

# Development of e-Sign Dictionary Using 3D Technology for the Deaf Community

Siew Hock Ow

Pek San Lim

Department of Software Engineering

Faculty of Computer Science & Information Technology

University of Malaya, 50603 Kuala Lumpur, MALAYSIA

Email: show@um.edu.my

## Abstract

*Although there are many learning resources available for the general public to learn a sign language, the use of electronic tools is likely to gain in popularity. This is because with the rapid development in Information Technology, electronic learning packages have become effective tools for the general public in the learning process. This paper discusses the development of e-Sign Dictionary, an electronic sign language dictionary of the Malaysian Sign Language. It is a trilingual system with instructions in English, Malay and Chinese. It is not only suitable for the deaf community but also the general public. In this regard, the objective of this system is to close the communication gap between the deaf community and the general public, thus, fostering better understanding between them.*

## 1. Introduction

Deafness or hearing loss is the result of damage to any part of the ear. It is rather difficult to classify deafness because the indication of deafness varies from person to person and is related to the individual's circumstances. In general, deafness can be caused by genetic disorders, diseases, illness, medications, physical trauma and aging. dBHL is used to measure the degree of deafness and hearing loss. dB is the abbreviation for decibels, whereas HL means hearing level. The greater the threshold levels in dBHL, the greater the hearing loss. Hearing loss can be divided into a few categories, namely, normal, mild, moderate, severe and profound [1].

Today, there are many types of equipment and support devices available for the use by the deaf or hard of hearing people in their daily life. They include [2]:

- Hearing aid: an electronic device, with special and extremely small batteries, and consists of three components – microphone, amplifier and receiver.
- Text-phone: a device that consists of a display screen and a keyboard for the user to type their message and at the same time read what is being typed in reply.
- Videophone: used to communicate in sign language.
- Loop system: helps people who use a hearing aid or loop listener to hear sounds more clearly by reducing background noise.

- Cochlear implant: a small, complex electronic device that helps to restore total or profound hearing loss.

Malaysian Sign Language (MSL) is the most widely used method of sign communication in Malaysia. It is also known as "Bahasa Isyarat Malaysia (BIM)." MSL had developed naturally, as languages do. It uses both manual and non-manual components: hand shapes and movements, facial expression and shoulder movement [3, 4]. It has many 'dialects' which differ from state to state. For example, Penang sign language is used by the Penang state deaf community [5, 6]. The American Sign Language (ASL) has a strong influence on MSL, but both are different enough to be considered separate languages.

## 2. Electronic Sign Language Dictionary

Today, new technologies are applied in the development of equipment and systems for the deaf or hard-of-hearing people. There are sign language dictionary systems in the market. Some of the systems are given free while others are not.

Although there are electronic sign language dictionaries in the market, there is none for the Malaysian Sign Language. Most of the foreign sign language dictionaries are usually available as CD-ROM while some are accessible on-line from the Internet. Hence, a project was initiated to develop a Malaysian sign language dictionary, namely, e-Sign Dictionary, specifically for the use of the Malaysian deaf community and the general public. The following sections describe the development of e-Sign Dictionary.

## 3. Functions of e-Sign Dictionary

e-Sign Dictionary is a Windows-based application that runs on the client/server platform. The system has eight main modules – Login, Character, Language, Search, Report, Administrator, Help and About. These modules are explained briefly below.

### 3.1 Login module

This module is meant to verify the status of the Administrator before he is allowed to carry out any administration tasks. This is to prevent any modification of data by unauthorised user and to safeguard the integrity of the dictionary.

### 3.2 Character module

This module provides four different animated characters – man, woman, boy and girl. A user can



choose one of the characters that he prefers to demonstrate the sign for the word. The character can be changed anytime, for example, from a man character to a woman character. The boy and girl characters are provided specifically for young users.

3.3 Language module

This module provides a choice of three languages, English, Malay or Chinese to view the instructions and the meaning of a word, its synonym or antonym. The language can be changed at anytime.

