Bilkent University

Department of Computer Engineering

Senior Design Project

Analysis Report

Project: Signify

Team Members: Ali Taha Dinçer, Çağlar Çankaya, İrem Ecem Yelkanat, Muhammed Naci Dalkıran, Sena Korkut

Supervisor: Ayşegül Dündar
Jury Members: Shervin Arashloo & Hamdi Dibeklioglu

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1.   Introduction

In society, people who are hearing impaired and/or speech impaired have difficulty expressing themselves and communicating with other people because most people lack knowledge of sign language. Even though the improvements in technology have changed the way people live and made the lives of people easier by, for example, transforming mobile phones from sound devices into multi-functional devices, communicating with people who are hearing impaired and/or speech impaired continues to be a problem in many areas including social and technical contexts. These communication activities include social life, healthcare, career development, and education. Furthermore, as a result of the Covid19 pandemic that started in late 2019, obligations regulated by most countries, including wearing face masks and social and physical distancing, have increased the communication and social challenges for hearing impaired people. For example, wearing face masks has led to some negative impacts in communication with other people as it eliminates speech perception by visual features through lipreading. Additionally, a considerable amount of face-to-face communications have turned into virtual communications, which results in more hardship for the hearing impaired and/or speech impaired people as some of the most used virtual communication services like Zoom, Microsoft Teams or Skype do not support sign language.

According to the World Health Organization (WHO), 5% of the people on the earth are hearing impaired, which is more than 350 million people [1] and will exceed 700 million by 2050 [2]. Considering that, sustainability of the social lives of hearing-impaired and/or speech impaired people will be an essential issue in the future. Therefore, we propose a solution to this problem named Signify. Signify is a mobile application with the main aim of helping hearing and/or speech impaired people in their social lives by translating sign language into text along with speech and text-speech to sign language translation in real-time.

This report consists of the description of the proposed system including requirements, system models, user interface mockup screens and other analysis elements such as various factors in engineering design, risk and alternatives, project plan, teamwork and ethical responsibilities.

2.   Proposed System

2.1.   Overview

Signify is a mobile application that aims to solve social problems regarding communication, understanding, and expressing for the hearing impaired and/or speech impaired people. By this means, Signify will help these people to improve their quality of life. In that manner, the application can be seen as a communication tool.

There are already existing applications such as "Hand Talk Tradutor para Libras" [3], "ASL Translator" [4], and "S.L.A.I.T." [5] for the hearing impaired and/or speech impaired people. However, "Hand Talk Tradutor para Libras" does not contain real-time translation over the video, which creates a one-way channel between communicators. "ASL Translator" is a paid application and works on pre-given text and video translations, in which translations are pretty limited, and for every new word or phrase, the app needs to be updated. Finally, "S.L.A.I.T." can only be used during video calls, and it is still in the beta phase.

Signify combines these apps in terms of their translational and conversational capabilities with tools like two-way translation. With Signify, users can easily communicate through video calls and use their mobile phones to real-time translate to both text and sign language in a day-to-day conversation. With this, hearing impaired and/or speech impaired people can join conversations even if the people in the conversation do not know sign language. Along with these innovations, we aim for Signify to be a swiss-knife for hearing impaired and/or speech impaired people during their everyday lives.

2.2.   Functional Requirements

2.2.1.   *Two-Way Language Translation*

The main purpose of the application is to provide a channel among hearing-impaired or speech-impaired people and society. For this intention, two-way language transformation is ensured. The application should be able to translate a speech or text in English to sign language through the instrumentality of animation for continuous visualization. For the reverse side, the application should also convert sign language from video to text and speech for the users who do not know sign language. For this, the user should be able to use the microphone and camera of their phones.

2.2.2. Real-time Language Translation

The application should work close to the real-time speed to achieve practical and effective communication, especially for online meetings and conferences. Users should be able to reach the translation synchronically with the initial communicator.

2.2.3. Language-free Guidance

For the straightforward usage of the application, guidance on the features should be done without language constraints. Guidance should be both with text and sign language to resolve the discordance happening from various impairments.

2.3. Non-functional Requirements

2.3.1. Usability

The application should have a user-friendly interface for users to navigate and appreciate any feature within two seconds. Also, because the target user is impared people, universal icons and modern designs will be used. In this way, the application gains higher usability.

2.3.2. Extensibility

The application architecture should be easily extensible for new learning models and additional features that will be done in 8 months.

2.3.3. Performance

Because machine learning related computation is computed by the user's device, the response time is expected to be 100 ms.

2.3.4. Security

The application should not leak any non-encrypted personal information in case of a data breach.

2.3.5. Compatibility

The application should be available for all operating systems, including Android, iOS, and web platforms, to deliver the service to all users.

2.3.6. Privacy

Any personal information and video and audio records should not be used or shared with any user, a third-party company, or application.

2.4. Pseudo Requirements

- Version Control Git/Github must be used as a version controller throughout the project.
- In order to implement the project, Dart programming language will be used.
- Application will be available on both Android and iOS platforms.
- Firebase will be used for the backend side of the project and Flutter will be used for the frontend side of the project.
- PyTorch will be used in order to implement the GAN models.
- WLASL Dataset will be used in order to train the models.
- The ONNX library will be used in order to extract weights of the models in order to be used in mobile devices.
- TensorFlow Lite will be used in order to implement models to the mobile devices.
- In order to implement real-time communication capabilities to the application, the stream WebRTC library will be used.

2.5. System Models

User H: A hearing-impaired person who can read and understand English.

User S: A hearing/speech-impaired person who understands only sign language.

User N: Has no hearing loss, deafness, or/and speech impairment

2.5.1. Scenarios

2.5.1.1. Sign Up & Sign In

- User wants to register to Signify application.
- User types username, email address and password.
- To verify the email, a six-digit verification code is sent to the typed email address of the user. The user verifies his/her email by typing this six-digit verification code.
- After verification, the user enters his/her personal information; such as name, surname, and condition. If the user has hearing and/or speech impairment, he/she

chooses the option "impaired". After choosing the impaired option, the user also indicates whether he/she can read and understand the Latin alphabet and English language.

- After the sign-up process, the user is directed to the Home Screen.

2.5.1.2. Add Contact via QR Code

- User S wants to add another user to his/her contacts.
- To add contacts, User S wants the other user's unique QR code that is displayed on his/her profile page. The name, surname, and unique QR code are shown on each user's profile page.
- User S goes to the "Add Contact" section and picks the option by QR code.
- User S scans the QR code of the other user and adds him/her to the contact list.

2.5.1.3. Add Contact via Email

- User H wants to add another user to his/her contacts.
- User H goes to the "Add Contact" section and selects the option by e-mail.
- User H enters the e-mail of the other user and sends a request.

2.5.1.4. Remove Contact

- User H wants to remove another user from his/her contacts.
- User H goes to the "Contacts" section and selects the contact who he/she wants to remove.
- User H navigates to the contacts profile screen and selects the remove option and removes the user from the contact list.

2.5.1.5. Create Real-Time Web Conference or Meeting

- User N wants to create a meeting.
- User N goes to the "Meeting" section and selects "Create Meeting".
- User N can either select people from the contact list or send invitations by writing email addresses.
- After choosing who to invite, User N creates the meeting.

2.5.1.6. Invite/Remove Another User To/From Real-Time Web Conference or Meeting

- User N wants to invite/remove someone to/from the meeting that he/she created.
- User N opens the tab and sees who is in the meeting.

- To kick he/she can just select someone from this list. To invite someone, he/she selects the invite option and sends an invitation either from the contact list or e-mail.

2.5.1.7.   Attend a Real-Time Web Conference or Meeting

- User N wants to attend a web conference.
- User N opens the invitation that came from one of the contacts and accepts the invitation.

2.5.1.8.   Communicate in a Real-Time Web Conference or Meeting

- User S attends an online meeting.
- He/She enables the camera input by clicking the camera button and the sign language he/she displays is automatically transferred into text or voice for User N and other participants.
- User N replies to User S by talking and the generated text or the animation is displayed at the bottom corner of his video view.

2.5.1.9.   Daily Conversation

- On the outside, User S wants to ask questions to user N.
- User S opens Signify and records User S's sign language movements. Signify translates sign language to both voice and text.
- User N taps the button for voice input and starts talking. Signify translates voice input to text and sign language animation.
- After the translation is generated by Signify, user N shows the output, namely text, and sign language animation, to user S.
- Since User S couldn't understand a part of the animation, he re-plays the animation.

2.5.1.10.   Change Settings

- User N wants to change the application settings regarding dark/light theming and application language mode.
- User N taps to the "Gear Icon" on the right top corner and navigates to "Settings Screen".
- User N taps to the switch button in order to change from light theme to dark theme or vice versa.
- User N taps to change the application language tile and selects one of the "Sign Language Icons" and "English" in order to change the language mode.

2.5.1.11.   Change User Related Data

- User N wants to change user related data regarding his/her email, username, password and profile picture.
- User N taps to the "Gear Icon" on the right top corner and navigates to "Settings Screen".
- User N taps to profile picture shown in the top of the screen as an avatar in order to see his/her profile picture in full-screen.
- Then, User N taps the "Edit" button on the top-right of the screen in order to open the dialog box asking the user to change profile picture by using camera, select a picture from gallery or remove the profile picture.
- User N either selects "Use Camera" to use the camera of the mobile phone in order to take a new picture and use it as profile picture, select "From Gallery" in order to select a picture from gallery and use as profile picture or select "Remove Picture" in order to delete the profile picture.
- User N taps to the tile containing his/her email in order to navigate to the "Editing Screen" designed for changing email.
- User N can write his/her new email address and will receive a confirmation mail to his/her old mail in order to complete the change.
- User N taps to the tile containing his/her username in order to navigate to the "Editing Screen" designed for changing username. User N can write his/her new username and save.
- User N taps to the tile containing "Change Password". User N will be navigated to the "Change Password Screen" designed to change password.
- User N enters his/her old password once and his/her new password twice. If the conditions for the new password are provided, a confirmation mail will be sent to the user in order to complete the change.

2.5.1.12.   Logout From Signify

- User N wants to logout from his/her account on Signify.
- User N taps to the "Gear Icon" on the right top corner and navigates to "Settings Screen". User X scrolls to the bottom of the screen shown.
- User N taps to the tile containing "Logout from Signify". A dialog box that warns the user about his/her action shown up.

- User N taps the "Logout" button and successfully logs out from his/her account.

2.5.1.13.   Delete Account

- User N wants to delete his/her account in Signify.
- User N taps to the "Gear Icon" on the right top corner and navigates to "Settings Screen".
- User N scrolls to the bottom of the screen shown. User X taps to the tile containing "Logout from Signify" in red color. A dialog box shows up in order to warn the user that all data contains the user's email, username, password and profile picture.
- User successfully deletes his/her account by clicking the red "Delete" button.

