Synchronizing Audio and Haptic to Read Webpage

By

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Business Information System Programme
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Approved by,

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(Dr Suziah Binti Sulaiman)

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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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HANIS IRYANI BINTI HASHIM

ABSTRACT

Constantly emerging technologies present new interactive ways to convey information on the Web. The new and enhanced website design has gradually improved sighted users' understanding on the Web content but on the other hand, it creates more obstacles to the visually impaired. The significant technological gap in assistive technology and the Web presents on-going challenges to maintain web accessibility, especially for disabled users. The limitations of current assistive technology to convey non-textual information including text attributes such as bold, underline, and italic from the Web further restrict the visually impaired from acquiring comprehensive understanding of the Web content. This project addresses this issues by investigating the problems faced by the visually impaired when using the current assistive technology. The significance of text attributes to support accessibility and improve understanding of the Web content is also being studied. For this purpose several qualitative and quantitative data collection methods are adopted to test the hypotheses. The project also examines the relationship between multimodal technology using audio and haptic modalities and the mental model generated by the visually impaired while accessing webpage. The findings are then used as a framework to develop a system that synchronizes audio and haptic to read webpages and represents text attributes to visually impaired users is to be develop. From the prototype built, pilot testing and user testing are conducted to evaluate the system. The result and recommendations are shared at the end of project for future enhancement.

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CHAPTER 1

INTRODUCTION

1.1 Background Of Study

The Internet has revolutionized communication, information transfer and simplifies almost every aspects of human life. The World Wide Web (WWW) is now the most popular way to share information. Constantly emerging technologies presents new ways to convey information on the Web. Websites nowadays not only provide dynamic content based on user profile, but also using latest technologies such as AJAX, Flash and Silver Light to increase the richness of the Web content (Sandhya et. al, 2011). The increasing complexity of the Web due to the technological enhancement inadvertently contributes to higher accessibility barriers for disabled users (Hackett et. al, 2004). As a result, these booming technologies present on-going challenges to maintain web accessibility, especially for disable users.

According to World Wide Web Consortium (W3C), a Website is accessible when its content can be accessed by almost everyone, including disabled users. In other words, Web accessibility means that people with disabilities can perceive, understand, navigate, interact, and contribute to the Web. Besides, Web accessibility also benefits others with changing abilities due to aging. As people grow older, the chance to live with disabilities is stronger. Most of them will lose some of their abilities to focus, resolve image, distinguish colour, and adapt to the changes of light (Hackett et. al, 2004). Therefore, maintaining Web accessibility would benefits a large portion of user groups and increases Web's audience.

Previously in the early usage of the Web, the content was primarily presented in a simple linear text-based structure. Visually impaired users can access most of the

Web content by using assistive technology such as screen reader and Braille output device. As website design become more advance, non-textual elements such as image, frames, tables, animation, streaming video, and audio flash are being included to enhance the browsing experience of Internet users in more complex ways. The new and enhanced website design has gradually improved sighted users' understanding of the Web content but on the other hand, it creates more obstacles to visually impaired users to obtain information on the Web.

The U.S. federal Government recognized the problem faced by the disabled users and came out with the Rehabilitation Act Amendments of 1998, which require Federal agencies to make their electronic and information technology accessible to disabled users. Section 508 aims to eliminate barriers in information technology in order to make it accessible to disabled users and to encourage development of technology that serve to fulfil this goal. The law applies to all Federal agencies when they develop, procure, maintain, or use electronic and information technology.

Another well-known organization that is working towards higher Web accessibility among the disabled users is World Wide Web Consortium (W3C). W3C outlined the standards for web content developers and developers of authoring tools in order to promote accessibility to people with disabilities by developing Web Content Accessibility Guidelines (WCAG). WCAG consists of fourteen guidelines that provide specification on how to develop an accessible website. The guideline does not discourage content developers from using non-textual elements; images, video, etc., but rather explain how to make multimedia content more accessible to a wide audience.

However, in a survey carried out by the Disability Rights Commission in 2004, 81% of the websites failed to meet the basic accessibility criteria. This is due the shortcomings of assistive technologies and insufficient presentation of the web content (Murphy et. al., 2008). In another study on private and non-profit websites by Lazar et. al (2003), 49 out of 50 websites were identified to have accessibility problem. Modern Websites are often difficult to be interpreted by the current assistive technologies. This is because non-textual elements in the Webpage are not readable by most of the assistive technologies. In a nutshell, there is a significant gap between the technological advancement in assistive technologies as compared to the advancement in Web application technology and design.

Audio feedback is no longer the sole modality to assist in Web browsing. Recently, haptic modality had been used to improve Web accessibility. Researches had shown that the usage of audio in conjunction with haptic modality would further benefit the visually impaired users in understanding the Web content (Yu et. al, 2002). In a study by Zainal Abidin et al. (2012), mental model of two-dimensional perspectives from visually impaired had been developed to enhance the web accessibility. The two dimensional mental model integrates tactile and audio feedback in their experiment. Then, Kuber et al. (2007) had come out with assistive multimodal interface to improve Web accessibility and navigation for the blind users.

Therefore, the project aims to address the problems faced by visually impaired Internet users to access websites through the implementation of a system which synchronizes audio and haptic. The system would aid visually impaired users to read webpages and at the same time, provides effective text attributes representations. Thus, the project is hoped to enhance the browsing experience of visually impaired users and reduces the accessibility barriers by providing dynamic accessibility to the Web.

1.2 Problem Statement

“The limitation of Web accessibility in terms of its text attributes representation in webpages hinders the visually impaired users from having a comprehensive understanding of the web content.”

- According to International Classification of Disease (2006), there are four levels of visual function; normal vision, moderate visual impairment, severe visual impairment, and blindness. In this study, the “visually impaired users” are categorized in the fourth category.
- Website accessibility for disabled Internet users is constantly challenged by the rapid technological advancement and the increased interactivity of the Web technology.
- Assistive technologies had been widely used to assist the visually impaired to access the Web. One of the most widely used assistive technologies to access the Web for visually impaired users is screen reader.
- However, the current assistive technologies possess several limitations in conveying the information from webpage. The screen reader only provides linear textual representations, it cannot read non-textual attributes.
- In this context, non-textual attributes consist of not only images or graphics, but also referring to the way texts are being represented. For example: bold, underline, and italic. These text attributes are important to convey in-depth meanings and subsequently improve the user’s understanding of the Web content.
- These limitations restrict Web accessibility among the visually impaired users from having a comprehensive understanding of the Web content.

1.3 Objectives

The objectives of the project are:

i) To investigate the significance of text attributes to support Web accessibility and improve understanding of the content:

   a) To determine from literature about Web accessibility.

   b) To ask from the visually impaired their Web browsing experience.

ii) To develop a system that synchronizes audio and haptic to read webpage and represents text attributes to visually impaired users.

iii) To test the audio haptic synchronization system with the visually impaired users.

1.3.1 Scope Of Study

The study focused on improving Web accessibility in term of text attributes representation among users with high degree of visual impairment. A system that synchronizes the audio and haptic feedbacks is to be developed to read webpage and represents the non-textual attributes in a more comprehensive way. The system is then to be tested by the visually impaired.

1.3.2 Relevancy of the Project

The project aims to increase Web accessibility among visually impaired, by representing text attributes in a webpage. According to World Health Organization (WHO), about 285 million people are visually impaired worldwide; 39 million are blind and 246 and have low vision. From the figures, about 90% of the world's visually impaired live in developing countries. In a study of accessibility by Microsoft in 2003 among adult computer users in the United States, 17% (21.9 million) of computer users have a mild visual difficulty or impairment, and 9% (11.1 million) of computer users have a severe visual difficulty or impairment. These statistics define the relevancy of the target users defined in this project.

The project also aims to develop a system that synchronizes audio and haptic to read webpage and represents text attributes to visually impaired users and eventually test the system with the target users. Numerous studies have proven the effectiveness of combining the two modalities to increase visually impaired performance in understanding webpage. Zainal Abidin et. al (2012) reported that there is a significance improvement in performance when audio and haptic feedback are being used while accessing webpage. In addition, Kuber et. al (2006) also highlighted the advantages of the audio and haptic multimodal interface in improving the Web accessibility of the visually impaired in his usability experiment which includes the enhanced perception of the spatial layout and webpage navigation.

Therefore, the project is relevant to be implemented. Successful implementation of the project would significantly benefits visually impaired users in term of Web accessibility. The visually impaired can have a comprehensive understanding of the Web content and eventually improve their browsing experience.

1.3.3 Feasibility of the Study Within the Scope and Time Frame

The project needs to be completed according to the allocated time frame given from the university. The research and development of the system should be completed in two semesters, which is approximately in six months duration. The first semester will be focusing on planning, researching, analyzing the system requirements, feasibility study, and documentation. The other half of the time frame is allocated for system development, system testing and system implementation. Since the time period is short, there are some limitations and challenges in acquiring deep and thorough research outcomes as well as the system development process.

CHAPTER 2

LITERATURE REVIEW

2.1 Existing Technologies to Improve Web Accessibility Among Visually Impaired Users

Internet is the major source of knowledge nowadays. In order to make the Internet available to visually impaired users, assistive technology is commonly used to remove Web accessibility barriers. Assistive technology is defined as the aiding tools used by disabled individuals (Edyburn, D.L., 2004). Assistive technology can also be regarded as ‘any device or system that allows an individual to perform a task that they would otherwise be unable to do, or increases the ease and safety with which the task can be performed (Cowan and Turner-Smith, 1999). In general, the goal of visual assistive technology is to provide equivalent, sight-enhancement or sight-substitution rehabilitation mechanism for computer and Web access that suitable to the respective degrees of disability (Michael et. al, 2005).

The assistive technology being used for the visually impaired is dependent on the degree and type of vision impairment. Users with high degree of vision impairment requires non-visual alternatives for conventionally visual tasks such as interpreting texts, selecting from menus, responding to system prompt, analyzing tables and navigating between different parts of Web sites. Generally, the assistive technology will translate visual screen display into auditory output, tactile output, or a combination of the two modalities. Examples of high degree visual impairment assistive technologies are screen reader, voice browser, Braille output devices, and voice recognition technology.

a. Screen Reader

Screen reader is a software application that transforms textual display into auditory output. It is used to verbalize everything on the screen into a computerized voice that is spoken out loud. Screen reader also transform graphical user interface (GUI) into an audio interface and provides keyboard shortcuts or hot keys that allow navigation of the content to be rendered to the screen in a non-visual way (Borodin et. al, 2010). The screen reader allows users to read everything in the Website from top to bottom, and from left to right (Sandhya and Devi, 2011). The most widely used screen access programs include Job Application With Speech (JAWS), WindowEyes, COBRA Professional, SuperNova and Seortek System Access to Go.

b. Web Reader

Currently, eBooks are not compatible with screen reader Web reader provides platform to read eBooks on the Internet. Example of Web reader is Google Web Reader. Web reader offers a medium for authors and publishers to sell their eBooks with extra accessibility features for disabled users.

c. Voice Browser

A voice browser is a web browser that provides interactive voice user interface to the users. It presents information aurally, using pre-recorded audio file playback or using text-to-speech software to render textual information as audio. According to Borodin et. al (2010), voice browser is generally implemented by augmenting the existing web browsers. IBM’s Home Page Reader is among the oldest representatives of voice browsers.

d. Refreshable Braille Output Device

Refreshable Braille output device provides tactile output from the information on the computer screen. Braille's cell is built of a set of dots. The pattern of the dots and various combinations of the cells are used in place of letters. Refreshable Braille displays mechanically-lifted small metal pins according to Braille characters. Users can read the Braille output device and refresh the display to read the next line.

e. Voice Recognition Commands

Voice recognition command allows user to give verbal command and enter data using their voice rather than using a mouse or keyboard. The system requires user to plug in portable microphone to the computer. It can be used to create text documents, browse the Internet, and navigate through application via voice commands.

f. Text-to-Speech (TTS) or speech synthesizers

Text-to-Speech (TTS) system receives user input in the form of text keys and synthesizes information on the screen into a computerized voice. Blind users can use text-to-speech system to hear what they are typing.

