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Robust Sign Language Interpreter for Deaf Persons

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***Abstract*—The present study focuses on a category of people who suffer from disorders of hearing and/or speaking and communicating orally with others, they are deaf and usually have difficulties in learning how to write and read text. That is why sign language has emerged as an effective alternative to expressing their thoughts, and that most people (who hear) do not know sign language, in this research, the development of an application design on a mobile phone that works without the use of the internet, to translate the Iraqi sign language through the development of the system to include copying text messages and converting them into sign language. Also, in the event that the word does not exist in the database, a note will be displayed to the recipient explaining that the apparent translation is an alphabetic translation and not a real translation, as well as adding a photo capture icon to take a picture for any text to be translated. As a result of applying the system to a number of volunteers, according to a questionnaire that was conducted for them, the system was 100 % efficient and accurate. It was programmed in Java under the Android environment, and the application interfaces were designed using the Extensible Markup Language (XML) Then it was implemented and tested under the environment of the Android operating system version (9.0). The Blender program was used to design images that represent words, letters and sign language numbers.**

***Keywords—Iraqi sign language, Sign Language translate, Arabic sign language Persons with disabilities, Means of communication, Deaf people, Language, Education*.**

I. INTRODUCTION

Human communication has evolved over time. Ancient humans used rock inscriptions, illustrations, and then moved to the alphabet, sounds, signs, and gestures as a means of communication in the present, the dominant mode of communication is based on alphabetic expression either orally, in writing, or as sign language [1]. There are some people who cannot communicate with society because of a hearing disability (deaf), and a deaf person is someone who has completely or partially lost their hearing. It is noted that many people confuse the deaf with the dumb, as deafness is related to hearing, either the dumb is related to speech, and the association of the dumb to the deaf is due to the loss of hearing speech or letters, which are essential in learning to speak [2][3]. Such people with hearing and/or speaking disorders communicate orally with others. In addition, they usually have difficulties in learning, how to write and read text. Thus, sign language emerged as an effective alternative to express their ideas [1].

Sign language can be defined as movements that are performed using one or both hands in addition to facial expressions, as deaf people use them to express their opinions, ideas and needs and to communicate with each other and with healthy people. Usually, the base is the use of the right hand, and in many words both hands are used.

Sign language consists of visual words (indicative symbols), which the deaf hear through the sense of sight, and the rule that says that the deaf hears with his eyes and speaks with his hands came to emphasize the role of sign language in the formation of mental images, and thus the formation of a cultural image store inside the deaf mind, as is the case with the spoken languages. For the deaf sense of sight entails two tasks, the first of which is an alternative to the sense of hearing, and the second is its natural role, which is vision [4].

II. PREVIOUS STUDIES

Many researchers have been interested in sign language translation systems, as many of them have presented fruitful research papers in this field. Here is a review of some of this research:

In (2016 AD), C. Eryigit et al., introduced a system for translating Turkish sign language, as the system displays signs using a virtual human (avatar). The system mainly focuses on translating, teaching materials in Turkish primary schools to help deaf students understand the subjects [5]. In (2017), Omar and Hassanein introduced a system for translating Arabic sign language. The system consists of an Arabic Speech Recognition Module (ASR) combined with the Arabic Signer model used to generate Arabic Sign Language signals. (ArSL), where the ASR speech discrimination model transforms spoken sentences into written text and segments sentences into words that are used as input to the Arabic Sign Generator model, so that these words are translated into their equivalents in sign language, the sign generator model uses the virtual human (avatar) to embody Signals [6]. In (2018 AD), Sarah Ebling et al., introduced a German Sign Language translation system, using a Microsoft Kinect v2 depth sensor and two GoPro Hero 4 Black video cameras that are placed in front of the person making the sign, in addition to using three cameras that are installed the top, right and left of the person in order to capture signals from different angles, and the well-known recording program (Bosphorus Sign Recording Software) was developed for the purpose of synchronizing the process of capturing images from different devices, starting and turning them on and off at the same time[7]. In (2019 AD) a mobile application for

