Designing a Haptic Tool to Help Visually-Impaired Musicians and Music Learners Learn/Read Musical Notes

By

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DISSERTATION

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Bandar Seri Iskandar

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Perak Darul Ridzuan

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CERTIFICATION OF APPROVAL

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Approved by,

(Dr. Suziah Sulaiman)

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DECEMBER 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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NURUL IZZATI BINTI OMAR

Abstract

With an historical point of view and with the bibliographic overview, the article discusses on the idea on developing a haptic tool to help the blind and visually-impaired users to learn musical notes from flat screen in example the computer screen. The current approach being used by the blind and visually-impaired musicians to learn the musical notes is by using Braille-transcribed musical scores or listening by ear. Since there is a number of problems that arose from the techniques, therefore we came out with a prototype which helps the blind and visually-impaired musicians and music learners to read and learn the musical notes without the need to depend solely on the Braille-transcribed musical scores, by transcribing the musical scores into a mechanically haptic tactile force feedback which can be sensed with the user touch sensation and with the use of SensAble Omni haptic device.

With the haptic device, musical notes on flat screens may be reinterpreted and presented mechanically to the user's haptic senses (kinaesthetic and tactile), where ideally, they can feel how the notes "looks", provided that users have a basic understanding on the types of notes and the beats that associates to the notes. In developing the prototype of this project, we described the hardware and supporting softwares which together reinterprets the conventional flat screen musical notes into haptic, touch-sensable notes that will differ in many senses as compared to the conventional flat screen musical notes.

The prototype has been developed based on critical requirements gathered and is implemented by using the incremental and iterative, prototyping based development cycle which are further refined through extensive researches and data gathering processes. Based from the researches and interview which has been done with the blind and visually-impaired musicians, it is proved that there is a lack in the current approach of learning musical notes. Therefore, with the implementation of the system, it is hoped that we can solve the problems that rose from the current approach of learning music for the blind and visually-impaired musicians and music learners. We expect that the haptic tool to help the blind to learn musical notes will become standard tools that will encourage the blind users to learn and read musical notes from flat screen.

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Nurul Izzati binti Omar

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CHAPTER 1
INTRODUCTION

1.1 Background of study

The project is developing a prototype model for helping the visually-impaired musicians and music learners learn musical notes from flat screen without being needed to transcribe into Braille with the use of haptic hardware in order to investigate the criteria of building such system.

"Haptics" is referred to the human tactile (cutaneous) and kinesthetic (muscle movement) senses of touch by applying forces, vibrations and/or motions to the user [6]. A haptic tool (interface) is a computer-controlled motorized device to be held in the hand by the user which displays information to the user's haptic senses.

By using haptics, we significantly reduce the burden on other information channels such as the audio and vision, thus will be freeing these channels for other tasks [1][5].

In certain instances, we believe that it is possible to completely substitute haptics for other sensory modalities [1]. In this way, the musical notes that is displayed on the flat screen in example the computer screen can be "read" by blind people who at the moment are having difficulties in learning and reading musical notes from the conventional flat surfaces in example in the flat computer screen. Therefore, incorporating haptics in the learning of musical notes will hopefully bring the hope to the new learning horizon for the visually-impaired music learners and musicians.

This research focuses on designing of a haptic tool to help the blind musicians to learn and read musical notes from the flat screen which will help to reinterpret and presented mechanically to the user's haptic senses (kinesthetic and tactile) where ideally they can feel how the notes “looks” like, provided that the users have the basic understanding on the types of notes and the beats that associates to the notes with the help of a PHANTOM Omni hardware developed by the SensAble Technologies Incorporated. It is a pen-like device which will be able to simulate different kinds of vibration frequencies and can be used to differentiate different kinds of musical notes based from the different kinds of vibration frequencies programmed so that the visually-impaired musicians and music learners can distinguish from one notes to another.

This will eliminate the needs for the visually-impaired musicians and music learners to transcribe the musical notes into Braille which the process is costly, complex and difficult to be done manually. Furthermore, by incorporating haptics into the process of learning musical notes, the visually-impaired musicians and music learners can now free themselves from the costly printed Braille musical transcription as with haptics, they can still distinguish the notes by different kind of vibration frequencies just like the different dotted Braille cells functioned.

1.2 Problem Statement

Blind musicians have had restrictions access to scores due to the scarcity and limitations of Braille transcription. Until the first quarter of the 19^{th} century, however blind musicians can learn music only by ear. Louis Braille changed that when he invented a system for transcribing musical scores into a tactile code. The tactile code, which known as Braille music, is made up of six dot positions, arranged in a rectangle containing two columns of three dots each and is raised so that the blind and visually-impaired can read. The Braille music, works just like the conventional Braille system that helps the blind and visually-impaired to read and write, and in learning music point of view, the raised dotted tactile system helps the blind to learn musical notes as well. The below figure summarize some of the common Braille music symbols and combination used in Braille music.

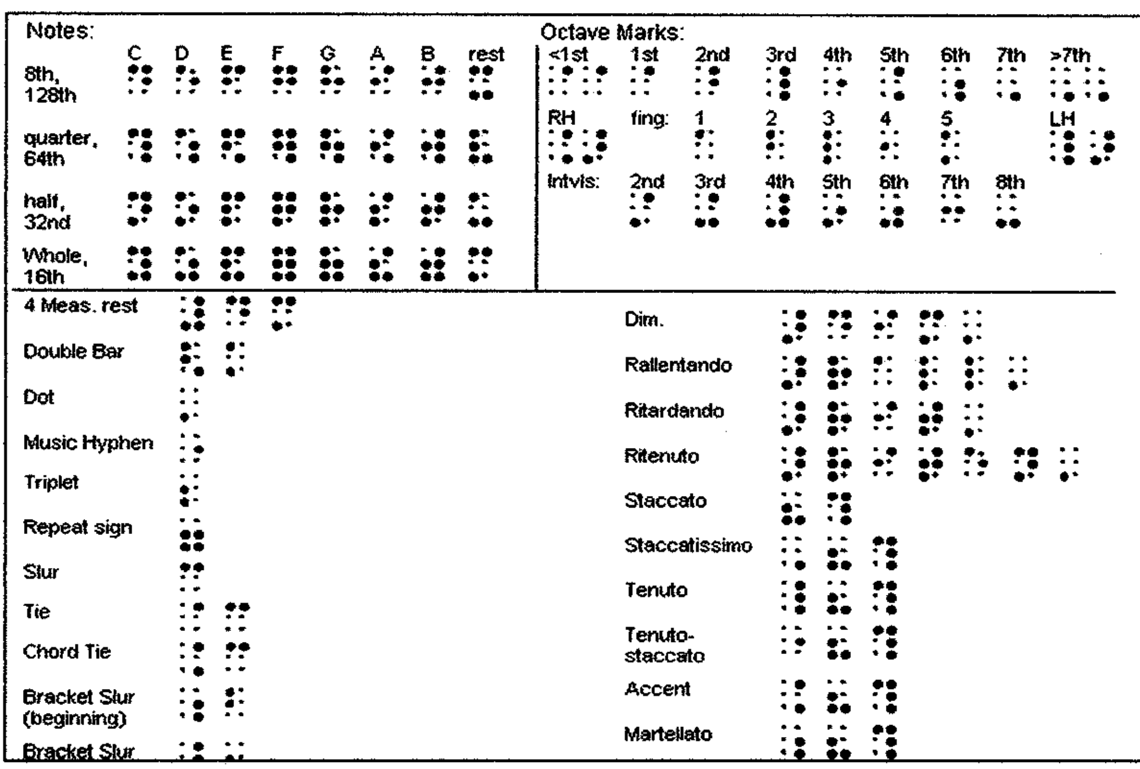

Figure 1.1: Common Braille music symbols and combinations in Braille music

Unfortunately, both transcribing – which had to be done by the sighted musicians – and reading Braille music proved difficult. Braille's linear format makes it hard to decipher the many aspects of music that occur simultaneously, such as chords or multiple voices.

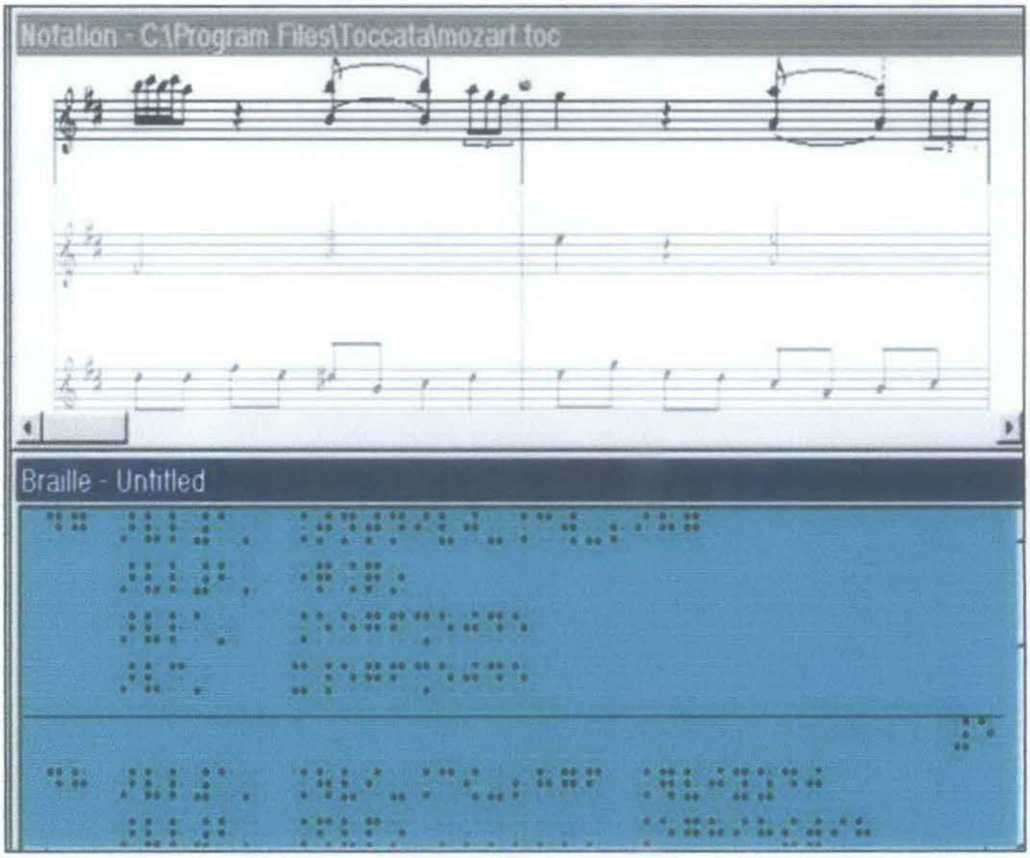

Figure 1.2: Transcribed Braille in lower window and original score in upper window

It is estimated that less than 15 percent of the printed music has ever been transcribed into Braille, and as much of that is locally available [2].

Other than using the Braille transcription, the musicians also learn the music by learning and play by ear. By using this technique, the musicians will listen, feel and hear the music in their mind and soul and they will be guided to reproduce exactly what they hear and listen and they will be taught how to put all the various components together (harmony, rhythm and improvisation) [3][4].

Unfortunately, by using this technique, simplest, most basic and actually most devastating aspect of only learning to play by ear is that the skill is by definition imitation.

A bassist, in example, that learns to play by ear can get really good at technique and playing other people's bass lines, but without the foundation of understanding music, when it comes to creating bass lines, those bassists generally get stuck and are forced to imitate the same bass lines and techniques they learned by ear, without being able to cross those techniques into trying new things.

Another flaw is that a beginner bassist with no ear training might just learn songs by ear incorrectly, choose the wrong notes, bass scales, and techniques, but be under the delusion they are right and simply just waste a lot of time without learning to play anything properly, which may not even become an issue until they decide to audition for bands. In addition, playing all the correct notes in a particular fashion may not be the best way, but without understanding the instrument, it can be hard to spot some very inefficient and sometimes counterintuitive ways to play certain bass lines [4].

1.3 Objectives

The objectives of this project are:

1. To identify the kind of musical notes that can be simulated and the kind of musical instrument that can be simulated in this prototype.

2. To determine the design requirements in order to develop a prototype for the instrument identified.

3. To implement and evaluate the haptic prototype based on the design requirements.

1.4 Scope of Study

For the purpose of the project, we will investigate the musicians who are included in the category of "totally blind" where it is necessary for them to learn via Braille or non-visual media [8] and the musicians that falls in the category of "legally blind" where it indicates that a person has less than 20/200 visual acuity in better eye with the use of a correcting lens [7] [8].

For this purpose of study, we will investigate on the totally blind and legally blind musicians and/or music learners that has the basic understanding on music and they have knowledge in reading the conventional music scores as well as they can differentiate each and every musical notes and the beats/tempo that lies in it. The scope will be covering on how the totally blind and the legally blind musicians and/or music learners learn and read musical notes as well as examining the current approach and technologies being used to help the blind and visually-impaired to read and learn music notes.

For this purpose of study, we will only investigate on seven (7) sample notes which are C,D,E,F,G,A and B flat on the timing signature of 4/4. These seven kinds of notes with the same timing will be distinguished by the blind and visually-impaired musicians with seven different kinds of vibration frequencies.

1.5 Relevancy of Project

The relevancy of project depends so much on how the blind and visually-impaired musicians and music learners views the effectiveness and the functionalities of the overall system as well as how the system will help them to read and learn the musical notes without the need for them to transcribe the notes in Braille which has been proven difficult. Therefore, with this project, it is hoped that the blind and visually-impaired musicians and music learners will gain a new horizon in learning the musical notes and will free themselves from the current approach being used to learn and read the musical notes.

1.6 Feasibility of Project within Scope and Time frame

The project is commenced to be developed within two (2) semesters time frame, where within the time, all design and requirements needed to develop a working prototype should be gathered and converted into a working prototype. Within the time also, all needed testing should be able to commence and all results must be documented.

This project has been developed within the time frame and within the scope stated above. However, for commencing the User Experience Testing of the project, we have opted into selecting random sighted respondents who has been blind-folded instead of testing with the target user. The reasons of this measure taken will be discussed further in the report. Other than that, all scopes needed to develop the project have been implemented in the prototype.

