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FAMAID: A TOOL FOR AIDING PEOPLE WITH DISABILITY

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1. INTRODUCTION

According to the World Health Organization [1], more than one billion people live with some form of disability and this number is dramatically increasing. Statistical studies and research predict that in the year 2050, an estimate of 2.5 billion people is subjected to have various levels of hearing loss. At least 700 million will need hearing rehabilitation. In addition, more than one billion young adults are at risk of permanent, avoidable hearing loss due to unsafe listening practices. Furthermore, over 5% of the world's population requires rehabilitation to address their 'disabled' hearing loss. Deaf people often suffer from bullying and depression in their personal and professional lives. As Helen Keller once stated: I am just as deaf as I am blind; to express the seriousness of the problems encountered by deaf people and their consequences. Improving communication access for deaf people has the potential to improve their educational level and everyday life tasks performance [2].

Web technology has invaded our lives in many different aspects including our daily activities and has become essential for everyone including people with disabilities. Most web applications do not take into consideration the capability of people with disabilities, including the deaf, to access various applications. Deaf and non-verbal people use sign language to communicate with each other. However, when it comes to society, not everyone understands sign language, thus the need for a communication tool that makes life easier for both parties. It is important to state that sign language differs from one country to another and deaf people around the world communicate with the sign language used in their specific country. In this research we built an Android mobile app that helps deaf/non-verbal people in communication with each other and with the community. The application offers its audience the opportunity to post donations, learn courses or chat with others through sign language translation. Software technologies used to build this app were node js, react js, postman, mongo dB and tensor flow library for the AI part of hand gesture recognition and image to text translation.

2. RELATED WORK

Many research works in literature have addressed several aspects related to people with disabilities and special community services offered to them. Of these we state recent studies that constitute mobile app development to help deaf people improve their professional, educational, and personal daily life. Moreover, we provide some work related to hand gesture recognition.

To enhance human-human and human-computer communication, hand gesture recognition has gained attention recently. Devices are recently designed to have built-in radars and radiofrequency sensors for hand movement recognition. Many techniques for hand gesture data representation for different machine learning and deep learning algorithms are presented in [3].

Abhishek et al. presented a recent study that recognizes hand gestures using mathematical algorithms for human computer interaction. The paper describes how hand gestures are trained to perform specific actions where the number of fingers can be determined by using gesture defect points and is in turn fed to a 3D convolutional neural network to recognize the gesture [4].

Guo et al. in [5] conducted a survey that allows readers to take a look on the research status of hand gesture recognition and the recent challenges. The survey takes the sensing method used by hand gesture recognition technology as an entry point, and makes a detailed elaboration and systematic summary by referring to a large number of research achievements in recent years.

Baguma et al. in [6] proposed a Web Design Framework for Improved Accessibility for People with Disabilities (WDFAD). The authors provided specific standards on how to develop Web applications that are accessible to people with disabilities and specifically the blind people consideration the three main components of Web applications; content, navigation, and user interface. Using the concepts of Non-Functional Requirements (NFR) Framework, the objectives of Web accessibility have been divided into primary goals and sub goals. The primary goals include the high-level accessibility design objectives, while the sub goals represent the requirements that need to be met in the Web development process to meet each primary goal. Both

goals help in revealing the best ways of attaining the Web accessibility during the Web design phase. The authors in this work concentrated on packaging the main components of the web applications leading to a precise nature of the framework. Consequently, web developers will easily understand and apply the requirements of web accessibility. In this work, the authors classified the web accessibility requirements among local and global. This classification process modularized the web accessibility guidelines hence making it easier for web developers to comprehend the needs of people with disabilities. A recent study in 2021 by Fadlilah et al. has been proposed to help deaf people in Indonesia where a mobile app was built to translate two kinds of Indonesian sign languages (SIBI and BISINDO) and help deaf people to communicate with each other via phone. The research involved developing a basic BISINDO website using PHP and MySQL, training some gestures in TensorFlow lite, and making CNN (Convolutional Neural Network) plan before developing the BisAndro android application. The app was built using Python with Tensorflow library for hand gesture recognition. The application is intended to allow easy communication between deaf people through the mobile phone [7]. Another chatting system that constitutes an EasyChat application for the deaf and non-verbal community is presented in [8]. EasyChat is a sign language chat application that can translate three main sign languages into simple English text and vice versa. The application can read British Sign Language (BSL), Makaton gestures/symbols, and lip movements. These steps are handled by four components as follows: (i) BSL into English conversion, (ii) lip reading conversion, (iii) Makaton gesture and Makaton hand symbol conversion, and (iv) text/voice to sign conversion that converts English text back into sign language-based images.