Pakistani Sign Language translation was designed by Parvez Komal et al. The selected samples were drawn from 192 deaf participants aged 5 to 10 years from two private pediatric institutions. The aim of this study was to determine the effectiveness of a mobile phone interface through an advanced mobile application for learning basic mathematical concepts using Pakistani Sign Language (PSL). This study bridges the gap between technology-based teaching methods and traditional teaching methods, which are used to teach mathematical concepts using PSL[8]. In the same year, Lozynska Olga et al. introduced the Tourist sign translation system into Ukrainian sign language, a mobile application that translates text or audio from any language into Ukrainian sign language, displaying the translation using a virtual human (avatar) or using real videos It is used as a mobile assistant system for tourism purposes to help deaf Ukrainians even when they travel to other countries The system has two main components:

• Offline Phrasebook This component allows downloading and storing the most frequently used phrases during a tourist trip, according to the desired language.

• Individual Translator is the component that performs the function of translating any sentence into Ukrainian Sign Language. This component consists of the following parts: (Translator into Ukrainian, Translator into Ukrainian sign language (Sign Translator), Sign Visualizer) [9].

In (2020 AD) luka Kraljevi´ et al., introduces a smart home automatization system specifically designed to provide real-time sign language recognition. The contribution of this system implies several elements, Novel hierarchical architecture is presented, including resource-and-time-aware modules—a wake-up module and high-performance sign recognition module based on the Conv3D network. To achieve high-performance classification, multi-modal fusion of RGB and depth modality was used with the temporal alignment. Then, a small Croatian sign language database containing 25 different language signs for the use a smart home environment was created in collaboration with the deaf community. The system was deployed on a Nvidia Jetson TX2 embedded system with StereoLabs ZED M stereo camera for online testing. Obtained results demonstrate that the proposed practical solution is a viable approach for real-time smart home control [10]. In (2021 AD) Arpita Haldera and Akshit Tayadeb introduce a methodology that simplified Sign Language Recognition using MediaPipe's opensource framework and machine learning algorithm. The predictive model is lightweight and adaptable to smart devices. Multiple sign language datasets such as American, Indian, Italian and Turkey are used for training purpose to analyze the capability of the framework. Real-time accurate detection using Support Vector Machine (SVM) algorithm without any wearable sensors makes use of this technology more comfortable and easy [11]. In the same year, Sonare et al., developed an interactive real-time video-based sign language translation system powered by efficient machine learning algorithms.[12]

In(2022 AD), Amandeep Singh Dhanjal & Williamjeet Singh developed an automatic system that translates the speech to Indian Sign Language using Avatar (SISLA).[13]

III. Weaknesses of previous work

Many Scientists and researchers have covered the issue of sign language translation in different ways, and each method has its own field of use, and each of them has achieved different success rates. The following highlights the weaknesses of the different systems of sign language translation:

A. Systems based on the use of cameras are characterized by their high cost and background problems and there are some systems that require the user to wear paws of certain colors, to be distinguished, and this reduces the flexibility of use.

B. Systems based on the use of electronic gloves equipped with sensors are also characterized by their high cost and lack of flexibility.

C. Systems that use large-sized video clips or images to translate sign language [14][15] and this requires the use of a dedicated server to store video clips and images, and therefore the need to use the Internet.

D. Systems that implement the translation process in one direction only. The present work finds that some systems only translate sign language into spoken language [16], and other systems only translate spoken language into sign language [17], and this prevents the full integration of deaf people with society.

In this case, it is better to use sign language translation systems represented by using mobile phone applications so that data is entered through the use of a keyboard, dedicated for this purpose, the use of such applications is easy and low cost.

IV. Research problem

The deaf segment suffers from difficulty in communicating and integrating with society, due to their lack of the means of communicating with others, which is the speech. Deaf people and throughout the ages have invented sign language to communicate with each other, but as is known, the use of this language was exclusively for deaf people only, and was not learned or used by healthy people because they did not need it, which led to a large gap in communication between people Deaf and healthy people.

By following up on some deaf cases who studied at the Al-Amal Institute for Special Needs in Mosul, Iraq, it was noticed that their ability to read and write in Arabic gradually weaken after graduating from the institute because they do not use it because they usually use sign language.

