Development of a Search Engine Tool for Visually Impaired Web Users

Development of a Search Engine Tool for Visually Impaired Web Users

By

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A Thesis

Submitted to the School of Graduate Studies
in Partial Fulfillment of the Requirements for the Degree

Master of Applied Science

McMaster University

MASTER OF APPLIED SCIENCE (Sept, 2019) McMaster University
(Software Engineering) Hamilton, Ontario

TITLE:	Development of a Search Engine Tool for Visually Impaired Web Users
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NUMBER OF PAGES:	viii, 170

Abstract

The internet has become useful in just about anything we do. Unfortunately, as vision degrades so does our ability to perceive the web. The design of Graphical User Interfaces (GUIs) has become overwhelmingly common and is meant to be coupled with a screen and mouse. The interface introduced in this thesis was developed to avoid graphically driven design and create a novel Search Engine interface intended for blind and low vision users. This is achieved by minimizing the total concern of the user (the userspace) to a handful of options and a predetermined structure to the Search Engine Results Page (SERP). This thesis describes the entire development process starting from the literature review and including implementation, evaluation, and future work.

Acknowledgments

An expression of thanks to my committee of supervisors; Dr. Alan Wassyng, Dr. Mark Lawford, Dr. Kourosh Sabri, and Dr. Shahram Shirani for your support, motivation, and instruction along the way. A special thanks to Natalie Fleming for help with administration, brainstorming, and discussion throughout the entire journey! I would also like to thank the children and parents that took time out of their day to try out the SerpUI application, your input goes further than you know.

Thank you to my additional committee members Dr. Jacques Carette and Dr. Fei Chiang for showing interest in my research. Thanks to the 'Crew in 102' (ITB102) for teaching me new skills and providing an endless supply of computers.

Another big thank you to everyone at W. Ross Macdonald School in Brantford for opening your doors and letting me explore the school! Special thanks to Vice Principal Laurie Moore and Principal Dan Maggiacomo for organizing my visits.

Thank you to Valerie Kitazaki for allowing me to tag along and learn about the beautiful community that you and the others have built in the YRDSB. Also thank you to Kai and Rachel for tagging along and helping our capstone teams with your insights and expertise.

And of course to my parents, family, and friends who help keep my spirits high and are always an excellent source for comfort and consultation.

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List of Acronyms

ADP Assistive Devices Program . . . 96

AODA Acessibility for Ontarians with Disabilities Act . . . 3

API Application Programming Interface . . . 6

AUI Auditory User Interface . . . 14

BLV Blind or Low Vision . . . 55

BML Blind Markup Language . . . 18

CSE Custom Search Engine . . . 43

EA Educational Assistant . . . 92

GC Google Classroom . . . 87

GUI Graphical User Interface . . . 1

HCI Human-Computer Interaction . . . 59

HLD High Level Design . . . 38

HTML Hypertext Markup Language . . . 12

IE Internet Explorer . . . 8

KAI Accessibility Kit for the Internet . . . 15

MAT Mobile Assistive Technology . . . 28

NVDA NonVisual Desktop Access . . . 8

OBS Open Broadcaster Software . . . 68

OS Operating System . . . 8

PCA Principal Component Analysis . . . 7

PDA Personal Digital Assistant . . . 18

PWN Physical World Navigation . . . 90

RBD Refreshable Braille Display . . . 22

SERP Search Engine Results Page . . . 3

SE Search Engine . . . 1

SSEB Specialized Search Engine for the Blind . . . 6

STT Speech-To-Text . . . ix

TTS Text-To-Speech 36

TUI Tactile User Interface 14

UI User Interface 1

URL Universal Resource Locator 52

VI Visual Impairment xiv

VO VoiceOver 8

W3C World Wide Web Consortium 16

WAI Web Accessibility Initiative guidelines 17

WoW WhatsOnWeb 6

YRDSB York Region District School Board 87

Declaration of Academic Achievement

This thesis outlines the in-depth development of the SerpUI Search Engine interface as a potential accessibility tool for Visual Impairment (VI) web users. The contribution of this work also extends to include a Literature Review that sheds light on previous contributions along with issues uncovered when analyzing the accessibility level of current online tools. Most intrinsic barriers are apparent when an interface is designed with only a subset of its users in mind. SerpUI is an attempt to create an interface specific to the VI community, focusing solely on this demographic.

This thesis will hopefully inspire other developers to enhance the accessibility of the internet in two ways; creating accessible interfaces, and improving the accessibility of existing applications.

Chapter 1

Introduction

Computers provide an invaluable advantage when performing everyday tasks, allowing people to complete increasingly complex tasks with the click of a button. The User Interface (UI) has become a crucial component for managing the way we interact with programs on our electronic devices (ie. phones, computers, IoT devices). These interfaces can be dense with menus, buttons, and information. The almost universal design decision to opt for a Graphical User Interface (GUI) can be attributed to finer screen resolutions allowing developers to fit large amounts of data in a single view. Another important factor is the accessibility speed of the application, that can be quickened when users can see all of their options at once. However, with VI a webpage can quickly turn from informative to overwhelming. Even more so, VI users do not only cope with accessing information (such as text and images) but also deal with the added challenge of conceptualizing the structure of each webpage by building a conceptual model [1] of its contents [2]. This aspect is commonly overlooked by web developers especially in recent years as the internet has shifted to favour visual appeal.

This thesis is concerned with the accessibility level of an online Search Engine (SE), and presents a new interface. SEs are good at answering simple queries and providing links to specific sites. A study by Ivory, Yu, and Gronemyer claimed that blind participants took twice as long as their sighted peers to explore these search results, and three times as long to look for information on webpages [3]. The literature, further examined below (section 2), showcases a collection of studies and products that focus on this form of web accessibility. The benefits of accessibility are universal and can extend past the VI community to other forms of disabilities.

As a result, the interface described in this thesis, SerpUI, is developed with VI users as the primary user. The SE can also be navigated using a JoyCon Switch Controller to provide a comfortable device and create an entertaining experience. Furthermore, SerpUI utilizes a 5-tile approach that attempts to limit the number of page elements to an amount that can be understood almost immediately. This design decision results from the amount of training that a VI user needs for minimal competency in existing platforms (discussed in section 2). The application is live and available to the public. Note that the release is optimized to work with the Google Chrome browser.

https://serpui.cas.mcmaster.ca

By having a central tile with surrounding navigational options the user is not concerned with where to look. Instead, the focus of the screen is on a specific page element and is presented in the center ('neutral') tile. This method of presenting information is evaluated to yield high predictability. As a result, users can spend less time understanding the page and more time completing the task at hand. With respect the thesis, the task is browsing search engine results. Once a user becomes proficient, they will be able to store the entire model of the interface in their head and rely on their navigational skills.

With existing webpages, these navigational skills depend on how the web designer structured the site. It aligns with the designer's graphical model for the layout of information. A sighted individual can understand the layout quick, but as vision degrades this model is more difficult to see and understand.

It is worth noting that SerpUI is simply an application of a tile-based approach where the user clicks through the information. For other applications the content could be different.

An interesting method of accessibility is the Rotor feature by Apple [4] that allows users to view the page by listings of categorized page elements (headers, links, text, ...). This *view* of a webpage is analogous to search results on a Search Engine Results Page (SERP) since the elements of a category (i.e., links) could be presented as the subheadings of a row (i.e., link1, link2, ...). For an example of how information is structured in the SerpUI application refer to section 8.1 for a high-level explanation.

1.1 Motivation

As identified in the literature review, the difficulties for VI web users are often multi-sided, and ranges from interface navigation to content accessibility. Furthermore, there is a particular lack of concern by the general public to ensure universal access. Though there are teams of developers working on modifying their current software, along with well recognized acts and guidelines (WCAG [5], and the Acessibility for Ontarians with Disabilities Act (AODA) [6]), there is not a standard interface that can easily be integrated. As a result companies are forced to allocate individual workers to study and implement these standards, more detail on certification and inspection can be found in the Act [6].

Ideally, computers and the internet should be simple enough so that anyone can access both without concern. However, decades of development and feedback from large pools of different users have resulted in certain tools and interfaces taking precedence. Something that can be largely agreed upon is the importance of search engines as a tool for accessing the internet. As a result, the usability and speed of search engines is vital. Unfortunately, as tools become tailored for the majority of users others get left behind, VI being one of those demographics.

The solution presented in this thesis is the development of a new web interface that is tailored specifically for visually impaired web users. It is important to note that this tool attempts to erase the need for skimming a webpage in order to navigate quickly.

Chapter 2

Literature Review

A literature review was composed that attempted to encapsulate the latest advancements in products and publications for computer tools for the visually impaired. The review was focused on search engines as a computer tool. The primary reason for selecting search engines is to concentrate on the most popular forms web usage. Furthermore, SEs are a common starting point of most web sessions and have become a standard homepage for most web browsers (Google, Bing, Yahoo!, etc.).

The tool was then broken down into its core attributes, each responsible for describing a different component of tool development. The attributes by order of relevancy in the review are:

- Navigation
- User Interface
- Information Accessibility
- Latency - for Search Engines this is also known as 'Search Time' [7] or 'Task Completion Time' [1]
- Discreetness
- Emotional Implications

2.1 *Tool*: Search Engines (SEs)

This review primarily focuses on the application of web-based Search Engines as a tool for computer users with visual impairment. This particular focus is largely due to the high daily dependance on SEs by computer users. Furthermore, there is benefit and independance when learning to use SEs efficiently.

The ability to locate desired information online is very useful. But since the internet is so large and complex, the user employees a SE to sift through potential results and rank them in relevancy. SEs provide a quick and accurate response to most general knowledge questions along with help in online navigation.

The concept of SEs is to provide the user with a 'glimpse' of a web page, along with bits of relevant information. By analyzing this response the user should be knowledgeable enough on the 'potential' of the web page (Webpage Potential - describes how likely is it that this website will be useful in answering the user's query) in order to decide if it is worth delving deeper.

The issue for VI users is the inability to quickly and accurately capture the glimpse of the webpage.

Additionally, a standard SE relies heavily on the input query in order to retrieve relevant results. By understanding related search terms and proper Boolean Logic (such as AND, OR, and NOT) the SE will provide links that are more accurate to answering the initial query [7]. These additions to standard search methods allow the user to narrow the search space, and as a result, focusing their efforts and reducing the amount of time they spend exploring results [8].

SE are extremely useful tools since they help users congregate a collection of relevant sites and data, otherwise difficult to locate.

As for current SE demographics, Google, Baidu, and Bing handle 74.80%, 11.32%, and 8.08% of the world's search queries, repectively [9]. Furthermore, Google handles 80.79% of searches on mobile devices, along with 85.43% of searches submitted by tablets [9]. These dominant statistics emphasize the need for a small set of assistive tools to aid the visually impaired.

In order to help VI users, various applications have been released to quicken the search process. Yang, Hwang, and Schenkman, have created a Specialized Search Engine for the Blind (SSEB) that breaks down the SERP [7]. The paer per also references an application by Google called Personalized Search which returns more relevant results to the SERP by basing current searches on past ones performed by the user [7]. By employing powerful Application Programming Interface (API) provided by the major SEs (ie. Custom Search Engine by Google or the Bing Custom Search by Microsoft) the developers do not need to reimplement these complex alogrithms. Google's PageRank, RankBrain, and Hummingbird search engine algorithms are intricate search techniques that would require lots of effort to recreate. As a result, when developing new tools it is recommended that the focus remains on elevating the user experience rather than optimizing the search results.

A different application called WhatsOnWeb (WoW) changes the SERP by tailoring it specifically to the user [10]. VoiceApp is a speech-based web search engine developed by Griol, Molina, and Corrales. Another useful application is TrailNote that manages the search process for each user to support "complex information seeking" [12]. The use of trail-managers is strongly recommended. Once implemented properly, VI users can focus on synthesizing the information at hand rather than memorizing past results. It is also important for the users to have quick accessibility to their trail, regardless of their proficiency level.

In addition, many studies have published research regarding the effectiveness of SEs, along with helpful concepts. Tsai, Lin, and Hung, focuses on query specification and the minimization of the search space to improving the quality of the SERP [8]. The paper also identifies the differences between novice and expert searchers [8]. Other papers study the level of brain activity while using an SE [13], preferred engines amongst users [14], and principal components (Principal Component Analysis (PCA)) that construct a standard SE search [3][8]. Several studies published results on SE metrics [15], ideal design [16][17], accessibility evaluation [18], and conformance levels [19]. Finally, a study by Sahib et al., has been published documenting how VI users navigate an SE and how they collect information online [20].

SE are applications that will only become more common due to their ability to reduce the work load of the user. It should be clear that VI users would benefit substantially from highly accessible SEs. Furthermore, sighted users would benefit equally with more efficient SEs. As a result, future developments and research should focus on conformance and adequate design to ensure global accessibility to all user types. Developers should also leverage user-oriented techniques since a user's context, history, or trail can impact future searches

2.2 Summary of Navigation

The idea of online navigation seems trivial; you scan the page, collect information, see an interesting link and away you go. But for someone who cannot simply browse information as freely due to a disability, navigation might seem a lot different. When reviewing the collection of tools targeted for easier navigation many offer creative ideas that tackle different issues.

A notable struggle delineated by Sahib, Tombros, and Stockman, is the difficulty of recalling previous states. The term used to describe a user's search history is called "The Trail" [12]. Applications like Search Trail and TrailNote were developed in an attempt to resolve this issue. Nevertheless, the idea of including a trail is an proactive way of offloading from the user.

The most common methods of webpage navigation are native or purchased screen readers. JAWS [21] being the most common amongst Windows users. While JAWS is widely accepted by VI users, it has several drawback including the overwhelming number of commands [22], irritating synthesized voice, and its high price. An alternative for JAWS is the Microsoft Narrator [23], a native screen reader with similar goals that comes installed with the Windows Operating System (OS). Another free tool is NonVisual Desktop Access (NVDA), a project with the initiative of providing total web access to VI users [24].

For Apple devices come with a pre-installed screen reader called VoiceOver (VO), most common for macOS and iOS users [25]. In computer or laptop usage, VO also includes the Rotor feature that uses finger gestures on the trackpad to access the available information by categories (ie. headings, text, links, etc.) [4]. Fortunately for Apple customers, this tools is native and supports all of the devices applications. This tools is highly recommended for VI users that want a simple, flexible computer experience.

It is worth noting that each of the tools mentioned in this subsection are user specific and can be used with a wide range of web browsers such as Chrome, Firefox, Internet Explorer (IE), and Safari. Since each of these programs works differently, users must learn their operation and choose a setup by preference.

2.2.1 *Attribute*: Navigation

1. **Scope** The internet being an endless source of information is most useful for those who know what they are looking for. If a user is proficient in their ability to navigate between webpages then it would be natural for that user to skilfully locate important information. The ability to navigate through a computer system or the internet is an invaluable skill that is being taught at increasingly younger ages. Even more so, computer proficiency is a common requirement when applying for most jobs.

2. **Difficulties faced by VI Users** Since most computers, along with their peripherals (mouse, monitors, keyboard, etc.) are designed for sighted users, universal accessibility is not highly prioritized. As a result, the internet is less accessible for non-sighted users that rely on these devices for navigation (more detail regarding information accessibility in Section 2.4.1). In addition, most webpages are designed to be used as

GUIs which heavily favour visual elegance over simplicity in navigation. Consequentially, it is very difficult for non-proficient visually impaired internet users to interact with the web, resulting in a less stimulating, slower online experience.

A common difficulty found by many VI users is virtual disorientation [17][26]. This may results from several situations:

(a) Inability to recall current virtual location[2]: *The website currently observed by user* <u>*or*</u> *the user's location within a web page.*

(b) Inability to recall previously visited webpages (Known as "The Trail" [12]): *The recent webpages previously visited by user that are relevant for the current session online.*

(c) Indecisiveness regarding future steps: *The websites that the user should visit next.*

Inexperienced users generally cope with this issue by refreshing the web page, restating the search or closing the browser altogether (more in section 2.7.1) [28]. This dramatic course of action commonly discourages and frustrates the user, since they are forced to retrace their virtual trail.

3. **Existing Products and ongoing Research** The issues with online navigation, as mentioned above, are important to consider due to their strong impact on the user experience online. Several technologies have been developed to resolve some of these problems. Yang, Hwang, and Schenkman, developed a SSEB, made to assist with user orientation and

[2] **Analogy:** Imagine the internet to be a physical interface that a person can traverse (similar to how a sighted user analyzes a single webpage on a screen). This is analogous to a person walking across their home. Since the space (their home) has been thoroughly navigated by the person it would be trivial for them to complete their journey. But if the space (or interface) is foreign to the person (ex. stranger's home) then the lack of sight would result in a significant disadvantage.

VI users, both in the physical and cyber worlds, have to remember where they have been (ie. their Trail) [27], their current *location*, and where they intend to go. As a result, VI users would benefit from assistive devices that manage their Trail and aid in the conceptualization of the internet.

access for those who struggle online [7]. The paper also provides guidelines when adding shortcuts to an application. Hakobyan et al., have developed the AudioBrowser, used to navigate the web on the go [29]. WoW developed by [10] creates a single browsable page that can be easily accessed by VI users [10].

The most commonly used application for navigation is JAWS, developed by Freedom Scientific [21]. This application is compatible with most Windows applications, including web browsers. Users can browse the web using their preferred web browser and special JAWS key commands [22]. The user receives web information through dictation synthesized by the JAWS application.