For users with low degree of visual disability, more conventional adaptations are being implemented such as screen magnifier and screen contrast enhancement system. These assistive technologies are being used to enlarge the contents on the screen, and enhance the image contrast of the materials being viewed on the Web site. Many computer operating systems such as Microsoft Window provide built-in screen magnifier and image contrast enhancement for disabled user's convenient. Examples of low degree visual impairment assistive technologies are screen magnifier and built-in image contrast enhancement.

a. Screen Magnifier

A screen magnifier is a virtual magnifying glass for the computer to magnify a portion of the screen in order to increase legibility and readability. It allows user to zoom in and zoom out on a particular area of the screen. Some screen magnifier programs enable visually impaired users to enlarge, adjust colour scheme, brightness and contrast to further enhance the screen visibility. Some of the popular screen magnifier softwares are ZoomText Magnification Software 9.1, MAGic, iZoom, and Optelec ClearNote Portable.

b. Image Contrast Enhancement

In order to "make computer easier to see", most operating systems offers accessibility options. This includes the high contrast options to improve the colour contrast of some text and images on computer screen, to make them more distinct and easier to identify by the visibility of the visually impaired users.

Figure 1: Screen views demonstrate output generated by operating system's built-in assistive technology. Image A is the normal screen view. Image B is the screen view with contrast enhancement and magnification options to improve accessibility among the low degree of visually impairment users.

However, the existing assistive technology still unable to provide ample Web accessibility to visually impaired users. Current assistive technologies impose navigational constraints and provide limited information on the Web layout (Murphy et. al, 2007). Screen readers, being the most widely used assistive technology among the visually impaired, cannot understand or describe images and other visual presentations on the Web. The only way that the screen reader can convey the meaning of images is by reading the alternative texts provided to explain the image. However, if the alternative texts are not provided by the Web developer, the screen reader cannot convey the meaning of the image. The same goes to other non-textual attributes such as tables, diagrams, and text attributes including bold, underline, and italic. .

This is particularly difficult because the Web content presentation and navigation paradigm is dependent on graphical interfaces with visual cues (Michael et. al, 2005). In addition, according to Kuber et. al (2007), non-textual content is often the key to fully understand the webpagess. The current assistive technologies only represent webpagess in a sequential order which in turn place restrictions to effectively representing the webpagess. Non-textual contents are often difficult to perceive using such assistive technologies. With the current assistive technology, visually impaired users also face difficulties to imagine the visual layout of the Web. Due to these factors, visually impaired users are not able to effectively benefits from the webpage contents.

2.2 Two-Dimensional Mental Model

The term "mental model" was introduced by Kenneth Craik in 1943 through his book "The Nature of Explanation". He suggested that human mind constructs "small-scale models" of reality that is used to predict homogenous future events. Mental model can also be defined as the internal conception that is developed by human brain to describe the location, structure of object and phenomena in computer system. Mental model play a huge role in guiding user performance by helping users predict commands and interpret system action (Norman et. al, 1983). It also plays a major role in cognition, reasoning, and decision making. Mental modal is not restricted to a specific modality. It can be constructed from multiple modalities such as visual, auditory and tactile.

Visually impaired users develop their own mental model when accessing the Web. Often, the mental models generated are not accurate due to the limitation of assistive technology used. Most Websites nowadays are design in a way that they provide two dimensional structure or layout, which include not only texts, but other non-textual attributes such as image, table, video, and sounds (Zainal Abidin et. al, 2012). The two-dimensional Website layout effectively facilitates sighted users in the information conveying process. However, for blind users, the complex two-dimensional layout would bring more confusion and navigational problem, thus increasing the Web accessibility limitations. The screen reader users can only obtain one-dimensional text fragments from the original content through auditory output from the screen reader.

In a study by Murphy et. al (2008), it is discovered that the visually impaired users try to remember the content and structure of the Webpage while scanning for desired information when browsing the Internet using screen reader, The mental model of the visually impaired while using the screen reader is in "vertical list". This is because the screen reader produces auditory output in a chronological order; from top to bottom and from left to right of the page. It is burdensome for the screen reader users to memorize the Web content and options in order to perform tasks. In some cases, the “vertical list” of information is so complex and widespread that it is impossible to be memorized. Furthermore, due to the nature of screen reader output, two-dimensional Websites are converted into a linear “vertical list”. Thus, many of the useful navigational options would be lost. Things become more complicated when the visually impaired try to access webpage with complex 3D graph presentations, because there are almost no techniques to convey this information in a non-visual way (Brewster, 2002).

The mental model created from the screen reader or other one dimensional assistive technologies would results in time consuming and confusing browsing experience for the blind. The absence of two dimensional representations in the mental model of screen reader users is the main obstacle for them to use the Internet effectively. In order to reduce the problems faced by the visually impaired and ultimately improve the understanding of the Web content, a two-dimensional perspective should be built in the mental model of the blind while accessing the Internet. One way to achieve it is by adopting multiple modalities into the assistive technology used. Multiple modalities are able to stimulate the brain of the visually impaired to construct a two-dimensional mental model of the structure and layout of the Website.

Visually impaired users also have trouble to built adequate mental model when accessing Websites with complex interfaces. In addition, many of essential and widely used software available today are not “user-friendly” for the visually impaired. For example, in Microsoft Excel, it is hard for the visually impaired to create and read spreadsheets without normal vision. This is because the structure of the document consists of rows and columns of cells, making it difficult for the visually impaired to develop mental model of the spreadsheet. In other words, the level of complexity of the software makes it impractical to enable an average blind user to develop an adequate mental model without some assistance from the sighted person (Landau, 1999). The properties of human short-term memory restricted the amount of information to be hold (Brewster, 2002). Too much information can cause the screen reader users to be overloaded.

In an experiment conducted by Zainal Abidin et. al (2012), it is proved that there's a significant difference in user's performance between the implementation of single and multiple modalities in conveying the information from the Web. Using touch screen display with audio feedback, the visually impaired users were able to get higher percentage of the correct arrangements of headings and cells as compared to using screen reader only. However, the study claimed that there is no performance difference in identifying complex Website layout. From the study, it is concluded that by using audio and haptic feedback, the visually impaired users' mental model of the Webpage is in two-dimensional perspective. As a result, they can perceive the overview of the Web correctly. This would help the visually impaired users to navigate the Webpage effectively.

2.3 Using Audio Feedback to Read Webpage

Audio feedback has been widely used to assist visually impaired user to access the Web. It has been used in assistive technology to convey information from the computer screen. Generally, non-visual web interfaces have traditionally relied upon the use of audio to provide a representation of page content. Among assistive technologies that utilize audio feedback are screen reader, voice browser, and text-to-speech or speech synthesizers.

Despite the significance popularity of audio feedback in assistive technology for the blind, the use of audio feedback is unable to effectively represent semantic information to the visually impaired. It imposes navigational constraints and offers limited information throughout the Web layout. The problem with audio feedback is that it is unable to convey non-textual Web attributes such as images, tables, and animation.

Audio feedback represents information in a linear form. It is time consuming as it reads every single line of words on the Web page. The visually impaired users would have trouble to imagine the layout of the Web. Furthermore, without the proper text attributes representations from audio feedback, the visually impaired encounter problems to comprehensively understand the meaning of a text structure. They cannot differentiate between paragraphs, and unable to identify bolded, italicized, or underlined words.

According to Jaijongrak et. al (2011), the sole usage of audio feedback in assisting Web browsing is lacks in the promptness to enable real-time access to the information. The drawback of screen readers is that it cannot convey information in real-time nature. User has to wait for the program to read the information on the webpage, one by one.

In term of haptic sense, accessing the Internet using haptic interface is an efficient way to provide assistance to the user. However, the sole usage of haptic feedback provides less meaningful information if not being deployed carefully. Therefore the combination of both modalities would complement each other in a more effective way. (Jaijongrak et. al, 2011).

Audio feedback is no longer the sole modality to assist in Web browsing. Researches had shown that the usage of audio in conjunction with haptic modality would further benefit the visually impaired users. (Yu et. al, 2002). In his study, Jaijongrak et. al (2011) proved that the use of auditory and haptic device can make the user perceive the map of USA better. This is because a two-dimensional mental model is built within visually impaired users by utilizing the auditory and tactile stimuli.

2.4 Multimodal Technology

Multimodal is the strategic use of two or more communication modes to make meaning; for example: image, gesture, music, spoken language, and written language. On the other hand, multimodal technology refers to the technology that combines features from different modalities such as text, audio, and image. It integrates more than one modality to convey information. In this context, the focus is on audio and haptic modalities.

Audio and haptic modalities have been used to improve the traditional practice of using audio as the sole modality to assist the visually impaired. The utilization of multi-sensory modalities allows the visually impaired users to have a "richer and more flexible" way in acquiring information non-visually (Brewster, 2002). Examples of the practical implementation of audio and haptic modalities in assistive technologies are synthesized speech and Braille device (Yu and Brewster, 2002).

Current assistive technology such as screen reader outputted information in a linear way. Key structural information contained in graphical forms is omitted by the program, making it is difficult for the visually impaired to gain a full comprehension of the information presented. Researchers have shown that the use of audio and haptic modalities would present greater benefits in reducing Web accessibility limitations.

Multimodal facilitates mental mapping process, enabling visually impaired users to gain better understanding of the Web elements or layout within the website. (Kuber et. al, 2007). The multimodal technology with audio and haptic would generate two-dimensional perspective in the mental model of visually impaired users in order to help them understand the non-textual website's contents.

Multimodal approach is to be used to improve Web accessibility and navigation. It also enhances visually impaired user's ability to adjust and familiarize within their environment. Furthermore, a clearer presentation of spatial information can be generated via multimodal feedback. This will enhance the blind's navigational accuracy and location of objects in webpage.

Many studies have recommended the use of multimodal approach to improve Web accessibility. For example, in a study of "blind users' mental model of webpage using touch screen augmented with audio feedback", Zainal Abidin et. al (2012), proved that there is a significant difference between browsing performances using screen reader and using touch screen display with audio feedback. However, the performance depends on the complexity of webpage layout. Using audio and tactile feedbacks, the visually impaired are able to get higher percentage of mental model accuracy as compared to those who only use screen reader program.

In another study by Kuber et. al (2007), multimodal interfaces have been used in facilitating visually impaired individuals to access visualization aids such as graphs and tables. The study describes a new approach of human computer interaction using multimodal interface. The approach successfully increases non-visual spatial awareness and accessibility.

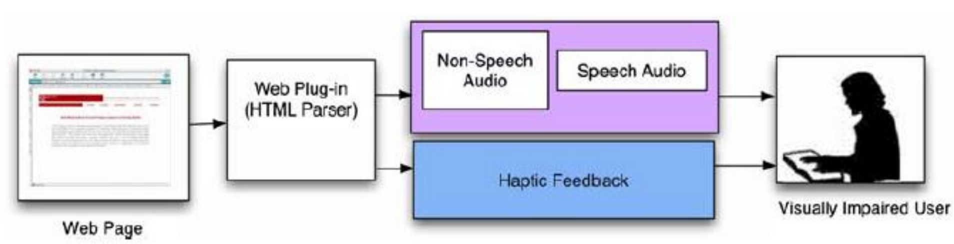

Figure 2: Multimodal approach.

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CHAPTER 3

METHODOLOGY

The purpose of the study is to examine the effectiveness of multimodal technology which integrates the use of audio and haptic in developing two-dimensional information mapping in the mental modal of the visually impaired users. It is hypothesized that the use of audio and haptic can improve the Web accessibility of the visually impaired users. A better mental model can be developed as a result of the multimodal technology implementation.

This chapter outlines the methodology in which the study is carried out. Research methodology refers to a set of procedures used to conduct a research project. Thus, this chapter will elaborate more on:

i) Research methodology
ii) Project phases
iii) Methods of data collection
iv) Sample design
v) Data representation
vi) Gantt chart
vii) Key milestone
viii) Development tools

3.1 Research Methodology

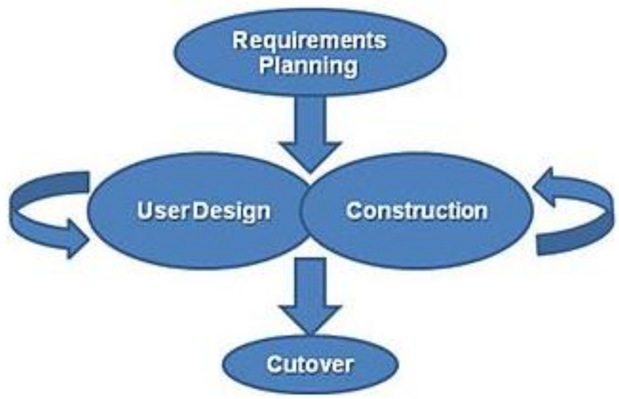


Figure 3: RAD processes.