With the advancement of science and technology, especially with regard to the means of communication, efficient ways have emerged to facilitate communication of deaf people with healthy people. Applications appeared in different languages, as well as the unified Arabic sign language. In Iraq, it was noted through reviewing previous studies that there was no application for social communication and learning for translating the Iraqi sign language for the deaf and dumb into text in Arabic and vice versa.

Due to the widespread use of mobile phones in various countries of the world, where the number of mobile

phone users increased from 1.9 billion users in late 2013 to 5.11 billion users in late 2019 [18], and by following a simple history of e-learning. It notes that when technology becomes available and accessible to users, followed by an effective use of this technology in education, and as it notes that mobile devices are one of the most proven technologies and spread around the world with such depth and speed, so the interest was to add an effective role in this field to benefit from this technology and employ it in the field of education and communication of deaf people. The main objective of this research was to develop, design an application on a mobile phone, to translate the Iraqi sign language into its equivalent in the Arabic language, and vice versa.

V. DEAF SIGN LANGUAGE INTERPRETER SYSTEM

The proposed system in [2][18] that will be developed in this research consists of two sub-systems (two modes): the first mode is to translate from Arabic into Iraqi sign language, and the second mode has translated sign language into Arabic. This system was designed using the integrated development environment Android Studio and under the Java Micro Edition (JME) platform. The application interfaces were designed for using Extensible Markup Language (XML), using a laptop with a core i7 processor, 2.9GH, 8G memory, and under Windows 10, and then it was implemented and tested under the Android operating system (9.0) A database was designed for the application using the extension (SQLite Manager) provided by the browser chrome. The Blender program was used to design images that represent sign language words, letters and numbers.

A. Database

1) Database1(Sign Language images): A database was designed for the application, using the extension (SQLite Manager) provided by the browser (chrome). It is managed by SQL (Structured Query Language) commands. It consists of five fields:

- "Word": Which contains words, letters and numbers in Arabic.
- "Img_name": Which contains the names of the images designated to represent words, letters and numbers in the Iraqi sign language, It is worth noting that each letter or number is represented using only one image (one frame), while most of the words are represented using several images (Several frames).
- "Categories": This field is for storing category names.
- "AdditionalImage": Contains the names of additional images.
- "EversedImage": contains the name of the image that is chosen for display in the second mode translation system.

2) *Database2*: Contains the moments of Arabic character images (7 moment values for each character).

B. Graphical User Interface (GUI)

When the user launches the application, the user interface is displayed as shown in Fig. 1, which consists of the following:

Algorithm (1): translates Arabic into Iraqi sign language.
Input: Arabic text| image of text.
Output: 3D animation video.
1 -The beginning.
2- Enter image of text or text.
3-If input is image then call procedure of convert image to text (Algorithm 2) and continue.
3-Divide the text into its component group of words, and store it in the matrix r. Let s = length of the array r , i=0.
4- Search the database1 for the word r[i]:
  a) If the word is found, retrieve the names of the images it represents and go to step(7).
  b) Otherwise, divide the word into its constituent group of letters and go to step (6).
5- Searching the database for all the letters that make up the word and retrieving the names of the images that represent those letters.
6- Retrieve the images that represent the letters of the word and go to step (9).
7- Retrieve the images that represent the word.
8- Presenting a 3D animation video that embodies the translation of the required word or letter into its equivalent in the Iraqi sign language.
9 -increment(i)..
10- If i<s repeat steps 4 to 11.
11- The end.

Algorithm (2): convert text image to text
Input: Image containing Arabic text
Output: text
1. The beginning.
2. Read the image and convert it to binary.
3. Cut the image horizontally into horizontal slices (lines) depending on the histogram.
4. Cut the horizontal slide image into vertical slides, each slide contains one word.
5. The image of the word is cutting into the images of the letters, the seven moments of the image of each character are taken.
6. Repeat step (4 and 5) on all horizontal slices.
7. With these steps, all characters of the message were obtained in the form of separate images.
8. The image is distinguished by its matching with a database 2 (containing the seven moments for each character).
9. Read the next character for each image.
10. Repeat steps (7-9) for all character's pictures.
11. The end.