CHAPTER 2
LITERATURE REVIEW

Introduction

The United Nations estimates that there are 650 million disabled people which correspond of 10 percent of the whole global population. Apart from the number, there could be a number of the blind and visually-impaired around the globe who is involved in music industry. Since the blind people have lose one sense (sight), thus, the other senses can become more accurate (such as sound) and this may help a lot to the blind people to learn music that has been stimulated by the extra senses.

Importance of Haptic Force-feedback to the Visually-Impaired

Visually-impaired people rely much on other senses other than sight in daily live, and one of the important sense to them is touch. Unlike the sighted, the visually-impaired regards the sense of touch as highly crucial and critical as a way to get feedback especially in touching objects and sensing forces like vibrations and motions. As mentioned by [17] haptic is referred to the touch and feel feedback and is defined as, "encompassing sensing and the actions are involved in touch and manipulation". In the view of the visually-impaired and blind people, haptic feedback is crucial in regards to performing their daily task, since they are unable to utilize the use of the sense of sight, and depend very much on other sense. A research done by [18] has concluded that the sense of touch is very much crucial and important to the visually-impaired other than sound, which highlights the importance of haptic feedback and tactile in learning perspective of the visually-impaired, other than just audio output.

A research done by [13] to find the relationship between type of musical instruments and the modalities based on five human senses that are relevant when playing different kind of instruments stated that the importance of the touch sensation in playing music as the touch senses scores higher for all types of instrument. Thus we can make hypothesis that it is important to include haptic (touch) sensation in learning and reading music notes, especially for the blind. The research result done by [13] has shown that the touch sensation has the highest mean scores and the lowest standard deviation values which indicate that the touch modality is rated the most important sense among all as stated in Table 2.1.

Type of Musical Instrument	Human Senses	Mean	Std Dev.
Chordophones e.g. piano, guitar, banjo, violin, fiddle, harp	Sight	1.00	.000
	Hearing	3.31	1.208
	Touch	**4.41**	**.883**
	Taste	4.07	1.166
	Smell	1.88	1.164
Aerophones e.g. flute, recorders, fife, harmonica, accordion, bugle, organ	Sight	1.58	1.058
	Hearing	3.21	1.254
	Touch	**4.31**	**.896**
	Taste	3.89	1.106
	Smell	2.01	1.267
Membranophones e.g. Drums, kazoos	Sight	1.70	1.139
	Hearing	3.48	1.204
	Touch	**4.28**	**1.003**
	Taste	3.91	1.213
	Smell	1.88	1.184
Idiophones e.g. Tap shoes, bells, maracas, castanets	Sight	1.67	1.088
	Hearing	3.35	1.226
	Touch	**4.13**	**1.077**
	Taste	3.84	1.172
	Smell	1.89	1.158
Electrophones e.g. electric guitar, electric bass, electric organ, synthesizer	Sight	1.69	1.085
	Hearing	3.51	1.259
	Touch	**4.22**	**1.066**
	Taste	3.99	1.154
	Smell	1.94	1.235

Table 2.1: Type of Musical Instrument versus Human Senses

Current Approach of Learning Music for the Visually-Impaired – The Drawback

The commonly used approach in learning and reading music for the visually-impaired is by using the Braille music; a system that uses a "cell" that contains six dots in different combinations that the blind people may read by touching the notes, which is the internationally unified code assigns different meaning to the dot combination [9]. Despite of the success of the Braille music notes, many blind musicians are still unable to read or learn the scores especially if it is displayed on the flat screen without converting it into the Braille music, in example in the computer screen. Plus, blind musicians have restricted access to musical scores due to scarcity of the Braille transcription where approximately 15 percent of printed music has been transcribed into Braille [2]. Furthermore, printing out Braille musical scores could be not an effective way as it requires special type of printer, which is called an embosser. This special type of printer will print out the Braille-transcribed musical scores into a tactile form that can be read by the visually-impaired and blind musicians. However, transcription process is not an easy task and the cost of an embosser is expensive.

Incorporating Haptic into Music

The fact that creating sound is a fundamentally mechanical anomaly has leads us to the believe that incorporating haptic in learning music is much more promising as compared to present visually. According to [5] he stated that "musical instruments are generally more interesting to feel than they are to look at and what is most important, it is through mechanical interaction with an instrument that we learn to make music."

There has been an increase in the attempt to integrate touch or haptic feedback into interfaces for music. [10] proved that the inclusion of haptic feedback to a performance system improved the playing accuracy and this should be able to address the problem raised by [11] in the lack of intimacy between the blind's haptic senses and the sound being produced during computer music performance. According to [12] that studied the affect of haptic feedback on the response of an instrument states that not only the performer responds to kinesthetic response when learning an instrument but it also helps in terms of haptic feedback that improves the playing accuracy. He has developed a virtual violin bow and develops the ideas to design for an alternative expressive music controller that according to him "improves the expressiveness or playability of the bowed-string physical model".

An interface has been developed by [1] to help the blind and visually-impaired sound engineers to navigate through the system screen like radio buttons, sliders and pull-down menus which give the user the feeling to be felt, located, identified and activated, through the same device input. According to Modhrain [1], by using the prototype device, "we have already implemented an interface for Microsoft Windows and have proven the feasibility and usefulness of the haptic interface approach for non-visual computer access" which is believed to be valuable in the design of application of music audio editing.

However, when developing an application using haptic device, several concerns need to be addressed by the developer. A study that has been done by [19] has showed that users need to learn how to feel the objects via an intermediate tool like the PHANToM haptic device. The PHANToM haptic device, which is a pen-like base device is commonly used to feel the virtual object that has been modeled on the computer or to feel the tactile, in example the vibrations and motions while [20] indicates that a learning period to practice the device would simplify the actual purpose of usage of the application. However, it must be realized and noticed that initial use of the software to teach the visually-impaired and the blind users will encounter difficulties and this is normal. Therefore, it is very important to explore the haptic display differently from its normal exploration, and the expected result would be the initial performance of untrained users is lower than what is reached after practice [20]. This method can be used to train the

visually-impaired musicians and music learners using the application since it is a new way of learning the musical notes.

Making Musical Scores Available For the Blind

[2] has introduced "Contrapunctus", a system that uses the Braille Music Markup Language (BMML) to reorganize written music into highly structured and accessible database so that the blind and visually-impaired musicians around the globe can download the enriched, multimedia scores from the digitally growing library and allow the blind to have a faster, easier access to the Braille scores. This system allows the user to access and share lots of information on different types of musical content with the use of the web which handles the specifities of Braille music notations and symbols and take into account the core features of the existing formats where this will increase the accessibility of Braille musical scores. This system will bring hope to many blind and visually-impaired musicians on eliminating the problem of the scarcity of Braille-transcription musical scores that has been highlighted before.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Project Methodology

The project has adopted the methodology of framework that comprises in three (3) phases which are the research phase, project development phase and the prototype development phase.

In the research phase, we mainly focus on the gathering of critical information in regards to the subject area from the previous research papers, journals, documents, books and articles. In this phase also, we finalize our target group which is the totally blind people and the legally blind musicians and music learners who has the knowledge in music and knows how to read the scores.

In developing the prototype for this project, the Incremental and Iterative methodology, the prototyping based - has been chosen which the development of the project will be based on several phases which will be visited sequentially, and to be revisited as required to suit to the needs and requirements of the project. Each revisit will be done for each new requirement and will be dubbed to the nth increment. Once all conditions are satisfied, the development is halted. This methodology is chosen to suit with the ever changing requirements and to adapt the changes found during the project development process, such as new user requirements.

The phases of the development are divided into Planning and Requirements Gathering, System Analysis & Design, System Implementation, System Testing and System Deployment.

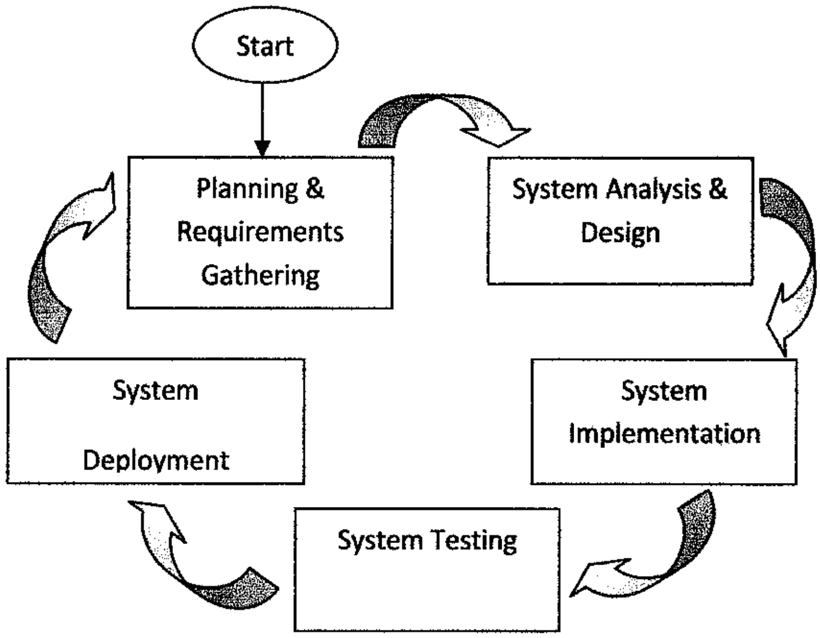

Figure 3.1: Project Methodology Flowchart

3.2 Project Phases

Sub-phase 1: Planning and Requirements Gathering

In this phase we will describe the nature and the concept of the project which includes the requirements of the project, the characteristic and the summary of the project as well as the studies that has been done in the research area. This sub-phase will be used as the baseline to monitor the project progress by stages. In this sub-phase, an interview is planned with a personnel from the National Council for the Blind Malaysia (NCBM) to gather initial requirements on developing the project as well as a dissemination of questionnaire questions to the selected respondents which were all blind and visually-impaired musicians so that we gain a better insight on developing the design of the overall system. The result of the interview and the questionnaire responses will be used as the major baseline of developing the application and the overall system.

Sub-phase 2: System Analysis & Design

The purpose of this sub-phase is we want to analyze and organize the data and information that has been gathered from the interview and the questionnaire responses that we have collected so that we can come out with the initial design prototype to comply with the requirements that we have collected earlier. Therefore, when the analysis of the project has ended, the designer should know what prototype will looks like, its function and its design. This sub-phase also provides extensive information gathering and analysis of each details of the project. The final stage of the analysis is we will organize the information into documents that will guide the works during the rest of the project implementation. The info in the analysis phase will be used in the design phase where users and technical resources will be involved throughout the process to ensure all requirements are incorporated into the design.

Sub-phase3: System Implementation

In the system implementation phase, a prototype is built based on the system analysis and design. All the deliverables that is gathered in the design phase will be converted to a complete and executable prototype where this phase involves the building of the interfaces and the coding of the modules. Once compiled, the built prototype is the main deliverable. The prototype developed will be tested by stages in a systematic manner. In the purpose of developing this project, executable file (.exe) which displays the console-based musical notes and its associated key press will be implemented and delivered, where this is the crucial application that helps the blind and visually-impaired musicians read the musical notes from flat screen and with the help of the haptic device, help them to mechanically transform the notes into haptic tactile. Other than that, a graphical user interface (GUI) developed using Visual Basic Express 2008 also will be implemented and delivered. In this interface, the function ReadScreen which is designed specifically to the totally-blind target user and the function MagnifyScreen which is designed for the legally-blind target user is developed as well as the basic functionalities of a GUI which consists of a Start button to start the application and loads the executable file (.exe) and the Exit button which will prompt the Exit Confirmation popup window.

Sub-phase 4 :System Testing

Once the system is built successfully, the system testing phase is used to test upon the implementations. The tests include the System Integration Testing which integrates all the modules and the system flow based on scenarios, and also the User Experience Testing which will test on the user overall experience of using the system. This testing phase will also be used to identify and fix any bugs that occur within the built system. The developed prototype will be evaluated by the target audience which is the totally blind and legally blind musicians and/or music learners. In this phase also, the overall project plan will be reviewed on the clarity of project purpose, the project timeline and the requirements related to this area of research.

Sub-phase 5: System Deployment

The final phase of the system is the system deployment where the system is ready for use. This activity will allow the system to be used in the actual music learning environment. Any data or new requirements are noted and changes to the system will move on to the next increment of the system built.

3.3 Project Activities Flowchart

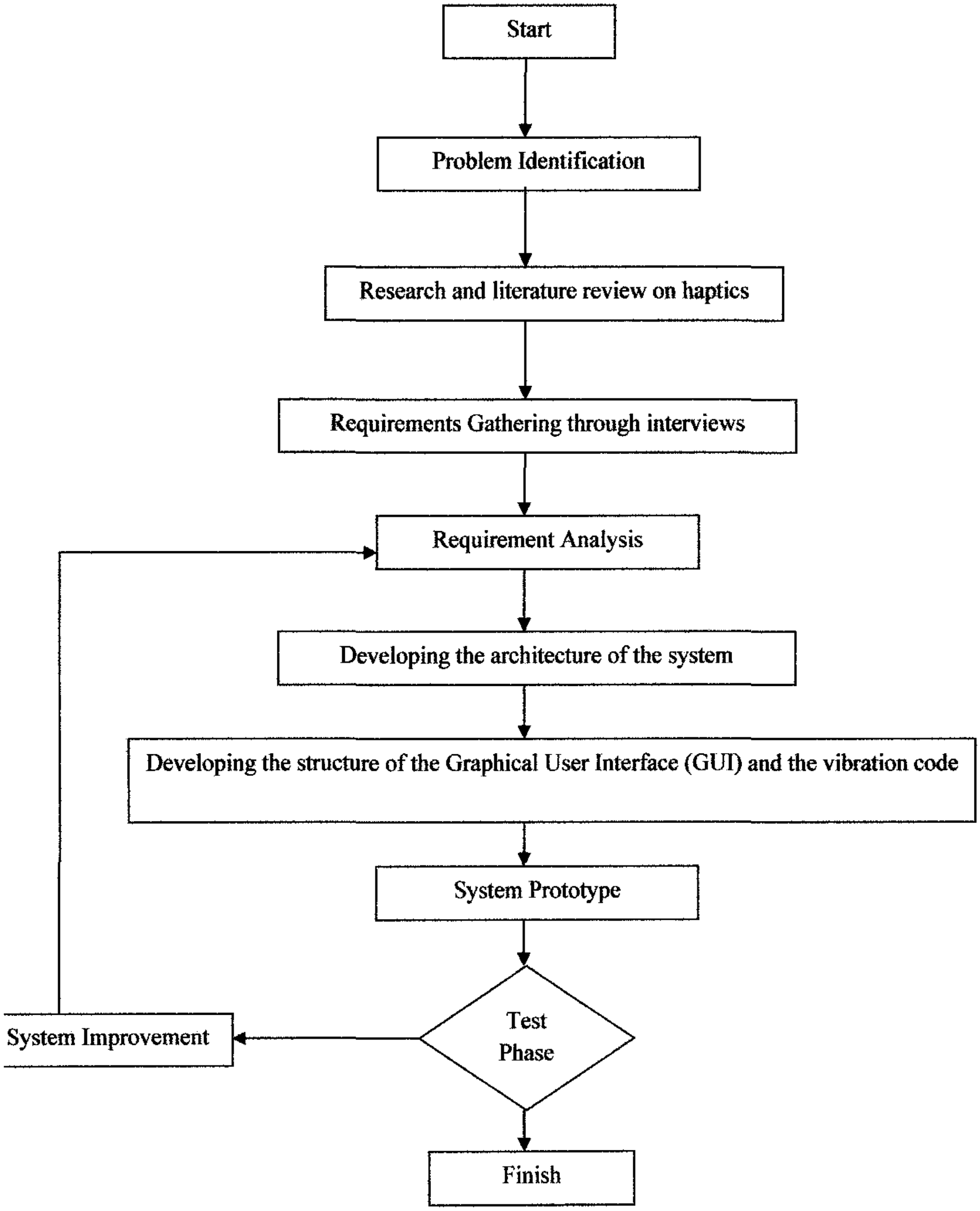

Figure 3.2: Project Activities Flowchart

3.4 Gantt Chart

See Appendix A

3.5 Tools and Equipment Used

3.5.1 Software Used

Table 3.1 shows a list of recommended software needed for developing the application.

