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BIM Sign Language Translator Using Machine Learning (TensorFlow)

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Abstract: This project is developed to provide an application service to assist the deaf community where the deaf community in Malaysia has been facing difficulties conveying their messages to the non-deaf community. This project aims to design an offline and stand-alone BIM sign language translator, develop a BIM sign language translator system using TensorFlow machine learning, and conduct acceptance and functionality testing of the prototype to the deaf community non-fluent BIM user. The study uses Waterfall Model as a software development guide and uses TensorFlow, Python, OpenCV, and Qt as a core development library. The working application that translates sign language is then tested on the target users. The testing result shows that the target user can easily use the application to translate their sign language and shows positive indications while using the application. Even though there exist some limitations, such as the lack of a sign language dictionary that the application can translate. Still, it is hoped that this application will benefit the users.

Keywords: Sign language, machine learning, tensorflow

1. Introduction

Malaysian Sign Language (also known as Bahasa Isyarat Malaysia in the Malay language, or BIM) is a Malaysian government official recognition of sign language which is used to properly communicate with the deaf community throughout the whole country. This project is developed to further provide a product-based service to assist the deaf community and provide a gateway or a bridge to translate sign language (BIM) and deliver messages to non-proficient BIM users. A report source from Jabatan Kebajikan Malaysia indicates that among 497,394 citizens who registered in OKU (Orang Kurang Upaya) state, there are 9.0% (44,523) of citizens suffer from hearing loss. [1]

The current system of translating Sign Language is mostly using American Sign Language (ASL). This proposed project is to use BIM sign language as a base for a sign-to-text translation machine. Many of the current translator technologies use gloves to capture the motion of signing, which can be large and tricky to use. This project should replace the gloves with camera technology. The current system uses English as the only translation language for sign language. This project is developed to provide a wider translation language for a different language (Malay, English, Chinese, Tamil) background of the community, including the deaf.

The project objective is to design an offline and stand-alone BIM sign language translator, develop BIM sign language translator system using TensorFlow machine learning, and conduct acceptance and functionality testing of the prototype to the targeted audience (deaf community and non-fluent BIM users).

To resolve the problem of the lack of an existing BIM translation machine, a system that can translate BIM sign language with an image processing approach has been designed. The solution proposed is to provide a deep learning

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algorithm using the TensorFlow neural structure network. The system mainly focuses on providing multiple languages that are translated from BIM sign languages.

2. Related Work

2.1 Malaysian Sign Language (BIM)

Sign language is one of the human languages that can take many different forms depending on the location and culture and are not universal nor mutually intelligible with each different version of sign language [2]. Sign language is defined as a system of communicating using hand movements rather than spoken words, as used by people who cannot hear [3]. BIM was established by the Malaysian Federation of the Deaf (Persekutuan Orang Pekak Malaysia) in 1998 [4]. BIM sign language was officially recognized by the Malaysian government in 2008 as a means of officially communicating with the deaf community under the Persons with Disabilities Act 2008 [5]. BIM sign language is a complex language to learn as it does not have a word or vocal to express the language [6]. Instead, it relies on the sign gestures of the communicator to express different meanings to the listener (without sound input). BIM uses the combination of Finger Spelling and communication signs that represent different items [7].

In BIM, fingerspelling is based on the alphabet of the national language of Malaysia, which are Bahasa Malaysia [8]. Fingerspelling is useful to spell out any proper noun, usually a name or a unique place, like Ali and Kuala Lumpur [9]. Numbers are also sometimes used to form a complex or a sequence of numbers, like a bank account number. In BIM, 26 sign gestures are representing 26 alphabets of the Malaysian language, and 10 sign gestures represent the base 10 numbering system [10].

2.2 Machine Learning (ML)

Machine learning is programmed to develop and aid software to perform a task without a complex programming or explicit set of rules [11]. Machine learning can be categorized as a subcategory of artificial intelligence (AI) that uses statistical techniques, such as deep learning (neural networks), and is inspired by the theory of how the human brain processes information. TensorFlow is designed for a machine learning end-to-end open-source platform with a set of an all-inclusive, adaptable environment of tools, libraries, and community resources that made advanced Machine Learning possible for developers to easily build and deploy Machine Learning powered applications [12]. The use of Linear Regression and Linear Classification are included in TensorFlow.