3.4 Search module

This module provides three types of search methods – search by category, by alphabetical order and by recent search. The categories included in the system are fruits, states in Malaysia, colours, vehicles, buildings, occupation, time and date, human body, alphabets, numbers and fractions, and emotions. *Recent search* allows words that have been searched previously to be reviewed. Users do not need to re-type the same words again.

3.5 Report module

This module provides a report to the users on the words that they have searched during a particular period, for example, in the last 24 hours, last week or last month. Thus, users will be able to know the words that they have searched most frequently and pay more attention to them.

3.6 Administrator module

This module which is used by an administrator has three basic functions – add, update and delete. An administrator can add new words together with its signs, antonym, synonym, sample sentence of the word and picture into the database using the add function. Likewise, words in the database can also be updated or deleted.

3.7 Help module

This module provides guidelines to users on the use of the system. All the functions provided are described in this module and explanations on how to perform certain operations are given.

3.8 About module

This module provides users with the information on the Malaysian Sign Language and deafness.

4. Design of e-Sign Dictionary

In the design phase, attention was paid to ensure that the system developed is easy to use. This was achieved by providing simple user interfaces that require minimal input from the users. The following sections describe the system components, user interface, and database design.

4.1 Components of e-Sign Dictionary

e-Sign Dictionary consists of five main components: the user interface, codes, database,

animation files and words' details. The user interfaces are linked to the database via the codes. The database stores all the animation files and details of the words are stored (Fig 1).

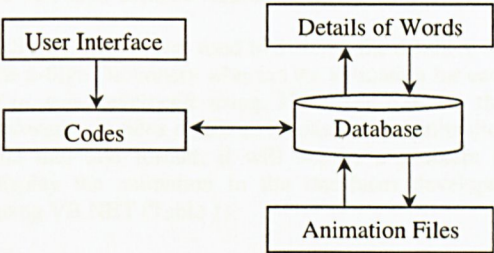


Fig 1. Components of e-Sign Dictionary

4.2 User interface design

The user interface allows interaction between users and the system. Some principles have been followed while designing the interfaces for the e-Sign Dictionary. User interface consistency is the prime consideration in e-Sign Dictionary to help the users to familiarise with the system quickly. System commands and menus used in the e-Sign Dictionary are similar throughout all the modules. All the buttons used in the system are consistent from page to page. Besides, user guidance is another important aspect to consider when designing the interfaces. There is feedback whenever an error occurs. A help function is also provided to assist users to use the dictionary. Fig 2 and Fig 3 show the user interface designs of e-Sign Dictionary.

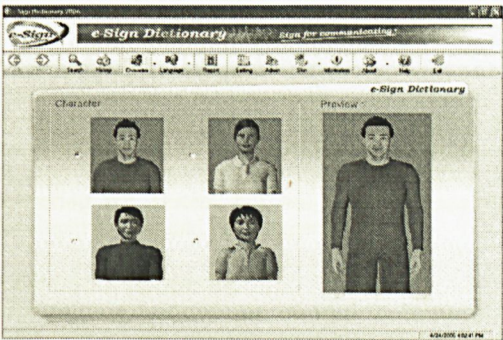


Fig 2. User interface design – choose character

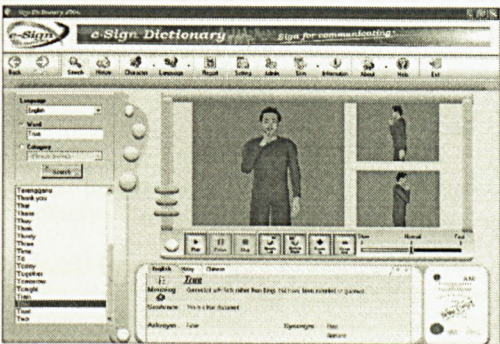


Fig 3. User interface design – search function



### 4.3 Database design

There are two processes involved in developing the database for the e-Sign Dictionary.

#### ■ Creating the database

There are seven tables in the database – Admin; BI\_Dictionary; BM\_Dictionary; BC\_Dictionary; Category; DictionaryHeader; and LastSearch.

Admin – stores the administrator's username and password.

BI\_Dictionary – stores all the English words together with their meanings, synonyms and antonyms.