Rapid Application Development (RAD) model had been chosen as the development methodology for the project. RAD was introduced and documented by James Martin in 1991 in his book, "Rapid Application Development". According to James Martin (1991), "Rapid Application Development (RAD) is a development lifecycle designed to give much faster development and higher-quality results than those achieved with the traditional lifecycle. It is designed to take the maximum advantage of powerful development software that has evolved recently." He highlighted four fundamental elements; tools, methodology, people and management in RAD. (Nik Daud, N.M. et al, 2010).

RAD is a software development methodology that requires minimal planning compared to the traditional software development models. It allows quick implementation of the system in real environment and serves the goal of fast implementation in restricted time frame for a small size system. The development methodology also emphasized on low cost implementation and the extensive involvement of user throughout the development process.

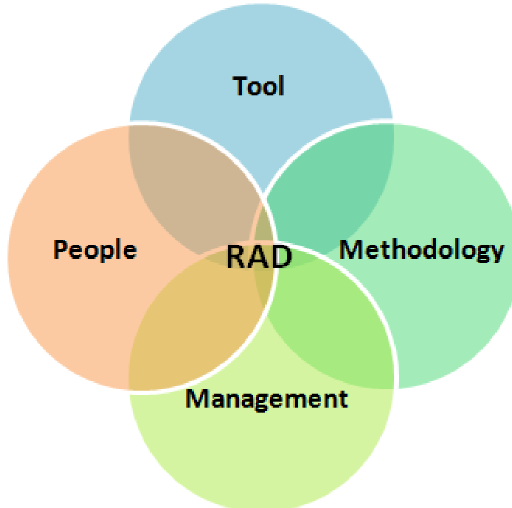


Figure 4: Four fundamental elements of RAD.

According to Nik Daud, N.M. (2010), RAD has several advantages over other system development methodology; ease of implementation, improved user satisfaction, and time-to-market. RAD is easy to implement because it does not focus only on a single-schedule oriented development practice. It requires a general framework to work together as one. RAD improves user satisfaction by extensive communication and involvement throughout the development process. It enables user to follow and revise the project progress from time to time. Last but not least, RAD is faster to be implemented and suitable for the rapid changing of technology in the real industrial environment.

Advantages	Disadvantages

• Increase speed.
  • Methods: Rapid prototyping, virtualization of system related routines, CASE tool.
• Increase quality.
  • Meets the needs of users through the involvement of the user in the analysis and design stages.
  • Low maintenance costs.
	• Reduced scalability.
	  • Occurs because a RAD developed application starts as a prototype and evolves into a finished application.
	• Reduced features
	  • Occur due to time boxing, where features are pushed to later versions in order to finish a release in a short amount of time.

Table 1: The above table summarize the advantages and disadvantages of implementing RAD in project development.

Therefore, this methodology approach is suitable for the development of audio-haptic synchronization system since the project has limited time frame and resources, need active user's involvement for system requirement gathering, usability acceptance and improvement, and involves rapid prototyping.

3.2 Project Phases

The project comprises of four stages according to RAD processes; requirement planning, user design, construction and cutover. The following sections will elaborate more on each project phases.

3.2.1 Requirement Planning

The requirement planning stage combines the system planning and analysis from the traditional System Development Life Cycle (SDLC). This stage establishes a high level view of the project in order to give a better understanding of the project and technologies involved.

i) Define Problem Statement

A problem statement is identified to clearly define and understand the project overview. In this study, the limitation of Website's accessibility in terms of its text structure and font attributes representation in webpagess is viewed as obstacles to the virtually impaired users from having a comprehensive understanding of the web content. Thus, a system that synchronizes audio and haptic to read Webpagess had been proposed to address the accessibility problem.

ii) Theoretical Understanding of the Project

A qualitative research is conducted from the related research works to understand the literature of the project. Several theories and concepts are derived from the studies to understand the mental model of the visually impaired users and how the implementation of multimodal technology through audio feedback and tactile representation can improve the Web accessibility of the blind.

iii) Data Collection and Information Gathering

Data collection and information gathering on user requirements is carried out through several data collection and information gathering methods such as interviews, observation, and experiment. Qualitative and quantitative results of these findings are graphically represented and examined for system requirements and understanding.

3.2.2 User Design

During this phase, the skeleton of the system is designed through interactive process with users. User requirements gathered are translated into a working model. UML diagrams are developed to give an overview of the system design. Interaction with user is made to help in the prototyping process.

3.2.3 Construction

The construction phase includes programming, system integration and testing. However, throughout the processes, user can still suggest for changes or improvement.

3.2.4 Cutover

The cutover phase comprises of the post development processes including testing, changeover from pre-development prototype into a commercialized system that is available and understood by the end user, user training and maintenance. If all of the objectives and system requirements are successfully met, the development cycle is finished.

3.3 Methods of Data Collection

3.3.1 Related Research Works Review

Related research works are reviewed as an essential part of academic research project in order to obtain a clear understanding of the project. Theoretical concepts, information and research findings are gathered through the review of related literatures on current visual assistive technologies, visually impaired’s mental model, audio feedback and multimodal technology. What has already been done on it, how it has been researched, and key issues existed are identified and thoroughly studied. The information gathered from related literature and research works are then analyzed and integrated to make connections between ideas, theories and research findings.

3.3.2 Interviews

Interview is chosen as one of data collection methods in the project to explore the views, experiences, and suggestions of the visually impaired users regarding the project. It is conducted in a semi-structured way consist of several open ended-and close-ended key questions that are designed to help define the research key areas. In order to pursue deeper ideas and responses from the visually impaired, some diverge questions are also being asked. This flexibility is important to enable the discovery of information that is important to the visually impaired users but may not have come across the mind of the interviewer. Among the focused key areas of the interviews:

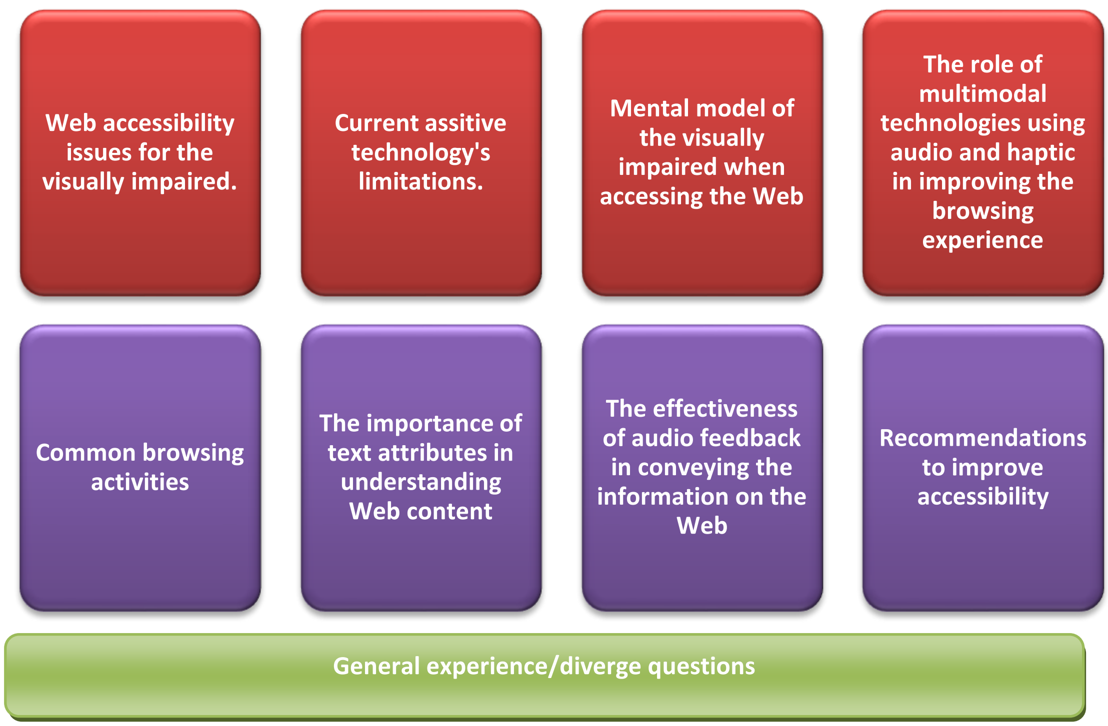


Figure 5: The focused research key areas during interview sessions.

The interviews are divided into two target groups:

i) Interview with experts

- Interviews had been conducted with the Director of Malaysia Association for the Blind (MAB) Kinta Valley, Ipoh, Perak. The interview aims to acquire a comprehensive understanding generally on the Web accessibility problems among the visually impaired users and the relevancy of the project in addressing the problems.
- Interview with MAB's Braille Instructor to get an overview of the Braille system being thought in MAB and how the implementation of audio-haptic synchronization system using Braille Line would help the visually impaired to improve their understanding of the Web content especially in recognizing text attributes.
- Interview with MAB's Literacy Trainer to get a detail understanding about the problems faced by the visually impaired when using screen reader to access the Web.

ii) Interview with average visually impaired computer learners

- Interview with the computer learning students of MAB to obtain the views and understanding from the perspective of average visually impaired users regarding the matters and issues mentioned above. This is important to design a system that suites the needs and ability of average users.

3.3.3 Observation

Observation is made while the visually impaired from MAB try to access the Website using JAWS screen reader during the screen reader demonstration session. The problems encountered during the session are observed and video-recorded for future reference.

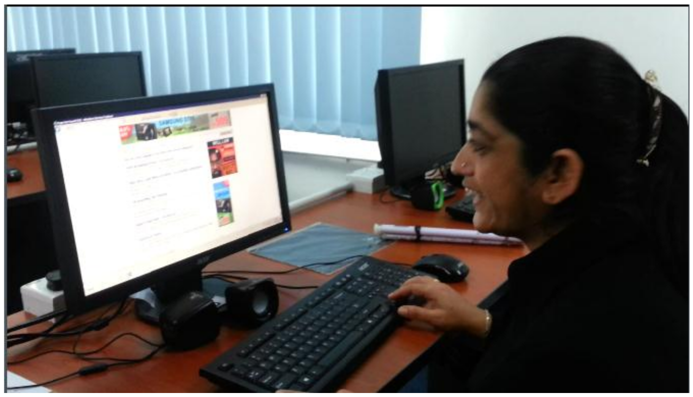


Figure 6: The demonstration of screen reader usage to access the Website.

3.3.4 Survey

Acceptance survey will be conducted to the visually impaired users in MAB with verbal assistance from sighted person. The survey aims to study the feasibility of the proposed system with the target users. It would also test specific hypotheses and examine the relationship between audio and haptic with the Web accessibility performance.

3.3.5 Experiments

A series of experiments are carried out to prove the theoretical concepts gathered from the related literatures and research works. The experiments are divided into two; pilot testing with the sighted users blindfolded to assimilate the visually impaired, and the visually impaired users. The purpose of the experiment is to investigate the differences of mental model developed by visually impaired users towards the two dimensional webpages by using two different approach; using audio haptic synchronization system, and the other using audio feedback only via screen reader.

*Refer appendices for the experiment framework.

3.4 Sample Design

3.4.1 Defining the Population

The target population of the study is the visually impaired group from Malaysia Association for the Blind (MAB) Kinta City, Ipoh. An acceptance survey will be conducted to the target population in order to evaluate the feasibility of the proposed system.

3.4.2 Sample Size

8 participants from MAB are to be involved in the survey. The number is small because there are currently only 8 students in MAB. However, considering the difficulties to recruit the visually impaired to do the survey, the sample size is reasonable. Most study involving the visually impaired usually consisted of only four to six people. (Takagi et. al, 2007)

3.4.3 Sampling Method

Probability sampling method is adopted in conducting the survey. With probability sampling, all participants in the population have the same opportunity of being included in the sample, and the mathematical probability that any one of them will be selected can be calculated.