Software	Requirements
Operating System	Window XP Service Pack 2
Supporting Software	Visual C++ 6.0 Visual Basic 2008 Express Edition OpenHaptics Toolkit Thunder Screen reader (a third party application that reads the screen) Desktop Zoom (a third party application that magnifies the screen)

Table 3.1: Software Specification Requirements

3.5.2 OpenHaptics Toolkit

- The OpenHaptics toolkit enables software developers to add haptic feature. The components of this toolkit are presented in Figure 3.4.
- Developers can use/control existing OpenGL code for specifying geometry, and supplement it with OpenHaptics commands to simulate haptic material properties such as friction and stiffness.
- OpenHaptics Toolkit Component [14]

The OpenHaptic toolkit has two (2) components which are:

a. HDAPI (haptic device API) and

b. HLAPI (haptic library API)

HDAPI is a low-level foundation layer for haptics rendering that is enabled to send force and read ADC manually. It modifies the rate of servo loop. HDAPI components controls the device, manage the state, setting parameters and sending forces.While HLAPI is designed for high-level haptics scene rendering and is built on top of HDAPI. It provides a higher level haptics control as compared to HDAPI and it is designed for easy use.[14]

For the purpose of this project, we are developing the code based from the HLAPI components, where it is much easier to use and it is handier for developers.
The below flowchart will further explain on the HLAPI program that has been used for this project:

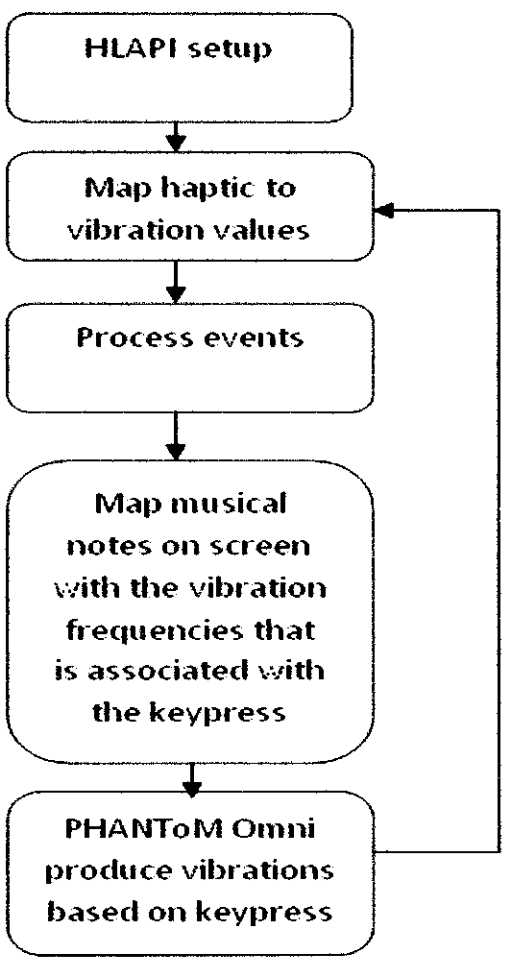

Figure 3.3: HLAPI vibration program flowchart

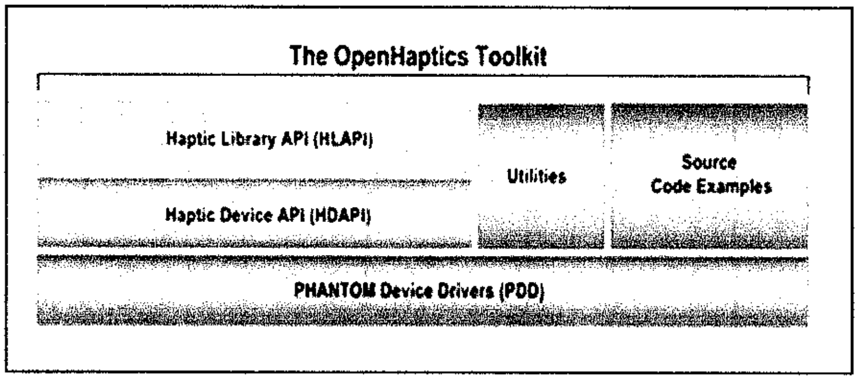

Figure 3.4: OpenHaptics Toolkit

Table 3.2 shows the hardware specification and requirements to develop a haptic application:

Hardware	**Model**	**Reason of usage**
Phantom Desktop		Compatible and stable
Central Processor Unit (CPU)	Intel ® Core 2 Duo T5600 @ 1.83 GHz	Compatible and stable
Main Memory	1.99 Gigabytes (GB)	To support the Operating System and to improve machine's performance
Hard Disk	80 Gigabytes (GB)	To support the operating system, server, database and other related documentation or storage.

Table 3.2: Hardware Specifications and Requirements

3.5.3 PHANToM Desktop

Figure 3.5: The PHANToM Omni force-feedback device

SensAble PHANToM Omni force-feedback device is a product by Sensable Technologies that makes it possible for users to touch and manipulate virtual objects. The feature of the device includes:

- Mechanically restricted device with a stylus
- Six degrees-of-freedom positional sensing
- Give force feedback to user through the stylus

The PHANToM Desktop technical specifications are stated in Table3.3 below:

Force feedback workspace	~6.4 W x 4.8 H x 4.8 D in. > 160 W x 120 H x 120 D mm.
Footprint (Physical area device base occupies on desk)	5 5/8 W x 7 1/4 D in. ~143 W x 184 D mm.
Weight (device only)	6 lbs. 5oz.
Range of motion	Hand movement pivoting at wrist
Nominal position resolution	> 1100 dpi. ~ 0.023 mm.
Backdrive friction	< 0.23 oz. (0.06 N)
Maximum exertable force at nominal (orthogonal arms) position	1.8 lbf. (7.9 N)
Continuous exertable force (24 hrs.)	0.4 lbf. (1.75 N)
Stiffness	X axis > 10.8 lbs. / in. (1.86 N / mm.) Y axis > 13.6 lbs. / in. (2.35 N / mm.) Z axis > 8.6 lbs. / in. (1.48 N / mm.)
Inertia (apparent mass at tip)	~0.101 lbm. (45 g)
Force feedback	x, y, z
Position sensing [Stylus gimbal]	x, y, z (digital encoders) [Pitch, roll, yaw (± 3% linearity potentiometers)
Interface	Parallel port, FireWire® option
Supported platforms	Intel or AMD-based PCs
OpenHaptics® SDK compatibility	Yes
Applications	Selected Types of Haptic Research, the FreeForm® Modeling™, and the FreeForm® Modeling Plus™ systems

Table 3.3: PHANToM Desktop Haptic Device Technical Specification

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Data Gathering and Analysis

4.1.1 Interview – Face-to-face interview and Dissemination of Questionnaire

The face-to-face interview had been conducted with personnel from the National Council for the Blind Malaysia (NCBM) which located in Brickfields, Kuala Lumpur. The interview has been done on 25th March 2011.The information obtained in this interview has been used as one of the major basis for developing the application as well as the functionalities and the requirements that is needed on the system.

The purpose of the interview is to get the information on how the blind musicians and music learners learn music in the current approach as well as the tools and equipment that are needed for the blind to learn and read musical notes for example the Braille embosser for printing out Braille-transcribed musical scores.

In this interview session also, we managed to pass questionnaires specifically designed for gathering information from the blind musicians that is within the contact of NCBM to be answered after the interview session. The results of the questionnaires will be revealed in detail in the later section in this report. As part of the study, all respondents are kept anonymous and no personally identifiable information is kept. All respondents were given the same set of questionnaires so that they may answer without prejudice for the data analysis phase.

The methodology of the face-to-face interview and questionnaires dissemination is as follows:

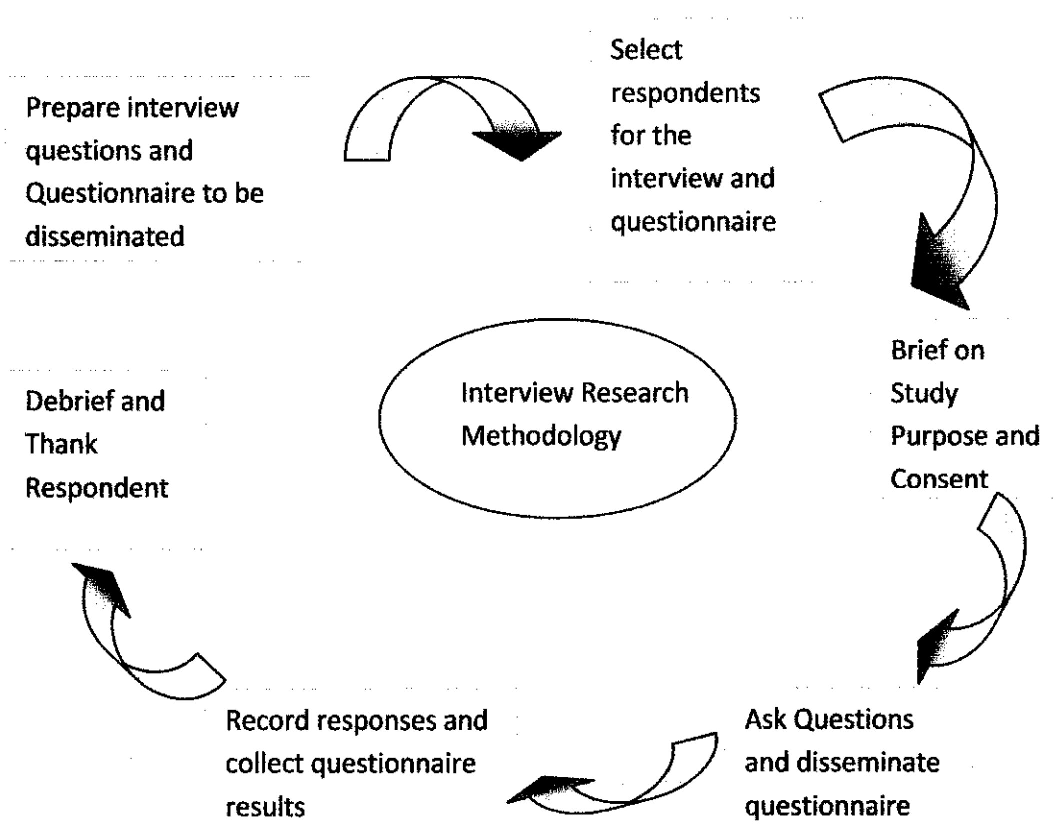

Figure 4.1: Research Methodology

1. Prepare Interview Questions and Questionnaire to be Disseminated

The interview questions were selected to gain information on how the blind learn musical notes in the current approach as well as the technologies available to help them read and learn the notes while the set of questionnaires which targeted for the blind musicians selected in order for us to get a detailed information on how the blind learn musical notes and to obtain their opinion on the importance of certain musical instrument that is associated with a certain human senses. The method chosen for interview is Structured Questions with Open-Ended Probing Questions while it is a Scaled-Closed-Ended Questionnaires.

See Appendix B – Questionnaires

2. Select Respondents for Answering Questionnaires

Selection of the respondent is made upon the contact with Mr. Moses Choo, a coordinator working with the National Council for the Blind, Malaysia. He has chosen a selected number of members from the council who were available for answering the questionnaires, which all of the respondents were blind musicians. The method of gathering the results of the questionnaires were all respondents has been disseminate with the same set of questionnaires through email contact of Mr. Moses Choo, and the responds has been sent to our email.

3. Brief on Study Purpose and Consent

A briefing of general information on the purpose of study is given to the respondents, and the consent form is given saying that no personally identifiable information will be kept.

4. Ask Questions and Disseminate Questionnaires

Questions were asked to interviewee mainly on the general information on how the blind musicians and music learners learn musical scores in the current approach and based from his opinions, what are lacking in the current approach of learning and reading music as well as the technologies available in NCBM in order to help the blind musicians and music learners read and learn musical scores.

While the questionnaires that has been disseminated to the contact of Mr Moses Choo which were all the blind musicians mainly to gather their personal opinion on the human senses versus musical instrument as well as the importance of the human senses to the selected instruments.

See Appendix B – Questionnaires

5. Record responses and Collect Questionnaires Results

The response from the interview with Mr. Moses is recorded while the questionnaire results have been collected based from the response email the respondents have sent us. The result of the questionnaires will be revealed later in this report.

6. Debrief and thank the participant

Debriefing the participant involves telling the participant what the project status is currently and how the project will be further developed.