BM\_Dictionary – stores all the Malay words together with their meanings, synonyms and antonyms.

BC\_Dictionary – stores all the Chinese words together with their meanings, synonyms and antonyms.

Category – stores all the categories of the words.

DictionaryHeader – stores all the animation paths for each word.

LastSearch – stores all the words that have been searched by the users.

#### ■ Entering data

There are two ways for the administrator to enter data into the database. Data can be entered directly into the database using MS SQL Server, or through the e-Sign Dictionary Add module (Fig 4).

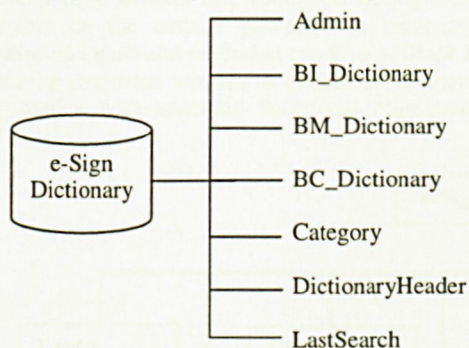


Fig 4. Database and tables in e-Sign Dictionary

## 5. Development of e-Sign Dictionary

This section discusses the development tools and technologies used to develop e-Sign Dictionary.

### 5.1 Development tools and technologies used

The e-Sign Dictionary interfaces and modules were developed using the VB.NET programming language [7]. Visual Basic combines conventional test based programming techniques with visual techniques using icons and menus. VB.NET provides a drag and drop function that allows users to draw the components (i.e. textbox, combo box and image) directly without writing the codes. It is much like using a paint program. In addition, the

buttons, textboxes and other objects that we have dragged into the window form will automatically recognise user actions such as mouse movements and button clicks. Thus, it is easy to design the interfaces as well as to write the source codes for the system.

MS SQL Server was used to develop the database for the e-Sign Dictionary whereas the animation for each sign was developed using 3D Poser 6.0. As this software provides direct conversion of an animation file into .avi format, it will not be a problem to display the animation in the interfaces developed using VB.NET (Table 1).

Table 1. Development tools of e-Sign Dictionary

Software	Application	Description
Microsoft® Windows XP	System Requirement	Operating system.
Microsoft® Visual Basic.NET	System Development	System coding.
Microsoft® SQL Server 2000	Database	Build the database to store and manipulate the data and animation files.
Microsoft® Text-to-Speech	System Development	Provide the pronunciation of the words.
3D Poser 6.0	Interface Design and Contents Design	Animation design.

### 5.2 Programming techniques

Good programming techniques are very important to ensure the success of a system. Adopting an inappropriate use of a programming technique to develop a system will not only cause delay in delivering the system but will also increase the development cost and other expenses.

#### a. Modular programming

Modular programming can be used to break up a large program into smaller and manageable units, or to create codes that can easily be re-used. A modular program consists of a main module and one or more auxiliary modules. Each module originates from a separate source code file [8].

As mentioned above, e-Sign Dictionary consists of eight modules – Login; Character; Language; Search; Report; Administrator; Help and About. This modular programming development approach helps to simplify the coding and testing processes.

#### b. Module integration

All the eight modules were integrated to form a complete system. Before integration, each module was tested to ensure that all its functions work



properly. It is important to ensure that the modules were properly and fully integrated.

5.3 Testing

System testing is an important process in developing a system. It is a critical phase when the functionality of the system and its performance are evaluated. It is done by executing programs to identify errors. Through testing, system completeness and reliability can be reviewed [9]. Some of the important testing techniques used in developing the e-Sign Dictionary are described below.

i. Module testing

The goal of module testing is to confirm that the module is correctly coded and it can carry out the function that it was designed to do. This type of testing ensures that the components perform properly and produce the expected outputs. In this technique, coding and testing are carried out in parallel. Fig 5 shows the sequence of module coding and testing. This testing technique was used to ensure that bugs could be fixed without side effects. The functions and procedures in each module were examined carefully after the coding process.

In module testing, white box and black box testing were performed on each module. White box testing evaluates the internal mechanism of a system or component. In black box testing, the testing focuses solely on the outputs generated in response to selected inputs and execution conditions. Black box testing evaluates whether a system or component complies with specified functional requirements [10, 11].

