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The use of TensorFlow Action Recognition as the Main Component in Making a Sign Language Translator Speaker for Speech-Impaired People

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Abstract:- Due to communication barriers, deaf and mute students are separated from their friends, families and communities as their schools do not offer sign language instruction. Consequently, this cluster of people may feel excluded from their communities, depriving them the chance of living a normal life that is free from discrimination. The objective of this quantitative experimental study is to use TensorFlow Action Recognition as the main component in making a Sign Language Translator Speaker for Speech-Impaired People. Based on the results, the device can successfully translate sign languages with an average of 5.91 seconds, and translate three signs per 30 seconds. Also, it was found that it can detect distances up to four meters. The study manifested that the device provides the service of breaking past the communication barriers to the speech-impaired and hearing-impaired individuals, which advocates and facilitates effective communication while fostering inclusivity. These results affirmed that it is feasible to make a Sign Language Translator Speaker with the use of TensorFlow Action Recognition. Thus, this Sign Language Speaker device offers the best services for deaf and mute people Qatar and all around the world, as the struggles of hearing and speech-impaired people can be alleviated.

Keywords:- *Artificial Intelligence, Assistive Technology, Sign Language Translator, Speech-Impaired, TensorFlow, TensorFlow Action Recognition.*

I. INTRODUCTION

Individuals utilize communication daily to exchange information and convey their emotions. It is essential when it comes to creating a connection with others; without a connection to others, people may struggle, experience depression, or feel a lack of belonging (Naar, 2021). Communication, however, requires a common language for both parties to understand each other—a flaw for those diagnosed as deaf or mute. More than 1.5 billion people, or almost 20% of the global population, live with hearing loss (World Health Organization, 2020). In the Philippines, nearly 1 in 6 people have serious health problems, in which 15% of the population have been diagnosed with moderate hearing loss (Newall et al., 2021). Meanwhile in Qatar, the Planning and Statistics Authority (2022) found that in 2020, 3,369 people were diagnosed with communication disabilities, while 4,640 were found to have a hearing impairment. Hearing-impaired and speech-impaired individuals represent two distinct groups with unique needs and troubles.

Living with a hearing or speech impairment can be a desolating experience. It can lead to a lack of educational and job opportunities, social withdrawal, and emotional problems. The Human Rights Watch Council (2022) emphasized that people who are deaf or hard of hearing often become excluded from their communities due to communication barriers as not many are proficient in sign language and that deaf students are separated from their families and communities because their school does not offer sign language instructions due to inadequate learning resources and limited awareness about the importance of sign language in society. Inadequate support has significantly affected the independence and quality of life of individuals with disabilities (Pearson et al., 2022). In a sample of 200 cases that documented disability discrimination lawsuits drawn from the Westlaw legal database, each of the cases was coded for gender, job, and disability type and analyzed using multinomial logistic models. The results showed that one’s gender and job, as well as disability type, influenced the discrimination that one experienced, such as firing, accommodations, hiring, and harassment in the workplace (Mosher, 2015). It was also found that the employment services to persons with hearing impairment at a workplace were not adequate to the level of training that persons with hearing impairment had (Abbas, et al., 2019). As the researchers concluded, employers did not provide equal participation to the hearing-impaired employees when it came to organizational consultation mechanisms; nor were technical and personal support, disability management service, and ample financial support provided to persons with hearing impairment. The discrimination and stigma faced by those with hearing loss or speech impairments can make it even harder for these people to connect with others and live independently. Moreover, the health needs of individuals with hearing or speech impairments are unmet by the health industry, as evident in the communication barriers between healthcare professionals and patients (Kuenburg et al., 2015).

