Re-Presenting Text in a Website for Visually Impaired Users using Braille Line

by

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CERTIFICATION OF APPROVAL

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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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MAHMUD MAZUIN BINTI MOKHTAHIR

ABSTRACT

As new web technologies emerging and being adopted in the design of a website, web accessibility has become a major issue especially for people with disabilities .Limitation of assistive technology to render webpage has also been contributing factor for poor web accessibility by the visually impaired users. This issue has caused visually impaired users loss semantic information of webpage besides creating frustration situation of web browsing. In this paper, factors that cause web browsing frustration to the visually impaired users and types of tactile effects that can be implemented in the Braille Line device to render the semantic information of webpage are explored. The main objectives of this project is to build a website reader and program a Braille Line 20 cell device for web browsing focusing on presenting non visual text elements such as font attributes and text hierarchy that can be critical to meaning of the text. Tactile technology have been chosen to be adopted in the Braille Line as the touch is the most active sense of visually-impaired people to acquire knowledge .From the prototype to be build, a sample group of visually impaired users will be taken to test and evaluate the website and the device in terms of technology as well as its effectiveness. The results and recommendations were shared by the end of the project as a key milestone for future renditions of the project.

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Finally, I would like to thank my parents for giving me the moral support along the completion of my final year project. I hope, with the support from all of the people mentioned above, this research will able to contribute as much as possible in improving readability of text in a website for visually impaired users.

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CHAPTER 1

INTRODUCTION

This chapter will describe the overview of the project that covers the following topics.

- Background of Study
- Problem Statement
- Significance of the project
- Objectives and Scope of Study
- Feasibility of the Project within the Scope and Time Frame

1.1 Background Of Study

Internet plays a major role as media to communicate information to anyone in the world having access to the internet. It has changed the way the world works and it has become more and more important in the human's daily life. It also has become a valuable information resource for people with vision impairment. Realizing the talent of disable people are wasted due to lack of access of information, many assistive technologies have been developed over the past years. Screen readers and talking browsers are example of technology developed and improved along with the evolution of the Web to help visually impaired users people obtain information from the Web.

Accessibility is a term used to describe degree of which the product is able to access by the user and benefit from it. It is a very important factor that determines the success of a product to reach to the customer. The same concept applies for the development of a website in order to reach the information to the user. Web accessibility has become a major issue as new web technology such as JavaScript and Flash are embedded into the web pages especially for people with disabilities. The complex forms of the website become inaccessible using the assistive technologies available. Since the late 1990s, the awareness of web

accessibility has been spreading all over the world. There are many research and efforts being carried out in order to solve this problem.

One of the main efforts to solve this problem creation of general set of guidelines to promote web accessibility by the World Wide Web Consortium (W3C). Besides that, the U.S. government has also established an act, Section 508 of the U.S Rehabilitation Act that requires all federal agencies 'electronic and information technology to be accessible to people with disabilities (Asakawa, Takagi, Fukuda & Maeda, 2003). In spite of all these efforts, there is still serious usability issues exist in many web pages even they follow the basic guidelines provided. These issues have created big frustration among visually-impaired users to understand the semantics of a website. Therefore, this paper aims to identify the current problem faced by the visually impaired users to browse internet. Besides that, it also aims to explore types of tactile pattern that can be implemented on the 20 pin Braille Line device for the purpose of rendering the semantic information on a webpage and to increase readability of the text.

1.2 Problem Statement

1.2.1 Problem Identification

Based on research done by Sullivan and Matson(2000) on the 50 most popular websites, about 82% of the website characterized as "inaccessible" by virtue of posing at least one accessibility problem. In other hand, according to the report of popular press, eWeek.com about 95 to 99 percent of sites is inaccessible to the people with disabilities (Vaas, 2000). These statistics clearly indicated that the most of the website even failed to deliver an accessible website to the sighted users and poses challenge to them to obtain information from it. Comparatively to the sighted users, this problem will create more challenges to non-sighted users as they are able to unable to view the graphics on the page to understand the information on the page.

Table 1: Summary of How Participants Responded to the Frustrating Experiences

How Did Participants Respond to the Frustrations?	*n*
I was unable to solve it	110
I knew how to solve it because it has happened before	54
I ignored the problem or found an alternative solution	48
I figured out a way to fix it myself without help	39
I asked someone for help	32
I tried again	18
I rebooted	15
I restarted the program	7

Table 1 shows the result of survey conducted on 100 blind users and how the blind users responded to the frustrating experience of browsing .This results clearly shows that the high percentage of users are unable to solve the problem when they face challenges during browsing (Lazar,Allen,Kleinman & Malarkey,2007). This situation forces them to abandon a task or force them to get sighted help.

Besides that, another factor that causes limitation to the visually impaired user to acquire information on a webpage is assistive technologies. According to Kuber, Yu and McAllister (2007), assistive technologies that are currently available in the market only able to output information on a webpage in a linear and time-consuming fashion. Most of the device failed to deliver the non-textual content such as text formatting, text structure, images and tables that often play as key to deliver comprehension information of a webpage.

In summary, besides poor web accessibility and usability issues, limitation of assistive technologies also limits the ability of visually impaired users to obtain information from a webpage. The frustration situation created by the both the webpage and assistive tools makes them loses valuable information.

1.2.2 Significance of the Project

According to the statics of World Health Organization, about 285 million people are visually impaired worldwide and 39 million among them are blind. In Gerber and Kircher (2001) journal, they have reported that in year 1999, there were approximately minimum 1.5 visually impaired computer users, including those who are blind. These statistics proves that they make large community and they are making initiative to go along with the new technology to acquire knowledge and to communicate. Neglecting this large amount of users will results in large amount of talent and human resources are wasted for a country. Therefore, issue of disabled accessibility need to be given importance.

Significance of this project is to explore the best way to represent the non-visual presentation of text in a website for visually impaired users and also to identify the effective way of communicating the information through assistive technology. Successful implementation of this project is able to benefit visually-impaired users to access information and go along with the trend of the world. Besides that, it also can help to increase productivity of visually impaired users in process of studying and doing research.

1.3 Objectives

The objectives of the paper are:

1) **To investigate how the visually impaired access information on the websites and the difficulties they may face in order to understand the content of the website.**
    - To identify the problems with the browsers and tools developed for disabled people to read the source code of the websites and then render it in the way they were designed.
    - To identify challenges faced by the web developers to design and build according to the disabled accessibility.
2) **To explore types of tactile effects that can be implemented to program Braille Line 20 cell device to assist in conveying semantic information of a webpage to the visually impaired users.**

The objective of the project is:

1) **To develop a website reader focusing on improvising the presentation of text structure and font attributes to the visually impaired users.**
2) **To program a Braille Line 20 cell device to render the important text formatting of a webpage along with text in order to increase the readability of the user.**

1.3.1 Scope of Study

Based on the objectives mention earlier, scope of the study is only focused to cater the blind users in visually-impairment group. Besides that, one of the main emphases of the project is to develop a website interface focusing on improvising the non visual presentation of the text for easier retrieval of information compared to the decorative look of a website. Lastly, is to develop a Braille Line to render the important text formatting of a webpage along with text to the user.

1.4 Feasibility of the Project within the Scope and Time Frame

In terms of time frame, a complete and thorough study of the subject matter especially in the verifying the effectiveness of the device outputting non visual presentation of text in a website to visually impaired users requires a high time commitment. Since the research period is very short, it is limiting the extensive research outcomes and transforming ideas and solutions into a working system will be quite challenging. With all the constraints that may be encountered throughout the development phase, the risk on the project size is medium.

The time frame of the project development will be two semesters of study, whereby the first semester the project will be more focused on the planning, analysis, research and design phase and the second semester will be mainly on developing the prototype and usability testing.

In terms of technical, website reader that focuses on textual representation is simple and feasible to build using C sharp language in a very short period. On the other hand, the Braille Line 20 cell device which need exploration of the function and process of the device are feasible to programmed within time frame as it only includes newly defined Braille code for representing the font attributes and font hierarchy in a text.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses on the general idea of the project. Several keywords discussed to address the statement of the problem in the previous chapter and a solution is proposed at the end of this chapter.

2.1 Problems faced by the visually impaired people to understand the content of the website

Petrie, Hamilton and King(2004) conducted studies on web accessibility with different type of impairment group consists of blind, partially sighted, dyslexic, physically impaired and hearing impairment to identify the common problems faced by them. As a result, the problems that mainly identified are cluttered and complex page layouts, confusing and disorienting navigation mechanisms, poor contrast between content and background, an incompatibility between screen-reading software and pages and text and graphics that are too small to read.

Besides that, Lazar et.al (2007) examined the top causes of blind users frustration using screen reader on a web. According to their research, the main frustration faced by them are due to the conflict between the screen reader and the application, page layout causing confusing screen reader feedback, no alternative text for pictures, poorly designed or unlabeled forms, pop up windows, misleading links, inaccessible PDF and screen reader crash.

According to King, Evans and Blenkhorn (2004) the most common problem faced by the visually impaired users to read and understand content of a website are due to the reliance of the webpage on visually-meaningful formatting rather than correct HTML mark up. As an example, usage of bold, centred and larger text to represent the headline instead of using the HTML “headline” in a webpage causes difficulty for the visually impaired users to recognize the title of the page. Besides that, the embedded non-text content in a HTML documents

and also adoption of Dynamic HTML (DHTML), event-driven code, typically known as JavaScript into HTML documents to provide functionality to HTML's hypertext document system also are also main obstacles for the non-sighted users to access web pages

2.2 Technology for visually impaired people

Over the past few years, there are various assistive technology devices and browsing alternatives have been developed to help visually impaired people to use internet effectively .These products can be categorized into four main groups which are:

a) Screen Readers

Screen readers are computer-synthesized speech software packages that reads out loud the content displayed on the computer screen (Lazar et.al, 2007). It has shortcut-driven interface and also edit modes to ease the visually impaired users to navigate between webpage. The most popular screen readers that are available in the market are JAWS and Window-Eyes besides the simple version screen readers build into operating systems. (Lazar, et.al, 2007).The main problem associated with this technology is some content cannot be accessed non-visually when the webpage is designed without following the proper guidelines. For example, content of the image cannot be understood by the visually impaired users when alternative text explaining the image is not provided. Besides that, the new web technologies such as flash, Silverlight and HTML 5, that widely used has made screen readers difficult to interpret the semantics of dynamic content and making web browsing a challenging experience for the visually impaired users (Borordin, Bigham, Dausch & Ramakrishnan, 2010).To sum up, the screen readers perform very minimal content analysis and limit the functionalities of navigation for non-visual browsing.

