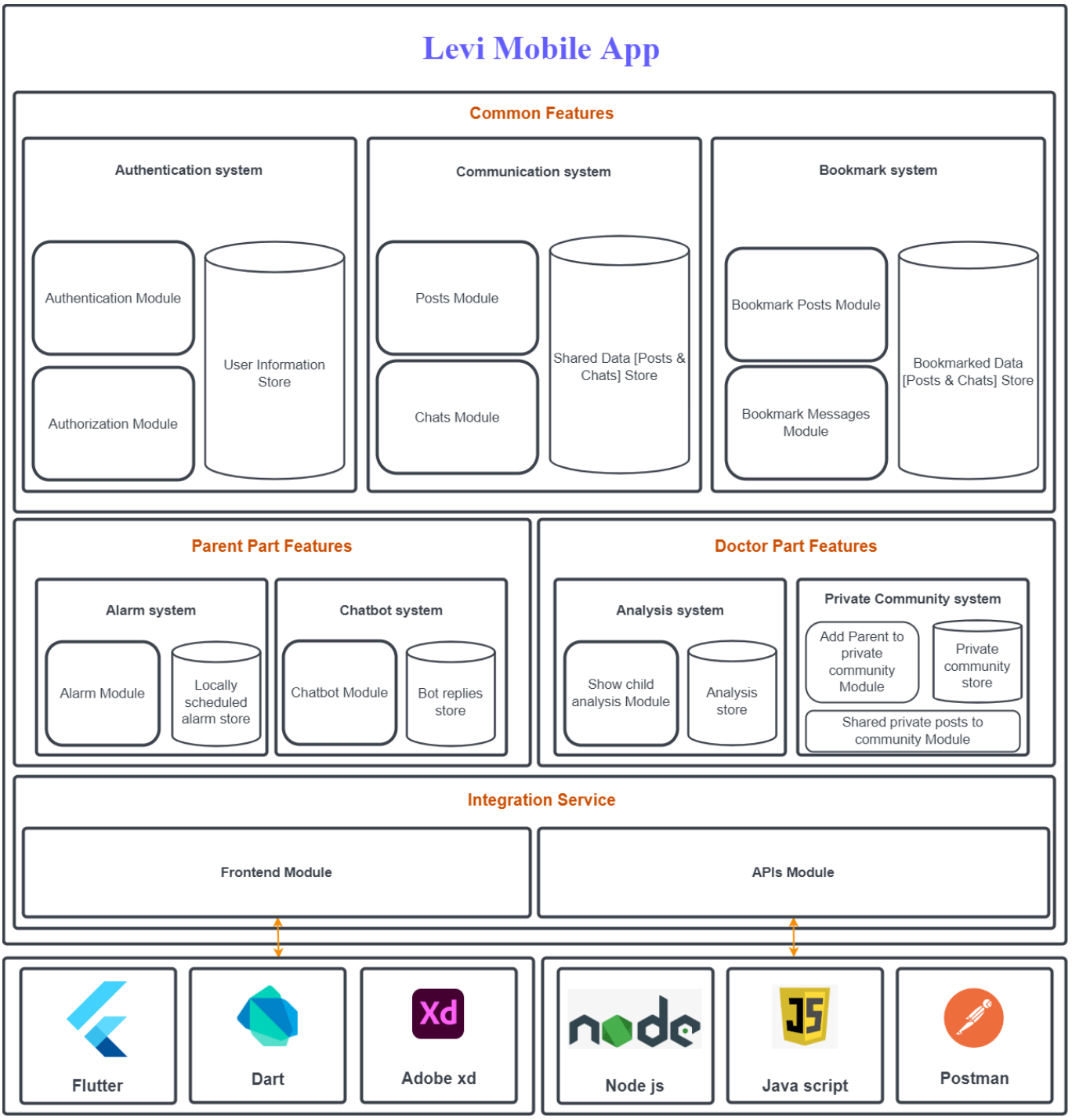


Figure 58. Mobile Application Architecture Diagram

3. App Integration

Our Mobile App. is written by a framework called "Flutter" which is maintained by Google it uses a programming language called Dart and it is also developed by Google.

3.1. Framework: Flutter

Flutter is an open source multiplatform framework that creates high quality and high performance apps. across many platforms like mobile apps. [Android and iOS], Web apps, desktop apps [Mac, Linux and Windows].

Figure 59. Dart & Flutter Logos

3.2. Design Pattern: MVC Architecture

We used an MVC design pattern for the app so we can handle every part of the app separately.

MVC stands for [Model View Controller] and it's a commonly used design pattern that its main purpose is to separate the app design and the business logic for better architecture.

To apply this design pattern in our app, we used state management to handle it called GetX.

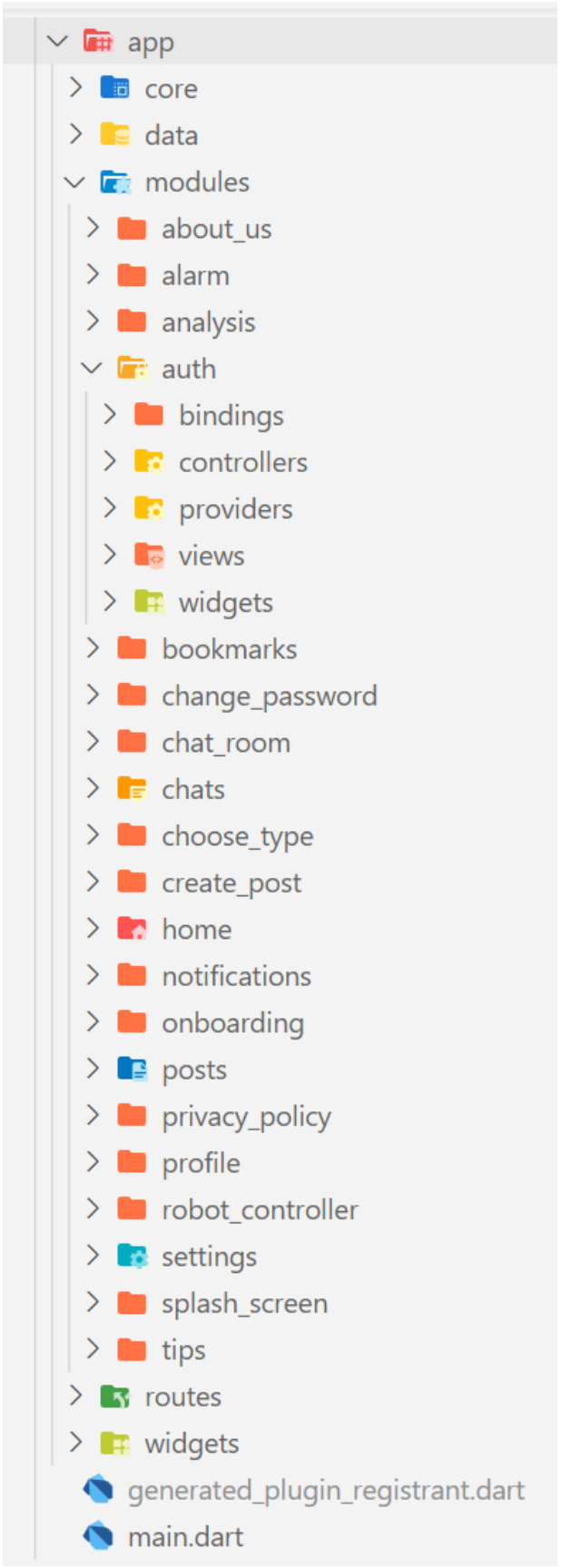
GetX is an extra-light and powerful solution for Flutter. It combines high-performance state management, intelligent dependency injection, and route management quickly and practically.