If using a Mac computer running the macOS by Apple, a helpful tool for web navigation is called the Rotor that comes installed with VO (the native Apple screen reader) [4]. This tool attempts to summarize the links, headings and other page elements into groups. So instead of 'tabbing' around from link to link, the rotor presents all common links in a single menu to increase navigational ease. These different groups are then presented in adjacent menus in the Rotor. This feature can be used on individual sites as well, congregating information into groups to assist the user. This feature is excellent for mac users with visual impairment that want more from VoiceOver.

The VoiceApp [11] and the Homer Web Browser [30] offer navigation using voice commands alone, the results are also returned via audio [30][11]. The Audio Hallway [31] provides navigation using head motions where the user passes 'rooms' as potential selection options. The physical movement allows the user to be immersed in the online experience, resulting in more control and focus.

For users that require multi-session tasks (online tasks that cannot be finished in one sitting), applications such as Search Trail and TrailNote

[27] were developed. They are particularly handy when the user wants to pause their current session, save relevant information locally, and be able to pickup where they left off once they resume their online activity. There is high importance for managing users between sessions since users may forget the mental map they worked hard to create in their previous session. This idea is also applicable with the use of relevance feedback [8], that allows the user to draw information from previous sessions.

As applications become increasingly complex, users are expected to keep up with the versatility of these tools. Even more so, users are expected to work on computers for more than just searching the web. The idea introduced by Sahib, Tombros, and Stockman that addresses 'the Trail' [27] is a powerful concept that highlights the difficulty of VI users to perform long-term computer tasks. This idea stretches to all types of tools, and as a result allows the user to focus on other components of the task at hand.

A significant portion of research is dedicated to collecting feedback from the user on desirable features. Common requests are the addition of more feedback from the web application to the user [28], along with an overview and general hints as to where the user is located virtually on the page [17][28]. Additional papers study how users with cognitive disabilities navigate the web [14], how VI users collect information online [20], and what elements are leveraged by VI users to aid in their navigational processes [3].

4. **Necessary Future Research and Consideration** There is a strong need for standardization. Though several navigation software may exist, they tend to develop their own set of commands and shortcuts that the user must memorize to become proficient. Even more so, new developments should aim to minimize the number of commands so that the user is not overwhelmed. Also, the user could simply begin their online tasks in an efficient and intuitive manner. VI users could benefit from an application that would provide a general overview of a web page and allow the user to skim the page similar to sighted users.

The concept of navigation is closely related to Search Engines (section 2.1) and Latency (section 2.5.1).

2.3 Summary of User Interfaces

The presence of user interfaces is something we take for granted. In actuality every website, media item, or tool likely has an interface. It is the responsibility of the developer to make these interfaces accessible to all. But as mentioned by Powsner and Roderer, the Internet is not well *arranged* [32]. Meaning that even though we can access every site through the magic of Hypertext Markup Language (HTML), each site is unique and may be composed of a brand new interface.

Most screen readers try to bridge these differences by providing a concrete set of commands available to the user. The issue at times is two-fold; how many available commands, and how long does it take to memorize (or at least familiarize). The former is an active issue with the JAWS screen reader, having so many commands which initially overwhelm the user [22]. The latter alludes to a learning curve associated with every application on a computer. It is worthwhile to make this learning curve as small as possible to allow the users to use recognition of states versus recall of commands [1].

A major issue with modern interfaces is the size of the *user-space* (see section 3). Explainehed simply, the web is an endless collection of information, commands, and interfaces, formally coined as the *cyberspace* [33]. At every moment on the web, whether sighted or impaired, the user has a finite number of available commands. This can be considered a *defined* cyberspace or the user-space. If the existing interface minimizes the user-space and still provides access to the <u>same</u> amount of information, then the user has less commands to memorize. More information can be found in the corresponding literature review.

Another major issue of web-based interfaces is a collective appeal for high graphical environments. The word *clickbait* is an informal term used to describe content that is intended to attract attention. This form of advertisement slows the user from reaching desired content. Unfortunately, with degradation of visual acuity it can become difficult for users to avoid clickbait content, ultimately wasting time. This form of media can manifest in many ways including; ads, banners, and suggestive headings. Although certain programs like adblockers try to fight this, clickbait content is a common method to gain views or site visits.

The main takeaway is best explained by the KISS principle often asscociated with Clarence Leonard (Kelly) Johnson, "Keep it simple, silly!" [34].

2.3.1 *Attribute*: User Interfaces

1. **Scope** When designing a product or device that aids in overcoming a disability it is crucial that the technology prioritizes the user. Too often are devices designed and tested by visually capable developers that seem to be counter-intuitive for the VI community, in practical settings. The purpose of assistive technology is to allow full accessibility to those in need without compromising the quality of information and the ease of accessibility.

2. **Difficulties faced by VI Users** Technologies that can be categorized with poor user interfaces are most noticeably those that neglect the learning phase of their application. If a technology is complex in nature, then the average user is less likely to rely on its recurring usage.

   When considering usage of search engines (more in section 2.1) by visually capable users, the level of simplicity often goes unnoticed. It is the responsibility of the designer to create an interface that conveys the same level of desired intuition as its graphical duality. This boils down to the ability of the designer to implement their interface in a format that could either be used by all or has the capability of transforming into a simplier interface.

The JAWS screen reader is an extremely common computer program useful in all computer tasks that an OS could offer. A noticeable drawback from its design is the amount of keyboard commands that are available to the user [22]. This results in a steep learning curve that must be overcome to achieve proper user proficiency [16][28]. Additionally, the user must memorize commands which map a keystroke to a 'physical' change on the screen (ie. buttons for scrolling or jumping between menus or text blocks). This issue forces the user to draw implicit assumptions regarding explicit changes on the screen, showcasing a poor conversion between visual and non-visual interfaces for the same application.

There are multiple screen reader options that are built custom for a specific OS. NVDA is a free screen reader [24] that is a part of an initiative to provide access for technology for all. Microsoft narrator is an additional option for those working with the Windows OS [23]. The tool is turned on with a keystroke combination available at all times. Users may prefer certain screen readers simply due to their key commands or the intonation of synthesized voice.

Visual authentication interfaces also pose difficulties for VI users. A common automated Turing Test service, CAPTCHA, requires a visually capable user to select or decipher components of images in order to prove the user is human. Although these tests are trivial for sighted users, they are nearly impossible if a person struggles with their vision [28].

3. **Existing Products and ongoing Research** Though user interfaces are related to accessibility, there is a clear distinction between the two when evaluating the user's operation within an application. The use of GUIs is extremely common since it is simplest for sighted users. Unfortunately, the GUIs are complex for VI users [35] due to their high visual dependency. As a result several studies have introduces other modalities that could be useful for VI users. The use of Auditory User Interface (AUI)s, Tactile User Interface (TUI)s, and combinations of all three (multi-modal systems) are commonly mentioned in the literature [30][2][29][36][31][37][38][39][7]. Other papers and products may not

specifically acknowledge the application of a specific UI, although their developments generated a unique non-graphical interface. Common non-GUIs are screen readers such as JAWS that offer accessibility to users on the entire spectrum of VI.

Several papers study existing UIs and develop guidelines [17][40][2][28][8][7], statistics [35][41][7], or evaluations [42][43][44][28][45][38] to improve the usability and intuition behind their respective applications. This extends to proper query formulation for search engines [8] or the acknowledgement of user's level of experience when developing applications (Net Savvy vs. Net Naive) [13].

Many product developments have also been well documented in the literature. JAWS is amongst the most common UIs for VI computer users. Unfortunately, its complexity is well known along with a high learning curve [28]. An interesting result noted by Menzi-etin et al., is the high preference of JAWS users towards Internet Explorer (IE) [44]. The issue with IE is the lack of online community support for the browser. Very little sighted users prefer IE which creates additional gaps between VI and sighted users. Other UIs for web accessibility are Mg Sys Visi [42], Accessibility Kit for the Internet (KAI) [36][43], WoW [10], and the Homer Web Browser [30]. Some applications like EasySnap developed by Jayant et al., aid VI users with photography as well as sharing their content online [46]. Siekierska and McCurdy, developed a product to provide users with an interface for physical world navigation, allowing them to use maps freely [37]. Sahib, Tombros, and Stockman, have developed a non-visual spelling support system [12]. Finally, Audio Hallway is a conceptual AUI product developed for browsing collections using head motions, giving the user an immersive experience [31].

4. **Necessary Future Research and Consideration** As noted above, there are many papers that indicate guidelines for developing an intuitive user interface. Developers would benefit greatly from referencing and considering these principles when developing applications. The user

should not be frustrated with the UI, because if developed with all users in mind these interfaces will become as simple as using a screen.

2.4 Summary of Information Accessibility

The ability of accessing virtual information is equally important to a user's ability of navigate to it. As a matter of fact, the final destination (ie. video, image, text, or other online medias) is the reason the user is online to begin with. Which becomes problematic if information is inaccessible.

As a sighted user it is easy to scan through information and pick out the pieces of data most relevant to you, but with VI this process is a increasingly difficult. To resolve this struggle, web applications have the option of providing descriptive text (also known as 'alt text') that could be heard by the user to provide an alternative form of accessibility for the same media. The issue is with rapid development and pressure to produce web content, developers commonly forget to add these adjustments making their content inaccessible to disabled users.

More surprisingly, many sites meant for universal accessibility are still found to be difficult to use. An example of this was uncovered through a study of university web terminals meant to keep students and staff up to date that yielded exceedingly poor compliance [44]. After evaluation it was clear that VI web users could not access a substantial percentage of university content [44]. These sites failed to comply with the Web Accessibility Initiative guildlines [45], an effort by the World Wide Web Consortium (W3C) set out in 1999 to ensure accessibility for all [5].

To fight the inaccessibility of public content the Ontario government (major Canadian province) has released an Act that envisions a "Barrier-Free Society for All People with Disabilities" [6]. Companies and organizations are expected to follow these guidelines restricting colour contrasts, font sizes, and other expected accessibility features.

2.4.1 *Attribute*: Information Accessibility

1. **Scope** The process of collecting and synthesizing information from the internet is an important skill to have in order to become efficient in using online applications. But for synthesis to occur, the information must be quickly and easily accessible to the user. Navigation assistance (section 2.2.1) is not enough to interact with information online, the user must also be able to understand and access the media they encounter.

2. **Difficulties faced by VI Users** The internet is commonly designed for sighted users resulting in highly graphical presentation of information. Furthermore, there is little consideration for visually impaired users that may be equipped with screen readers or assistive aids [43]. Consequentially, the VI user may read a web page while having to subconsciously guess the contents of information that is inaccessible to them.

   As an example, consider a university web page terminal that allows students and staff to check for events and updates around campus. Several studies have compared a collection of university sites that are ideally supposed to be accessible to all students [47][44][45]. After evaluating the compliance levels of each site it becomes clear that most visually impaired students cannot access a substantial percentage of university content. This results in lack of knowledge and frustration for the students. In addition these sites did not comply with the Web Accessibility Initiative guidelines (WAI) published by the W3C [5].

   It is also important to avoid overloading the user when they are browsing for content [28]. Since it is quicker to skim through a document visually, it is expected that the online experience is fast. But in the case of VI users the experience may be slowed down to accommodate for screen readers. If the technological aid reads an excessive amount of information from the web page, then the user will experience a slower consumption rate (the rate at which a user is presented with new information). Conversely, if the aid outputs lots of audio, then the user may feel overwhelmed and is forced to slow down equally.

3. **Existing Products and ongoing Research** The ability to provide accessibility to computer and online applications is extremely important since virtual media (ie. text, images, videos, etc.) is how the relevant data is commonly represented. As a result, much of the effort is placed in converting standard sites to become accessible. As a humanitarian effort to ensure accessibility, the government of Ontario (Canada) has filed the AODA detailing standards and regulations that organizations and individuals should abide to make their products or services more accessible [6]. The AODA also provides good teaching, coding, and design practices that extend past the web to improve the accessibility of public places and schools. Halimah et al., have developed a translator that can convert HTML to multiple mediums, including; voice output, braille, or text. Due to this versatility, the translator can be employed by an array of users including the elderly and other individuals with ranging disabilities [42]. Macias, Gonzalez, and Sanchez, developed a product named KAI that is composed of two modules. The first, a markup language designed for the blind, Blind Markup Language (BML) [36][43]. The other is an application called WebTouch, a multi-modal web browser used in conjunction with BML [36][43].

   Another application, VoiceApp, allows web browsing using voice commands alone [11]. The VoiceApp generates markup metadata called VoiceXML that indicates relevant voice information to be transmitted [11]. The Web Access Project, developed by Yang and Hwang, adds captions and audio descriptions to video clips as context for VI users [39]. SSEB [7] also adds to the accessibility of the web, by allowing the user to comfortably search for webpages. Additionally, the paper by Yang, Hwang, and Schenkman, indicates a minimum requirement claiming that, anyone should be able to understand the contents of any web page [7]. Though this goal may seem ambitious, it depicts the ideal compliance status of the web. Chen, Ma, and Zhang, focuses on web browsing via, "handheld computers, Personal Digital Assistant (PDA) and smart phones" [40]. Their application compartmentalizes web content so that it can be accessed using small form-factor devices [40].

Wearable technology is used as a method of accessing information. AlterEgo, a smart, non-invasive, wearable computer which sits externally around the human vocal cords. AlterEgo allows the user to communicate with computers without audibly voicing a word [48]. This provides human-computer interaction that is totally discreet (more in section 2.6.1). Other physical products are used to provide VI users with access to physical graphical information, such as maps [29][49][37]. These technologies are not only useful when transporting from one location to another but their use declines once the user becomes familiar with the space, indicating the use of successful learning methods [49].

Additional studies are focused in researching ways to improve accessibility. Several papers have studies the issue of overloading the user [17][28][38]. Others indicate that the use of multiple modalities (audio, touch or both) are good ways of replacing graphical information [35][11][43]. Baguma and Lubega, have produced a list of requirements that aid developers to assure accessibility [17].

4. **Necessary Future Research and Consideration** When generating new web content in the future, it is important to take preemptive measures such as; adding alternative text to images and videos, focusing on web page accessibility, and performing proper testing to ensure accessibility with adequate, non-visual computer peripherals (keyboard only). For products and applications that are developed in this field, it is crucial to remember that users have a range of visual impairments along with other disabilities that could also benefit from their product. Current accessibility applications are complex with a large learning curve that is overwhelming for the elderly or naive online users. Developers must consider what is important in terms of accessibility and what can be omitted.

2.5 Summary of Latency

The shift towards relying on search engines was not solely for pooling a wider range of sites but also to improve speed. By employing search engines, users can answer their questions, and reach information much faster. The latency, also known as 'search time' [7] or 'task completion time' (with focus on SEs) is an attempt to quantify the efficiency of the interface. This includes studies measuring latency for online users [44], speed of information access [3], and the importance of developing more efficient UIs for SEs [16]

Products have been developed that take different approaches than just modifying the interface. AlterEgo is a prototypical device that sits like a necklace on the vocal cords capable of converting silent mouth movements to text on the computer by digitizing the signals in nearby nerves [48]. This device is a creative way of reducing time on the input side rather than through the software's output.

Sizable initiatives by the large corporations focus on the development of personal assistants. Examples of these include; "Siri" by Apple, "Hey Google" by Google, "Alexa" by Amazon, and "Cortana" by Microsoft[50], to name a few.

2.5.1 *Attribute*: Latency

1. **Scope** The efficiency of the web, more specifically search engines, has allowed internet users to spend significantly less time looking for results. Consequentially, a standard user is expecting quick retrieval. The latency, also known as 'search time' [7], or task completion time, of a web search is the time difference between initial formulation of query and final intake of information. This could also be extended to describe the amount of time a user spends on a website to absorb the information.

   Note the this attribute is not limited to SEs since all computer tools are expected to work quickly. Another reason for Latecy to be regarded as an important attribute is that it attempts to numerically quantify how useful and accessible a tool is.

2. **Difficulties faced by VI Users** The internet has become an endless pool of knowledge that can be ideally accessed by anyone. The major distinction between VI and sighted users is their ability to consume information quickly. Since a sighted users has higher visual acuity they are comfortable skimming through dense pages with lots of data. Conversely, VI users are forced to examine the same page more carefully, resulting in a slower online experience. Each VI user then spends more time per webpage and therefore experiences more latency between query and result.

   Mack and Rock, have also addressed the issue of latency but with an attempt to identify its source. They claim that VI users construct explicit perceptions of webpages, rather than visually driven implicit observations [51]. These explicit perceptions are more difficult to comprehend and force VI users to spend more time online.

3. **Existing Products and ongoing Research** Several studies attempt to quantify the difference in time duration between VI and sighted users. Menzi-etin et al., captured the latency of VI users when completing online tasks [44]. Ivory, Yu, and Gronemyer, also focus on speed of information access and collected measurable metrics on user evaluation time [3]. Others have highlighted the advantage of using mobile devices [8], and the importance of developing more efficient user interfaces for SE users [16].