2.5.2.   *Use Case Model*

2.5.2.1.   Main Menu Navigation
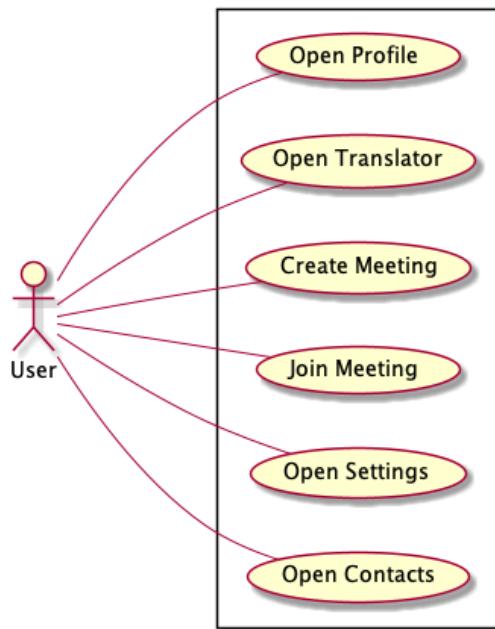
Figure 1: Main Menu Use Case Diagram

2.5.2.1.1.   Open Profile

- **Participating actor:** All Users
- **Entry condition:** The actor goes to the Home Screen.
- **Exit condition:** The actor chooses a subsection.
- **Flow of the events:**

- User is on the home screen.
- User presses Open Profile button
- Profile section is opened.

- **Special requirement:** None

2.5.2.1.2.   Open Translator

- **Participating actor:** All Users
- **Entry condition:** The actor goes to the Home Screen.
- **Exit condition:** The actor chooses a subsection.
- **Flow of the events:**
    - User is on the home screen.
    - User presses Open Translator button
    - Translation section is opened.
- **Special requirement:** None

2.5.2.1.3.   Create Meeting

- **Participating actor:** All Users
- **Entry condition:** The actor goes to the Home Screen.
- **Exit condition:** The actor chooses a subsection.
- **Flow of the events:**
    - User is on the home screen.
    - User presses Create Meeting button
    - New page for creating a new meeting is opened.
- **Special requirement:** None

2.5.2.1.4.   Open Settings

- **Participating actor:** All Users
- **Entry condition:** The actor goes to the Home Screen.
- **Exit condition:** The actor chooses a subsection.
- **Flow of the events:**
    - User is on the home screen.
    - User presses Settings button
    - The Settings section is opened.
- **Special requirement:** None

2.5.2.1.5.   Open Contacts

- **Participating actor:** All Users
- **Entry condition:** The actor goes to the Home Screen.
- **Exit condition:** The actor chooses a subsection.
- **Flow of the events:**
  - User is on the home screen.
  - User presses Contacts button
  - Contacts section is opened.
- **Special requirement:** None

2.5.2.2.   Web Conferencing
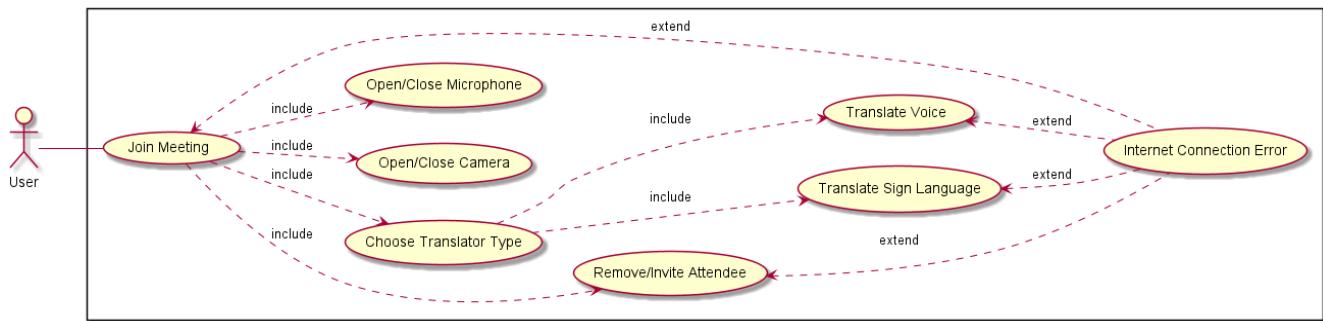
Figure 2: Web Conferencing Use Case Diagram

2.5.2.2.1.   Join Meeting

- **Participating actor:** All Users
- **Entry condition:** The actor joins the meeting.
- **Exit condition:** The actor ends the meeting.
- **Flow of the events:**
  - Other users invite the user.
  - The user accept the invitation
  - The user joins the meeting.
- **Special requirement:** None

2.5.2.2.2.   Invite/Remove Attendee

- **Participating actor:** All Users
- **Entry condition:** The actor invites/removes attendee
- **Exit condition:** The actor returns to in-call screen

- **Flow of the events:**
  - The actor invites/removes attendee
    - The attendee accepts the invitation
    - The attendee is removed from the meeting.
- **Special requirement:** None

2.5.2.2.3.　Choose Translator Type

2.5.2.2.3.1.　Translate Sign Language

- **Participating actor:** All Users
- **Entry condition:** The actor chooses translator type as sign language to text/voice
- **Exit condition:** The actor change translator type or ends meeting
- **Flow of the events:**
  - The actor wants to translate sign language to text/voice.
  - The actor chooses a translator type to translate sign language.
  - The actor perform sign language
  - The application translate sign language to text/voice
- **Special requirement:** None

2.5.2.2.3.2.　Translate Voice

- **Participating actor:** All Users
- **Entry condition:** The actor chooses translator type as voice to text/sign language
- **Exit condition:** The actor change translator type or ends meeting
- **Flow of the events:**
  - The actor wants to translate voice to text/sign language.
  - The actor chooses a translator type to translate the voice.
  - The actor speaks.
  - The application translate voice to text/sign language
- **Special requirement:** None

2.5.2.2.4.　Open / Close Camera
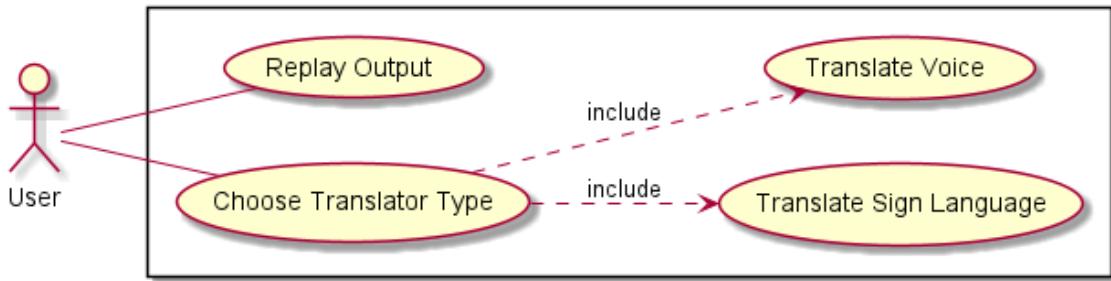
- **Participating actor:** All Users
- **Entry condition:** The actor opens/close Camera
- **Exit condition:** The actor ends meeting
- **Flow of the events:**

○ The actor wants to open/close the camera.

○ The actor opens/close the camera

● **Special requirement:** None

2.5.2.2.5.   Open / Close Microphone

● **Participating actor:** All Users

● **Entry condition:** The actor opens/close Microphone

● **Exit condition:** The actor ends meeting

● **Flow of the events:**

○ The actor wants to open/close the microphone.

○ The actor opens/close the microphone

● **Special requirement:** None

2.5.2.3.   Daily Conversation

Figure 3: Daily Conversation Use Case Diagram

2.5.2.3.1.1.   Translate Sign Language

● **Participating actor:** All Users

● **Entry condition:** The actor chooses translator type as sign language to text/voice

● **Exit condition:** The actor change translator type or ends meeting

● **Flow of the events:**

○ The actor wants to translate sign language to text/voice.

○ The actor chooses a translator type to translate sign language.

○ The actor perform sign language

○ The application translate sign language to text/voice

● **Special requirement:** None

2.5.2.3.1.2.   Translate Voice

- **Participating actor:** All Users
- **Entry condition:** The actor chooses translator type as voice to text/sign language
- **Exit condition:** The actor change translator type or ends meeting
- **Flow of the events:**
  - The actor wants to translate voice to text/sign language.
  - The actor chooses a translator type to translate the voice.
  - The actor speaks.
  - The application translate voice to text/sign language
- **Special requirement:** None

2.5.2.3.2. Replay Output

- **Participating actor:** All Users
- **Entry condition:** The actor replays the translation.
- **Exit condition:** The actor ends the translation
- **Flow of the events:**
  - The user wants to replay the translation.
  - The application replays generated sign language translation for voice to sign language or generated voice/text translation for sign language to voice/text.
- **Special requirement:** None

2.5.2.4. Settings
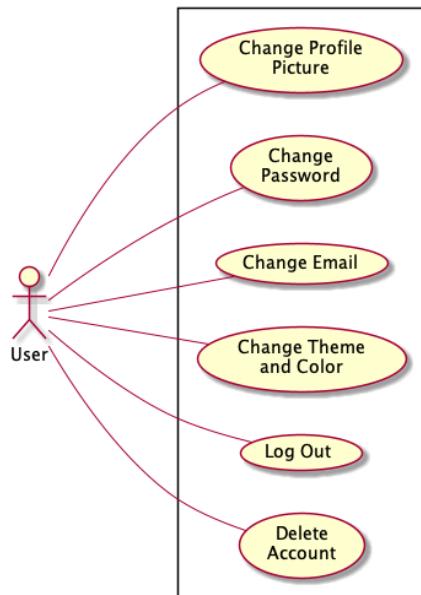
Figure 4: Settings Use Case Diagram

2.5.2.4.1.   Change Profile Picture

- **Participating actor:** All Users
- **Entry condition:** The actor enters the Settings section.
- **Exit condition:** The actor goes back.
- **Flow of the events:**
  - The actor wants to change profile picture.
  - The actor is directed to the gallery.
  - The actor chooses a new profile picture.
  - The profile picture of the actor is updated on the whole system.
- **Special requirement:** None

2.5.2.4.2.   Change Password

- **Participating actor:** All Users
- **Entry condition:** The actor enters the Settings section.
- **Exit condition:** The actor logs out.
- **Flow of the events:**
  - The actor wants to change the password.
  - The actor enters the old password.
  - The actor enters a new password.
  - The password of the user is changed in the whole system. The actor is being logged out to log in again with the new password.
- **Special requirement:** None

2.5.2.4.3.   Change Theme and Color

- **Participating actor:** All Users
- **Entry condition:** The actor enters the Settings section.
- **Exit condition:** The actor goes back.
- **Flow of the events:**
  - The actor wants to change the theme of the application.
  - The actor is directed to the theme gallery.
  - The actor chooses a new theme.
  - The UI of the app is changed in the view of the actor.
- **Special requirement:** None

2.5.2.4.4.　　Log Out

- **Participating actor:** All Users
- **Entry condition:** The actor enters the Settings section.
- **Exit condition:** The actor logs out.
- **Flow of the events:**
  - The actor wants to log out.
  - The actor logs out and is directed to the login-signup screen.
- **Special requirement:** None