Figure 60. Getx State Management Logo

3.3. Mobile App Structure

The structure contains one main folder called app folder that contains all the app on it, and also the main.dart file [the file that has the main function that the compiler can start running from it].

The following table explains the app structure in detail,



In app folder, there are 5 main folders:

Core Folder,
Contains the theme data of the entire app, and utils [any constants or extensions used in the app].

Data Folder,
Contains the models and services that can run asynchronously with the app, and also contains API providers for handling the dealing with backend.

Modules Folder,
Contains all the app pages, each page contains the business logic and the design separately.

Routes Folder,
Contains the path for each page and the binding logic that is used by this page.

Widgets Folder,
Contains every UI component that is commonly used in more than one page.

3.4. Dealing with APIs and Sockets

[API] stands for Application Programming Interface which is a set of definitions and protocols for building and integrating application software.

APIs let your product or service communicate with other products and services without having to know how they're implemented. This can simplify app development, saving time and money.

APIs can be used through a link called [route] that we can send a request to and receive a response from it.

Through APIs, we can make CRUD functions [Create, Read, Update, Delete] using Restful API Methods [POST, GET, PUT, DELETE].

Method	**Description**
GET	Retrieve information about the REST API resource
POST	Create a REST API resource
PUT	Update a REST API resource
DELETE	Delete a REST API resource or related component

Examples in API Methods used in Mobile Application:

<table>
<tr><td colspan="2">https://levi-robot1.herokuapp.com/api/signup</td></tr>
<tr><td colspan="2">API used in registration for both parent and doctor</td></tr>
<tr><td colspan="2">Method used: POST</td></tr>
<tr><td>Request: Parents will send [fullname, email, phone number, password, role] and doctor will send the same data</td><td>Response: if status code 201, that means the doctor or parent register successfully and Otp code</td></tr>
</table>

with some additional data [national id, certificate image, clinic phone number, clinic location].	will be sent to his email to complete verification. and if status code 400, that means that there is an error in the submitted data so the response will return which input parameter did this error. and if the status code is other than 201 or 400 so it means that there is an internal server error.
https://levi-robot1.herokuapp.com/api/parents/$id	
API used to get parent profile data	
Method used: GET	
Request: Parent or doctor will send his id to get his data.	**Response:** if status code 200 that means the data retrieved successfully and the parent profile data will be in the response body. and if the status code is other than that, that means there is an error in the server.
https://levi-robot1.herokuapp.com/api/posts/$id	
API used to delete post	
Method used: DELETE	
Request: Parent or doctor will send his post id that he wants to delete.	**Response:** if the status code is 200 that means the post was deleted successfully. and if the status code is other than that, that means there is an error in the server.

https://levi-robot1.herokuapp.com/api/doctors/$id	
API used to Update doctor profile	
Method used: PUT	
Request: Doctor will send his id with the data that he wants to update in his profile.	**Response:** if the status code 200 that means the doctor data was updated successfully. and if status code 400, that means that there is an error in the submitted data so the response will return which input parameter did this error. and if the status code is other than 200 or 400 so it means that there is an internal server error.

For testing the APIs we used Postman, it is an API platform for building and using APIs. Postman simplifies each step of the API lifecycle and streamlines collaboration so you can create better APIs—faster.

Figure 61. Postman Logo

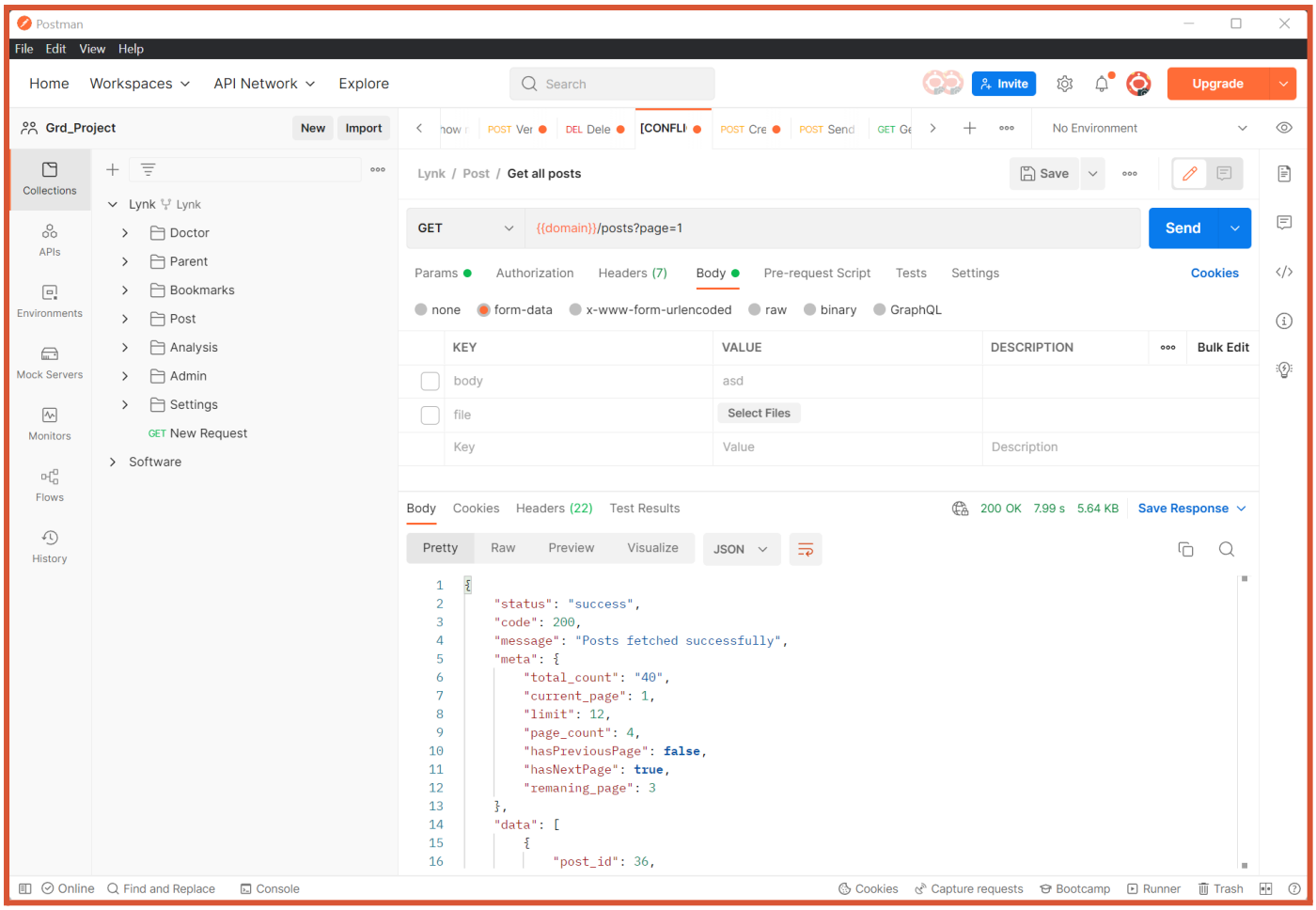


Figure 62. API Testing in Postman

3.5. Web Sockets

The WebSocket API is an advanced technology that makes it possible to open a two-way interactive communication session between the user and a server. With this API, you can send messages to a server and receive event-driven responses without having to poll the server for a reply.

We used it in the chatbot part in our application.