Algorithm (3): translates the Iraqi sign language into Arabic.
Input: An image representing a word or letter in the Iraqi Sign Language.
Outputs: a word or letter in Arabic.
1- The beginning.
2-Display the drop-down list to choose one of the categories.
3 -Searching the database1 for a group of words within the selected category and retrieving them, and retrieving the names of the images selected for display and the names of the stock images.
4-Retrieve images from the image store in the application based on their names, and display them.
5 -Choose an image by clicking on it.
6-Displaying the word or letter that represents the translation of the sign represented by the selected image into Arabic in the text display bar.
7 -The end.

Fig. 1. User Interface

Text entry bar, indicated by the number (1). The "Translate" button, indicated by the number (2), to implement the first mode, that is, the process of translating from Arabic into Iraqi sign language. The three-dimensional character, Vincent, indicated by the number (3), to perform sign language movements. The "sign language" button was indicated by the number (4), to go to the translation system in the second mode. A button to show and hide the sign language keyboard indicated by the number (5). The keyboard was indicated by the number (6), is designed to contain Iraqi sign language letters and numbers to facilitate the process of teaching deaf people to read and write in Arabic, as well as teaching healthy people the letters and numbers of sign language. This keyboard includes all the letters of the Arabic language (28 characters in addition to the special characters (ة – ؤ– ئ – ء– ى), a button has been added to erase and another to add a space between words, as well as a button to display the keyboard for writing numbers that contain numbers In the Iraqi sign language from (0-9) and a button to return to the sign language characters keyboard. A button to read the messages were indicated by the number (7), which provides the user with the ability to translate his received messages into the Iraqi sign language. So, it is transferred to the text entry bar, and when the "Translate" button is pressed, this message is translated into Iraqi sign language. Send messages button was indicated by the number(8). A button is to take a picture of the text which indicated by the number (9).

C. The first mode

The system of translating Arabic into Iraqi sign language. The work of the system in the first mode can be explained by algorithm (1) and (2).

D. The second mode

The system of translating the Iraqi sign language into Arabic.

The modus operandi of the Iraqi sign language translation system into Arabic can be explained by algorithm (3).

E. Improvements to the deaf sign language translation system

- This application works on the Iraqi dialect as well as converting written words into sound (spoken words) and thus this system enables a deaf person to communicate with a blind person or a person who cannot read and write, or even with the child, through the deaf person clicking on a picture and it is translated into a word and then send this word to the translation program that provides the feature of converting the written word into a spoken word that the blind person or the child can hear.
-

Fig. 2. Alphabetical Translation

- The recipient can know if the translation shown is an alphabetic translation (not real) through a message indicating that, Fig. 2 i.e., in the event that a word that has no translation in the Iraqi sign language (not available in the database) is entered, it will be translated in an alphabetical manner, with a note that this translation is an alphabetical translation in order for the recipient to distinguish that it is not a true translation of the word.
- An icon has been added to take a picture. This enables the user to take a picture of the text that he wants to translate into sign language. And the method adopted for distinguishing is the seven moments. The method was applied to the type of font (simplified Arabic) and the size of 14 .

VI. COMPARING THE SYSTEM WITH PREVIOUS WORKS

It notes, through many previous works, that video clips were used that were recorded for people while performing sign language movements. These clips are very large, which requires the use of a special server to store them, and therefore the need for Internet service to operate these systems. Many systems have also used large-sized photographs, which require large storage spaces. While, through this research, the avatar was used to represent sign language images, thus obtaining images with storage sizes much smaller than in many previous systems, which led to achieving a very important advantage, namely the absence of the need to use the Internet to run the application. In terms of cost, the system is considered to be very low in cost compared to systems that use devices such as (cameras - electronic paws - LMC ... etc.), in addition to the absence of the need for people to perform sign language movements.

By comparing the proposed system with the research presented by Omar and Hassanein [6], which is the closest system to the proposed system in this research, note Table (I).

There are several researches that used the avatar, including the research presented by C. Eryigit et al., [5] which is a one-way system that translates text written in Turkish into Turkish sign language, and is directed to Turkish students.

