CHAPTER 1

INTRODUCTION

1.1 Background of Study

Learning disability is a common problem that the young generation worldwide faces nowadays. According to Wikipedia, learning disability is a classification including several areas of functioning in which a person has difficulty learning in an academic area in a typical manner. Dyslexia is one type of learning disability that is common among the young children. It is a brain type learning disability that specifically affects a person's ability to read. From studies that have been conducted by Persatuan Dyslexia Malaysia, it is estimated that 10% of school-age children experience dyslexic-type difficulties and about 4% have problems that are severe enough to be a real handicap to their learning in a traditional classroom. These statistics alone shows that dyslexia is not a minor problem and should not be ignored.

Difficulty with phonological processing or manipulation of sounds is the common characteristic of dyslexia, according to a feature online article from The Star. Due to this, dyslexics face problems with spoken language and find it difficult to express themselves clearly or fully comprehend what people are saying. Dyslexics also have trouble in spelling, writing and word pronunciation which cause them having difficulty to comprehend rapid instructions or remembering sequence of things. Children with dyslexia may become discouraged at school because of these learning problems as it affects a person's self-image. Some of them may fall into depression or even worse, get involved in vice.

Directional confusion is one of the difficulties that are associated with dyslexics. Dr. Beve Hornsby in her book Overcoming Dyslexia, says directional confusion may take a number of forms, from being uncertain of which is left and right to being unable to read a map accurately. It also affects other concepts such as up and down, top and bottom, compass directions, keeping one's place when playing games, being able to copy the gym teacher's movements when he is facing you, and so on. As many as eight out of ten severely dyslexic children have directional confusion, she says. Directional confusion is the reason for reversing of letters, whole words or numbers, or for so-called mirror writing. The following symptoms indicate directional confusion:

- The dyslexic may reverse letters like *b* and *d*, or *p* and *q*, either when reading or writing.
- He may invert letters, reading or writing *n* as *u*, *m* as *w*, *d* as *q*, *p* as *b*, *f* as *t*.
- He may read or write words like *no* for *on*, *rat* for *tar*, *won* for *now*, *saw* for *was*.
- He may read or write *17* for *71*.
- He may mirror write letters, numbers and words.

In Malaysia, about 314,000 school-going children have dyslexia as been told by Malaysia Education Ministry. According to Dyslexia Association of Malaysia (DAM) president Sariah Amirin, 80% of dyslexic children cannot read well. This is consistent with the fact that dyslexia affects a person’s reading ability. Sariah Amirin also said that there would be dyslexic children every school as statistics show that one in 20 children (5%) has dyslexia. This is to stress the need for school with special classes for dyslexic children throughout the country in which the country is lacking. Currently, there are just more than 40 of such schools. In addition, interventions for dyslexia in Malaysia are still not at a satisfied level. The reason is the lack of knowledge about the learning disability among the teachers and currently there is no dyslexia curriculum in teachers’ training courses. Therefore, effective methods for dyslexia intervention should be thoroughly researched so that it will be feasible, practical and effective enough to be included in the teachers’ training courses. This way, more dyslexic children can be helped in the future.

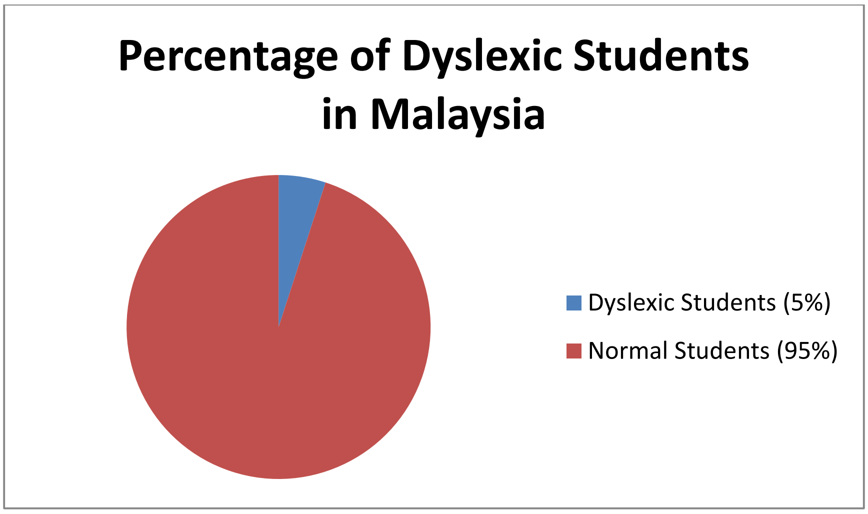

FIGURE 1.1 Percentages of Dyslexic Students in Malaysia

1.2 Problem Statement

The intervention for dyslexia in Malaysia is currently not widely and effectively implemented. Hence, there is the need for further research on developing effective methods for dyslexia intervention so that managing dyslexia for dyslexic children would be easier.

One of the effective methods for dyslexia intervention is using multisensory approach. This includes visual, auditory and kinaesthetic modalities. The multisensory approach is helpful in reading, spelling and writing aspects. However, there are not many applications that implement these modalities effectively in managing dyslexia. For example, a previous haptic interface implementation done by a research project have an issue in its kinaesthetic-tactile element. Its implemented haptic technique or method does not feel natural to then end user. When user tried to trace an alphabet, he or she may stuck at line intersections of the alphabet. This may hinders user from using the interface or application which would be frustrating to them. A haptic interface that can implement an effective haptic technique would make it easier for the end user, dyslexic children to use it. Hence, it would make learning faster and more enjoyable for the dyslexic children.

1.3 Objectives and Scope of Study

The aim for this project is to investigate and implement suitable haptic techniques for a haptic interface in order to accommodate fast and easy learning for dyslexics. Hence, this project will use the latest available technology and involves practical testing with dyslexic learners throughout the project development in order to achieve that goal. The objectives for this project are:

1. To examine various techniques to implement haptic interface
2. To integrate the techniques into a haptic interface to be used by dyslexic children in their learning
3. To test the implemented haptic interface

This project's scope covers the development of prototype for learning basic English words that dyslexics have difficulty to read and recognize them. This project also only covers the utilization of visual and kinaesthetic modalities in the haptic interface design. This project also focuses on the techniques to be implemented in haptic interfaces.

This project will utilize the theory and practical knowledge of software development, programming skills and also academic research. Hence, it is can be said that it is relevant to Information and Communication Technology (ICT) academy syllabus of Universiti Teknologi PETRONAS (UTP). This project is to be done in two academic semesters. The first semester of this project will focus on planning, academic research and design draft and conceptualization. The second semester will focus on development, testing and evaluation.

CHAPTER 2

LITERATURE REVIEW

2.1 The Advantages of Computer Assisted Learning (CAL) for Dyslexics

In developing effective literacy skills, large amounts of practice are still required for all children, regardless of whether they struggle with literacy. Children who lag behind in literacy development, as dyslexics do, gain far less practice than other children (Torgosen, Rashotte & Alexander, 2001). Consequently, it would become more difficult for them to catch up with other peers. Computers offer improved prospects of catching up as computers have the particular advantage of being able to deliver large amount of practices in a stimulating and enjoyable way.

Singleton (1991) identified five principal advantages of computer assisted learning (CAL) for dyslexic learners:

- Enhanced motivation
- Individualised instruction
- Delivery of immediate informative feedback
- Provision of an active learning environment
- Capacity to monitor the student's performance in real time.

Singleton and Simmons (2001) reported a study of the use of a popular CAL program, 'Wordshark' in 403 primary and secondary schools. Used in around 20% of UK schools, it provides traning in word recognition and developing phonic skills for reading and spelling by using a wide range of different entertaining and challenging games. The program includes different wordlists, including those drawn from the intervention programme ‘Alpha to Omega’ (Hornsby & Shear, 1974), from the original National Literacy Strategy materials, and from the ‘Letters and Sounds’ framework for teaching synthetic phonics, making the program is sufficiently flexible to be used with any of these teaching schemes. Type of speech feedback (whole-word or segmented) varies according to the particular task. Wordshark is not designed to be used to provide regular practice for the child in order to reinforce and consolidate phonic principles that are newly acquired from instruction delivered by the teacher; rather than as a stand-alone intervention. To use Wordshark program, the teacher first identifies the phonic components that the child needs to learn, and the child then picks games that provide practice on those components. Thus instruction is individualised according to the child’s needs. The child’s progress is also constantly monitored by the program so that the teacher can decide when to move the child on to new components.