   Products that have been developed to aid VI users have tackled a variety of issues. AlterEgo, a wearable input device, allows the user to input information to a computer at a faster rate and at any distance since the wearable collects muscle movements directly from the vocal cords [48]. EasySnap, an application for sharing pictures and videos, is intuitive and easy to operate [46]. This allows users to become faster with simple activities, reducing latency in processes such as sharing media. Search Trail, a multi-session assistant for VI users, reduces the resumption time between sessions by allowing the user to revisit their virtual trail and pick up where they left off [27]. Wikipedia, the online encyclopedia, is a good source for quick descriptions [11].

With immediate accessibility to the web, many applications are capable of answering questions, providing guidance and help manage personal devices. Examples of these applications include; "Siri" by Apple, "Hey Google" by Google, "Alexa" by Amazon, and "Cortana" by Microsoft [50]. Other examples specifically for SEs include the Featured Results at the top of the Google SERP that attempts to determine the most confident result.

4. **Necessary Future Research and Consideration** When interacting with online applications, users generally favour those that reach solutions quicker. Whether it is the start-up time, resumption time, or time spent completing tasks, developers and engineers must focus on minimizing the latency of the overall experience.

2.6 Summary of Discreetness

Though it may seem redundant to mention, computers have the ability of operating in near silence. This property is what allows for quiet classrooms and libraries. Users are able to access their media and interact with their device without disturbing their surroundings or attracting attention. The issue when introducing user-voicing (applications that rely on audition as the main method of feedback and control) is that silence becomes difficult to achieve. For instance think of personal digital assistant like Siri (more in 2.5), though this feature is powerful it is not intended to be used in absolute silence.

Several applications have been developed in an attempt to resolve this barrier. The use of Refreshable Braille Display (RBD) is a leading method for computer access due to their compact design and silent operation. By converting the text to braille, the user can read text line-by-line and is able to work in public settings while developing their literacy. A known manufacturer of RBDs is HumanWare which designs and sells the BrailleNote device [52]. AlterEgo is an interesting project discussed above (more in 2.5) that allows the user to input commands and text in silence [48].

The need for better, more efficient, and faster interfaces is growing as with the expansion and intricacy of the internet. This idea extends past the VI community to all web users that enjoy a seamless experience.

2.6.1 *Attribute*: Discreetness

1. **Scope** The usage of computers and assisted devices are often helpful for those that require support due to a disability. But users are most likely to favour devices that allow them to operate in a discreet manner. The user is then free to explore the web as they please, without the fear of stigmatization or the negative social implications of using obtrusive devices. Note that the concept of discreetness extends past the context of computer usage, and into all fields of assistive devices.

2. **Difficulties faced by VI Users** During standard computer usage, especially in public settings, it often goes unnoticed that a sighted user is capable of using their devices discreetly. The user enjoys privacy via speechless text entries, auditory feedback through headphones, and small sized screens that can be hidden from others. The user can then reduce their noticeability and can blend with the local setting (ie. library, coffee shop, waiting room, etc.). This concept is most prevalent in youth settings, where phone and computer usage is common, while everyone is fixed on their own device.

   The concept of discreetness is not only concerned with others hearing its operation, but also seeing its operation. Since computers are extremely helpful in completing rudimentary tasks, such as; checking emails, sending money, and setting reminders, they may be quite helpful for VI users in their everyday routine. But in order to help the user employ the technology more comfortably it would be beneficial if the operation is physically hidden (or at the least discreet).

As an example, imagine designing a new controller for VI users. If the device requires the user to swing their arm violently, then it would be rejected by others due to social norms, negatively affecting the individual.

So although the device may operate efficiently and accurately, it would still be rejected by the end-user. It is the responsibility of the designer to account for a wide range of usages in order to determine if the device is user friendly in public settings.

Finally, the users should not be required to disclose their handicap online. As a result VI users may appear as an ordinary user to others. This form of confidentiality has positive emotional implications (more in section 2.7.1).

3. **Existing Products and ongoing Research** Discreetness can be broken-down into two components; user-voicing, and audio feedback. For user-voicing application discreetness is more difficult to achieve since the user is forced to audibly operate the application. While for audio feedback applications the user may use computer peripherals like a keyboard, mouse or touchpad to silently interact with the computer. Examples of user voicing applications can be found in [11][42][26][38]. Examples of audio feedback applications can be found in [30][2][11][29][42] [26][46] [48][43][28][31][37][38][25].

   A wearable, non-invasive device called AlterEgo, is designed to allow the user to communicate with a computer without verbally pronouncing words [48]. When using audio feedback devices, VI users must be audibly focused for long periods of time without distraction. As a result, the developments of TUI or multi-modal interfaces would be beneficial [2]. Siekierska and McCurdy, have developed map interfaces for physical world navigation that focus on tactile interfaces allowing the user to have their ears listening for dangers or physical threats to their commute (ie. cars, other pedestrians, traffic light signals, and more) [37].

The AlterEgo device developed by Kapur, Kapur, and Maes motivates the possibility of creating a fully discreet system. By allowing the user to quickly send text phrases as input, the system may be operated anywhere in public. Similar to how SMS messages are a totally discreet form of communication, with the help of devices like AlterEgo, VI users will now be able to send and accept computer data without being noticed. The current methods for discreet text entry include a standard 'QWERTY' keyboard, mobile keyboards with predictive text, and other forms of non-verbal entries.

4. **Necessary Future Research and Consideration** The need for discreetness is growing since users have developed a dependence on internet accessibility, resulting in quick and quiet access all the time. Once VI users can comfortably operate their devices and participate in online activities regularly, they will be more likely to develop independence and social awareness.

2.7 Summary of Emotional Implications

Every computer tool employed by a user requries a human-computer interface. So as the human user collects information through their biological sensors (i.e. sight, audition, touch, etc.) they synthesize the data and produce a response through responders (such as fingers, limbs, or voice) [1]. If the user has difficulties building a conceptual model then it becomes unclear how to respond. This is a sign of a poor interface, which can often result in negative emotions towards the application.

The review mentions a collection of studies carried out to evaluate the user's emotions when interacting with web applications. The results indicate that poor UI's lead to frustrated users. If net naive (inexperienced) users [13] are faced with complex UI's then they are less likely to spend time using them. This concept extends to all users. Such barriers shows the importance of reducing the learning curve in order to minimize the difference between net naive and net savvy (experienced) users [13].

The idea of emotional implications extends even further to include the idea of stigmatization. The reason for developing accessible applications, especially for mobile use is to help the user feel less stigmatized when using devices in public [29]. This approach signifies that by increasing accessibility of tools they become more attractive to larger portions of the demographics.

2.7.1 *Attribute*: Emotional Implications

1. **Scope** The emotions that a user feels when facing challenges in an unfamiliar environment is important to the success of a product. Whether it is happiness, confusion, frustration, or dispair, the response of a user to the functionality of a product is a definite indication of its usability and accuracy.

2. **Difficulties faced by VI Users** Common negative reactions by individuals using web browsers are frustration since the user is unable to determine their virtual location or recall previously acquired knowledge. Depending on the experience of the user, a potential solution would be to close the program and retrace their steps (discussed in section 2.2.1) [28].

   Additional frustrations and confusions are common when content is found to be inaccessible. Furthermore, partially accessible webpages are also problematic since text may be easily understood via screen readers but images and videos are unobservable. This form of inaccessibility is critical since many sites rely on visual content to convey the most relevant information.

   The use of standard webpages and search engines browsing constitutes for a large part of computer usage. In addition, participating in social media platforms has become a standard for many. Although there are conflicting views on the effects of social media, Jayant et al., have indicated that social media is beneficial for VI users [46]. Since social media allows for anonymity in social settings, people with visual impairment can freely express themselves without real-world confrontation [53]. Additionally, VI users can share their experiences with others almost instantaneously and receive positive feedback from their peers online.

3. **Existing Products and ongoing Research** Several studies in the literature have focused their research to understand the human factors of accessible products. Menzi-etin et al., have noted the importance of usable products since they make its users happy [44], these factors are commonly overlooked. Tsai, Lin, and Hung, attempts to quantify the amount of time it takes for a VI user to get frustrated while using the web [8]. Murphy et al., also indicates the frustration behind online application [28], while, Andronico et al., describes the need for less frustrating user interfaces that are more user-oriented [16]. Other papers describe the dependency of VI users [54] and the increased brain activity used by Net Savvy (experienced) users [13], emphasizing the non-intuitive nature of online platforms.

   The World Health Organization [53] highlights the importance of online communities as a method to overcome barriers experienced by face-to-face interaction [53]. Wu et al., studied a text-based online social network platform, Twitter, displaying the levels of influence by specific VI groups [55]. Wu and Adamic, analyzed the social network density, size and usage of VI and sighted Facebook users [25]. VI users on Facebook were identified by their use of Apple's iOS voiced accessibility feature, VoiceOver, these users statistically received more feedback from peers [25]. Jayant et al., found that sharing pictures and videos online had a positive effect on the individual [46]. Other research indicated that VI users feel as though they are missing out on a perceptual experience online [28], referencing the stimulus of visual content. In educational setting, Muwanguzi and Lin, has studied the reactions of VI students when accessing web-based educational content, as well as, their ability to communicate with professors and colleagues virtually [45].

   When analyzing products, Ismail and Zaman, presents the disappointment of VI users when using voice activated browsers [26]. Hakobyan et al., studied the motivation behind the development of a Mobile Assistive Technology (MAT), discovering that, "individuals feel less stigmatized or labelled", when using these products [29], this topic relates well to the concept of discreetness discussed in section 2.6.1. Search Trail, an application that aids VI users with multi-session tasks, provides the users with confidence knowing that the program tracks their virtual trail [27]. The most frequent reasons for not using applications or devices is the lack of interest, cost, or simply being unaware of its availability [41].

4. **Necessary Future Research and Consideration** This section supports the need for humane considerations of emotional implications while developing future products, devices and applications. It is not enough to make a product that it is accessible, but also one that allows the user to enjoy the online experience. It should not be a burden for the user to interface with online applications but rather an integral part of a person's life. If an application causes users to become frustrated, the likelihood of repetitive use declines dramatically, resulting in abandoned devices and products. Developers and engineers must consider the end user in their entirety.

Chapter 3

Understanding the Userspace

When designing a UI there's a constant battle between providing user freedom or an overwhelming amount of information. By binding user commands to keystroke combinations, the user spends less time while achieving more functionality. But first, they must spend time memorizing commands [28]. This concept of user preference for 'recognition over recall' is exemplified by Scott MacKenzie [1], in his analysis of menus. So where is the balance? The easy answer is, it depends. Primarily on the users of the application along with their preferences and capabilities.

First let's define what the user wants to reach, perhaps everything. Since this review is centralized around search engines lets focus on the SERP. A space that encompasses all the information retrieved from a single search query (*cyberspace*, coined by William Gibson in 1982 [33]). This idea encapsulates the struggle of UI design. Since users want to traverse the cyberspace as quickly as possible without memorizing steps.

Let's refocus by concentrating on a single webpage. By forgetting (for a moment) all the places this page could take you in the form of external links, it becomes easier to see how a single webpage is a *well-defined* cyberspace. More specifically, a webpage has a limited set of elements and actions available to the user if they choose to interact.

¡¡¡¡¡¡¡ HEAD As an example consider the SERP. Being a results page it holds a finite number of search results. By manipulating the way in which the user interacts, they might find a more efficient method of accessing the same information. In the case of VI users, this is definitely true. Primarily due to a large majority of webpages being designed for sighted user.

To conclude it is important to consider the users' space of possibilities when designing tools. In the context of SEs the user's end result is unpredictable since the space is infinite. But for other tools like word processors or music applications that allow the user to interact with different content the space may be very well defined. As a result, by looking at the whole picture designers may find interfaces that benefit users of all type regardless of their visual acuity. ======= To conclude it is important to consider the users' set of possibilities when designing tools. In the context of SEs which may return billions of results, the user's space is large and unpredictable. But for other tools like word processors or music players that allow the user to interact with local and predictable content, the space becomes more well defined. ¿¿¿¿¿¿¿ 4880659bbdafd66de42a7387ba37b0f6274dc67f

Chapter 4

Assumptions

- This system is used on any device connected to the internet (intentionally large scope)
- The systems target audience are people with visual impairment that cannot comfortably read the screen of the device they are using
  - Ranging from Mild VI to total Blindness
- The user has experience with search engines and interacting with the internet
  - Avoid learning curve
- The user can hear well
- The user can speak well
- The user can type proficiently
  - As a replacement for speech
  - As a method of discreet communication

Chapter 5

Relevant Definitions

Note that each definition listed below correlates to italicized terms used in sections 6 and 6.1.

Query: The question that the user wants an answer for (this will be the input to the search engine)
Domain: The area in which the Search Engine will
Search Engine (SE): Search engine is a service that allows Internet users to search for content via the World Wide Web [3]
Discreet: Has the capability to be used with any third party hearing its operation
Overwhelm: Provide information for the user to feel as though its irrelevant
Irrelevant Information: Information that is not related to answering the query
Search Results: The available set of links provided by the SE and the default results that the SE might generate (ie. Google Featured Snippets)
Track The User: This feature will follow the users input and relay real-time sounds indicating that the users query is structured properly (ie. read every word after being typed)
Available Results: Set of links returned by the SE
Search Constraint: Restrictions and limits in order to narrow the search results (ie. Google Tools Tab in a standard Google Search)
Guide The User: This feature will allow the user to systematically go through a set of options while being able to traverse the set both forwards

and backwards

Virtual Disorientation: The feeling a user may have online when they do not know their location online. This may occur from not remembering past visited sites and plans for future sites (ie. Google solves this by altering the colour of the link)

Focus: In the context of web-based navigation, the focus will be on reading main bodies of text rather than jumping to links in order to move the user forward

Rationale: the user needs to focus on the information of the current page rather than where to go next

Visual Content: Any content online that can only be accessed by sighted or low VI user (ie. pictures, videos, GIFs...) and would require Image Recognition

Image Recognition: An algorithms that could detect and explain the contents of a picture reliability to a person who cannot see the content

Trust Their Peers: Allow a VI user to follow the search of a sighted user that has completed the search before them. This requires a sighted user to have previously developed this query and found a sufficient results

Quick: The system must act fast enough to allow the user to feel engaged at all times

In Control: The user must always have the ability to jump between stages of the query process which they find slow them down

Related Queries: Previously entered search queries that have similar meaning but are more commonly entered and returned satisfactory results

Confidentiality: No user information will be required to use this tool

Rationale: Since standard google searches do not require user information neither should this system

Excessive Functionality: Functions in the system that are designed to help those with worse vision that the user (ie. Text-To-Speech if the user can read very large font)

Chapter 6

Requirements

This section will list the requirements of the application and will explain each one.

This list will reference each requirement numerically. Note that italicized text is used to denote terms that require definitions, found in Section 5.

1. The system should be *discreet*
   (a) Rationale: the user should be able to keep the system and its usage completely confidential
2. The system will be independant of an OS
   (a) Rationale: the system is not tailored to a specific OS but focuses on the Internet
3. The user must generate the *query*
   (a) Rationale: the query was fully formulated by the user without system bias
4. The user will select the *domain* of the query
5. The system will *track the user* to ensure the query is entered correctly
   (a) Rationale: to ensure that the user follows the proper procedure for entering a query

6. The system shall confirm that the input query is what the user intended
   (a) Rationale: the user can read back the query for confirmation
7. The system must not *overwhelm* the user with *irrelevant information*
8. The system shall reduce the amount of *avaliable results* so that the user is not overwhelmed
   (a) Rationale: the user can be frightened or offput by excess info
9. The user shall be able to set *search constraints* to further enhance the search
   (a) Refers to the standard SE constraint options
10. The system will only read text that the user wants to hear
    (a) Implies additional user control
11. The system will *guide the user* through the list of available *search results*
    (a) For this application, the first ten will be satisfactory
12. The system will not guide the user once a specific link is selected
    (a) Websites selected from the SE results are outside the scope of the application and must include their own accessibility features
13. The system shall keep track of the user's state in order to avoid *virtual disorientation*[4]
    (a) Rationale: to allow the user to recall and track their own state
14. The system should be able to describe past states to the user upon request
    (a) Rationale: the user can access their history at any time
15. The system will *focus* on text that answers the query rather than links

   (a) This helps the user find information rather then direction on where to go next. Ultimately this will reduce the amount of time spent online

16. The system will not be responsible for analyzing and explaining *visual content*

    (a) Due to current scope of application, alt text will ideally be provided

17. The process between stages of the search must be *quick*

    (a) Rationale: This is to reduce time spent online

18. The system will protect the user's *confidentiality*

19. The systen will not indicate that the user has VI

    (a) Rationale: To not expose the user or set them apart from searches performed by sighted users

20. The user will be able to turn off features that are tailored for users with heavier VI

    (a) Rationale: The user will not be slowed down by excessive functionality

21. The user will be able to stop audio output at any time

    (a) Related to AR2

22. The user will have the following options for Text-To-Speech (TTS) Synthesis:

    (a) Volume Control (Increase and Decrease)
    (b) Speech Speed
    (c) Voice preference (gender independent; male, female)

6.1 Advanced Requirements

The following list of secondary requirements can be overlooked to achieve the base mandatory functionality.