b) Voice browsers

According to Borodin et.al paper, voice browsers are basically an augmented web browsers.IBM's Home Page Reader and Brookes Talk are some of the example of self-voicing browser. The latest IBM's plug-in; aiBrowser can be implemented with Microsoft Internet Explorer which enables the visually impaired users to access multimedia content. Other than that, Hearsay is one of the famous self-voicing browsers that can convert web content into VoiceXML dialog for aural interaction in multiple platforms. The current available web browsers focus on communicating semantic information to the user by different technique. For example, BrookesTalk provides summaries and keywords of the webpage, Asakawa et al.'s talking web browser try to indicate emphasis on a webpage by communicating it through background music and tactile output. According to Zajicek (1998) report, interpreting a page for its important semantic meaning is very difficult computing problem, thus the results provided by this modern voice-browsers are inaccurate.

c) Text browsers

Text browsers are browser that represents the content of a webpage as a text only flat document to be accessed with screen reader (King, et.al, 2004).This type of browsers will ignore graphics on web pages and it allows the use of the keyboard to activate the hyperlinks in a page (Loo, Chris, 2004).Besides that, it also provides functionalities to navigate cells of HTML tables in website for easier understanding the structure of real table. Example of text browsers are WebFormator from Webwizard and Frank Audiodata from Baum (King et.al, 2004)

d) Using a transcoding proxy server

According to King et.al research paper, proxy is one of the existing solution to alter the HTML document to provide font, font size, colour and other settings desire by the user in much similar way as the use of the accessibility functions of a client. However this method is not preferable as full access information of the HTML document content requested by the proxy server in order to do the transmission. Thus, this causes the secure transmission no longer usable.

In conclusion, it is important to realise that the use of current refreshable Braille and speech techniques for communication purposes can often results in significant loss of information. As an example, much important information such as the colour attributes and colour types in visual text can be critical to meaning and it is usually lost when it is converted into the Braille or speech form (Burger, Suchard, Barker & Martin, 1992).

2.3 Common website design problems that makes the website inaccessible to the visually impaired users.

There are number of guidelines build by the World Wide Web Consortium (W3C) to promote the accessibility of the Web as well as to set general definition of Web accessibility. The two main guidelines that are developed by W3C are the Web Accessibility Initiative (WAI) and Web Content Accessibility Guidelines (WCAG) (Petrie, Kheir, 2007).However, large number of web designers failed to compile with the guidelines provided thus making the website inaccessible to the users.

Based on Lazar et.al research on hundred blind users, the general website design problem that causes frustration to them are:

a) Alternative text

Alternative text is used to provide brief information of the image present in a webpage. Absence of alternative text will make the visually impaired users lose lot information conveyed by the images. The common problem associated with alternative text is inappropriate use of alternative text or non-descriptive alternative text. Examples of inappropriate text are “space”, “shadow” which actually not represents the image by the format of the picture (Asakawa, 2003). All these useless alt texts interfere with visually impaired user’s browsing and challenge them more to understand the semantic content of the web page.

b) Links

The major problem faced by the participant of Lazar's research related to links is misleading links where the label of the link does not accurately describe where the links directing to in a website and also make the user cannot find the link they are searching for. Apart from that, the skip navigation links that are presents on the top of page to take the user directly to the main content area is also missing in most of the websites. Skip navigation usually invisible and it is presented only in the screen reader to reduce visually impaired user's frustration browsing and also to save their time.

c) Forms

The commonly problem faced by the visually impaired user in the process of online form filling is the forms are poorly labelled or not labelled.

d) Plug-ins

Plug-ins is a set of software component that runs simultaneously with web browsers to deal with certain type of external file such as Java applet, PDF and also flash. Plug-ins can be really irritating to the user when itself might not accessible or the file accessed through the plug-in cannot be accessed. Besides that, sometimes there is conflict between the plug-in and the screen reader.

e) Layout

Page layout is a very important factor to enhance the aesthetics look of the webpage and also for easier retrieval of semantic information from the webpage. Improper layouting are one of the top causes of frustration by visually impaired users as the screen readers read out the webpage linearly or serially. This causes neighbouring information to be lost when it is arranged closely. Another problem that happens in this case is when the pop-up boxes appear. When the pop-up box appears, it will reset the

screen reader to the top of the page again and it causes distraction to the visually impaired users to browse.

2.4 Challenges for web designers

Most of the assistive technology available in the market failed to render the content of the webpage are due to the incompatible format of the webpage with the assistive technology used. This problem mainly happens due to the failure of the web designers to understand visually-impaired user's problem and lack of non-visual browsing experience. It has been big challenge for web designer to a design a website and test the website to be accessible and usable to the visually impaired users. There are some methods currently adapted by the web developers such as testing using automatic validation tools, manual evaluation with accessibility guidelines, general inspection, detailed exploration, viewing with browsers and assistive technologies and also usability evaluations .All these methods however have its own drawbacks and it failed to provide an all-encompassing method for fully accessible sites (Rowan, Gregor, Sloan, Booth, 2000).

The current available methods for testing of website accessibility are:

a) Automated validation tools

   Example of popular automatic validation tools are Bobby and W3C HTML Validation Tool. These tools are used to help the web developers to verify the accessibility of their websites. These tools are limited only to check simple guidelines provided by the W3C and it is unable to check the semantics of accessibility metadata (Borodin et.al, 2010)

b) Manual evaluation with accessibility guidelines

   Checking using W3C's Web Content Accessibility Guidelines only provide an approximation of the level of accessibility of resources .However, it does not indicate the level of usability of the resources. A resource will have low level of accessible if it fails to reach target level of usability. Besides that, the complete set of website accessibility available is simply too great to be reduced to a usable number of heuristics (Mankoff, Fait & Tran, 2006)

c) Usability evaluations

Usability evaluation is evaluation directly carried with the visually-impaired users. The major drawback of this method is time consuming and expensive.

d) Viewing with browsers and assistive technologies

This method requires the sighted developer itself to browse the website using assistive technologies to test the website. This method able to provide better resulting website as the designer conduct the testing in the view of visually impaired users. However, this method is difficult to be carried out by the sighted developer as it takes time for them to learn the features of the assistive technology.

According to Mankoff et.al (2006) research, in order to find both empirical and WCAG accessibility problems, it is most consistently effective to use multiple evaluators using a combination of a screen reader and monitor.

2.5 Types of technology using sense of touch to deliver information

There are many theories and technology relating sense of touch have developed over the year to partially replace missing visual capabilities especially in the task of acquiring knowledge. The following are some type of touch based technology that widely adopted in development of assistive technology for visually impaired users:

a) Haptic technology

According to research paper of Saddik (2007), the term "haptics" is derived from a Greek verb "haptesthai" which means "relating to the sense of touch". Basically; it refers to the science of manipulating surrounding objects and environments through the sense of touch. It also have brought has biomechanics, psychology, neurophysiology,

engineering, and computer science together in the study of human touch and force feedback with the external environment.

The term “haptic” which manipulates the science of touch can be divided into three subcategories, namely tactile, thermal and kinesthesic.These methods are routinely being substituted by the mechanical term “force feedback”. Force feedback represents stimulation of the perception of the body. This force feedback method is being utilized to build haptic device to give a physical consistency to objects displayed on the screen. (Savioz, Markovic and Perriard, 2011).

According to Christian paper (2000), haptic device is a device that combines the tactile perception with kinaesthetic sensing. Examples of device that directly manipulate environments are Braille displays, Braille readers, and tactile diagram and graph interpreters.

b) Tactile technology

Tactile is actually a subcategory of the haptic theory. The word “tactile” simply means it is perceptible by touch. According to Ramstein paper (1996), device or system that is designed to carry information through skin is tactile technology. Examples of them are Braille, vibrotactile simulators and computer mouses with tactile feedback.

2.6 Braille

In 1840, Louis Braille has introduced a new tactile method to help visually impaired users to read and write. This Braille has been widely used in book, signs, elevator buttons and currency to help visually impaired users to communicate with world.

In the standard Braille code library, the alphabets and punctuations are represented by embossed characters made up from one to six dots arranged in a configuration of two columns of three dots each. In another hand, to represent comprehend mathematical symbols and also to be compatible with ASCII

character set,8 dot Braille system (2 columns of 4 dots) have been developed(Alan, Marvin and Larry,1996)

2.7 Exploring the Impulsion and Vibration Effects of Tactile Patterns that can be Implemented on Braille Line

Braille is a method that defines the associations between a dot matrix, the sense of touch, and also alphabetical characters. As the users move their finger on Braille displays, each configuration points on the board will produce a specific sensation on finger tips of the users (Christophe, 1996)

According to research paper written by Muhammad, Gilles and Eric (2008), it stated that tactile patterns are created in a tactile Braille cell using combination of different piezoelectric actuators or bimorphs which moves the 8 pins in the device in a specific order. These pin can have either two different states: raised or lowered which can be manipulated to different states to represent different types of information. In the paper also stated that basically there are two types of tactile patterns which are static and dynamic. They have used the variation of static patterns (impulsion) and dynamic patterns (vibration) in their study to explore the impulsion and vibration properties of different tactile patterns. The differences between the impulse pattern and vibrating patterns are that an impulse pattern is displayed suddenly and once whereas the vibrating pattern is raised up for *n* number of times during a specified time interval. Below are the results of their experiment according to test conducted:

a) Vibration test
   - The less time left between the appearances of two consecutive patterns, the higher the number of errors occurs
   - Increasing the number of patterns within average selection time can increase the number of errors because it becomes gradually difficult for the users to remember different patterns.
   - The type of pattern selected also effects the number of errors produced. Higher distance value able to make higher chance of the tactile patterns to be recognized.
   - In this test, it has been observed that the users performed passive touch which means hold the finger over the pattern

b) Impulsion test

- Higher delay up time causes the pins to stay longer and be recognized more efficiently.
- The delay up time has no effect on the selection time for impulsion set

CHAPTER 3

METHODOLOGY

It is crucial to choose the right methodology in developing software or application. Different methodologies could cater different needs of a project in a period of time. Thus, this chapter will elaborate on:

- Research Methodology
- Project phases
- Methods of data collection
- Sample Design
- Data Representation
- Gantt chart
- Tools for development

3.1 Research Methodology

There are wide variety of application development models that have evolved over the years and can be applied on web development with their own pros and cons. The criteria of methodology that have to be considered before being implemented include the size of the project, urgency and client requirements. After carefully analyze all the methodologies, Rapid Application Development (RAD) have been chosen as the best methodology for this project.