Due to the rapid development of Linked Data, public access of vast related datasets has been granted. However, it has been noted that many applications in Linked Data haven't been made available for people with disabilities; although the population of such groups of people are turning out to be exceedingly literate in technology. The authors in [9] presented SAMi, an accessible web application which uses icons instead of text to help in YouTube video search. Using this interactive web application, the objective of the work is to develop worldwide access on the Web using an alternative way of Web search other than the text. This web application is a starting point for the definition of an accessible independent interaction for people with reading and writing difficulties. Moreover, this web application contributes to granting access to the majority of web users without taking into consideration the degree of literacy. User tests evaluation have been conducted to examine the first-rate performance, higher satisfaction and total autonomy in their interaction with SAMi. Perez et al. in [10], described a system that provides more accessibility to multimedia content on the Web, by automatically translating subtitles in oral language to written sign language known as SignWriting to help deaf/non-verbal people. The proposed platform has a core component that automatically converts any web page to a web page compliant with level AA of WAI guidelines [10] where different adapters are needed to complete the conversion. The Deaf People Accessibility Adapter is one of these adapters whose functionality is to provide accessible web content for the Deaf together with a video subtitle translator system. Performance evaluation of this system was done using accessibility tests and the results showed the effectiveness of this platform in enhancing the accessibility of video content available on the Web for Deaf people. Since the World Wide Web has become a necessity for everyday life, and due to the fact that deaf/non-verbal people have a problem in accessing/using certain web pages, some technological solutions were provided where video windows showing hand sign translation dominate the screen to aid the understanding of deaf/non-verbal people. In this regard, authors in [11] proposed a solution where transparent sign language videos appear on the screen based on demand to avoid video windows dominating the screen all the time hence interfering with the presentation and distracting the public, who have no need of a bilingual web site. The authors developed a system that embeds selective interactive elements into the original text in appropriate locations, acting as triggers for the video translation into sign language. The video window automatically closes after the short video ends and the original web page is displayed again. Performance evaluation of the system showed the effectiveness of the proposed system in helping deaf people.

In a similar perspective, and since communication and Interaction are becoming very crucial in life, authors in [12] focused their work on building a model and finding appropriate solutions for the communication problem with deaf and mute disabled population around the globe. Real-Time Machine Learning techniques for sign language detection along with Application Programming Interfaces has been implemented. Computer vision has been integrated to build this model to be able to detect the signs in the region of interest and convert them into the suitable format. The objective of this model is to focus on the reduction of the communication gap between people with deaf-mute disabilities and the ability to bring the sensation of having a normal daily life.

The implemented work in this paper offers its audience not only a chatting system, but also the opportunity to communicate with organizations, view/post donations from organizations and engage in learning and other open-source services once accessing the app through sign language translation. To the best of our knowledge, no application has integrated hand gesture recognition, chatting system and donation system for people with hearing disabilities.

3. FUNCTIONAL AND NONFUNCTIONAL REQUIREMENTS

Requirements analysis is very crucial since it is a process that enables the success of a system or software project. Requirements are generally split into two types: Functional and Non-functional requirements. Hereby we will provide the functional and non-functional requirements of our software app.

3.1 Functional Requirements

Functional requirements are the facilities that the end user expects to have in the application. In our system, the functional requirements are displayed in Table 1.

Table 1. System Functional Requirements

System Functional Requirements
Sign up
○ There shall be three level accesses. - Level access for the user - Level access for the admin - The user, admin, organization would be asked to enter their specified information ○ For the organization, the admin would check the form and approve or disapprove of the status after validating the forum's information. - Those information are validated they will be sent to the data base. ○ The button signup will take the user to the signup form.
Login
○ The user will be asked to specify if he is a user, admin, organization. ○ The user will be asked to enter his username and password to log in to his accounts. ○ A submit button. a. Submits the email and password from the login form to the Home page.
Delete Account
○ User can delete the account if they do not want it anymore. ○ The application will prompt the user to confirm that they would like to delete the account before taking the action. ○ Admin can delete users accounts.
Edit Account
○ The customer can edit data. - Customer can edit his personal information. ○ The organization can edit data. - Organization can edit its personal information.