The motivational aspects of Wordshark are instantly apparent. An example is the game called ‘Sharks’, in which the child uses the mouse pointer first to ‘catch’ a shark (whilst avoiding being ‘eaten’): this involves some manual dexterity. When a shark is ‘caught’ the computer pronounces a word from the current word list and the child has to type in the word. When the child gets the word correct the shark is rendered harmless (it loses its teeth).

The above example of a game in Wordshark illustrates how the program provides an active learning environment with immediate informative feedback. This is may be contrasted with the passive learning environment encountered when carrying out learning activities using conventional book-based or pen-and-paper materials. Singleton and Simmons (2001) also found that 91% of children using Wordshark show improvements in reading skills, including 27% who made significant improvement. 93% made improvements in spelling, including 36% who made significant improvement.

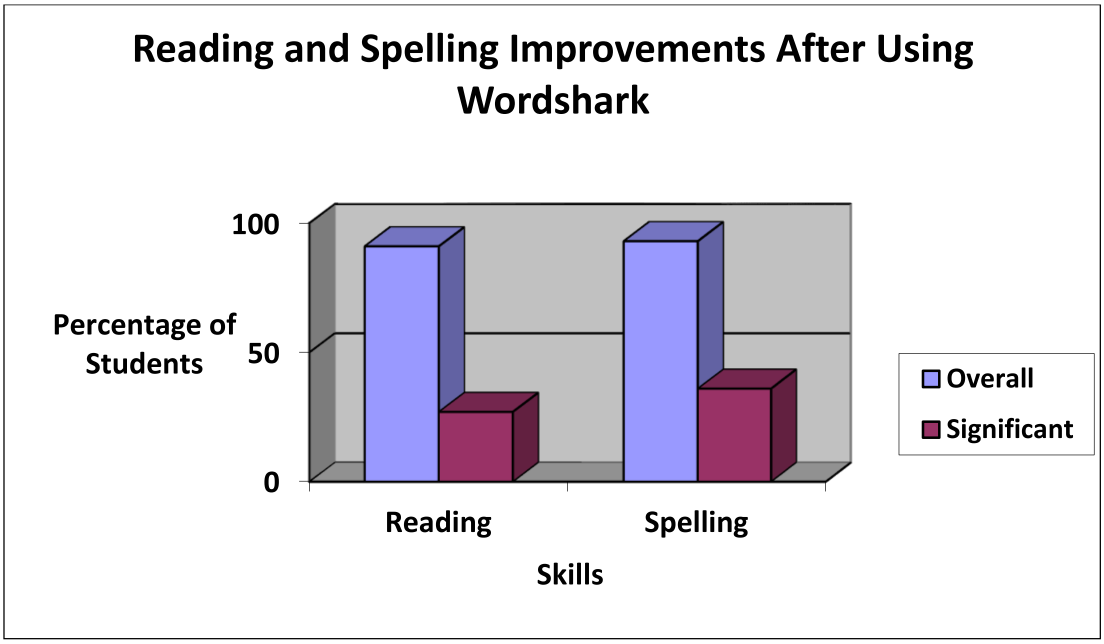

FIGURE 2.2 Reading and Spelling Improvements after Using Wordshark

2.2 Multisensory Teaching Approach for Dyslexia

Bradford, J. mentioned that a multisensory teaching method is the most effective teaching method for children with difficulties learning to read, as supported and shown by studies from the National Institutes of Child Health and Human Development. According to him, a multisensory teaching approach is referred to as teaching or helping a child to learn more than one of the senses. Most teaching in schools is done using either sight (visual) or hearing (auditory). The sense of sight of the child is used in reading information, looking at diagrams or pictures, or reading what is on the teacher's board. The sense of hearing is used in listening to what the teacher says or instructs. A child with dyslexia may experience difficulties with either or both of these senses. For example, the child's vision may be affected by problems with visual tracking, visual processing or seeing the words become fuzzy or move around. The child's auditory memory or auditory processing may be weak although the child's hearing is satisfactory.

The same article by Bradford, J. also mentioned that VAK Modalities is known to be effective multisensory methods. The three modalities of learning involved are Visual, Auditory and Kinaesthetic. The new modality or sensory introduced here is kinaesthetic, which is the tactile where a person touches and handles objects. The best teaching method is to involve the use of more of the child's sense, especially making the use of touch and movement (kinaesthetic). The addition of this modality will give the child's brain tactile and kinaesthetic memories to hang on to, as well as the visual and auditory ones.

The table below shows the difference between each of the three modalities in terms of sound/symbol association and syllables:

Content	**Visual**	**Auditory**	**Kinaesthetic-Tactile**
Sound/Symbol Association	-Look at the mouth of the teacher -Look at the letters -Discriminate the letters -Look at the card with the letter and key word or picture	-Listen (hear) the sound and identify its name with symbol -Listen/hear the sound and identify it with its symbol -Say key word & sound -Discriminate sounds	-Feel articulatory (lips/facial) muscles move -Trace shape of letter with arm of fingertip -Skywriting -Write letter on roughened surface of fingertip
Syllables	-Look at mouth of teacher -Look at word to identify number of syllables -Look at word to identify vowel sounds	-Listen (hear) syllables in spoken words -Discriminate number of syllables in spoken words -Segment words into syllables -Blend syllables into a word	-Feel movement of the articulatory muscles -Pat or tap out syllables -Build syllables with letter cards -Segment words into syllables & use syllable markers

TABLE 2.2 Difference between Visual, Auditory and Kinaesthetic Modalities

2.3 Kinaesthetic Learning

Kinaesthetic learning or tactile learning style is defined as a learning style in which learning takes place by the student carrying out a physical activity, rather than learning by listening to a lecture or watching a demonstration (Walter, Sviniki & Yuying, 2009). It is estimated that tactile-kinaesthetic learners make up about five percent of the population, according to Studying Style website.

Rita Dunn contends that kinaesthetic and tactile learning are the same style (2009). Galeet BenZion asserts that kinaesthetic and tactile learning are separate learning styles, with different characteristics (1999). She defined kinaesthetic learning as the process that results in new knowledge (or understanding) with the involvement of the learner's body movement. This movement is performed to establish new (or extending existing) knowledge. Kinaesthetic learning at its best, BenZion found, is established when the learner uses language (their own words) in order to define, explain, resolve and sort out how his or her body's movement reflects the concept explored. One example is a student using movement to find out the sum of 1/2 plus 3/4 via movement, then explaining how their motions in space reflect the mathematical process leading to the correct answer.

A study entitled “Kinesthetic Approach to Site Word Identification Experiment” was carried out by Manne, A. (1999) in which the purpose of this study was to explore the effectiveness of using a kinaesthetic approach to site word identification among kindergarteners. The aim of the study is to determine that if a group of kindergarteners are taught to recognize sight words by using kinaesthetic/multisensory activities, for ten minutes, three days a week that they will be able to read the words with more accuracy then the students who do not use a kinetic approach. The findings of the research indicated that kindergarteners who used a kinaesthetic approach to learning sight words increased their accuracy rate by 35%. The control group, who did not use a kinaesthetic approach but a more traditional, whole school approach, increased their accuracy by 23%. The experimental group had a 13% higher rate of accuracy then the control group. The findings of the research display that a kinaesthetic approach to identifying sight words may help some students improve their accuracy of identifying sight words. According to this research, some students are able to improve their identification of sight words without using a kinaesthetic approach. The results also reveal that the experimental group may have benefited by receiving the small group kinaesthetic approach combined with the traditional, whole class approach. During the whole class approach the teacher would hold up a sight word, spell it and then have the students repeat the proper spelling. All students were sitting on the rug in a circle. There was no movement or manipulative used during this time. This instruction lasted for fifteen minutes. In the results there was no significant difference among boys and girls, or the age of the children because all children who participated were five years of age.