Rapid Application Development (RAD) is a development lifecycle designed to provide much faster development and higher-quality results than those achieved with the traditional lifecycle. According to Berger, Baynon-Davies & Clearly (2004), RAD is an iterative process where the system development will undergo the same process for more than a time and it involves prototyping. This is due to

the added functionalities that evolve during the system development phase based on the user requirements. Therefore, this methodology is suitable for the development of the website reader and the device where the final output targeting on increasing readability of structural content for the visually impaired users and to be delivered within a shorter time scale.

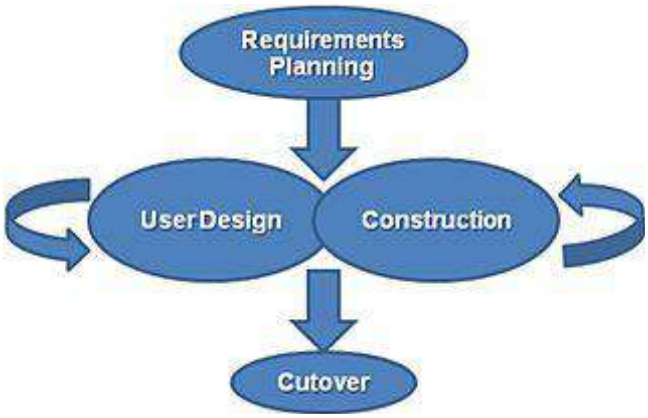


Figure 1: Describes the processes in Rapid Application Development (RAD)

3.2 Project Phases

Phase 1: Requirements Planning

In the RAD life cycle, requirements planning focus on planning and analysing of the project. The elements that are incorporated in this stage are:

a) Define research problem

For this project, the problem has been identified where the need to improvise the non visual text structure presentation of a website to the visually impaired users and also to build an assistive technology for web browsing in order for them to understand and retrieve the semantic information of a webpage.

b) Review concept and theories/Review previous research findings

Critical analysis on the literature is conducted to have a better understanding on the current problem visually impaired user facing in browsing and also to review the existing theory and guidelines on web accessibility by other researcher.

c) Data Gathering

Gather data and information on the user requirements using different methods of data collection such as interview with the visually impaired users on the experience of browsing.

Phase 2: User Design

During this period, models and prototypes that represent all system processes, inputs, and outputs are designed. It is a continuous interactive process that allows users to understand, modify, and eventually approve a working model of the system that meets their needs.

In the Table 2, it shows the Braille code that were newly defined to represent the non visual text structure presentation of a webpage which include font attributes and text hierarchy. The font attributes (bold, italic, underline) codes were adopted from format determined by Braille Authority of North America (BANA) and the text hierarchy (heading, sub heading and paragraph) were symbolized using short form of the word itself.

Table 2 Braille code for font attributes and text hierarchy in a text

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

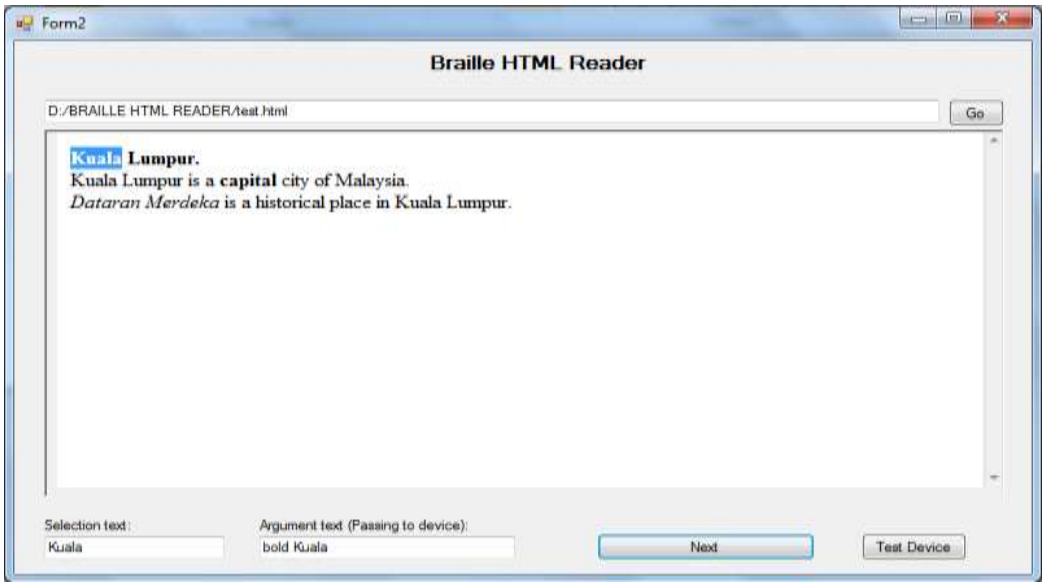


Figure 2 Design of Braille Reader

The figure above is the design of website reader to be used with the Braille Line. The website reader is designed in a very simple way to ease the visually-impaired user to browse the internet. They have to only press the next button in the reader in order to read the text in a webpage word by word. The next button can be navigated easily using space bar in the keyboard.

Basically, the user design phase determines how the prototype will be implemented in the real environment. In this case, the prototype that will be developed will act as assistive tools to visually impaired users to read and understand the semantic information of the text on the webpage. The illustration of the interface and the Braille code is determined based on the findings received from requirement planning stage.

Phase 3: Construction

This phase focuses on coding and testing of the project. It actually involves the actual development of the system where the system specification is converted into an executable system. Then, the project needs to be tested for conformance with the system requirements. There are two types of testing that is planned to be conducted on this stage:

a) Testing by the developer itself using the method proposed by Mankoff et.al in his research, is to use multiple evaluators such as automated checkers, manual evaluation with accessibility guidelines and also screen reader for testing the accessibility and readability of the website interface.
b) Usability testing on the visually impaired users to get their feedback on the effectiveness of using the 20 pin Braille Line device to read text of a webpage.

Phase 4: Cutover

The primary objective of this stage is to 'transit' the system from development into production, making it available to and understood by the end user. The activities of this phase include training the end users and beta testing the website and the device to validate it against the end users' expectations. The product is also checked against the quality level set in the inception phase. If all objectives are met, the Product Release Milestone is reached and the development cycle is finished.

3.3 Methods of Data Collection

Data gathering will be conducted by using sources as listed below:

- Interview with the IT department manager of Malaysia Association for the blind(MAB) in Kuala Lumpur to have comprehensive understanding on the current problem facing by the visually impaired users using internet technology and what can be their requirements or recommendation on this project.
- Interview with 30 visually impaired users in order to identify the problem faced by them accessing internet and also to gather their requirements on the project. Besides that, also to survey on the relevancy of the project to be implemented to assist them.
- Reviews and comments based on the testing of the prototype of the project will be collected from the visually impaired users to verify whether requirements are met or not.

- Theoretical information will be gathered through review of related literature of current technology and theory used to overcome the inaccessibility of a webpage by visually impaired users.

3.4 Sample Design

3.4.1 Defining the Population

An acceptance survey will be conducted among the visually impaired students in Malaysia Association for the Blind (MAB) .They are the targeted population to test the feasibility of the proposed system.

3.4.2 Sample Size

Due to time constraint, the targeted sample size to be carried out interview will be 30 visually impaired users and for the testing of the prototype estimation of 10 – 15 visually impaired users will be involved.

3.4.3 Sampling Method

Probability sampling method is a method that requires a sample population to be chosen in order to conduct a survey. It is one of the best methods for data collection as according to Doherty (1994), if the sampling is properly conducted, there will be no bias in the result. Therefore, in this project it is suitable to adapt this method to conduct survey on the visually impaired users to test the acceptance of the project.

3.5 Data Representation

Once data collection is complete, interpretation and analysis of data will be carried out to gather the information in both qualitative and quantitative methods.

- **Qualitative Method:** It concerns with the views and opinions of the sample population derived from the interviews with regards to how the proposed system able to help in improvise readability of a website. This analysis able to provide a clearer view on how the project can be improvised.

- **Quantitative Method:** This method is concerned with the initial hypothesis made at the beginning (McBride & Schostak, n.d.). In this research study, the hypotheses will be;
  - **H0:** Visually impaired users takes a very long time to visualize non visual text structure presentation of a webpage or unable to visualize it at all.
  - **H1**: Visually impaired users takes a very minimal time to visualize the non visual text structure presentation of a webpage and able to increase their readability of text.

At the same time, this method uses numerical evidences to support the data gathered from the questionnaires or acceptance survey that will be carried out to the specific respondents. The data will be depicted in graphs and charts with percentages to be able to draw an informed conclusion.

3.6 Gantt Chart

See appendix A (Gantt chart)

3.7 Tools

3.7.1 Hardware

Below are the specifications of the hardware used in the development of the prototype:

a) Braille Line 20 cell

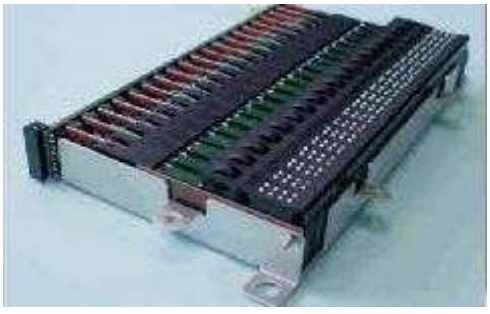


Figure 3 – Braille Line 20 cell

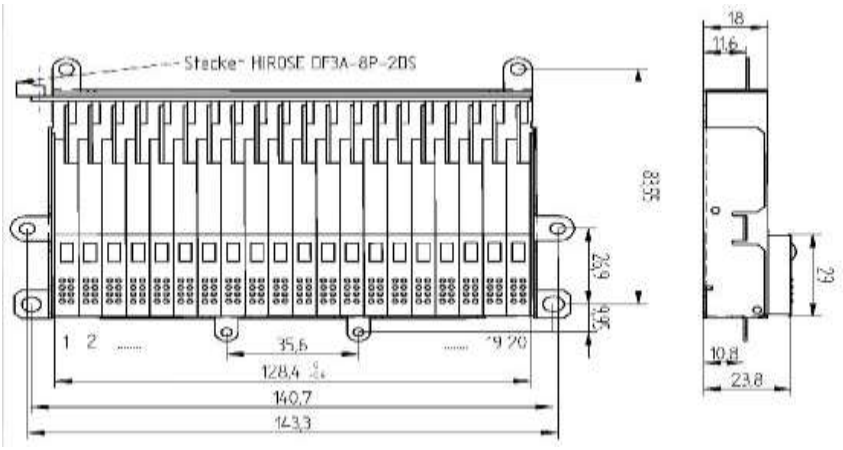


Figure 4- Technical sketch of the Braille Line 20 cell

Technical data :

- 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

b) Development Machine Specification (CPU Unit)

- Platform – Microsoft Windows XP Professional (32-bit)
- RAM – 1.00 GB
- Processor – Intel (R) Core(TM)2 Duo CPU (2.53GHz)

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.