4.1.2 Questionnaire Results

The questionnaire that has been conducted for the blind that contains four (4) parts, which are Part A, to get the overview information on the demographic background of the respondents, where in this part, respondents is required to provide their gender, the age range and their type of blindness. While Part B gathered the information on the respondents' experiences in music and their understanding in music and how they get the access to the musical scores resources. Part C gathered the information on the relationship of musical instruments and human senses. In this part, respondents need to clearly justify and select based on their opinion, which human senses are important while playing certain types of musical instruments, based from the five different kind of senses which are sight, hearing, touch, taste and smell and respond Yes or No.

While Part D is asked to gather the information on the importance of human senses in playing a musical instrument. In this part, respondents were required to select, based on their opinion, from the scale 1 to 5 on the importance of the different kind of senses in playing certain types of musical instruments. A total of three (3) respondents have responded on this questionnaire and they are the blind musicians that have been successfully contacted by a representative from the National Council for the Blind (NCBM) which headquarters in Brickfields, Kuala Lumpur. Their age range is from 29 years old to 39 years old and all respondents are female.

Below is the synopsis of the questionnaire:

Part A: Demographic Information

- A total of 3 respondents – all are female
- Their age range is from 29 years old and 39 years old
- One respondent have indentified her type of blindness as "Others – Totally blind" while the other two just identified their type of blindness as "Others" only without any specific reason.

Part B: Experience in Music

Question 1: Do you know how to read musical scores or do you have understanding in music?

All of the respondents agreed that they know how to read musical scores and/or they have an understanding in music

Question 2: How do you learn music?

Two (2) of the respondents agreed that they learned the music by learning by ear and by music Braille and one (1) respondents agreed that she learned music by music Braille only.

Question 3: How do you access the music scores?

Two (2) of the respondents agreed that they access the musical scores from the available Braille score resources and from the internet before transcribing the score into music Braille by Braille embosser and one (1) respondent agreed that she access the musical score by the available Braille score resources only.

Question 4: Do you play any musical instrument?

All respondents agreed that they do play any musical instrument.

Question 5: What type of musical instruments do you play?

Two (2) respondents agreed that the type of musical instrument that they play is chordophones only which is vibrating string instrument in example piano, guitar, banjo, violin, fiddle and harp. One (1) respondent have identified she play two types of instruments which are chordophones (piano) and electrophones, which is the instrument is amplified electrically (synthesizer)

Question 6: How often do you play a musical instrument?

One respondent agreed that she played less than one (1) hour weekly, while another respondent agreed that she played for 1 to 3 hours weekly. The other respondent agreed that she played for more than five (5) hours weekly.

Part C: Musical Instrument vs. Human Senses

Type of Musical Instrument	**Human Senses**				
	Sight	Hearing	Touch	Taste	Smell
Chordophones e.g. piano, guitar, banjo, violin, fiddle, harp	**1**	**3**	**3**		
Aerophones e.g. flute, recorders, fife, harmonica, accordion, organ	**1**	**3**	**3**		**1**
Membranophones e.g. Drums, kazoos	**1**	**3**	**3**		

Idiophones e.g. Tap shoes, bells, maracas, castanets		**2**	**2**		
Electrophones e.g. electric guitar, electric bass, electric organ, synthesizer		**2**	**2**		

Legend: **1** – Only one (1) respondent believes that the type of human senses is important to the type of musical instrument stated.

2 – Only two (2) respondents believe that the type of human senses is important to the type of musical instrument stated.

3 – All respondents believe that the type of human senses is important to the type of musical instrument stated.

Based from the above question, it is evident that the sense of touch is agreed by all respondents as one of the major human sense that help them to play the musical instruments apart from hearing.

Part D: The Importance of Human Senses in Playing a Musical Instrument

For this part, only two (2) respondents have taken part while the other one believe that she can't relate directly the type of musical instruments with regards to human senses in general as she believes that music is played within the heart, and it is hard for her to indicate which senses is most important in playing certain types of musical instruments. For Participant 2, based from her opinion, there is no relevance for the sense of taste and smell for each musical instrument, therefore she kept it unchecked.

Type of Musical Instrument	Participant	Human Senses	Not important				Very important
Chordophones e.g. piano, guitar, banjo, violin, fiddle,	**Participant 1**	Sight	1	(2)	3	4	5
		Hearing	1	2	3	(4)	5
		Touch	1	2	3	(4)	5

harp		Taste	(1)	2	3	4	5
		Smell	(1)	2	3	4	5
	Participant 2	Sight	1	(2)	3	4	5
		Hearing	1	2	3	4	(5)
		Touch	1	2	3	4	(5)
		Taste	1	2	3	4	5
		Smell	1	2	3	4	5
Aerophones	**Participant 1**	Sight	1	(2)	3	4	5
		Hearing	1	2	3	(4)	5
e.g. flute, recorders, fife, harmonica, accordion, bugle, organ		Touch	1	2	(3)	4	5
		Taste	(1)	2	3	4	5
		Smell	(1)	2	3	4	5
	Participant 2	Sight	1	(2)	3	4	5
		Hearing	1	2	3	4	(5)
		Touch	1	2	3	4	(5)
		Taste	1	2	3	4	5
		Smell	1	2	3	4	5
Membranophones e.g. Drums, kazoos	**Participant 1**	Sight	(1)	2	3	4	5
		Hearing	1	(2)	3	4	5
		Touch	1	(2)	3	4	5
		Taste	(1)	2	3	4	5
		Smell	(1)	2	3	4	5

	Participant 2	Sight	(1)	2	3	4	5
		Hearing	1	2	3	4	(5)
		Touch	1	2	3	4	(5)
		Taste	1	2	3	4	5
		Smell	1	2	3	4	5
Idiophones e.g. Tap shoes, bells, maracas, castanets	**Participant 1**	Sight	(1)	2	3	4	5
		Hearing	1	2	(3)	4	5
		Touch	1	2	(3)	4	5
		Taste	(1)	2	3	4	5
		Smell	(1)	2	3	4	5
	Participant 2	Sight	1	(2)	3	4	5
		Hearing	1	2	3	4	(5)
		Touch	1	2	3	4	(5)
		Taste	1	2	3	4	5
		Smell	1	2	3	4	5
Electrophones e.g. electric guitar, electric bass, electric organ, synthesizer	**Participant 1**	Sight	1	2	(3)	4	5
		Hearing	1	2	(3)	4	5
		Touch	1	2	(3)	4	5
		Taste	(1)	2	3	4	5
		Smell	(1)	2	3	4	5
	Participant 2	Sight	1	(2)	3	4	5
		Hearing	1	2	3	4	(5)
		Touch	1	2	3	4	(5)

		Taste	1	2	3	4	5
		Smell	1	2	3	4	5

4.1.3 Data Gathering

General Analysis

Based from the above question, it is evident that the sense of touch is agreed by all respondents as one of the major human sense that is important for them to play the musical instruments apart from hearing.

Based from the interview that has been done and the questionnaire results gathered, the current approach for the blind musicians to read and learn music notes are still using the Braille transcriptions available and transcribe conventional musical notes to Braille by using Braille embosser with the help of transcription software, which according to NCBM personnel, it is costly as the cost of the embosser is RM20, 000 per unit and it is not easily accessible. Some of the response that has been highlighted on the lacking of learning and reading musical scores from the conventional musical scores that is transcribed to Braille via transcription software is:

"Embosser is only a printer; it does not turn normal print into Braille. It involves a person (the transcriber, usually the sighted musicians), a software (the transcription software) and the printer (the embosser). I just remember one thing, at times we just have to copy manually" – Participant 3

Other by learning the musical notes via Braille music transcription, the blind musicians also learned by ear.

"Among the blind, most of us either learn music by Braille music scores (which means learning a new set of codes and symbols) or by ear (applicable to those with perfect pitch, the ability to identify the notes simply through hearing)" – Participant 3

Requirement Analysis

Based from analysis of the interview and the questionnaire disseminated, it has brought us to several conclusions about the development requirements.

It is crucial to implement several major implementations on the requirements which are:

- Implementation of Sound
- Implementation of Screen Magnification
- No-Sight Testing
- Incorporated Braille Music Markup Language (BMML) with application prototype
- Guidance and Restrictions

1. Implementation of Sound/Audio

According to the personnel interviewed, most of the blind navigate systems through audio by the help of screen reader. Therefore, audio and sound implementation is crucial to be integrated into the system, as one of the major help for the blind, especially the totally blind musicians to navigate the implemented system. By incorporating sound as the navigator to the blind musicians in navigating the system, it will ease the user in using the system without the need to have sighted person to help them navigate the system later as quoted by interviewee on the importance of audio feedback:

"Blind people use text to speech software with computers. Some of the commonly used text-to-speech software is like Thunder, OpenBook 8.0 and JAWS (Job Access with Speech)." – Interviewee 1

The inclusion of audio and sound elements has been developed by incorporating third party freeware that helps to read screen. The software that is used is Thunder Screen Reader developed by Sensory Software. This freeware works well in Windows platform which includes Windows XP, Windows Vista or Windows 7. It also supports Microsoft Active Accessibility (MSAA), an Application Programming Interface (API) for user interface accessibility.

Iteration 1: **Requirement is feasible for implementation and is accepted**

Iteration 2: The implementation of sound (screen reader) in the system has been analyzed to be an important element for the visually-impaired, especially the totally-blind musicians and music learners to navigate the system. The implementation of the sound (screen reader) can be done by incorporating third party screen reader software that helps to read the screen and helps the visually-impaired musicians and music learners to navigate the screen so that the dependencies on the sighted can be lessen. This **requirement is completed** and coded by incorporating Thunder Screen Reader software (upon clicking) in the Welcoming Page of the system.

2. Implementation of Screen Magnification

Since the target user for this application includes the legally-blind musicians and music learners with the visual acuity of 20/200 which needs a distance of two feet to spot the letters on a standard eye chart that is 20 feet away. Therefore, the implementation of screen magnification is crucial to suit with the needs of the legally-blind musicians and music learners, so that they may navigate the system with the minimal dependencies on the sighted or by navigating through the screen reader.

The inclusion of screen magnification has been developed by incorporating a third party screen magnification freeware that helps to magnify the screen for the use of the legally-blind musicians. The software that has been used in order to develop this application is Desktop Zoom. It is completely portable and can zoom an area around the mouse, zoom a fixed window or the entire window. This application also comes with the basic speech support so that the visually-impaired musicians can navigate the system with the aid of speech synthesizer.

Iteration 1: **Requirement is feasible for implementation and is accepted**
Iteration 2: The implementation of screen magnification in the system has been analyzed to be an important element for the visually-impaired, especially the legally- blind musicians and music learners to navigate the system. The implementation of the screen magnification can be done by incorporating third party screen reader software that helps to read the screen and helps the visually-impaired musicians and music learners to navigate the screen so that the dependencies on the sighted can be lessen. This **requirement is completed** and coded by incorporating Desktop Zoom software (upon clicking) in the Welcoming Page of the system. The setting of this freeware can be customized according to the user preferences for the better and easiness to navigate the system.

3. No-Sight testing

A "No-sight" testing is a method of testing the system using a blindfold. Testing the system using the haptic device would mean that restricting tests to only the blind would require a set of blind users throughout the development of the project, which is not feasible due to the location of the haptic device and the proximity to all the users as well as the difficultly to involve the visually impaired in every step of the project. Therefore No-Sight Testing has been resorted to imitate the blind and visually-impaired responsiveness and acceptance behavior in experiencing and using the system prototype.

"In order for you to understand how is it to be like the blind, you need to test the system as the blind" – Paraphrased from Interviewee 1

Iteration 1: **Requirement is feasible for implementation, and is accepted.**

Iteration 2: The completed prototype is tested for the blindfolded users. A number of 5 respondents have been blindfolded in the testing of the system prototype. The result of the testing will be revealed in detail in the User Experience Testing section in this report.

4. Incorporated Braille Music Markup Language (BMML) with application prototype

Braille Music Markup Language (BMML) is an XML-based markup language that allows music scores to be access easily via the net. The format enables Braille music notations and symbols specificities to be handled by BMML and takes into account the core features of existing formats, where the main objective is to improve the accessibility of the Braille musical scores.

By incorporating Braille Music Markup Language (BMML) within the application prototype, the visually-impaired musicians and music learners can now resort to a readily set of musical scores that is available in Braille instead of transcribing them with transcription software. BMML provides enriched, multimedia scores from the ever growing digital library that allows the visually-impaired musicians and music learners to study with great flexibility and add new scores to the library [2].

Iteration 1: **Requirement is feasible for implementation, and is accepted.**

Iteration 2: In the 2nd iteration, implementing Braille Music Markup Language (BMML) requires the OpenHaptics library and interfacing GUI to be connected with Braille Music Markup Language libraries and need to be mapped with the associated musical notes and symbols with the associated vibration frequency variation in order for the visually-impaired musicians and music learners to learn the musical notes and symbols with the vibro-tactile force-feedback SensAble Omni haptic device that produces vibrations. The requirement is changed to "Requirement Rejected" for this prototype as to take into consideration of time constraint and to scope down development to pure haptic study. However, the requirement is highly recommended for future works as integrated features.

5. Guidance and Restriction

Guidance and Restriction is the portion of the system that put restrictions to allow the visually-impaired musicians and music learners navigate the system and using the SensAble Omni Haptic device with safety, since this is a mechanical device. A restriction (cap) on the vibration values is implemented to prevent the possibility of ever increasing the vibration amplitude to dangerous limits. Therefore, all sets of the sample musical notes that have been coded associated with its vibration frequencies that is based on the keypress, is coded within the permissible limit.

Iteration 1: **Requirement is feasible for implementation, and is accepted.**

Iteration 2: The OpenHaptics library allows for modification on how much vibration frequencies that is associated with the keypress will be produced. This setting is implemented successfully, and the **requirement has been coded and completed**.