In the module testing process of e-Sign Dictionary, the following aspects were considered:

- *Code review*  
At the beginning of module testing, the program codes were examined to ensure that all the algorithms used in the program are correct. For example, the processing paths and algorithms of the Search module to perform the three types of search – by category, by alphabetical order and by recent search, were executed and tested thoroughly to identify bugs. Besides, the program codes were checked for any data or syntax errors. Throughout the checking process, syntax errors, logic errors and deviations from coding standards were discovered and corrected [12].

In addition, the specifications and the designs of the system were compared with the specific codes. This is important as it helps to ensure that all the relevant cases have been considered. For example, in the testing of the Report module, dates within last 24 hours, last week and last month were input, to test the words that were searched during those specific period. The test results were compared to determine whether if all three test cases generated results that matched the expected results. Also, other possible test cases were developed to show that the inputs are properly converted to the desired outputs. The program is run once to evaluate the results and to eliminate the remaining syntax errors, if necessary.

- *Interface*  
All the interfaces of e-Sign Dictionary were tested to ensure that they are clearly understood, the colour settings are suitable and the flow of information from one module to another module is correct.

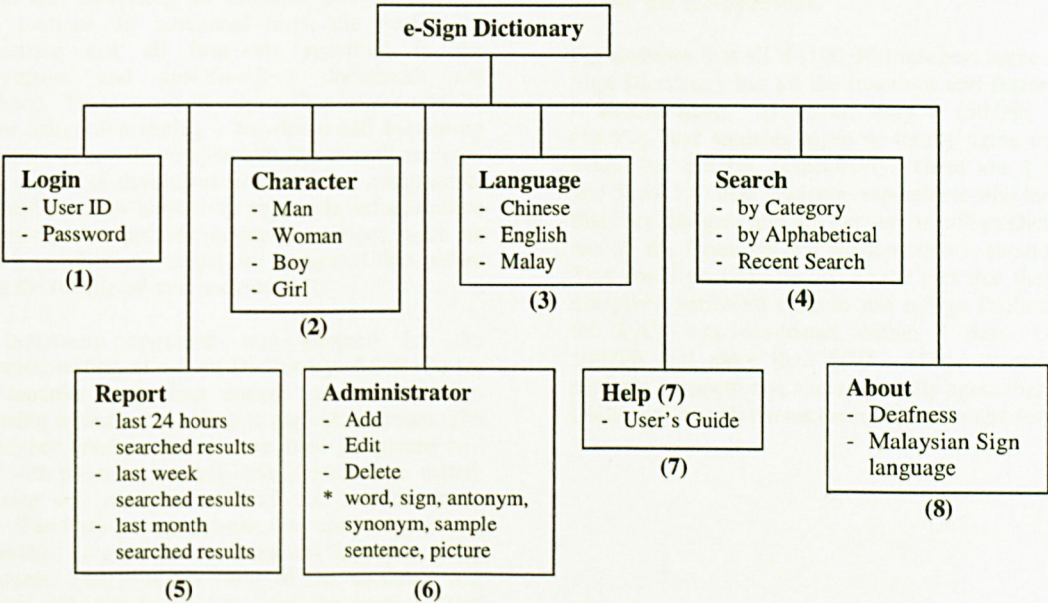


Fig 5. Sequence of module coding and testing



- *Errors handling paths*

All errors handling paths were checked to detect and recover all fatal errors during system execution. It is also important to ensure that the routine for all the error handling works correctly, as directed. For example, when entering the date for words searched last month, the ending date should be later than the starting date and both starting and ending dates should not be future dates. An error message would be displayed if invalid dates are selected.

- *Independent paths*

All the independent paths throughout the system structure and paths of conditional statements such as *if-then-else*, *do-while* and *repeat-until* were tested to ensure that all the statements in each module have been executed at least once.