2.3 Existing Translation Sign Language System

Table 1 shows the comparison between existing translation systems such as Sign-to-Speech Translation Using Machine-Learning-Assisted Stretchable Sensor Arrays [13], Project KinTrans [14], JARI [15], and the proposed system. The comparison has highlighted the interface language, translated language, type of sign language, number of translations, technology requirement, and type of sign language. From the results of the comparison, the proposed system is concluded that the system should translate BIM sign language, to another language like English and Bahasa Malaysia with more general and high availability of technology such as a computer with an HD camera. The proposed system should use sign-to-text translation while maintaining a high number of translations.

3. Materials & Method

3.1 Materials

This project requires some amount of software and hardware to develop the application. For the system of the translation project to be working smoothly, both developers and users need to have hardware and software requirements that can support the developed project. Thus, a refined detail about the developer’s and user’s software and hardware requirement will be listed in table 1 and table 2.

Table 1 - Developer's hardware and software requirement

Category	Item	Note
Hardware	Computer with input-output devices	• With HD camera • Windows 8 & above • Minimum 4 RAM • Quad-Core Processor • NVIDIA GPU card with CUDA architectures 3.5, 3.7, 5.2, 6.0, 6.1, 7.0 or higher • Have internet accessibility. • 50GB of memory storage. • Mouse & Keyboard
Software	Google Colab	• Require active internet session. • Reduce computation resources. • Online saving and help forum are available. • Does not support OpenCV • Python integrated development environment
	PyCharm	• Community Edition 2020.3 • Computation extensive (efficient execution) • Support OpenCV • Python integrated development environment
Programming Language	Python	• Version 3.0 • Pip features included • Main programming of the project
	TensorFlow	• Require Python 3.0 installed • Acquire using pip • Handles Data and Machine Learning
	PyQt (version 5)	• Require Python 3.0 installed • Acquire using pip • Create GUI template
	OpenCV	• Require Python 3.0 installed • Acquire using pip • Handles Images and Camera function

Table 2 - User's hardware and software requirement

Category	Item	Note
Hardware	Computer with input-output devices	• With HD camera • Windows 8 & above • Minimum 4 RAM • Quad-Core Processor • NVIDIA GPU card with CUDA architectures 3.5, 3.7, 5.2, 6.0, 6.1, 7.0 or higher. • 1GB of memory storage. • Mouse & Keyboard
Software	None	

3.2 Method

The waterfall model is a sequential process where the model straight forward [16] and to continue to the next phase of the chain, the previous phase must have been completed [16]. The waterfall model includes six phases which are Requirements, System Design, Implementation, Integration and Testing, Deployment of the System, and Maintenance [16]. The waterfall model is used to due to the project's system is required to complete each phase or module to continue the following phase(s).

The Requirement phase is the first stage in the Waterfall methodology. It requires the research and data gathering about the comprehensive information of the project requires before the project could take place in development [17]. Table 3 shows the project requirement of this project.

Table 3 - Project requirements checklist

Item	Note
Installation module	To install necessary items with ease
Creation of a new gesture module	To insert new data on sign language
Capture gesture module	To snap and take new sign language in the image and store them.
Rotate image module	To rotate newly taken photos vertically for left-hand and right-hand data.
Analyze image module	To detect and analyze data of the image taken.
Display sign gesture module	To display the current sign language gesture dataset stored.
Training module	To train and enhance the dataset with machine learning.
Main interface module	To opens a panel for sign language gesture translation.

System Design determines the hardware and system requirements of both developers, as well as the user that contributes to the system architecture [16] For this project, the flowchart, navigational structure, and storyboard, was produced. Table 4 shows the project architect of the project during development.