4.2 System Architecture

Iteration 1:

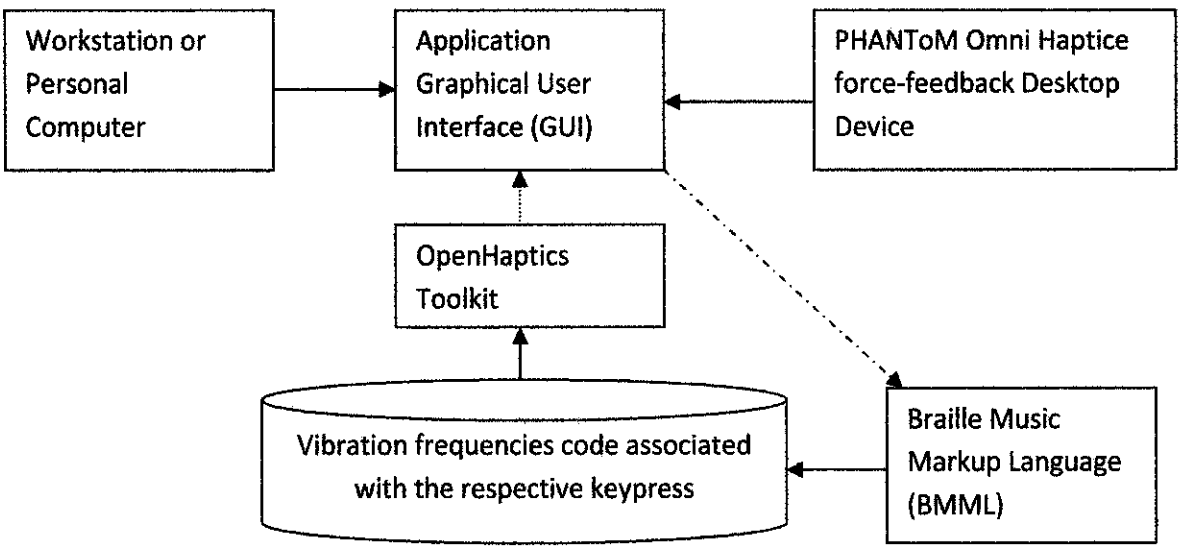

Figure 4.2: System Architecture –Iteration 1

The system architecture for the first iteration used is a workstation or a personal computer connected with a haptic device which runs and then loads the application. The application will utilize the OpenHaptic toolkit which will process the vibration based on the keypress associated so that the visually-impaired musicians and music learners can sense the different kind of vibration frequencies associated with different musical notes, that connects directly to the BMML page that allows the user to "view" the available Braille-transcribed musical scores and read them with the help of haptic device.

Iteration 2:

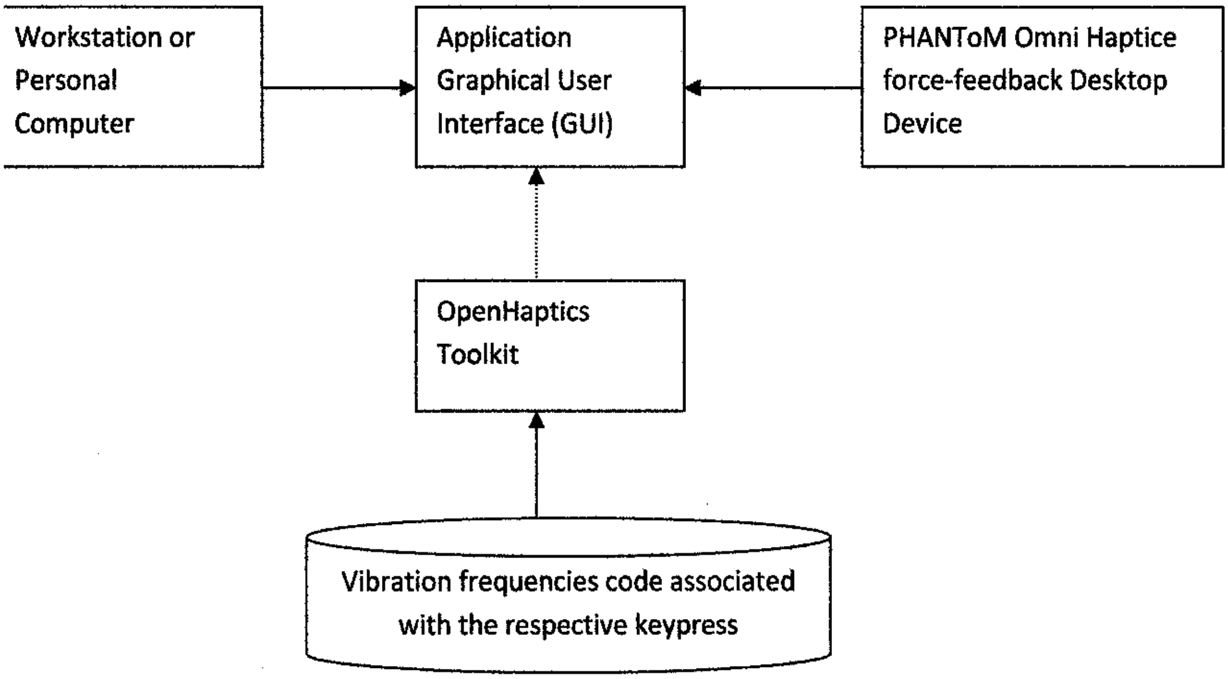

Figure 4.3: System Architecture – Iteration 2

The refined system architecture representation is made to suit the application closer. The workstation runs the learning application, and the application is navigated using the haptic device. The application will utilize OpenHaptic toolkit that process the vibration frequencies based on the keypress associated so that the visually-impaired musicians and music learners can sense the different kind of vibration frequencies associated with different musical notes, that is associated with the keypress and navigate the system by using haptic device.

4.3 System Use Case

For the use case in Iteration 1, the actor(s) involved are the visually impaired users; specifically the visually-impaired musicians and music learners or which will directly access the system. The system will load the interfacing GUI will allows the user to select function based on the type of their blindness, the MagnifyScreen function ideally for the legally-blind musicians while the ReadSreen function ideally for the totally-blind musicians. This function is an optional and is loaded upon click; therefore users can navigate the buttons of these functions with the help of the "Tab" key on the keyboard.

Iteration 1:

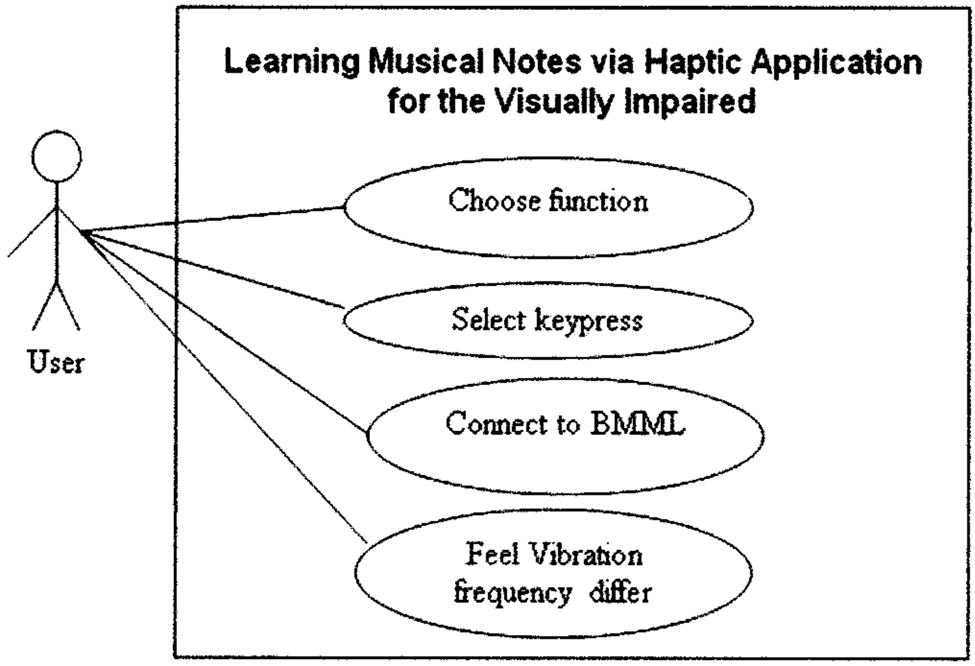

Figure 4.4: System Use Case for Iteration 1

Based from the first iteration System Use Case, it is decided that the user can perform four (4) functions within the system which are:

1. Choose function – A single button clicked to load the function MagnifyScreen or ReadScreen to suit with their type of blindness.
2. Select key press – This function will load the vibration frequency that is associated with the key press, which these key is associated with the respective musical notes. This function enables user to differentiate between one musical notes to another with the help of different vibration frequencies that is loaded when the respective key is pressed.

3. Connect to BMML – This function will connects the user with the ever-enriched library of Braille-transcribed musical scores online and will help them to map the Braille-transcribed notes into vibro-tactile force-feedback output sensed with the help of SensAble Omni Haptic Force-feedback Desktop device.
4. Feel frequency differ – The user can experience the differences between one musical notes to another with the different kind of vibration frequencies that is coded associated with the respective key press. This can be done with the help of the haptic device.

Iteration 2:

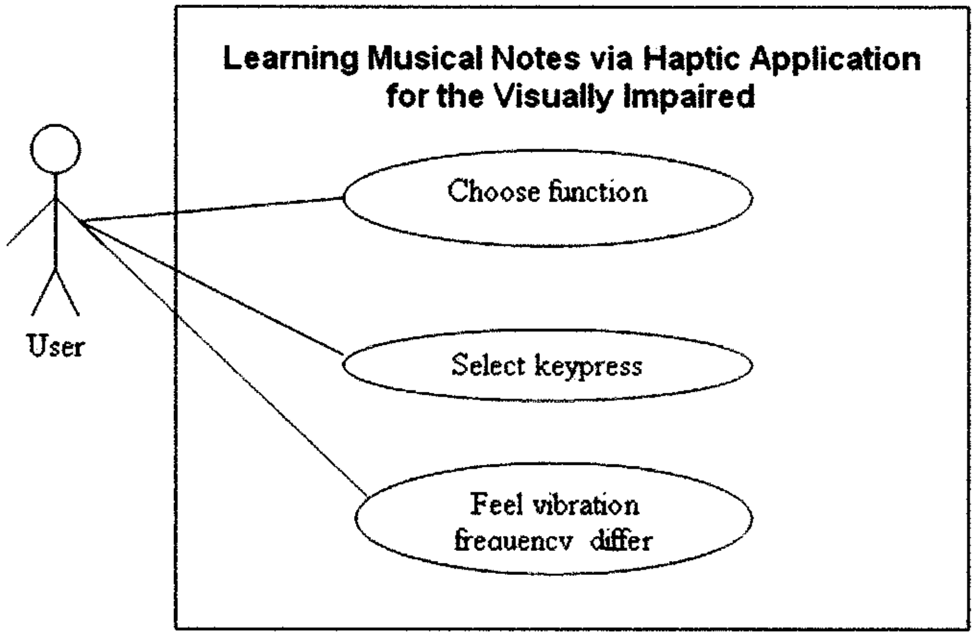

Figure 4.5: System Use Case for Iteration 2

Based from the second iteration System Use Case, it is decided that the user can perform three (3) functions within the system which are:

1. Choose function – A single button clicked to load the function MagnifyScreen or ReadScreen to suit with their type of blindness.
2. Select key press – This function will load the vibration frequency that is associated with the key press, which these key is associated with the respective musical notes.

This function enables user to differentiate between one musical notes to another with the help of different vibration frequencies that is loaded when the respective key is pressed.

3. Feel frequency differ – The user can experience the differences between one musical notes to another with the different kind of vibration frequencies that is coded associated with the respective key press. This can be done with the help of the haptic device.

4.4 System Flowchart

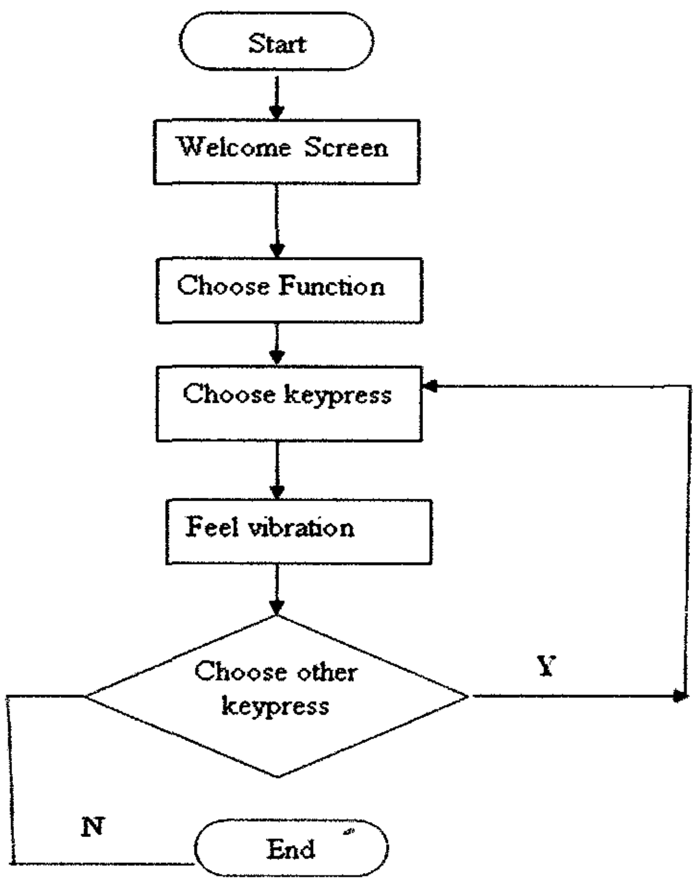

Figure 4.6: System Flowchart

The process begins with the user accessing the application, which will bring to the Welcome Screen. From there, the user would be presented with the choice of selecting what functions they wish to execute based on their type of blindness. Once the user has selected the functions that are appropriate to their type of blindness, they can navigate easily the screen with the help of the functions. The system will then display a console-based application once the user click button "Start". Next, the user can experience for real the kind of musical notes that is indicated by pressing certain keys to generate vibration frequencies that will differ from one another, so that they may differentiate the difference between one musical notes to another via the different kind of vibration frequencies.

4.5 Interface

4.5.1 Welcome Page Graphical User Interface (GUI)

The system will start in the welcome page which contains the general instructions of the system. The user can start navigating the system by clicking "Start" button to continue or "Exit" button to exit the application.

