Gesture Detection Translator Application for Converting ASL Alphabet Gesture to Text

Rafael Vincent T. Fausto, College of Computing and Information Sciences, Systems Plus College Foundation

Vince Andrei P. Cabral, College of Computing and Information Sciences, Systems Plus College Foundation

Kian Jacob T. Ponce, College of Computing and Information Sciences, Systems Plus College Foundation

The advancement of technology has paved the way for innovative solutions aimed at improving communication accessibility for individuals with hearing impairments. This study introduces an application designed to interpret American Sign Language (ASL) alphabet gestures and convert them into text using gesture recognition technology. By utilizing a dataset of ASL letter representations, the system analyzes and translates hand movements in near real-time, enhancing communication for users with little to no prior knowledge of sign language. The study employs a combination of image processing techniques and machine learning models to ensure accuracy and reliability. With an emphasis on mobile device accessibility, the application is optimized for user-friendly interaction, adapting to varying hand positions and environmental conditions. While the system focuses on static alphabet gestures rather than full ASL sentences, it lays the foundation for further developments in sign language recognition. The results highlight the potential of gesture-based translation tools in bridging communication gaps, demonstrating the feasibility of integrating machine learning into assistive technology solutions.

1 INTRODUCTION

Disability is no stranger to the ears and eyes of the general people. It refers to the inability of a person to fully utilize the functions of a normal human body due to several health, physical, or environmental factors. According to data fact sheets from the World Health Organization (WHO) in 2024, 1 in 6 people experience significant disability in the world which contributes to 16% of the global population amounting to an estimated number of 1.3 billion people experiencing such disabilities. As time passes and more factors affecting these people emerge, these numbers will continue to see even more growth. Based on another data statistics provided by the Philippine Statistics Authority regarding the 2020 Census of Population and Housing (2020 CPH), an estimated number of around 9% from a total of 97.60 million of the household population experiences disabilities to some extent. This amounts to around 8.5 million people aged 5 and above that are having difficulty in properly functioning using their senses. The data statistics mention that these numbers experience difficulties in performing in at least one of the six domains of functionality which are classified as: seeing, hearing, walking, remembering or focusing, self-caring, or communicating. This data was taken in reference to the released 2020 CPH in October of 2022 detailing the statistics of people with disabilities living under a Philippine housing setting which shows the population density of the disabled in a more proximate scenario.

Disabilities affect anyone regardless of age, gender, sex, religion, identity, culture, etc. Influenced by their disabilities, they continue to face more hardship as they continue on with their life. They are met with discrimination against their disability, they become subject to peoples' abeliest and stigmatic thoughts and action

2 Literature Review

2.1 Disabilities

Disability is a widely recognized term that refers to a person's inability to fully use the functions of a typical human body, often due to health, physical, or environmental factors. Disabilities greatly affect a number of our world's population. In 2024, data from the World Health Organization (WHO) revealed that approximately 1.3 billion people worldwide, or 16% of the global population, will experience significant disability. This means that 1 in 6 individuals are affected by such disabilities. This greatly shows how prevalent disabilities are in our society. Disabilities have no specific target as anyone can easily be subjected to its effects depending on your health, environment, and other factors. Anyone can be put in the spectrum of disability as it can be seen as a universal human experience. Studies and statistics surrounding this particular topic don't necessarily dive deeper into its related topics. As said by Ciezaet al., 2018, disability as information is often divided into those that are and those that are not, limiting the knowledge for specific disabilities on its wide spectrum. Said study proceeds to highlight how existing instruments are mostly used in recording set standards for measuring disability, further backed by lack of data surrounding the levels of disability a person may have.

WHO has been making efforts in introducing aids and helps in facilitating a better environment with proper accessibility and assistance for increased functionality for said individuals. With how disabilities can be greatly affected by the environment, such actions would help create, alleviate or prevent progress of some disabilities (Ciezaet al., 2018). Addressing each part of the disability spectrum is a step that needs to be taken bit by bit in order to understand more of the different disabilities which in turn may create more opportunities for studies that can either help heighten the existing knowledge or help create solutions and aids to specific levels of disabilities.

2.2 Sign Language

Communication is one of the key parts in our lives, being used in order to interact with one another, by this, they can learn, express their feelings and exchange their ideas (Sanaullah et al., 2022). Even with all the languages out and about, some may be rarely used by the majority making it harder to communicate with such a demographic. According to Jin et al. (2016), due to the relative lack of pervasive sign language usage within our society, deaf and other verbally-challenged people tend to face difficulty in communicating on a daily basis.