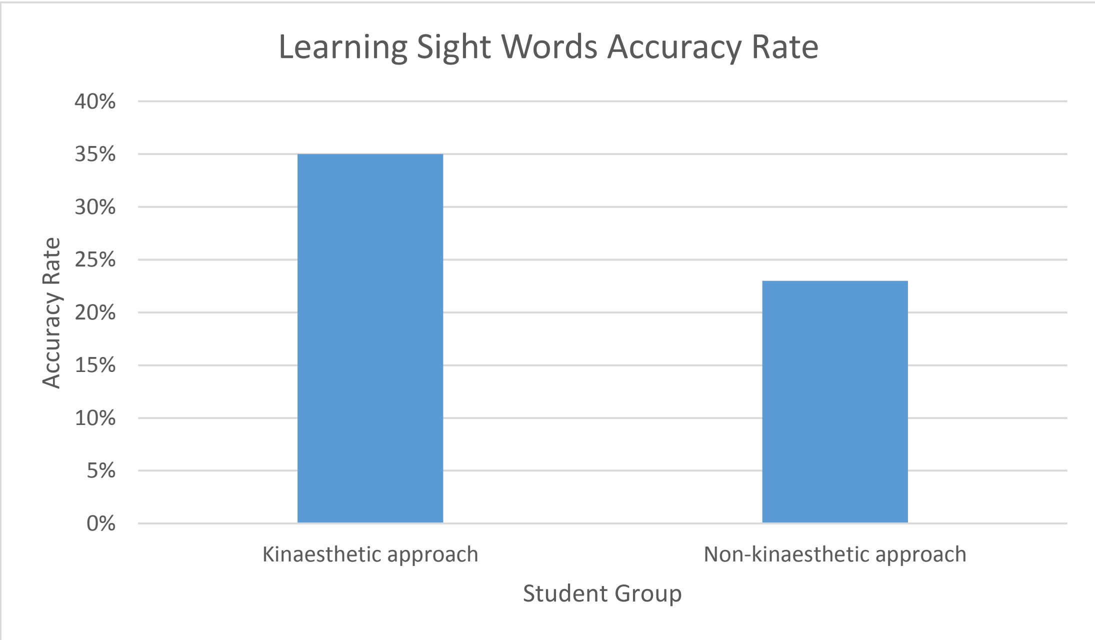

FIGURE 2.3 Learning Sight Words Accuracy Rate Comparison

2.4 Designing Haptic Interfaces

Haptics refers to the modality of touch and associated sensory feedback. Researchers working in the area are concerned with the development, testing, and refinement of tactile and force feedback devices and supporting software that permit users to sense ("feel") and manipulate three-dimensional virtual objects with respect to such features as shape, weight, surface textures, and temperature (McLaughlin, M., Hespanha, J., Sukhatme, G., 2001). In haptic interfaces, the information exchange between virtual environment, haptic device and user is bidirectional (Minogue, J., Jones, M. G., 2006). This is the basic thing that one need to know before designing haptic interfaces.

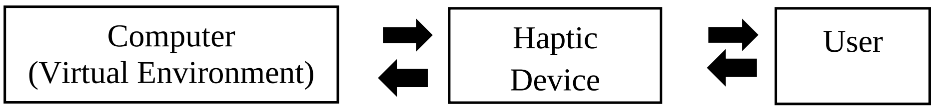

FIGURE 2.4 Bidirectional Information Exchange Unique to Haptic Interfaces

2.4.1 Haptic Interface Design for Visually Impaired Users

There are several rules of thumbs when designing point interaction haptics for visually impaired users:

i. Navigation

Well defined and easy-to-find reference points in the environment should be provided as they are necessary to facilitate navigation. Natural reference points are for example the corners of a room. Good reference points are easy to find and come back, and they should also be easy to identify. Besides, the reference system should not be changed unnecessarily. A disabled haptic button should not be removed, but rather "greyed out" for example by giving it a different texture and making it impossible to click. This way the button can still be used as a reference point even though it is non-functional (Sjöström, C., 1997).

ii. Finding objects and getting an "overview"

With pure one-point haptics it is easy to miss an object even if one is really close to it. It is important to compensate for this when designing haptic software by using an enlarged interaction point, magnetic objects, or different surface characteristics, for example. Moreover, it can be just as difficult to determine that an object does not exist, as it is to find an object. It is always easier to move along some kind of path (a ridge, a groove, a magnetic line, etc.) to the place where the object is located or where there is no object. In both of the cases mentioned earlier one can also choose to give the user a "virtual search tool" instead of changing the virtual objects. A virtual search tool could be for example a bar, or a magnet (Sjöström, C., 1997, 1999).

iii. Understanding objects

It may be beneficial (and sometimes essential) to help the user follow the outline of the object even if it is not absolutely necessary for the haptics to feel like something real. It is easy to make a thin touchable hose easier to find by giving it the appropriate attractive force. It is almost impossible to feel the hose in 3D without such a force (Fritz, J. P., Barner, K. E.). In addition, sharp edges and corners are much more difficult to feel and understand than rounded shapes when they are felt from the "outside". The user almost always loses contact with the object when moving past a sharp corner, thereby disturbing the cognitive process that translates the impressions received into an inner picture. Moreover, it is difficult to determine the size of the angle; many users believe that the angle is more acute than it really is (Sjöström, C., 1997). To even out the edges, or at least use normal interpolation is necessary to minimize the problem of sharp edges.

iv. Haptic widgets

The finger often accelerates a great deal when going through a thin wall or past an edge. Consequently, the next wall or edge should not be very close since there is a risk that the finger will go through that wall as well (sometimes without the user noticing). In this case it can sometimes help to replace the thin walls (between the areas) with a magnetic line that pulls the user to the centre of the area instead. The problem becomes apparent when one wishes to represent menus and coordinate systems (Miller, T., Zeleznik, R, 1998).

v. The physical interaction

Thee manipulandum design is a thing one should be careful of. The manipulandum is the tool that the user grasps in his hand. In the PHANToM the manipulandum is a stylus or a thimble. In other cases it might be a mouse-body, a joystick handle or some specialized tool. The choice of manipulandum can affect the haptic sensation a great deal. This is due to the fact that the form and surface of the manipulandum have an effect on how the resistive force is applied to the user, the kind of movements used, and the feeling of being in contact with the virtual object. For example, a thimble with sandpaper on the inside causes many people to use less force when grabbing a virtual object because they get the sensation that the objects are less slippery (von der Heyde, M., 1998).

2.4.2 Techniques Used in Implementing Haptic Effects

A study by Wai Yu, Ramesh Ramloll and Stephen Brewster (2001) discusses the techniques that can be used to render haptic graphs for visually impaired users.The line modelling technique using cylinder objects, which are simply jointed together, does not give users a smooth sensation at the joints. This problem can be contributed by the single point contact given by PHANToM haptic device as the user's pointer cannot stay on the surface of the cylindrical objects easily. It clearly shows that traditional emboss technique used to present text and diagrams to blind people is not suitable for force feedback devices. Instead, an engraving technique is proposed here to present line graphs on the haptic interface. Curved lines can be represented by a groove on a flat surface so that users can easily locate and follow the track of the groove (Figure 2.4.2). Techniques of modelling and joining this kind of groove segments by polygons have been developed. Initial testing showed this technique is effective and can solve the problems stated above.