3.5 Data Representation

Information and data collected from quantitative and qualitative methods are then represented for interpretation and analysis purpose. In practice, most researchers agree that the combination of quantitative and qualitative techniques or sometimes called "mixed method" would produces a richer and more comprehensive understanding of a project. Both qualitative and quantitative data provide distinct outcomes, but when being used together would provide a broader understanding of the key research areas and give a full picture of the study.

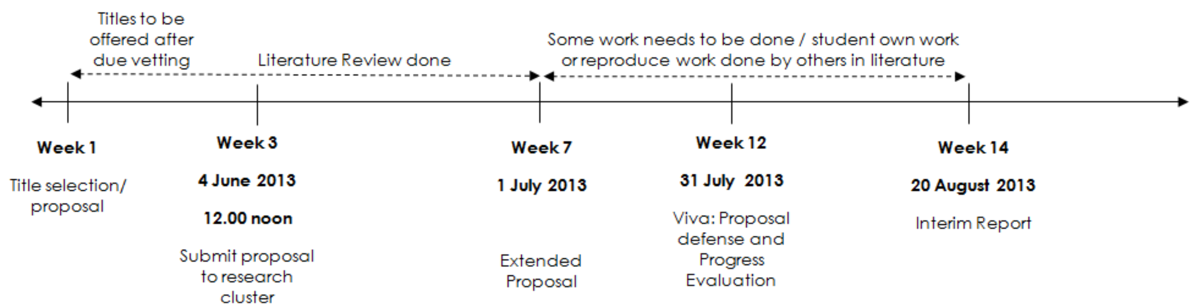
3.5.1 Qualitative Method

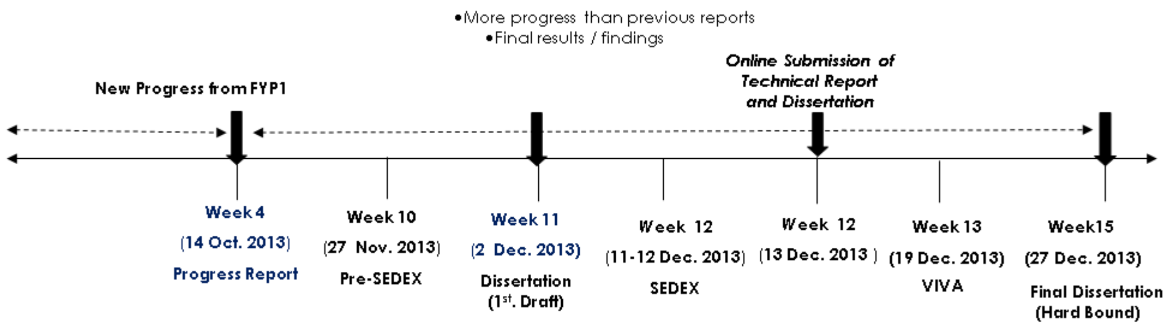
Qualitative method concerns with the observation, views and opinions from the sample population in their natural setting. In this project, the qualitative data derived from interviews and observations are documented in the form of descriptive report, audio, and video recordings. The analysis of these quantitative data provides in-depth understanding of the subject while providing constructive suggestions and ideas for project improvement.

3.5.2 Quantitative Method

Quantitative method concerns with numerical analysis related to the initial hypotheses made in the study. The analysis of the quantitative data produces quantifiable and reliable data to support the qualitative findings. Quantitative data from acceptance surveys and experiment results are presented in inferential statistics and graphical form to be examined. Conclusions are then drawn from the statistical findings.

3.6 Key Milestone





Milestone		**Assessment (%)**	**Week**
FYP I	Project Proposal	-	3
	Extended Proposal	10	7
	Proposal Defense	40	12
	Interim Report	50	14
FYP II	Progress Report	10	4
	Pre-SEDEX	10	10
	Technical Report	10	12
	Dissertation Draft	-	12
	Oral Presentation	30	13
	Final Dissertation	40	15

Figure 7: Key Milestones of Final Year Project I & II

3.7 Gantt chart

*Refer appendices for Gantt chart

3.8 Development Tools

3.8.1 Hardware

i) Braille Line 20 Cell

Braille Line 20 Cell is a 20 cells Braille line output device equipped with flat tactile caps and one interactive button. The hardware is assembled on a strong metal tray to ensure safe mounting and protect the cells. Each Braille cell has 8 piezo-actuated dots, with chip-on-board technology, integrated drive electronics and direct output of the interactive buttons on the cells. The following are the detailed specification of the Braille Line 20 Cell:

- Dimensions (w x h x d): 130 x 81.5 x 23.5mm
- Dot spacing: 2.45mm
- Dot height: ca. 0.7 mm
- Cell spacing: 6.42mm
- Tactile force: min. 17 cN
- Connector: SIL 2.0 mm, 8 Pins
- Drive electronic: low-power ASIC electronic mounted on the cell

Figure 8: Braille Line 20 Cell

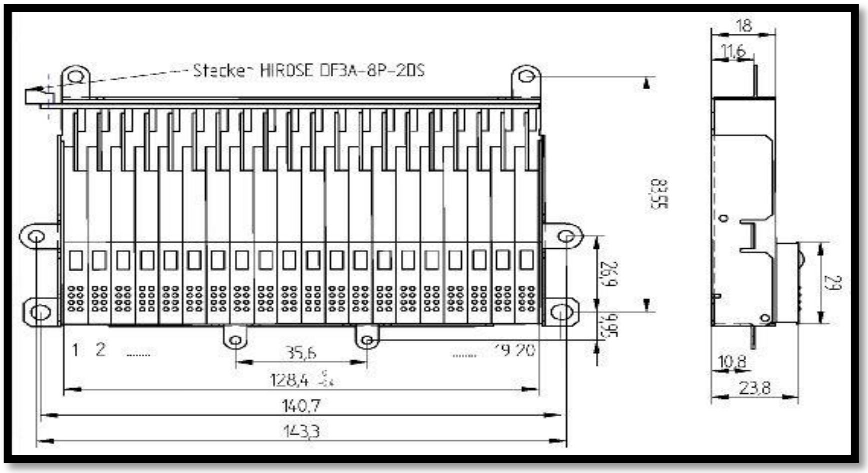


Figure 9: Technical sketch of the Braille Line 20 Cell.

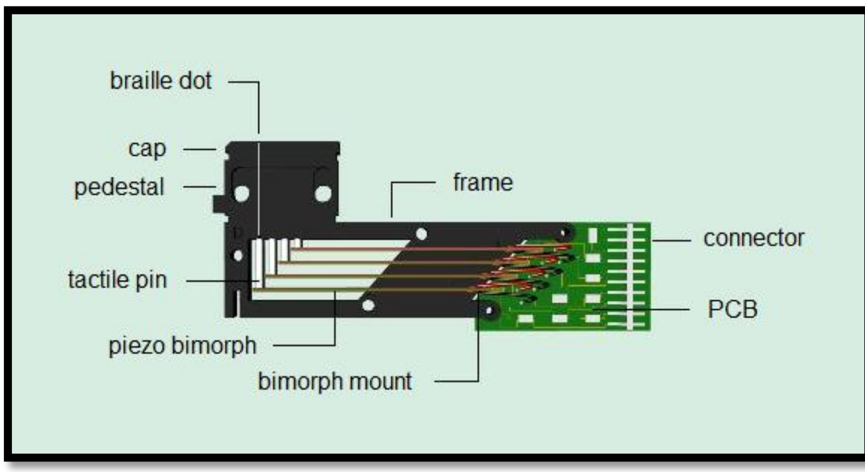


Figure 10: The basic parts of a Braille cell.

ii) Development Machine Specification (CPU Unit)

- Platform : Microsoft Windows XP Professional (32-bit)
- RAM: 2.00 GB
- Processor – Intel Pentium P6200

The development environment to program the 20 cell Braille Line only supports Windows XP. Therefore, Windows XP has been chosen as platform to develop the prototype. However, the prototype can be configured to be run in Windows 7 and later by running using VMware Workstation. VMware workstation allows user of 64 bit computer to set virtual machine and run along with the actual machine.

3.8.2 Software

i) Borland C++ 5.02

Borland C++ 5.02 is a C++ an integrated development environment platform for MS-DOS and Microsoft Windows. The software is used to program the Braille Line 20 Cell device.

ii) Microsoft Visual Studio 2008

Microsoft Visual Studio 2008 is an integrated development environment (IDE) for Microsoft Windows. It enables user to develop console, graphical user interface (GUI), Windows Forms, web sites, web applications and web services for all platforms supported by Microsoft Windows. Microsoft Visual Studio 2008 is used to develop a program to automate the synchronization of audio and haptic feedback output from the devices, user interface design, and web site rendering automation.

iii) Job Access With Speech (JAWS)

Job Access With Speech (JAWS) is a screen reader program for Microsoft Windows which assist visually impaired people to access information on the computer screen. JAWS facilitates the visually impaired users through text-to-speech output or by a Refreshable Braille display. It works with the computer to provide access to software applications and the Internet. JAWS is used to provide audio feedback in the prototyping and testing on the subject.

iv) Web Interface: Notepad++ 6.4.2

Notepad++ is an advanced source code editor software with colored element identification text that can support various programming, scripting, and markup languages. It can run on MS Windows and governed by GPL license. Notepad++ supports tabbed editing which enables user to work in multiple opened files. Users may also manually set the current language, overriding the extension's default language. Besides, Notepad++ has the ability to automatically detect the language in a given file, and supports auto-completion for some programming languages. In the system development process, Notepad++ is used for sample webpages prototyping and testing.

v) Oracle VM VirtualBox 4.2.16 for Windows Hosts

Oracle VM VirtualBox is a simple yet powerful cross-platform operating system virtualization application. It extends the capability of a computer to run on multiple operating systems virtually at the same time, provided the disk space and memory are sufficient. Oracle VM VirtualBox can run almost practically everywhere; from small embedded systems or desktop machine to datacenter deployments and even Cloud environment. It is used to virtually set up the current 64-bits Windows 7 computer into 32-bits Windows XP operating system virtual machine in order to provide suitable development platform to program Braille Line 20 Cell.

CHAPTER 4

RESULT & DISCUSSION

4.1 Preliminary Study: Result of Interview with Malaysian Association for the Blind (MAB)

Interviews had been conducted with several representatives from Malaysian Association for the Blind (MAB) Kinta Valley Rehabilitation Centre, Ipoh, Perak; Datuk Paduka Haji Ahmad Salleh, the MAB Kinta Valley Programme Director; Ms. Meena Kumari, the MAB's Computer Literacy Trainer; and Mr. Arif Abu Farid, the MAB's Braille Instructor. The objectives of the interview are:

i) To investigate problems faced by the visually impaired in order to understand the Web content.

ii) To examine the relevancy of the project in improving Web accessibility among the visually impaired.

The following is the summary of the interview findings:

a. The Visually Impaired Users in MAB

Since MAB Kinta Valley provides English and computer learning for its students, most of its residents are active Internet users. They are required to memorize the keyboard keys in order to use the computer. They frequently use the Internet to search for English words on the online dictionary. The learning activities usually involve the use of simple functions in the Microsoft Office software.

b. Current Assistive Technologies being Used in MAB

JAWS screen reader is the main assistive technology used by the visually impaired users in MAB to access the Web. All MAB's students are made to be familiar with the JAWS screen reader. The screen reader can interpret displays on the computer screen and represent them in the form of auditory output to the users.

MAB also use Braille embosser to render text into tactile Braille display, printed on embossed paper. Braille embossers usually need special Braille paper which is thicker and more expensive than normal paper.

c. Limitation of the Current Assistive Technologies

However, the current assistive technologies used possess some limitations for the visually impaired to access the Web. The JAWS screen reader users cannot imagine the structure and layout of the webpages because it cannot read graphics, tables and other non-textual attributes including text attributes such as bold, underline, and italic. Moreover, JAWS read every single "readable thing" on the screen; regions, hyperlinks, buttons and URLs. This results in confusing browsing experience because the visually impaired will hear multiple auditory outputs at the same time. The Literacy Trainer, Ms. Meena Kumari described the browsing experience as "confusing and annoying" but she has no other choice.