3.7.2 Software

a) Braille Line 20 cell development

Borland C++ 5.02 – Borland C++ is a programming platform for MS-DOS and Microsoft Windows. This platform has been adapted to program the device as the original function of the device is programmed using this development environment.

b) Braille Reader

Microsoft Visual Studio 2008 – Microsoft Visual Studio is a popular integrated development environment (IDE) used for developing application with graphical interface, web sites and web applications .In this system, it was used to design the interface of the reader and also to program the reader to render the webpage.

c) Website Interface

Notepad ++ - Notepad ++ is a source code editor that supports several programming languages such as C, C++, HTML, CSS and others. I have used this editor to program the website interface as it easy to debug code whenever there are bugs.

CHAPTER 4

RESULT AND DISCUSSION

This chapter discusses on all of the results collected from most of the phases in the system development process. The result helps to support the evidence towards achieving the objectives together with the discussion. This chapter will describe on several main aspects mentioned below.

4.1 Result of Pilot Study

Before the system was implemented, a pilot study was done earlier in order to get more detail insights on the general problem faced by the visually-impaired users to access internet. The pilot study also aims to get their feedback on the idea of representing the non visual text structure in a website using Braille Line 20 cell device. A set of questionnaire has been prepared to be asked with 30 visually impaired participants. The participants were guided by the sighted people to answer the questionnaire. Most of the participants were young adults from the age of 20 to 35.

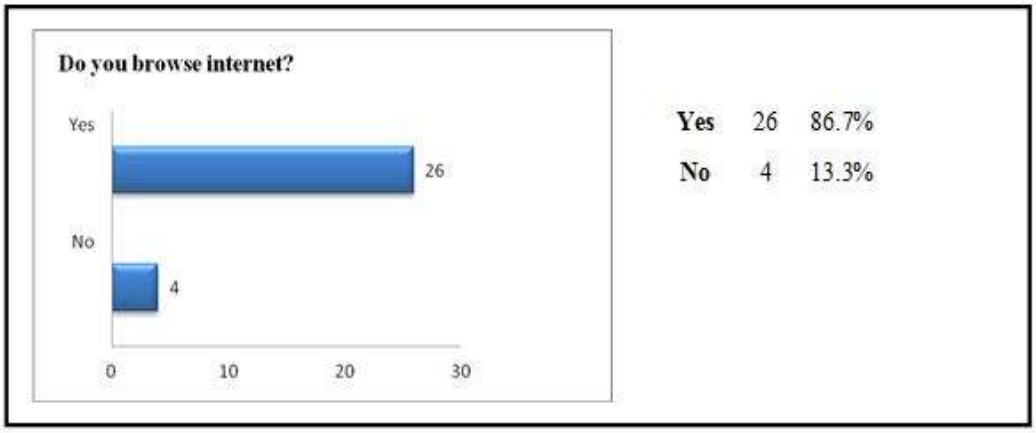


Figure 5- Response on number of respondents browse internet.

Analysis – According to the bar chart, most respondents browse internet. This support relevancy of the project as well as the literature reviews.

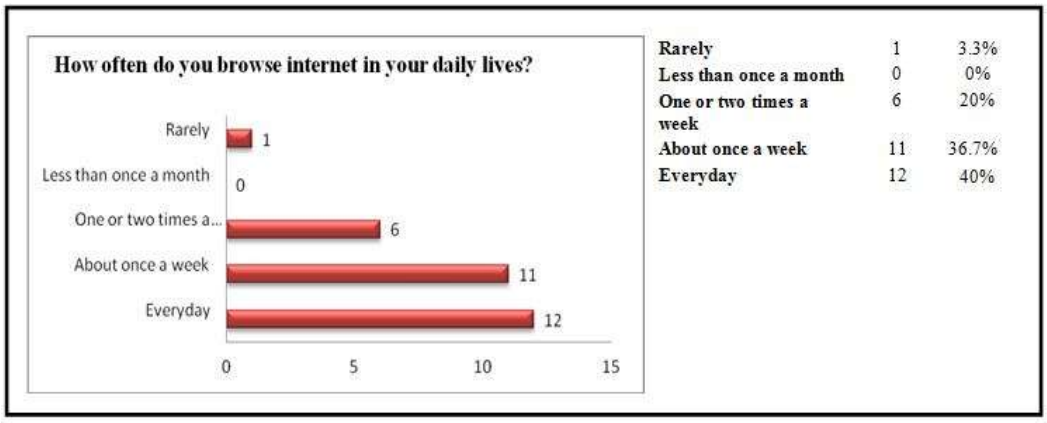


Figure 6 – Response on frequency of net browsing by the respondents

Analysis: Most of the respondents uses frequently internet in the daily lives for various purposes. This statistics clearly shows that internet also has become major tools to communicate information among visually impaired users.

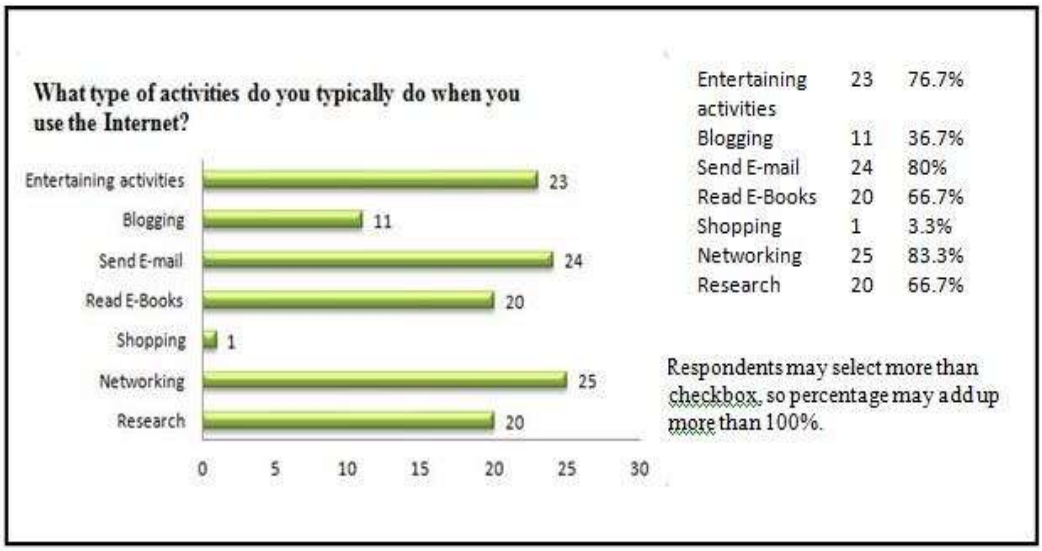
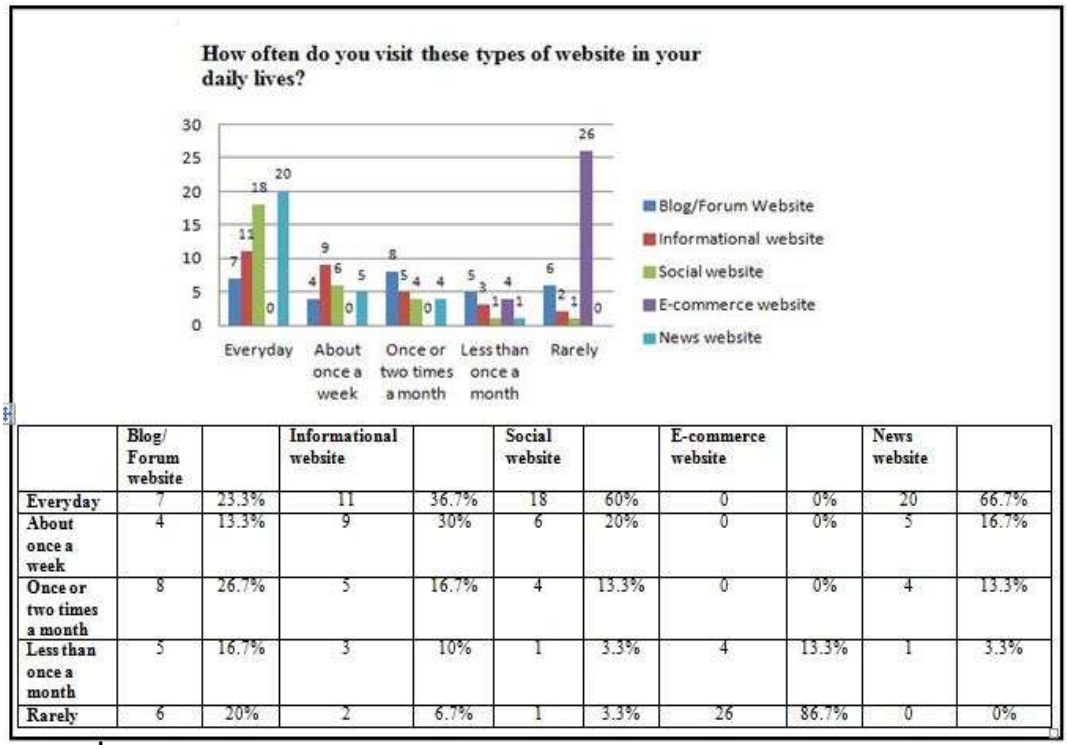


Figure 7 – Response on type of activities respondents do when browsing internet

Analysis – According to the graph, high percentage of the respondents uses internet for networking, send e-mail and for entertaining purposes. Besides that, they also uses for researching and to read e-books. This statistics clearly indicates that the visually-impaired users uses internet as tool to communicate with others and as media to acquire knowledge.



	Blog/ Forum website		Informational website		Social website		E-commerce website		News website	
Everyday	7	23.3%	11	36.7%	18	60%	0	0%	20	66.7%
About once a week	4	13.3%	9	30%	6	20%	0	0%	5	16.7%
Once or two times a month	8	26.7%	5	16.7%	4	13.3%	0	0%	4	13.3%
Less than once a month	5	16.7%	3	10%	1	3.3%	4	13.3%	1	3.3%
Rarely	6	20%	2	6.7%	1	3.3%	26	86.7%	0	0%

Figure 8 – Response on types of website respondent visit in their daily lives

Analysis – The respondents visit news and social networking website most frequently in their daily lives. Besides that, they also visit informational website like Elsevier in average. The main element of the news and informational websites are information. It is very crucial to present this information in a simple and easy way for them to read and acquire the knowledge. Therefore, it is relevant to give importance on factors that can increase the readability of the webpage.