Table 4 - Project architecture

Item	Note
Installation module	• Programming: Python • Execution: Install necessary items such as TensorFlow.
Creation of a new gesture module	• Programming: Python and TensorFlow • Execution: Create a new category of BIM sign gestures, including folder creation.
Capture gesture module	• Programming: Python and TensorFlow • Execution: Capture an image from an HD camera and store it in an image file.
Rotate image module	• Programming: Python • Execution: Rotate the image horizontally and store it in the image file
Analyze image module	• Programming: TensorFlow • Execution: Analyse the image dataset using a build-in algorithm and determine output.
Display sign gesture module	• Programming: Python and TensorFlow • Execution: Display a list of recorded BIM gestures.
Training module	• Programming: Python and TensorFlow • Execution: Capture and store images of BIM sign gestures repeatedly.
Main interface module	• Programming; Python and TensorFlow • Execution: Capture BIM sign gestures, and display prediction outcome (translated text)

The task of the BIM Sign Language Translator had been thoroughly analyzed and turn the task analysis into Figure 1. According to the figure, there are five tasks that the BIM Sign Language Translator should do, which are to launch the application, select the first time/new environment, select the translation module, select admin control, and select exit. For the launch of the application task, the user is required to launch the application and enter the main menu interface. Once the user is inside the main menu interface, the user can do the select first time / new environment task. Here the user needs to follow the procedure so that the system could generate the histogram adjustment. If the user had previously done this task, the user can resume to translation module task where all the translations of BIM sign language will be conducted. If the user is admin, then the user can proceed to the admin control, otherwise, the user can skip. The admin control task provides a few sub-tasks which are displaying all gestures, adding gestures, training modules, and load image tasks. The sub-tasks allow the user to do the task in any order while configuring the ML of the system to be more accurate. These sub-task has their subtask and must be done in sequence. For the last task, the user selects the exit button and shows the confirmation notice. Here the user can choose to select ‘Yes’ or ‘No’.

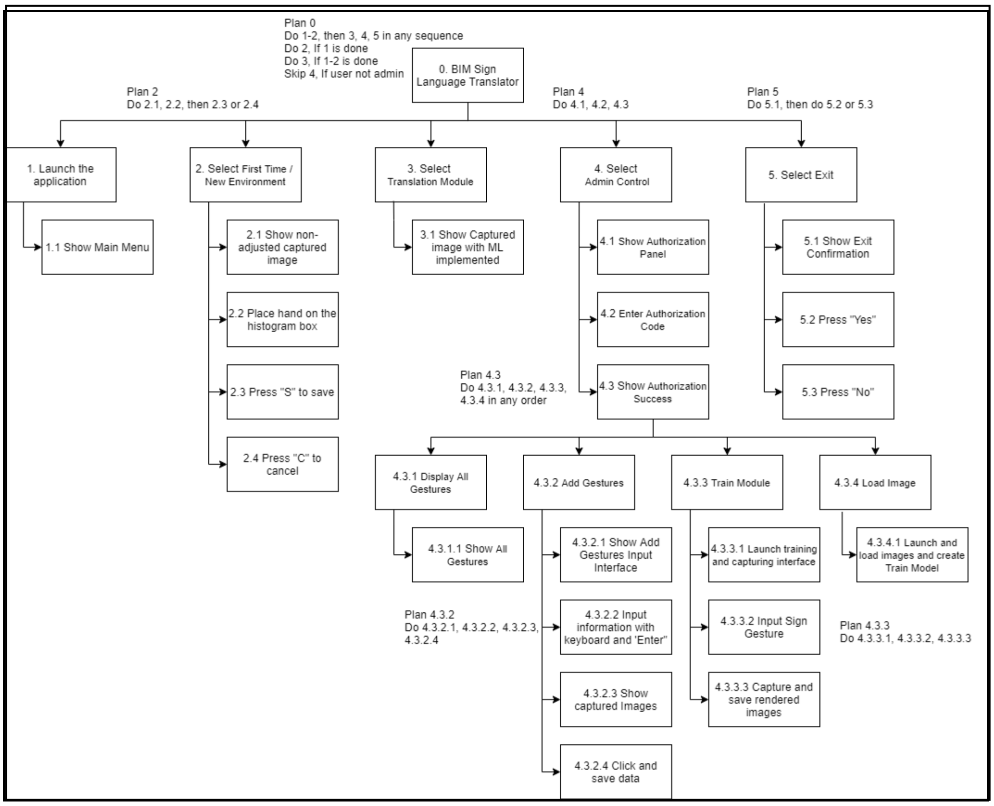

Fig. 1 - Hierarchical task analysis

For any successful projection of the project, a Flowchart is necessary as it can virtually show the flow of the system, processes, and data structure in the most unsophisticated way. The Flowchart of the BIM sign language translator project is divided into seven sub-flowcharts as it comprises a different module that works with separate functions. The sub-flowcharts include the Main Interface Flowchart, Set Histogram, Main Translation Interface, Display All Gesture, Add Gesture, Train Module, and Load and Create ML. The completion of all the sub-flowchart will become the Overall Flowchart of the Translation Project as shown in figure 2.