For the Braille embosser, MAB's Braille Instructor, Mr. Arif Abu Farid said that after 2-3 times of usage, the embossed Braille dots printed on the Braille paper become "flat" and cannot be used anymore. It is troublesome for the visually impaired to reread the printed materials when necessary.

d. The Importance of Text Attributes in Understanding Web Content

The text attributes such as bold, underline and italic are important to get a comprehensive understanding of a sentence especially in English learning. For example, italicized words in a sentence may indicate that the words are in foreign language, and the quotation marks may represent an improper English usage and so on. However, JAWS and Braille embosser cannot represent these text attributes, thus the visually impaired are unable to recognize them. The ability to recognize the text attributes would make the process of conveying information much more powerful.

e. Mental Model of the Blind

According to Ms. Meena Kumari, the visually impaired users have difficulties to imagine the layout of Website using JAWS. This is because they are relying on the keyboard to navigate throughout the webpage. The visually impaired users cannot effectively locate Website's structures such as buttons and regions. They can just keep scrolling using "arrow keys" without knowing the cursor position on the Website. Therefore, they are unable to built adequate mental model of the webpage using the audio feedback from the JAWS screen reader.

As for the Braille embosser, the visually impaired can only acquire textual information as if they are reading books with textual display.

f. Multimodal Technology

The interviewees agreed that multimodal technology through audio and haptic would improve their browsing experience as a non-sighted person. The implementation of audio and haptic to that allow the visually impaired to understand Web content and simultaneously recognize the text attributes would be a useful innovation in improving the level of Web accessibility among visually impaired community.

g. Recommendations and Other Relevant Information

Just as the sighted persons, the visually impaired also have equal intellectual ability to contribute to the society. Thus, the technological advancement in assistive technology is doubtlessly essential to enable them to have the tool to non-visually “see” the world. Synchronizing a system with audio and haptic modalities to represent text attributes in a webpage is one of the innovative initiatives towards empowering assistive technology for the blind. The interviewees suggested that more non-textual attributes are to be represented using audio and haptic approach. Beyond imagination, the experts hope that one day, the technological advancement could represent color, graphics and animation to the visually impaired.

4.2 System Flow Chart

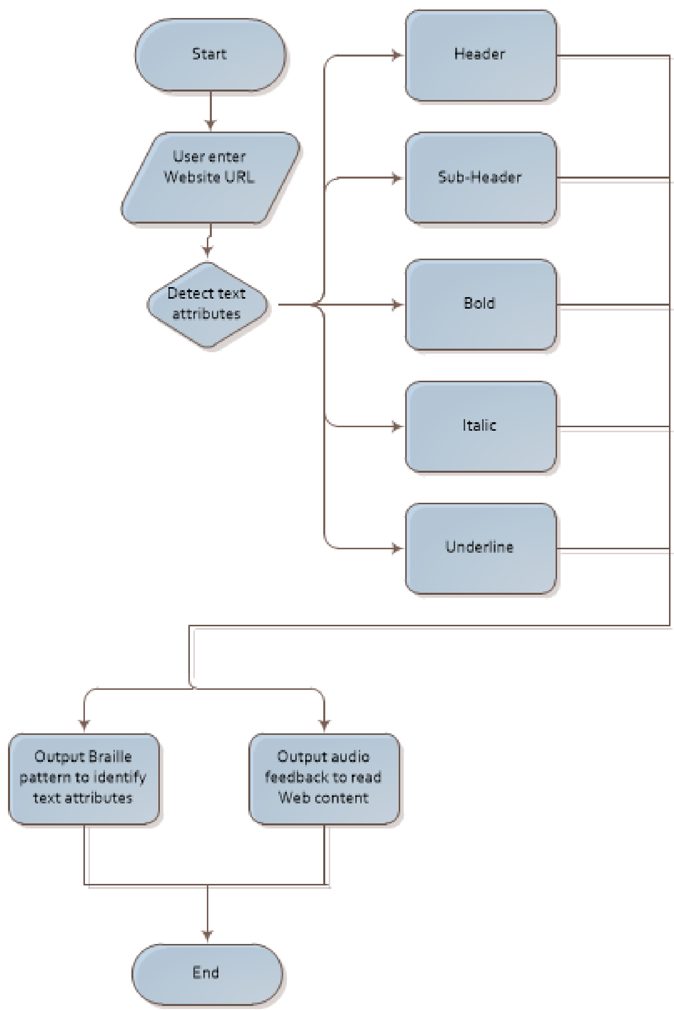


Figure 11: System flow chart.

i) User input the URL of the intended Website into the system.

ii) The system detects the text attributes found in the webpage and determine whether they are header, sub-header, bold, italic or underline.

iii) The system renders the webpage and output synchronized audio and haptic feedbacks through computer's speaker and Braille Line device respectively.

iv) User reads the rendered webpage by hearing the auditory output of Web content and feels the tactile output of text attributes on the Braille Line device.

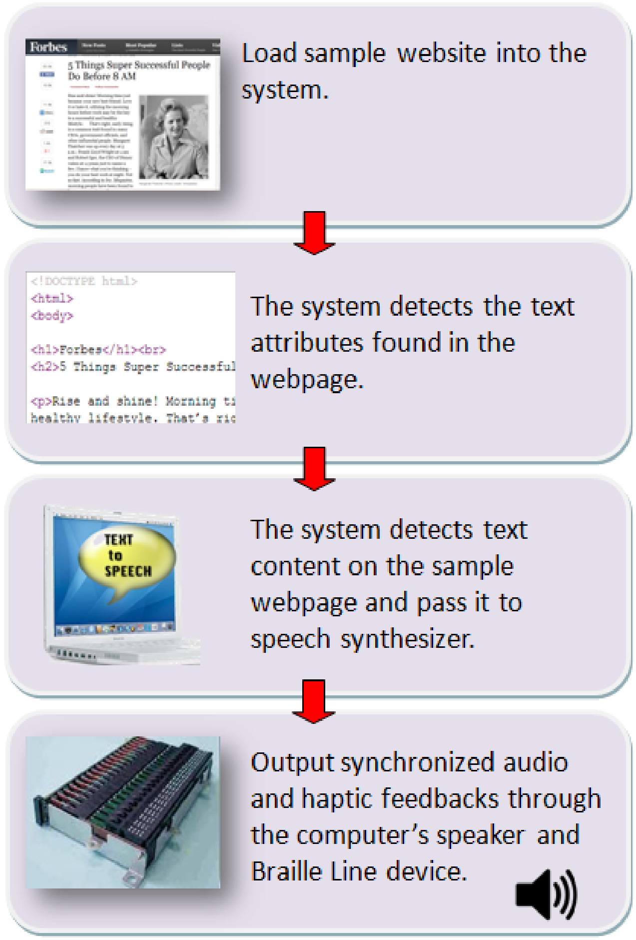


Figure 11: Summary of how the system works.

4.3 Prototype Design

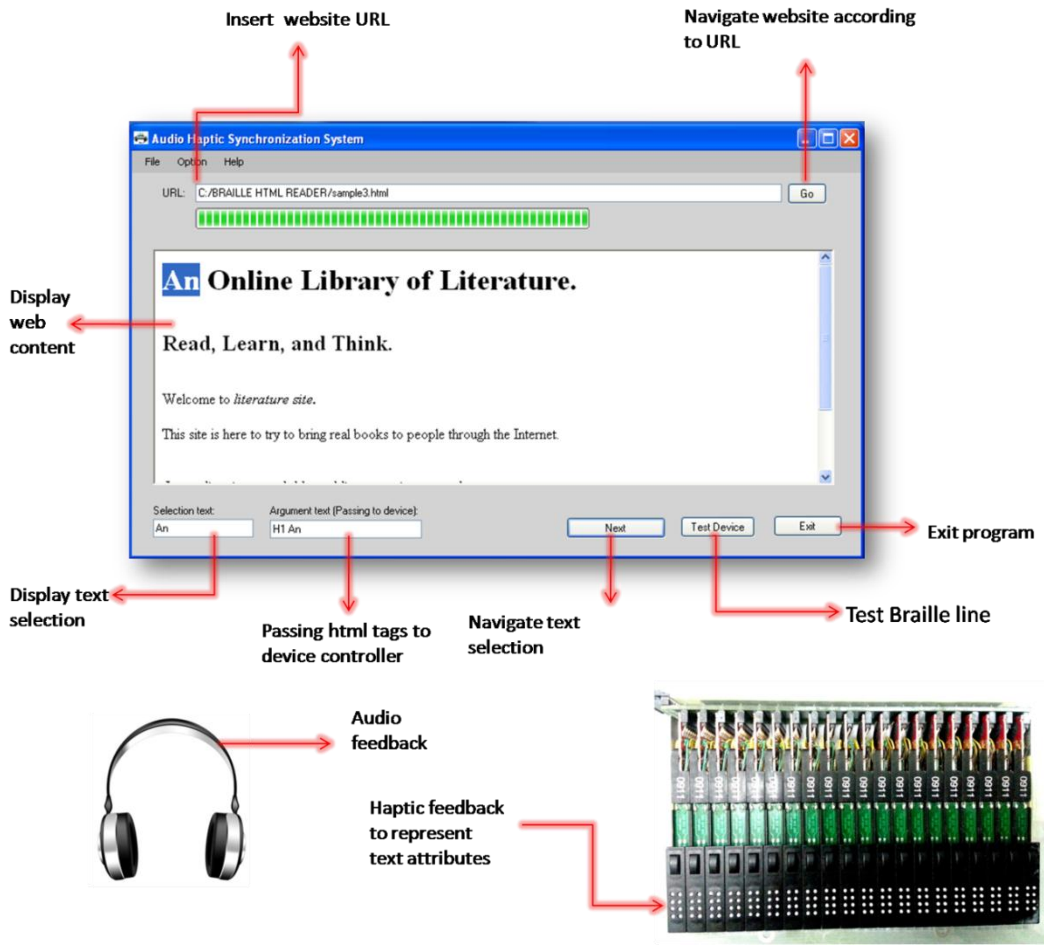


Figure 12: The prototype.

The prototype consists of three integrated components; the audio haptic synchronization system, the Braille line 20 cells and the speaker. The speaker and Braile line 20 cells are plugged to the computer as external devices. As the system is developed specially to assist the visually impaired users in high degree of impairment group, it is designed with a simple graphical user interface (GUI) that minimized user's efforts to navigate throughout the system. This is to promote the ease of use and provides system flexibility for the visually impaired users. The system design criteria are summarized as follows:

Keyboard Shortcuts

- Standardize keyboard shortcuts are used to navigate the system.
- The keyboard shortcuts for the system are designed according to "Microsoft Windows Guidelines for Designing Keyboard User Interface". This is to ensure efficiency in usage, so that visually impaired user does not have to learn new keyboard shortcuts.
- The following are the proposed keyboard shortcuts for the system:

Keyboard Shortcut	Function
ALT+F4	Close the active item, or quit the active application.
SPACE	To start the program.
CTRL+C	Copy selected items.
CTRL+X	Cut selected items.
CTRL+V	Paste, cut or copied items.
DELETE	Delete selected items. (To delete URL)
ENTER	Confirm action. Carry out the default command of the dialog box or command of the selected control.
ESC	Cancel
F1	Display Application Help.

Table 2: Proposed keyboard shortcuts.

Direction of GUI Navigation

- The system navigational direction must be logical and in line with the language in which the system is written.
- Since the system is in English language, the GUI navigation order moves from left to right and top to bottom.

Interface Optimization

- Only important information are displayed on the system.

Data Entry Confirmation

- Pressing ENTER key does not immediately execute the system action. It just confirms data entry into the current input field.
- The system will ask user to confirm data entry into the system before executing.

4.4 Lists of Functions

The following functions are listed in the main program. These functions are written in C#.

Function	**Description**
`GetTextRange()`	To determine the text range in html file.
`SpeechSynthesizer()`	Provide access to host computer ‘s speech synthesizer engine
`SpeakAsync()`	Generate speech from string.
`UsbBraille Device.GetFirstDevice()`	To get the first device connected via USB hub.
`.Connect`	To connect the device to the system.
`PassingValueTo DeviceController()`	This function passes the values from the system to the device controller. A link to device controller is included to connect the two programs.
`FindTextMode()`	To identify types of text attributes.
`GetTextRange()`	To identify word by word.
`MoveRange()`	To navigate from one word to another.

The following functions are listed in the device controller. These functions are written in C++.