2.5.2.4.5.　　Delete Account

- **Participating actor:** All Users
- **Entry condition:** The actor enters the Settings section.
- **Exit condition:** The actor's profile is deleted from the database.
- **Flow of the events:**
  - The actor wants to delete the profile.
  - The profile is deleted from the system.
  - The actor is directed to the login-signup screen.
- **Special requirement:** None

2.5.3.   *Object and Class Model*
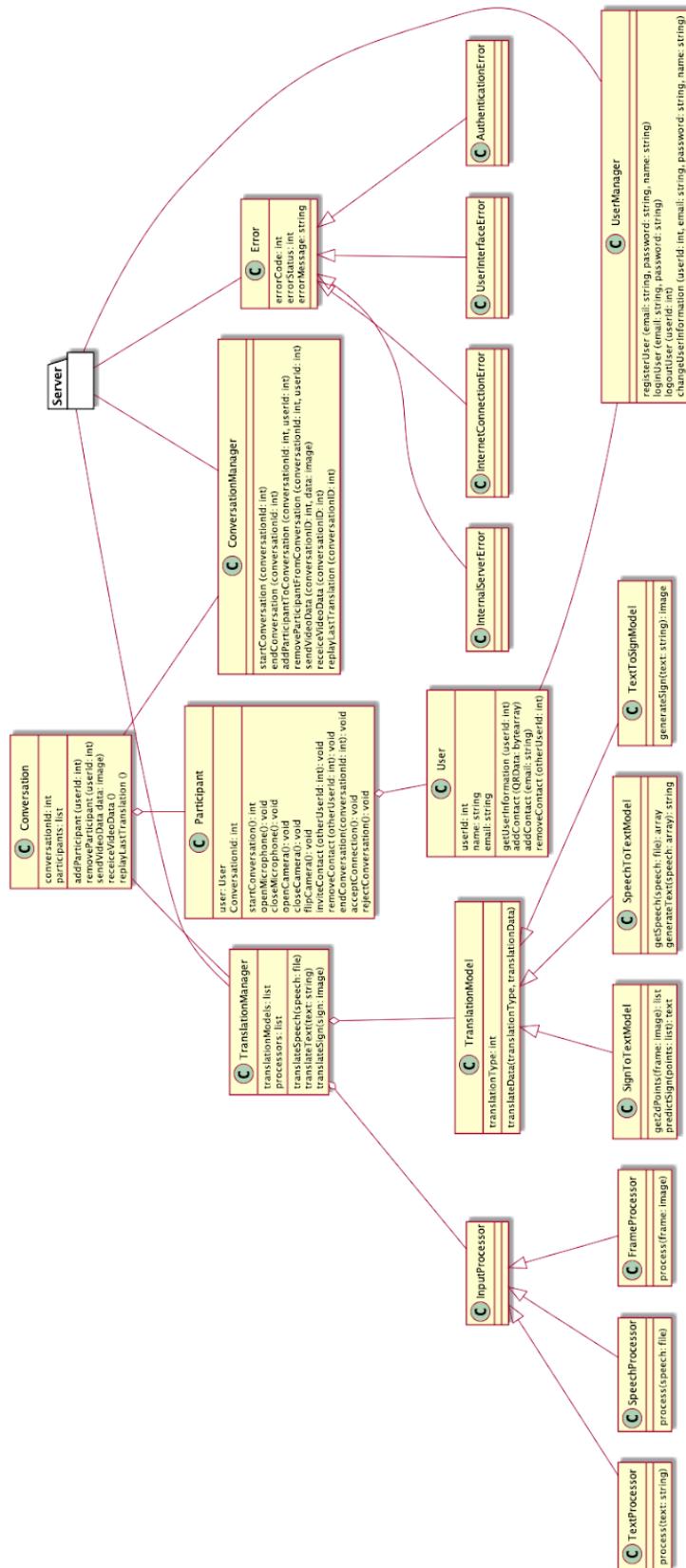
Figure 5: Object and Class Diagram