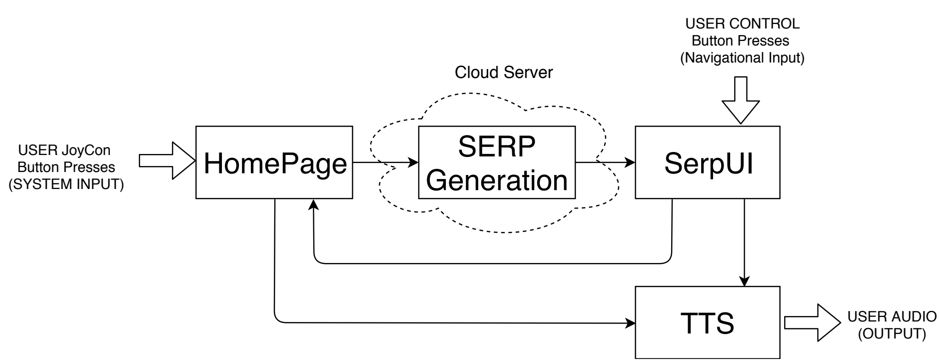
1. Allow the user to *"trust their peers"*
   (a) Leverages the capabilities of previously answered queries
2. The user must feel *in control*
   (a) Related to emotional implications
3. The system should offer *related queries* that could better describe the user's queries
   (a) Refers to 'previously asked'
4. The system will be able to be used on smartphones and tablets
   (a) Rationale: A large majority of visually impaired internet users from entire spectrum of VI use smartphones [5] (Ref found in Requirements document)
5. The system should know the user's state online - Advancement on R13 and R14.
   (a) Rationale: To leverage the patterns in the user's search history
   (b) Also refers to:
      i. What they saw (past states)
      ii. What they want to see (desired future states)

Chapter 7

High Level Design (HLD)

This section will explain the High Level Design (HLD) of SerpUI as a derivative of its requirements. This section will also include block diagrams explaining its operation. The following block diagram highlights the major components of the application. More information regarding each block can be found in the subsections below.

Figure 7.1: High Level Design - Block Diagram



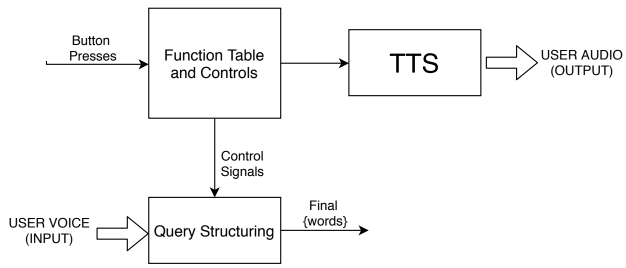
7.1 Homepage - Query Formulation

Input: JoyCon/Keyboard button presses [Controller via Bluetooth Module] + user query information (through voice OR keyboard)
Output: "query" (*single string*) [SERP Generation 7.2]

Objective: A preliminary UI that will aid the user in formulating their desired search query. The user can then submit their query when satisified. As per its name, this UI is the landing-page of the application where the user begins their search.

Satisfied requirements: 3, 4, 5, 6, 7, 9, and 17.

Figure 7.2: Block Diagram of Homepage



The following table (Table 7.1) describes the Functional Key Mapping between the JoyCon Buttons/Keyboard and their respective functions. The mapping in Table 7.1 indicates the purpose of each button along with the conditions on when it should be available to the user (invocation condition).

Table 7.1: Function Table - Homepage JoyCon and Keyboard Bindings

Functionality	JoyCon buttonID (right only)	Keyboard Equivalent	Function Name
Read Query Text Field	RT	SHIFT	clarifySTT()
Suppress TTS	PLUS	CTRL	TTS(“”);
Location	R	? button (‘/’ without shift)	TTS(“Home Page”)
Submit Query	A	Right Arrow	submit()
Start Recording	X	Up Arrow	start()
Stop Recording	B	Down Arrow	stop()
Clear Query	Y	Left Arrow	clear()
Refresh Homepage	HOME	ESC	Similar to ’F5’
Increase Volume	RSR	(use speaker control)	changeVolume(“up”, optionsTTS)
Decrease Volume	RSL	(use speaker control)	changeVolume(“down”, optionsTTS)
Helper Mode	RA	n/a	helpMe()

Table 7.2: Function Table - Homepage Invocation Condition

Functionality	Invocation Condition (if ...)	else ...
Read Query Text Field	NOT RECORDING	TTS("Press down to stop recording")
Suppress TTS	At any time	
Location	NOT RECORDING	TTS("I'm listening!")
Submit Query	NOT RECORDING && Query != null	null
Start Recording	NOT RECORDING	null
Stop Recording	RECORDING	null
Clear Query	NOT RECORDING	null
Refresh Homepage	At any time	
Increase Volume	At any time	
Decrease Volume	At any time	
Helper Mode	At any time	

7.1.1 Brief Explanation

As stated above, the objective of this subsystem is to formulate the search query, making this page the theoretical equivalent to the a standard SE Homepage (such as www.google.com). The user is simply using this environment to structure their search query. As denoted by the block diagram (Figure 7.2), the user navigate with button clicks to send commands to the homepage. The user then uses their voice or keyboard to input the query. A STT algorithm runs in the webpage background in order to record and synthesize the user's voice, only upon request.

In addition to reading back (via TTS) the contents of their current query, the user also has the flexibility to manipulate this search query in a definite number of ways. The user may;

1. **Record** additional clips (which should concatenate at the end)

2. **Clear** the query

3. **Submit** the query to the next subsystem (Section 7.2)

4. **Modify** their query directly using the keyboard

This page will always be the homepage of the application. Regardless of the user's location in the rest of the application, it is essential that the user is aware of this as their only homepage. This additional condition is to increase online familiarity to reduce confusion, along with projected reduction in long-term latency.

7.2 SERP Generation

Input: "query" (*single string*) [Query Formulation - Homepage 7.1]
Output: Structured JSON File (*.json*) [SerpUI 7.3]

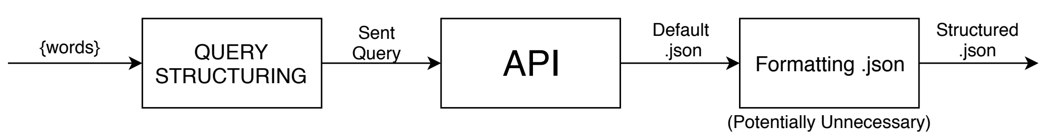
Objective: To convert the string query to a JSON file, containing the SE results of a given search engine. This application will utilize the Google Custom Search API to attain real-time search results.

Satisfied requirements: 2, 17, 18, and AR4.

The reason for using external API's is not only to reduce the amount of overhead when developing this application but also to reduce inherit biases or inaccuracies that could arise from direct implementation. It is important that the user is provided with the same set of SE results as any other user that decides to access Google in a different modality.

Although the ideal implementations should return identical results, some SERP information may be inaccessible due to search history, preferences and restrictions by the API provider. The most prominent issue being the Feature Search Result, commonly isolated at the top of the Google SERP in order to provide a confident solution for the user.

Figure 7.3: Block Diagram of SERP Generation



7.2.1 Brief Explanation

There is no UI for this subsystem. It is the responsibility of the application to collect the search query from the user as intended, request the SERP data from the SEs servers, and return a JSON file structured for the SerpUI interface in the application's front-end. The user will simply wait this small time period until the SerpUI is ready for engagement. Hard time constraints should be set by Requirement 17. This hidden interaction should occur in the back-end by SerpUI servers to offload from the user's device.

As noted by the block diagram (Figure 7.3), additional formatting may be required by the application so to comply with the SerpUI data structure. Although different Search Engines may return varying file structures, most common APIs tend to return similar file types that can be formatted for SerpUI (built for JSON files). Due to this application being *ad-hoc*, only Google's Custom Search Engine (CSE) was analyzed for formatting.

JSON files were chosen as the desired filetype due to the output of the API, along with their simplicity for online apps. This decision is subject to change if the implementation uncovers different issues.

7.3 SerpUI

Input: Structured JSON File (*.json*) [SERP Generation 7.2]
Output: Tile Data (*string*) [TTS 7.4]

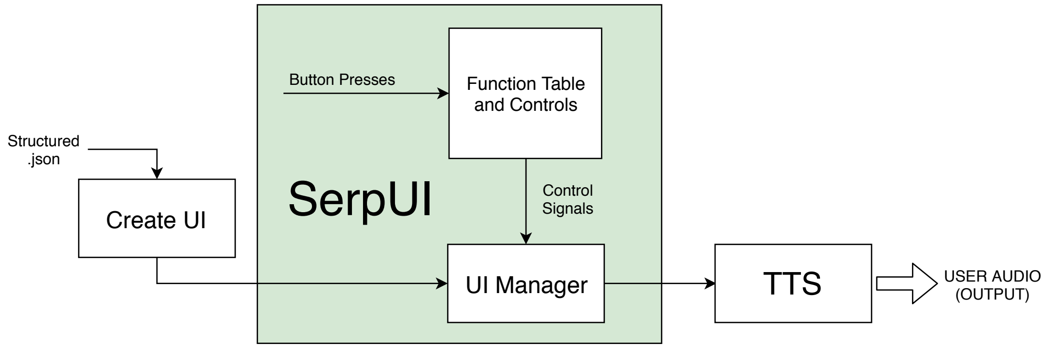
Objective: Transform JSON file structure to navigational real-time UI for user. Each JSON element is considered a 'Tile' that user may 'be on' (interact with). When a user moves to a new tile the tile data is output to the TTS subsystem. This module must respond to user motion via JoyCon or keyboard button commands in fast real-time.

As an additional objective, it is important that the user can focus on a single tile at a time. As a result each tile must resolve a single operation and denote a single information of data. Sample operations can include: text dictation, user text entry, video playback, and other common HTML elements functionalities.

Satisfied requirements: 1, 2, 7, 10, 11, 12, 13, 15, 16, 17, 18, 19, AR2, AR3, and AR4.

By default the contents of each tile will be read upon entry. The user then has the option of suppressing this output with a button click. The user should also be able to request positional information about the SERP, more specifically, the search result number and the data heading (for example, "Search result 10, observing Snippet").

Figure 7.4: Block Diagram of SerpUI



Tiles have 2 types: {Full, Empty}

Full Tile - Tile containing SERP data from json file (shown as Green in Figure 7.6)
Empty Tile - Border with no SERP data, used to indicate positional data for user (shown as Red in Figure 7.6), more in Section 7.3.3

The following table (Table 7.3) describes the Functional Key Mapping between the JoyCon Buttons/Keyboard and their respective functions. The mapping in Table 7.3 indicates the purpose of each button along with the conditions on when it should be available to the user (invocation condition). It is imperative that the functionality of each button does not change, since users rely on absolute consistency.

Table 7.3: Function Table - SerpUI JoyCon and Keyboard Bindings

Functionality	JoyCon buttonID (right only)	Keyboard Equivalent	Function Name
Read Neutral Tile Content	RT	SHIFT	TTS(getNeutralText(user), optionsTTS)
Suppress TTS	PLUS	CTRL	TTS(“”); toggleVideo()
Location	R	? button (‘/’ without shift)	TTS(getUserLocation(user), optionsTTS)
Next Heading	A	Right Arrow	moveToTile(‘right’)
Previous Result	X	Up Arrow	moveToTile(‘up’)
Next Result	B	Down Arrow	moveToTile(‘down’)
Previous Heading	Y	Left Arrow	moveToTile(‘left’)
Redirect to Homepage	HOME	ESC	goHome()
Increase Volume	RSR	(use speaker control)	changeVolume(“up”, optionsTTS)
Decrease Volume	RSL	(use speaker control)	changeVolume(“down”, optionsTTS)
Helper Mode	RA	n/a	helpMe()

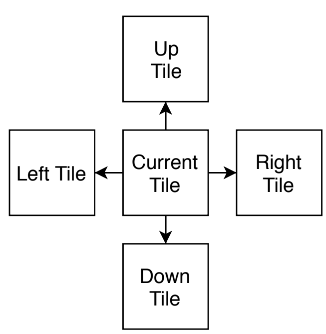
Table 7.4: Function Table - SerpUI Invocation Condition

Functionality	Invocation Condition (if ...)	else ...
Read Neutral Tile Content	At any time	
Suppress TTS	At any time OR exists active iFrame Video	exists inactive iFrame Video
Location	At any time	
Next Heading	No Right Border	TTS("BORDER")
Previous Result	No Up Border	TTS("BORDER")
Next Result	No Down Border	TTS("BORDER")
Previous Heading	No Left Border	TTS("BORDER")
Redirect to Homepage	At any time	
Increase Volume	At any time	
Decrease Volume	At any time	
Helper Mode	At any time	

7.3.1 Brief Explanation

The SerpUI application used the minimal amount of commands possible while still providing access to the whole SERP in a logical manner. A model of the user environment for a single tile is represented in Figure 7.5.

Figure 7.5: SerpUI Model

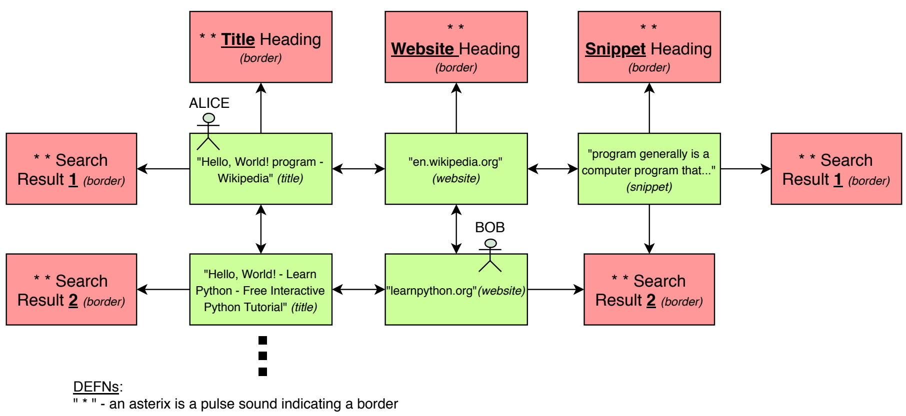


The search results are presented orthogonally to the content found in each result, seperating the two information types. This distinct seperation allows the structure to be more easily conveyed. Vertical motion, Up and Down, is how the user browses between the different results, starting with the first result at the up-most position and moving downwards. With horizontal motion, left and right, the user navigates between the headings of the same result, uncovering more specific headings as they advance rightwards.

The initial position when entering the UI is at the up-most and left-most position. The location of this tile is (Result 1, Heading 1) $\rightarrow (1, 1)$

7.3.2 Visual Example of SerpUI

Figure 7.6: SerpUI - "Hello World"



In this example we have two users, Alice and Bob, who both enter the same query at the same time yielding identical SerpUI layouts. For visual reference follow Figure 7.6.

Alice is located in SerpUI's initial position, signifying the most relevant heading of the first search result. The user will always be initialized in this position to avoid disorientation (related to R13). Available to Alice are all of the SerpUI commands with the execption of Move Up and Move Left, these border movements contain no content (known as empty tiles) and simply indicate that the user has reached a border. By moving rightward Alice can explore more of the first result, and by moving downward she can move on to more results.

Alice's Location: (Result 1, Heading 1)

Bob has already began his journey and is currently observing content from the second result. Bob also has all the SerpUI commands available with the exception of one, Move Right. Since Bob is observing the *second* heading and the SE API only yeilded *two* headings of information for this result, Bob cannot access more data by moving right. If more search results were available they will appear sequentially in the rows below. Otherwise Bob will uncover a border when requesting a Move Down command.

Bob's Location: (Result 2, Heading 2)

It is important that both Alice and Bob are able to request their location at any time to realign themselves within the UI.

7.3.3 Why Borders?

The use of borders in the SerpUI application is to aid with virtual orientation. By limiting the user to a defined *space* that has concrete borders, they tend to understand the user-space more accurately. Similar to traversing a physical space with VI, individuals seek out hints and indicators that convey direction from their surroundings. Virtual borders attempt to provide the same feel, by creating hard barriers that remind the user of where they are in the SERP.

As a result, users cannot move into a border tile. If they 'hit' a border the user's location will not change, only an indicator will trigger. **Note that the use of visual indicators (like colours) as the only method for user notification are insufficient for VI applications, the addition of audition and/or tactition is vital.**

7.4 Text-to-Speech (TTS)

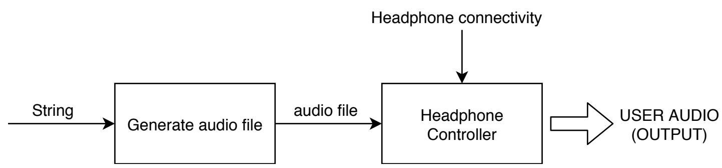
Input: Tile Data (*string*) [SerpUI 7.3]
Output: Sound (via headphones or speakers)

Objective: Accept string input or sound command of arbitrary length and generate an audio dictation using TTS for the user. This module implements a TTS library with synthesized voice.

Satisfied requirements: 1, 10, 21, 22

Due to the overhead in implementation and to avoid inaccuracies in text conversion, this subsystem is abstracted by an external API. It accepts a string as output by the SerpUI subsystem and generates an audio file that plays back immediately. The user always has the capability of supressing the audio output at any point (see Table 7.3). For the scope of this application the user will not be able to pause, play and rewind. As a secondary objective it would be benficial if the interface will be compatible with RBDs to allow for different forms of information accessibility.