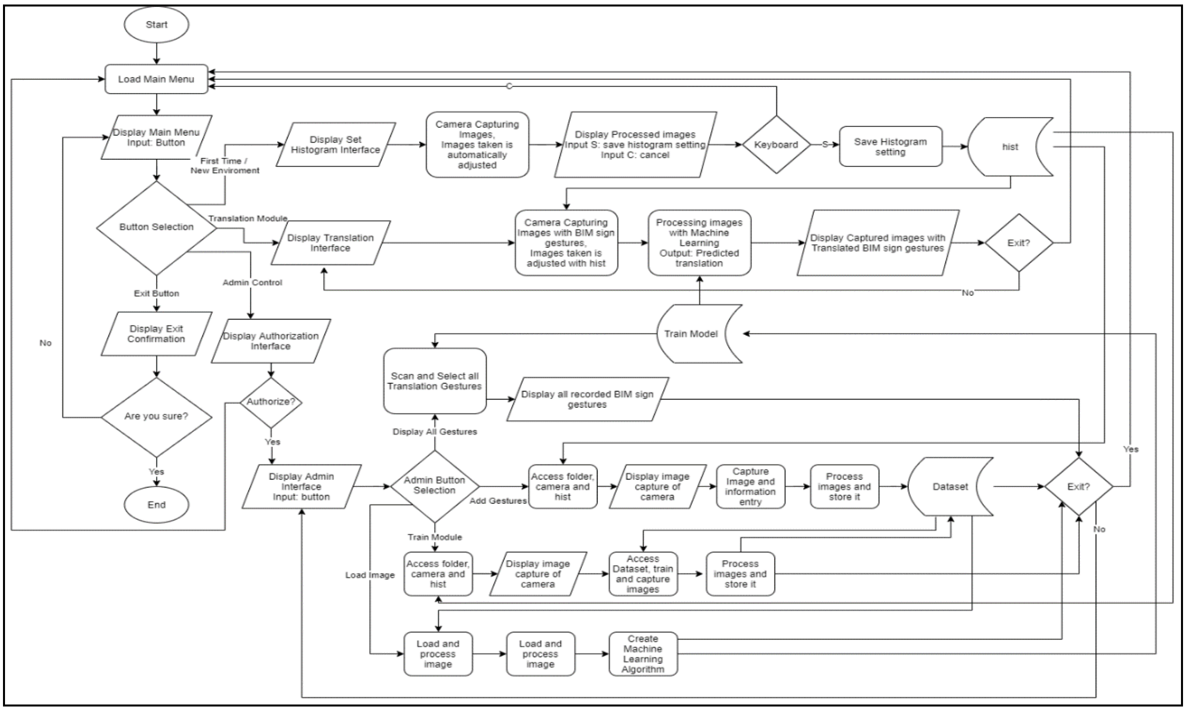

Fig. 2 - Overall flowchart of the translation project

4. Implementation

4.1 Installation module

Upon completion of the Implementation phase, a prototype of the project shall be created and can be used for further inspection of the project's requirements and to be used for further development in the next phase. The installation module is of the utmost importance so that the installation process of the system to the target user is smooth and easy. For this, the system is being converted to a stand-alone executable so that the user does not need to install any additional supporting programs on their computer. The user would download the files and launch the GUI_Interface.exe file to launch the application as shown in figure 3.