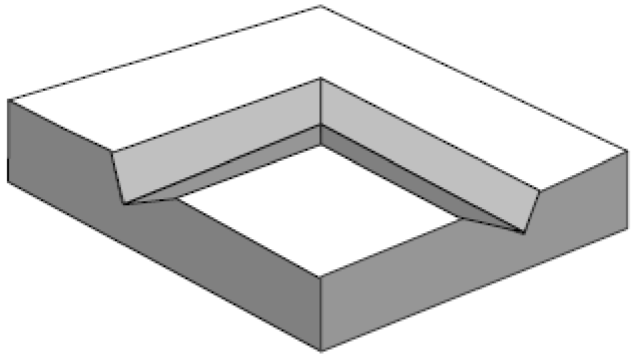

FIGURE 2.4.2 Engraved Line on a Flat Surface

The problem with intersections between multiple lines is that users get confused when they reach the crossover points. They may lose their sense of direction at the junction where two lines intersect. There are various ways to solve this problem. All the lines on the graph can be displayed selectively, therefore when the user's pointer is moving in a groove, the other lines can be automatically hidden from the user so that smooth transitions can be provided. Alternatively, different textures can be applied on the surfaces of the grooves so that users can tell which groove they are supposed to follow by distinguishing the different sensation. In addition, sound hints can be produced by giving an auditory feedback when users switch between grooves.

There are many different parts on a graph so that various surface textures can be applied in order to tell them apart. Since preliminary results have shown that users can distinguish different frictions applied on the lines, mixtures of friction and texture can be used as a distinctive feature of an object. Using surface texture not only can solve the confusion of multiple lines but also gives an indication of different parts of the graph so that users will know where they are on the graph.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

The basic methodology to be used for completing project is Rapid Application Development (RAD) method. This software development methodology uses minimal planning in favour of rapid prototyping. This methodology is chosen for this project because of the limited time constrain of this project which is less than 6 months. This methodology allows software to be written much faster as it lacks extensive pre-planning.

This methodology is also chosen due to the nature of this project that has short period of development phase that requires rapid programming. During the development process, testing also need to be done simultaneously and this methodology allows just that. It also allows any changes to be made during the development phase if there is sudden requirements change. Hence, it provides the flexibility that other methodologies cannot offer.

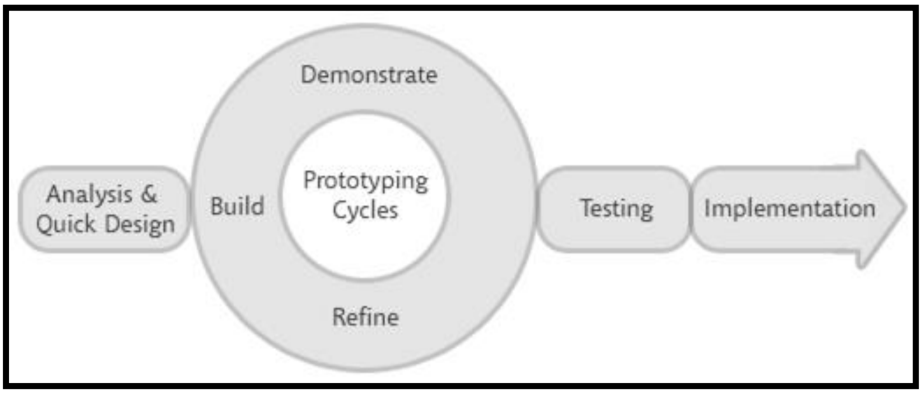

FIGURE 3.1 Rapid Application Development Cycle

In the analysis and quick design phase, research and analysis needed to be done in order to give the idea on how to make the prototype. Based on the analysis, a quick design will be drafted to give a rough idea on how the prototype will look like. This phase is essential for the next phase, prototyping.

The prototyping phase consists of three sub-phase, build, demonstrate and refine. First, the prototype first draft will be built. Then, the draft will be demonstrated to check the functionality of the draft. The draft will be refined if there is something essential to the prototype is missing or not properly built. This cycle will continue until the prototype is ready to be tested (final draft).

In the testing phase, the prototype will be tested on the actual users as well as by the programmers for early evaluation of its effectiveness and whether it meets the user requirements. This phase is critical as only prototype that passes the testing can proceed with the next phase, implementation.

The implementation phase is the last phase as the prototype will be implemented or deployed to the mass users in the actual environment. The deployed prototype will be evaluated further as a review for future researches.

3.2 Project Activities

Activities involved in this project can be divided into several phases, which follow RAD cycle:

A. Analysis & Quick Design

1. Identify the problem among dyslexics to get better understanding on the problem to be solved in the project.
2. Study on conventional methods for dyslexia intervention; emphasis is given on the way dyslexics read and write, and alphabets that are confusing to them.
3. Study on previous design and implementation of haptic interface.

4. Research on various techniques of haptic effects; this include engraved, embossed and “sticky-heavy”.
5. Design and plan prototype based on research done.

B. Prototyping Cycles

i. *Build*

1. Design 3D models in Blender software.
2. Import 3D models into haptic interface and apply haptic effects on them.
3. Fix camera angles in the haptic interface for easy viewing.
4. Create user interface to simplify the access to the techniques implemented.

ii. *Demonstrate*

1. Run tests to examine functionality of prototype.

iii. *Refine*

1. Troubleshoot the application codes for each errors that exist.
2. Refine the 3D models design and haptic effects.

C. Testing & Implementation

1. Do preliminary testing
2. Do extensive testing to the end users
3. Analyzes the results from the testing for project review and future research

3.3 Key Milestones & Gantt Chart

Below is the key milestones for this project, presented in a Gantt chart form which spans for about 28 weeks:

FINAL YEAR PROJECT I															
No	**Task \ Week**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Analysis & Quick Design															
1	Initial studies on previous haptic interface implementation														
2	Literature review														

	- Computer assisted learning - Dyslexia intervention methods - Kinaesthetic learning - Haptic interface design														
3	Research on various techniques of haptics effects														
4	Initial prototype planning and designing														
FINAL YEAR PROJECT II															
No	**Task \ Week**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Prototyping Cycles															
Build															
5	Design 3D models in Blender - Engraved - Emboss														
6	Import 3D models into haptic interface														
7	Apply haptic effects to 3D models														
8	Optimize camera angle														
Demonstrate															

9	Run simple tests to examine basic functions and design feasibilities														
Refine															
10	Troubleshoot errors encountered														
11	Optimize prototype design														
Testing															
12	Preliminary testing on prototype function and effectiveness														
13	Complete testing on all prototype features to the end users														
Implementation															
14	Finalize the prototype to deploy to users														
15	Further analysis on prototype for future works recommendations														

TABLE 3.3 Gantt Chart

3.4 Tools

Tools required:

A. Hardware:

   1. SensAble PHANTOM haptics device

B. Software:

   1. OpenHaptics Toolkits
   2. Blender 3D modelling software
   3. C++ and Visual Basic programming
   4. Microsoft Visual Studio 2005

FIGURE 3.4 Sensable PHANTOM Haptics Device

There are several tools required to develop this project. The first one is Sensable PHANTOM haptics device. It is a device that makes it possible for users to touch and manipulate virtual objects. It provides precision positioning input and high fidelity force-feedback output.

The next tool is OpenHaptics Toolkits which enables application development for PHANTOM haptic devices. This haptics toolkit is patterned after the OpenGL API and C++, making it familiar to graphics programmers and facilitating integration with OpenGL applications. OpenHaptics Toolkits will be the foundation writing the coding for developing the prototype.

Blender is a free and open-source 3D computer graphics software product used for creating animated films, visual effects, interactive 3D applications or video games. This software is going to be used to model 3D objects to implement techniques of haptic effects.

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop console and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both native code together with managed code for all platforms supported by Microsoft Windows. This software is used to write and compile the prototype coding as well as designing user interface.

CHAPTER 4

RESULTS AND DISCUSSION

Based on the researches done in the literature review, it can be implied that computer assisted learning (CAL) and visual, auditory and kinaesthetic (VAK) modalities are a good combination to be implemented in dyslexia interventions. Previous studies as mentioned in the literature review has proved the effectiveness of both methods in helping children with learning disabilities like dyslexia. Besides, kinaesthetic learning has been proven to be very helpful in learning especially to those who having difficulty in other sensory like visual and auditory, i.e. dyslexics. There are several criteria required for a good haptic interface design as discussed in the literature. Thus, the design of the haptic interface prototype that is developed for this project will be based on those characteristics. This project specifically develop two haptic interface using three different technique: engraved, embossed and “sticky-heavy”. Two words are also chosen: bed and chess, as they consists of alphabets that dyslexics can easily get confused.