Figure 7.7: Block Diagram of TTS



In a tile-based method for navigation, the user has the option of abandoning the mouse. They can now rely on the arrow keys to reach anywhere in the interface. Consequentially, the metrics used to determine user speed and difficulty need to be reconsidered. In this section, a new perspective of Fitts' Law (a quantifier for rapid-aimed movements)[1] will be assessed.

Fitt's Law is a predictive model for the speeds and success of rapid-aimed movements in humans [1]. By definition, the original model predicts how quickly a user can move a set distance (A) from the cursor to the center of the target, given the target's width (W). The difficulty to complete a movement is calculated with the following equation,

$$ID = \log_2 \left(\frac{2A}{W} \right) \tag{7.1}$$

A drawback of Fitts' Law (Eq.7.1) is its limitation to graphical interfaces (GUI) that do not extend easily to other UIs. If an interface is independent of mouse and keyboard then the difficulty of motion requires a new quantifier. We hypothesize that the Index of Difficulty (ID) will not only necessarily change for VI users, but will need to be redefined altogether. SerpUI introduces a new method for navigating a webpage that does not rely on the same computer peripherals attributed to Fitts' Law, the mouse.

SerpUI is an attempt of creating an interface that reduces the ID to zero. By generating a tile-based interface where the user 'jumps' between page elements with a single button stroke. As a result, the distance between elements (A) is zero.

$$ID = \log_2\left(\frac{2 * 0}{W}\right) = undefined \tag{7.2}$$

In this new approach, Fitts' Law can be reimagined as a unitless factor, based on time rather than distance. This can be better quantified by analyzing the number of button presses it takes to reach an element on the page. To further this research, Hick's Law should be considered to integrate the time taken by users to make decisions [**mackenzie˙hci**].

In a single SERP generated by SerpUI the farthest a user can travel is ten rows down (the 10 search results) and four columns across (the 4 headings). Being the same set of search results presented on Google's first results page, excluding the Content Column (4th heading). Therefore the *farthest* possible location can be reached in 12 button presses, 9 to reach the 10th result, and 3 to reach the 4th column. When compared with the Google SERP and pressing 'TAB' to advance it would take a minimum of 20 clicks (two per search result) to reach the tenth result. And a handful more after that to reach the main content, depending on the site itself.

The notable limitation with the above comparison is that it assumes that SerpUI can be mapped to any site while yielding the same level of accessibility. Although this seems complex it may be explored further since its implications may be significant. What remains is the idea of remodeling a webpage to care about the underlying information rather than colour, shape, and beauty. Though these elements hold valuable intrinsic information, a tile-based approach can reduce the site's Index of Difficulty tremendously.

To establish a new *ID* first we must define what is being evaluated. To draw a parallel between the two approaches, Fitts' Law is not concerned with what is at the destination but simply how hard it is to get there. Analogously, SerpUI is an interface concerned with user location rather than tile data. So the evaluated metric is distance. In a tile approach the most infinitesimal motion is one tile in any direction. We also assume, in the general case, that the SERP can be any size MxN. As a result, we can determine the distance between two tiles by finding the difference of their vertical distance and adding that to the horizontal distance of the destination tile (the horizontal coordinate resets to the first column on vertical motion).

So given an initial tile coordinate,

$$Tile_i = (m_i, n_i) \tag{7.3}$$

And a final tile coordinate,

$$Tile_f = (m_f, n_f) \tag{7.4}$$

The distance between two tiles is

$$Distance = |m_f - m_i| + n_f \tag{7.5}$$

Where,

$$ID \propto Distance \tag{7.6}$$

Remember that the vertical position is given by variable, m, and the horizontal position by variable, n. Since the rows reset on every vertical change then n_i is negligible.

Chapter 8

Implementation of Tool

This section will explain the development of SerpUI as a computer tool for VI internet users. Once implemented the components of the HLD (Section 7) are divided between the backend and the frontend, the server and the client, respectively.

The live instance of SerpUI can be found through this link:

https://serpui.cas.mcmaster.ca

8.1 High Level Explanation

The goal behind the SerpUI interface is to reformat the information available through SEs in a way that is more accessible. As a basis for existing implementations of SE interfaces, the Google homepage and SERP were considered.

First we took a detailed look at the Google Homepage (Figure 8.1) as a user types in the phrase "hello world". The page is easy to understand and has lots of signifiers [56] indicating what the user could do next. In the case of Google, the site is so common that most users could even guess what it would look like next. This being a strong positive feature in their design since it interface yields high predictability, helping the user build a better conceptual model. In addition, Google's algorithm proposes a large set of potential answer all in an effort to reduce the task completion time. This feature was difficult to resolve in the case of visual impairment.

But if a VI user were to encounter such a blank page it may be misleading. The buttons and text are small making them easy to miss. Google Chrome also includes a feature where the typed text would be displayed in the Universal Resource Locator (URL) rather than the box where the user has clicked. To resolve some accessibility issues the homepage offers a STT option invoked by pressing the microphone icon at the end of the text field. Depending on the severity of the visual impairment this may be difficult to locate. Although the microphone button expands to indicate that the state has changed to recording (Figure 8.2), there are no auditory cues or dramatic contrast changes present.

Figure 8.1: Google Homepage

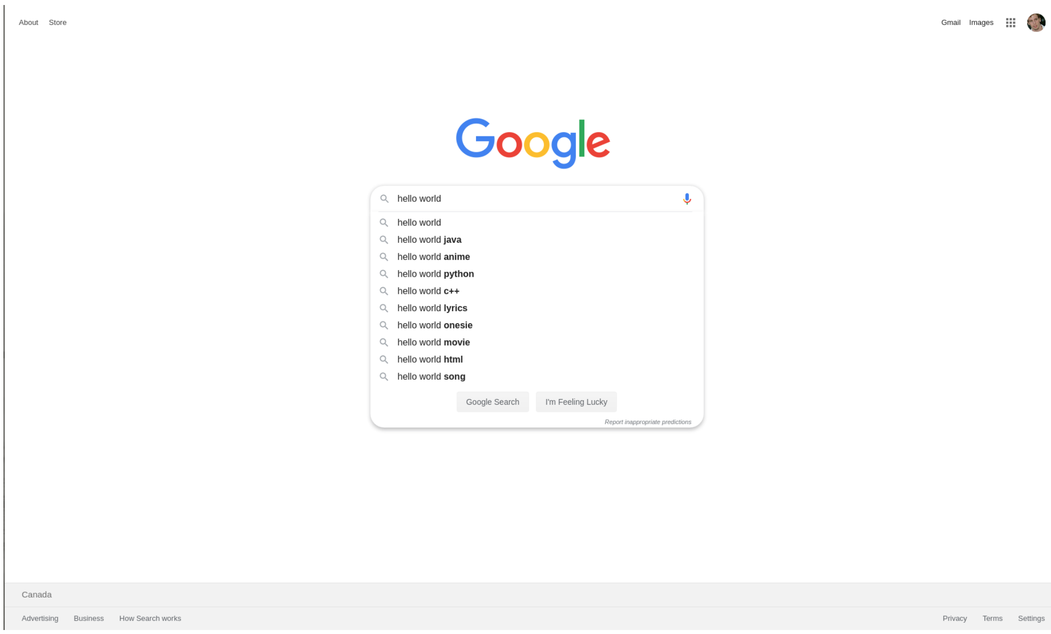
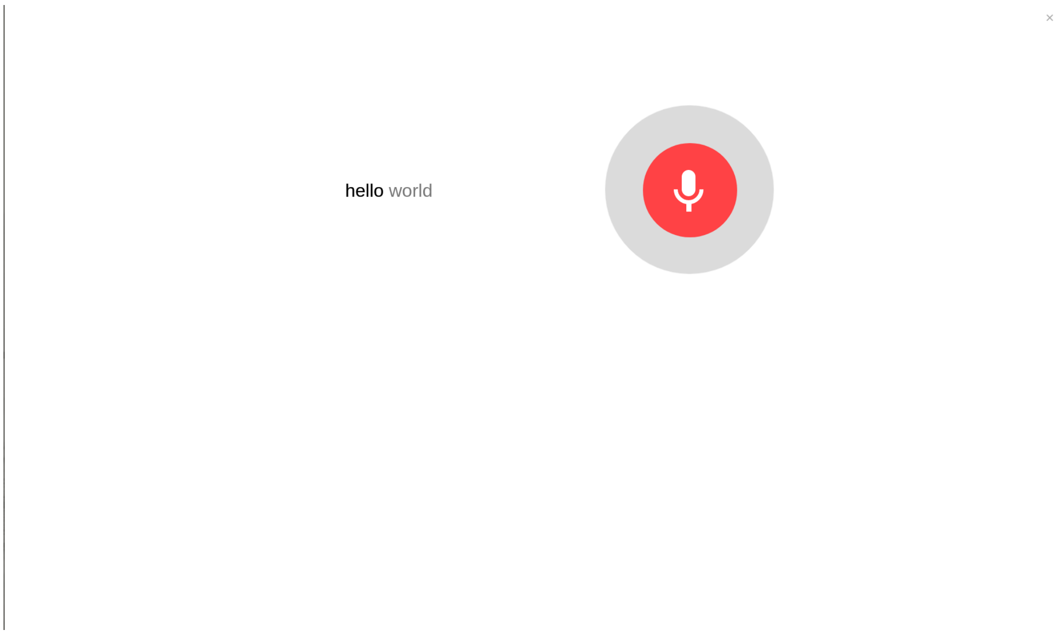


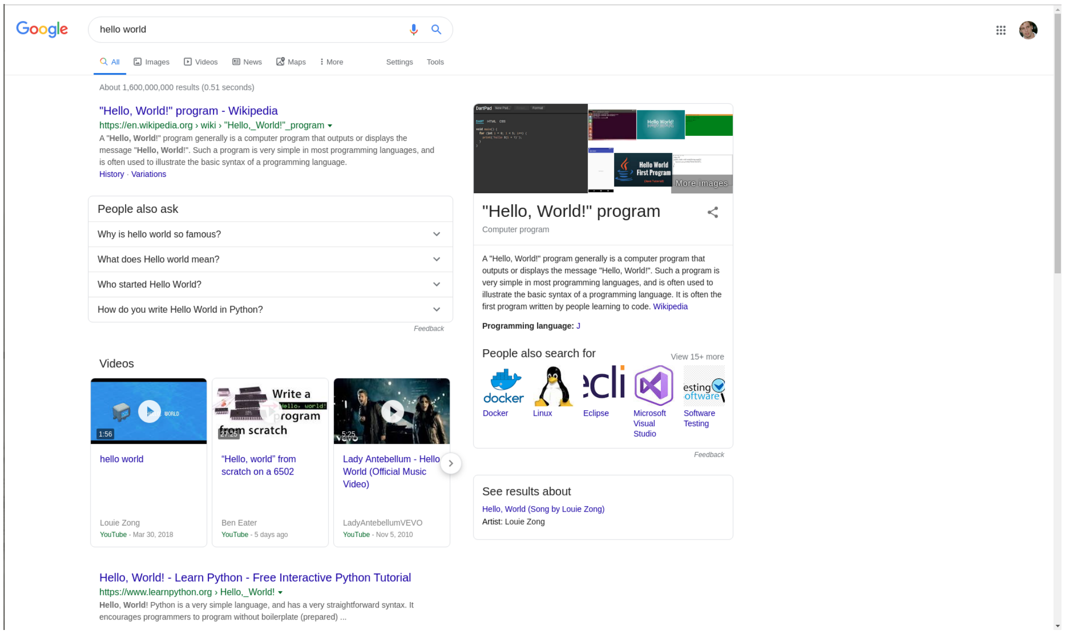
Figure 8.2: Google STT Query Input Feature



Certain characteristics of the Google homepage were motivational when constructing SerpUI. More specifically, the text entry box was included with a submission button, though this is the standard format across most major SEs. The ability to enter text with speech was also mimicked but with keyboard button presses that are independent of the mouse and its location. As future work, we would recommend further research that will explore possible solutions for related searches and proposed queries.

Upon submission the Google homepage would redirect to the SERP (Figure 8.3). For sighted users the density of the webpage is comfortable. In the corresponding figure (8.3) where a we input "hello world" as the search query, we are able to see lots of useful information; our query, the first result, the featured snippet (right column), related questions, videos and more. By condensing the information is an organized manner it is very easy to skim. Unfortunately that's where the barrier resides for the VI users, particularly the inability to 'glimpse' the search result. Often, the user wouldn't need to enter the webpage to know if the search is useful. This is a consequence of all the result information being synthesized as one object. All is left for the user to decide is whether to click or not to click... that is the question! But as vision degrades information is lost, perhaps due to lack of granularity, focus or other factors. As a result, the glimpse (total understanding of the usefulness of a search result), becomes more uncertain.

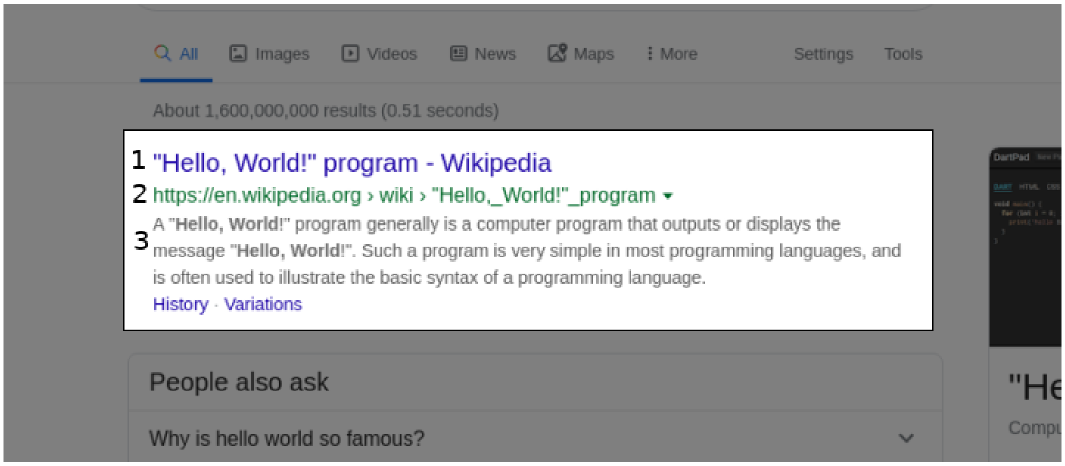
Figure 8.3: Google SERP



As mentioned before, SerpUI attempts to provide that total understanding for a search result by allowing the user to progress through important information at their own pace. Even more so, SerpUI tries to separate the pieces of information stacked up by Google so that each one sits on their own tile. Then the tiles which make up each search result are lined up horizontally. This helps users understand the result at their own pace. As shown in the design section, users can change between results by moving vertically, with the most relevant result at the top.

Since the columns are the constituents of a search result it is important that they are useful and predictable. The motivation for the headings of the columns root from the same ordering as on Google. Depicted in Figure 8.4, if a sighted user would read the page in decending order they would first read the title, then the display link, then the snippet. As a result the same ordering was assumed in SerpUI. The justification for this design decision is strictly to mimic the Google SERP since it is assumed that this interface is constantly optimized. Evaluation results show that this ordering may be problematic when implementing a tile-based interface. Similar breakdown analysis is evident in the literature where Yang, Hwang, and Schenkman attempt to create a customized SE interface for the Blind or Low Vision (BLV) community [7].

Figure 8.4: Google Search Result Breakdown



A feature that does not exist with a standard SE, or other customized solutions is the 'content' tile. Where users can access the site directly on the SERP. The motivation for this is to allow users to dynamically transition between search results in a responsive environment. With existing solutions the user is forced to either change tabs (introducing a new environment) or make use of the 'Back' button in the browser.

8.2 The Backend

The SERP Generation block is the prominent backend element primaily responsible for contacting an SE's API, along with structuring the data so it can be rendered easily. The reason for offloading this component from the client is to enhance the user experience by allowing for dedicated servers to do most of the 'heavy lifting'.

For this initial development of SerpUI the goal was to achieve a stable version that could be evaluated against other methods of web accessibility. As a result the lightweight server environment, *NodeJS*, was selected. Furthermore to direct traffic, the *Express* framework is sufficiently suitable. The server is responsible for accepting and responding to user page requests (GET and POST), along with API calls and file manipulations for generating the data files.

To generate raw search results, the *Google Cloud Services* offer a *Custom Search Engine* API that responds to query-based calls with a JSON file of the ten most relevant Google results. Unfortunately, the free API is limited to one hundred (100) requests per day. Though this limit seems reasonable, developers must be careful when testing their application so to not exceed the limit. Other cloud services were considered, such as the *Microsoft Azure Suite*, but were declined due to Google's significant market share [9]. Ultimately, this design decision is to avoid any result bias that may occur from the different search engines.

In order to maintain runtime and continuity of the main server script (app.js), the *NPM Forever Package* was used to make the application live.

8.3 The Frontend

The purpose of SerpUI is to act as a standard SE, being available universally across all major platforms and browsers. The user should not be restricted to a specific setup simply for accessing the same information with a different interface. The application is simply a method of interfacing with the user, providing the necessary sensory output and accepting control commands at high throughput. It is important to note that SerpUI is simply a method of accessing the exact same information as any standard search engine only with a different interface.