Function	Description
`void test()`	Identify the text attributes and determine the Braille codes associated with it.
`void process()`	This is where basically the process to output the Braille dots take place.
`WrZeile8Mod()`	Sends the Braille data for the 8 Module of a Block (Position %8) and reads the data from the global line.

4.5 Snapshot of Important Codes

i) Connect device via USB.

```
UsbBrailleDevice device = UsbBrailleDevice.GetFirstDevice();
 if (device == null)
            {
                Console.WriteLine("No device found");
            }
            else
            {
                if ( !device.Connect() )
                {
                    Console.WriteLine("The device is not connected!");
                }
                else
                {
                    Console.WriteLine( "Buttons:        {0}",
BitConverter.ToString( device.Read() )  );
```

ii) Pass the values from program to device controller.

```
void PassingValueToDeviceController(string argument)
        {
            string filename = @"C:/AudioHaptic/SOURCE CODE/Device
Controller/DeviceController.exe";

            System.Diagnostics.Process.Start(filename, argument);
        }
```

iii) Identify Text Attributes.

```
string FindTextMode(string word, string line, int start, int end)
        {

            int strong = line.IndexOf("<STRONG>");
            int endstrong = line.IndexOf("</STRONG>");
            int italic = line.IndexOf("<I>");
            int enditalic = line.IndexOf("</I>");
            int underline = line.IndexOf("<U>");
            int endunderline = line.IndexOf("</U>");


            if (strong >= 0)
            {
                start += 8; //<STRONG> is 8 character.
                end += 8;
                if (start >= (strong + 8) && end <= endstrong)
                    return "bold";
            }
            else if (italic >= 0)
            {
                start += 3; //<I> is 3 character.
                end += 3;
                if (start >= (italic + 3) && end <= enditalic)
                    return "italic";
            }
            else if (underline >= 0)
            {
                start += 3; //<U> is 3 character.
                end += 3;
                if (start >= (underline + 3) && end <= endunderline)
                    return "underline";
             } else

            {return "normal"; //return normal as a default, if the
above creteria is not match
        }
```

iv) Passing the text attributes values to be displayed on the Braille Line.

```
void PassingValueToDeviceController(string argument)
        {
            string filename = @"C:/formAudioHaptic/SOURCE CODE/Device Controller/DeviceController.exe";

            System.Diagnostics.Process.Start(filename, argument);
        }
```

v) Generate speech

```
SpeechSynthesizer read;

read = new SpeechSynthesizer();

int wCounter = 0;

read.SpeakAsync(sp[wCounter++]);
```

vi) Determining text range.

```
string GetTextRange()
        {
            if (webBrowser1.Document != null)
            {
                IHTMLDocument2 document =
webBrowser1.Document.DomDocument as IHTMLDocument2;
                if (document != null)
                {
                    IHTMLBodyElement bodyElement = document.body as
IHTMLBodyElement;
                    if (bodyElement != null)
                    {
                        IHTMLTxtRange range =
bodyElement.createTextRange();

                        if (range != null)
                        {

                            return range.text;

                        }
                    }
                }
            }

            return null;

        }

string text = GetTextRange();
            string[] textlines = new string[1000];
            string[] textlinesdraft = text.Split(new string[] {
Environment.NewLine }, StringSplitOptions.None);
            int j = 0;
            for (int h = 0; h < textlinesdraft.Length; h++)
            {
                if (!textlinesdraft[h].Equals(""))
                {
                    textlines[j] = textlinesdraft[h].ToString();
                    j += 1;
                }


            }
```

x) Output Braille pattern for text attributes.

```
void test()
{
	char ttt[100];
	char *pttt=ttt;
	int i;
	//If changed write text via Change Table in the braille Line
	strcpy(ttt,value.c_str());  //strcpy(ttt,Edit1->Text.c_str());
	//std::cout << ttt << std::endl;

	if (mode == "normal")
	{
		Zeile[0]=0;
		Zeile[1]=0;
	}
	else if (mode == "bold")
	{
		Zeile[0]=28;
		Zeile[1]=20;
	}
	else if (mode == "italic")
	{
		Zeile[0]=20;
		Zeile[1]=0;
	}
	else if (mode == "underline")
	{
		Zeile[0]=28;
		Zeile[1]=3;
	}
	else if (mode == "H1")
	{
		Zeile[0]=HardwareChange('T');
		Zeile[1]=HardwareChange('T');
	}

	else if (mode == "H2")
	{
		Zeile[0]=HardwareChange('H');
		Zeile[1]=HardwareChange('R');
	}
```

4.6 Proposed Braille Codes for Text Attributes

The text attributes in webpage are presented through tactile mappings on the Braille Line 20 Cell device. For that purpose, new Braille codes are defined to represent the text attributes (bold, italic and underline). The following Braille codes were adopted from the format developed by Braille Authority of North America (BANA):

Elements	Braille code
Header	(TT)
Sub Header	(HR)
Bold	(456,46)
Italic	(46)
Underline	(456,36)

Table 3: Proposed Braille codes for text attributes.

4.7 Sample Websites

For testing purpose, three sample websites from different categories are used. Each of this sample website contains related html tags for the intended text attributes. The websites are then simplified for testing purpose. The objective of testing multiple sample websites to the system is to demonstrate the role and the importance of text attributes in improving the understanding of visually impaired from different perspectives; business, literature and English learning.

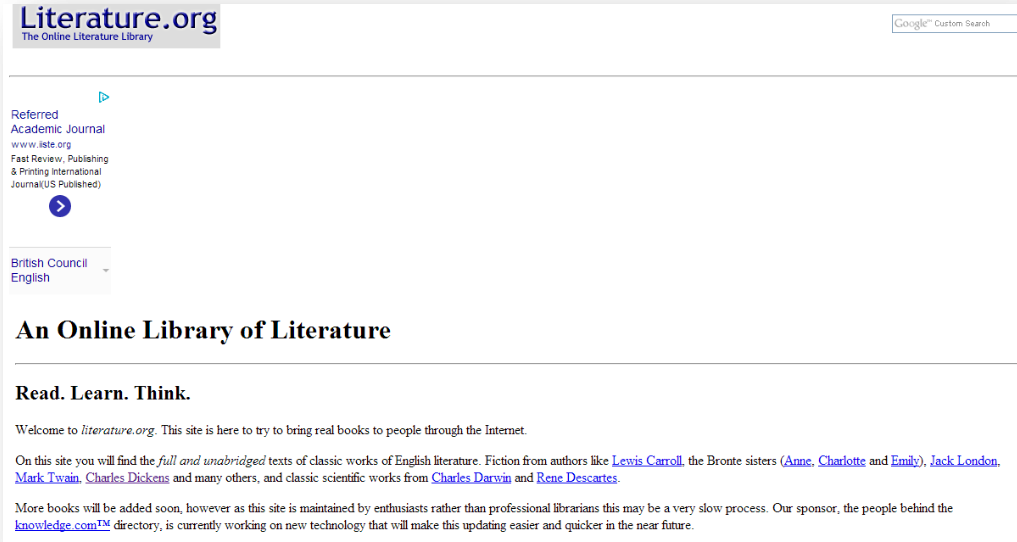
Bold is used to highlight important words, phrases and sections. On the other hand, italic is traditionally used to mark passages that have a different context, such as words from foreign languages, book titles, and the like. In websites, underline is often used for hyperlink. Only some of the text contents on the Internet nowadays use underline to put emphasis on a particular word.

i) Business Website

Simplified version:

```
<html>
<H1>Forbes. </H1><BR>
<H2>5 Things Super Successful People Do Before 8 AM. </H2><BR>
<P>Rise and shine. </P><BR>
Let's explore 5 of the things <STRONG>successful people do before 8 am.
</STRONG><BR>
<STRONG>1) Exercise. </STRONG><BR>
It'll help wake up your body, and <I>prep</I> you for your day. <BR>
<STRONG>2) Map Out Your Day. </STRONG><BR>
Maximize your potential by mapping out your schedule for the day, as well as
your goals and to dos. <BR>
<STRONG>3) Eat a Healthy Breakfast. </STRONG><BR>
Not only is breakfast good for your physical health, it is also a good time to
connect socially. <BR>
<STRONG>4) Visualization. </STRONG><BR>
Take a moment to visualize your day ahead of you, focusing on the successes you
will have. <BR>
<STRONG>5) Make Your Day Top Heavy. </STRONG><BR>
Do that least desirable task on your list first. <BR>
Also on Forbes <U>14 Things Successful People Do On Weekends. </U><BR>
```

ii) Literature Website



Simplified version:

```
<html>
<H1>An Online Library of Literature. </H1><BR>
<H2>Read, Learn, and Think. </H2><BR>
<P>Welcome to literature site. </P><BR>
This site is here to bring  <STRONG>real books to people via Internet.
</STRONG><BR>
<I>Science and literature are not two things, but two sides of one thing</I> -
Thomas Huxley. <BR>
<U>Authors Index</U>  is updated. <BR>
</html>
```

iii) English learning. Website

Simplified version:

```
<html>
<H1>Oxford Dictionary. </H1><BR>
<H2>Definition of haptic in English. </H2><BR>
<STRONG>haptic. </STRONG><BR>
<P>adjective. </P><BR>
relating to the sense of touch, in particular relating to the perception and
manipulation of objects using the sense of touch and proprioception. <BR>
<I>haptic feedback devices create the illusion of substance and force within the
virtual world. </I><BR>
</html>
```

4.8 Experiment

In order to test the effectiveness and usability of the audio haptic synchronization systems, a series of experiments are conducted. The experiments are divided into two part; experiment with the sighted users (pilot testing) and experiment with the visually impaired users (user testing).

4.9 Pilot Testing with the Sighted Users

A pilot testing is conducted to test the effectiveness and overall usability of the audio haptic synchronization system in representing text attributes and improving the understanding of the web content among the visually impaired users. The performance of the system is then compared to the screen reader to verify for its strength, weaknesses and future enhancements. The pilot testing is also done to test the experimental framework design, so that it can be improved and adjusted later in the user testing with the actual population - the visually impaired users.

Ten participants from Universiti Teknologi PETRONAS aged between 19 and 22 years are recruited to participate in the pilot testing. It is acknowledged that they have no prior experience using screen reader or any other assistive technology for the visually impaired. They also have no knowledge on reading Braille codes. The visually impaired are not being used in the pilot testing in order to apply a controlled condition whereby the degree of visual impairment is constant (Stevens et. al, 1996). In addition, according to Ramstein et. al (1996) and Yu W., et al (2001), there are no significant differences in performance between visually impaired users and blindfolded sighted users to complete the tasks. However, this may not be the case in all scenarios. The participants are blindfolded for all tasks to assimilate the visually impaired users.

Figure 13: Participant is blindfolded to assimilate the visually impaired users .

4.9.1 Pilot Testing Result

Participants	Time taken (s)		Accuracy (%)	
	Screen reader	Audio Haptic Synchronization System	Screen reader	Audio Haptic Synchronization System
Participant 1	107.08	88.00	40	100
Participant 2	117.61	38.00	40	100
Participant 3	75.00	50.51	20	100
Participant 4	135.95	106.00	20	100
Participant 5	63.00	62.00	60	100
Participant 6	64.15	96.00	60	100
Participant 7	103.00	110.00	60	100
Participant 8	60.51	60.26	60	100
Participant 9	109.00	54.00	40	100
Participant 10	106.00	48.00	40	100
Mean	94.13	71.28	44	100

Table 4: Mean for time taken (in seconds) and accuracy (in percentage) for tasks completion.

The result of pilot testing in table 3 shows the mean for time taken and percentage of accuracy for all tasks. The result indicates that the time taken to complete the tasks using audio haptic synchronization system is lesser than using the screen reader. This reflects the efficiency of the new proposed system in conveying information and representing text attributes to its users.

In terms of effectiveness in identifying text attributes, the participants are able to 100% identify the text attributes accurately using the audio haptic synchronization system compared to only 44% in average using the screen reader. This is because screen reader cannot identify text attributes. The participants can just use their logical thinking or “trial and error” to complete the tasks.

4.9.2 Pilot Testing Post Survey Result

In post testing, the participants are required to complete a set of survey questions to confirm the level of usability of the system. Please refer appendices for the sample post survey questionnaires. The following are result and analysis of the post survey after the pilot testing.