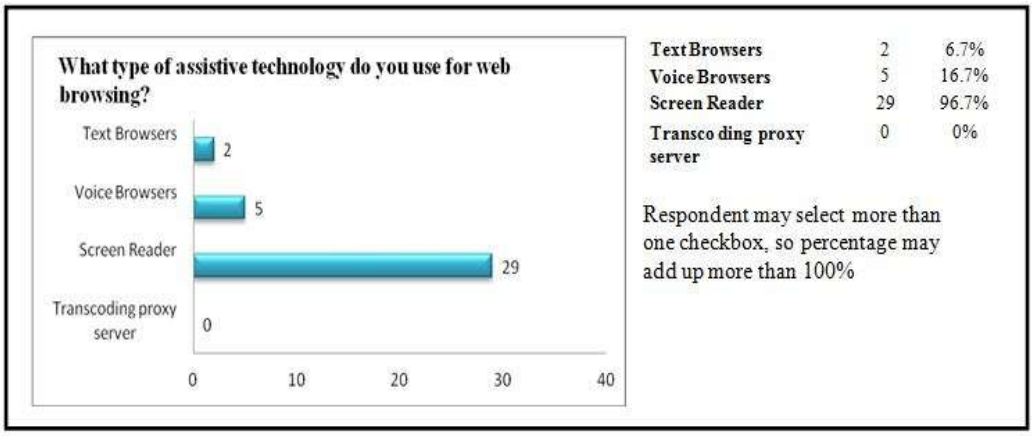


Figure 9– Response on type of assistive technology that currently respondents are using for web browsing.

Analysis – Currently, the most famous assistive technology being used by the visually impaired people are screen readers. Apparently, screen readers are popular because it able to provide better content analysis compared to other assistive technologies. Therefore, the effort of including additional features such as indicating font attributes and highlighting the hierarchy in a text is relevant to improvise the ability of content analysis of a device.

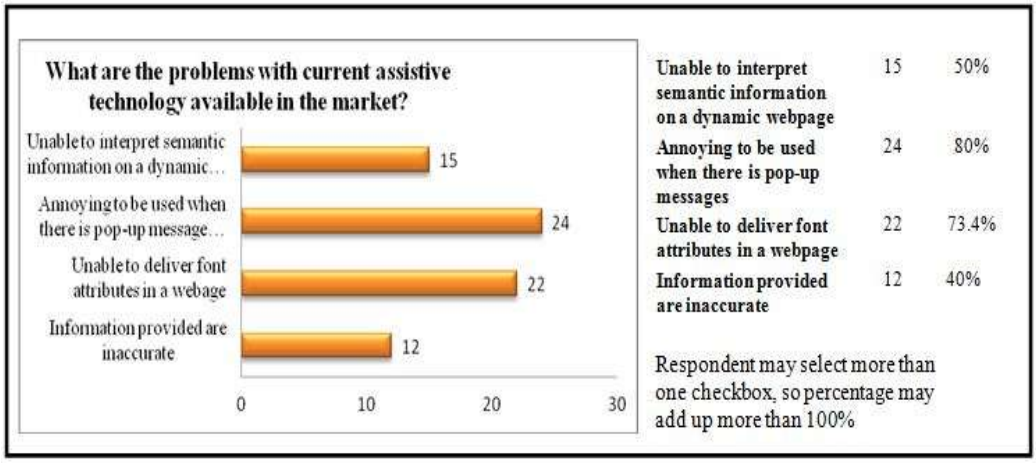


Figure 10 – Response on problems with current assistive technology available in the market.

Analysis – This result clearly indicates that the currently available assistive technologies are unable to deliver font attributes in a webpage such as bold and italic. Therefore, including this feature in this Braille Line device able to create a unique value among the assistive technologies currently available in the market.

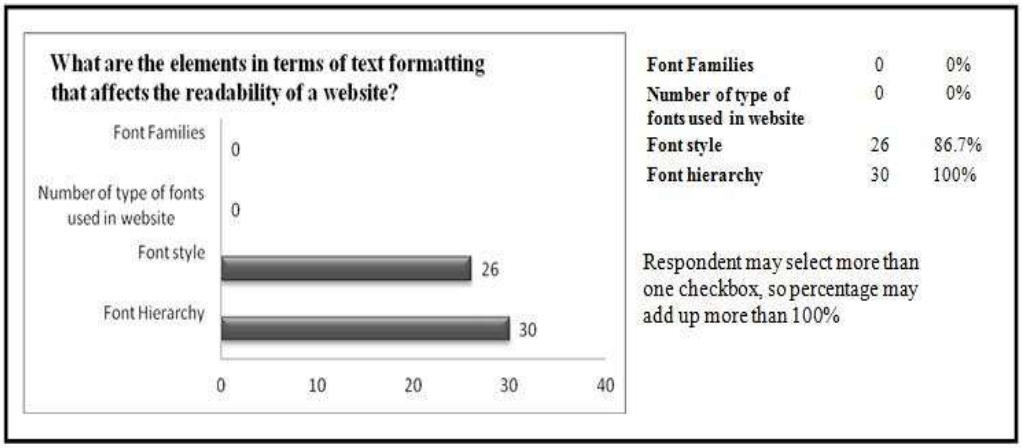


Figure 11 – Response on respondent's opinion on type of elements in terms of text formatting that affects the readability of a website.

Analysis – According to respondent's opinion, text hierarchy and font style are elements that affects the readability of a website. Therefore, it is relevant to include those elements when conveying information on a website to the visually impaired users.

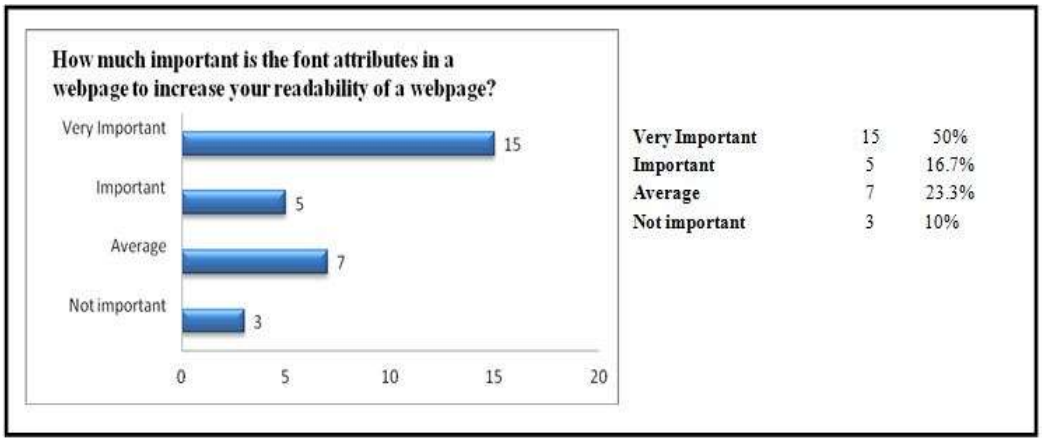


Figure 12 – Response on respondent's opinion on the level of importance of font attributes in a webpage to increase the readability of a webpage.

Analysis – Basically, the respondents agree that font attributes in a webpage is important to increase the readability of a webpage. This statistics supports the objective of the project to program a Braille Line device to convey font attributes in a text along with text.

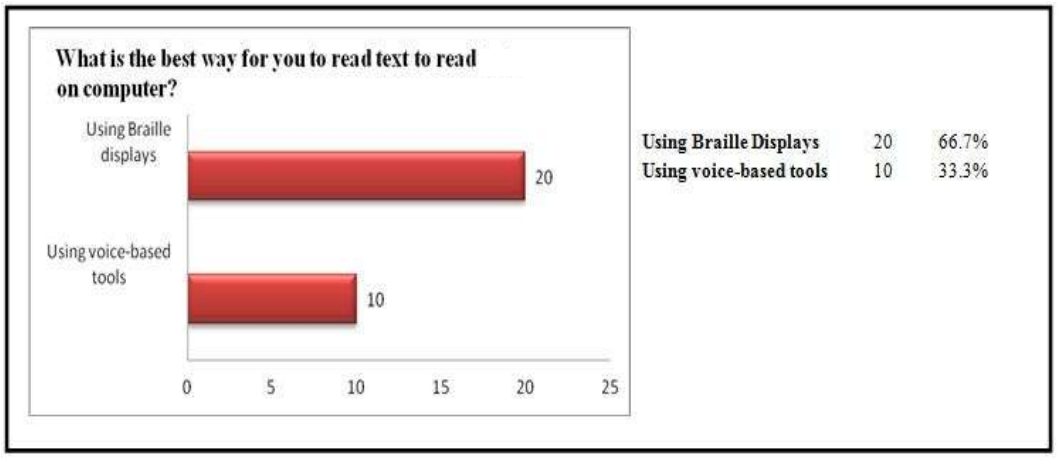


Figure 13 – Response on respondent's view on the best way to read text on a computer.

Analysis – It seems that most respondents prefer to use Braille displays compared to voice-based tools to read text on a computer. This could show the relevancy of the objective of the project to program a Braille Line to render semantic information on a webpage for visually impaired users.

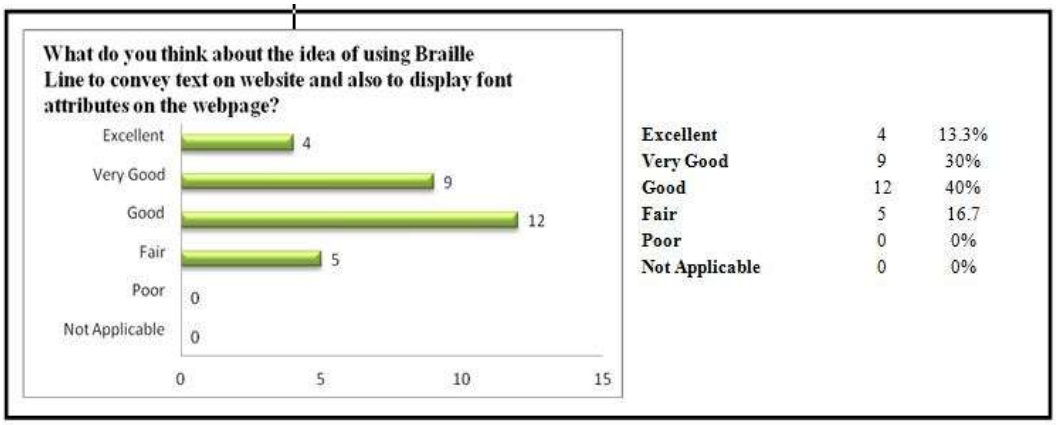


Figure 14 – Response on respondent's view on the idea of using Braille Line to convey text and to display font attributes on a webpage.