2.5.4.   Dynamic Models

2.5.4.1.   Activity Diagrams

## 2.5.4.1.1.   Translation
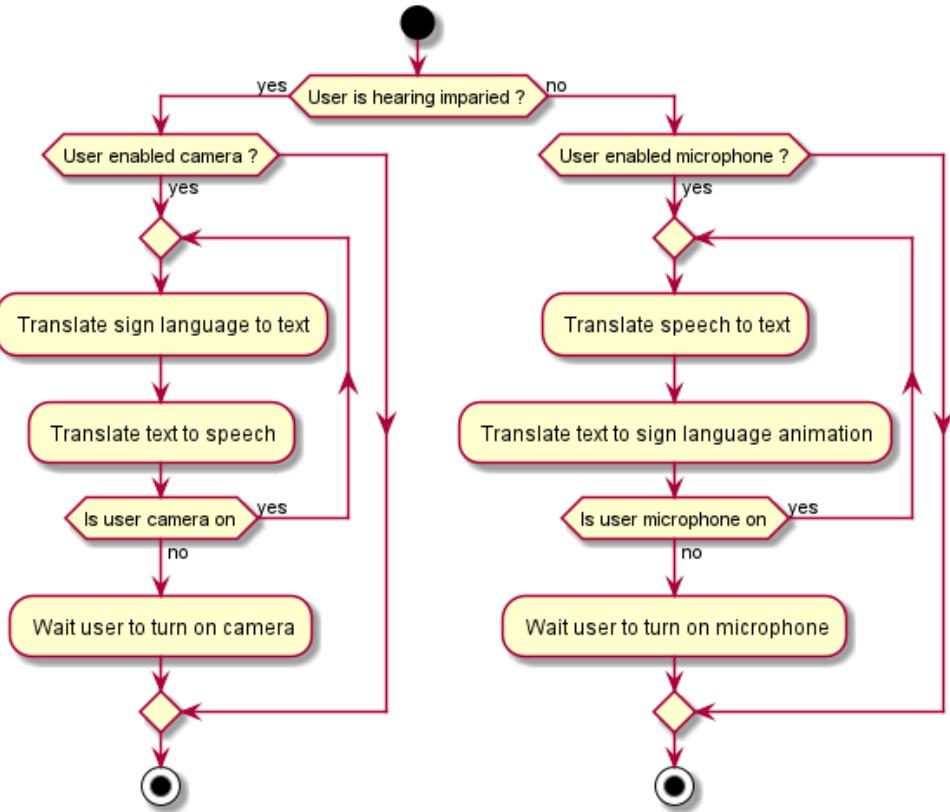
Figure 6: Translation Activity Diagram

2.5.4.2.   Sequence Diagrams

2.5.4.2.1.   Conversation
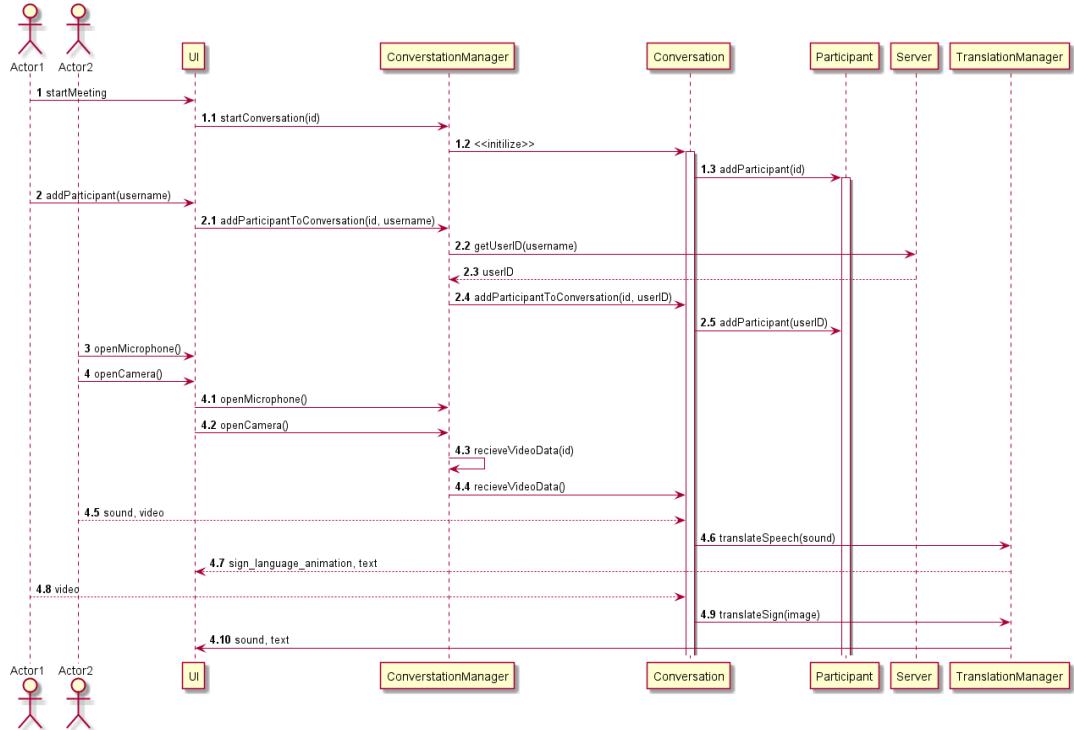
Figure 7: Conversation Sequence Diagram

### 2.5.4.2.2.   Registration
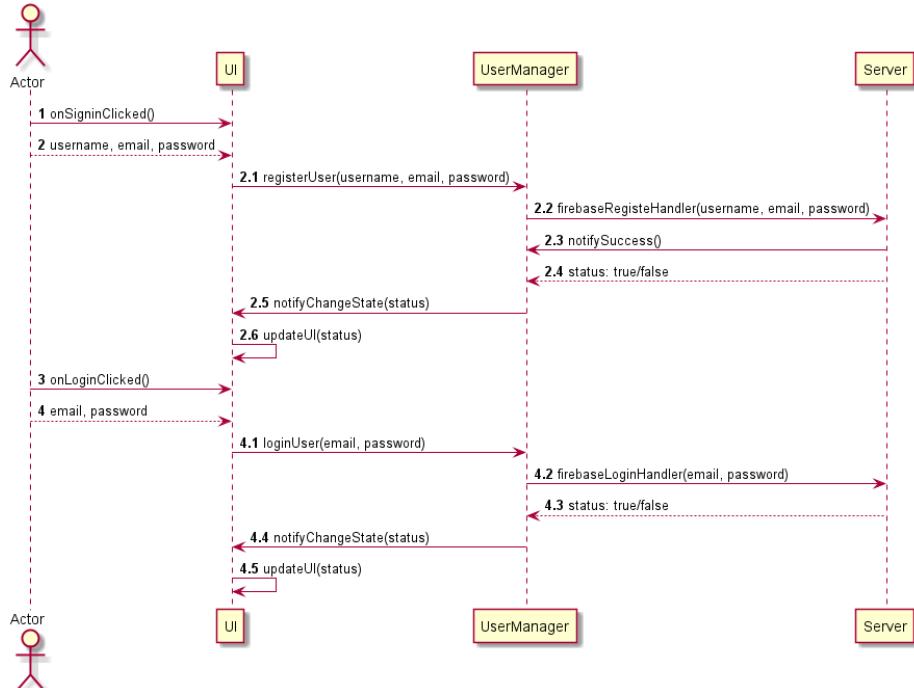
Figure 8: Registration Sequence Diagram

2.5.4.3.   State Diagrams

2.5.4.3.1.   Turn Based Conversation
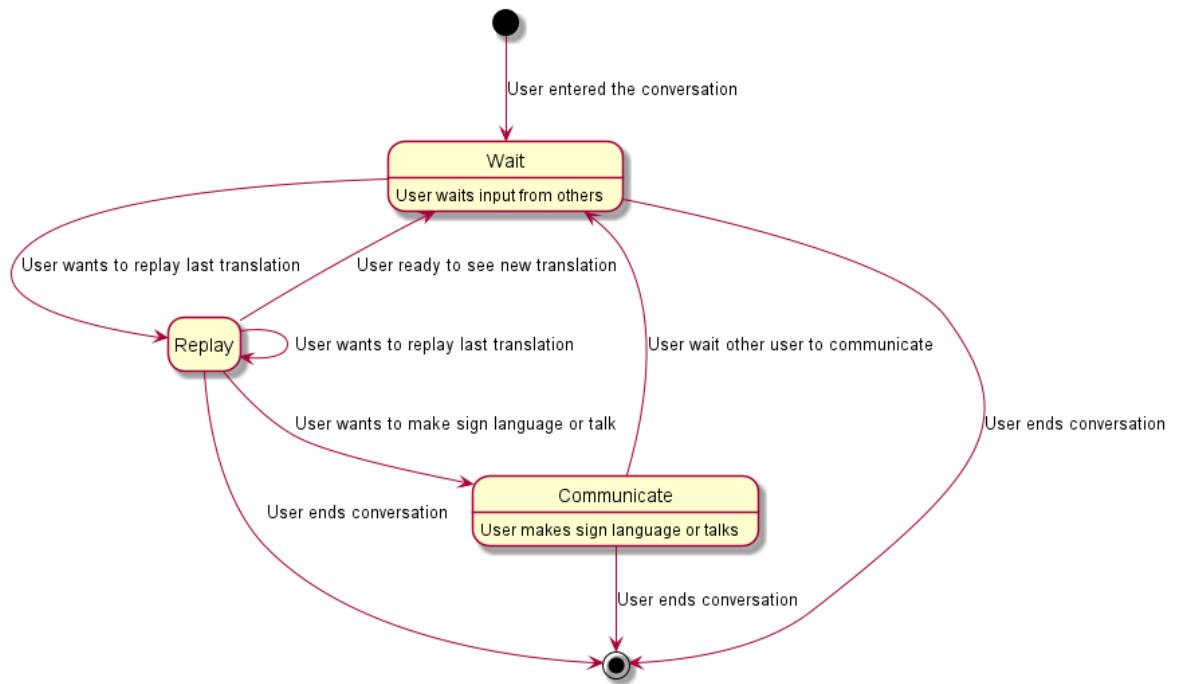
Figure 9: Turn Based Conversation State Diagram

2.5.5. *User Interface-Navigational Paths and Screen Mock-ups*

2.5.5.1. *User Interface*

2.5.5.1.1. SignUp Screen
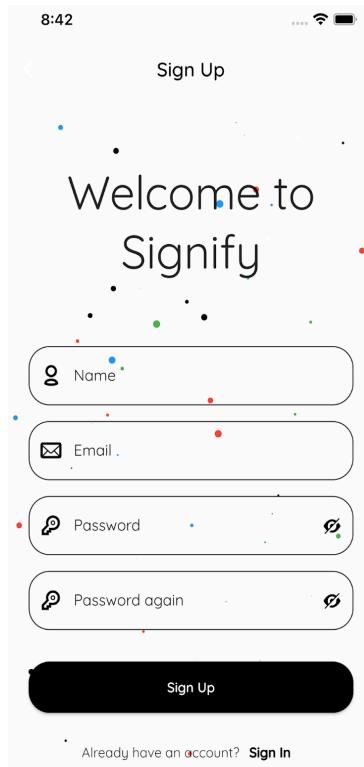
Figure 10: SignUp Screen User Interface

This is the first screen that users see when they open the application for the first time. Users can register to Signify by this screen. The registration requires a name, email address and a strong password. After Users press the Sign Up Button, a validation mail will be sent to the user in order to authenticate to Signify. In addition, Users who already have an account can press the Sign In Button to navigate to the SignIn Screen.

2.5.5.1.2.   SignIn Screen
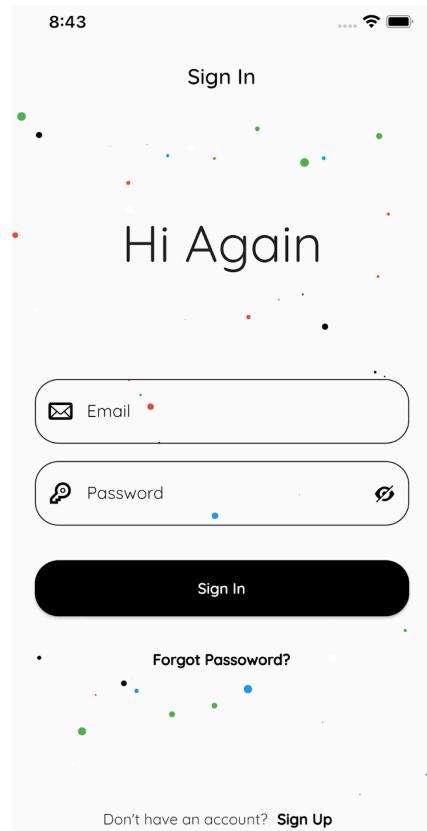
Figure 11: SignIn Screen User Interface

This is the SignIn Screen where users who already have an account on Signify can use in order to authenticate to the application. After entering the email and password, users will wait for a few seconds in order to login to Signify and then will be navigated to the Home Screen. Additionally, Users who forgot their password can press the Forgot Password button in order to navigate to the Forgot Password Screen, or Users who accidentally pressed the Sign Up Button in the Sign Up Screen can return to Sign Up Screen by pressing Sign Up Button.

2.5.5.1.3. Forgot Password Screen
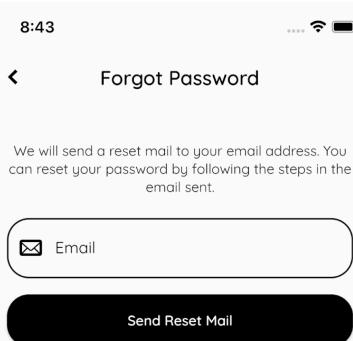
Figure 12: Forgot Password Screen User Interface

This is the Forgot Password Screen. Users who forgot their passwords will be navigated from Sign In Screen to this screen when they press the Forgot Password Button. Users can enter their emails in order to receive a Reset Password mail from the server.

2.5.5.1.4.   Home Screen

Figure 13: Home Screen User Interface

This is the Home Screen where authenticated Users see when they logged in to the Signify. This screen will contain tutorials related to Sign Language and Signify. It is planned to add more content on this screen. Users can see their account related information such as unique QR Code, profile picture and email address by tapping to the button in the top-left of the screen. Additionally, users can navigate to the Settings Screen by tapping the button in the top-right side of the screen. Finally, users can navigate to other screens, which are Call Screen, Translate Screen and Contacts Screen by using the navigation bar positioned in the bottom of the screen.

2.5.5.1.5. Call Screen
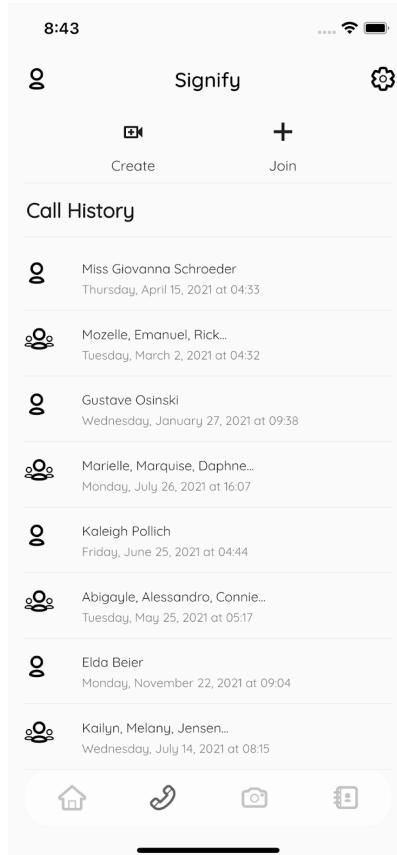
Figure 14: Call Screen User Interface

This is the Call Screen where Users are navigated when they press the second button of the navigation bar positioned in the bottom of the screen. Users can either start a call or join a call by tapping Create and Join Buttons respectively. Users who created a call or correctly entered the ID and Password of an on-going call will be navigated to the In Call Screen. Additionally, Users can see their call history along with participants names and the time that the calls happened on that screen. Users can either delete a call by swiping left or navigate to the Call Details Screen by tapping any call in the history. Finally, users can navigate to other screens, which are Home Screen, Translate Screen and Contacts Screen by using the navigation bar positioned in the bottom of the screen.

2.5.5.1.5.1.   Call Details Screen
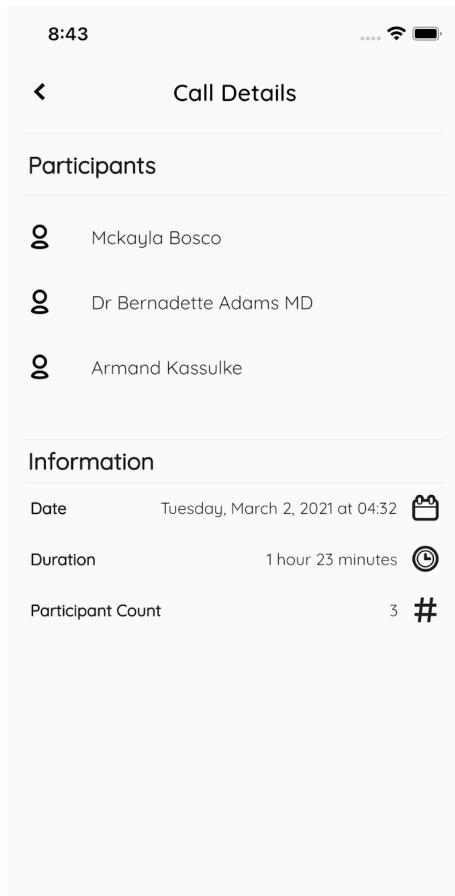
Figure 15: Call Details User Interface

This is the Call Details Screen where Users navigated when they pressed to any call in the history that was available in the Call Screen. Users can see the participant information in addition to the date, duration and participant count information. Users can return to the Call Screen by pressing the Back Button positioned in the top-left corner of the screen. It is planned to add a feature related to sending invites to the users by swiping left the tile where the participant name and profile picture is available.