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TensorFlow Action Recognition is utilized in the development of a Sign Language Translator Speaker. For instance, in the study by Hou et al. (2019), the authors addressed the challenge of the lack of a comprehensive sign language dataset by creating their dataset. They collected data from gyroscope sensors to capture angular velocity and utilized accelerometer data, which combined linear acceleration and gravity information. To separate acceleration data from gravity, they employed the Android system's application programming interface (API) and applied a Kalman filter. Volunteers wore smartwatches equipped with sensors on their right wrists to collect data from gyroscopes, accelerometers, and linear accelerometers. The dataset specifically focused on fingerspelling, involving 26 alphabet signs performed by five volunteers, each sign repeated 30 times. This dataset division allocated 75% for training purposes, leaving the remaining portion for evaluation, providing valuable insights into the development of a Sign Language Translator Speaker using TensorFlow Action Recognition (Hou et al., 2019).

Regardless of differences, hearing and speech-impaired people have similar salient characteristics: reduced language acquisition ability and verbal communication skills, resulting in limitations in social communication (Aras et al. 2014; Real et al. 2021),making it harder for these people to resort to sign language, a gesture-centered language, to communicate. Unfortunately only few are fluent in this language, most of whom are deaf. The hearing people, with whom they frequently engage, are still not literate and almost inept in sign language. Fundamentally, it would be equivalent to conversing with someone with little to no understanding of another's language. Additionally, cognition, a person's conscious intellect, is significantly lower in individuals with untreated hearing. As Taljaard, et al. (2016), found the degree of cognitive deficiency is significantly associated with the degree of both untreated and treated hearing impairment. Furthermore, deaf American Sign Language users are isolated from mass media and healthcare messages and communication—which, when coupled with social marginalization, places these people at a high risk of inadequate health literacy (McKee et al., 2016), creating a communication barrier that hearing or speech-impaired people face daily.

With the stigma of needing to learn sign language for common inclusivity for people, technology as one knows it must continue to deliver solutions that do not require the worldwide effort of learning American Sign Language. While considerably more practical, creating such a gadget could provide a transitory answer. Although the world is already taking steps towards inclusion and accessibility, the majority of the fundamental services, industries, and essentially, day-to-day life amenities are still immensely inaccessible to impaired people. Furthermore, it takes knowledge of varying disciplines, including computer vision, computer graphics, natural language processing, human-computer interaction, linguistics, and Deaf culture, to create effective sign language recognition, generation, and translation systems (Bragg et al., 2019). However, despite these challenges, technology has the power to make a difference in the lives of those with disabilities.

An approach has been designed for hand image recognition inherent in sign language translation systems. This study and model of Pandey and Jain (2015) emphasized the origin and comparison of features from 2D hand images stored in a database. Practicality in real-world situations and ease of implementation, compared to more complex 3-D models, benefits from techniques like skin color region detection and segmentation for hand identification—while being susceptible to lighting changes and background interference. Scientists continue to investigate this topic by implementing Adaboost and feature diversity to boost accuracy in hand-part segmentation and reduce occlusion limitations. A study of great significance sought the importance of efficient hand image recognition techniques and their relevance to the advancement of sign language translation systems.

From artificial throats to cochlear implants and bone conduction aids, varying tools are available to help those with hearing or speech impairments communicate more easily. Unfortunately, many of these technologies are prohibitively expensive, making them inaccessible to those who need them most. Hearing aids range from $1,000 to $5,000, while an FM system costs from $150 to several thousand dollars. Most of these are sold for a single unit, making it the most impractical solution, and without access to sufficient or cheap assistive technology, a person would incur a few additional expenses and unfulfilled demands (Mitra, et al., 2017). Consumers typically pay for aids and fittings out of pocket because Medicare and most insurance plans do not cover them. ARHL affects both ears, and a pair of aids typically cost around $6000, which exceeds many seniors' price ranges. Cost was a common reason given by participants in a recent population-based prospective study for not purchasing hearing aids (Blustein & Weinstein, 2016). Therefore, it becomes critical that our society continues to develop the most efficient means to innovate novel strategies with reasonable costs, delivering the same level of convenience and experience as one would to a non-disabled person.