Analysis – It seems that most of the respondents agree that using a Braille Line to display text on a webpage is a fair and good idea to assist them in read a webpage. Therefore, this statistics supports the idea of programming to increase the readability of the visually-impaired users.

4.2 Result of interview conducted with Manager of IT Department, Malaysia Association for the Blind (MAB)

An interview was conducted with the Mr. Silatul Rahim Bin Dahman, Manager of IT Department of MAB. He shared his experience and opinion of browsing internet as visually-impaired user. Below are the summary of his interview:

- The common problem that faced by the visually-impaired users during browsing are irritating pop up messages in the website, assistive technologies incompatible with web browsers and also improper web layout design.
- The assistive technologies that are currently available in the market for internet browsing are text browsers, voice browser and also screen reader. Screen Readers has been widely used by the visually-impaired people as it can interpret display on the screen and represent it to the user in form of text-to-speech, sound icons, or through Braille output device. However, all these assistive tools are unable to provide the detail content analysis of the webpage.
- He also agrees that Braille displays are more efficient tools to be used to read text on a webpage compared to synthetic speech. According to him, visually impaired using Braille to read is similar to sighted person reading a print. As the sighted people feels they have better understanding when they read using eyes, the same concept applies to the visually impaired user. They can capture information better with their sensory of touch compared to sensory of hearing.
- Besides that, he also feels that emphasis code in a text is important as it delivers the important points of the text. The bold, italic and underline word in text delivers information in different mode of feeling to the reader. He agrees that these elements are very important to increase the readability of a text in a webpage. He also supported the idea of including indication of text hierarchy in webpage.
- According to him, there is no any standardized Braille code available for font attributes except for underline word. In Braille books, underline word are indicated with Braille dots (46).He suggested to use maximum two Braille cells for indicating the non visual text structure presentation as it is easier to remember.

As conclusion, the result of the interview supports the significance of the project to be developed.

4.3 Flow chart

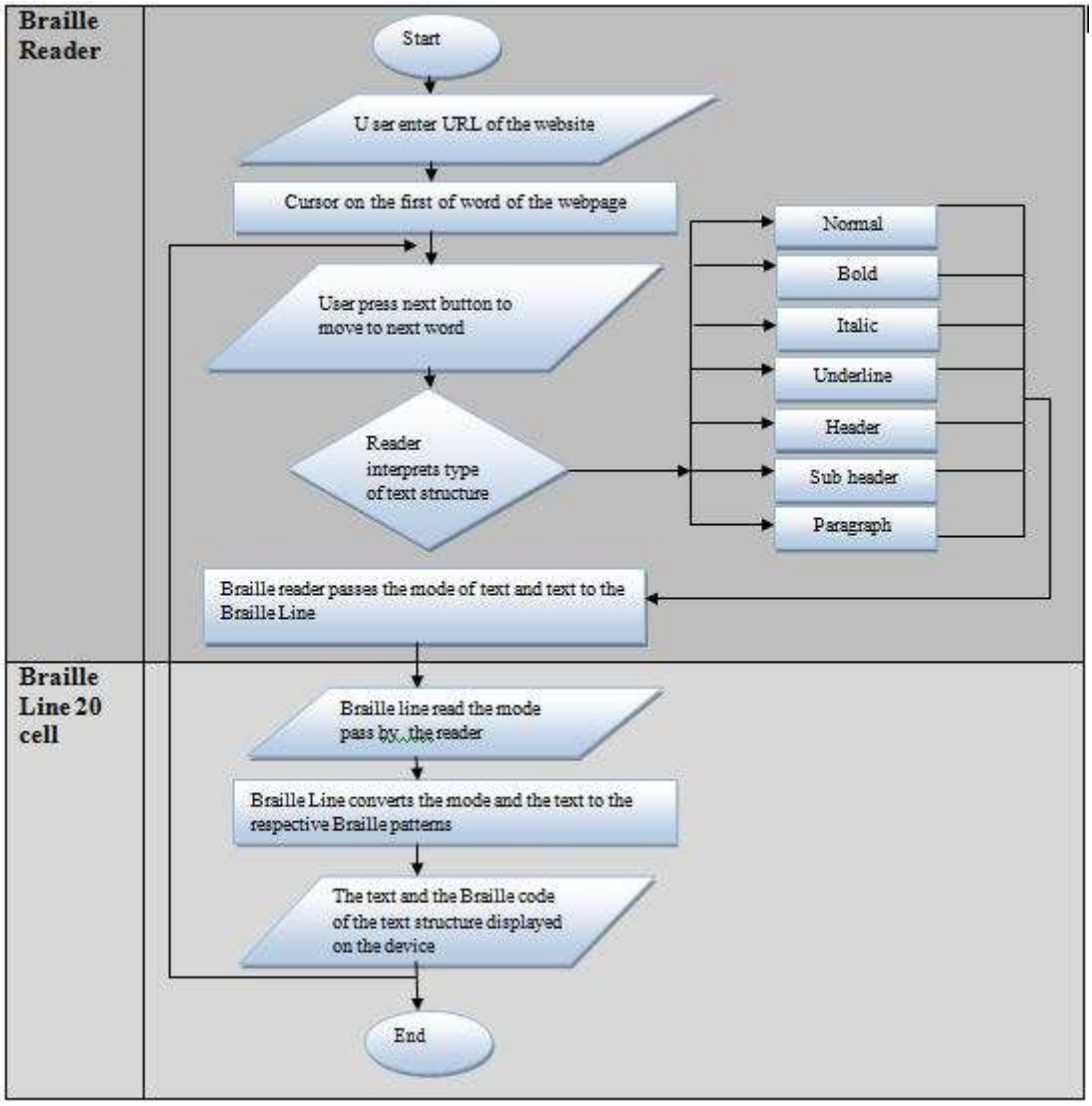


Figure 15 – Flowchart of the process on how the text are rendered to display on Braille Line

4.4 User testing

The user testing is done mainly for the evaluation of the Braille Line device using a subjective evaluation by the users. The main features being tested on the device is on the improvement of readability of a text when presentation of text structure are emphasised. The testing targeted 10 visually impaired users who are able to read Braille, active user of computer and screen reader user. The following are the procedures on how the user testing was conducted:

1) Targeted users are provided with a Braille Line device, sample webpage and also list of codes that represent font attributes and text hierarchy in a webpage. They were given 30 minutes to get used to the list of codes and also the device before starting user testing.
2) Then, the users were given a new sample webpage for them to test the device. They were required to identify the font attributes and text hierarchy presents in the article of the webpage. They were assisted by a sighted user to fill in the questionnaire provided to them. *Refer Appendix C for the sample questionnaire.* Each task was timed and recorded for completion.

Table 3. List of elements in an article that need to be identified by the visually impaired users.

Task	**Elements**
1	Header of the article
2	Sub-header of the article
3	Paragraphs in the article
4	Bold word in the article
5	Italic word in the article
6	Underline word in the article

3) The users were required to identify the same attributes using screen reader. The time taken to identify each attributes also has been noted to compare the results with the Braille Line device.
4) After the device was tested, the users were required to rate and give comments on the project

4.2.1 Demographics of the participants in user testing

The participants in our study ranged in age from 20 to 35,with the mean age being 26,and most of the participants were female (8 out of 10).Six out of 10 participants are students in the IT department of Malaysia Association of Blind and another four participants are students from University Malaya. The average number of years that participants reported using Internet was one to three years, and the average amount of time spent using Internet are around several times a week. Besides that, about 50% of them are intermediate user of computer. All the recruited participants were required to have used screen reader for net browsing and also know to read Braille. Because the average visually impaired users might have less experience with Braille than the participants in this study, it is likely that they might have far more difficulty reading text of a webpage represented in Braille character than the study participants did.

Some of the participants are expert users of screen readers and have more than 5 years of experience reading Braille. To account for previous experience, we calculated the impact previous experience had upon the average completion rate and time spent on successfully identify the text elements in a website and included it in Table 4. The time taken to identify the text elements in webpage improved when a user had previous experience.

Table 4. Previous Experience and Mean Completion Time for Successful Tasks

Assistive technology tool	**User with Experience**	**Experienced Users**	**Inexperienced users**
Braille Line	5 out of 10	81.5 seconds	102.3 seconds
Screen Reader	4 out of 10	180 seconds	190 seconds

4.2.2 Result of user testing

Table 5 illustrates the percentage of successful task completion for each task using the given assistive technology. The statistics clearly indicates that overall performance of user using Braille Line is about 2 times better compared to using screen reader.

The screen reader has no data for tasks 3, 5 and 6 because it does not include indication of paragraph, italic and underline when conveying the text to the users. Besides that, task 2(identify sub-header of an article in a webpage) using screen reader took user very long time with a mean of 239 seconds (or 3.98 minutes) with least percentage of task completion, 20%.This is because screen reader does not distinguish between header and sub-header in an article of webpage but some experience users are able to identify them after navigating through the website for some time.