2.5.5.1.5.2.   In Call Screen

Figure 16: In Call Screen User Interface

This is the In Call Screen where Users navigated when they created or joined a call from the Call Screen. Users can change the settings such as opening/closing their video, opening/closing their microphone or change the translation type from text to sign language or sign language to the text by using buttons placed on the top right of the screen, respectively. Opening and closing video and microphone is designed for the Users who do not have any impairment, as the application allows adding up to four people to the conversation and an always on video and microphone approach can create issues related to privacy. In addition to that Users can see real-time translations from the box positioned in the bottom of the screen, where Users also be able to replay the translation by pressing the Replay Button positioned in the bottom-right of the box. Finally, Users can finish or leave the call by pressing the End Call Button positioned in the top-left of the screen.

2.5.5.1.6.   Translate Screen

Figure 17: Translate Screen User Interface

This is the Translation Screen where Users are navigated when they press the third button from the left in the navigation bar. Users can real-time translate to sign language from voice or voice to sign language on this screen. Users can see the real-time translations from the box positioned in the bottom of the screen. In addition to that, users can open/stop the camera or microphone, replay the translation or change the translation type by using the buttons positioned under the appbar of the screen, respectively. Opening or closing the camera or microphone is designed for the Users, as an always on video and microphone approach can create issues related to privacy. The box positioned under the appbar can be hide/unhide by tapping the screen. Finally, users can navigate to other screens, which are Home Screen, Call Screen and Contacts Screen by using the navigation bar positioned in the bottom of the screen.

2.5.5.1.7. Contacts Screen
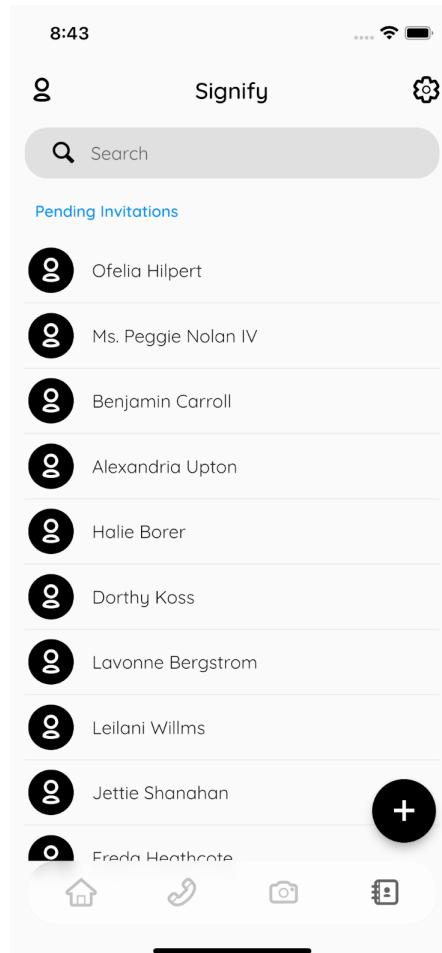
Figure 18: Contacts Screen User Interface

This is the Contacts Screen where Users are navigated when they press the last button of the navigation bar. Users can search through their contacts list by using the search bar available at the top of the screen. Users can see their contacts and tap one of the tiles in the list in order to navigate to the related contacts Contact Details Screen. Users can tap the Pending Invitations Button in order to navigate to the Invitations Screen. Also, Users can press the Floating Plus Button in order to activate Add Contacts Screen. Finally, users can navigate to other screens, which are Home Screen, Call Screen and Translate Screen by using the navigation bar positioned in the bottom of the screen.

2.5.5.1.7.1.   Contact Details Screen
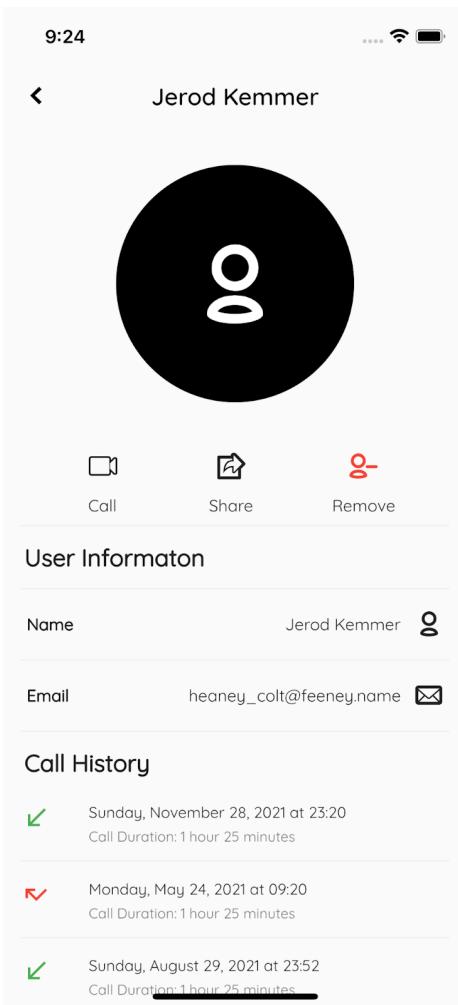
Figure 19: Contact Details Screen User Interface

This is the Contact Details Screen where Users navigated when they pressed the tile of a contact that was available in the Contacts Screen. Users can see the profile picture, name and email of the respective User in addition to the call history containing the information related to the calls made between User of the application and the respective user. Users can also create direct calls, share respective Users' contact info, which is the name and email of the respective User, and remove the user from contact list. Users can also navigate back to the Contacts Screen by pressing the Back Button positioned on the top-left of the screen.

2.5.5.1.7.2. Add Contact Screen
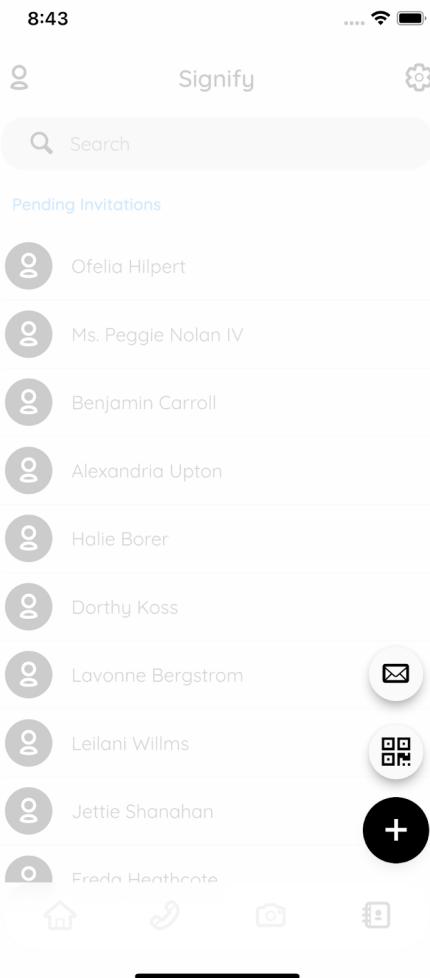
Figure 19: Add Contact Screen User Interface

This is the activated Add Contacts Screen when Users pressed the Floating Plus Button available on the bottom right corner of the Contacts Screen. Users can either press Add via QR Code or Ad via Email Buttons in order to send an invitation to a user regarding adding as a contact. As Signify respects the Users' privacy, in order to make calls or invite Users to a call, the respective User(s) must be already available in the contacts. When Add via QR Code Button pressed, a screen that scans QR Code will be opened. When Add via Email Button is pressed, a dialog box asking for other Users' email will be opened. In either way, when the QR Code or Email is valid, an invitation will be sent to the respective User. Users can deactivate the screen by pressing the Floating Plus Button again or anywhere on the screen which is not in the hitbox of the Add via QR Code or Ad via Email Buttons.

2.5.5.1.7.3.　Invitations Screen
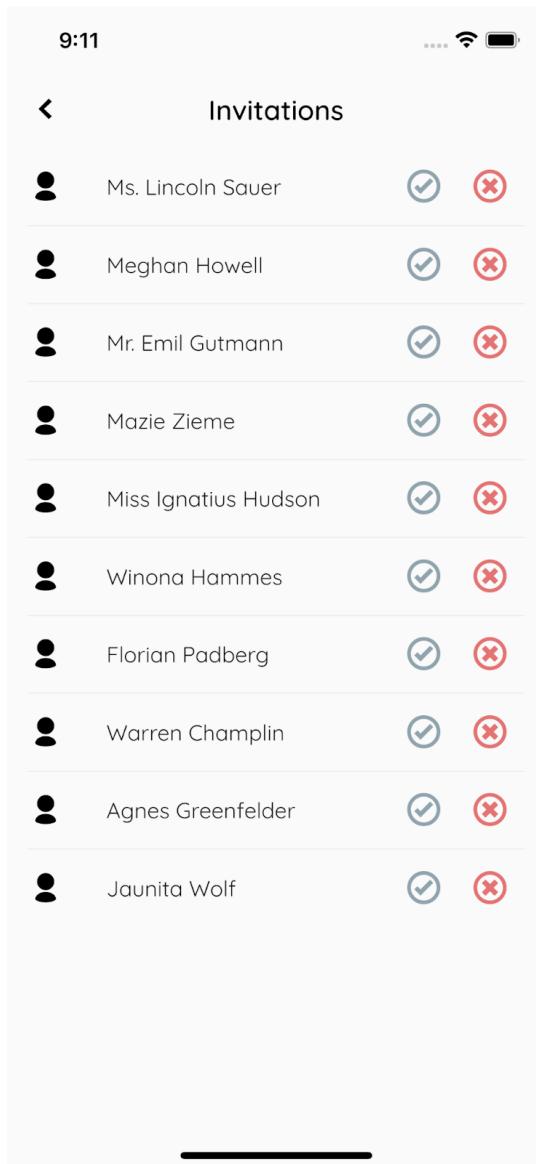
Figure 20: Invitations Screen User Interface

This is the Invitations Screen where Users navigated when they pressed the Pending Invitations Button available in the Contacts Screen. Users can see pending invitations sent from other users via email using the activated Add Contacts Screen. Users can either accept or reject the invitation by using the Accept and Reject buttons available on the right side of the respective Users' invitation tile, respectively. Users can also navigate back to the Contacts Screen by pressing the Back Button positioned on the top-left of the screen.