According to Yadav et al. (2021) sign language is an effective mode of conversation for persons who have difficulty speaking or hearing. There are numerous media accessible for translation or for identifying sign languages and converting those to text format, However, methods for converting text to sign language have been few and even not web-based software, owing to the scarcity of resources. These types of problems further regress the progression of sign language as well as hinder its dissemination to the mass. With the emergence of various technological advances, problems such as these may be alleviated by constructing a well planned solution with the help of technology.

Incorporating a common practice between two demographics will help in creating a middle ground of basic communication for both parties. With this taken into account, gestures come to mind. Gestures have always been an everyday occurrence for us with the simple wave of hands in greeting and goodbyes, as well as raising your hand for stopping someone or raising a concern. Gestures are a form of communication that is universally understood by the majority of people (Eswaran, 2021).

One angle that this research is looking into is catering to those young ones in the field of sign language, be it the literal and the metaphorical way. Those new to these sign languages will be having difficulties processing the plethora of different sign language gestures for every single word. Not to mention that they will most likely have to get down to the basics of sign language in order to familiarize themselves with basic concepts like the letters of the alphabet. Starting from the basics and properly knowing such concepts may help aid in strengthening the foundation of new signers regarding their signing..

2.3 Translation

Interpreters are a great help for the non-hearing community to communicate with others, yet this also limits them in their interaction. Some problems may arise from this such as how interpreters can introduce extraneous factors into the testing situation, for example, poor or unequal translation, misunderstanding of content or intention of original test items, leading translation, interpreting by someone who is unqualified, and lack of guidance for interpreters on how to handle items that do not translate easily from one culture to another (Montoya et al., 2004). Others have also explained through surveys conducted by Soogund and Joseph (2019) that it is harder to socially interact with others and make friends when having an interpreter translate for them.

With the current technology there were projects that made Sign Language translation possible with applications, an example of this is “Sign4PSL” an app made under the study “A Real-Time Automatic Translation of Text to Sign Language” this study utilizes 3D models in order to convert text input into sign language by representing it with a 3D animated human doing the sign language. This application was able to achieve 100% accuracy on alphabets, digits, words and phrases but only managed to achieve 80% accuracy on sentences, this is due to ambiguous sentences that may have double meaning which confuses the program. The study plans to further extend this project in the future by supporting complex signs and non-manual features of sign language and adding more signs that ca be done in the application, the study has shown that there are issues with the limitations on the grammar of sign language, but the study plans to extend support for these in the future.

Other solutions from Soogund and Joseph (2019) can also be seen through their paper: SignAR: A Sign Language Translator Application with Augmented Reality using Text and Image Recognition. This study has shown how Augmented reality is used to provide real time translation to words detected by the system. Words were not only its source as pictures can also be detected and translated. Their findings concluded that the application provides great help in teaching both the hearing and non-hearing to learn about sign language. The study’s test respondents also provided feedback such as “...loved the idea and agreed that SignAR will be an indispensable tool in deaf education.” Further feedbacks are also being considered such as the user interface as well as additional features like whole sentence translation which the study aims to continue unto.

Even with all of these studies, the scope of studies for areas regarding disabilities are still stagnant. Shortage of benchmark datasets remains a primary challenge in the field. Scarcity of software and applications for sign language recognition and translation is still apparent (Alaghband et al., 2023).

2.4 Gestures and Gesture Detection Scanners

Gestures have always been an everyday occurrence for us with the simple wave of hands in greeting and goodbyes, as well as raising your hand for stopping someone or raising a concern. Gestures are a form of communication that is universally understood by the majority of people (Eswaran, 2021). They are utilized in various contexts, including interactions between deaf and deaf-mute individuals, robot control, human-computer interfaces, home automation, and medical applications. Research on hand gesture recognition has employed a variety of methods, often relying on sensing technologies and Internet vision. As a result, hand gestures can be categorized in several ways, such as by their position and movement, or by being either dynamic, stable, or a combination of both (Veluri et al.,2022).

Gesture recognition in computing technologies is the ability of a device to recognize human motion,these devices may vary from cameras to wearable devices the user can use to input data into an algorithm that analyzes the movement and recognize gesture. A study by Sushira Mitra and Tinku Acharya titled “Gesture Recognition: A Survey“ states that the technology of gesture recognition can be applied for sign language recognition, Soft computing tools pose a promising application to static hand gesture identification. This is done via finding the similarities of a test hand shape model and then determining it based on its hand contours.