4. App Design

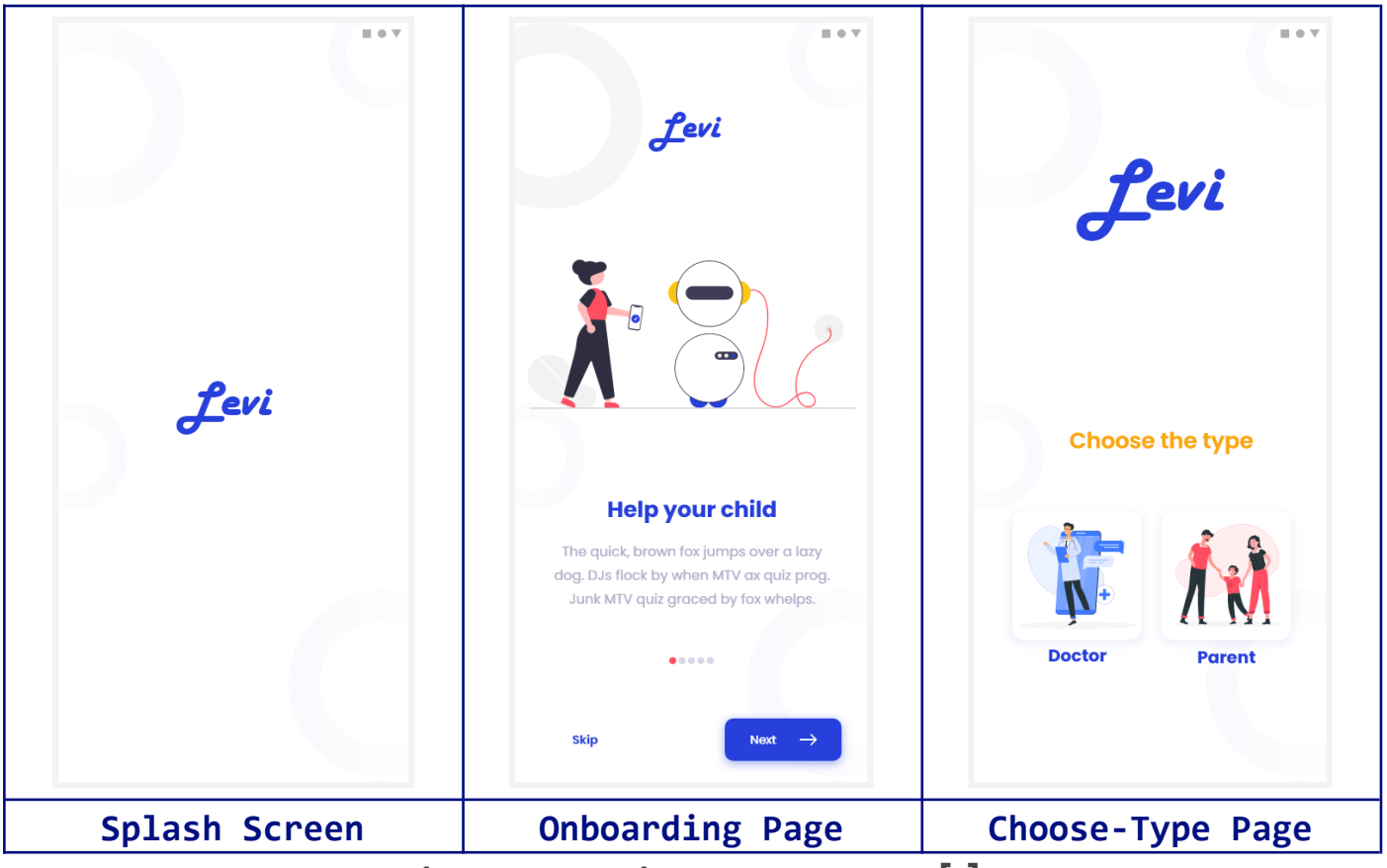
In application design, we used the Material UI design language that was made by Google to make every page as simple as possible and also make it more comfortable for the eyes.

We used the Material guidelines to make the design language look the same on every page.

Our app design is divided into three sections:

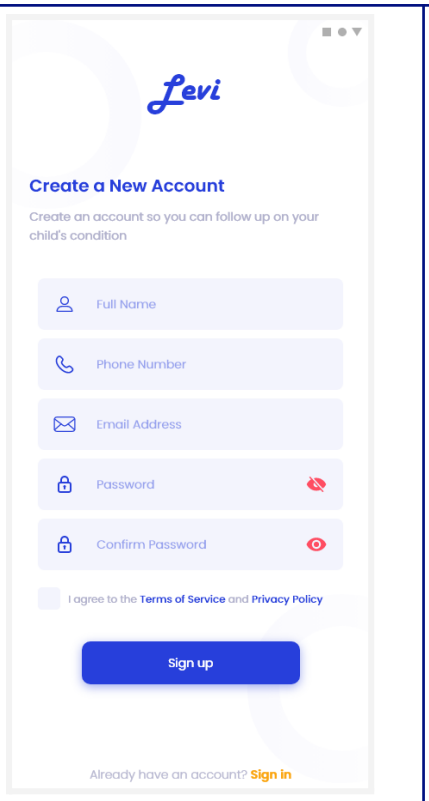
- Doctor targeted pages.
- Parent targeted pages.
- Common pages between doctor & parent.

4.1. Mobile App Snapshots

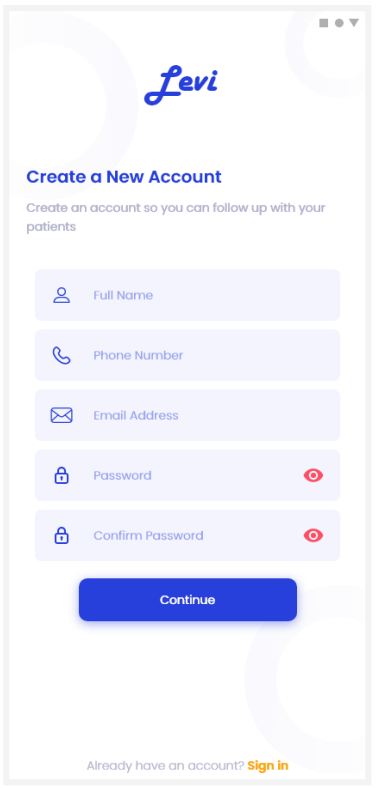


Splash Screen	Onboarding Page	Choose-Type Page

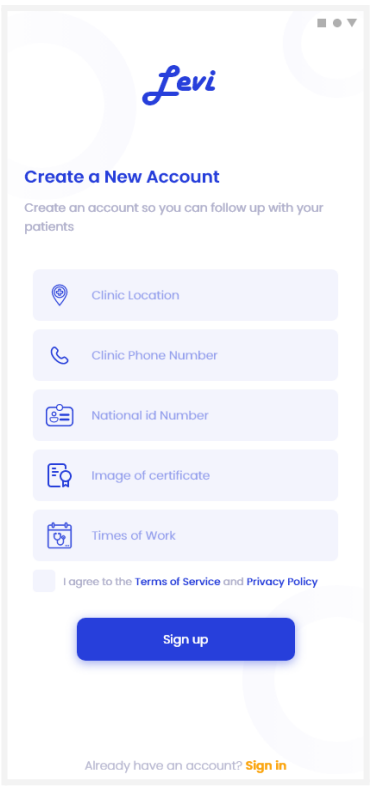
Figure 63. Mobile App Snapshots [1]