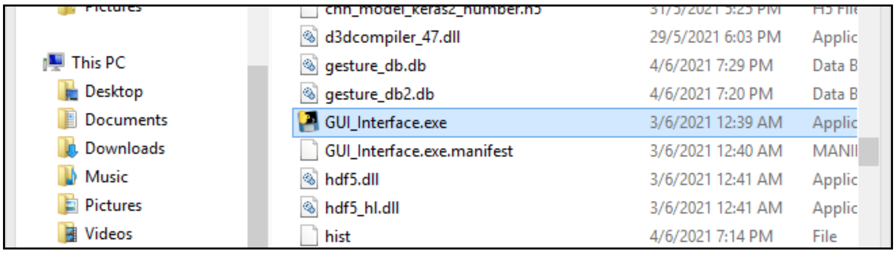

Fig. 3 - Executable file of the translator application

Create New Gesture Module is a module that allows users to create a new sign language gesture. This newly created gesture will be saved into the database. This newly created gesture will be saved into the database using the SQL command. Figure 4 shows the create a new gesture implemented into the Add Gestures Interface.

Fig. 4 - Add gestures interface

Capture Gesture Module is to use snap and take new sign language in the image and store them into the local file. This program uses the OpenCV library to display the image captured on screen, access the device's camera, capturing the image, process the image, and stored the image as JPG. Figure 5 shows the capturing process of using this module.

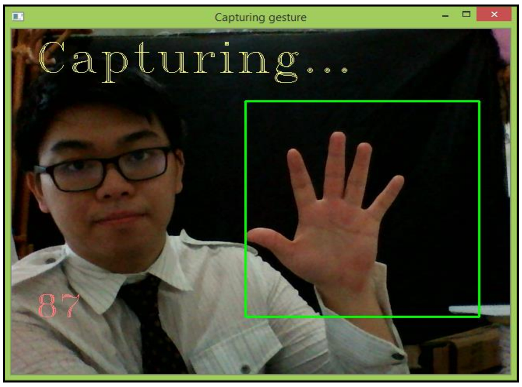

Fig. 5 - Running capture gesture module

Rotate Image Module is to flip the sample taken horizontally. This allows the machine learning to register left-hand and right-hand sign gestures. Figure 6 shows the output of the Rotate Image Module. Analyze Image Module is to label all the image samples to be used for later processes as shown in figure 8. The labeling of all image samples can be used to shuffle the testing of machine learning and random selection for training machine learning.

Fig. 7 - Running rotate image module

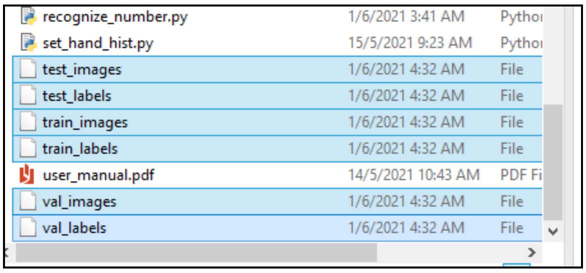

Fig. 8 - Labels data stored locally

4.2 Training Module

The image samples created from Analyse Image Module are then used by the Training Module where the module is the core of creating a machine learning system. It allows the machine to learn certain patterns and self identifies the images associated with its ID. Figure 9 shows the interface of the Training Module. Display Sign Gesture module as displayed in figure 10 allows the system to display all the types (ID) of gestures recorded.

The main interface is where all the translation occurs as shown in figure 11. This is where the user with non-fluent BIM and fluent BIM could interact with. The fluent-BIM use would wave sign gestures into the green box and the machine learning system would predict the gesture and display the highest probability of prediction, which can translate to Bahasa Malaysia, English, Chinese, and Tamil on the right side of the window. The translated word can be read by the non-fluent BIM user to understand the sign gesture waved by the BIM fluent user. The Language Dictionary Module is similar to the Create New Gesture Module. The purposed of the language dictionary module is to store all the possible translations of different languages into a single table that can be further used in the translation process.