This Sign Language Translator Speaker is a cost-effective solution that utilizes TensorFlow, which is an open-source platform that simplifies and speeds up machine learning tasks. Specifically, TensorFlow Action Recognition enhances the precision of tracking sign language movements by generating prior maps that can identify variations in the image sequence caused by illumination (Shakeri & Zhang, 2019). Furthermore, by applying the Neural Translation Machine to estimate the likelihood of a succession of words, generally modeling complete sentences in a single integrated model, the Sign Language Translator Speaker can provide increased translation and linguistic accuracy (Kalchbrenner & Blunsom, 2013), while still, becoming a highly accessible and cost-effective device that organizations such as schools, companies, and the sort can produce with minimal effort. In addition, Abadi, et al. (2016) stated that TensorFlow is a machine learning system that works in diverse environments

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and at scale. Dataflow graphs are used by Tensor-Flow to represent computation, shared state, and the operations that modify it. TensorFlow supports a wide range of applications, with a focus on deep neural network training and inference. TensorFlow has been widely adopted for machine learning research and is used in several Google services.

After recognizing TensorFlow as the study's Artificial Intelligence (AI) platform, the words and phrases utilized to test the effectivity of the Sign Language Translator Speaker came from the First 100 Spoken Collocations; which according to Clouston (2013), the aforementioned word list ranked the first 100 most frequently-spoken collocations in 10 million spoken words in the British National Corpus (BNC). Some of these words include: (1) 'you know,' (2) 'I think (that),' (6) 'a lot of,' and (8) thank you—which were chosen using six criteria, including frequency, word type, and so on. Clouston further emphasized that the survey article dwelled on the literature of word lists for vocabulary to teach English as a second or foreign language to students.

With the innovation of the industry, it can utilize a more practical and cost-effective method to become more accessible, remaining to offer the best services they could render possible. Hearing and speech-impaired people can have their struggles alleviated and receive the assistance that would improve their lives little by little without having to make costly sacrifices. Moreover, future researchers can utilize this study as it can provide references, findings, data, and materials for researchers conducting studies on sign language equipment. Also, this research can assess the validity of other relevant studies, reducing errors to produce higher-quality products. For the betterment of humankind, little by little, through communication. As the saying goes, "communication is key." As in our lives, it is the foundation upon which trust, respect, and understanding is built.

➢ *Research Questions*

The objective of this study is to make a Sign Language Translator Speaker with the use of a Tensorflow Action Recognition. Specifically, it answers the following questions:

- What is the time interval between the gesture and the decoded translation on the Sign Language Translator Speaker in terms of seconds?
- How many signs can the Sign Language Translator Speaker translate in a 30-second full statement?
- How far can the Sign Language Translator Speaker's camera recognize gestures in terms of meters?

II. METHODOLOGY

This study utilized the experimental design of research; the process of carrying out research in an objective and controlled fashion so that precision was maximized and specific conclusions could be drawn regarding a hypothesis statement (Bell, 2010). This research design also explained and evaluated research, but did not generally apply to exploratory or descriptive. In this study, the TensorFlow Action Recognition Program and the Disused Speaker were the independent variables, and the Sign Language Translator Speaker was the dependent variable. Furthermore, this experiment quantitatively ensured the accuracy of data and the availability of the said data to answer the research questions efficiently. Moreover, this method was vital because it provided control over the variables that demonstrated an outcome and was advantageous in finding accurate results.

A. *Research Locale*

This research study was conducted in Philippine School Doha, State of Qatar, specifically in Bldg. 01, St. 1008, Zone 56 Mesaimeer Area.

B. *Data Gathering Procedure*

The procedure shows the step-by-step process of how to make the TensorFlow Action Recognition Sign Language Translation Speaker.

➢ *Ensuring Protection and Maintaining Safety*

Wear personal protective equipment such as safety goggles, safety gloves, safety shoes, and a laboratory coat while performing the procedure for the making of the Sign Language Translator Speaker to avoid hazardous conditions.