2.5.5.1.8.　Settings Screen
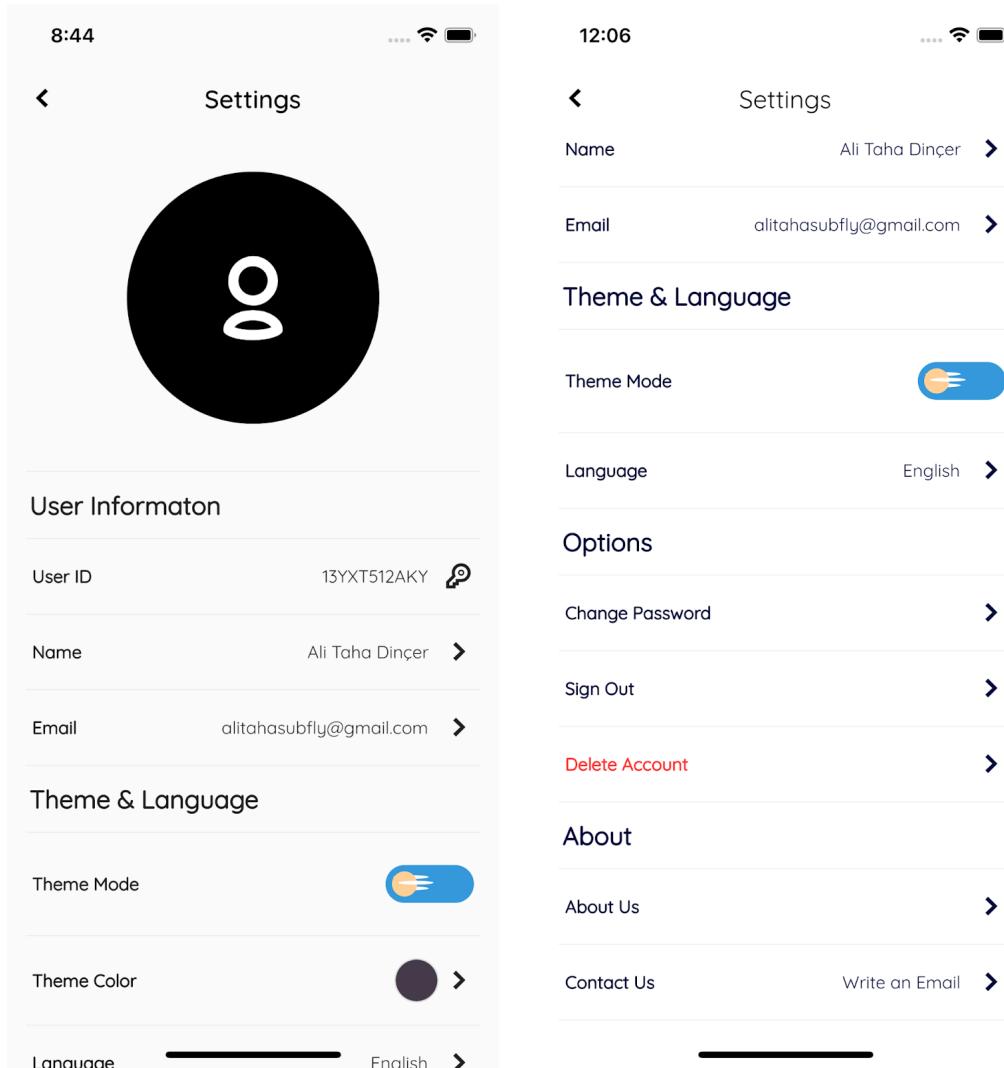
Figure 21: Settings Screen User Interface

This is the Settings Screen where Users navigate when they press the Settings Button available on the top-right of the four main screens, which are Home Screen, Call Screen, Translate Screen and Contacts Screen. The first available content on the screen is the profile picture of the User. Users can change or delete their profile picture by tapping the Circle Avatar that contains the default profile picture or their picture. Next, the User Information section contains the Users' unique ID assigned by the Firebase, name and email. Along these three information, Users can only change their name and email information by tapping these tiles. Under the Theme and Language section, Users are able to change the theme mode and language of the application. In order to change the theme mode, Users can interact with the animated switch button available on the right side of the tile. In order to change the language,

users can tap the respective tile which opens a dialog box to select between English and Sign Language. Under the Options section, Users are able to change their password, sign out from Signify or delete their Signify account. Sign out and delete account options will open a dialog box that warns the User in order to continue to proceed. Under the About section, the available actions are About Us tile and Contact Us tile, which shows a dialog box containing developers information and navigates to a screen that lets the Users write an email regarding their opinions or requests related to Signify, respectively. Among all available options, changing name, email and password tiles will navigate to a screen similar to the Forgot Password Screen in order to edit the respective information. Finally, Users can return to the last screen where they have interacted with the Settings Button by pressing the Back Button available on the top-left of the screen.

2.5.5.1.9.   Crash Screen
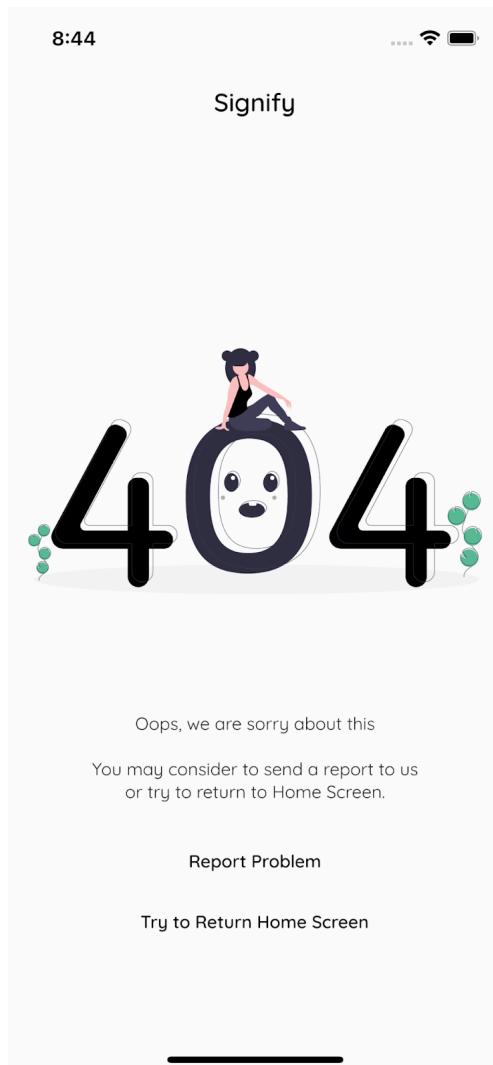
Figure 21: Crash Screen User Interface

This is the Crash Screen which is only available when an exception appears while using Signify. The purpose of the screen is to be used as a fall-back screen. Users can either report the problem to Signify Team by pressing Report Problem Button or restart the app by navigating to the Home Screen by pressing Try to Return Home Screen Button.

2.5.5.2.   Navigational Paths
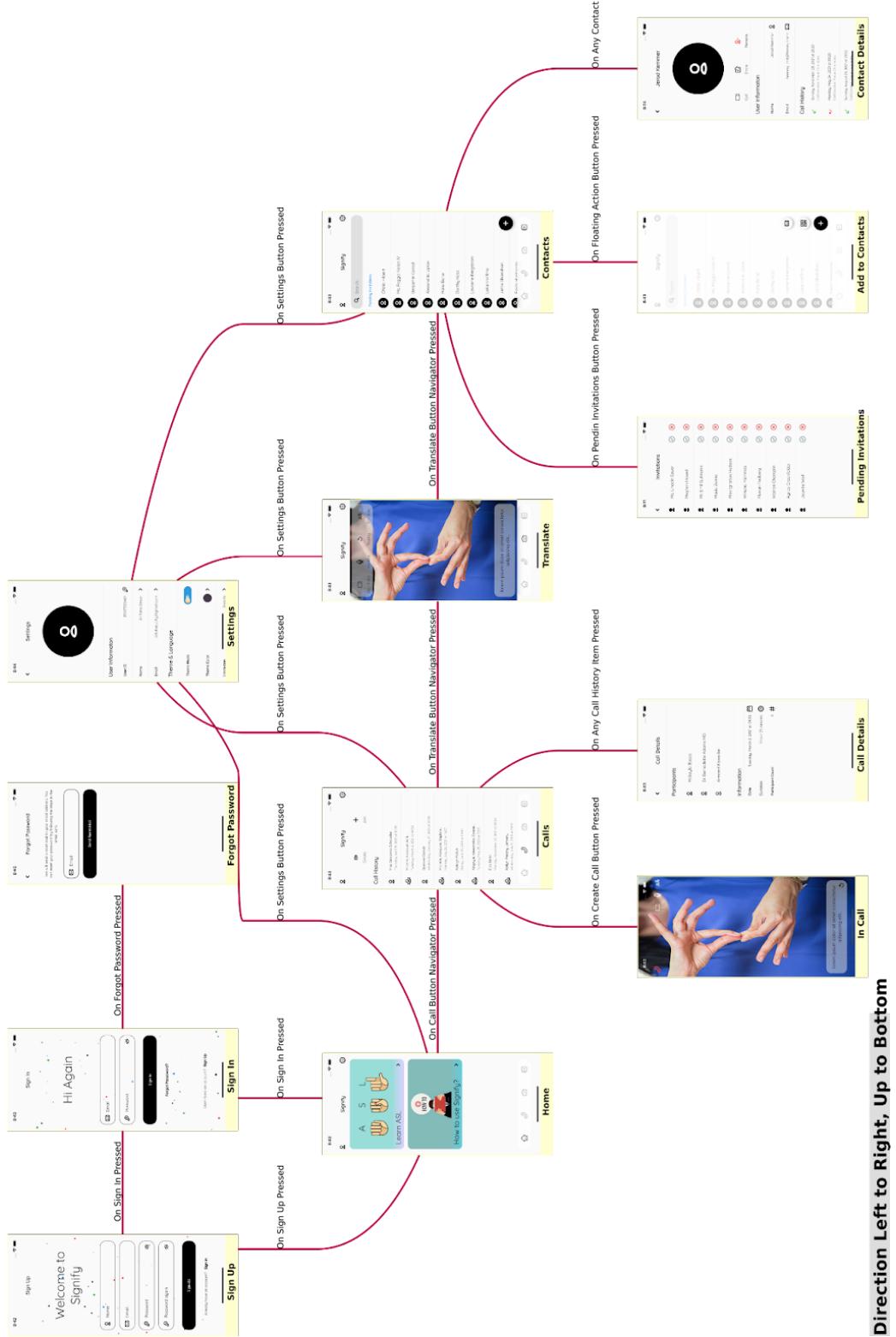
Figure 22: Navigational Paths of User Interface

3.   Other Analysis Elements

3.1.   Consideration of Various Factors in Engineering Design

To conduct a project, different factors should be considered to produce a product which provides great user experience, solves people's problems etc. The chief consideration is to organize and plan the project progress. Since it is a team-work project, team members should collaborate and communicate with each other. The one part might have a huge impact on other parts; therefore, team members should consider the consequences of their actions. To ensure this communication and collaboration, we decided to follow agile and scrum methodology for developing the project. The team has weekly meetings to determine the road map of the week.

Another consideration is related to user experience. The application should be user-friendly. It has not only a modern user interface but also simple, flawless, and fast design to provide the best user experience.

Furthermore, the user should have no security concern. The personal and sensitive data should be protected against any adversarial attack. Nowadays, a lot of applications are exposed to adversarial attacks. The application should be protected against them. All personal and sensitive data should be encrypted and stored safely. Also, any non-required data which has no impact on application performance should not be stored or taken by the user. To comply with "General Data Protection Regulation" - GDPR and "Kişisel Verilerin Korunumu Kanunu" KVKK, any personal and sensitive data should not be shared with third parties.

The last consideration of the project is related to finance. The application is determined as free so that everyone can use the application. The application should be affordable for not only users; but also developers. Therefore, all machine learning work is made by the phone's gpu or special unit which is made for enhancing the computational power of the phone. If the server or any external service is used for these tasks, the server fee becomes much more expensive as the application grows.