Hand gesture recognition still faces several challenges due to variations in gestures, lighting conditions, background complexity, and the diverse ways in which people perform gestures. Another issue arises in real-time gesture recognition, as the time it takes for individuals to perform gestures can vary. This makes it difficult to detect and classify gestures immediately or even before their completion, which is essential for providing rapid feedback. Additionally, leveraging new hardware capabilities and improving the recognition of previously unseen gestures are important considerations, particularly for real-time applications (Rastgoo et al., 2020). Other approaches in this field involve detection not entirely based on sensors but data sets. Studies such as that of Chen and Tian (2023), machine vision-based gesture recognition was used which did not rely on physical contact with the user or the use of extra

sensors or specialized equipment. Instead, it required training on a large dataset of images to develop a highly accurate recognition model, enabling precise gesture identification.

On another study titled "Hand Gesture Recognition for Human-Computer Interaction Using Computer Vision", the researchers were able to create an application that uses the Hand Gesture recognition technology, with this they are able to use gestures to control the computer such as moving the mouse and adjusting the volume using predetermined gestures. With the help of computer vision and machine learning, it is made possible to create an algorithm that is able to detect the position of fingers and use these to calculate their distances and predict a gesture. The study suggests that this can aid in future Gesture recognition projects such as processing body movements of sign language, or full body tracking.

Incorporating such concepts to this study helps create a great foundation for not just the application but also the process of parting the right knowledge to its users. Gesture detections create the means of guiding the users on how to properly do the corresponding gestures for each letter, as well as being the judge on how accurately can users portray the gesture they intend to convey.

2.5 Synthesis

Studies surrounding the disabled and how they interact with the society as well as incorporation of different existing technologies into providing a medium of inclusivity have been seeing more exposure. This synthesis aims to coalesce and explore such findings garnered from a variety of studies in order to fully understand all of their different perspectives and approaches in this field of study.

2.6 Conceptual Framework

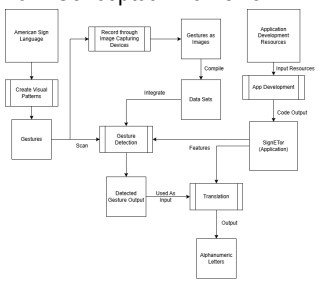

Fig. 1. Conceptual Framework Diagram of the Application

The conceptual framework for this study incorporates fundamental concepts that define the core operational structure of the "Gesture Detection Translator Application for Converting ASL Alphabet Gestures into Text."

Fundamentally, the application is centered around the concept of detecting gestures and applying appropriate translation for detected gestures. The application makes use of a number of images of pre set gestures as data sets for recognizing gestures. These data sets are the primary and sole basis of the application in recognizing the different gestures to be inputted by the users.

Coding the application from a working prototype to the final application comes first in this process. The early prototype will be used as a medium for testing the accuracy of the detection based on the data sets available. The ensuing stages comprise the collection of the data sets. These data sets are gathered by the developers through the use of image capturing devices. The developers are to capture images of the different ASL alphabet letters, starting from basic signing gestures then slowly incorporating different angles while still being accurate in portraying the letters. Different angles help the application accurately recognize user gestures that may vary in position, angle, distance.

Once sufficient data sets are obtained, incorporation to the application comes next in the process. The incorporated data sets help raise the application's accuracy in gesture recognition which greatly helps in properly recognizing the signs of similarly arranged letters.

The research converges into a presentation of the application with accurate gesture detection technology partnered with appropriate translation systems along with its other features to create a seamless translation application that makes use of gesture inputs. The findings of this study will help the disabled community, specifically the deaf and the mute have a functional letter based translation for their communication as a whole.

3 Methodology

3.1 Research Approach

The aim of this study is to develop a functional gesture detection and translation application that converts American Sign Language (ASL) alphabet gestures into text using gesture recognition technology. The application's gesture detection feature relies on a large collection of high-quality image datasets, each corresponding to a specific ASL letter, to ensure accurate gesture recognition. Given the focus and nature of this study, a mixed-methods research approach will be used. A quantitative approach is chosen because of the substantial amount of data required for the application to effectively recognize gestures. The more image datasets incorporated, the greater the accuracy of the recognition. Additionally, a qualitative approach is essential due to the need for high-quality images in the datasets. Each image must accurately represent its corresponding ASL letter, as each letter is associated with a unique sign gesture. Thus, the images must meet strict quality standards to function effectively as data sets.