Sign up Parent

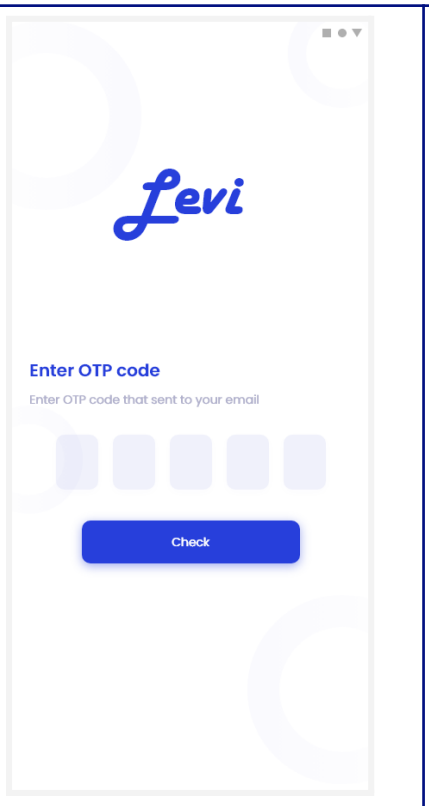


Sign up Doctor

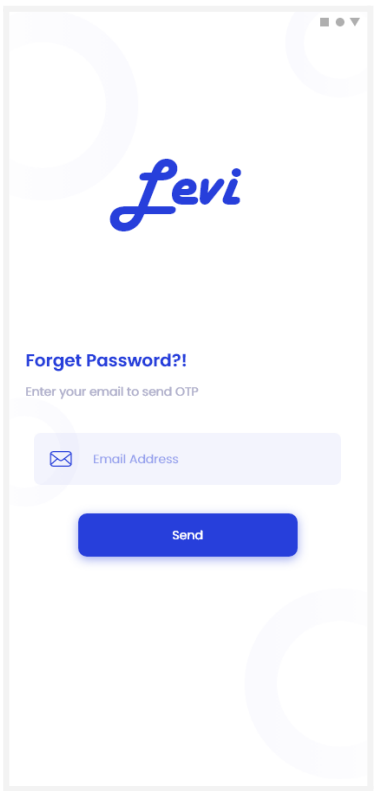


Sign up Doctor 2

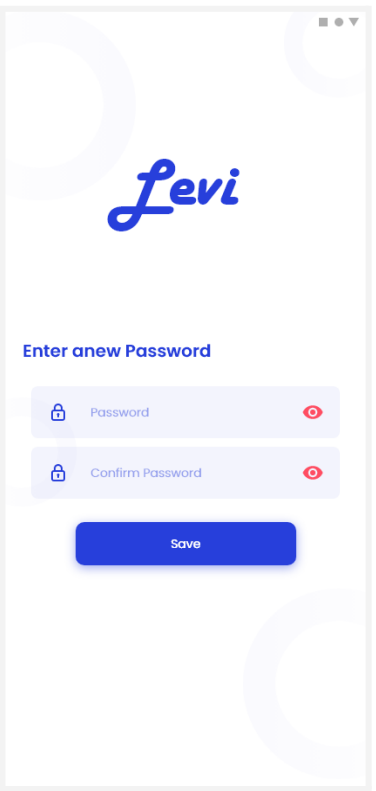
Figure 64. Mobile App Snapshots [2]



Otp Code page

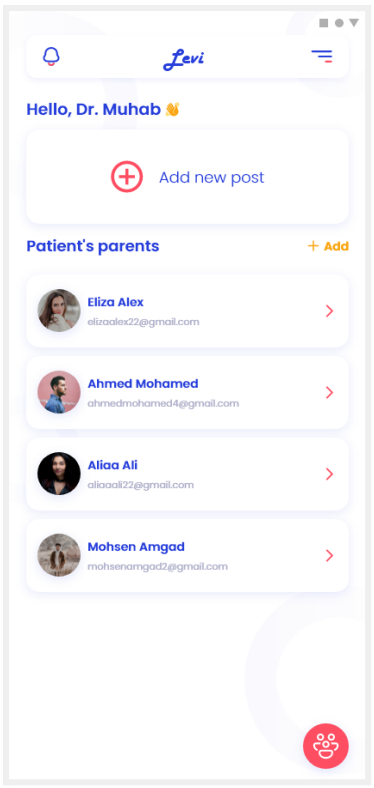


Forget Password Page

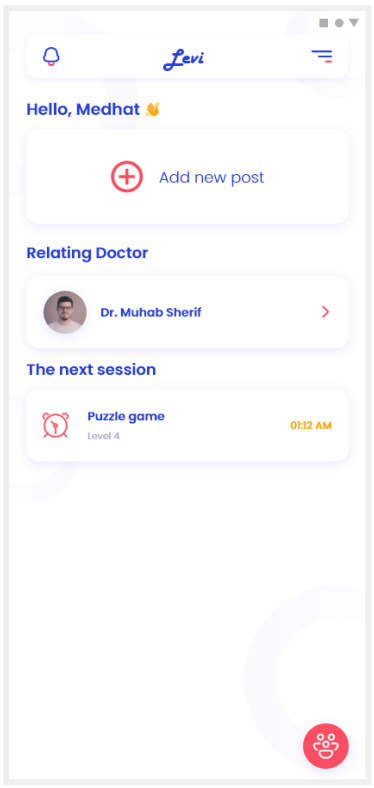


Add new password

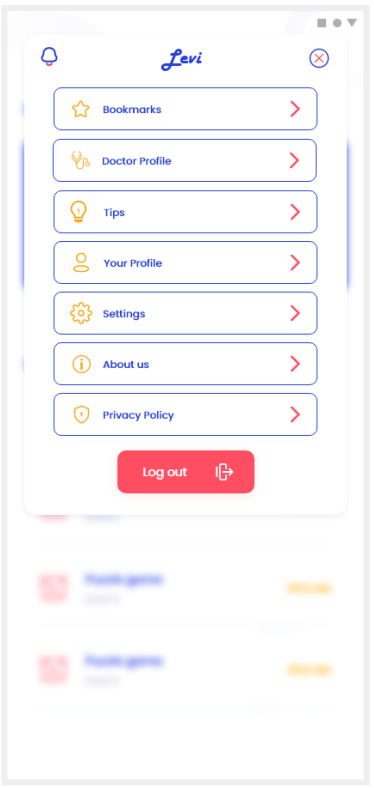
Figure 65. Mobile App Snapshots [3]



Doctor Home



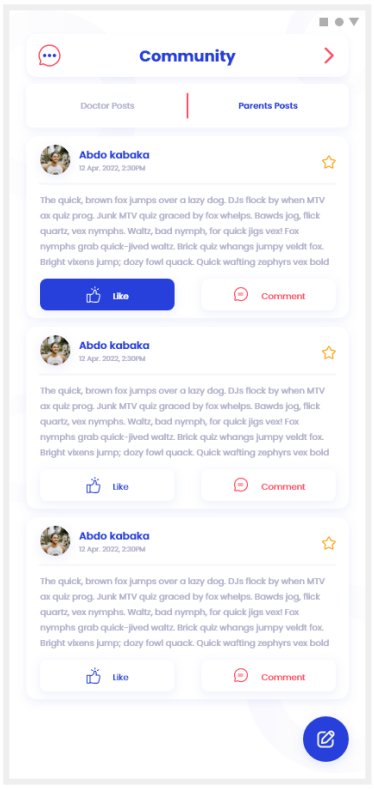
Parent Home



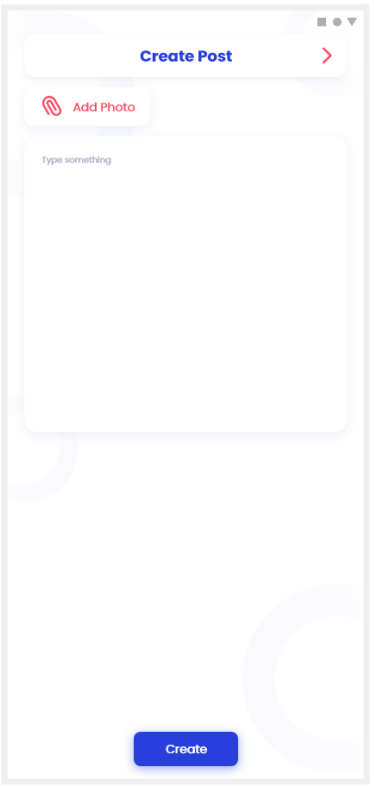
Drawer

Figure 66. Mobile App Snapshots [4]