	Effect Level	Effect
Cultural Factors	9	Change in learning model outputs due to cultural differences in spoken-sign language.
Public Safety	8	General Data Protection Regulation

Public Health	1	Impaired people's health should be considered, however, it is not the main purpose of the application.
Public Welfare	2	Reducing the communication limits among impaired people.
Economic Factors	6	The application should be free.
Environmental Factors	1	It is not in the scope of this project.
Social Factors	5	Language barrier for hearing impaired people in the sign up process.
Global Factors	8	Translation is done only between English and ASL.
Technological Factors	10	Change in design of learning models due to the publication of new technologies.

Table 1: Factors that can affect analysis and design

3.2.   Risks and Alternatives

First risk is related to internet availability and speed. For online meetings, internet connection and speed are essential parts since two users should communicate with each other without delay and connection problems. If the user encounters any internet availability issue, it might be related to hardware -receiver- problem and signal -internet provider- problem. Users should be notified if any internet availability problem occurs. If the internet connection is low or unstable, meeting configuration can be changed automatically for enhancing user experience. The quality of the video conference is changed to reduce the bandwidth load. Also, for this case users are informed about the reduction in video quality. Second risk is related to any malfunction in the phone unit which is used for computation of machine learning and producing results. In this case, the user is warned to check their device. For this problem, we plan to implement live support for translation functionality. This is our B plan and it is not core functionality of the project. If all planned functionality is implemented and working correctly, we are going to implement live support service to improve user experience. The last risk is about the performance of machine learning algorithms used in the application for translation, namely sign language to voice/text and voice to text/sign language. If the user reports that the translation is not correct, the technical team who are working on machine learning algorithms examines the reports and validates them. In any case

the algorithms are indeed not working correctly, algorithms are enhanced to provide sustainability and best user experience.

	Likelihood	Effect on the Project	B Plan Summary
Not Sufficient Internet Connection	High	Users will not be able to use communication feature	Change online meeting configuration to reduce bandwidth.
A malfunction occurance on user's phone	Very Low	Machine learning dependent functionalities will not work	User will be guided into live support functionality
Low machine learning performance	Medium	Real-time experience will be affected negatively	Algorithms will be enhanced to provide sustainability

Table 2: Risks and Alternatives

3.3. Project Plan

As part of the planning activity, the project goals are listed and divided into work packages (WPs). Each work-package has a leader and at least two students work on a WP. For each WP, the start and end dates, major milestones, objectives and deliverables are planned. At the end of detailed explanation, a Gantt chart is designed to express the project schedule.

WP#	Work package title	Leader	Members involved
WP1	Project Specifications Report	Çağlar	Everyone
WP2	Analysis Report	Ali Taha	Everyone
WP3	User Interface Implementation	İrem	Ali Taha
WP4	High Level Design Report	Naci	Everyone
WP5	Sign Language Translation (From Video to Text)	Sena	Çağlar
WP6	Sign Language Translation (From Text to Animation)	Çağlar	Naci
WP7	Database Connection	Ali Taha	Sena
WP8	Mid Testing	Naci	Everyone
WP9	Demo-Presentation	Sena	Everyone

WP10	Real Life Communication	İrem	Taha
WP11	Video Conference Communication	Naci	İrem
WP12	Low Level Design Report	Çağlar	Everyone
WP13	Final Testing	Ali Taha	Everyone
WP14	Final Report	Sena	Everyone
WP15	Final Presentation	İrem	Everyone

Table 3: List of Work Packages

WP 1: *Project Specifications Report*

Start date: *1/10/2021*   **End date:** *11/10/2021*

Leader:	*Çağlar Çankaya*	**Members involved:**	*Muhammed Naci Dalkıran, Ali Taha Dinçer, İrem Ecem Yelkanat, Sena Korkut*

Objectives: *Name and briefly describe the project. Identify initial project requirements,*

constraints and professional & ethical responsibilities.

Tasks:
Task 1.1 Introduction and Literature Review **:** *Literature review and market research will be conducted to analyze the problem and previous solutions published. It will also give the project title and brief description of the project along with its features.*

Task 1.2 Constraints and Requirements **:** *These subsections will discuss the project constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability. It will also discusses the requirements, both functional and non-functional.*

Deliverables
D1.1: Project Specifications Report

WP 2: *Analysis Report*

Start date: *20/10/2021*   **End date:** *08/11/2021*

Leader:	Ali Taha Dinçer	Members involved:	Sena Korkut, Çağlar Çankaya, Muhammed Naci Dalkıran, İrem Ecem Yelkanat

Objectives: *The analysis report contains a detailed analysis of the problem. The analysis of the system or solution, requirements, and related formal expressions, models, diagrams, and charts will make the major portion of the report.*

Tasks:
Task 2.1 Requirements and Constraints : *The requirements and the constraints of the proposed system will be updated according to new changes after the recommendations of innovation expert.*

Task 2.2 Proposed System Models : *Use case and scenarios, object and class models and dynamic models will be proposed based on the major features of the project.*

Task 2.3 Other Analysis Elements : *Various factors in engineering design, risks and alternatives, project plan, teamwork and ethical responsibilities will be discussed detailly.*

Deliverables
D2.1: *Analysis Report*

WP 3: *User Interface Implementation*

Start date: *1/11/2021*   **End date:** *08/11/2021*

Leader:	İrem Ecem Yelkanat	Members involved:	Ali Taha Dinçer

Objectives: *Implementing some basic UI-based application functionalities without the logic and the main features of the project.*

Tasks:
Task 3.1 Sign in and Sign up Screens : *Sign in and sign up screens will be designed. Specifically, the screen will ask the username, email, and password.*

Task 3.2 Settings : *Settings screen will be designed. It will include user information, theme and the status of the user's language ability. Users will be able to change passwords and sign out from the settings section.*

Task 3.3 Contact and Call History : *Contact and call history will be designed to be used for adding contacts and calling contacts.*

Task 3.4 Home Screen: *Home screen will include "how to use" and "learn ASL" sections along with the buttons to change to other functionalities.*

Deliverables
D3.1: *A basic application interface that can switch screens without functionalities and logic.*

WP 4: *High Level Design Report*			
Start date: *20/11/2021* **End date:** *24/12/2021*			
Leader:	*Muhammed Naci Dalkıran*	**Members involved:**	*Sena Korkut, Çağlar Çankaya, Ali Taha Dinçer, İrem Ecem Yelkanat*

Objectives: *High-level system design is the transportation of the analysis model into a system design model. The detailed information about the high-level design and the related formal expressions, models, diagrams, architectures, charts will be the major part of your high-level design report.*

Tasks:
Task 4.1 Software Architecture **:** *Subsystem decomposition, data management, security and access, control,global software and control and boundary conditions will be discussed in great detail.*

Task 4.2 Teamwork Details **:** *Contributing and functioning effectively, creating an inclusive environment, and taking lead and sharing leadership will be discussed.*

Deliverables
D4.1: *High Level Design Report*

WP 5: *Sign Language Translation (From Video to Text)*			
Start date: *Beginning of December* **End date:** *End of January*			
Leader:	*Sena Korkut*	**Members involved:**	*Çağlar Çankaya*

Objectives: *Related computer vision and natural language processing models will be used to translate sign language in a given video to text.*

Tasks:
Task 5.1 Related Work **:** *Literature review will be conducted in the field of sign language translation. The advantages and drawbacks of papers found will be analyzed.*

Task 5.2 Dataset **:** *Related datasets will be searched and appropriate ones will be chosen to train the learning model.*

Task 5.3 Learning Models **:** *Both NLP and computer vision models to be used will be decided based on literature review. Some changes and improvements on model architectures can also be considered.*

Task 5.4 Training and Testing **:** *Models will be trained and tested with the datasets chosen and the results will be discussed.*

Deliverables
D5.1: A functioning learning model containing multiple network architectures.

WP 6: *Sign Language Translation (From Text-Speech to Animation)*

Start date: *Mid of November*   **End date:** *End of February*

Leader:	Çağlar Çankaya	Members involved:	Muhammed Naci Dalkıran, Sena Korkut

Objectives: *Related computer vision and natural language processing models will be used to convert an audio or text to sign language animation.*

Tasks:
Task 6.1 Related Work **:** *Literature review will be conducted in the field of speech-to-text translation, sign language translation and animation reconstruction based on pose data. The advantages and drawbacks of papers found will be analyzed.*

Task 6.2 Dataset **:** *Related datasets will be searched and appropriate ones will be chosen to train the learning model.*

Task 6.3 Learning Models **:** *A new model will be constructed to have successful transitions between speech to text, text to pose (sign language translation) and pose to animation.*

Task 6.4 Training and Testing **:** *Models will be trained and tested with the datasets chosen and the results will be discussed.*

Deliverables
D6.1: A functioning learning model containing multiple network architectures.

WP 7: *Database Connection*

Start date: *Beginning of December*   **End date:** *End of December*

Leader:	Ali Taha Dinçer	Members involved:	Sena Korkut

Objectives: *A working database that can hold user data in a secure way.*

Tasks:
Task 8.1 Decision **:** *Database type will be chosen based on economic and security constraints.*

Task 8.2 Integrate **:** *The database will be integrated to the application. The user will be able to modify data from the database with the help of user interface provided.*

Deliverables
D8.1: A functioning secure database.

WP 8: *Mid Testing*

Start date: *Mid December*   **End date:** *Before Demo Day*

Leader:	*Muhammed Naci Dalkıran*	Members involved:	*Sena Korkut, Çağlar Çankaya, Ali Taha Dinçer, İrem Ecem Yelkanat*

Objectives: *Test all features implemented so far.*

Tasks:
Task 8.1 Test Application: *User interface and database connection will be tested considering corner cases.*

Task 8.2 Test Learning Models **:** *The success of learning models will be tested again in terms of different performance metrics. Improvements will be done if needed.*

Deliverables
D8.1: An error free application and rather-successful sign language translation model.