Iteration 1:

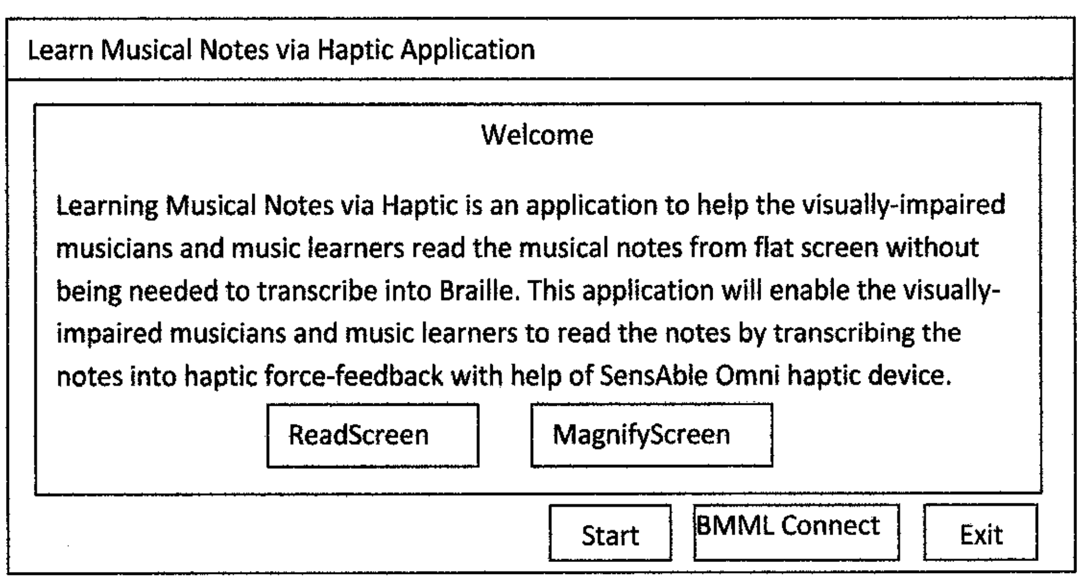

Figure 4.7: Welcoming Page GUI – Iteration 1

In the first iteration of the development of the Welcome Page GUI, the page consists of five (5) buttons that helps the user to make selection. For example, if the user that is using the prototype is a legally-blind musician, he/she may select and click button "MagnifyScreen" and navigate the screen by using mouse or "Tab" key. So as the button "ReadScreen" – which this is ideally implemented for the totally-blind musicians. The "Start" button will load the console-based executable file that contains the interface for the musical notes and its associated keypress. The "BMML Connect" button, once pressed, will load the BMML [2] webpage that allows the user to access the available Braille transcription and it will be mapped and transcribed into vibro-tactile force feedback with the help of Omni haptic device. The "Exit" button, once clicked, it will pop-up a window for exiting application that requires user's confirmation whether to quit the application or not. Once click "Yes" the application exited. If the user clicked "No", the application returns to the Welcome Page GUI.

Iteration 2:

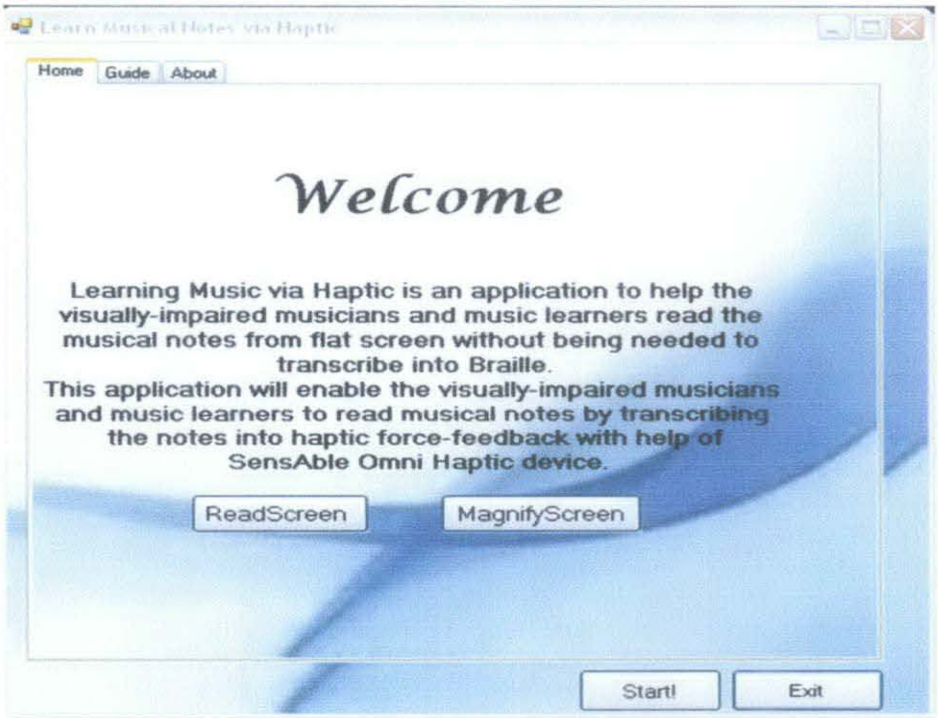

Figure 4.8: Welcoming Page GUI – Iteration 2

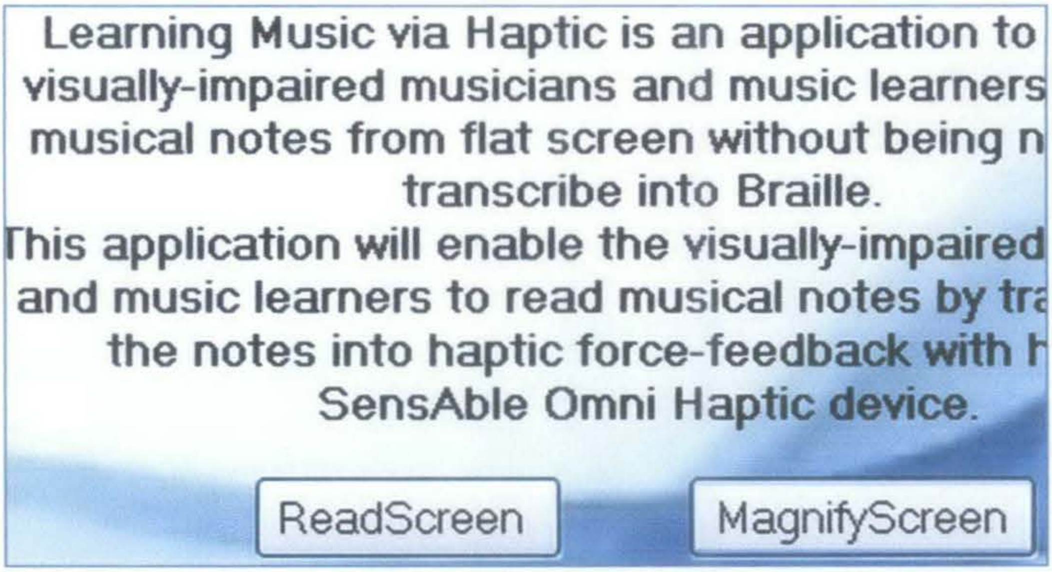

Figure 4.9: Welcoming Page GUI with MagnifyScreen function – Iteration 2

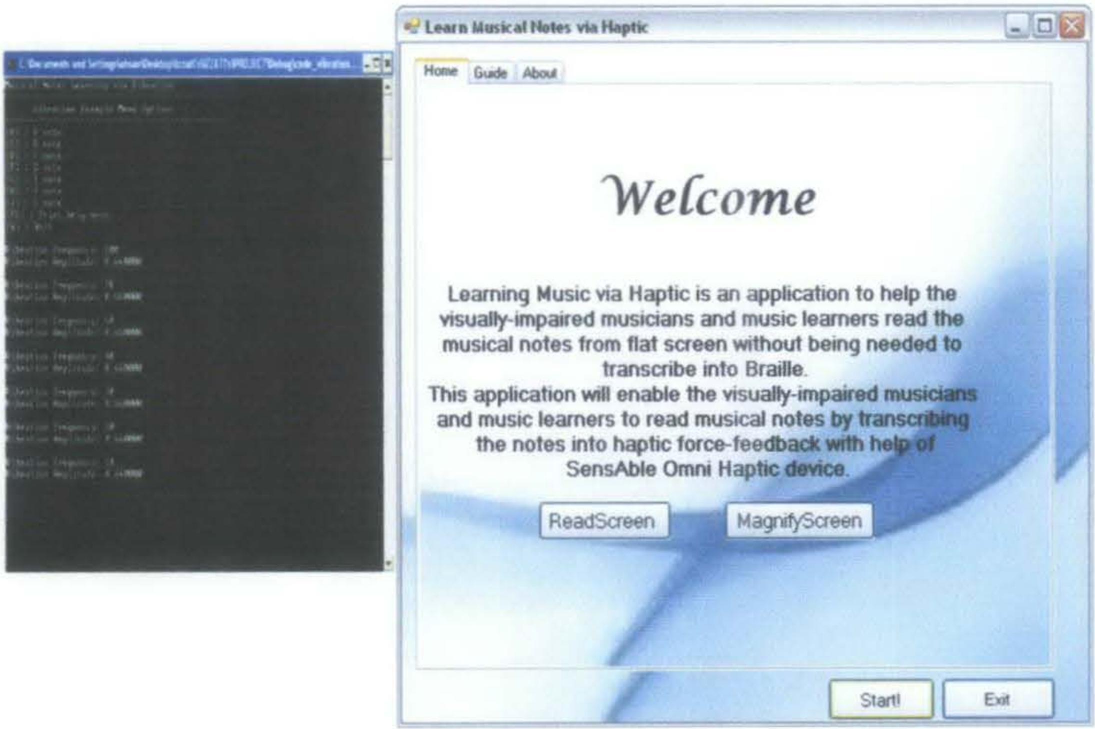

Figure 4.10: Welcoming Page GUI with Start button function on the right and the console-based interface with the vibration values on the left – Iteration 2

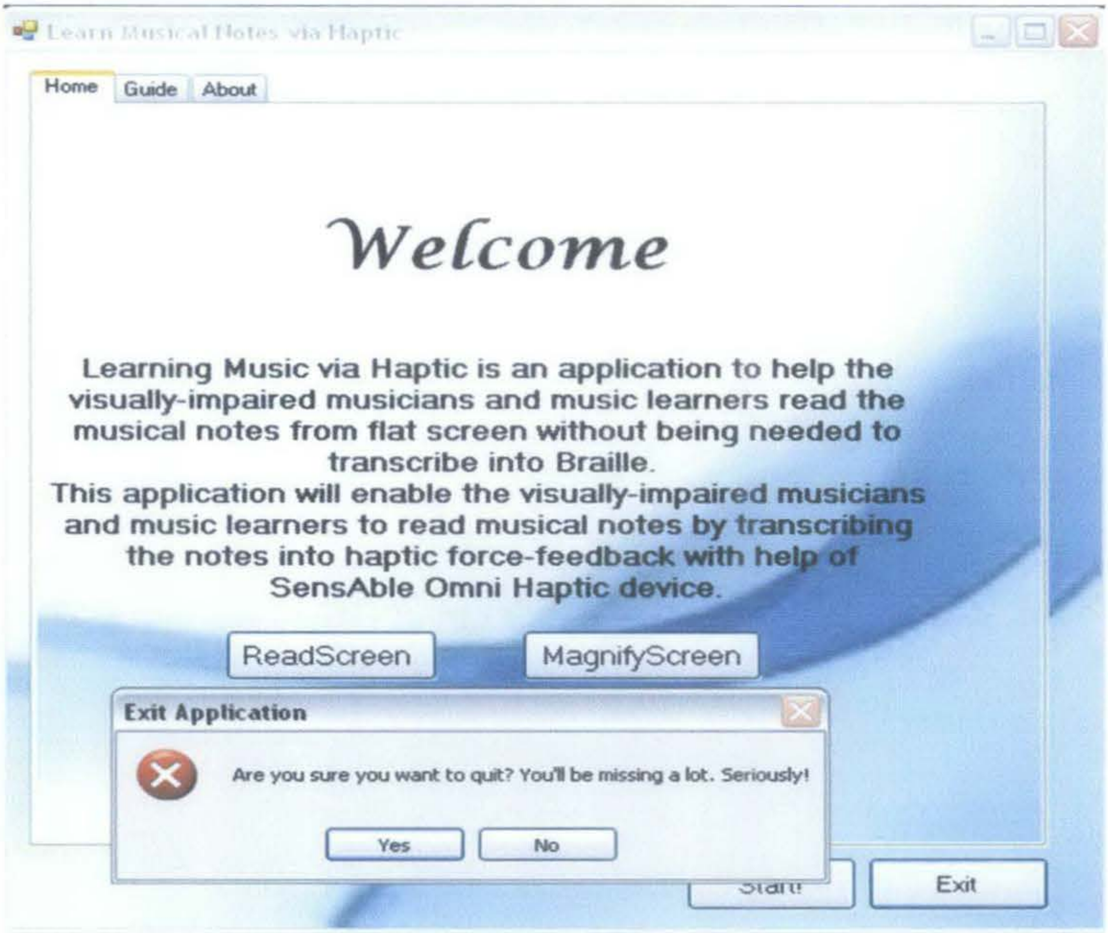

Figure 4.11: Welcoming Page GUI –Exit Application – Iteration 2

In the second iteration of the development of the Welcome Page GUI, the page consists of four (4) buttons that helps the user to make selection. For example, if the user that is using the prototype is a legally-blind musician, he/she may select and click button "MagnifyScreen" and navigate the screen by using mouse or "Tab" key. So as the button "ReadScreen" – which this is ideally implemented for the totally-blind musicians. The "Start" button will load the console-based executable file that contains the interface for the musical notes and its associated key press. The "Exit" button, once clicked, it will pop-up a window for exiting application that requires user's confirmation whether to quit the application or not. Once click "Yes" the application exited. If the user clicked "No", the application returns to the Welcome Page GUI.

4.6 Prototype codes for each musical notes

For this purpose of study, we will only investigate on seven (7) sample notes which are C,D,E,F,G,A and B flat on the timing signature of 4/4. These seven kinds of notes with the same timing will be distinguished by the blind musicians with seven different kinds of vibration frequencies, which they will be using the keyboard to help them navigate the musical notes.

Therefore, we develop vibrations based on seven types of frequencies to be associated with the respective notes and these notes are associated by seven different kinds of keystrokes. The table below indicates the notes associated with the frequency of the vibration and the keystroke:

Types of musical notes	Vibration Frequency	Key press	Amplitude value
"A" note	100	A	0.1
"B" note	80	S	0.1
"C" note	60	D	0.1
"D" note	40	F	0.1
"E " note	30	G	0.1
"F" note	20	H	0.1
"G" note	10	J	0.1

Table 4. 1: Musical notes type, the frequency, the amplitude value and the keystroke associated

4.6.1 Accessing Key press on Keyboard

The key press selected for each and every musical notes as stated in the above table is selected based from the QWERTY keyboard design. The reason why we are incorporating QWERTY keyboard design instead of any other keyboard design is because the QWERTY keyboard is the standard design and it is highly accessible [15].