Create New Event
○ The organization will press on create event button. ○ The organization will fill the form. ○ Done button is pressed and the event is created.
Create Question
○ The user Enter the Q&A page ○ Press Ask button ○ Fill in the question. ○ Press submits button.
Answer Question
○ The user Enter the Q&A page ○ Press the question. ○ Press the answer button. ○ Fill in the answer. ○ Press submits button.
View Organization
○ The user Enter Organization page ○ Press the organization title. ○ The details and the events of this organization is displayed.

Turn Text to Speech
○ Press the turn text to speech button. ○ The new page will display the embedded algorithm which will turn speech to text and vice versa.
Hand Sign Recognition
○ Press the hand sign recognition button. ○ Upload a video or take a live video through opening the camera. ○ The video will translate the hand signs to text in real time.
Make Donation
○ Users enter the donation segment. ○ The user press donates button. ○ The user would enter an image and the description about location and the item. ○ The user press submits button.
View Group
○ The user can search for a group by pressing the search bar and entering the name of the group. ○ The user can add the group by pressing the add button. ○ The user could remove the group if its already added. ○ The user can delete the group if it was made by him. ○ The user can change the description of the group if the group was made by him.
Message
○ The user selects the group which is already added. ○ The user types a message. ○ Press send button to send the message to the group. ○ The message is displayed in the group chat.

Block User
○ The admin would add a customer email to the block user table in the data base. ○ This user's email would be prevented from creating an account again.
Unblock User
○ The admin would remove a customer email from the block user table in the data base. ○ This user's email would be available for creating an account again.
Add Tutorial
○ The user must be a trainer. ○ The trainer would press a submit tutorial button. ○ The trainer would fill the form. ○ Then press submit button. ○ the admin would check the tutorial and approve or disapprove.
View Group
○ The user can search for a group by pressing the search bar and entering the name of the group. ○ The user can add the group by pressing the add button. ○ The user can remove the group if its already added. ○ The user can delete the group if it was made by him. ○ The user can change the description of the group if the group was made by him.
Message
○ The user would select the group which is already added. ○ The user would type a message. ○ Press send button to send the message to the group. ○ The message is displayed in the group chat.
Block User
○ The admin would add a customer email to the block user table in the data base. ○ This user's email would be prevented from creating an account again.

Unblock User
○ The admin would remove a customer email from the block user table in the data base. ○ This user's email would be available for creating an account again.
Add Tutorial
○ The user must be a trainer. ○ The trainer would press a submit tutorial button. ○ The trainer would fill the form. ○ Then press submit button. ○ The admin would check the tutorial and approve or disapprove.

Additional features that implement the proposed plan constitute: (i) Converting text to speech option, (ii) hand sign recognition, (iii) uploading or taking a real time video using the camera where the hand signs in the video will be translated to text in real time, (iv) making donations via donators or organizations.

3.2 Non-Functional Requirements

Non-functional requirements (NFRs) are a set of features that express the potentials and limitations of the operation of the system and attempt to enhance its functionality. Basically, these are the requirements that outline how well the system will operate. Our system is very responsive as it should not take more than 4 seconds to respond to any request and retrieve the data from the database. Moreover, as to the load balance, it can support a substantial number of customers without degradation. Regarding the password requirements, constraints related to length, special characters and expiry are imposed with a five-second time limit to process the verification. The Graphical User Interface (GUI) of FAMAID ensures ease of use when utilizing system functionality along with supportability to usage and operation. The database used for this system can engulf many users insuring that users' data are safe and secure. FAMAID also provides documentation to inform users about the system functionality and updates.

4. FEASIBILITY STUDY

In this section, we will provide a preliminary exploration of our proposed project involving various aspects of feasibility that are specified in Figure 1. Our focus did not cover economical feasibility since our main goal is to aid disabled people. As for technicalities, our project is technically feasible since there are no constraints because all software technologies used in the project are open source.