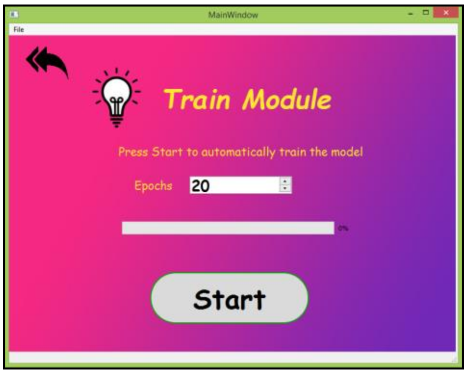

Fig. 9 - Labels data stored locally

Fig. 10 - Display sign gesture module

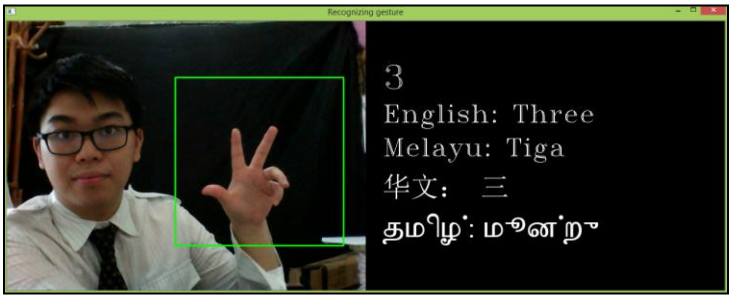

Fig. 11 - The main interface of the translation

4.3 Integration and Testing

The Integration and Testing phase of the methodology is the combination of each unit developed in the previous phase into a system after each unit is thoroughly tested [16]. All modules that are developed in the previous phase will be integrated into a complete system that can work.

After the completion of the system development, thorough functional testing and non-functional testing will be initiated towards the target user. After the functional and non-functional testing in the previous phases is complete, the system shall be deployed to the target user. The deployment of the system will be in the executable file. PyInstaller was used to convert the Python file and any of its dependencies to an executable file. After that, include the necessary database, samples, and images so that the executable file can work with. The outcome data of this testing will be used for the following phase.

The maintenance phase is the last phase of the Waterfall methodology. The last phase of this project is to improve and modify any changes to the system or small components that consist of minor problems, defects, or minor programming errors after the deployment of the system [16]. The improvement of the developed system in this project will be initiated and any bugs that arise during the previous phase will be fixed. The accuracy test of the previous phase can be used to better train and design the system so that higher efficiency and accuracy could be achieved.

5. Results and Discussion

Alpha testing is the fundamental testing process that tests the functionality and the successful operation of each module in a project. It is done throughout the development process and the testing was done for each button, navigation, launching operation of module, and image integration. Improvement is immediately made if any error is found. Table 5 shows the alpha testing result of the application based on the functionality aspects.

Table 5 - Results of alpha testing

Test Unit	Expected Result	Actual Result	Action taken
Hovering Button	The button would change color (pointed state)	Working well	No action taken
Navigation Button	The button would navigate to the desired page	Working well	No action taken
Language ComboBox	The ComboBox would list the available language of the interface and change the user-selected settings	Working well	No action taken
Feedback Output (Loading Bar, Message Box)	The feedback output would provide feedback to the user once a certain action is performed	Working well	No action taken
Proper exit application	The application is properly exited via window exit or application exit	Working well	No action taken
Password Authentication	The password authentication should be encrypted and allow access only for the admin.	The password phrase input in the QLineEdit is not clear after login	Clear the QLineEdit after login
Program Modules	The module would run perfectly in the background	The program would crash once the program is exported to an executable file	Include the gesture folder and H5 file in the distribute folder
Images	The image would display in the interface in the correct place.	The image is not displayed once the program is exported to an executable file	Include the Img folder in the distribute folder

6. Conclusion

The BIM Sign Language Translator application had been developed according to the requirements and problems that both the deaf community and non-deaf community are facing. The user feedbacks received from the target user indicate that the application has proven to be effective at providing a framework that the deaf community can communicate with non-fluent BIM users with BIM sign language. The application can be used in a wide variety of places and workspaces such as schools, agencies, and service providers. Some advantage of the application includes the application can be run on multiple platforms such as Mac, Linux, Raspberry Pi, Android, and iOS tablets as Python can be run cross-platform, is easy to use and interactive with the graphical user interface, and is a built-in function where user can choose preferred language setting, easily expandable. However, limitations of the application include the inability to translate any motion of BIM sign, could not view the content of the database via the application, being only able to translate alphabets and numbers, and the user might crash the application due to lack of compatibility of the device. Suggestion for future work of this application includes the upgrade to recognize motion picture (via video classification), integrating an interface for easily viewing the database, expanding its dictionary via updated version from time to time, and including the minimum recommended device specification to run the application.