- *Animation of signing*

The words stored in e-Sign Dictionary are based on the book entitled: "Belajar Bahasa Isyarat Dalam 10 Jam" (meaning: Learn Sign Language in 10 Hours) by Tan Yap, President of the Society of Interpreters of Selangor and Federal Territory and an MSL expert [13]. He helped to check the sequence of animation in signing each of the words stored in the e-Sign Dictionary to ensure correctness in the signing of the words.

## ii. Integration testing

The process of system integration involves building a system from its components and testing the resultant system for problems that arise from the interactions of the components. It involves identifying clusters of components that deliver some system functionality and integrating these by adding codes that make them work together. Integration testing includes structural tests and functional tests. Structural tests place emphasis on exercising all the input and output parameters of each module and exercising all modules and all calls to utility routines. In functional tests, the goal is to demonstrate that all functions specified in the requirements and specifications documents are completed. There are two approaches that could be used in integration testing – top-down and bottom-up integration. In top-down approach, the overall skeleton of the system is developed first, and the components are added to it. In bottom-up approach, infrastructure components that provide common services, such as network and database access are integrated first before adding the functional components [12].

The bottom-up approach was adopted for the integration testing of e-Sign Dictionary. All the lower level modules were first coded and tested before integrating upwards according to logical sequence. The next higher level modules were then integrated and tested with the modules that have already been tested. This step was repeated until all the modules were tested. The testing environment was consistent for all the modules in terms of interfaces and function calling procedures. The program flow of the modules was reviewed and identified. At the end, the program flow for the entire system was reviewed and identified [14].

The criteria considered while conducting integration testing for e-Sign Dictionary are:

- All the functions in the system were tested to uncover functional errors.
- The data passed between interfaces were checked for any loss of data across the interfaces.
- Performance tests were conducted to verify that the system performs a function within the specified time. For example, the results of the search function are displayed within 30 seconds.

## iii. System testing

The functions in e-Sign Dictionary were tested when all the modules were integrated. This testing requires much time as the system is quite comprehensive and consists of eight main functions. It is, important to perform system testing to ensure that e-Sign Dictionary meets all the requirement specifications. The testing was performed by the development team members and by three independent testers.

## iv. User acceptance test

User acceptance testing (UAT) is a critical phase in any software project. It requires the participation of the end users. To be acceptance for use, an acceptance test plan was developed to plan precisely, and in detail, to achieve system acceptance ultimately. In order to conduct this testing, the deaf school teachers and deaf students of the Community Service Center for the Deaf, were invited to participate. A set of evaluation criteria was formulated. Four teachers and sixteen deaf students were given hands-on practice before they gave their feedback to the set of evaluation questions. Their satisfaction with the system indicates that the users' requirements have been fulfilled. Although the sample size is small, the feedback from the UAT test is a good reflection of the practical use of the system and its usefulness as a sign language dictionary. Fig 6 and Fig 7 show the survey results.

Fig 6 shows that all 4 (100.0%) teachers agree that e-Sign Dictionary has all the functions and features that it should have. However, only 8 (50.0%) and 2 (12.5%) deaf students agree or totally agree with the evaluation criteria, respectively. There are 1 (6.2%) and 5 (31.3%) deaf students respondents who indicated that they disagree and are not sure if e-Sign Dictionary has all the functions and features that it should have. This could possibly be due to the fact that they were not given sufficient time to use e-Sign Dictionary as the UAT was conducted within 3 days. Overall, 100.0% and more than 60.0% of the teachers and students, respectively, agree or totally agree that e-Sign Dictionary has all the necessary function and features.



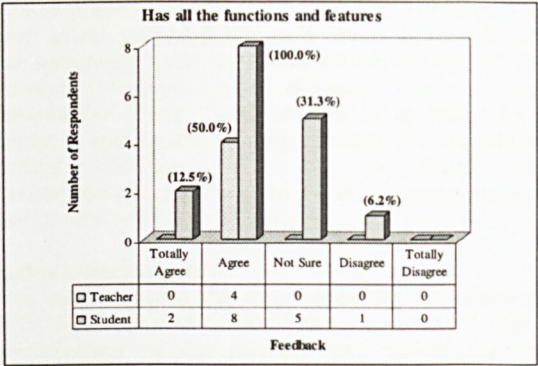


Fig 6. Feedback on e-Sign Dictionary - has all the functions and features that it should have