For best performance use the Google Chrome with a Windows 10 or Linux OS. Bluetooth cennectivity is required for JoyCon Controller usage. Such preference is a result of the limited testing environment and compatibility with the Gamepad API. Several MacOS distributions were found to be difficult to work with. More specifically, the computer either does not offer connectivity to the JoyCon, or if connected will not load the API in the browser. Unfortunately, the lack of flexibility for developers is common due to the closed nature of MacOS and iOS devices.

8.3.1 Homepage

The homepage interface is the landing-page of the application, therefore, it is important to notify the user that they have reached this environment. As a result, the browser will output "Homepage" to audio. The user can then follow the commands found in Table 7.1 for further interaction.

All TTS transcriptions are thanks to the *ResponsiveVoiceJS* API. In order to ensure that the user is aware of moments when they are being recorded, the background colour of the application changes, along with a tone indicating the start and end of recording. Three different tones from the C Major scale were selected to represent the three text field options; the first (C) indicating the start of recording, the third (E) indicating an empty query or a clear query request, and the fifth (G) indicating the end of recording. The C Major scale was chosen due to its pleasant and comforting human association. If the user is being recorded the background is blue, otherwise the application is idle and the background is black, shown in Figures 8.5 and 8.6 respectively.

Figure 8.5: SerpUI Homepage During Recording

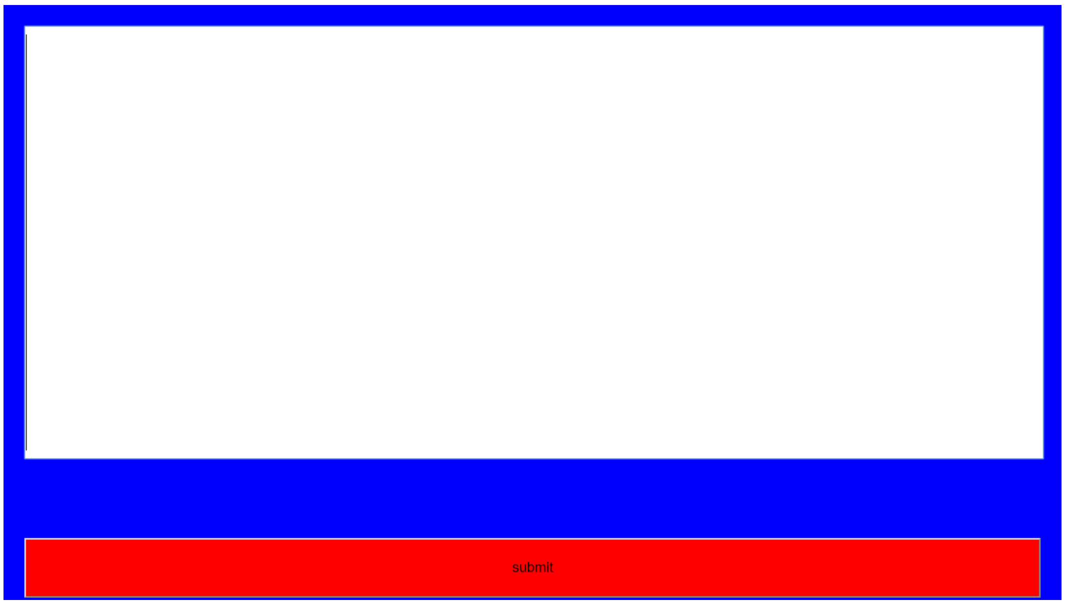
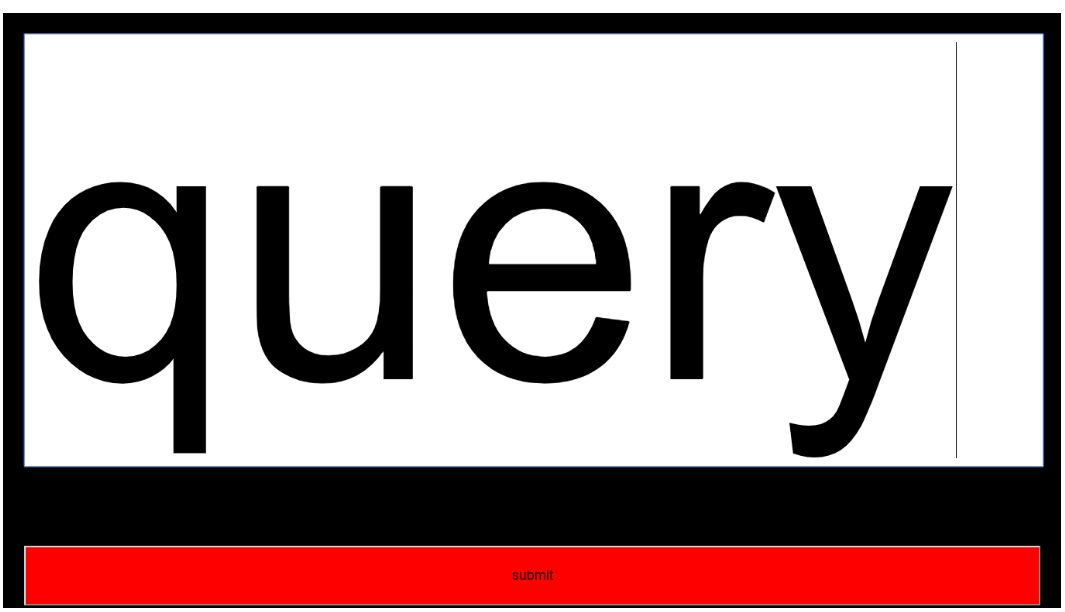


Figure 8.6: SerpUI Homepage after the user records the phrase ”query”



The user has full control of the interface solely with a "qwerty" keyboard but may choose to use to *JoyCon Switch Controller* for simpler maneuverability. In order to integrate the JoyCon, the browser must be compatible with the *Gamepad API* which can be found in the MDN Web Docs by Mozilla.

https://developer.mozilla.org/en-US/docs/Web/API/Gamepad_API

Along with keyboard typing, the user also has the option of dictating their query. To facilitate this interaction the *Google Cloud Services Speech* API was used. The user can speak as slow or fast as necessary during the recording time window. Once the user is comfortable with their dictation they can review the query letter-by-letter or hear it via playback (follow commands in 7.1). The Speech API has proved to be quite accurate over time with minor mistakes, that may arise due to user voice amplitude, false prediction, or noisy environments. Unfortunately, the *webkitSpeechRecognition* library used to support TTS functionality is highly experimental (as of May 2019) and is not supported by all browsers. For maximal performance use the Google Chrome browser.

Additional libraries include jQuery, Lodash, and RequireJS.

8.3.2 SerpUI

The SerpUI interface follows similar implementation for TTS transcription and JoyCon controls as described in Homepage (Section 8.3.1).

The map of available Tiles is a collection of Tile objects that the user can move between. There are no direct connections between the tiles (no pointers). As the user moves from one tile to another their coordinates change generating information requests for the corresponding object. This requires the program to track the user's spatial location while loading tile data in real-time.

Colour selection is a vital decision, especially in the field of Human-Computer Interaction (HCI) for VI users. The colour scheme found in both webpages is to create high contrast environments that mitigate ambiguity. Since the requirements are not overly specific about the levels of VI that users may possess, colours were chosen to be as distinct as possible (primary colours). Ideally, the application will provide personalization options such as; colour scheme, letter sizing, reading speed, connectivity to a refreshable braille display, etc.

In Figure 8.7 a QR code is found on every page. The motivation is to create a method for users to share their findings. As the user moves between unique tiles, QR codes will be automatically generated that represent their respective user-spatial location, specific to their current tile and current search query. As a result users can store and share specific pieces of information online.

Figure 8.7: Screen Captures of SerpUI

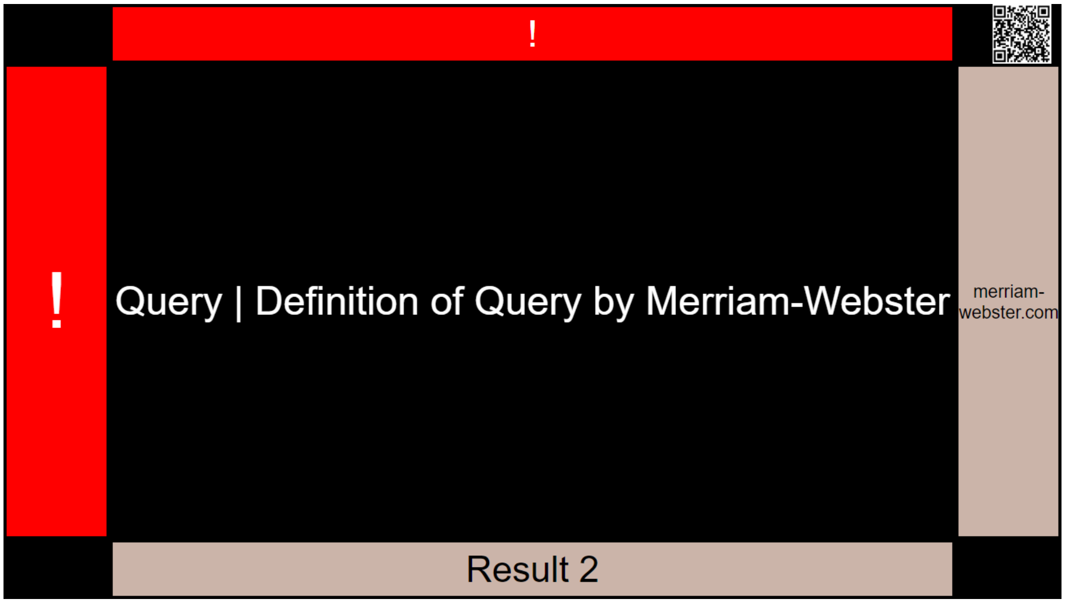


Figure 8.8: A Tile in the SERP with full user control

In order to maintain consistency a design decision was made that differs from the HLD. When a new result is selected (up or down) the new result row will reset to its first tile (left-most position). This forms a top-down approach for understanding the SERP results. When analyzing common SERPs each result is presented in a similar fashion, the common pattern is:

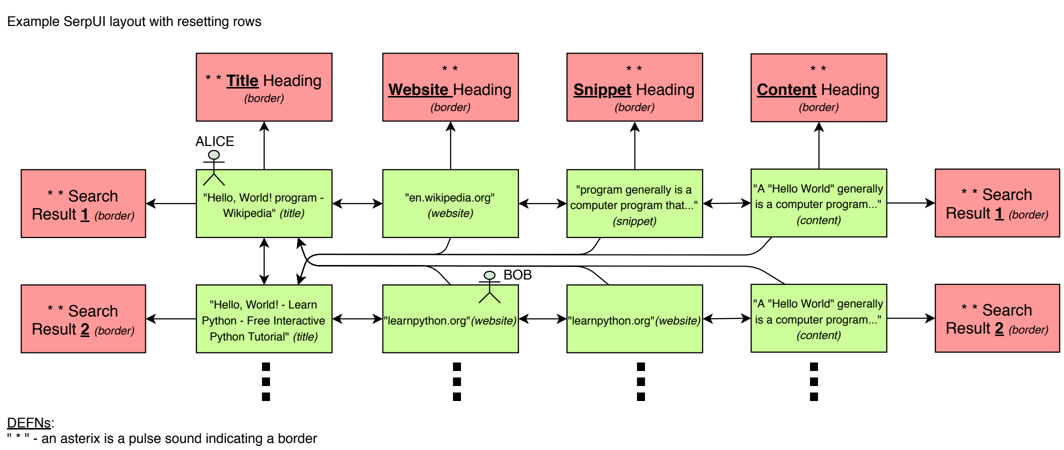
$$\text{Title} \rightarrow \text{Sitename (Display Link)} \rightarrow \text{Snippet} \Rightarrow \text{Content}$$

At its current state in development, SerpUI does not provide further interaction with the webpage itself. Right now users are only able to read the page in its entirety without pausing, or selecting a specific line of text. In the future this will be the main focus of development.

SerpUI simply isolates these information types 'physically' with coordinates (horizontal versus vertical motions). This concept of 'physical separation' in computers is necessary since it gives way to a modality that can be discussed by both visually enabled and disabled users. Furthermore, it resolves the case when the user moves down a row with no information below (present in Figure 7.6 in the 'Snippet' column), making the information types truly orthogonal and separate in their concerns.

This is exemplified in Figure 8.9, notice how moving vertically will reset Bob's horizontal position to the first column.

Figure 8.9: SerpUI with Resetting Row - "Hello World"



Additional libraries include jQuery, Lodash, RequireJS, and STRML-TextFit.

8.3.3 Changing the Starting Position

In an attempt to reduce the latency, the starting position has been altered to the snippet column, the third column of tiles (reference Figure 8.9). Now, the user will automatically go to the site's content rather than being bogged down by subsidiary information. By moving to the Left, the user can still learn about the source of this information. By moving Right, the user can access more information like text or video from the webpage. The application can also detect if a video is requested (ie. YouTube search result) in which case the video content is prioritized. This results in the video playing immediately, the effects of this can be evaluated.

The motivation for this change arose in an exchange while showcasing the product to family. Although they were sighted, it was noticeable that the title and display link were less interesting than the answer to their query. When drawing parallels to other PDAs, Siri and 'Hey Google' behave just as described by providing answers immediately after the question is asked, even if it is incorrect. Though this may seem counter-intuitive we like this approach. As the user, we typically know what type answer to expect. So in the case that the information falls outside our range of answers, we check the site for credibility and/or move on top the next result. If there is no information found on the page then the snippet will read "Page Not Found". In which case they can still move over to the site name and title to uncover the source data.

Change Reverted: In a mock evaluation with a blindfolded participant it was indicated that the starting at an ambiguous position is confusing. As a result the change was reverted to eliminate this kind of confusion and remove ambiguity during the evaluation.

Chapter 9

Additional Benefactors

Along with the targeted demographic being BLV, there are other groups that are potential users of this application. The elderly may benefit from using SerpUI as it allows for the slow progression of information, as opposed to websites with headers, banners, and ads. The major benefit that appeals to users without severe VI is the ability to uncover the SERP at their own rate while focusing on small pieces of information at a time. The text being displayed would ideally be customizable for cases with degrading vision to allow for user flexibility.

Chapter 10

Preliminary Evaluation of SerpUI

The first presentation for a potential user was with Participant *Ti* (to ensure anonymity), a high school student with visual impairment (no concrete information on his condition). SerpUI was in early-stage development and was simply capable of showcasing the interface without the homepage. As a result, the meeting was centered around the *Ti*'s ability to conceptualize the UI. Meaning that he was able to understand what the tiles mean and how to use them.

Results from that meeting were positive since *Ti* was quickly able to start navigating. The significance of this result is weak since only one person participated in the study, yet there may be positive potential for the UI.

Ti also mentioned that the colour scheme is difficult to differentiate which resulted in the selection of strongly contrasting colours for the central tile.

In order to prove the effectiveness of SerpUI an evaluation was developed to show the statistical significance of faster information access times. When comparing search engines aside from SerpUI, their quality can be attributed to a collection of factors. Most notable being latency (time to find desired information), SE category (images, scholar, news...), and familiarity.

Chapter 11

Heuristic Evaluation

The evaluation outlined below attempts to quantify a set of dependent variables in order to assess the usefulness of the SerpUI interface. As background knowledge, dependent variables are "human behaviours that can be measured" [1]. This is because the value of the variable is *dependent* on the human user.

Objective: to attain both numerical and heuristic results about the usability of the SerpUI interface.

This evaluation intends to assess two dependent variables; *Task Completion Time*, and *Error Rate*.

Table 11.1: Independent Variables Being Evaluated

Variable Name	Units	Value Space	Explanation (what does the variable quantify?)	Indicators
Task Completion Time	seconds	integers	The time between the query formulation and the retrieval of answer	time
Error Rate	errors per task	decimals	The number of errors made by the user in a single task. This quantity is inversely Proportional to Learning Rate	Misclicks, incorrect button usage, forgetting functionality

11.1 Daily Activities Description

The evaluation is broken down into several sections outlined below.
Introduction
To start the day we will explain our daily activities and warm up with some ice breakers. Participants and their guardians will have an opportunity to ask questions regarding the proceedings of the day.

Entry Survey
This short survey of eight (8) questions is used to collect basic information about the participant.

At this point we will begin recording using a single webcam and microphone. This content is used to review the evaluation with others in the project and as analysis for the quality of the interface.

Warm Up
The participants will begin using their computer to get in the headspace of using assistive devices. This section involves a simple task retrieval.

Focus Group
In this section we will be talking as a group, where the guardians can participate as well. The idea is to get a better understanding of how the participants use technology.

Using the Interfaces
This is where we will use both their own devices and the new device developed for assessment. Participants will be given short information retrieval tasks that they can complete in a couple of minutes.

Exit Survey
The final survey, six (6) questions, is a way of summarizing the experience and collect heuristic information about the interface.

Currently there is no time restriction on the total evaluation time, although the researcher should consider the participant's fatigue allowing breaks if necessary. The sections indicating "Warm Up" require the participant to use the corresponding interface for a short while to gain familiarity.

Alongside the quantitative portion of the evaluation, where the subject uses SerpUI and their own device, the researcher will be required to track their progress. A camera will be recording the participant along with a running clock to indicate timing intervals for task completion. More is explained below.