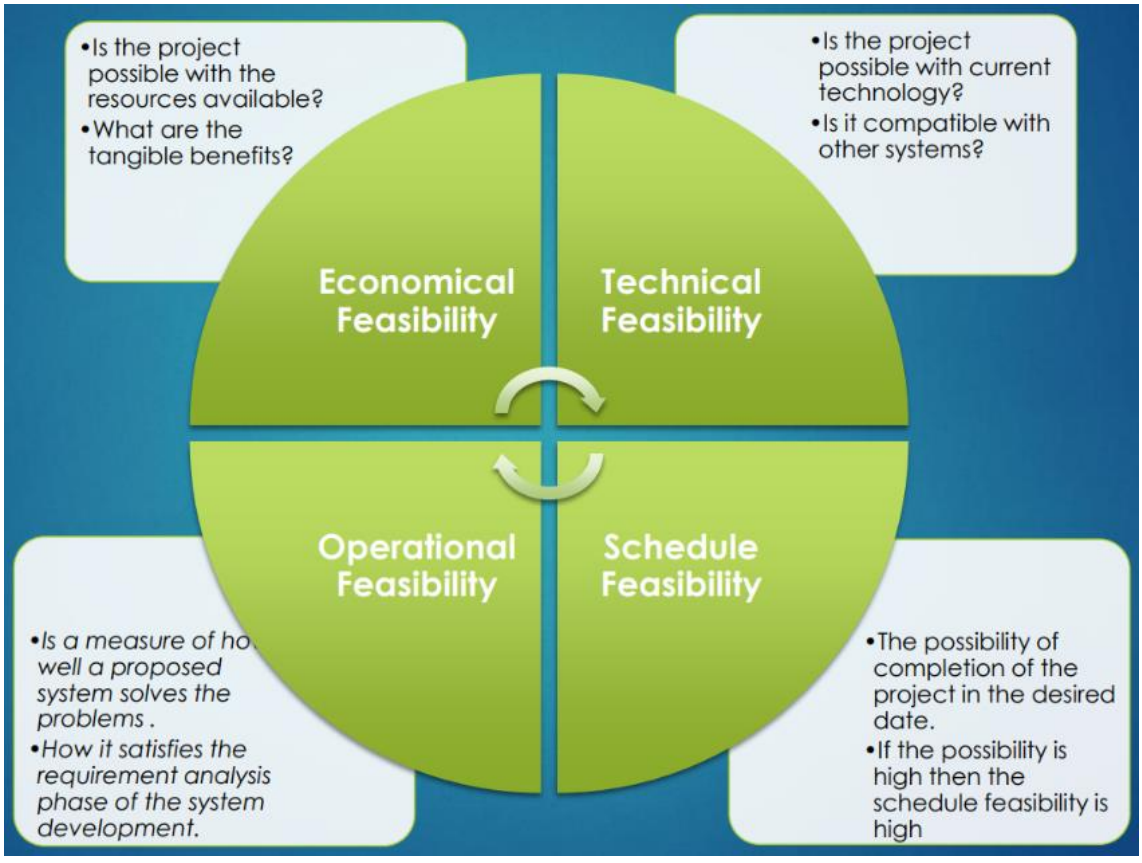

Fig.1: Different Aspects of Feasibility Study

As for the operational feasibility showing the community need for such a software application and its high rate of acceptance, we based our study on a survey that has been conducted on a sample of 75 participants with hearing disabilities. This survey consisted of different questions, each of which measures a specific functionality of our application. The survey with its results displayed in Table 2, served as a qualitative study for operational feasibility.

Table 2: Statistical Results of Qualitative Study

Questions	Answers		
	Yes (%)	No (%)	I do not know (%)
Is a Speech to Text Translator useful for Deaf People?	89.9	10.1	-
Is sharing events by organizations with people with disabilities helpful?	92.6	7.4	-
Since learning hand sign language is difficult, do you think adding tutorials is useful?	92.8	7.2	-
Do we have enough services in Lebanon to facilitate their life?	20.5	72.6	6.8

5. IMPLEMENTATION

Our software project was designed to address all functional and non-functional requirements together with additional features that will be provided in section 5.2. To be able to implement the app, we first designed the system with the aid of multiple software engineering tools like Use Cases, DFDs, and class diagrams. Those were done using Visio software and the Main System Use Case is presented in Figure 2 [13].