As well as the system presented by L. Olga et al.,[9] for translating the Ukrainian sign language, which is directed to the benefit of the Ukrainian deaf tourist. Also, this system is one-way only that works to translate the audio or text from the Ukrainian language into the Ukrainian sign language.

VII. METRICS FOR EVALUATING THE PERFORMANCE OF THE PROPOSED TRANSLATION SYSTEM

Due to the absence of approved fixed standards for such applications, as most of the standards used in previous studies were related to sign language processing applications using image or video processing, so the system was tested on a volunteer segment (30 users) from Al-Amal Institute for Special Needs Care in Mosul, and from Graduates of the institute who work in Al-Hadba Association for People with Special Needs and some of their supervisors in the association, to implement the system on the ground as an initial experiment to identify the advantages and disadvantages of the system during the application, and it was highly appreciated by the volunteers. A questionnaire was conducted to observe the efficiency of the system, and the results were as follows:

1) *Efficiency and accuracy:* The proposed system is 100% efficient and accurate in translating and displaying data in the first and second modes, according to the questionnaire.

TABLE I. A COMPARISON BETWEEN THE PROPOSED TRANSLATION SYSTEM AND THE CLOSEST SYSTEM TO IT

The system introduced by [6]	***The proposed translation system***
1 -The system works in one direction (one mode) only, i.e. from a healthy person to a deaf person, and this prevents the full integration of deaf people into society, as it will not help the deaf person to express his views, ideas and needs**.**	1 -The system works in two directions, through which a text written in Arabic is translated into the Iraqi sign language, and vice versa. This system achieves an integrated method for the integration of deaf people into society.
2 -The system entries are voice only, and the text is not used as input, so a deaf person will not be able to use it as an educational tool to learn and test his ability to write in Arabic.	2 -The proposed system uses the text and image as an input in the system of translating the Arabic language into the Iraqi sign language, and as an output in the system of translating the Iraqi sign language into the Arabic language.
3 -The system uses the Unified Arabic sign Dictionary.	3 -The system uses the unified Iraqi school sign dictionary, and no system has been designed to translate the Iraqi sign language, so this system is considered the first of its kind in Iraq and directed to the deaf Iraqis in particular.

2) Speed: The translation speed encourages the user to interact with the application without getting bored and away from waiting.

3) *Size:* The method of designing images using the blender program led to a very large saving in memory size.

4) *Accuracy and clarity of images:* The method used to design images produces clear and accurate images that are not affected by noise and different lighting conditions.

5) Cost: The system is a free application available on the Internet, and its use will not require the availability of Internet service, and thus it will not require the user any significant cost.

6) *Flexibility:* The system is characterized by high flexibility so that it can be used at any time and place, because it is not linked to the availability of Internet service, and also because the system is available on mobile phones, which are characterized by their wide spread and availability among a very large group in society and ease of use and portability.

7) *Usage:* The system is used by both the deaf person and the healthy person alike, as it is used to teach the deaf person to read and write, and to teach the healthy person sign language, as well as being a means of social communication because it works in real time.

8) *The system is open source*, which provides high flexibility in adding images and words, and thus, the possibility of gradually covering all the vocabulary of the language.

VIII. CONCLUSIONS

Through the application of the proposed system, the following conclusions were reached:

1) Although, many hearing-impaired people are proficient in sign language, few “normal” individuals understand and/or can use sign language. This affects communication with the deaf and results in a kind of isolation between them and the "normal" world. With this app this gap has been reduced by using a system that allows sign language to be automatically translated into text and vice versa. Thus, it facilitates the integration of deaf people into society through the use of the easiest and most widely used means in the world, namely mobile phone applications, thus removing barriers between deaf people and healthy people and facilitating the process of communication between them.

2) This application is an educational system that can be applied to teach the deaf Iraqi sign language. It also teaches them how to read and write in Arabic. In addition, the application teaches healthy people the Iraqi sign language easily.

3) The large-sized images need to use a special online server to store them, so the presence work conclude that the use of the Blender program made it possible to dispense with the use of the server and the ability to store the huge amount of images needed by the application by dividing the images and reducing the display resolution, thus reducing the size.

4) Using the application without the internet, makes it easy to use it anytime and anywhere.

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