"We uses keyboard so much in navigating between the system – selecting buttons, opening new application, together with the help of screheen reader software, unlike the sighted, because they can detect the location of the mouse cursor" – Interviewee 1

4.6.1.2 Navigating using Raised Bar/Dot on Home Keys

However, the blind can still gain the advantages of accessing the keypress which is located at the home row of the QWERTY keyboard design since many modern computer keyboards nowadays have a raised dot or bar on the home keys for the index finger to help them discover the correct position of the keys as indicated in Figure 4.12. With the help of the raised dot or raised bar that can be found on the keyboard, the visually-impaired and blind musicians can easily detect the key location since, the key "F" which has the raised dot or bar is at the middle location of the seven keys (A –S – D – **F** – G – H – J). Therefore, the visually-impaired can use the raised dot or raised bar in "F" key to navigate within these seven keys, which three keys to left of the "F" key is the "A", "S" and "D" key while three keys to the right of "F" key is "G", "H" and "J " key.

4.6.1.3 Navigating using the "Tab" key as the Reference Key

Besides that, since the blind and the visually-impaired computer user uses "Tab" key to navigate between buttons, radio buttons, skipping from links to links, dialog boxes and pressing "Spacebar" or "Enter" key to make selection, we make the "Tab" key as our reference key for the blind and visually-impaired to navigate the selected keypress that has been highlighted in Figure 4.12. The sequence of navigation will be, first of all, they will locate the "Tab" key which is referenced above the "Caps Lock" key. Since the "Caps Lock" key is just below the "Tab" key, and the first key next to "Caps Lock" key is the "A" key, followed by "S" key, followed by "D" key, followed by "F" key, next is "G" key, followed by "H" key and the last key is "J" key. The location of these keys are located in a row and in sequence so that the visually-impaired and the blind users can easily detect from one key to another with the help of the main reference key, which is the "Tab" key.

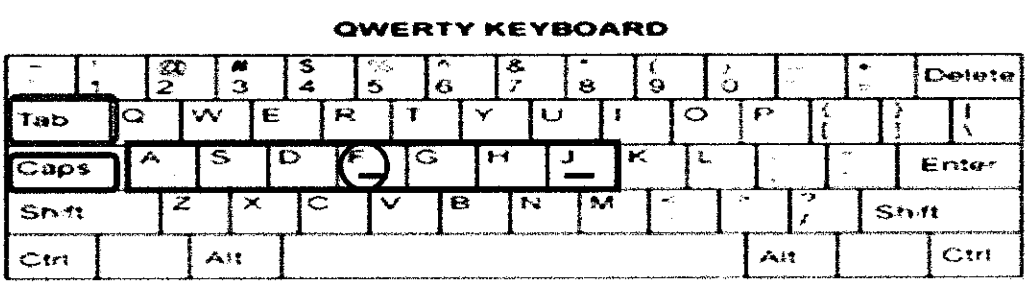

Figure 4.12: QWERTY keyboard design

4.7.1.2 Vibration Values and Vibration Amplitude

The vibration values and the amplitude has been set accordingly so that the user can detect the differences between one musical notes to the other with the different vibration frequencies. The vibration values that has been set associated with the respective keypress has been tested the blindfolded respondents in order to see their responsiveness towards the vibration frequencies and to check whether can they differentiate from one note to another by differentiating the vibration frequencies. The result of the findings will be revealed later in the User Experience Testing section in this report.

The vibration amplitude value is kept constant and is set with restricted value (cap) since we want to prevent from the possibility of ever increasing the vibration amplitude to dangerous limits. Therefore, all sets of the sample musical notes that have been coded associated with its vibration frequencies and amplitudes that is based on the keypress, is coded within the permissible limit.

```
-----------------------------------------------\n\
      Vibration Example Menu Options\n\
===============================================\n\
[A]  :  A note\n\
[S]  :  B note\n\
[D]  :  C note\n\
[F]  :  D note\n\
[G]  :  E note\n\
[H]  :  F note\n\
[J]  :  G note\n\
[F1]  : Print help menu\n\
[Q]  :  Quit");
```

Figure 4.13: Excerpt Coding for Console menu on Musical Notes Learning via Vibrations

```
while (HD_TRUE)
{
    if (_kbhit())
    {
        keypress = toupper(getch());

        if (keypress == 'Q')
        {
            break;
        }
        else if (keypress == 'A')
        {

                nFrequency = 100;

            hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                                  HD_DEFAULT_SCHEDULER_PRIORITY);
        }
        else if (keypress == 'S')
        {

                nFrequency = 80;

            hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                                  HD_DEFAULT_SCHEDULER_PRIORITY);
        }

  else if (keypress == 'D')
  {

          nFrequency = 60;

      hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                            HD_DEFAULT_SCHEDULER_PRIORITY);
  }
  else if (keypress == 'F')
  {

          nFrequency = 40;

      hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                            HD_DEFAULT_SCHEDULER_PRIORITY);
  }
  else if (keypress == 'G')
  {

          nFrequency = 30;

      hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                            HD_DEFAULT_SCHEDULER_PRIORITY);
  }
```

```
else if (keypress == 'H')
{
        nFrequency = 20;

    hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
 else if (keypress == 'J')
{
        nFrequency = 10;

    hdScheduleSynchronous(SetVibrationFreqCallback, &nFrequency,
                          HD_DEFAULT_SCHEDULER_PRIORITY);

}
```

Figure 4.14: Excerpt Coding on the seven kinds of vibration frequency with its key press associated

```
else if (keypress == 'A')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
 else if (keypress == 'S')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
 else if (keypress == 'D')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
 else if (keypress == 'F')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
```

```
else if (keypress == 'G')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
else if (keypress == 'H')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
else if (keypress == 'J')
{
    amplitude = .1;

    hdScheduleSynchronous(SetVibrationAmplitudeCallback, &amplitude,
                          HD_DEFAULT_SCHEDULER_PRIORITY);
}
```

Figure 4.15: Excerpt Coding on the key press and its associated amplitude

4.7 System Integration Testing

The system integration testing is performed by creating scenarios that will occur throughout using the application. The two scenarios identified are:

1. Using the application with MagnifyScreen function

We need to test the application once the legally-blind users execute the MagnifyScreen function, which by default; it is supposed to load the third pary screen magnifier tool which is the DesktopZoom that will magnify the screen. Once this is successfully done, the user can proceed with starting the application by pressing "Start" button. Once clicked, by default, it will load the console-based executable file program (.exe) which will be the interface that displays the "Vibration Example Menu Options" menu.Users can test to feel the vibration by holding the PHANToM Omni haptic device and pressing the key press for the associated musical notes. Once done, the interface should allow the user to exit the application without errors.

2. Using the application with ReadScreen function

We need to test the application once the legally-blind users execute the ReadScreen function, which by default; it is supposed to load the third party screen magnifier tool which is the Thunder Screen Reader that will read out the screen. Once this is successfully done, the user can proceed with starting the application by pressing "Start" button. Once clicked, by default, it will load the console-based executable file program (.exe) which will be the interface that displays the "Vibration Example Menu Options" menu. Users can test to feel the vibration by holding the PHANToM Omni haptic device and pressing the key press for the associated musical notes. Once done, the interface should allow the user to exit the application without errors.

Execution and System Integration Testing

The system integration testing has been completed in Iteration 2 and logged into Table 4.2. It is considered that the system has passed both the scenarios described without any recorded fail or blocked status in both scenarios. System Integration Testing is passed and therefore we can move on to User Experience Testing.

Test Case	Test Condition	Expected Result	Actual Result	Execution Date	Result
Using the application with MagnifyScreen function 1) The Welcome Page GUI is displayed 2) User select the MagnifyScreen function and start the application 3) User can feel the vibration difference based on the keypress pressed					
Using the application with MagnifyScreen function	Start the prototype	The prototype loads correctly	The prototype loads correctly	23/11/2011	Pass
	Click on the MagnifyScreen button	The interface loads the third party desktop magnifier tool and magnify the screen	The interface loads the third party desktop magnifier tool and magnify the screen	23/11/2011	Pass
	Click on the Start button to start the application	The interface loads the executable file program (.exe) that displays "Vibration Example Menu Options"	The interface loads the executable file program (.exe) that displays "Vibration Example Menu Options"	23/11/2011	Pass
	Press the keypress to feel the vibration	The vibration is felt once the user press the key associated with the musical notes	The vibration is felt once the user press the key associated with the musical notes	23/11/2011	Pass
	Exit application by pressing "Q"	Application is terminated	Application is terminated	23/11/2011	Pass

Using the application with ReadScreen function **1) The Welcome Page GUI is displayed** **2) User select the ReadScreen function and start the application** **3) User can feel the vibration difference based on the keypress pressed**					
Using the application with ReadScreen function	Start the prototype	The prototype loads correctly	The prototype loads correctly	23/11/2011	Pass
	Click on the ReadScreen button	The interface loads the third party screen reader tool and read the screen	The interface loads the third party screen reader tool and read the screen	23/11/2011	Pass
	Click on the Start button to start the application	The interface loads the executable file program (.exe) that displays "Vibration Example Menu Options"	The interface loads the executable file program (.exe) that displays "Vibration Example Menu Options"	23/11/2011	Pass
	Press the keypress to feel the vibration	The vibration is felt once the user press the key associated with the musical notes	The vibration is felt once the user press the key associated with the musical notes	23/11/2011	Pass
	Exit application by pressing "Q"	Application is terminated	Application is terminated	23/11/2011	Pass

Table 4.2: System Execution and Integration Testing Result

4.8 User Experience Testing

The ReadScreen and MagnifyScreen testing is developed to suit with the target user that will be using this program, which is the legally-blind and the totally-blind musicians and music learners.

For the purpose of the User Experience Testing, a pilot testing has been done where we have selected random set of sighted respondents to test the system because it is quite difficult for us to conduct the testing with our target users based from several reasons for example the time needed to conduct the overall testing process with the blind and visually-impaired musicians.

According to [16], there is a lack of formal testing methods to test the haptic software for the blind, thus the following method are used as the basis of the user experience, in order to fulfill the requirements.

Methodology

A random set of sighted respondents that have been blindfolded, including two (2) short-sighted respondents (they were not blind-folded, but were required to take off their correcting lenses) have been chosen to test and experience the system. This method is used by [16] to use blindfolded respondents for several of the haptic models that were being tested and a number of 3 to 6 respondents are used as a source of feedback which depends on time constraint, amount of unique feedback given as well as cost associated.

The respondents have been briefed on the purpose of the study which is to build a prototype that helps the visually-impaired and blind musicians and music learners learn musical notes without being needed to transcribe into Braille, with the help of haptic as well as the purpose of the testing that will be done to them. Each and every respondent has been given a consent form and all of the information regarding the respondents is kept anonymous.

To begin with, a total of five (5) respondents who have been has taken part in this testing with 3 of the respondents have been blind-folded to imitate the behavior of the totally-blind users while two (2) of them who is short-sighted with lens power more than 400 (-4.00 Diopter) in both eyes, to imitate the behavior of the legally-blind users.

Testing Procedures

1. Respondents were greeted and were assured their anonymity and confidentiality of information that has been provided, and nothing is identifiable from them. All respondents were told that the results of the testing will be used to investigate how effective the system functionalities and how they experience the system in overall. All respondents were informed in the consent form that they may withdraw in any moment without prejudice.
2. All respondents were briefed on the purpose of the study and the purpose of the testing. They were allowed to ask questions if they have any and to comment in regards to the system usefulness at any time. All respondents were given the same set of questionnaires to be answered at the end of the testing period so that they may respond without prejudice. All data is collected from this time.
3. For respondents who were short-sighted, they were not blind-folded, however they were required to take off their spectacles and try to navigate the system without the help of their correcting lenses. While the respondents which has been blindfolded were guided by the Guide for the first testing of the prototype, so that they were familiar especially with the keypress location, since many of the sighted didn't remember the keypress location of the alphabets and depend solely on their sight.
4. All respondents were given approximately 10 minutes to navigate the system and to feel the differences of the vibration from one note to another while the Guide explain to them what they actually doing with the prototype.

5. After all respondents have done the test, they can take-off the blindfold and wear their spectacles back and all of them are required to answer a questionnaire on the appropriateness and the functionalities of the system.
   See Appendix C – User Experience Test Questionnaire
6. All respondents were debriefed on what was happening when they were navigating the system.
7. Respondents were thanked for their time and willingness to take part in the test.

Data Gathering

All respondents were given the same set of questionnaire that consists of two (2) parts which is Part A: Demographic Information and Part B: Appropriateness of the System Navigation and System Functionalities. For Part A, a total of five (5) respondents have taken part in the test where three (3) of them were female while the rest were male. Their age range is 21 years old till 31 years old. For Part B, a total of five (5) scale-based questions have been asked to investigate the functionalities and the system effectiveness in the eyes of the respondents while an open-ended opinion-based question has been asked in the last section of Part B to gather the respondents' comments and opinions in regards to the overall system and their further recommendations to make the system better.

Testing Results

BY THE NUMBERS : APPROPRIATENESS OF SYSTEM NAVIGATION AND FUNCTIONALITIES AS TESTED IN 5 RESPONDENTS INCLUDING 2 SHORT-SIGHTED RESPONDENTS WITH LENS POWER > 400 (-4.00 Diopter) FOR BOTH EYES				
60% Respondents rate the system appropriateness and functionalities in terms of the use of big display (screen magnifier) and touch sensation (vibration) in navigating and using the system as "Good"	**40%** Respondents rate the system appropriateness and functionalities in terms of the use of sound (read screen functionality) and touch sensation (vibration) in navigating and using the system as "Good"	**60%** Respondents rate the system appropriateness and functionalities in terms of the position of the keys associated to the musical key notes (key A,S,D,F,G,H and J) and the easiness to navigate these keys as "Easy"	**80%** Respondents rate the system appropriateness and functionalities in terms of the easiness to differentiate different kind of vibrations associated with different kind of musical notes as "Easy"	**80%** Respondents rate the overall "Learning Musical Notes via Haptic Application" functionalities in terms of touch sensation, sound and display as "Good"

Rating Scale: From 0 to 5; 0 is rated as "Bad or Hard" and 5 is rated as "Good or Easy"

Figure 4.16: System Appropriateness and Functionalities Result (up) and blindfolded respondents (down)

During the testing, some of the respondents have commented in regards to the system functionalities. These comments were logged in the Table 4.3.