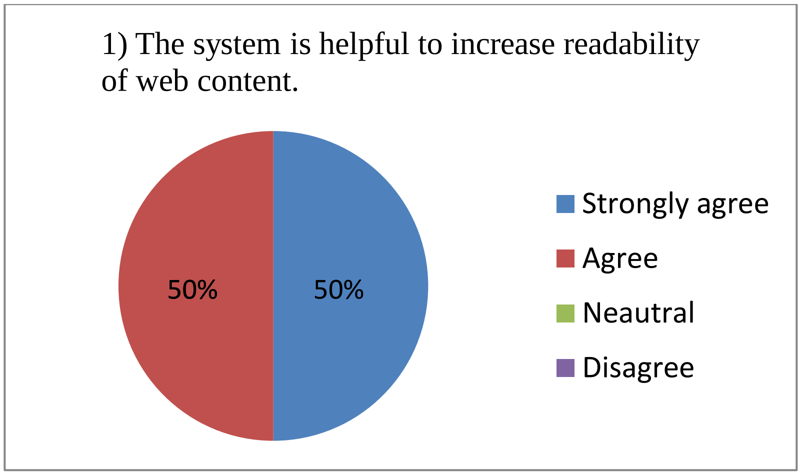


Figure 14: Response on the system helpfulness in increasing readability of web content.

Analysis:

The result shows that the majority of the participants agree that the audio haptic synchronization system is helpful in increasing the readability of the web content. With the new proposed system, users are able to identify text attributes present in the web, thus adding more meaning to the sentences.

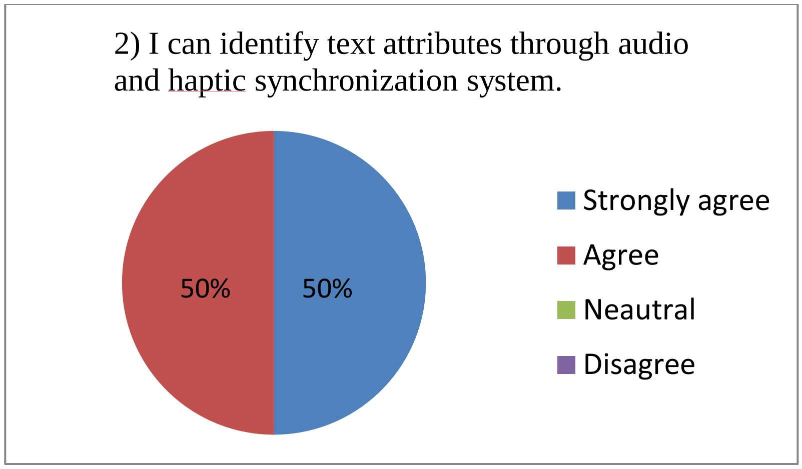


Figure 15: Response on the ability to identify text attributes through the synchronization of audio and haptic in the system.

Analysis:

50% of the respondents strongly agreed and another 50% agreed that they can identify text attributes through the new proposed system. This result highlights that the main objective of the system to identify the text attributes is achieved.

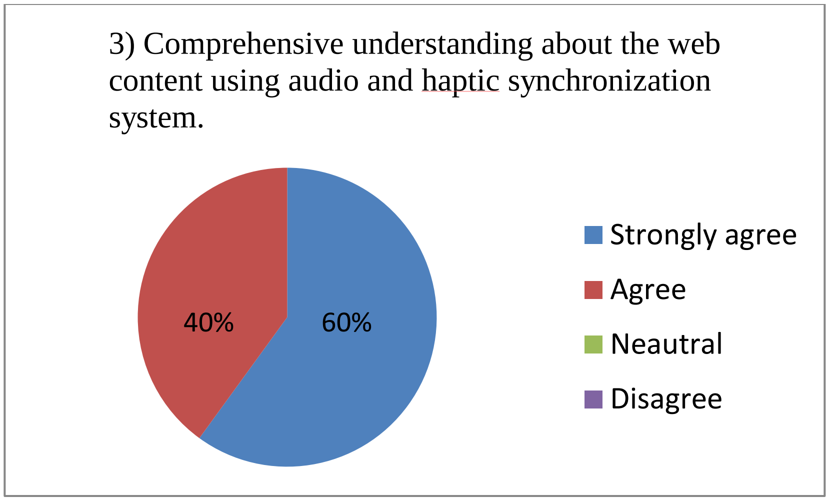


Figure 16: Response on the ability to get a comprehensive understanding about the web content using the new proposed system.

Analysis:

Most respondents claim that the system provides them with comprehensive understanding about the web content. This proves that multimodal technology can non-visually improve user's understanding on the website.

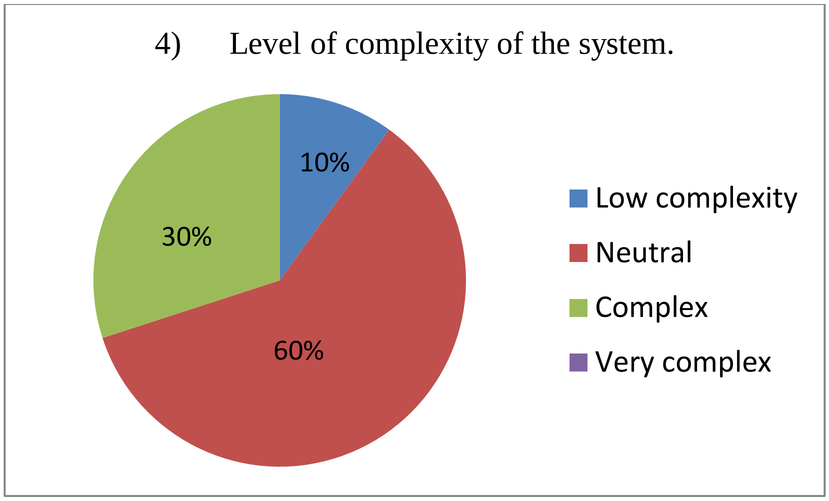
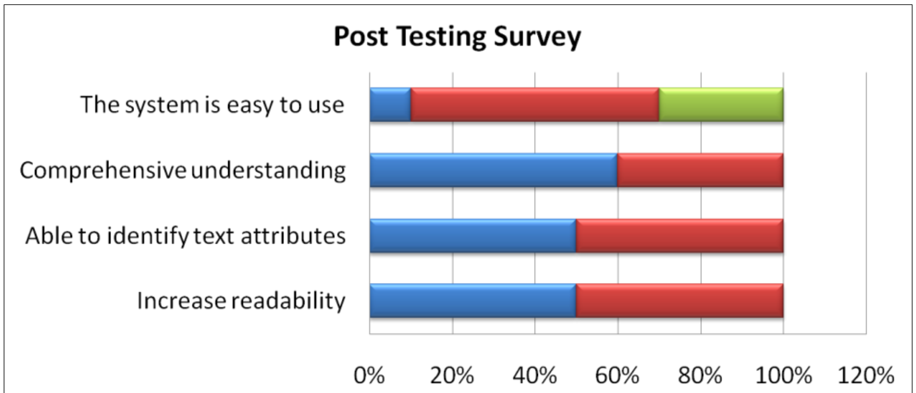


Figure 17: Response on the level of complexity of the system.

Analysis:

60% of the respondents are natural about the level of complexity of the system, while 30% regards it as complex, and 10% finds the system is easy to use. This is because all of the participants in the pilot testing have no prior knowledge and experience in Braille. Some of them find it difficult to feel the Braille characters of text attributes on the Braille Line device. In addition, they have been introduced to new Braille codes during the pilot testing, which they need to remember in short time. However, most of them mention about the likelihood of improvement in performance if they are given more training on Braille.



	Increase readability	Able to identify text attributes	Comprehensive understanding	The system is easy to use
Strongly agree	50%	50%	60%	10%
Agree	50%	50%	40%	60%
Neutral	0%	0%	0%	30%
Disagree	0%	0%	0%	0%

Figure 18; Summary of the post testing survey.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Relevancy to Objectives

Based on the previous discussion, the objectives of the project are:

1) To investigate the significance of text attributes to support Web accessibility and improve understanding of the content:
   - To determine from literature about Web accessibility.
   - To ask from the visually impaired their Web browsing experience.
2) To develop a system that synchronizes audio and haptic to read Webpagess and represents text attributes to visually impaired users.
3) To test the audio haptic synchronization system with the visually impaired users.

The project serves the earlier mentioned objectives. Research has been conducted regarding Web accessibility amongst visually impaired Internet users. This was done to get a better understanding of the project's foundations. The paper also examines the existing assistive technology limitations that hinder visually impaired users from acquiring comprehensive understanding of the Web content. The project is seen to be relevant to improve the browsing experience of the visually impaired users. The second and third objectives of the project which are to develop an audio-haptic synchronization system to read webpagess and represent the text structures and font attributes as well as the system testing with the target users shall be fulfilled along the way of completing the Final Year Project 2 (FYP II) on the next semester future work.

From the study, it can be concluded that it is important to maintain Web accessibility for disabled people. This is to ensure that people with disabilities especially the visually impaired users have access to information on the Web. It is essential to provide equal access and opportunity to disabled users. An accessible Website can also encourage disabled people to participate more actively in the society.

In addressing the Web accessibility challenges, two-dimensional mental model can be used to enhance the browsing experience of visually impaired users. Unlike the one dimensional linear representation of texts via assistive technology such as screen reader, the two dimensional mental model would help visually impaired users to gain better view of the website and improve users' web navigation.

The future assistive technology should implement multimodal technology to improve the mental model created by the blind user. Researches had proved that multimodal technology helps in assisting visually impaired people to access visual presentations. To do so, a system with synchronized audio and haptic approaches can be utilized to represent Web content and non-textual representations in a more effective way.

5.2 Suggested Future Work for Expansion and Continuation

For future work, the author will continue with user testing with the visually impaired in Malaysian Association for the Blind (MAB). The user testing is conducted to test the usability of the system with its potential users. The results and comments after the user testing will be used to improve the current system.