4.1 Prototype Development

In developing the prototype, there are three stages involved. The first stage is modelling both engraved and emboss 3D model using Blender application. The second stage is importing those 3D models in the haptic interface and then applying haptic effects to them. The third stage is developing graphical user interface for easy and centralized access to all of the techniques implemented.

4.1.1 Blender 3D Modelling

The latest version of Blender application (2.64) creates 3D object from the top view of the application. For example, when creating new text type object, the text can only be read from the top view. It is important to know about this when importing object rendered from Blender so that developers can adjust the camera angle to properly view the imported object in their applications. For the prototype, four objects will be rendered, two for engraved technique and another two for emboss technique. Each of the two objects of respective technique are basically a cube object and a text object. Please note that any parameter values that are not mentioned in the below explanation are left to their default values set by Blender. All of the 3D models created will exported as Waveform(.obj) format. Currently this is the only format that OpenHaptics toolkit support without any errors. However, Waveform format only support one material colour per 3D object. This explains why two objects are needed for each technique. Each of the two objects has contrasting colours to distinguish between each other and to make the text more readable.

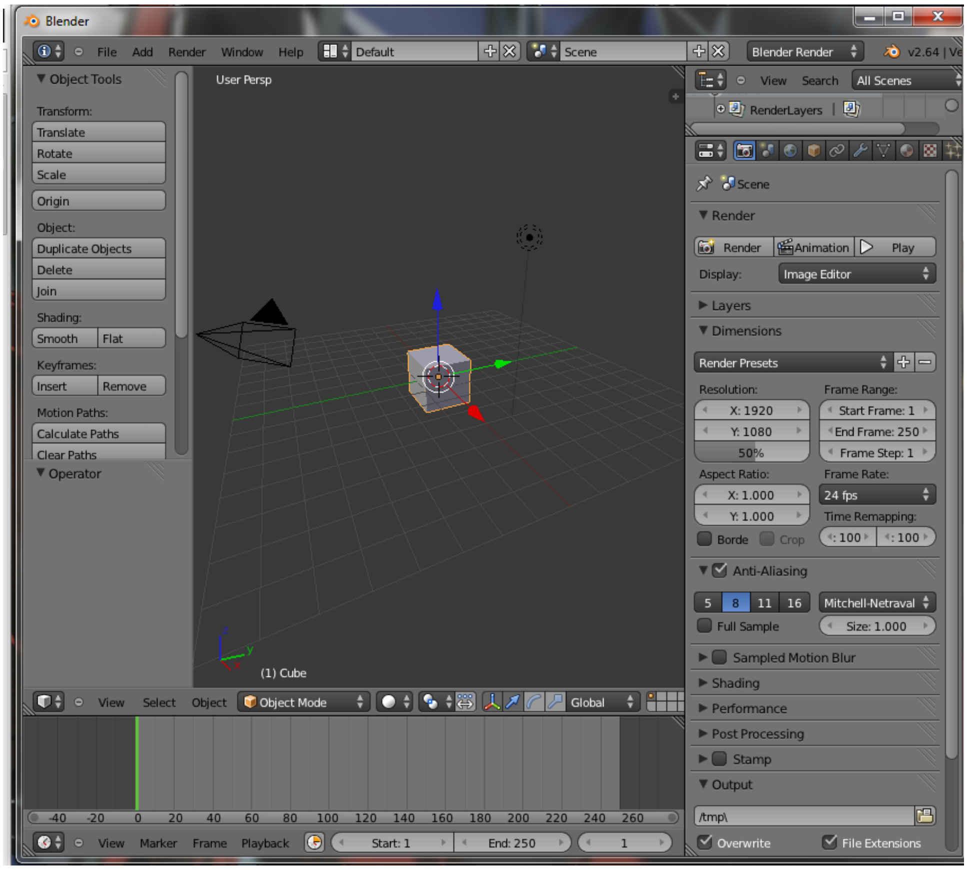

FIGURE 4.1.1 Blender 3D Modelling Software

4.1.1.1 Engraved Technique

Modelling engraved technique requires two object intersects with each other. Using displacement method, a text object can be engraved to a cube object. After removing the text object, the engraved effect can be seen on the cube object as the text object displaces the intersected portion of the cube object according to the text shape.

First, a simple cuboid is created with the following transform scale, X: 2.0, Y: 1.0 and Z: 0.3. Then, a text object is created with the caption “bed”. The text object has the following font parameter, size: 2.0, and geometry modification parameters, extrude: 0.05, offset: -0.035.

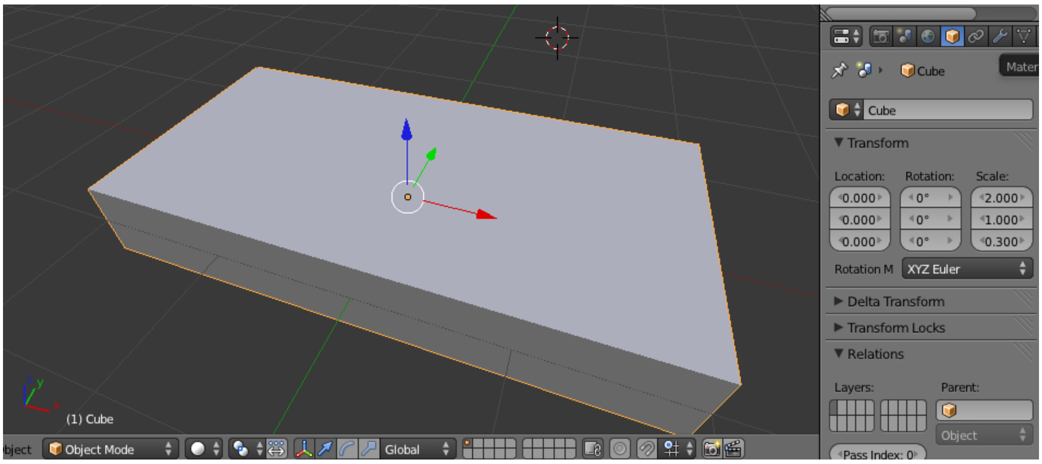

FIGURE 4.1.1.1.1 A Simple Cuboid in Blender

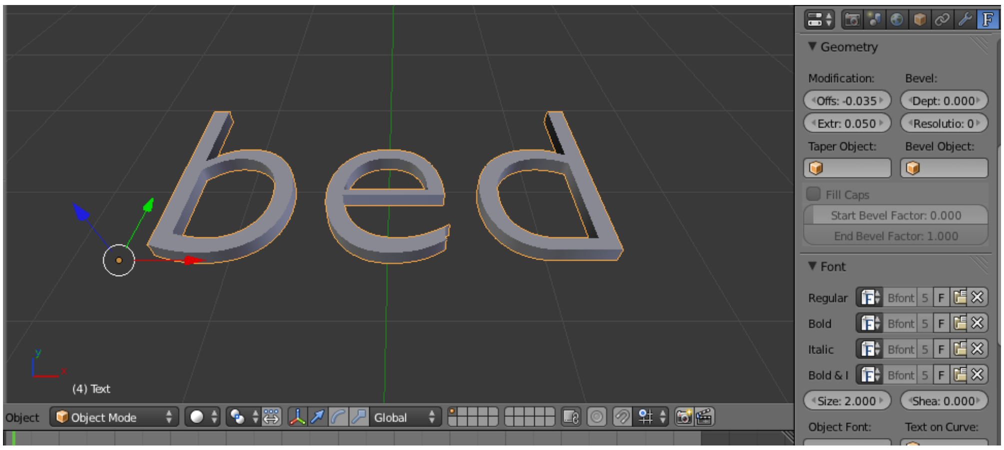

FIGURE 4.1.1.1.2 A Simple Text in Blender

Next, the text object is moved to intersect with the cuboid object with the following transform location parameters, X: -1.5, Y: -0.6, Z: 0.26. Note that some of the text object portion is vertically 'submerged' into the cuboid object.