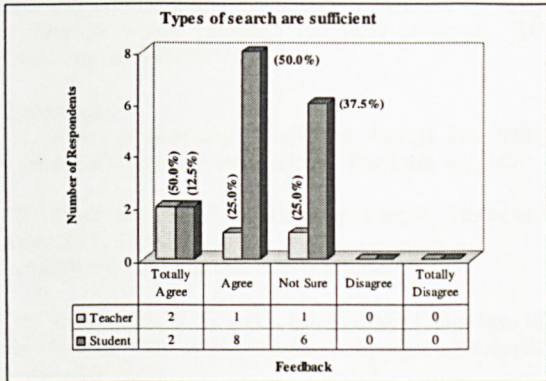


Fig 7. Evaluation on e-Sign Dictionary - types of search are sufficient

Fig 7 shows that 1 (25.0%) and 2 (50.0%) teachers, respectively, agree or totally agree that the types of search provided by e-Sign Dictionary are sufficient. There are also 8 (50.0%) and 2 (12.5%) deaf students, respectively, who provide similar feedback. However, 1 (25.0%) teacher and 6 (37.5%) deaf students are not sure if the types of search are sufficient as other types of useful search could be included as well. These include search for words that contain specific alphabets in the middle or at the end of the words. Overall, 75.5% and more than 60.0% of the teachers and students, respectively, agree or totally agree that the types of search provided by e-Sign Dictionary are sufficient. A similar survey could be conducted when the dictionary is put into practical use and feedback from a large number of users could be analysed to confirm the usefulness of the dictionary.

6. System Evaluation

Evaluation is the final phase in developing a system. It has to be conducted before delivering the system to the end users. System evaluation is more than merely comparing the outcomes with the expected outcomes. The system was evaluated based on strengths, weaknesses, application and usefulness to the deaf community and the general public who are interested to learn Malaysian Sign Language (MSL). Hence, MSL

experts and the general public were invited to give comments on these perspectives.

6.1 System strengths

e-Sign Dictionary has many useful, unique and important features and functions as its strengths. These include:

a. Trilingual system

It is a trilingual system with instructions in Malay, English and Chinese.

b. Animation

It allows the users to view the sign language of a word from different angles – from the front, left and right.

c. Rotation

The animation shown can be rotated 90° to the left or to the right. In addition, e-Sign Dictionary also has “zoom-in” and “zoom-out” features which allow the users to adjust the size of the animated objects according to their preferences.

d. Four types of models

e-Sign Dictionary allows the users a choice of their favourite animated model, i.e. a man, woman, boy or girl, to demonstrate the sign language.

e. Text-to-Speech

With Text-to-Speech features incorporated into e-Sign Dictionary, users can learn the pronunciation of the word that they are searching.

f. Information about deafness

Information about deafness and Malaysian Sign Language also can be found in the e-Sign Dictionary. This will actually help the users to know more about deafness and the Malaysian Sign Language.

6.2 System weaknesses and limitations

Some of the weaknesses and limitations identified in e-Sign Dictionary include:

a. Administration of database

To add a new word into the e-Sign Dictionary, the administrator needs to construct the sign for the word beforehand. Thus, the administrator must not only know the sign language of a word but also how to construct the sign using 3D Poser 6.0.

b. Animation models

There are four types of animation models, but none of them has the Malaysian look.

c. Text-to-Speech

The Text-to-Speech modules used in the e-Sign Dictionary are not complete. Text-to-Speech in Malay and Chinese versions can only provide a man's voice and the Text-to-Speech module is available in English version only and limited to man and woman voice.

7. Conclusion

e-Sign Dictionary is an electronic sign language dictionary that focuses on Malaysian Sign Language. It



can be a good learning tool for the deaf community as well as the general public as it covers 400 words that are commonly used daily. This system includes all the features available in a dictionary such as the meaning(s) of the word, sample of its usage in a sentence and illustration using pictures. It is hoped that e-Sign Dictionary can help to bridge the communication gap between the deaf community and the general public.

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