WP 9: *Demo-Presentation*

Start date: *Mid December*   **End date:** *End of Fall Semester*

Leader:	*Sena Korkut*	Members involved:	*Muhammed Naci Dalkıran, Çağlar Çankaya, Ali Taha Dinçer, İrem Ecem Yelkanat*

Objectives: *Present the current system and discuss future implementations for the jury.*

Tasks:
Task 9.1 Slide **:** *Prepare presentation slides.*

Task 9.2 Demo **:** *Prepare a video of the current system and its features.*

WP 10: *Real Life Communication*

Start date: *Beginning of March* **End date:** *End of March*

Leader:	İrem Ecem Yelkanat	Members involved:	Ali Taha Dinçer	47

Objectives: *Add sign language translation features to the application.*

Tasks:
Task 10.1 Connection **:** *A new section will be designed for communication in real life using the application.*

Task 10.2 Apply learning models **:** *Two-way translation model will be applied to this section. It will be able to take video data from the user and translate it to text. It will also be able to record audio and translate it to sign language.*

Deliverables
D10.1: *A platform that is able to translate sign language in both ways.*

WP 11: *Video Conference Communication*

Start date: *Beginning of March* **End date:** *End of March*

Leader:	Muhammed Naci Dalkıran	Members involved:	İrem Ecem Yelkanat

Objectives: *Video conferencing features will be added to the application.*

Tasks:
Task 11.1 Connection **:** *An online video conferencing tool will be designed for communication via phones.*

Task 11.2 Integrate **:** *It will be integrated to the application where users are able to add contacts and start a video conference.*

Task 11.3 Apply learning models **:** *Two-way translation models will be applied real time while people are talking-signing during the conference.*

Deliverables
D11.1: *Video conferencing platform that is able to translate sign language in both ways.*

WP 12: *Low Level Design Report*

Start date: *TBD* **End date:** *TBD*

Leader:	Çağlar Çankaya	Members involved:	Muhammed Naci Dalkıran, Sena Korkut, Ali Taha Dinçer, İrem Ecem Yelkanat

Objectives: *Comprehensive low-level design of the system so that the implementation goes smoothly.*

Tasks:

Task 12.1 Software Design Architecture : *Decide on which software architecture fits the best to the current and proposed system.*

Task 12.2 System Models : *Design system models for the implementation.*

Deliverables
D12.1: *Low Level Design Report*

WP 13: *Final Testing*

Start date: *Beginning of May*   **End date:** *End of May*

Leader:	Ali Taha Dinçer	Members involved:	Muhammed Naci Dalkıran, Çağlar Çankaya, Sena Korkut, İrem Ecem Yelkanat

Objectives: *Finalize the project and test all the features provided.*

Tasks:
Task 13.1 Test Application: *User interface, database connection, irl section, video conferencing platform will be tested.*

Task 13.2 Test Learning Models : *The success of learning models and those models' reliability on the application features will be tested to finalize.*

Deliverables
D13.1: *A functioning, error free final product.*

WP 14: *Final Report*

Start date: *TBD*   **End date:** *TBD*

Leader:	Sena Korkut	Members involved:	Muhammed Naci Dalkıran, Çağlar Çankaya, Ali Taha Dinçer, İrem Ecem Yelkanat

Objectives: *Final, complete information about the system.*

Tasks:
Task 7.1 Architecture : *Decide on the final architecture of the system.*

Task 7.2 Maintenance Plan : *Provide a maintenance plan.*

Task 7.2 Social Impact : *Discuss social impacts of the project*

Deliverables
D7.1: *Final Report*

WP 15: *Final Presentation*

Start date: *TBD*   **End date:** *TBD*

Leader:	İrem Ecem Yelkanat	Members involved:	Muhammed Naci Dalkıran, Çağlar Çankaya, Ali Taha Dinçer, Sena Korkut

Objectives: *Present the current and final system and discuss the impacts of the project.*

Tasks:
Task 9.1 Slide : *Prepare presentation slides.*

Task 9.2 Demonstration : *Prepare a video of the finalized system and its features.*
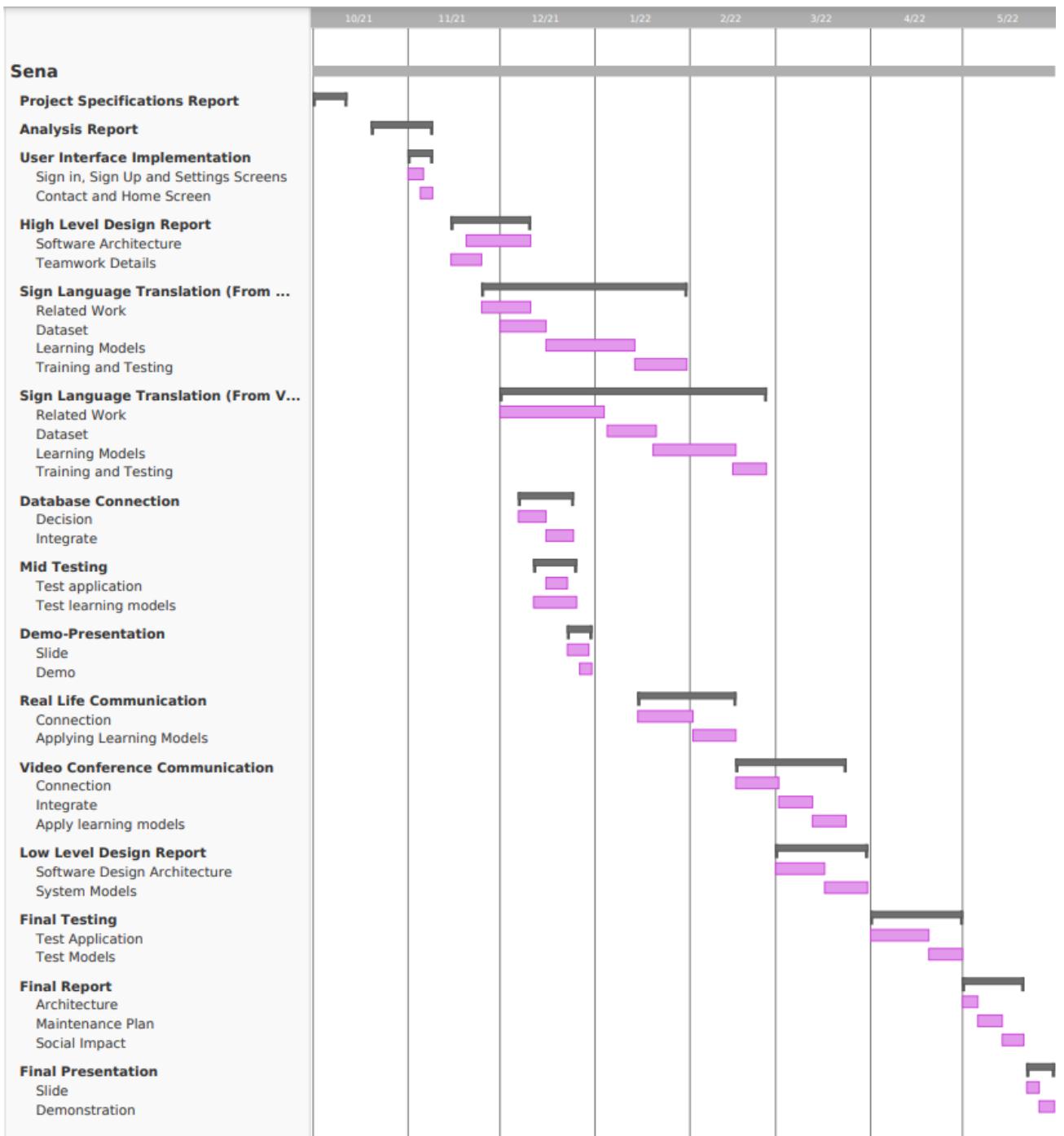
Figure 23: Gantt Chart of Project Plan with Work Packages

3.4.   Ensuring Proper Teamwork

Each member in the team has different soft skills.

- Çağlar Çankaya: Arranging meetings and internal/external communication

- Muhammed Naci Dalkıran: Prioritizing the task and managing requirements

- Ali Taha Dinçer: Conflict management and problem solving among team members

- Sena Korkut: Managing report and project
- İrem Ecem Yelkanat: Managing work pipeline and checking on work done

All team members had work experience and worked on different team projects. Therefore, we know the importance of ensuring proper teamwork. We distributed different rules among us; since each member in the team has different overwhelming soft skills. However, some soft skills are common. For example, all members are aware of the importance of giving/taking feedback, critical thinking, and communication.

We use Google Drive. We have timesheets, reports, external documentation and task sheets in Google Drive for collaboration and sharing information about the project transparently. Also, team members can follow the progress, make changes in the documentation, and access the documentations simultaneously.

- Github

Github is used for all code based documents. In this way we can manage version control, see contributions for planning project progress, and organizing our code based documents. We have three different repositories for different fields of the project, namely mobile application development, machine learning model development and diagrams. For creating diagrams, we use PlantUML. In this way, we can create diagrams with code and save time which is spent in the diagram design.We split mobile application development and machine learning model development repositories to avoid merge conflicts.

- Weekly Meetings, Agile & Scrum

We make weekly meetings to share weekly work done by each team member, plan the next week, give/take feedback, prioritize tasks, and discuss the topics brought on the agenda. All meetings are made in Zoom or face to face if applicable. In the beginning of the meeting, each member mentions what he/she did in the previous week. Then, the agenda of the week is mentioned to members. The tasks are determined and prioritized to be done next week. Then, tasks are assigned to team members. If any member has a topic which the member wants to discuss, these topics are discussed. The end of the meetings, meetings notes and assigned tasks are mentioned again. After the meeting, meeting minutes are shared with all members via email and assigned tasks are written on the task sheet in the Google Drive.

3.5. Ethics and Professional Responsibilities

Our target users hear and speech impaired people; therefore, some ethical and professional responsibilities must be taken. The most significant moral obligation is to provide equal opportunities in the usage of the application.

To ensure the ethical responsibility mentioned above, the dataset used in training should not be biased. The dataset should be representative of all ethnic groups. The training data should appeal to all the users to not humiliate the users' identity and to provide a better user experience. Since the project aims to improve the standard of hearing and speech impaired people, it should be sufficient and representative to make correct and similarly accurate predictions without discriminating against any user. Furthermore, the output of the voice to text and sign language models should not be discriminative. The caption generated by the application should not be biased regarding any race, gender, or social class.

Furthermore, some conversations might include private information about the user; therefore, this information should be protected and should not be shared with other users or third-party companies. As the application grows, user feedback and some recordings of the meetings can be utilized to enhance the performance of the machine learning models. In these cases, any personal information, such as name, address, and job should not be revealed. Additionally, to serve the machine learning models, we will use APIs; however, any information about the user will not be sent to APIs to protect the user's data.

In conclusion, in the development of this project, a representative and unbiased dataset should be selected not to cause any discrimination. Moreover, the machine learning models' output should not include phrases that imply gender inequality, humiliation, and ethnic-based bias. Finally, users' personal information will not be shared with other users or third-party companies and will be protected.

3.6. Planning for New Knowledge and Technologies

For a voice to sign language task, we need to build a machine learning model with Generative Adversarial Network (GAN); however, we had no prior knowledge about GAN before. GAN models are used to generate data, images, videos etc. We plan to use it to generate sign language animations for voice to sign language translation. We will learn GAN models and

general concepts of GAN. Also, we will find the dataset for train GAN models. Two of us take a GAN course to learn and construct a GAN model.

For the application, we decided to use Flutter since it is a toolkit for building natively compiled applications for mobile and web. It is created by Google and includes rich libraries for UI and UX. Two of us have project experience using Flutter; however, other members have not used Flutter before. Two members who had experience using Flutter will inform other members how to learn Flutter. Then, other members will learn Flutter deeply by watching online courses and reading its documentation.

We decided to deploy the machine learning models into mobile phones to reduce output delay. None of us had experience about this topic before. Therefore, we should learn how to deploy machine learning models into mobile phones. To acquire this technical skill, we will examine the applications that currently use this method for computation power of machine learning models. We will research libraries, packages or API to deploy our machine learning models.

4. References

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