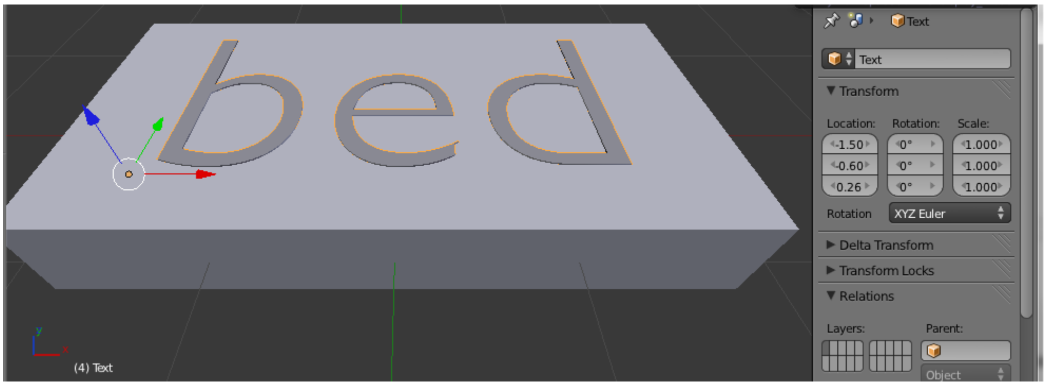

FIGURE 4.1.1.1.3 Merger of Text Object and Cuboid Object

The next step is to apply engraved effect onto the cuboid object. First, the text object must be converted to a mesh type by pressing "Alt+C" and select the option "Mesh from Curve/Meta/Surf/Text". Next, select the cuboid object. Then in the object modifiers menu, add a Boolean modifier with 'difference' operation is set and the object is set to the mesh text object. After that, delete the mesh text object and the cuboid object can be seen with a text has been engraved to it. Now, that object can be exported as a Wavefront (.obj) file.

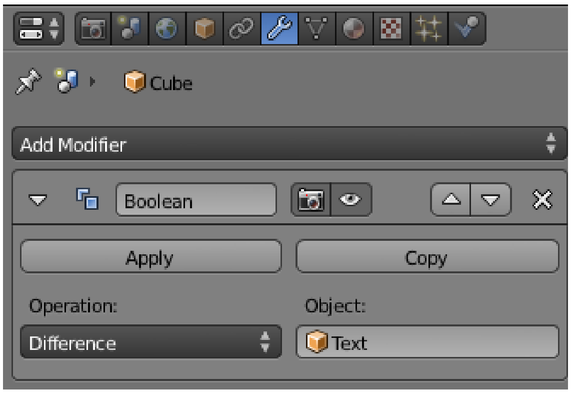

FIGURE 4.1.1.1.4 Applying Engraved Effect

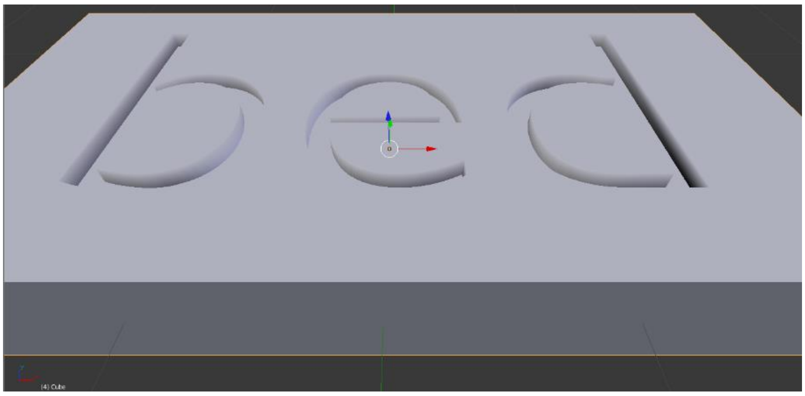

FIGURE 4.1.1.1.5 Cuboid Object with Engraved Effect

The last step is to make the engraved text readable. A new text object is created with the same parameters as the previous text object except the geometry modification parameter, extrude: 0.0. After that, convert it to a mesh type. Now, set a contrast material colour to the text object, i.e. blue. Set its transform location parameter to be the same as previous text object parameter. These two objects now represents how the final product will look in the haptic interface. Lastly, delete the engraved object. The object can now be exported as a Wavefront (.obj) file.

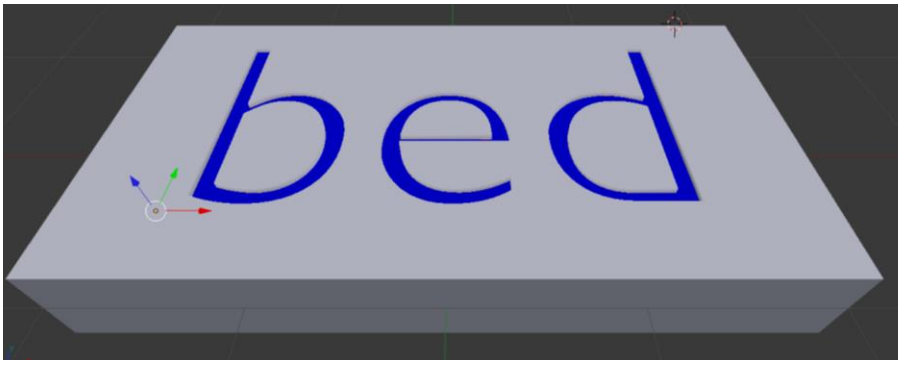

FIGURE 4.1.1.1.6 – Engraved Cuboid Object with Readable Text

4.1.1.2 Embossed Technique

Modelling embossed technique is easier than engraved technique. It just requires two objects to be combined together. However, the text created must be modelled so that it does not feel too slippery when haptic effect is applied. Therefore, the text modelled has bevels on its edges.

First, a cuboid cuboid with the same parameter values as in the engraved technique is created. Change the material colour of cuboid, i.e. blue. This is to distinguish between engraved and emboss technique as the final rendered will look similar between them. Export the cuboid object as a Waveform (.obj) file.

Then a new text object is created with the caption “bed” and has the following font parameter, size: 2.0, geometry modification parameters, extrude: 0.01, offset: -0.04, and geometry bevel parameters, depth: 0.04, resolution: 10. Next, move the text object on top of the cuboid object using the following transform location parameters, X: -1.5, Y: -0.6, Z: 0.325. Lastly, delete the cuboid object and convert the text object to a mesh type. Export the mesh text as a Waveform (.obj) file.

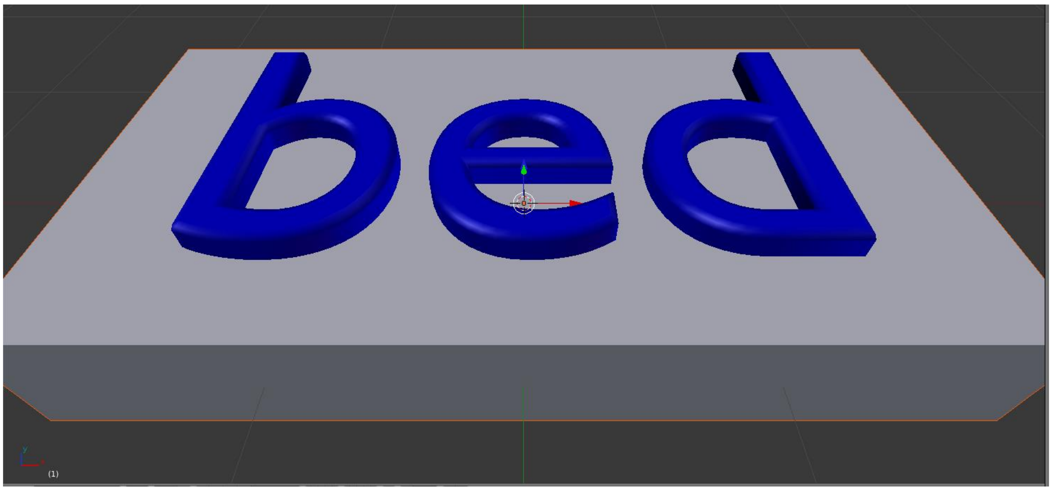

FIGURE 4.1.1.2 Object with Embossed Effect

4.1.1.3 “Sticky-heavy” Technique

“Sticky-heavy” technique is the easiest to model in Blender among the three techniques. This technique is almost solely dependent on haptic effects. This is because the effect produced from this technique is achieved by applying different friction forces to the text object and cuboid object. This results in the user to feel the alphabets to be “sticky” and “heavy” when tracing them. So, it only requires the placement of a simple text object on top of a cuboid object. The same steps as the embossed technique are used to model for this technique with the exception of geometry modification parameters, extrude is set to default value and transform location parameters is set to X: -1.5, Y: -0.6, Z: 0.31.