Community Page 1



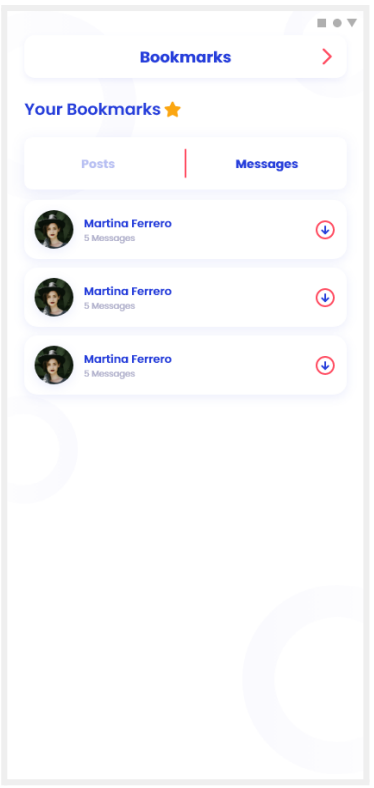
Community Page 2



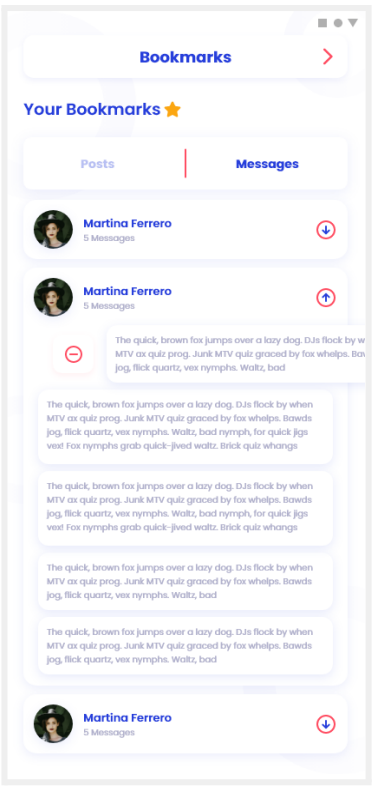
Create Post Page

Figure 67. Mobile App Snapshots [5]

Bookmarks Posts

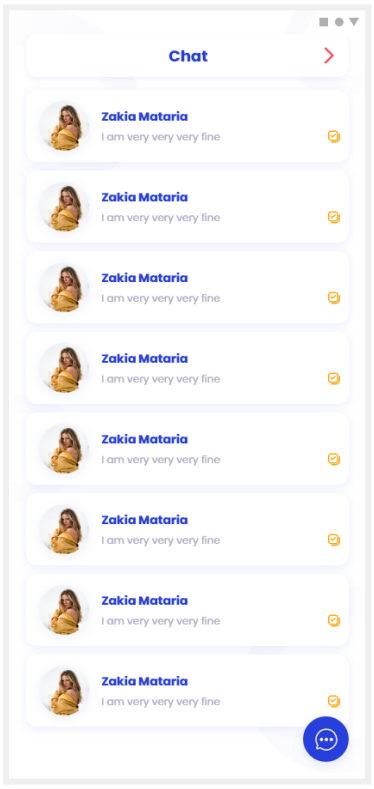


Bookmarks Messages 1

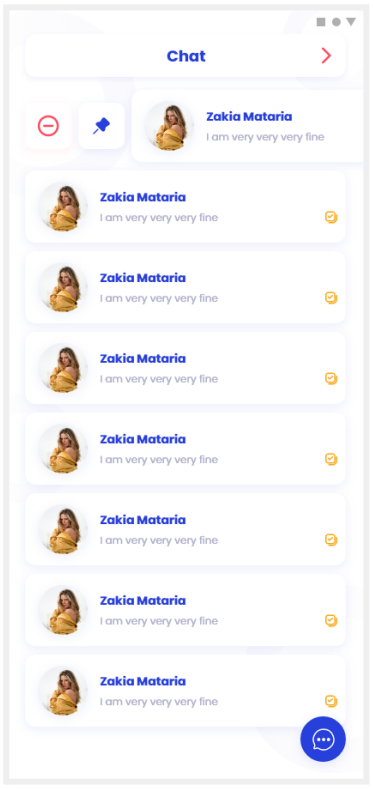


Bookmarks Messages 2

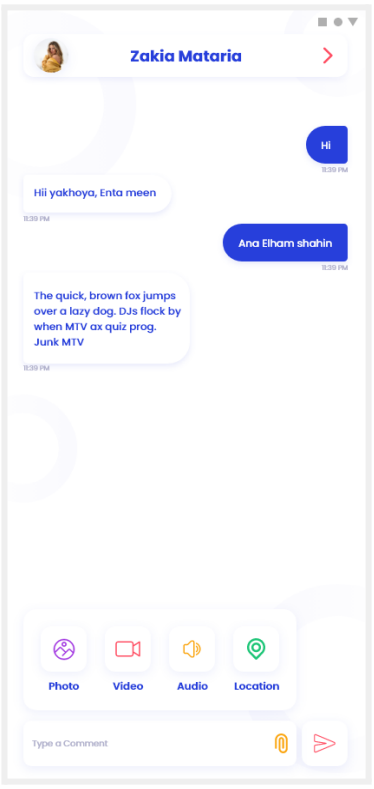
Figure 68. Mobile App Snapshots [6]