3.2 Research Design

An action based research will be used in this study in order to construct an accurate and working application. Action researches make use of a repeating process: plan, act, observe, reflect. With a lot of data needed to create a more accurate application, continuous input of data and reviewing of its accuracy will be regularly conducted. After observing if each letter is or is not easily being recognized, more data will be inputted into the application based on the specifics of the observation.

- Quantitative Objective: To measure the accuracy of the application in translating ASL gestures into text, as well as its speed in processing gestures.
- Qualitative Objective: To explore user satisfaction and experience with the application, focusing on its usability,

effectiveness in communication, and any challenges or limitations encountered.

3.3 Data Collection

The data needed by the application will be exclusively coming from the developers. The data sets consist of a number of images per letter of the ASL alphabet. The data is collected by capturing images of the researchers doing the alphabet of American Sign Language. These images are then stored and organized into folders based on what letter they represent.

Data from surveys of different experts on related fields will also be made use of in order to determine the efficiency and usability of the application based on the perspective of experts that are knowledgeable in their appropriate fields.

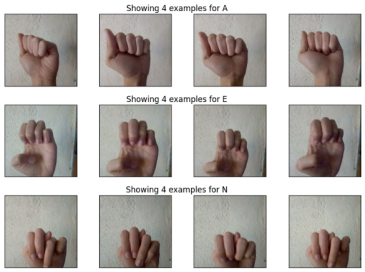

Fig. 2. Images of Different ASL Letter Gestures Used as Data Sets

3.4 Data Analysis

This concrete analysis would proceed into signifying basic assessment measures: accuracy, speed, and user experience. Measurements on relevant metrics would include gesture recognition measurement by calculating true positives, false positives, false negatives, and precision. An efficiency evaluation for real-time processing can be determined by measuring latency, frame rate, and processing time per gesture. An analysis that could be conducted under this category would include the types of errors that are misinterpretations, types of hand shape and position variations, and ambiguous gestures. It can also be checked through user feedback and experience users may have had concerning frequency of errors and ease of use. The comparison with other existing systems may also serve as a good measure for performance evaluation of the system; while those differences have been noted, statistical tests can be used to verify if these differences are due to a real effect. Data collected from experts will be filtered based on its feasibility and how relevant it is to the study for it to be considered. Data collection and generalization of the model will look into the learning curve as well.

3.5 Ethical Consideration

This study adheres to the ethical principles required to ensure responsible research practices, with particular attention to protecting privacy and maintaining transparency, as all data for the application will be sourced exclusively from the developers, and no user gestures will be stored or collected. Survey feedback data will also be used after garnering proper permissions from experts involved in such surveys.

The data collection side of the study will only make use of data provided by the developers in the form of image data sets of ASL alphabet letter gestures. These data sets will exclusively be used in training the application to create accurate and fast detections, taking into account slight tilts or distance difference of gestures. The application will be operating by translating gestures from users without saving or recording any user data. This also means that the application will not retain any form of user data into the system after every use.

In the application use side of the study, the application makes use of the built in camera in the users' mobile devices. The users will be prompted permission accordingly regarding this feature.

Review on the application use and efficiency will be determined from data taken from experts of certain fields after conducting surveys centered around the usability, functionality, and efficiency of the application based on its scope and limitations. Proper permission will be taken from the experts involved regarding anonymity of data gathered from them. As the data needed from these experts are only feedback regarding the application and their credibility in their respective field, any other irrelevant data are not be taken and used.

3.6 System Development Methodology

This study will mainly utilize an Iterative Methodology approach for its system development. The iterative system or model in research projects keeps on being a major approach, since it can be made flexible and used for gradual development and fine-tuning based on new understanding. It helps reduce risk as problems can be identified and dealt with at an early stage in the development of the project. This functional model also forms a basis of constant feedback and assessment, making it very suitable for projects whose requirements have experimental aims.