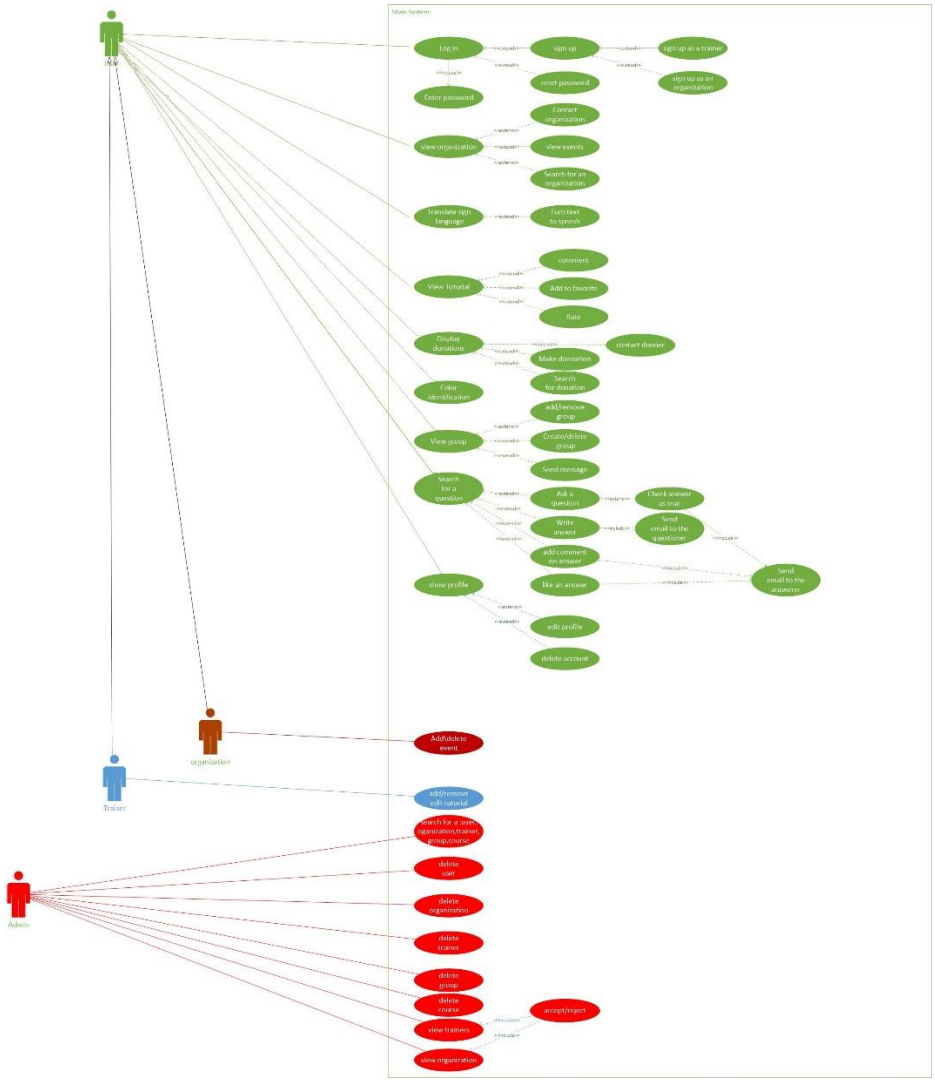

Fig.2: Main System Use Case

Two samples of sequence diagrams demonstrating the user sign up process and the organization registration are shown in Figure 3.