➢ *Programming the Sign Language Detector*

- Install TensorFlow, TensorFlow-gpu, opencv-python, mediapipe, sklearn, matplotlib libraries. Import cv2, numpy, os, pyplot, time, and mediapipe dependencies.
- Access mediapipe model to read the frames, make detections and draw landmarks to render to the screen. Draw face, pose, left and right hand detections.
- Get xyz values of landmarks and concatenate in an array. Extract keypoints.
- Create paths for exported data, then create variables for actions to detect, lastly create folders for each action and inside are other folders for sequences.
- Copy mediapipe loop from step two, then add code to loop through the actions, sequences, and video length, then apply collection logic, export keypoints, lastly collect frames for each action.
- Import train_test_split and to_categorical dependencies, then create a label map.
- Build the neural network and compile the model lastly, train.
- Store results inside a variable. Write code that np.argmax will pass through the first values from the results array then passed into the actions array.
- Save Model Weights.
- Import metrics from scikit learn to evaluate the performance of the model, then make predictions. Run multi-label confusion matrix, Lastly pass through the accuracy score method.

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➢ *Programming the Grammar Translator (Neural Machine Translation)*

- Install TensorFlow, TensorFlow-gpu, sklearn, matplotlib libraries.
- Import einops, numpy, the sign language dataset, and pyplot.
- Add a start and end token to each sentence.
- Clean the sentences by removing special characters.
- Create a word index and reverse word index.
- Pad each sentence to a maximum length.
- Create a tf.data dataset.
- Begin text preprocessing by unicoding normalization to split accented characters and replace compatibility characters with their ASCII equivalents.
- Vectorize the text with the preprocessing model layers for standardization to handle vocabulary extraction to token sequences.
- Process the dataset.
- Encode the tokens.
- Decode the predictions.
- Combine the model components.
- Build the training model.
- Implement a masked loss and accuracy function.
- Configure the model for further training.
- Execute the text to text translations.
- Input the translation to the audio transmitter.

➢ *Programming the Audio Transmitter*

- Toggle the auto-play setting for newly exported mp3 files.
- Install the dependencies IBM Watson through the PIP installcommand.
- Set up a TTS service with AI machine learning.
- Get the service URL and API key and pass them through.
- Import the IAM authenticator to begin server authentication.
- Convert a string or body of text to output a text file.
- Write out the inputted text file.
- Synthesize the converted output speech.
- Pass keyword parameters.
- Choose the language model and ensure the output as an mp3 file
- Strip out blank spaces and ensure that they are concatenated together.
- Start auto playing the output from the exported audio file.

➢ *Connecting the Computer to the Sign Language Translator Speaker*

- Connect the Sign Language Translator Speaker's audio jack plug to the Computer's audio jack.
- Open Device Manager In the Computer's settings.
- Ensure the device is listed on the speaker and audio drivers.
- Add it through on the drivers list if the device is not listed.
- Activate the auto-play feature and include it in the translator program.

III. RESULTS

This study aimed to create a Sign Language Translator Speaker using TensorFlow Action Recognition. The following section focuses on the results and interpretation of data that was collected during the testing phase of the product where it fulfilled the three main research questions such as the time interval between the gesture and the decoded translation, the number of signs the Sign Language Translator Speaker translated in a 30-second full statement, and the distance the Sign Language Translator Speaker's camera recognize gestures in terms of meters. In attaining the results that exhibited the efficiency of the sign language translation speaker.

A. The Time Interval between the Gesture and the Decoded Translation on the Sign Language Translator Speaker in Terms of Seconds

Table 1 The Time Interval between the Gesture and the Decoded Translation

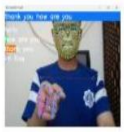
Trials	1st	2nd	3rd	Average
Hello				 18.45
Time (in seconds)	18.28	18.67	18.40	18.45
Thank you				 5.67
Time (in seconds)	5.67 seconds	5.85 seconds	5.49 seconds	5.67 seconds
How are you?				 5.91333333333
Time (in seconds)	6 seconds	6.21 seconds	5.53 seconds	5.91 seconds

Table 1 shows the time interval between the gesture and the decoded translation on the Sign Language Translator Speaker in terms of seconds. For reliable results, a total of three trials were conducted and the average was taken by dividing the summation of three trials of time by three. In the "hello" sign language the first trial had a time interval of 14.3 seconds which was the least out of the three trials, the second trial had a time interval of 18.67 seconds making it have the longest time interval out of the three trials, the third