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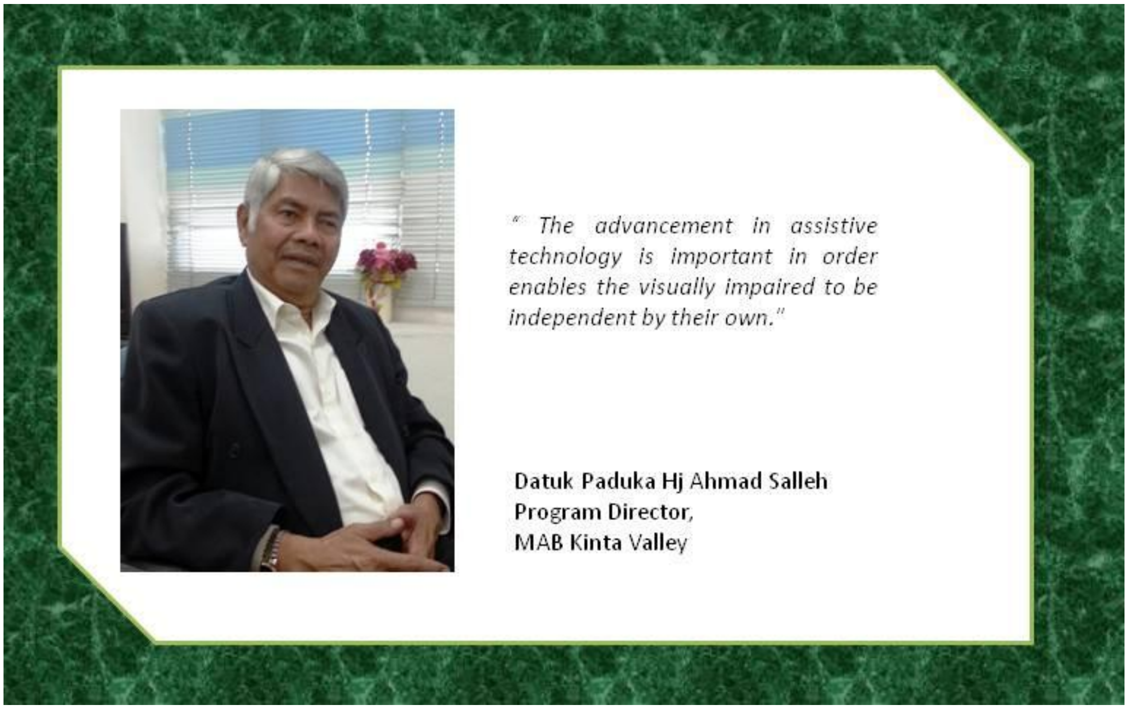
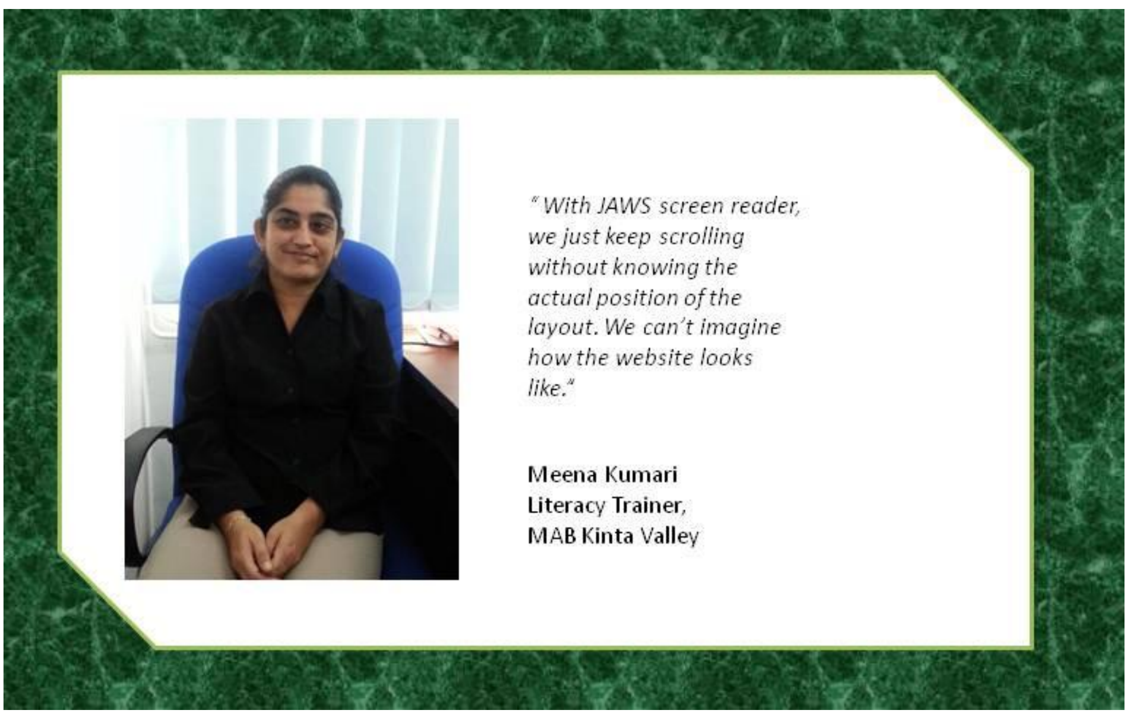
APPENDICES

Interview Participants from Malayisa Association for the Blind (MAB)





"Text attributes are important especially in quotation and things like that. Because mostly, the words in English are perfectly in correct grammar except those in the quotation marks."

Arif Abu Farid
Braille Instructor,
MAB Kinta Valley

Photo session with MAB’s staffs after the interview.

Interview Questions

Background Information	▪ Full Name ▪ Gender ▪ Age
Research Area	▪ Do you browse Internet? ▪ Are you an active computer and Internet user? ▪ How often you browse Internet? ▪ What are the types of browsing activities you do? (Research/networking/shopping/reading/entertainment/blogging/e-mail) ▪ How often you visit these types of websites?
Current Assistive Technologies	▪ What type of assistive technology you use? ▪ What are the limitations/problems with the current assistive technology used? ▪ Which is your preferred method to access webpage? (Screen reader or Braille display).
Text Attributes	▪ Do you think the text attributes such as bold, underline, and italic are important in understanding web content? ▪ How important are they?
Mental Modal	▪ Do you have problem to imagine the structure of Website using the current assistive technology?
Audio Feedback	▪ Do you have problems to understand Web content through audio feedback (screen reader)? ▪ In your opinion, how effective is audio feedback in providing comprehensive understanding of the Webpages content?
Multimodal Technologies	▪ Do you agree that the integration of audio and tactile modalities would improve your browsing experience and eventually improve your understanding of the Web content?
Recommendation :	▪ What are your recommendations to improve Web accessibility among the visually impaired user?

Pilot Testing Experiment: The Effectivesness and Efficiency of Audio and Haptic Feedback in Reading Webpages.

1.0 Purpose of the Experiment

To investigate the effectiveness and effiency of audio haptic synchronization system in identifying text attributes and improving the understanding of a webpage.

2.0 Scope

i) Recognizing text attributes in the two dimensional webpage. In this experiment, the basic text attributes are being tested are:
   - Bold
   - Italic
   - Underline
   - Header
   - Sub-header

ii) The effectiveness of audio and haptic in understanding the content and structure of a webpage.

3.0 Hypothesis

Audio haptic synchronization system is able to help users to identify text attributes and improve the understanding of a webpages as compared to screen reader.

4.0 Variables

Constant Variables	The webpages content structure. Similar web content structures are used in both experiments.
Manipulated Variables	The implementation of multimodal technology; audio and haptic feedback.
Responding Variables	i) Time taken (in seconds) to identify each text attributes. ii) Accuracy of the identified text attributes (in percentage)

5.0 Tools and Materials

- Braille Line 20 Cell
- CPU Unit (Window XP)
- Screen Reader
- Earphone
- Papers
- Multicolour highlighter.
- Stop watch
- Camera

6.0 Procedure

1) Explanation of the study and briefing about the experiment to participants.
2) The participants are provided with laptop, screen reader, Braille Line Cell 20, and earphone.
3) The participants are trained to use the provided devices and software.
4) The participants are blindfolded to assimilate the visually impaired users.
5) The participants are asked to explore the sample webpage with screen reader.
6) After done exploring the sample webpages, they are asked to highlight the printed paper with multicolour highlighters. Each colour represents a particular text attributes.
7) The time taken to complete the task is recorded using a stop watch. The verbal descriptions are also recorded for future reference.
8) Repeat steps 5-7 using the audio haptic synchronization system..
9) Data for both experiments are recorded.
10) Participants are required to give feedbacks and comments on the project.

7.0 Result

Time taken (in seconds) to identify each text attributes.

Participants	Time taken (s)	
	Screen reader	Audio Haptic Synchronization System with Braille line
Participant 1		
Participant 2		
Participant 3		
Participant 4		
Participant 5		
Participant 6		
Participant 7		
Participant 8		
Participant 9		
Participant 10		
Mean		

The accuracy (in percentage) in identifying text attributes.

No.	Participants	Screen reader		Screen reader with Braille Line	
		Score	%	Score	%
1	Participant 1				
2	Participant 2				
3	Participant 3				
4	Participant 4				
5	Participant 5				
6	Participant 6				
7	Participant 7				
8	Participant 8				
9	Participant 9				
10	Participant 10				
Mean					

8.0 Conclusion

User Testing Experiment: The Effectiveness of Audio and Haptic Feedback in Improving Visually Impaired User's Mental Model

1.0 Purpose of the Experiment

The purpose of this experiment is to investigate the differences of mental model developed by visually impaired users while accessing a two dimensional webpage with text attributes presentation, by using two different approaches:

i) Audio and haptic feedback using audio-haptic synchronization system.

ii) Audio feedback using screen reader.

2.0 Scope

The study focuses on two areas:

iii) Recognizing text attributes in the two dimensional webpage. In this experiment, the basic text attributes are being tested are:

- Bold
- Italic
- Underline
- Header
- Sub-header

iv) The effectiveness of audio and haptic in understanding the content and structure of a webpage.

3.0 Hypothesis

The use of audio and haptic feedback would enable the visually impaired users to recognize text attributes in a webpage while having two-dimensional perspective of the webpages in their mental model. This would help them to gain better understanding of the web content.

4.0 Variables

Constant Variables	The webpages content structure. Similar web content structures are used in both experiments.
Manipulated Variables	The implementation of multimodal technology; audio and haptic feedback.
Responding Variables	i) The effectiveness of text attributes recognition and web content understanding. It is measured by observing and recording the accuracy of the diagrammatic foam block representations. ii) Time taken (in seconds) to identify each text attributes.

5.0 Tools and Materials:

1) Braille Line 20 Cell
2) CPU Unit (Window XP)
3) Screen Reader
4) Foam blocks with different shapes.
5) Mounting board
6) Stop watch
7) Camera

6.0 Procedure

1) Explanation of the study and briefing about the experiment. Participants are divided into two groups; group A and group B.
2) The participants are provided with laptop, screen reader, Braille Line Cell 20, and earphone.
3) The participants are trained to use the provided devices and software.
4) Group A is asked to explore the sample webpage with screen reader, while group B is asked to do the same thing using screen reader and Braille Line Cell 20.
5) After done exploring the sample webpages, they are asked to describe briefly about the page and the text attributes identified.

6) The time taken to read and identify text attributes in the webpage is recorded using a stop watch. The verbal descriptions are also recorded for future reference.
7) Group A and B are then being asked to construct a layout of the sample webpage using diagrammatic representation of foam blocks. Different shapes of foam block represent different text attributes. The pattern of the layout is recorded for future reference.
8) Repeat steps 4-7. This time around, group B is asked to explore the sample webpages with screen reader, while group A is asked to do so using screen reader and Braille Line Cell 20.
9) Data for both experiments are recorded.
10) Participants are required to give feedbacks and comments on the project.

7.0 Result

The percentage of accurate arrangement of text attributes and webpages content are calculated and recorded.

Groups	**Participants**	**Accuracy (%)**	
		Screen reader	**Screen reader and Braille Line Cell 20**
A	Participant 1		
	Participant 2		
B	Participant 3		
	Participant 4		
	Average (%)		

The times taken to read and identify text attributes are calculated and recorded:

Groups	**Participants**	**Time taken (s)**	
		Screen reader	**Screen reader and Braille Line Cell 20**
A	Participant 1		
	Participant 2		
B	Participant 3		
	Participant 4		
	Average (s)		

8.0 Conclusion

Usability Survey:

1) The system is helpful to increase readability of web content.
    - ☐ Strongly agree
    - ☐ Agree
    - ☐ Neutral
    - ☐ Disagree

2) I can identify text attributes through audio and haptic synchronization system.
    - ☐ Strongly agree
    - ☐ Agree
    - ☐ Neutral
    - ☐ Disagree

3) I get more comprehensive understanding about the web content using audio and haptic synchronization system.
    - ☐ Strongly agree
    - ☐ Agree
    - ☐ Neutral
    - ☐ Disagree

4) Level of complexity of the system.
    - ☐ Low complexity
    - ☐ Neutral
    - ☐ Complex
    - ☐ Very complex

5) Suggestions:

    ____

    ____

    ____

Gantt chart

No	Activities	FYP I				FYP II				
		May	June	July	Aug	Sept	Oct	Nov	Dis	Jan
1	Selection of FYP Topic									
2	FYP 1: Research Class I									
3	Preliminary Research									
4	Submission of Project Title Proposal		*							
5	Approval of Project Title Proposal		*							
6	FYP 1: Research Class II									
7	Paper Work on Extended Proposal									
8	Chapter 1:Project Background									
9	Chapter 2: Literature Review									
10	Chapter 5: Conclusion and Recommendation									
11	FYP 1: Research Class III									
13	Submission of Extended Proposal			*						
14	Extended Project Research									
15	Paper Work on Interim Report									
16	Chapter 3: Methodology									
17	Chapter 4: Result and Discussion									
18	Pre-Development of Project									
19	Preparation on VIVA									
21	VIVA: Proposal Defense				*					
23	Submission of Interim Report				*					
24	System Development									
25	User Testing									
26	Submission of progress report							*		
27	Pre-SEDEX							*		
28	Technical Report Submission								*	
29	1st Draft Dissertation									
30	VIVA: SEDEX								*	
31	Final Dissertation & Hardbound								*	

The symbol * indicates the key milestones of the project.

Table 5: Final Year Project 1's Gantt chart