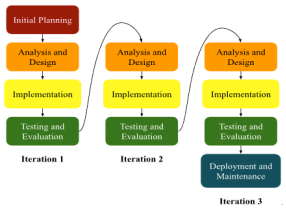

Fig. 3. Iterative Model Diagram for Gesture Detection Translator Application

The initial planning of the project consisted of brainstorming for ideas and concepts that can be applied to the proposed application. Browsing various online studies and journals in order of relevance to the chosen topic are done separately for better field coverage. Observations on similar products were conducted to see the features, scope, and limitations of said apps. Identification of required materials were also considered as preparation for the next phase of the development cycle. This phase also included the identification of the scope such as the specific language to be used for the sign language and coding, as well as the limitations that the project will face based on the known objectives set for the project.

Planning is skipped on the first iteration as the Initial Planning phase is already conducted. The next phase is the requirements phase, wherein the identified materials to be used were briefly reviewed again for

verification. The researchers then gathered said resources after the brief review. These included libraries, development resources, design resources, as well as the data sets to be used for the gesture detection. Capturing the data sets consisted of using image capturing devices These were all the resources that the application will need and use on the first iteration.

The succeeding phases were done by analyzing the materials as well as the plan for the construction of the application, designing the backend and frontend was then considered basing on the set objectives on the features included before the implementation phase of the project. Proper quality control for the data sets also falls in this phase, as accurate data sets are required to provide output that are just as accurate.

Implementing all of these resources and design into a working application comes next in the development life cycle. The application is shaped based on the data from the planning/ initial planning phase. This is the phase where the different data sets, libraries, etc. are compiled into a proper code to create a working prototype.

Testing and Evaluation are vital phases in the development of this application. As the app's features are tested and evaluated in this phase where different factors are considered such as the flaws in the prototype to be more specific. Evaluation does not only come from the researcher as different consultations are conducted with the researchers' adviser to gather feedback on the current status of the prototype. These evaluations are then used as basis in creating another plan, identifying additional requirements such as more data sets, further analysis, implementation of the project, which would then lead to further testing and evaluation.

Objectives of the study are to be considered in each iteration, making sure that every objective is fulfilled before finally creating the final product. This final product will undergo deployment onto its target users for practical use, finally fulfilling the final objectives of the study. The data collected for training data is processed by organizing the collected images to their respective folders, these images are then imported to a Google Collab folder running a Jupyter notebook. The Jupyter notebook installs and imports "mediapipe-model-maker" and "mediapipe" to process the data, the library helps in processing the images and training the model which results in a ".task" file which contains the processed data for recognizing gestures.

3.7 Summary

Development of a gesture detection application integrated with American Sign Language (ASL) alphabet gestures and text includes a mixed methodology and a combination of quantitative methods for accuracy and qualitative methods for rich data. The research methodology proceeds through action research patterns of planning, acting, observing, and refining. Quantitative features include measures of accuracy and speed, while qualitative goals focus on usability and user satisfaction. The creation and the structuring of ASL datasets by developers form the basis of data collection. Also, functionality is evaluated by means of survey feedback.

Training data are processed using "mediapipe-model-maker" and "mediapipe" libraries in a Jupyter notebook environment. Ethics only provide that the user data should not be stored. The only training data is by developers. The consent for the collection of survey feedback is anonymized. Applications use cameras on mobile devices and it uses user permission to do so. Limitations pertain to the fact focusing is on static ASL letters; that there are chances to lack accuracy owing to outside factors; that there is dependency on datasets from the developer; and that prototype application is mobile, therefore affecting the application in the wider scenario.

4 Results and Discussion

4.1 Data Description

Survey questions were distributed for the different experts depending on their field of expertise in order for the application to be reviewed and evaluated by experts in the respective fields relevant to the topics of the application. Experts with specialized knowledge in sign language, mobile development and or UI/UX design were carefully selected. The specialists' feedback was based on how well the application meets its objectives based on its target demographic as well as the ease of use of the application based on their expertise.

4.2 Qualitative Findings

The responses garnered from each expert were identified and analyzed by the proponents. The reviews were focused on the functionality of the application from the point of view of mobile developers and UI / UX experts as well as its functionality based on the view of a sign language expert.

The user interface and design was well received for its simple design which greatly helped in navigating through the application. Few recommendations on the color theme of the application were said by some, recommending a few color palettes that may suit the theme of the application. Other notes by the specialist were in regards to proper button placements and text sizing for better visibility and accessibility when using the application.

The application's functionality was also tested and reviewed by the experts, citing its ease of use and accuracy of detection. The application was praised for its accuracy in detecting proper ASL alphabet letters as well as the few included simple gestures. Some points regarding the speed of word construction were raised, but was still commended for creating a functioning application that fulfills its designated objectives. The experts also raised questions regarding the limitations of the application and how it may be great as a reference for future research as well as a helpful application for those starting ASL and learning the alphabet and simple gestures.