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trial had a time interval of 18.40 seconds. In the "thank you" sign language the first trial had a time interval of 5.67 seconds which was the least out of the three trials, the second trial had a time interval of 23.41 seconds making it have the longest time interval out of the three trials, the third trial had a time interval of 5.49 seconds. In the "how are you" sign language the first trial had a time interval of 6 seconds, the second trial had a time interval of 11.16 seconds making it have the longest time interval out of the three trials, the third trial had a time interval of 5.53 seconds making it have the least time interval out of the three trials.

After the assessment, the results denote that the device was relatively quick in translating a given gesture, ranging from 6 to 18 seconds. This outcome implies that the Sign Language Translator speaker can, in fact, be used in real-time scenarios as it can promptly provide a translation based on gestures utilized in a conversation. This is further backed up by a research where the model, called the real-time sign language translator, was designed to focus on the Indian Sign Language (ISL) (Sinha et al., 2022). This sign language consisted of alphabets from A to Z and digits from 1 to 9, which counted to 35 signs in total. The research had an accuracy of 50-80%, but obtained a loss of 0.227 on the trained model.

Another one is the study of Kau et al. (2017), which proposed a wireless hand gesture recognition glove for Taiwanese Sign Language. The device used flex and inertial sensors to discriminate different hand gestures. The finger flexion, the palm orientation, and the motion trajectory were the input signals for the system. This led to an accuracy rate of up to 94% on sensitivity for gesture recognition.

B. The Number of Signs the Sign Language Translator Speaker Translated in a 30-Second Full Statement

Table 2 The Number of Signs the Sign Language Translator Speaker Translated in a 30-Second Full Statement

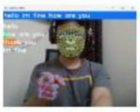
Trials	Number of sign language	Images
1st	2	
2nd	3	
3rd	3	
4th	3	
5th	2	
Total		2.6 Signs per 30-seconds

Table 2 shows the amount of signs that the Sign Language Translator Speaker translated in a 30-second full statement. Five trials were carried out in total and the average was calculated by dividing the sum of the five trials by five. This was to ensure accurate and consistent results. In the first trial, it can be seen that there were two (2) signs it could translate.. In the second, third, and fourth trial, it can be seen that the average signs it could translate was three (3). This means that this was the most amount of signs it could translate. Lastly, in the fifth trial, it can be seen that there were two (2) signs it could translate.

Combining all the results of the five trials and dividing it by five, the total average reached is 2.6 signs per 30-seconds. Therefore, the number of signs that the Sign Language Translator Speaker can translate in a 30-second full statement is 2.6 signs per 30 seconds.

The results indicate that the TensorFlow Action Recognition program is able to catch on and comprehend lengthy statements, thus translating accurately. This assures that the device is an effective tool of communication as it can recognize the correct meaning to a given gesture. This was also evident in a research that was based on a real-time smartwatch-based sign language translator (Hou et al., 2019), which is an energy-conserving device that provides real-time sign language translating services for the American sign language recognition (ASLR) system. It is a device that has an average translation time of approximately 1.1 seconds for a sentence with eleven words. Another research was conducted where systems-based sensory gloves for sign language recognition also showed success on comprehending lengthy statements where forty sentences made up the dataset, which was recorded with two DG5-VHand gloves (Ahmed et al., 2018). The suggested solution's performance achieved 98.9% recognition accuracy.

C. The Distance the Sign Language Translator Speaker's Camera Recognize Gestures in Terms of Meters

Table 3 The Distance the Sign Language Translator Speaker's Camera Recognized Gestures

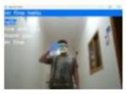
Distance	Photo	Detection
1m		Success
2m		Success
3m		Success
4m		Success
5m		Fail

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Table 3 illustrates the Sign Language Translator Speaker's ability to recognize a gesture from a distance. At one to four meters, the speaker was able to recognize the correct sign language and translate accordingly. However, at five meters, the device translated "I'm fine" instead of the gesture, "hello;" thus, no longer being able to interpret sign language accurately.