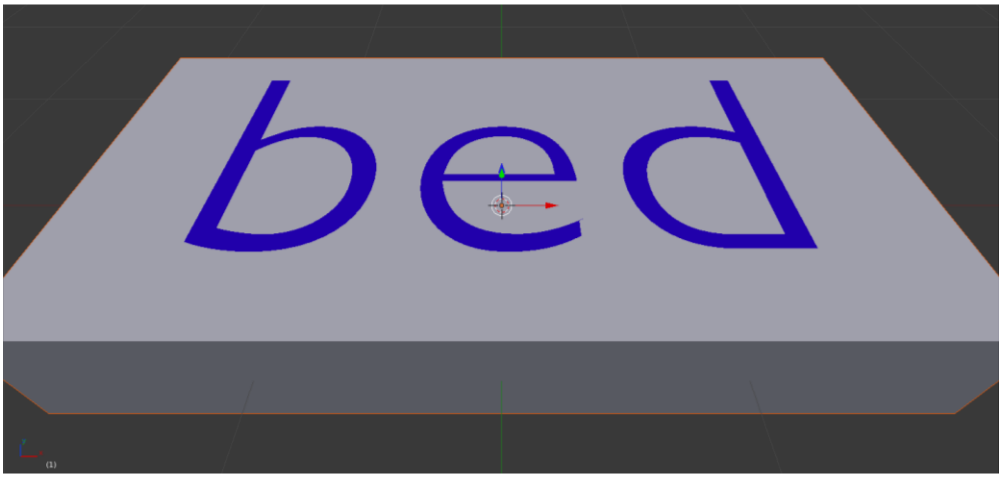

FIGURE 4.1.1.3 Object for “Sticky-Heavy” Effect

4.1.2 Haptic Interface

4.1.2.1 QuickHaptics Micro API

The haptic interface is developed using OpenHaptics Toolkit which is provided with PHANTOM Haptic Device. The device can be programmed using QuickHaptics micro API, HLAPI and HADPI. For this project prototype, QuickHaptics micro API is used to write the application.

The QuickHaptics micro API is implemented in C++ and defines four primary functional classes:

• DeviceSpace—Workspace through which the haptic device can move

• QHRenderer—base class for QHWin32 and QHGLUT. On-screen window that renders shapes from a camera viewpoint and lets the user feel those shapes with a haptic device

• Shape—Base class for one or more geometric objects that can be rendered both graphically and haptically

• Cursor—Graphical representation of the end point of the second link on the PHANTOM device. This end point is sometimes called the haptic interface point (HIP).

FIGURE 4.1.2.1.1 How to use PHANTOM Haptic Device

A typical QuickHaptics micro API program has the following structure:

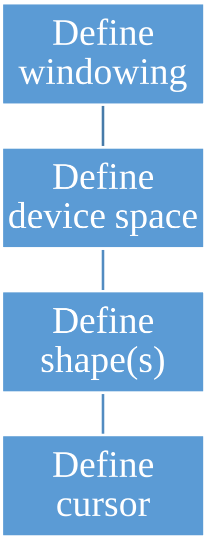

FIGURE 4.1.2.1.2. QuickHaptics Micro API Program Flow

4.1.2.2 QuickHaptics Micro API Programming

The entire coding for the prototype is done in Microsoft Visual Studio 2005. Below is the step-by-step guide to write the haptic interface that use engraved technique. Similar steps are used for embossed and “sticky-heavy” effect technique.

1) Initial declarations is defined in order to start programming with QuickHaptics Micro API. The first line is to include the necessary header file. The second line is the framework for the program main body. The following is the snippet for the initial declarations:

```
#include <QHHeadersGLUT.h>
void main (int argc, char *argv[]) { }
```

The following steps below are written in the program main body.

2) Create a display window:

```
QHGLUT* DisplayObject = new QHGLUT(argc,argv);
```

3) Initialize the PHANTOM device:

```
DeviceSpace* Omni = new DeviceSpace
DisplayObject->tell(Omni);
```

4) Import the first pre-built 3D model from Blender:

```
Trimesh* letter = new Trimesh("models/engraved1.obj");
```

5) Apply haptic effect to the imported 3D model. The first line is to set how ‘hard’ the object is when the cursor touch it. The second line is to set the ‘smoothness’ of the 3D model when cursor is dragged along its surface. The fourth line is set the 3D model to be static and its position cannot be changed by the user.

```
letter->setStifness(1.0);
letter->setFriction(0.7,0.5);
letter->setUnDraggable();
DisplayObject->tell(letter);
```

6) Repeat step 4 and 5 for the cuboid 3D model

```
Trimesh* plane = new Trimesh("models/engraved2.obj");
plane->setStifness(1.0);
plane->setFriction(0.7,0.5);
plane->setUnDraggable();
DisplayObject->tell(plane);
```

7) Create a cursor:

```
Cursor* OmniCursor = new Cursor;
DisplayObject->tell(OmniCursor);
```

8) Change camera view from front to the top:

```
float FOV1, FOV3;
float NearPlane1, NearPlane3;
float FarPlane1, FarPlane3;
hduVector3Dd Eye1, Eye3;
hduVector3Dd LookAt1, LookAt2, LookAt3;
hduVector3Dd UpVector1, UpVector3;

DisplayObject->setDefaultCamera();

DisplayObject->getCamera(&FOV1,&NearPlane1,&FarPlane1,&Eye1,&LookAt1,&UpVector1);
```

```
FOV3 = FOV1;
NearPlane3 = NearPlane1;
FarPlane3 = FarPlane1;
Eye3 = Eye1;
LookAt3 = LookAt2 = LookAt1;
UpVector3 = UpVector1;

Eye3.set(LookAt2[0],Eye1[2],LookAt2[2]);

DisplayObject->setCamera(FOV3, NearPlane3, FarPlane3, Eye3, LookAt3,
UpVector3);
```

9) Set everything in motion:

```
qhStart();
```

10) Compile and run the program.

However, for the "sticky-heavy" effect technique, step 5 is different. The friction value for the text 3D model is different in order to realize "sticky-heavy" effect. The higher for the dynamic friction make users to feel the surface of the model to be "sticky" and "heavy". The value for friction is as follow:

```
letter->setFriction(0.5,0.99);
```

4.1.2.3 Haptic Interface Sample Run

It should be noted that for each techniques implemented, all of the haptic interface appearance would be the same. Users cannot distinguish which technique is implemented in the each of haptic interface by just looking at it. Users can only differentiate them when they touch the objects using PHANTOM haptic device.

FIGURE 4.1.2.3.1 Haptic Interface for the Word "bed"

The figure above shows the haptic interface for the word "bed". The word bed is chosen as the alphabet it consists of can make dyslexics to be confused. The letter 'b' can be confused with letter 'd', 'p' or 'q', meanwhile the letter 'e' can be confused with the letter 'c'.

FIGURE 4.1.2.3.2 Haptic Interface for the Word “chess”

The figure above shows the haptic interface for the word “chess”. The letter “c’ can be confused with the letter ‘e’, the letter ‘h’ can be confused with the letter ‘n’, and the letter ‘s’ can be confused with the number ‘8’.

4.1.3 User Interface

A simple user interface is developed to ease the access to each of the techniques implemented. It is coded in Visual Basic (VB) programming language with Visual Studio 2005 software. The user interface is designed to be as simple as possible so that it is user friendly and will not get in the way of the user to access haptic interface.

The first window is a welcome screen to greet user to the program. Colourful picture is used for aesthetic value as well as to attract the users. A “START” button is there to help user to navigate to the next window.