Table 5 Mean Percentage of Task Completion and Mean (in seconds) for Successful Tasks

Task	**Mean Percentage of Task Completion**		**Mean (in seconds) for successful tasks**	
	Braille Line	***Screen Reader***	***Braille Line***	***Screen Reader***
1) Identify header of an article in a webpage	100%	100%	31.5	20.5
2) Identify sub-header of an article in a webpage	100%	20%	162.1	239.0
3) Identify paragraphs in the article	100%	-	83.8	325.0
4) Identify bold word in the article	100%	30%	79.2	200.0
5) Identify italic word in the article	100%	-	73.0	-
6) Identify underline word in the article.	100%	-	74.5	-
Mean	100%	50%	84.0	196.1

4.2.3 Result of post survey

In post testing, they were required to complete the question 2, 3 and 4 of the section 3. *Refer Appendix C for the sample questionnaire.* The following are the results and analysis of the post testing:

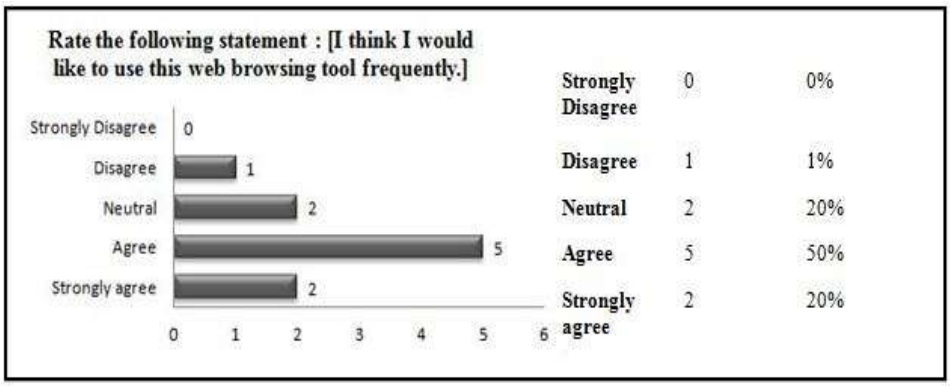


Figure 16 – Response on the respondent's like hood of using Braille Line 20 cell device

Analysis: The result indicates that the respondents would like to use the device frequently when net browsing.

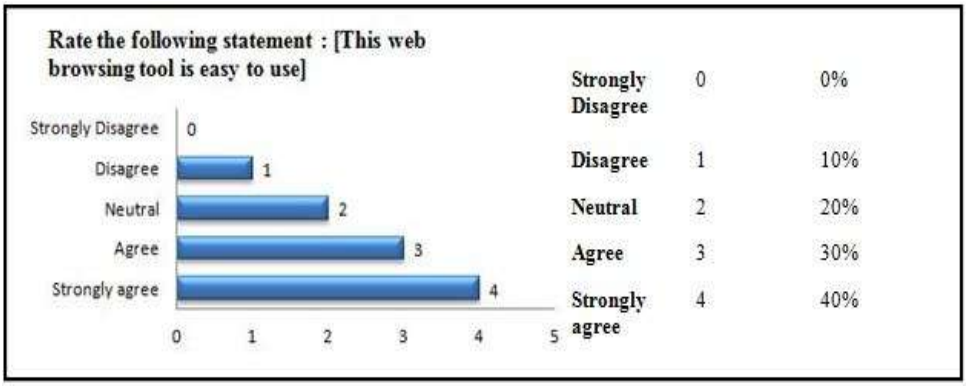


Figure 17 – Response on the usability

Analysis: Most respondents think that the device is easy to use to read text on a webpage because only space bar needed to be used to navigate through the text in a webpage. Besides that, the texts are also easy to be captured as it is displayed word by word as the cursor moves.

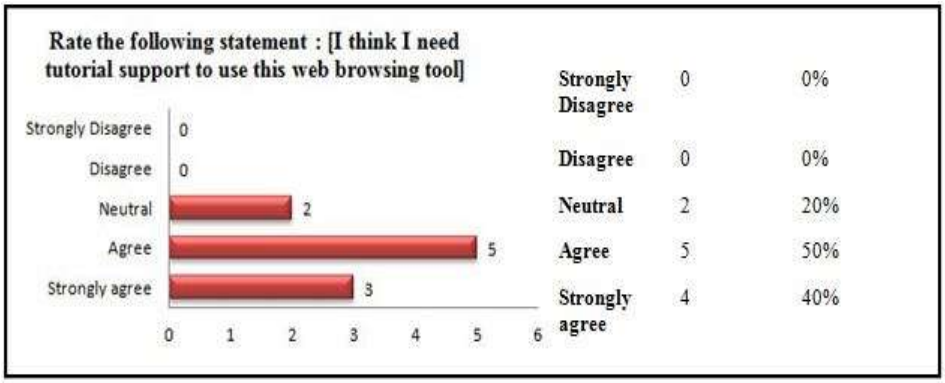


Figure 18 – Response on the need of tutorial by the participants to use the Braille Line

Analysis: Based on the response above, most of the respondents think that they need tutorial support to use this web browsing tool. This is because the font attributes and text hierarchy code that are displayed on the device are new codes for them. New codes are introduced to represent the text elements because there are no any standardized codes available currently.

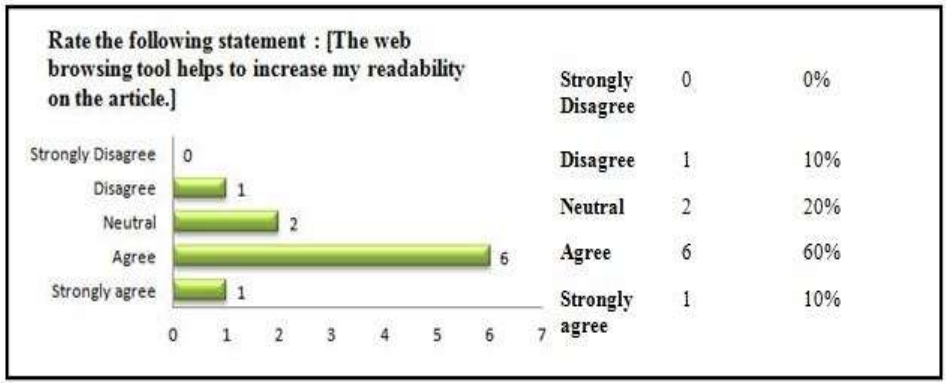


Figure 19 – Response on the function of the device to increase readability of an online article.

Analysis: The objective of the device is to increase the readability of a website by conveying font attributes and text hierarchy in a webpage to the users. Most of the respondents do agree that the text elements help to increase their readability of the webpage.

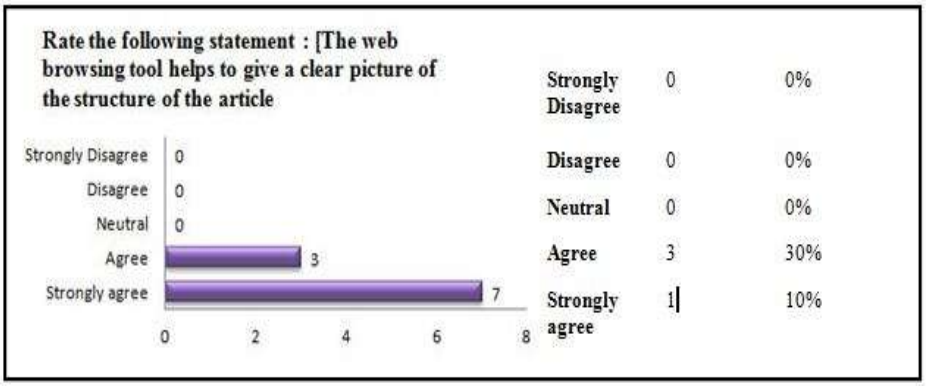


Figure 20 – Response on the indication of text hierarchy in the Braille Line

Analysis : Based on the graph, it could be said that the device are able to clearly presents the text structure such as heading and paragraphs in an online article to the users.

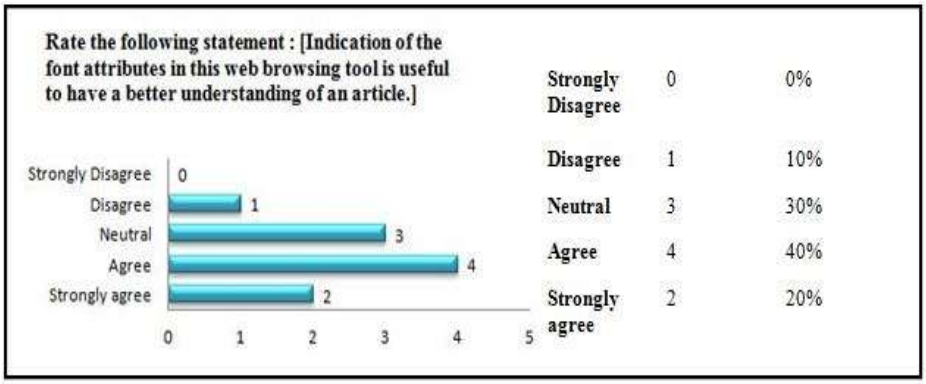


Figure 21 – Response on the ability of users understanding on an online article when font attributes of a text is indicated

Analysis – Based on the statistics represented by the graph, the objective of conveying semantic information of a webpage could be achieved.

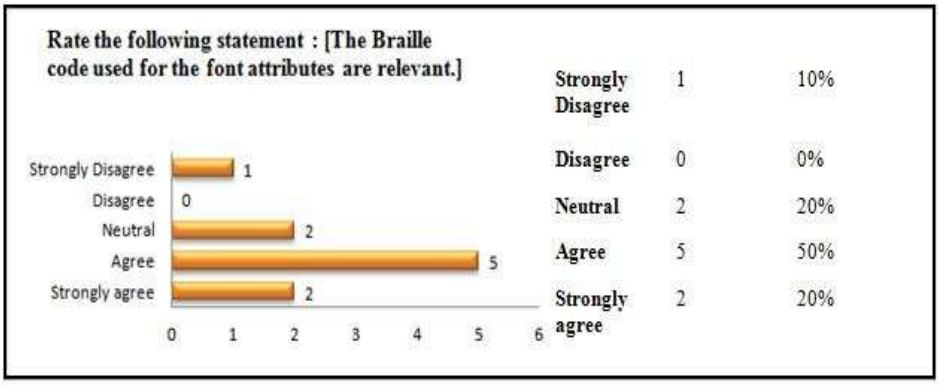
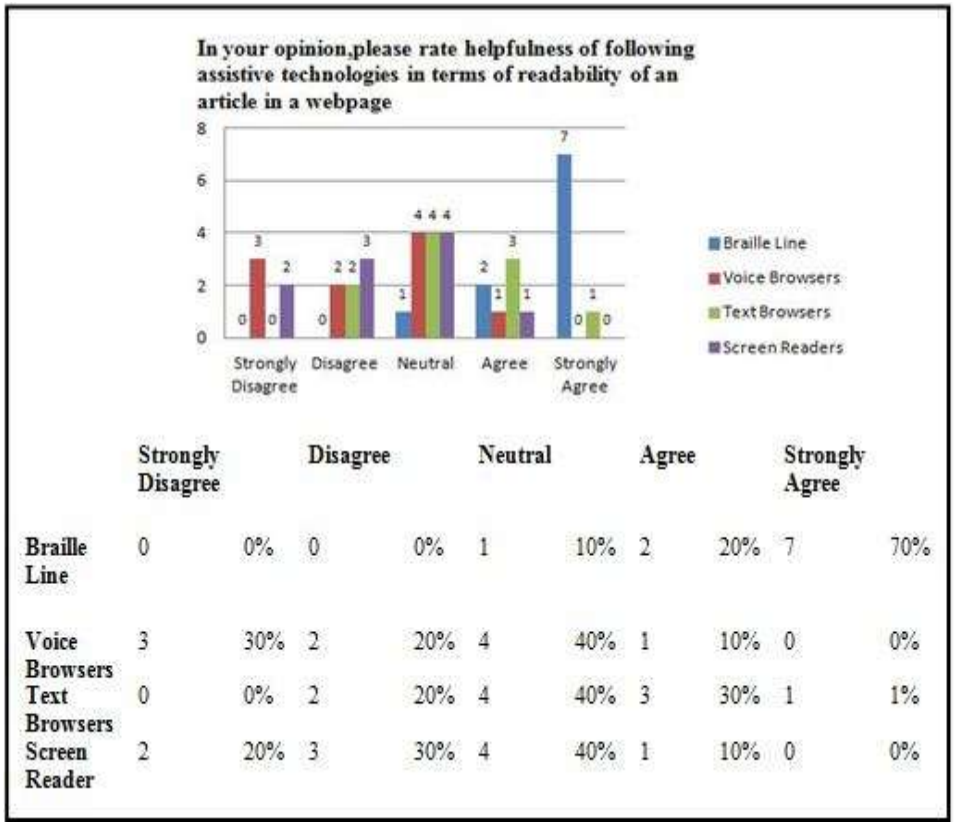