11.2 Apparatus

- SerpUI Computer
  - Connected to Internet
    - Access to SerpUI
  - Peripherals
    - Keyboard
    - Mouse
    - Speakers
    - Microphone
    - Bluetooth
  - Computer Charger
- Participants preferred method of accessing search engines **(they must bring this with them)**
  - Laptop with their preferred Screen Reader installed
- Camera/Webcam with Tripods (x2)
- Microphone
- Work Station + Recording Station
  - Desk
  - Chair
  - Adequate Lighting
- Lab Computer (Recording Station)
  - Recording Software: Open Broadcaster Software (OBS)
  - Computer Charger

11.3 Evaluation Setup

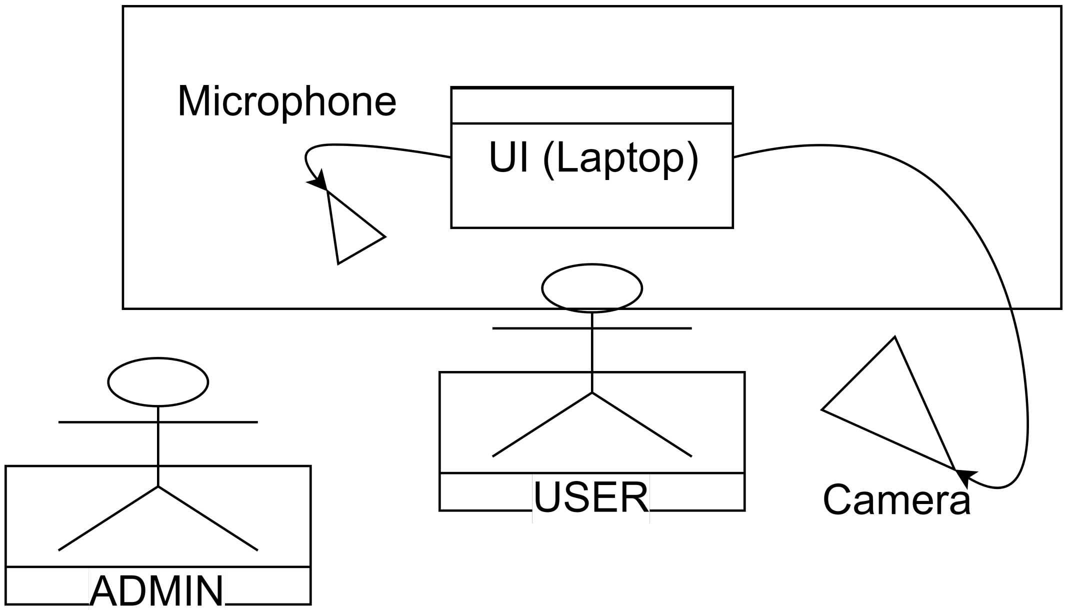
The room used to host the evaluation was large enough to host a focus group arranged in a circle. The setup for both the user workstation and the recording station included a desk, chair, and laptop connected to a charger (to avoid interruptions in the evaluation).

The recording webcam was placed over the shoulder with focus for hand movements. Originally the setup included an additional camera located with a view of the participant's face and body, in order to record expressions and reactions, but was removed for privacy concerns. During the evaluation, a single camera was placed over the participant's shoulder with view of the screen, keyboard, and hands. A microphone was placed near the laptop in a location that does not interfere with the interaction. Both recording devices were connected to the laptop in the recording station. The program used for recording the video and audio content is Open Broadcaster Software (OBS), version 23.1.0, 64-bit, Windows OS.

The room was silent to eliminating any false recordings when using SerpUI and to allow for concentration. The researcher was out of view from the cameras, although they can still be heard in the audio. Remember that the purpose of introducing an invigilating researcher was to support the participant and help with the evaluation setup. The researcher was also responsible for monitoring the recording station to ensure that the user does not leave the frame.

Shown in Figure 11.1 is a theoretical setup of the evaluation environment indicating the approximate location of the recording equipment. Both the microphone and camera were connected to the Laptop on the workstation and recorded the events using Open Broadcaster Software (OBS).

Figure 11.1: Evaluation Setup



11.4 Participants

The desired demographic is relatively specific when compared to the general public, therefore, the number of participants was small. The first round of evaluations took place on Monday Sept. 16, 2019, with two children ages 9 and 6. The participants were selected randomly according to availability and connection to our research team. Their vision was quite good and could use a screen with normal font size but required to be closer to the monitor.

11.5 Evaluation Hypothesis

When evaluating the task completion time of fact retrieval we hypothesize that SerpUI will yield slower results when compared to the participant's preferred method of accessibility. This is conjecture is based on two reasons, the first being the capabilities of larger corporations like Apple and Google to produce quick and accurate results through elements like Google's "Featured Snippet". And secondly, the participants will likely be somewhat proficient with their device and navigate more confidently.

If considering the Learning Rate which is deduced from the Error Rate, we predicted that SerpUI will show promising results. This should be observed when participants are asked which interface they prefer. As well as when error rates decline rapidly due to SerpUI's oversimplified breakdown of user possibilities. We predict that by the fourth or fifth retrieval task the Error Rate will be negligible (no more than one mistake per task). The justification for such preference is due to the small size of the user-space and consistency with affordances and signifiers.

As for task completion time of video retrieval specifically with YouTube, we project that SerpUI will be faster than common methods since the videos are embedded in the interface allowing for efficient sampling of content.

11.6 Ice Breakers

Having something release the tension at the beginning of an experiment can really relax the participants and make for a smooth experience.

A potential idea for an ice breaker that is tailored to a small group of very young participants is proposed in Appendix A.1.

11.7 Entry Survey

*** RECORDING STARTS NOW ***

A brief qualitative survey will be held. It is designed to produce an understanding of the participants' level of competency prior to completing the practical portion.

The survey should be digitized so the participants can access and submit the survey using their own accessibility methods. Recall that graphs and charts are poor formats for accessibility and that lists, radio buttons, or accessible drop-down menus are ideal. The researcher may need to assist participants if a question arises.

The survey questions can be found in the Appendix A.2.

11.8 Warm Up

This section of the evaluation required the participants to start using their devices and get in the mind of internet usage. At this time the participants had just used their preferred method of accessibility that they were instructed to bring along with them. The researcher addressed the group and asked each participant to retrieve a cast-list of their favourite movie. Participants were then required to present their findings to the group by introducing the movie title, plot summary, and favourite characters.

The purpose of this interactive game is to prime the participants for the Focus Group, since they would have just completed a common information retrieval task with a standard SE.

Task:

- What is the name of your favourite movie? Your task is to find the following:
  - A cast list of all the actors and actresses in the movie
  - The name of your favourite character, and the actor who played them
  - One other movie that the actor played in

When they were finished we had presented it to each other.

11.9 Focus Group

To collect data about the difficulties faced online by the participants a set of questions were discussed as a group. The goal of the focus group is to initiate a discussion addressing difficulties online. The reason for a group setting rather than an individual is two-fold.

The first relating to the age of the participants, as it is estimated that most will be under the age of 18. As a result, a group setting helped each individual be more comfortable through their peers. The reason for a young pool of participants is due to the university's affiliation with pediatric medicine. And the second was to establish a group mentality where participants built off of each other's ideas. More specifically, by allowing the participants to interact the conversation had developed to more collective issues faced by the community.

To initiate the discussion and to maintain a focus for the conversation regarding Search Engines, an initial question was asked by the moderator;

1) What are some things that you {browse/use} the internet for?

Question 1 was meant to draw examples of use-cases for the internet. Since it is assumed that all participants had used the internet prior, this question also allowed every participant to contribute to the conversation helping loosen the tension in the room. Potential answers had indicated specific site names or content types (ie. articles, videos, blogs...) that the participants access frequently. As a follow up question that alludes to accessibility, the moderator would ask;

2) What do you find difficult when using the internet? **OR** *What is hard about the internet?*

Question 2 had sparked conversation that most participants can relate to and would yield answers that may be common by all participants. It was hypothesized that the screen readers will be more heavily criticized than the websites themselves.

This focus group had lasted no less than 10 minutes as the conversation needed time to build. There is no limit to the length of the conversation, though it is up to the moderator's discretion of when the group had lost interest. The moderator was instructed to avoid giving examples of their own to not influence the answers of the group.

A set of questions to help motivate conversation can be found below in Appendix A.3.

11.10 Quantitative Section - Using the Interfaces

Opening speech by researcher: "This part of our day is an online scavenger hunt! During your turn you will either use your own device or *the device we made* (do not provide the name) to answer a couple of short questions. You can use any website on the internet that you think will help, unless you are using the new device that just uses one website. When you think you have the right answer we can help you note it down and you can start the next question. When you finish all the questions you can move on to the final stage!"

Note to researcher: The important concepts to remember for this section are Latency and Learning Rate.

For Task Completion Time, the researcher ensured that the cameras were running and that it was possible to track timing intervals by viewing the screen and the time simultaneously. For Error Rate which was slightly more abstract, wave your hand in front of the camera noticeably to signify that the participant seems comfortable with the usage of the interface. This had provided a rough time estimate for learning rate. The researcher understood that it was possible that they may never wave at the camera for certain participants.

Below is a pool of question available to the researcher that are sampled for the subjects. Each participant was responsible for completing a total of eight (8) retrieval tasks. The distribution of the questions had been randomized for each participant.

Stage 1 - Existing Technology (using personal device):
2 Fact Retrieval **AND** 1 Video Retrieval

Stage 2 - New Interface using Keyboard:
2 Fact Retrieval **AND** 1 Video Retrieval

Stage 3 - New Interface using JoyCon:
2 Fact Retrieval

Fact Retrieval Tasks:
Theme: THE SOLAR SYSTEM

The reason for using this theme was to ensure that the terminology being used and the content being covered is understandable by all ages. It is assumed that the participant have heard of "The Solar System" and can recall the names of the planets, this proved to be a poor assumption for young children, particularly of the ages involved (under 10 years old).
Question Structure for Fact Retrieval:

1. How far away is $< Object >$ from Earth?
   (a) TEXT ENTRY
      i. Rationale: This task is timed and will be compared to other timed tasks
      ii. Question Type: TIMED FACT RETRIEVAL

Options for Objects: (distances included - HIDDEN FROM PARTICIPANTS!)

- The Sun
  - 149.6 million kilometers
- Planet Mercury

  - 77 million kilometers
- Planet Venus
  - 40 million kilometers
- Planet Mars
  - 54.6 million kilometers
- Planet Jupiter
  - 588 million kilometers
- Planet Saturn
  - 1.2 billion kilometers
- Planet Uranus
  - 2.6 billion kilometers
- Planet Neptune
  - 4.4 billion kilometers

Video Retrieval Tasks:
Theme: Youtube Music Videos

The reason for using this theme was based on the capabilities of SerpUI being limited to YouTube content. Additionally, it was assumed that the participants were familiar with the YouTube platform and have been exposed to mainstream North American pop culture. The pool of tasks below includes more questions than necessary which allowed the participants to skip songs that they do not know. The importance of this section was to retrieve music that the participant enjoys. This has helped the tasks seem less like a chore.

It was advised that the researcher is alongside the participant for this section to validate their success. The pool of songs was based on a list of the "10 most viewed YouTube videos of all time" [57].

Question Structure for Video Retrieval:

1. Find the YouTube Music Video for the song called < *Song Title* > written by < *Artist Name* >?
   (a) TEXT ENTRY

i. Rationale: This task is timed and will be compared to other timed tasks
ii. Question Type: TIMED VIDEO RETRIEVAL

Options for Artist Name and Song Titles: (view counts included)

- Artist Name: Luis Fonsi, and Song Title: Despacito ft Daddy Yankee
  - 6.41 billion views
- Artist Name: Ede Sheeran, and Song Title: Shape of You
  - 4.37 billion views
- Artist Name: Wiz Khalifa, and Song Title: See You Again ft. Charlie Puth
  - 4.22 billion views
- Artist Name: Masha and the Bear, and Song Title: Recipe for disaster
  - 4.11 billion views
- Artist Name: Mark Ronson, and Song Title: Uptown Funk ft. Bruno Mars
  - 3.64 billion views
- Artist Name: PSY, and Song Title: Gangnam Style
  - 3.41 billion views
- Artist Name: Pinkfong, and Song Title: Baby Shark Dance
  - 3.32 billion views
- Artist Name: Justin Bieber, and Song Title: Sorry
  - 3.18 billion views
- Artist Name: Maroon 5, and Song Title: Sugar
  - 3.02 billion views
- Artist Name: Katy Perry, and Song Title: Roar
  - 2.89 billion views

11.11 Qualitative Survey #2 - Post

To summarize the evaluation a set of Mean Opinion Scores and Multiple Choice questions were asked to gauge a level of satisfaction and usability. The researcher was also able to take notes of the heuristic characteristics of the participant such as their interest level and facial expressions that may have been outstanding. It is important to remember that these added notes are simply factors to improve the evaluation and are weak scientific arguments.

The survey questions can be found in the Appendix A.4.

Chapter 12

Evaluation Results

In the priminary evaluation (10) the purpose was to showcase the usability of the interface in a way that does not focus on the actual information.

12.1 Critique to Moderator

A notable result from the evaluation is not directed to the product but to the method of evaluation. When showcasing a device to young, untrained users, the evaluation needs to be an experience in itself. It must be enjoyable and riddled with hidden mysteries that they discover along the way. A common occurrence was asking questions we already knew the answer for, to keep the train-of-thought progressing and provide a basis for them to expand on.

Several mistakes we made as moderators include; speaking too formally, using big words, and not providing enough examples. To improve our efforts we would interact with children leading up to the event (contacting family, or visiting schools). In creating the evaluation we struggled knowing what activities to they do for fun, and how much they interact with computers. <u>If further research is to be conducted for this project, then the researchers must spend time with the BLV community more frequently.</u>

Don't forget to make use of other people in the room. The staff and guardians that are sitting in there with you are also interested in trying new technology. Provide tasks for them to do, unless they influence the results. If things are being recorded their effects can be further analyzed. This is a component that we were unprepared for. It was challenging enough to entertain the participants and direct conversation that we did not think of reaching out.

12.2 Heuristic Results

The most obvious issue was the distance between the “Title” column and the content, which was too far. The most popular tiles amongst the participants were these two, generally skipping over the ‘jargon’ in between. The proficient of the two participants would speed between results seemingly enjoying the responsiveness of the application. Once they understood the structure of the SERP they seemed comfortable when navigating. The proposed method for restructuring columns is to the following order:

$$\text{Title} \rightarrow \text{Content} \rightarrow \text{Snippet} \rightarrow \text{Display Link}$$

This new setup is a method for placing the most popular tiles side-by-side. This is more obvious if considering YouTube, since the video is all that matters. When analyzing the YouTube UI in retrospect, it does exactly that. The moment a user lands on the content page, the video plays.

Interestingly with older participants the order was not an issue. On the contrary, an older participant is quoted saying that the order is logical. Further implmentation should consider customization that allow for reordering of columns.
It’s worth noting that when browsing farther into less relevant results it seemed unlikely that they were intaking the content. This gives rise to a potential improvement to the application where more information could be packed into a single tile. For example, by adding a thumbnail to the background of the tile, the user would have understood the output of this search result faster.

Another key visual component was the recognition of specific markers. Since the new interface completely replaces the visual presentation there was not enough indication that they reached a familiar site. When presented with fact retrieval tasks we specifically asked for the Wikipedia (Wiki) page of a familiar topic to the child. Since M indicated that they had a science project on the Western Prairie Orchid, we asked them to retrieve the Wiki page for this plant. But since the Wiki page was titled under the taxonomic name (Platanthera Praeclara) they clicked right past it. Unfortunately, we did not get a chance to try the same query with an existing method, it was assumed that the participant would choose the most relevant result (Wiki).

It did not take long to realize that the STT functionality was useful. One of the participants made note of this and was further emphasized by the mother. Specifically to remove the need for a keyboard, making it easier to input text.

On the downside, the STT encountered lots of false positives. Perhaps the two button solution for the invocation of STT is too complex and can be reduced to one with automatic timeouts, or holding periods (only recording when the user is holding).

Other button functions that can be corrected is the volume control that should apply to video volume as well. The inability to control the video (ie. pause, play, fast forward...) hinders the experience and forces the user to resort a mouse.

Another point of emphasis is that the target market was loosely defined. Originally, it was generalized to include the whole community. But through evaluation with young users who have little exposure to computer the requirements should be reassessed. Additionally, the young participants were often inability to understand the structure of the SERP. Furthemore, it was hard for them to remember the need to turn the STT on or off. At points they would just speak to the screen, expecting a response. Other times they would forget to stop the STT and would keep recording. This made for a very messy query for the SE. Even so, the first search result was either relevant or exact.

The controller was an important feature. Although we only had a short (unrecorded) chance to present the functionality using the keyboard, the JoyCon controller seemed entertaining enough. It fit well in their hands and looked comfortable. One participant indicated they were left-handed but was comfortable with right hand usage. Most participants initially rotate the controller in a way thats held with two hands, they said it was due to past experience with the JoyCon and with other games. Some participants noted that they "already knew" the functionality of the home button. After using the JoyCon controller for a total of 8 retrieval task participant M indicated that, *"its hard to use the Nintendo Switch Controller"*. This reaction came as a surprise since they seemed proficient while using the controller and required little explanation. Justification for this could be the layout of command which could be improved to make the controller usage more intuitive.