This shows the Sign Language Translator Speaker's capability to be utilized in conversations up close or from a distance and further proves its effectiveness in various scenarios, such as seminars or online meetings, where a person might change their distance from the camera regularly.

Evaluating the results, the speaker works at distances one to four meters. The sign language system is less effective for communication over distance (Stokoe, 2005). Additionally, It was found that deaf and hard of hearing participants better understood interpreters at a closer distance of 5 feet rather than 15 feet. These studies further back the Sign Language Translator Speaker's effectiveness according to distance (Kushalnagar, 2015).

IV. CONCLUSION

Speech-impairment continues to be a timely issue. About 70 million people in the world are deaf-mutes. On the other hand, 360 million people are deaf—out of these, 32 million are children. Because of this, the World Health Organization (2021) estimated that by 2050, 1 in 4 people will suffer from some degree of hearing loss. Due to this, a demand for a device that can cater to the necessities of the speech and hearing-impaired community is imperative.

In recent years, there have been many advancements in the field of technology. Sign Language Translator Speakers made with a machine learning algorithm called TensorFlow is one of those that serve as a new and innovative form of assistive technology in the modern world. It provides the service of breaking past the communication barriers to the speech-impaired and hearing-impaired individuals, which advocates and facilitates effective communication while fostering inclusivity. Sign Language Translator Speakers allows direct communication between hearing and hearing-impaired people. This also allows the hearing-impaired society to not be dependent on human interpreters (Kahlon & Singh, 2021).

Based on the results, the time interval between the gesture and the decoded translation on the Sign Language Translator Speaker varied depending on the sign gesture being used. The gesture "hello" took the longest time to translate, with an average of 18.45 seconds while the gesture "thank you" took the shortest time to translate, with an average of 5.67 seconds. The Sign Language Translator Speaker was able to translate full sentences from sign language gestures to spoken language in approximately 2.6 signs per 30 seconds; 2 signs being the least amount of signs translated among the five trials. Moreover, the Sign Language Translator Speaker demonstrated its ability to successfully recognize and correctly translate sign gestures from a distance of 1 meter until 4 meters. All these results affirm the hypothesis that it is feasible to make an effective Sign Language Translator Speaker with the use of a TensorFlow Action Recognition.

The integration of TensorFlow into the Sign Language translator speakers has led to the result of significant improvement in terms of the accuracy and efficiency of sign language translations. After equipping the machine model and training it with a vast array of sign language motions, the model became capable of identifying and converting the sign language motions into spoken and written languages.

This research is capable of bridging the gaps of communication for the deaf and mute people. The use of an innovative tool such as a Sign Language Translator Speaker can contribute to a more inclusive world where communication barriers are substantially reduced; overall promoting inclusivity and empowering sign language users to interact more effectively in multiple settings, such as in a classroom or workplace.

Moreover, future researchers are advised to utilize a laptop with a greater graphics card and a camera with a higher resolution to reduce the lag of the program and improve the time interval between the gesture and decoded translation, the number of signs translated in a 30-second full statement, and the distance that the device can recognize gestures.

Furthermore, future researchers may also take advantage of this study and use it as a reference in creating a project that may have a similar output or used similar materials. Future researchers may incorporate more words and phrases to be translated into the program to maximize the capability of the device. Also, the current researchers urge to familiarize oneself with American Sign Language or consult an expert to have a better understanding of the technicalities and forms of the language when it is used in a conversation.

Additionally, Qatari and Filipino communities are encouraged to implement devices such as the Sign Language Translator Speaker in public places to urge acceptance, accessibility, and inclusivity amongst all people. The TensorFlow Action Recognition program is an effective variable in creating a translator speaker in the way that it is able to recognize gestures accurately and efficiently. Furthermore, this device is cost-efficient as it was made from scrap materials, all the while contributing to the advancement and improvement of society when it comes to the timely problem of language barrier.

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