Chat page 1

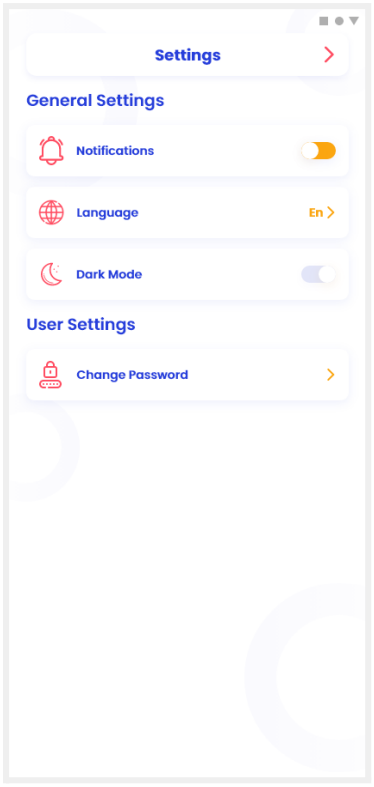


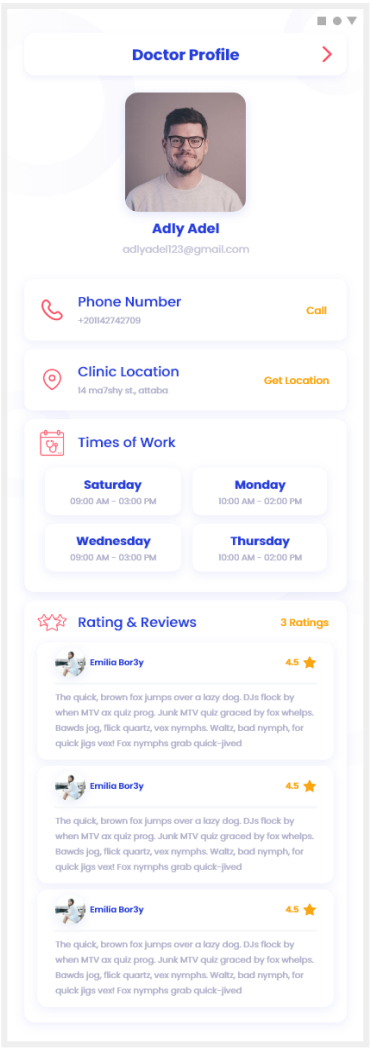
Chat page 2

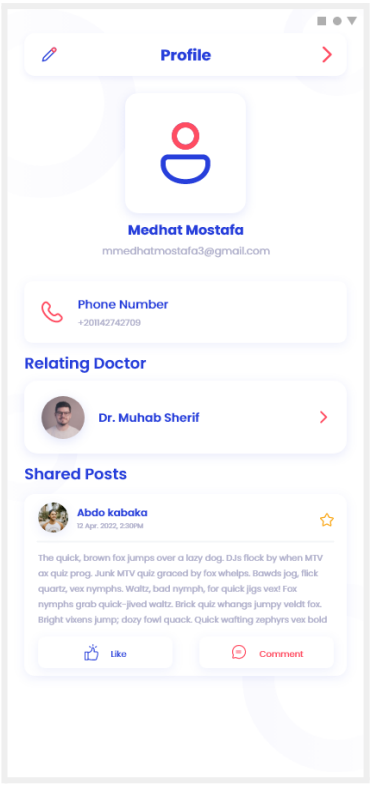


Chat room page

Figure 69. Mobile App Snapshots [7]

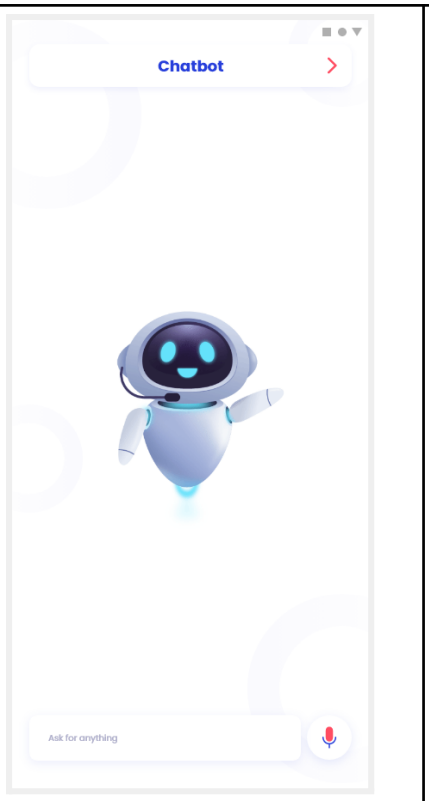




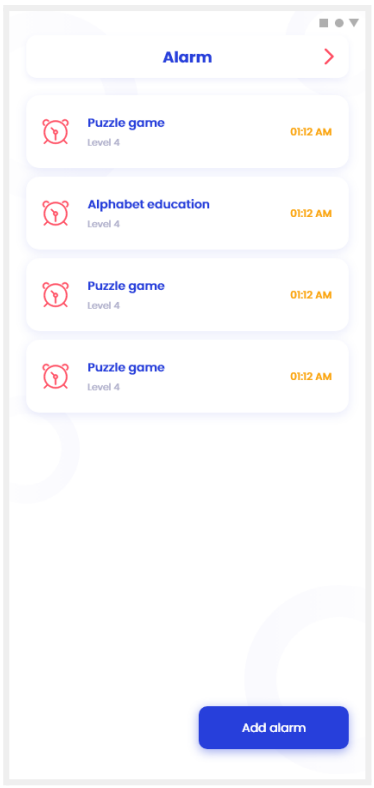


Settings page	Doctor Profile	Parent Profile

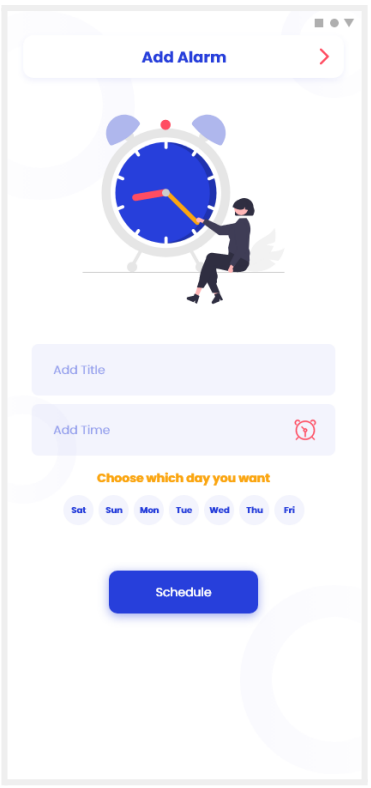
Figure 70. Mobile App Snapshots [8]



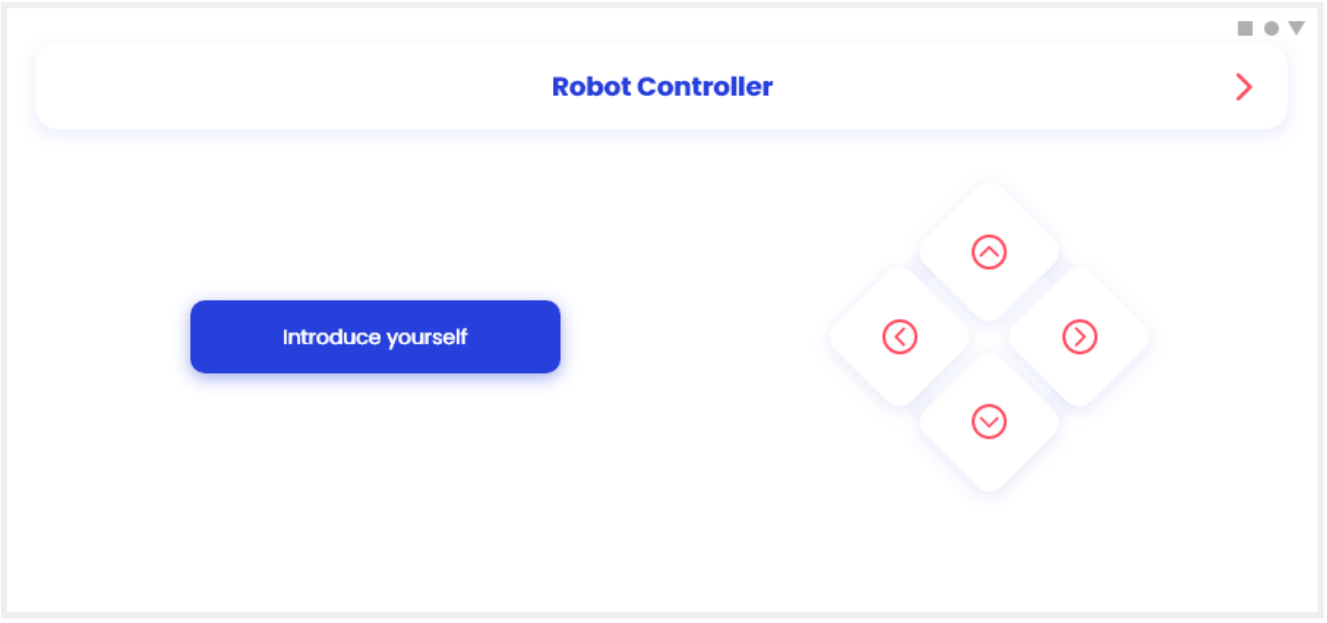
Chatbot



Alarm page



Add alarm page



Robot Controller page

Figure 71. Mobile App Snapshots [9]

5. App Services

Our Mobile Application provides the following services for both the parent of a child with autism and the doctor responsible for treating him:

5.1. Services for Parents

1	Registration to the system.
2	Otp code that will be sent to his email for verification and also in case he forgets his password.
3	Link with the Robot so the parent can control the movement of the robot and also to link the database of the robot with the database of the parent.
4	Link with the doctor who is responsible for treating his child.
5	Alarm for scheduling sessions of the child. The parent can add an alarm to every session individually every day or he can set it once and it will ring every day at the scheduled time.
6	Chatting with the doctor that is responsible for treating his child and also can chat with other parents with the same doctor.
7	Can add posts to the community and interact with other posts.
8	Also he can see the private posts that the doctor adds only to his parents that follow with him.
9	Can add any post or any message in chats into a bookmark so he can get it quickly.
10	Chatbot that can help the parent if he asks any question about autism or how he can deal with his child.
11	Can review the doctor and give him a rating.