Issues(Comment)/Respondents	R1	R2	R3	R4	R5
Make sound more clearer/ provide clearer narration of instruction	√	√			√
Key position issue. Respondent were unable to locate correctly the key position			√	√	
It's quite hard to differentiate the kind of vibrations associated with the kind of musical notes			√		
Take into consideration of incorporating other language like local language other than English since using local language can enhance the acceptability of the system		√			

Table 4.3: User Experience Testing Logged Issues – 2nd Iteration

Based from the testing and the results gathered, the issues highlighted is prioritized and are examined in order for us to indicate the implementation feasibility. This implementation feasibility will be looked again and will be developed again in the next iteration.

Issue	Priority	Description	Solution Status
Make sound more clearer/ provide clearer narration of instruction	High	The sound produced by the third party screen reader software is monotone and it is hard for the user to indicate what is being said	We may shift to any other freeware screen reader software that is available besides using the existing screen reader software. Status: Done and implemented in 3rd iteration
Key position issue. Respondent were unable to locate correctly the key position	Medium	Users were having difficulties in locating the keypress for the associated musical notes because they depend solely on their sight while using the keyboard.	Train users to reference the keys by using the "F" key which is easily detected because it has the raised bar/raised dots on it. From there, they can navigate the keys, which is 3 keys from left of "F" key is "A,S and D" and 3 keys to the right of "F" key is "G,H and J".

			Status: Done and implemented in 3rd iteration
It's quite hard to differentiate the kind of vibrations associated with the kind of musical notes	Medium	Users were having difficulties in differentiating from one musical note to another since the vibration frequency from one note to another does not differ much and the frequency is high.	Set the vibration frequency value to below 100 because it is more detectable by users' haptic sense. Status: Done and implemented in 3rd iteration
Take into consideration of incorporating other language like local language other than English since using local language can enhance the acceptability of the system	Low	Users recommend that developer use other languages as well besides English since based on his opinion, this will enhance the system acceptability.	Each user has different perception in regards to the system. Future Proposal: Implement multi-language welcome page and multi-language screen reader

Table 4.4: User Experience Testing – Action Taken

Table 4.5 shows the third iteration User Experience Testing result that has been done in 3 randomly selected respondents:

Comment/ Participant	P1	P2	P3
Clearer sound and more friendly narration	√	√	√
Still difficult to differentiate the kind of vibrations associated with the kind of musical notes			
Still difficult to locate correctly the key position		√	

Table 4.5: User Experience Testing Result Iteration 3

From the comments above, we can see that the trend of navigating the system as well as the system functionalities and effectiveness increases as the number of logged issues decreases between users. From the UET done in Iteration 3, only one (1) user still finds it difficult to locate correctly the key position, and this can be solved with proper training in regards to locating the keys.

Based from the user experience testing result, 80% of the respondents agreed that they were satisfied with the application in terms of the overall functionalities which includes touch sensation, sound and big display without any major complains with the system functionalities and appropriateness of operability. Many believe that this system can be used with the blind, to help them learn the musical notes in a new learning horizon.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Through this project we intend to design and develop a prototype to help the blind musicians and music learners to read the musical notes in the musical scores from flat surface like the computer screen by the help of a tool that will mechanically "transform" the musical notes in the screen into a haptical, touchable sense that will be received through the user's haptic senses.

By implementing this project, hopefully the visually-impaired musicians and music learners can now cross the boundaries that limit their interest in learning and playing music and there is no need for sole dependency on learning and reading musical notes with Braille-transcribed musical scores.

Recommendations

Throughout developing this project, there are several recommendations that have been identified to be explored for future developments of the system to help the visually-impaired learn musical notes. The needs for the future works on these recommendations has been gained from the interview session conducted with the National Council for the Blind Malaysia (NCBM) as well as personal opinion gathered from the blind musicians that took apart in the survey.

- ✓ Integrate to BMML for widening scope

  Braille Music Markup Language (BMML) is an XML-based markup language that allows music scores to be access easily via the net. The format enables Braille music notations and symbols specificities to be handled by BMML and takes into account the core features of existing formats, where the main objective is to improve the accessibility of the Braille musical scores.

By incorporating Braille Music Markup Language (BMML) within the application prototype, the visually-impaired musicians and music learners can now resort to a readily set of musical scores that is available in Braille instead of transcribing them with transcription software. BMML provides enriched, multimedia scores from the ever growing digital library that allows the visually-impaired musicians and music learners to study with great flexibility and add new scores to the library [2]. A further implementation can be done to map the musical scores with the haptic so that it will benefit the blind and visually-impaired musicians and music learners.

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APPENDIX

APPENDIX A

Project Gantt Chart

System Milestone

	Jan	Feb	Mar	Apr	May	Sept	Oct	Nov	Dec
Iteration 1									
-Planning & Requirements Gathering					X				
-System Analysis and Design									
Iteration 2									
-System Analysis & Design									
-System Implementation							X		
System Testing								X	
Iteration 3									
-System Implementation									
-System Testing									
- System Deployment									X

X

Milestone

APPENDIX B

Questionnaire

The purpose of this survey is to get information on the blind people on how they learn music and/or how they perceive musical instruments and senses in their opinion.

PART A: Demographic Information

Please select accordingly based from below questions.

1. What is your gender?

Male

Female

2. What is your age?

Less than 17 years old

17-24 years old

25-29 years old

30-34 years old

35-39 years old

More than 39 years old

3. What is your type of blindness?

deaf-blind or

color-blind (which is the disability to perceive between some colors that others can distinguish) or

night- blind (which is the difficulties in seeing under situations of decreased illumination) or

snow-blind (which is the loss of vision after exposure of eyes to large amounts of ultraviolet or lights) or

Others (Please specify)

PART B: Experience in Music

Please select accordingly based from below questions.

1. Do you know how to read musical scores or do you have understanding in music?
   Yes (if YES, Proceed to Question 2)

   No (if NO, Proceed to questions in PART C and D)

2. How do you learn music?
   Learn by ear or
   by music Braille or
   Others (Please specify):

   ____

3. How do you access the music scores?
   from the available Braille score resources or
   from the internet and transcribed into music Braille by the Braille embosser or
   Others (Please specify):

   ____

4 . Do you play any musical instrument?

Yes or

No (if NO, skip the rest of the questions in this part and continue answering questions in PART C and D)

5 . What type of musical instruments do you play?

Chordophones – which is vibrating strings (e.g. piano, guitar, banjo, violin, fiddle, harp)

Aerophones – which is Vibrating air (e.g. flute, recorders, fife, harmonica, accordion, bugle, organ)

Membranophones – which is Vibration of a stretched skin (e.g. Drums, kazoos)

Idiophones – which is Vibration of the instrument itself (e.g. Tap shoes, bells, maracas, castanets)

Electrophones – which is Instrument that is amplified electrically (e.g. electric guitar, electric bass, electric organ, synthesizer)

5. How often do you play a musical instrument?

Less than1 hour per week or 1-3 hours per week or

3-5 hours per week or More than 5 hours per week

PART C: Musical Instrument vs. Human Senses

In your opinion, which human senses are important when playing a particular type of a musical instrument listed? Please choose appropriately. (You can choose more than one human senses for each type of the instrument.)

Type of Musical Instrument	Human Senses				
	Sight	Hearing	Touch	Taste	Smell
Chordophones e.g. piano, guitar, banjo, violin, fiddle, harp					
Aerophones e.g. flute, recorders, fife, harmonica, accordion, organ					
Membranophones e.g. Drums, kazoos					
Idiophones e.g. Tap shoes, bells, maracas, castanets					
Electrophones e.g. electric guitar, electric bass, electric organ, synthesizer					

PART D: The Importance of Human Senses in Playing a Musical Instrument

Please circle the appropriate number on the scale from 1 to 5 based on the importance of the specified human sense to the type of musical instrument indicated.

Type of Musical Instrument	Human Senses	Not important				Very important
Chordophones e.g. piano, guitar, banjo, violin, fiddle, harp	Sight	1	2	3	4	5
	Hearing	1	2	3	4	5
	Touch	1	2	3	4	5
	Taste	1	2	3	4	5

	Smell	1	2	3	4	5
Aerophones e.g. flute, recorders, fife, harmonica, accordion, bugle, organ	Sight	1	2	3	4	5
	Hearing	1	2	3	4	5
	Touch	1	2	3	4	5
	Taste	1	2	3	4	5
	Smell	1	2	3	4	5
Membranophones e.g. Drums, kazoos	Sight	1	2	3	4	5
	Hearing	1	2	3	4	5
	Touch	1	2	3	4	5
	Taste	1	2	3	4	5
	Smell	1	2	3	4	5
Idiophones e.g. Tap shoes, bells, maracas, castanets	Sight	1	2	3	4	5
	Hearing	1	2	3	4	5
	Touch	1	2	3	4	5
	Taste	1	2	3	4	5
	Smell	1	2	3	4	5
Electrophones e.g. electric guitar, electric bass, electric organ, synthesizer	Sight	1	2	3	4	5
	Hearing	1	2	3	4	5
	Touch	1	2	3	4	5
	Taste	1	2	3	4	5
	Smell	1	2	3	4	5

- Thank you -

APPENDIX C

USER EXPERIENCE TEST

The purpose of this questionnaire is to get information on the blind people on how they perceive the "Learning the Musical Notes via Haptic Application" and how they rate the usability aspect of the application.

<u>PART A: Demographic Background</u>

Please select accordingly based from below questions:

1. What is your gender?
   ☐ Male ☐ Female

2. What is your age?
   ☐ 16-20 years old ☐ 26-30 years old

   ☐ 21-25 years old ☐ 31 years old and above

<u>PART B: Appropriateness of the System Navigation and System Usability</u>

Please select accordingly based from below questions:

1. Based from your experience in doing the pilot test of the system, please rate the system appropriateness and functionalities in terms of the use of big display (screen magnifier functionality) and touch sensation (vibration) in navigating and using the application.
   (0 = Bad, 5 = Good)

0 1 2 3 4 5

2. Based from your experience in doing the pilot test of the system, please rate the system appropriateness and functionalities in terms of the use of sound (read screen functionality) and touch sensation (vibration) in navigating and using the application.
   (0 = Bad, 5 = Good)

0 1 2 3 4 5

3. Based from your experience in doing the pilot test of the system, please rate the system appropriateness and functionalities in terms of the position of the keys associated to the musical notes (key A, S, D, F, G, H, and J) and the easiness to navigate these keys.
(0 = Hard, 5 = Easy)

0 1 2 3 4 5

4. Based from your experience in doing the pilot test of the system, please rate the system appropriateness and functionalities in terms of the easiness to differentiate different kind of vibrations associated with the different kind of musical notes.
(0 = Hard, 5 = Easy)

0 1 2 3 4 5

5. Based from your experience in doing the pilot test of the system, how do you rate the overall "Learning Musical Notes via Haptic Application" functionalities (touch sensation, sound and display)?
(0 = Bad, 5 = Good)

0 1 2 3 4 5

6. Do you have any comment in regards to the application's functionalities and operability? If yes, please state below:

____

____

____

APPENDIX D – Study Document

23rd March 2011

Utilizing Haptics (Touch) for Helping the Visually-Impaired Read/Learn Musical Notes From Flat Screen: General Information

Project Purpose

Thank you for volunteering to participate in this study. This is an interview session as part of a study aimed at obtaining the understanding of how the visually impaired learns musical notes in the current approach and the technology available for them to learn and read the musical notes. This study will contribute toward the research topic of a university student Final Year Project to create a software program in able to help the blind and visually-impaired musicians read and learn musical notes from flat screen without being needed to transcribe them into Braille.

We assure you that all the recorded items will be strictly used for the purpose of this study only and will be kept in such a way that you cannot be identified from the data.

We are very grateful for your participation. However, you will not receive compensation of any kind for participating in this project.

The whole study takes about 10 to 20 minutes. Please feel free to answer as honestly as possible. Please do not feel forced in answering any questions.

Please feel free to ask questions pertaining to this study through the corresponding contact address. While the researcher will be happy to answer any general questions you may have, s/he has been instructed not to discuss some aspects of the study until the end.

Attached in the next section is a Consent Form pertaining to this study very shortly. Please read the form.

Thank you.

Interview Questioning Consent

Universiti Teknologi PETRONAS

Bandar Seri Iskandar,

31750 Tronoh,

Perak Darul Ridzuan.

Tel: 019-52229311

Email: izzati.omar89@gmail.com

Researcher name: Nurul Izzati binti Omar

Date: 23 March 2011

Initials: N.I.O

CONSENT FORM

Title of Study: Utilizing Haptics (Touch) for Helping the Visually-Impaired Read/Learn Musical Notes From Flat Screen

1. *I confirm that I have read and understood the general information sheet for the above study and have had the opportunity to ask questions.*

2. *I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.*

3. *I agree to take part in the above study. If I do not agree by these terms, I will not answer any questions.*

I give my consent to participate in this study:

______________________________ ______________

Signature of Study Participant Date

I give my consent to be audio taped in this study:

Signature of Study Participant   Date

Signature of Person Obtaining Consent   Date

User Acceptance Testing Consent Form

Universiti Teknologi PETRONAS

Bandar Seri Iskandar,

31750 Tronoh,

Perak Darul Ridzuan.

Tel: 019-5229311

Email: izzati.omar89@gmail.com

Researcher name: Nurul Izzati binti Omar

Date: 23rd November 2011

Initials: N.I.O

CONSENT FORM

Title of Study: Utilizing Haptics (Touch) for Helping the Visually-Impaired Read/Learn Musical Notes from Flat Screen – User Acceptance Testing

1. *I confirm that I have been briefed thoroughly of the objectives of the study and have had the opportunity to ask questions.*

2. *I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.*

3. *I agree to take part in the above study. If I do not agree by these terms, I can withdraw myself immediately.*

I give my consent to participate in this study:

Signature of Study Participant	Date

I give my consent to be audio taped in this study:

______________________________ ______________

Signature of Study Participant Date

______________________________ ______________

Signature of Person Obtaining Consent Date