FIGURE 4.1.3.1 User Interface First Window

Below is the code snippet for the first window (Form1):

```
Public Class Form1

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        Me.Visible = False
        Form2.Visible = True
    End Sub

End Class
```

FIGURE 4.1.3.2 Form1 Code Snippet

The second window give users the option to choose between two words for them to write in the haptic interface. Related image is put to give users the general idea what they are going to write.

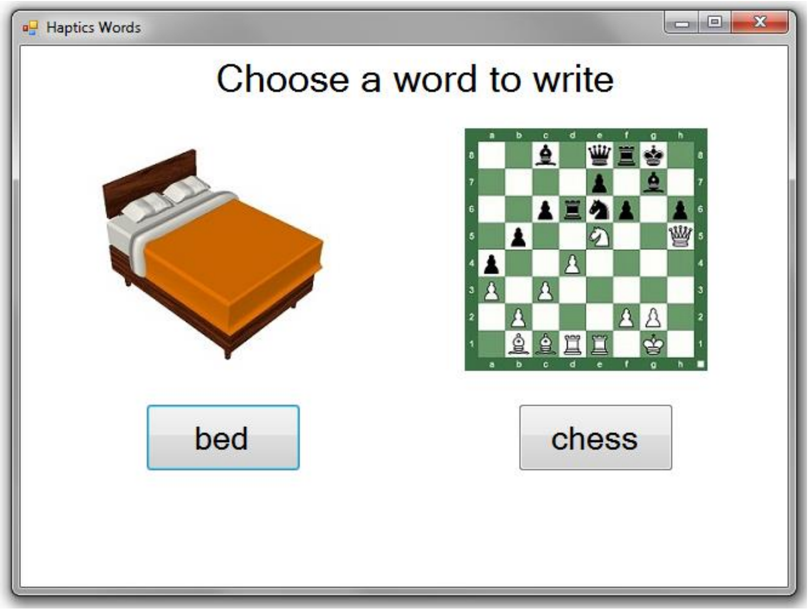

FIGURE 4.1.3.3 User Interface Second Window

Below is the code snippet for the second window (Form2):

```
Public Class Form2

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        Me.Visible = False
        Form3.Visible = True
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button3.Click
        Me.Visible = False
        Form4.Visible = True
    End Sub
End Class
```

FIGURE 4.1.3.2 Form2 Code Snippet

The third windows appears when users click the button “bed” in the second window. In this windows, users are given the choice to choose a technique for them to write the word “bed”. A click on each button will directly start haptic interface application for the respective techniques. A “Back” button is also there for user to go back to the second window for them to choose another word.

FIGURE 4.1.3.3 User Interface Third Window

Below is the code snippet for the third window (Form3):

```
Public Class Form3

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button4.Click
        Me.Visible = False
        Form2.Visible = True
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\bed\engraved\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\bed\engraved\pickApplesGLUT.exe")
        End If
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button2.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\bed\emboss\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\bed\emboss\pickApplesGLUT.exe")
        End If
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button3.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\bed\friction\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\bed\friction\pickApplesGLUT.exe")
        End If
    End Sub
End Class
```

FIGURE 4.1.3.3 Form3 Code Snippet

The fourth window appears when user click "chess" button in the second window. It is basically the same with the third window. The only difference is this window will start haptic interface application for the word "chess" for each technique.

Below is the code snippet for the fourth window (Form4):

```
Public Class Form4

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button4.Click
        Me.Visible = False
        Form2.Visible = True
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\chess\engraved\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\chess\engraved\pickApplesGLUT.exe")
        End If
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button2.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\chess\emboss\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\chess\emboss\pickApplesGLUT.exe")
        End If
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button3.Click
        Dim Res
        Dim Filename
        Filename = "C:\FYP12684\chess\friction\pickApplesGLUT.exe"
        If Dir(Filename) = "" Then
            MsgBox(Filename & " not found. Please specify the path correctly.", vbInformation)
        Else
            Res = Process.Start("C:\FYP12684\chess\friction\pickApplesGLUT.exe")
        End If
    End Sub
End Class
```

FIGURE 4.1.3.4 Form4 Code Snippet

4.2 User Testing

A preliminary user testing has been done upon completion of the of the prototype. The testing is done on one dyslexic adults and four normal adults. Due to time constrain and late approval from Ministry of Education and school, complete testing on the real user, dyslexic children cannot be completed throughout the project.

For each technique, users are requires to give usability score on a scale 0 to 10. Their feedback is also recorded and will be discussed in the next paragraphs. Below is the table of usability score given by five testing participants:

Technique	**Usability Score (/10)**				
Candidate	**1**	**2**	**3**	**4**	***5***
Engraved	7	8	7	6	*7*
Embossed	2	4	3	1	*2*
“Sticky-heavy”	5	6	6	4	*5*

TABLE 4.2 Usability Score

For the haptic interface with the engraved technique, users can easily trace the shape of each letters without much problem. The user will be ‘forced’ to be able to trace the specific letter shape only. According to a tester with no dyslexia, the interaction of his hands with the virtual object feels very similar to the real world object and admit that this can be beneficial to dyslexics. Another non-dyslexic user said that, “Wow, this is very interesting, it’s almost like the real one!” A dyslexic tester said she can correctly trace the letters without much effort. She also said that the prototype is much easier to use compared to other implementations which she had used before. “I think this one (the prototype) feels very similar to the real world engraved blocks”

As for the haptic interface with emboss technique, the user needs to rely more on his or her vision as that technique requires users to be more careful in tracing the letters shape. Failing to do so will result in the cursor ‘slips’ away from the original letter shape. As dyslexics cannot really rely on his or her vision, this technique seems to be less effective. The same dyslexic user who test the engraved technique earlier said, “I don’t really like this one, it feels very slippery”. She failed several times to correctly trace the shape. She also commented that it is not really good idea to use the emboss technique. A non-dyslexic user said that he already predicted this technique implementation would be more difficult than the engraved technique. And this proved to be true when he tried it.

For the haptic interface with "sticky-heavy" effect technique, users can feel the shape of the letters but cannot enforce the shape when user tracing the letter. So the user can still have the cursor to be 'slip' away from the original letter shape like the embossed technique. The same dyslexic user said, "I like how it feels but it still 'slippery' like the last one (embossed technique)". Other non-dyslexic users also have similar opinion like her.

Summary of testing results for each technique:

1. Engraved
    - Can 'feel' the letter shape
    - Able to guide user to trace letter shape
2. Embossed
    - Can slightly 'feel' the letter shape
    - Cannot guide user to trace letter shape properly
3. "Sticky-heavy"
    - Cannot easily 'feel' the letter shape
    - Can just slightly guide user to trace the letter shape

From this preliminary test, it is suggested that engraved technique seems to be the best choice for users to write in the haptic interface. It feels more 'natural' to the hand when using it compared to the emboss technique and "sticky-heavy" effect technique. Hence, engraved technique seems to be the more suitable choice if it is to be implemented in helping dyslexic children.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the study findings, it is suggested that engraved technique seems to be the more suitable choice in implementing and rendering haptic alphabets in a haptic interface for supporting dyslexic children learning. This technique appears to be good in 'enforcing' the shape of the alphabets so that the users can only write and trace the actual shape of the alphabets. However, a proper and rigorous testing needs to be done on dyslexic children to further support and verify the study findings.

It is hoped that this project will be beneficial and helpful to dyslexic children, especially in Malaysia. The use of technology along with conventional methods will catalyse the development of effective and efficient dyslexia interventions. Dyslexia interventions in the near future would become easier and more effective with the existence of this kind of project and its similar projects.

5.2 Recommendations

The suggestion and recommendation for future progress would be to continue improving in the implementation of the techniques. There must be some weakness in the current prototype even if it not yet discovered. Hence, this project should not be just stop at here.

Moreover, exploring more techniques in applying haptic effects is also feasible as this project only explore three techniques. There can be another ways that more effective than them in the future, if not now. Besides, this will allow efforts in improving the society and humanity can be continued. So any future projects that improve upon this project most welcome.

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APPENDICES