5.2. Services for Doctors

1	Registration to the system and the very important thing that he must add identifies proves that he is a doctor and this data will be checked by the admins of the app and an email will be sent to the doctor about if his data was verified successfully or not.
2	Otp code that will be sent to his email for verification and also in case he forgets his password.
3	Add his parents to his list so he can add them to his community and he can also see their childs' analysis with the robot through them.
4	Chatting with the parents or any other doctor in the public community.
5	Can add posts to the community and interact with other posts, the posts that he can add either public [anyone can see the post] or private [only his parents list can see the post].
6	Can add any post or any message in chats into a bookmark so he can get it quickly.
7	Can see the analysis of each child with the robot.

Module 6: Testing

1. Doctors Feedback

1.1. Dr. Salma Ayman

1.1.1. Idea:

The application is a good way for today's children to interact with, as the children these days are more attracted to screens instead of physical games like blocks, football...etc.

1.1.2. How much it will help:

- The application helped in enhancing the interaction of children, as there's a part in the app that waits for the child interaction, not just showing the child videos and music as most applications do.
- Helps to improve the sensation of children.
- As more people use technology the children will need to explore it, so the software helped to overcome this problem.
- A simple and friendly application with interactions that limits the use of technologies and applications to just educational applications to help the children recover or reduce autism.

1.1.3. Software:

- The application has good interactions as well as simple which proved to catch the children's attention.
- The application proved to simulate/copy a lot of techniques used in sessions by doctors with autistic children, for example making a clapping sound when the child finishes the puzzle correctly.

- The application is categorized into groups.
- Provided good educational techniques.
- Took care of the sensation part which is a main part of autism.
- Friendly design.
- Good choice of colors which catch the attention of children.
- Using the painting game idea to give the children their space of freedom to play.
- The touching screen proved to be a good choice for interacting as the children behaved better on touch screens than using a mouse and keyboard.

1.1.4. How to improve it:

- Increase the feedback to the children to contain different actions whenever the child interacts with the application.
- Add more languages, especially Arabic Egyptian for this project.
- Add more common items that the children in some environment can see or interact with.
- Make the cards shuffled, to allow the child to memorize the items instead of being static.
- Add more items in each category and verbs.
- Add a time interval that will check that the parent is watching the child not leaving him with the robot, that's by using some sort of question that only adults can solve.

1.2. Prof. Dr. Mona Ezz Eldeen

1.2.1. Idea:

The idea is very good since the category of children with autism needs to shed light on them and develop their educational and communication skills which will relieve a lot on the shoulders of parents.

1.2.2. How much it will help:

It will greatly help children with autism and their parents, knowing that the effect will be different from one child to another, depending on the degree of autism they have.

1.2.3. Mobile Application:

The idea of the application is a great idea, especially since parents will be in a larger community of their own and share their experiences together.

1.2.4. The movement of the robot:

The idea that the robot has little movement and that the arms are immobile was one of her suggestions since children with autism are very sensitive to a lot of movement.

1.3. Dr. Jihan Ahmed

1.3.1. Software:

She talked about the importance of the therapeutic sessions that the robot gave to the child with autism and praised the child's admiration for the LEVI robot and the positive impact on his condition, and she expects that the continuation of the sessions with the robot will develop the child's skills a lot.

1.3.2. Mobile Application:

One of the most important points that the doctor focused on is the importance of parents in the lives of their children with autism and the development of their child's life. She praised the application because it allows parents to learn a lot about autism and benefit from the experiences of other parents and that this makes it easier for them a lot. It is important to spread awareness among parents about autism.

1.3.3. Movement of Robot:

A child with autism is very afraid, and a lot of movement may make him uncomfortable, so she suggested to us that the robot arm be fixed and the movement of the robot be less, and this is what we applied.

1.3.4. How to improve it:

- Add more items in each category and verbs.
- Add the Arabic Language.