4.3 Comparison with other research

The proposed application is distinctive among other applications and research in a way that it highlights the importance of the basics in sign language and how it may be more helpful for those that are starting in comparison with other applications that are focused on creating translations that are based on words. Most existing applications and research makes use of words as basis for translation, but with the plethora of words that have their own corresponding unique sign, this application goes for a simpler and more functional approach with the use of letters. These letters also have their unique sign, but in contrast to words with differing signs for each and every word, spelling out these

words using letters will make use of the corresponding signs for letters without changing anything based on the word to be translated. As ASL letters can spell out any word, additional time and resources will be saved in creating an application that focuses on the countless words that one may use.

4.4 Practical Implications

This study has made significant contributions to the advancement of sign language translation technology and mobile gesture detection. Through the assessment of experts' views on a gesture detection sign language translation application, the research has emphasized key factors like usability, accuracy, and user satisfaction. The results demonstrate the application's potential to support future research and development in this area.

The study emphasizes the significance of creating a well running application that can be fully created and utilized with the limited development time-frame. While research on this topic is few and scarce, providing more materials for future research will help in surpassing the challenges and obstacles they may face. For instance, this study highlights the use of letters for translation instead of words which may be used as a basis for similar research as they build their applications. The scarcity of relevant resources shows the ongoing problem that the disabled face, which is having accessible services in regards to their inclusivity.

4.5 Limitations of the Study

Given the scope of existing research in gesture recognition, where impressive functionality is often achieved only after processing large datasets over extended periods of time, this study intentionally narrows its focus. By concentrating solely on recognizing ASL alphabet letters and basic gestures, the study both defines its scope and acknowledges its limitations. The development of the prototype will primarily focus on mobile applications, as it is being created by mobile development students. The application will be capable of recognizing gestures based on data provided exclusively by the developers. However, its functionality may be restricted depending on the availability of certain mobile features, such as a working camera for gesture recognition. This application will primarily cater to translating individual ASL letters through gesture detection.

The study's limitations stem from several factors. First, the focus on static ASL hand shapes, rather than dynamic gestures, phrases, or grammatical constructions, limits the application's ability to facilitate full ASL communication. Additionally, external variables such as hand shape variations, lighting conditions, and background interference could impact the system's accuracy. The need for user-specific training to account for differences in signing styles may further limit its general applicability. Limited scope of data collection for the data sets may also affect the quality of detection as well as hardware limitations, including variations in camera quality and device performance, could also affect the overall reliability of the application. Furthermore, the use of specific letter only type of datasets, poor contextual comprehension, and the exclusion of regional ASL variations all restrict the system's adaptability to real-world applications.

5 Conclusion and Recommendations

5.1 Summary of Findings

The project aimed to create an entry level translator application for sign language users that makes use of mobile gesture detection technology. Through a process of continuous development and expert assessment, several key points were clarified.

The research showcased the practicality of effectiveness of using letter-based translation for entry level users in sign language. The application provided accurate detection and proper translation that adheres to its specified objectives. Performance-wise, the experts raised few concerns on the speed of word creation with the compiled letters but are mostly satisfied with its results as it works as intended. Moreover, proper gesture detection can be attained by having sufficient light source and proper signs. The application itself surmounted the obstacles of creating a simple and functional design as per the expert's response. Further evaluation shows that albeit that the application has reached its desired outcomes based on predefined objectives that were met, various improvements may be implemented such as the speed and scope of the application.

5.2 Conclusion

In conclusion, the project successfully developed an entry-level sign language translator application using mobile gesture detection technology. Through iterative development and expert feedback, the application proved effective in providing accurate letter-based translations for beginner sign language users. While the experts highlighted some minor concerns regarding the speed of word creation, overall, they were satisfied with the application's performance, as it met its predefined objectives. The application demonstrated the ability to overcome challenges in design and functionality, providing a simple yet effective tool for sign language translation. Moving forward, there is potential for further improvements, such as enhancing the speed and expanding the scope, which could contribute to even greater user satisfaction, effectiveness, as well as future research in this field.

5.3 Recommendations

The researches proposes the following recommendations in regards to the findings garnered and expert evaluations conducted:

- Incorporating more fully translated words
- Exploring the feasibility to make it into an accessible app
- Adopt more translations
- Incorporate into existing language translations

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