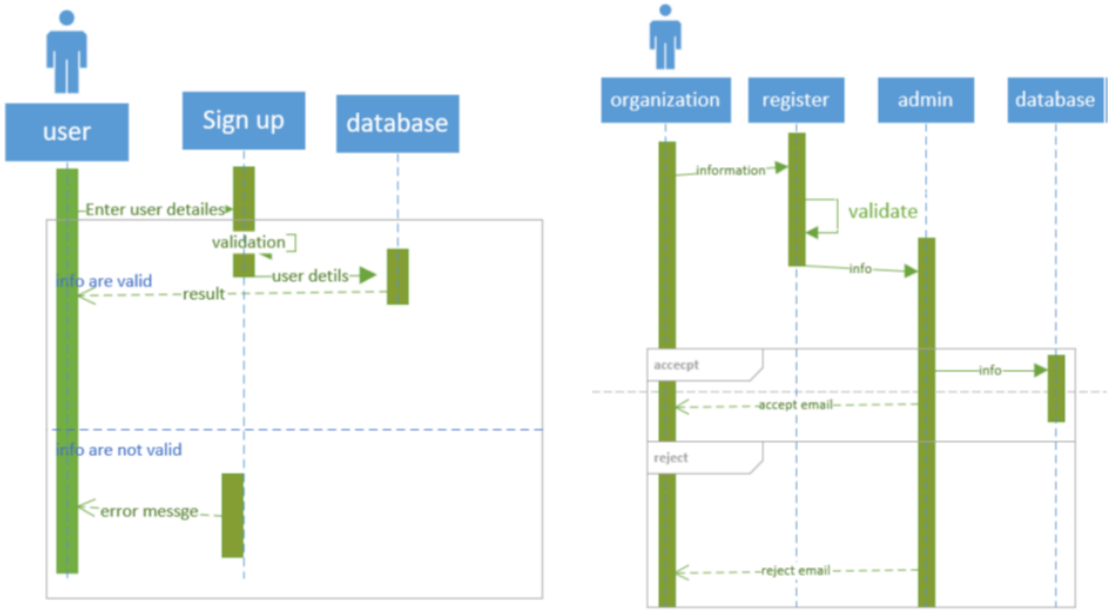

Fig.3: User Sign Up & Organization Registration Sequence Diagrams

After design, comes implementation. Software tools used to implement the project are presented in section 5.1.

5.1 Software Tools

Software tools used to implement the application are Postman [14], MongoDBCompass [15], Vscode [16], Wsl2 [17], and python with Tensor flow library package [18]. JavaScript was used as the client-side scripting language. Nodejs runtime environment was used to launch both the frontend and backend of the web app using JavaScript. ReactJS was used to create a dynamic web application, MongoDB for the database and Postman which is an API (application programming interface) to manage the API backend and frontend.

As for the artificial intelligence part where the gesture recognition occurs, Tensorflow library in python was used. The customized code in our app was designed to read the nodes of the finger representing the sign (hand gesture) by measuring distances between these nodes and the corresponding angles using different dependencies related to hand motion and available in the tensorflow library. This is illustrated in Figure 4.

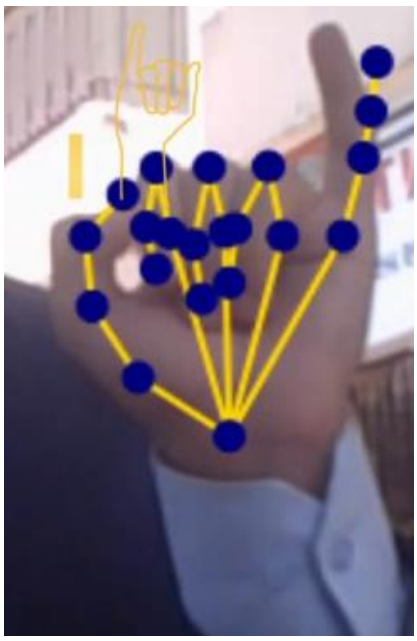

Fig.4: Finger Nodes Captured by Software

5.2 App Features

The features of a successful web application vary based on the nature of the users. In FAMAID a set of features has been implemented to constitute a successful application, especially that this application addresses people with disabilities. As mentioned in section 3.1, the 'Sign Up' phase has three access levels: user level, admin level and organization level; where the user should choose among these levels based on her/his status.

On the user's level, the features available are: (i) reset password, (ii) edit or delete her/his account, (iii) view events, (iv) search for organization, (v) translate sign language, (vi) turn text into speech, (vii) view tutorials, add comments on tutorials, rate these tutorials and even add a specific tutorial to the list of favorites, (viii) display donation, contact the donners, search for donation and even users can make donations and (ix) create a new group, send a message on a group, search for or ask a question and even comment or like a certain answer on a question.

On the admin's level, the features available for the admin users are as follows: (i) search for an event, (ii) search for an organization, (iii) search for a group, (iv) search for a tutorial, (v) search for any user, (vi) delete events, organization, group, tutorial and even any user, and (vii) accept/reject any organization or any trainer trying to sign up.

On the organization level, users have the following features: (i) Add events (ii), edit events and (iii) delete an event.

6. CONCLUSION

Based on statistics, around 2.5 billion people in year 2050 will be subject to various levels of hearing loss. Our work provides a tool for aiding people with hearing disability who can use sign language to access a web app via a camera. This web application integrates several features including chat system, donation system and hand gesture to text translation. This tool serves as a community for people with hearing disability. This work is considered a user-friendly tool that prevents people with hearing disability from feeling inferior.

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