2. Analysis Report Sample

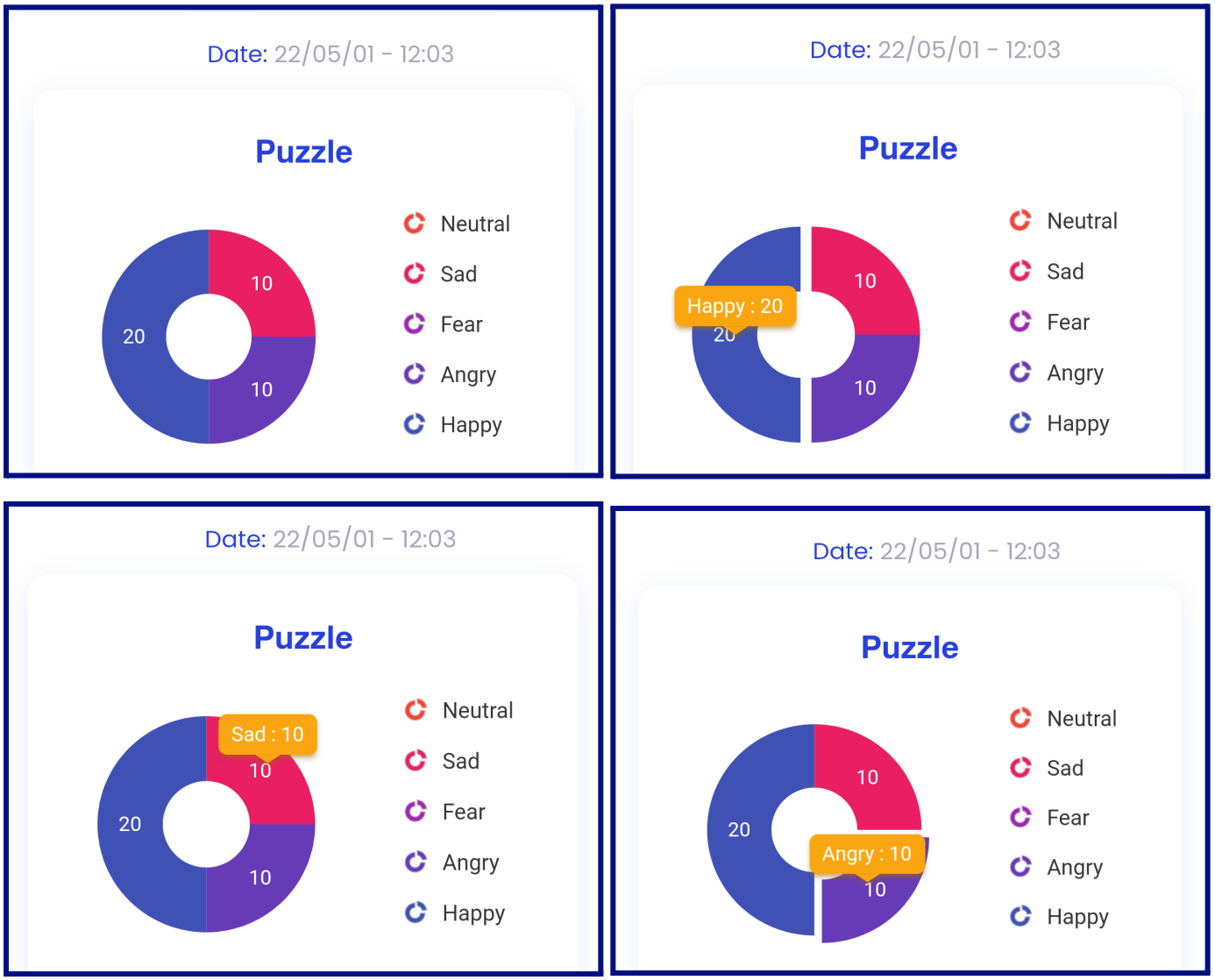


Figure 72. Analysis Report Sample

Summary

There are three levels of autism, this project targeted children with autism with level 1 and level 2 only within the age of 3 to 10 years old to reduce the effect of autism on them and develop their communication, social and educational skills.

From the treatment trials testing on children with autism, Most of the doctors praised the impact that the robot had in the trials they made on, The children were very excited during their session with the robot and were interacting with it and this was a good sign.

As the robot has nice colors, a beautiful background, and a design that can catch the child's attention, it also has software that covers most of the therapies and techniques used by doctors to help the children improve their skills.

The mobile application received good feedback from both the doctors and parents that the robot can generate an analysis report for the session and view it from the mobile application was a good addition to helping the doctor.

Future Work

Different adaptations, tests, and experiments have been left for the future due to lack of time since the experiments with real patients are usually very time-consuming, requiring even weeks. Future work concerns the deeper analysis of particular mechanisms and new improvements and suggestions to make adjustments recommended by doctors such as

- Increasing the feedback to the children to contain different actions whenever the child interacts with the application.
- Adding more languages, especially Arabic for this project.
- Adding more common items that the children in some environment can see or interact with.
- Making the expression cards shuffled, to allow the child to memorize the items instead of it being static.
- Adding more items in each category and verbs.
- Adding a time interval that will check that the parent is watching the child not leaving him with the robot, that's by using some sort of question that only adults can solve.

Project Timeline

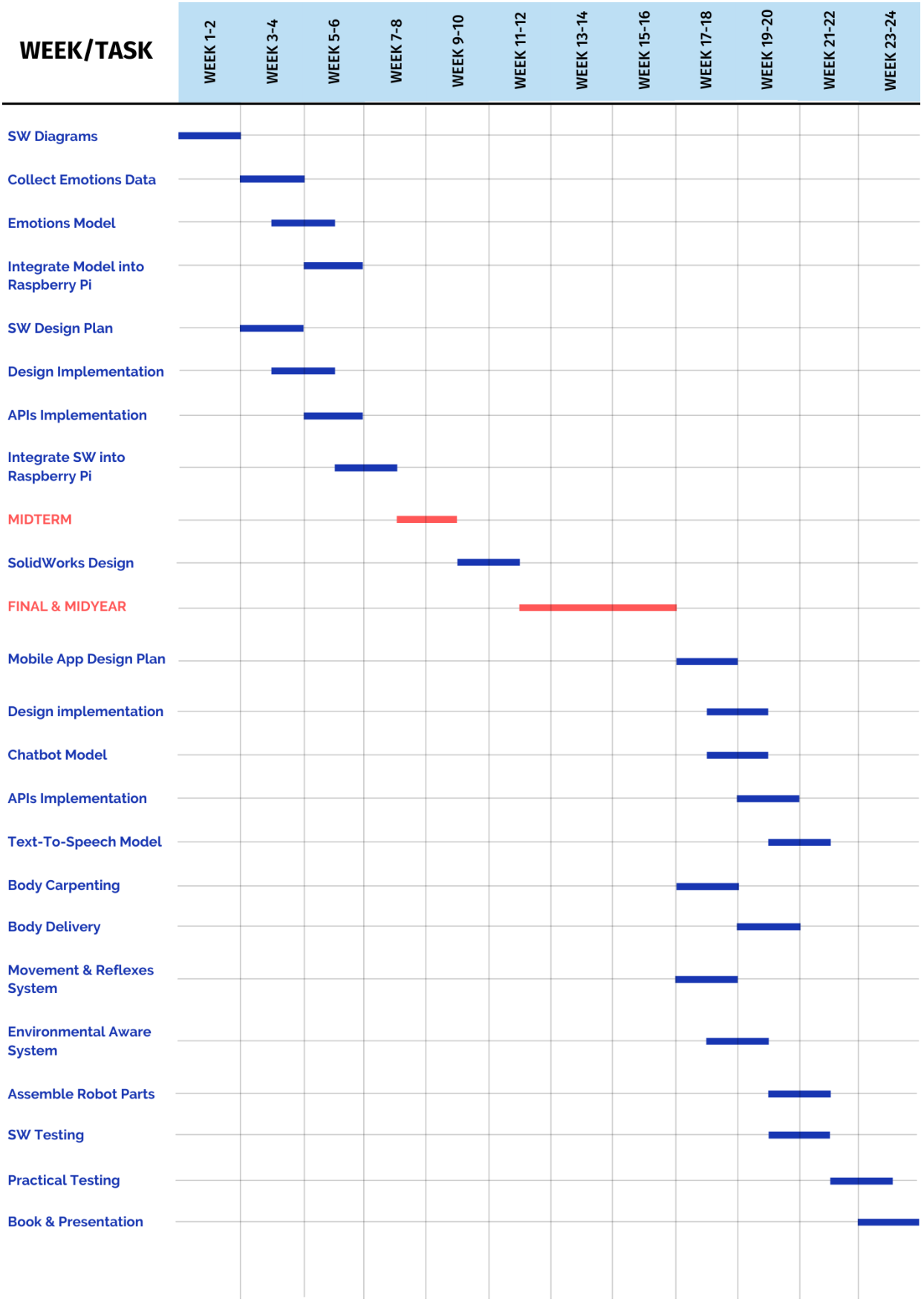


Figure 73. Project Detailed Timeline

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18. What Is Node.js? Here's How to Use Server-side JavaScript | makeuseof.com

19. The Model View Controller Pattern – MVC Architecture and Frameworks Explained | freecodecamp.org

20. MVC (Wikipedia)

21. Choosing an Activation Function for Deep Learning

22. An overview of activation functions used in neural networks | adl1995.github.io

Appendix

1. Flutter | flutter.dev
2. dio | Dart Package | pub.dev
3. bloc | Dart Package | pub.dev
4. dart-vlc | Flutter Package | pub.dev
5. TensorFlow | tensorflow.org
6. TensorFlow.Keras | tensorflow.org/api_docs/python/tf/keras/
7. Keras | keras.io
8. Top 8 Datasets Availble For Emotions | analyticsindiamag.com
9. fer2013 | Kaggle.com
10. Autism: Autism: Parents face challenges, too | medicalnewstoday.com
11. Sequential Model | keras.io
12. Raspberry Pi Technology | watelectronics.com
13. Raspberry Pi 4 Model B Tech Specs | raspberrypi.com
14. Raspberry Pi Documentation - Camera | raspberrypi.com
15. NEMA 17HS4401 Datasheet | datasheet4u.com
16. PostgreSQL REST API Connection | hevodata.com
17. JWT | jwt.io
18. Node.js | nodejs.org
19. JavaScript | javascript.com
20. PostgreSQL | postgresql.com