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References

[1] J. K. Malaysia, Buku Laporan Statistik JKM. (2018). Jabatan Kebajikan Malaysia, Persiaran Perdana, Putrajaya, p. 152.

[2] D. M. Perlmutter.(1991). “What is Sign Language?”, Linguistic Society of America, Washinton,

[3] A. S. Hornby, The Oxford Advanced Learner's Dictionary of Current English, 10th ed, Editor Diana Lea, Oxford: OUP, 2020.

[4] A. Lai. (2012). “97-year-old offers free lessons for the deaf”, TheStar. [Online]. Available: TheStar, https://www.thestar.com.my/news/nation/2012/11/12/97yearold-offers-free- lessons-for-the-deaf. [Accessed November 9, 2020].

[5] Undang-Undang Malaysia, Akta Orang Kurang Upaya. (2008).Akta 68.
[6] P. Kulasagaranm, (2014), “Must language be spoken to be heard?”, TheStar. [Online]. Available: TheStar, https://www.thestar.com.my/news/education/2014/07/27/must-language-be-spoken-to-be-heard-the-development-of-sign-language-in-malaysia. [Accessed November 9, 2020].
[7] R. b. Ma’rof, N. A. b. Ahmad, M. N. A. b. Mesan.(2016). Bahasa Isyarat Komunikasi Tahun 1, Dewan Bahasa dan Pustaka, Kementerian Pendidikan Malaysia, Kuala Lumpu.
[8] H. C. Omar, Penterjemahan dan Bahasa Isyarat, 1st ed, Wisma ITNM: Institut Terjemahan Negara Malaysia Berhad, p. 43, 2009.
[9] R. Ma’rof, N. A. Ahmad, M. N. Aszlan.(2016).Bahasa Isyarat Komunikasi Tahun 1, Dewan Bahasa dan Pustaka, Kementerian Pendidikan Malaysia, Kuala Lumpur.
[10] M. Muharam .(2007). “Translator Of Malay Text To Kod Tangan Bahasa Melayu”, Master of Science (Information Technology Entrepreneurship) dissertation, Fac. Comp. Sci. Info. Syst., Univ. Teknologi Malaysia, M.
[11] C. M. L. Services.(2020).What is machine learning?”, Google Cloud. [Online]. Available: Google Cloud, https://cloud.google.com/what-is-machine-learning. [Accessed November 11, 2020]
[12] TensorFlow. .(2020). “An end-to-end open source machine learning platform”, TensorFlow. [Online]. Available: TensorFlow, https://www.tensorflow.org. [Accessed November 12, 2020].
[13] Z. Zhou, K. Chen, X. Li, S. Zhang, Y. Wu, Y. Zhou, K. Meng, C. Sun, Q. He, W. Fan, E. Fan, Z. Lin, X. Tan, W. Deng, J. Y. J. Chen.. (2020). “Sign-to-speech translation using machine-learning-assisted stretchable sensor arrays”, PhD dissertation, UCLA Samueli Sch. Eng, CN.
[14] K. Inc, “Project KinTrans Hands Can Talk uses AI to learn and process the body movements of sign language”, KinTrans, 2020. [Online]. Available: KinTrans, https://www.kintrans.com/. [Accessed November 11, 2020].
[15] S. B. Saja. (2018).“Malaysian Sign Language Translator”, Deg. Dissertation, Uni. Tun Hussein Onn Malaysia., Johor, MY.
[16] L. Sharma. (2016). “What is WaterFall Model?”, ToolsQA, [Online]. Available: ToolsQA, https://www.toolsqa.com/software-testing/waterfall-model. [Accessed October 12, 2020].
[17] L. C. Team. (2020). “What the Waterfall Project Management Methodology Can (and Can’t) Do for You”, Lucidchart Content Team,. [Online]. Available: Lucidchart Content Team, https://www.lucidchart.com/blog/waterfall-project-management-methodology. [Accessed October 12, 2020].