Figure 22 – Response on relevancy of Braille code to represent font attributes

Analysis – Most of the respondent agree that the newly introduced Braille code to represent the font attributes and text hierarchy are relevant and easy to remember.



	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Braille Line	0	0%	0	0%	1	10%	2	20%	7	70%
Voice Browsers	3	30%	2	20%	4	40%	1	10%	0	0%
Text Browsers	0	0%	2	20%	4	40%	3	30%	1	1%
Screen Reader	2	20%	3	30%	4	40%	1	10%	0	0%

Figure 23 – Response on user's rating on helpfulness of assistive technologies available in the market in terms of increasing readability of a webpage.

Analysis – According to the survey, it could be concluded that the most respondents feel that the device able to convey semantic information on a website compared to other assistive tools that available in the market.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

This chapter concludes the overall objective of the project and suggests future works that can be done to expand this project.

5.1 Relevancy of the Objectives

As stated previously, the objective of this research is to investigate the problems faced by the visually impaired users to access information on a website and also to explore the techniques that can be used to program the Braille Line device to render the semantic information represent by the non visual text structure presentation of a webpage. In terms of relevancy, it can be concluded that it is relevant to the objectives proposed earlier where the documentation is a supporting material to assist the development of this project.

Thus, several conclusions have been made:

- It is important to raise awareness among web developers to build an accessible website for people with disabilities as most of the website available in the internet is inaccessible to this group of users.
- Choosing to program Braille line 20 cell device as assistive technology to render rendering semantic textual representation of a website is relevant as the haptic or tactile based devices are becoming available for implementing futuristic human computer interaction(HCI) methods and are proven to be a useful infrastructure for creating intuitive HCI(Nishino,Fukakusa,Hatano,Kagawa & Utsumiya,2012).
- Proposed guidelines by W3C for web accessibility could be applied to design a website but it doesn't not provide 100% accessible website. In order to increase website accessibility, combinational method of testing could be used by the web developers to build an accessible website to all categories of users.

In short, the proposed system does follow the objectives and scopes defined. The activities that have been conducted that include research and mostly application of theories into practices are relevant to the objectives specified.

5.2 - Suggested Future Work for Expansion and Continuation

In developing a system, there are always rooms for expansion. For the proposed project, there is limitation for the Braille reader to read only website with standardized HTML tags. The Braille reader can be improvised to read variety of HTML tags in order for the device to be used with any website.

Besides that, the project only caters to convey semantic information focusing on textual representation on a webpage. It can be expanded to analysis techniques that can be used to convey the semantic information of graphics in a webpage. In order to increase the effectiveness of this device, integrating other features such as pattern of sound together with haptic technology for web browsing could be a good path to explore as there are more senses of the visually-impaired users are being utilized to convey the information.

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APPENDICES A – GANTT CHART

No	Activities	Sept	Oct	Nov	Dec	Jan	Feb	Marc	Apr	May
1	[FYPI]Selection of the project topics									
2	[FYPI]Preliminary research									
3	[FYPI]Submission of preliminary research									
4	[FYPI]Seminar 1: Preliminary report									
5	[FYPI]Project work on progress 1: 5.1 Literature review 5.2 Identify project requirements									
7	[FYPI]Submission of progress report 1									
8	[FYPI]Seminar 2: Progress report 1 Project work on interim report 8.1 Literature review 8.2 Design 8.2.1 Plan system 8.2.2 System design 8.2.3 Interface design									
9	[]FYPI] Oral presentation				☆					
9	System development					☆				
10	[FYPII]Seminar 1: Submission of progress report 1									
11	[FYPII]Testing 11.1.1 System testing 11.1.2 User testing									
12	[FYPII]Poster exhibition & pre- edx							☆		
13	[FYPII]Submission of dissertation - softbound									
14	[FYPII]Oral presentation									
15	[FYPII]Submission of dissertation - hardbound									☆

☆- Key Milestone

APPENDICES B – PILOT STUDY SURVEY

Section 1 : Background information

Gender :

- ❑ Male
- ❑ Female

Age :

- ❑ 18-21
- ❑ 22 -29
- ❑ 30-45
- ❑ 45 and above
- ❑ Other: [ ]

Section 2 : Research area

1) Do you browse internet?
   - ❑ Yes
   - ❑ No
2) How often do you browse internet in your daily lives?
   - ❑ Rarely
   - ❑ Less than once a month
   - ❑ One or two times a month
   - ❑ About once a week
   - ❑ Everyday
3) What type of activities do you typically do when you use the Internet?
   - ❑ Research
   - ❑ Networking
   - ❑ Shopping

- ❑ Read E-Books
- ❑ Send E-mail
- ❑ Blogging
- ❑ Entertaining activities – Ex : Listening songs

4) **How often do you visit these types of website in your daily lives?**

(Please tick in the appropriate box) *

	Rarely	**Less than once a month**	**One or two times a month**	**About once a week**	**Everyday**
Blog / Forum Website					
Informational website (Ex:Big Think, Elsevier)					
Social website (Ex:Facebook,Twitter)					
E-commerce website					
File-sharing website (ex:Youtube,Flickr)					
News website (Ex:Star.com)					

5) What type of problems do you face during web browsing?

- ❑ Assistive technologies incompatible with web browsers
- ❑ Improper web layout or design
- ❑ Misleading or missing alternative text or links
- ❑ Irritating pop up messages

6) What type of assistive technology do you use for web browsing?

- ❑ Text browsers
- ❑ Voice browsers
- ❑ Screen Reader
- ❑ Transcoding proxy server

7) What are the problems with the current assistive technology available in the market?

- ❑ Unable to interpret semantics information of dynamic webpage.
- ❑ Annoying to be used when there is advertisement or pop-up message in the webpage.
- ❑ Unable to deliver font attributes in a webpage
- ❑ Information provided by the assistive technology is inaccurate.

8) In your opinion, what are elements in terms of the text formatting that affects the readability of a website?

- ❑ Font Families
- ❑ Number of type of fonts used in website
- ❑ Font style
- ❑ Font hierarchy

9) In your opinion, how much important is the font attributes in a webpage to increase your readability of a webpage?

- ❑ Very important
- ❑ Important
- ❑ Average
- ❑ Not important

10) Based on your preference, what is the best way or the easiest way for you to read text on a computer?

- ❑ Using voice-based tools
- ❑ Using Braille displays

11) Do you think Braille line would help to ease web browsing compared to current voice based tools?

- ❑ Yes
- ❑ No

12) In your opinion, what do you think about the idea of using Braille Line to convey text on website and also to display font attributes on the webpage?

- ❑ Excellent
- ❑ Very Good
- ❑ Good
- ❑ Fair

- ❑ Poor
- ❑ Not Applicable

APPENDICES C – USABILITY EVALUATION

Section 1 : Background information

Gender :

- ❑ Male
- ❑ Female

Age :

- ❑ 18-21
- ❑ 22 -29
- ❑ 30-45
- ❑ 45 and above
- ❑ Others: [ ]

Section 2 :Experience of using assistive technologies for web browsing

1) How would you rate your knowledge on computers?

- ❑ Beginner
- ❑ Intermediate
- ❑ Expert
- ❑ Advanced

2) How long have you been using the Internet?

- ❑ Less than 3 months
- ❑ 3 months to a year
- ❑ 1 to 3 years
- ❑ More than 3 years

3) How frequently do you use the Internet?

- ❑ Every day
- ❑ Several times a week, but not every day
- ❑ A few times a month
- ❑ Less than a few times a month

4) What type of assistive technologies do you use to access the Internet?

- ❑ Screen Readers
- ❑ Voice Browsers
- ❑ Text Browsers
- ❑ Others: _____

Section 3 :Usability testing

1) Based on the website provided, please kindly identified the following elements and list it down :

Elements	**Braille Line**	**Screen Reader**
1) Header of the article		
2) Sub-header of the article		
3) Paragraphs in the article		
4) Bold word in the article		
5) Italic word in the article		
6) Underline word in the article		

Task	**Time for task completion using Braille Line**	**Time for task completion using Screen Reader**
1) Identify header of an article in a webpage		
2) Identify sub-header of an article in a		

webpage		
3) Identify paragraphs in the article		
4) Identify bold word in the article		
5) Identify italic word in the article		
6) Identify underline word in the article.		

2) Please rate the following statements for this project.

	Strong Disagree	Disagree	Neutral	Agree	Strongly Agree
I think I would like to use this web browsing tool frequently.					
This web browsing tool is easy to use					
I think I need tutorial support to use this web browsing tool					
The web browsing tool helps to increase my readability on the article.					
The web browsing tool helps to give a clear picture of the structure of the article					
Indication of the font attributes in this web browsing tool is useful to have a better understanding of an article.					
The Braille code used for the font attributes are relevant					

3) In your opinion, please rate helpfulness of following assistive technologies in terms of readability of an article in a webpage :

	Strong Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Braille Line					
Voice Browsers					

Text Browsers					
Screen Readers					

4) Recommendation/Suggestion for future improvement on this project :