The older participant enjoyed the row-resetting feature and the placement of buttons. A significant note from the older participant is the fact that they, "dont have to actually use [their] eyes to focus on things". They would use this product for research of the web while pairing usage with a tablet for note-taking. The older particiant noted their lack of computer usage as well, often interacting with tablets. Future developments should consider the dangers of a non-reversible action like the 'Home' button without the ability to retrieve the SERP.

Generic notes to summarize this section can be found in Appendix A.5.

12.3 Numerical Results

This tables provides a list of all the retrieval tasks given to each participant along with the numerical results that were observed. Due to the poor setup, all the tasks were done on the SerpUI interface with no opportunity for proper comparison. Comments on the issues with the evaluation and proposed changes can be found in section 12.

It is worth noting that there are not enough participants to draw strong numerical results. Task completion times begin when the user starts dictating their query, and end when the SerpUI screen reader announces the right result.

A long standing issue with the interface is the inability to retrieve the 'Featured Snippet' from Google or Bing that attempts to answer the query immediately. Task competition times are expected to drop dramatically for info based queries once integrated.

Table 12.1: Evaluation Tasks for Each Participant

Participant [name]	Task Number [int]	UI	Task Type [info/video]	Query [text]
M	1	SerpUI	video	"photograph Ed Sheeran"
M	2	SerpUI	video	"perfect" (song by Ed Sheeran)
M	3	SerpUI	info	"wikipedia western prairie orchid"
M	4	SerpUI	video	"sorry by Justin Beiber"
M	5	SerpUI	info	"how far away the Moon is"
M	6	SerpUI	info	"how far is the Sun"

M	7	SerpUI	info	"how many people are in Canada"
M	8	SerpUI	info	"how many people are on the world"
Ie	1	SerpUI	video	"dancing with a stranger"
Ie	2	SerpUI	video	"Minecraft 2 yeah YouTube"
Ie	3	SerpUI	video	"Minecraft YouTube how do you stop recording"
T	1	SerpUI	info	"What is the distance between Mars and Earth"
T	2	SerpUI	info	"How far is Jupiter to the Earth"
T	3	SerpUI	info	"the distance of Uranus from Earth"
T	4	SerpUI	video	"Uptown funk music video"
T	5	SerpUI	video	"Gangam style music video"
T	6	SerpUI	video	"Miami heat Harlem shake music video"
T (with JoyCon)	7	SerpUI	info	"How far is Mercury from Earth"
T (with JoyCon)	8	SerpUI	info	"how far is Venus from Earth"
T (with JoyCon)	9	SerpUI	info	"what is the distance between Neptune and Earth"
T (with JoyCon)	10	SerpUI	info	"how far is voyager one to earth"

T (with JoyCon)	11	SerpUI	video	"music video of sorry by Justin Bieber"
T (with JoyCon)	12	SerpUI	video	"not alike music video by Eminem"
T (with JoyCon)	13	SerpUI	video	"NF music video outcast"
T (with JoyCon)	14	SerpUI	video	"Shape of you music video Ed Sheeran"
T (with JoyCon)	15	SerpUI	video	"what is the difference between the X and the Y chromosome"

Table 12.2: Task Results by Participant

Participant [name]	Task Number [int]	Task Completion Time [sec] (Result Number)	Number of Errors [int]	Correct Result [Yes/No]	Required Help [Yes/No]
M	1	69 (1)	0	Yes	Yes
M	2	16 (1)	0	Yes	No
M	3	42 (1)	2 (missed answer)	No	No
M	4	47 (3)	0	Yes	No
M	5	93 (1)	Participant is distracted with others in the room	Yes	Yes
M	6	-	1 (missed result) + stopped exploring	No answer found	No
M	7	21 (1)	0	Yes	No
M	8	25 (1)	2 (missed answer)	Yes	No
Ie	1	115 (1)	3 (false positives STT)	Yes	Yes (Lots)
Ie	2	63 (1)	2 (false positives STT)	-	Yes
Ie	3	-	9 (false positives STT) + stopped exploring	-	Yes

T	1	127 (2)	?	Yes	Yes (recalling button functions)
T	2	63 (2)	0	Yes	No
T	3	72 (2)	0	Yes	No
T	4	14 (1)	0	Yes	No
T	5	13 (1)	0	Yes	No
T	6	15 (1)	0	Yes	No
T (with JoyCon)	7	44 (1)	3	Yes	Yes (button clarification)
T (with JoyCon)	8	131 (2)	1	Yes	No
T (with JoyCon)	9	59 (1)	4	Yes	No
T (with JoyCon)	10	90 (2)	0	Yes	Yes (mediator suggested second result)
T (with JoyCon)	11	13 (1)	0	Yes	No
T (with JoyCon)	12	17 (1)	0	Yes	No
T (with JoyCon)	13	16 (1)	1	Yes	No
T (with JoyCon)	14	16 (1)	1	Yes	No
T (with JoyCon)	15	97 (2)	0	Yes	No

Chapter 13

Conclusion

As familiarity settles in for the lightweight structure of the application, SerpUI's users would become proficient with the interface and navigate more quickly. The UI minimizes the number of user possibilities at a given moment, *the user-space*, having the space both defined and significantly reduced. In order to accomplish this reduction in complexity, a simple 5-tile approach is used. The central tile (current tile) includes content from the user's current location, while the four surrounding tiles (up, down, left, and right) indicate the available navigational options. It is important to note that the functionality of the four navigational tiles does not change, only the contents it uncovers. The reduction in commands is to make the application easier to learn [16][28], and allow the user to work online with confidence since they know what to expect as new commands are requested. The novelty with this interface is that it does not change the information found on the SERP, but simply represents it in a new format. The process of gathering data is through a request to the Google Custom Search Engine API along with the user query. The results data is then represented with orthogonality such that the detail of the result (title, display link, snippet, and content) are explored by moving horizontally (left and right). While the different results (one to ten), are found by moving vertically (up and down). The intention is to provide a physical separation of concerns.

Two evaluation were conducted; one focused on heuristics, and another on numerical timing results. After the two tests the interface was evaluated as incomplete, but has potential. Older participants seemed to favour the separation of concerns especially with degrading VI. But the younger participants who's vision was still quite good were easily overwhelmed by the number of commands. Additionally, the signifiers indicating which button does what were unclear, more so in the Homepage. Once participants passed into the SERP their interaction gained fluidity.

The application is also available with two methods of control; the keyboard, and Nintendo JoyCon controller (right only). This design decision is meant to simply the concern of the user since every function in the application can be mapped to the set of ten commands described in Table 7.3. A Help function will ideally be developed in the future that will help the user if the commands are forgotten. At its core, the user can quickly reach every point in the SERP with only four buttons! Furthermore, these buttons are navigational and are recalled from natural intuition once familiarized. Young participants that have little to no exposure with computers struggled in memorizing these commands, while also had difficulty building a conceptual model of the interface. This issue diminished when observed older participants.

Chapter 14

Future Work

The SerpUI application in its current version is mainly an example of a novel web interface for VI users. As a result may options, features, and expansions were held back to achieve the required functionality.

Do same evaluation with similar kids using VO, we hypothesize that the overwhelming user-space in the VO application will result in much poorer results than observed in section 12.3. The VO application, along with other screen reader provide more functionality and flexibility with other programs but require the user-space to expand to a size that is far too ambition for such young users to comprehend.

As future work, several additions are planned including access to; search history (The Trail [12]), the different search domains (ie. images, videos, news...), relevant common queries, and QR code generation for sharing the user's cyberspatial location (read on for more). Furthermore, the application should extend to allow any site to be accessed with a 5-tile interface. This can be preempted by providing an API that converts a site to be W3C compliant [5]. Finally, the tool will be developed so it can be integrated with a refreshable braille display. By providing both auditory and tactile outputs the user has the flexibility of chosing their desired method of accessibility and discreetness, without sacrificing literacy.

This idea of single webpage location (shared by QR codes) can even be taken a step further by numbering the finite number of tiles for a single page. This gives way for sharing exact locations of information. This concept is not limited to browsing SERP results as it is a way of referencing exact snippets of the web. Since it is difficult for VI users to follow or identify a specific location in a webpage, indicated by teachers using Google Classroom (GC) for presenting slides. This was observed by teachers in the York Region District School

Board (YRDSB) and uncovered to us in the volunteering visits (see section 15).

As a result from the school visits and volunteering discussed in section 15, the GC application seemed important to integrate. By the number of teachers that used the GC platform it would be extremely beneficial if an interface was developed specifically to satisfy the needs of VI users in the classroom. Perhaps the SerpUI 5-tile approach could be a basis for developing such an interface.

An interesting development for accessing of random webpages is to re-purpose Apple's Rotor feature. When browsing the web, the Rotor has a finite number of heading types, aligning with the core principals of SerpUI. The most significant improvement is the reduction of key commands. So in order to navigate the Rotor when implemented with SerpUI, the user only needs the 5-tiles.

Chapter 15

Volunteering

15.1 Preempt

It is worth noting that the volunteering described below occurred after the development of the application. If the project is attempted again it is highly recommended that these connections with the target demographic be established before committing to a design. Notes on future changes and justification of design principles are mentioned below in *ITALICS*.

15.2 Summary of visit to the W. Ross MacDonald School for the Blind

Date: May 7th 2019,
Date: May 15th 2019

Day Structure:

- Arrival - 9:30
- Meeting with Vice Principal
- Tour of the school
- Dropped in with classes grades 6 - 12
- Toured hallways and main areas
- Meeting with Assistive Devices Specialist
- Observing the library
- Wrap-Up Meeting with VP

Kids were encouraged to use their preferred method of accessibility. These methods include the Perkins braille typewriters with paper, computer tools like VoiceOver and Jaws (which could be accessed by sound, and braille readers like the BrailleNote).

Notes on development of Physical World Navigation (PWN) products:
Hallways and main areas are designed for VI in PWN. Most areas included a tall metal railing that guides students by brushing their hands as they walk along. Hallway intersections are designated with lighter coloured floors, and bright lights. In certain areas the floor changes from laminate to hardwood to indicate intersections via sound. Students also have indicators on the walls that act as landmarks, orienting the student in direct lines towards specific areas. A student would find the marker corresponding to their assigned seat and would know to walk in a perpendicular line from the wall.

Notes from meeting with Assistive Devices Specialist

- Showcased an array of refreshable braille readers.
  - *Ideas of SerpUI being integrated with this device*
- Canute Multiline Braille displays
- BrailleNote Touch - Very Expensive!
  - *Motivation for an inexpensive solution*
- Apple has best accessibility options
  - *Important: The Rotor (VoiceOver feature) was further explored. The layout of the Rotor draws parallels with SerpUI without prior influence*
  - all based on keystrokes
  - Apple has accessibility for long time
  - Microsoft has poor accessibility
    - This point was a surprise and requires further research
- Siri voice is desired over JAWS
- ASCII over everything!
  - *This concept was later reiterated with others, particularly to the use of GIF images*
  - start with notepad → convert to other formats after

- Audio dictation fast but Braille is literacy
- SpeakUp
- Braille is important!
  - ***This is a recurring theme by all professionals and Braille users***
  - its a form of literacy
- PDF is problematic (can often be unreadable to Screen Reader)
- Much data online is inaccessible
  - ***This is a recurring theme by all professionals and Braille users****. Particularly images and videos*
  - no alt text
  - GUI based
- Succession of Elementary to High School = 100%
  - We dont let them fail - quote from VP
  - *Shows potential for the commercialization of this project since a slight appeal by the student body might motivate W Ross and similar school to adopt the app.*
- What would be important?
  - improved web readers
  - better online accessibility

Library:

- Kids hanging out
- Working on their own devices
- Students browsing for books
  - *This could be an application of SerpUI*
  - Showing interest in standard literature like: Mockingbird, Percy Jackson
- Books are rare and large

  - *This could be an application of SerpUI - (Nov 2019: McMaster Computer Science Capstone team working on this development)*
  - A single handheld book, when accessed in braille is translated to a collection of several 'oversized' books, since braille is significantly larger than 12pt font.

Meeting with Vice Principal (VP)

In the final meeting with the VP we simply discussed the daily events and plans for future visits.

The teachers, Educational Assistant (EA) and staff were upbeat, driving lots of energy when interacting with myself or the children. The staff have to be patient and allow the students to explore for themselves.

This attitude justifies the focus for reducing the learning curve. Directly appealing to the students.

Notes on development of PWN products:
With regards to maneuverability, the staff may have to assist their student with walking, navigating, etc. In addition, the school's curriculum is committed to instructing students on how to use canes, dogs, and other mobility tools necessary.

It is understandable that families would want their children to attend W. Ross even if it requires relocation from their hometown and public schooling. It was mentioned by the VP that many public schools may not have the infrastructure to provide the same level and support for students, ultimately making it easier to attend specialized schools.

Many students only attend W. Ross temporarily until they develop the adequate social and technical skills necessary in the public school system. It was noted several times by an array of faculty that once the student accepts their blindness and starts to work on overcoming their difficulties, then their biggest positive change occurs.

Ideas of generalizing SerpUI to replace multiple tools (not only SE) to assist the VI community long-term.

Sitting in on Classes:

Classes observed are technology and drama. In drama class there are students learning how to use the audio and lighting equipment. During technology classes students were listening to screen readers at blazing speeds, and often had full menu systems memorized in their head.

This observation is an example of the high learning aptitude that students can exemplify when a program has direct benefit. SerpUI should have the option to enable an 'Advanced' mode allowing users to move even faster.

Being trained users, their proficiency was impressive, although the learning curve included learning JAWS for minimal competency.

15.3 Summary of visit to various schools in the YRDSB

Date: June 19th 2019,
Date: June 21st 2019,
Date: June 24th 2019

Description:

The schools visited were public elementary schools in the YRDSB. The O&M (Orientation and Mobility) instructor for the BLV program, was kind enough to set up a weeks worth of visits to several schools in order to observe and interact with an array of different students. Students ranged in ages, quality of sight, and necessary support. The visit was around an hour in length and was generally composed of sitting with the students in the 'Braille Room' or in class along with the ability for questions and light discussion. Student and teacher names will remain anonymous.

Comparison to W. Ross:

Public school students seemed to be ahead in development. Many students encountered at W. Ross needed more care, and on occasion with more severe developmental issues. I have received verbal confirmation that this is generally the case.

Reinforcing for the development of an 'Advanced' mode for more capable users.

A big point in comparison is the sense of community and level of care available at W. Ross. Students that are struggling with severe VI tend to cope better in environments that are substantially tailored to their needs. For example, in some schools there is no braille on doors and signs, and no sense of VI community since they might be the only BLV student in the school.

Ideas of developing a Social Media tool for the BLV community

In the public schools classrooms still seemed very accepting, students sat with their sighted peers and took part in all subjects, from music to gym and everything in between. The Braille Rooms were generally a place to mimic the environment at W. Ross, providing access to braille printer, tactile workbooks along with other dedicated supplies.

Insights:

A lot of students prefer the use to braille. This came as a partial surprise as I thought that a large majority would simply prefer the ease of voice synthesizers. JAWS was far from popular as most students migrate to Apple products, using Voiceover, ZoomText, and the native features from the HumanWare devices (Brailliant and BrailleNote Touch). It was also noted by a student that JAWS crashes abruptly during normal use, leaving them stranded. Unclear if this occurs more than once.

From the students I have met so far there seemed to be significant proficiency in reading and writing braille. This is not a surprise since it is a major focus in the curriculum set by the board of education. It's actually quite impressive to hear about the quickness at which the students were able to achieve this proficiency. For instance, certain students had progressed from no literacy to two-handed typing with a Brailliant in the matter of a single year.

Braille must be preserved since it is a form of literacy!

An insight that reinforced a pillar of my research is the accessibility of search engines.

On multiple occasions we were able to observe a student attempting to access the SERP or Youtube content with partial success and little ease.

Although the primary tool for accessing web content is with PDA like Siri, this application only resolves simple questions. The reason for inaccessibility of SEs include; alternative braille formats (web browsers may operate with different Braille contractions), and clustered page layouts (the Google SERP has 3 advertised results before desired content). Especially in the case of children, the SERP is not only inaccessible but substantially boring, meaning that surfing the web feels like a chore.

In order to increase web usage of VI users the experience must be more pleasant.

Another insight is the lack compatibility from several Google applications, the most prominent being the GC. As a popular method of delivering curriculum content in an interactive format many teachers use GC, allowing students to follow along with the material as the teacher instructs. Due to the inaccessibility by the assistive devices (such as Screen Readers and RBD), instructors must get creative. Often teachers resort to copying the material line-by-line to a word processor where it is more easily accessed. On occasion teachers are forced to print visuals and manually add tactician so that the image has some semantic information through touch.

By seeing the excess work required for the teaching staff it becomes clear that significant effort goes into supporting a single student. Although the teachers are glad to put in the extra effort, it is the software that ultimately slows down the progression of the student.

Feedback for Development of SerpUI:

Noted by a computer tools teacher: Everything in lists! The conclusion is that lists provide an easy way to discuss the same information without requiring vision. Once a two dimensional coordinate is introduced clarity degrades.
By organizing information in lists students have a more concrete structure for the content they are observing. There's also an indication that the nested structure of the internet is problematic, referring to nested menus and content pop-ups when interacting. Graphical modalities are to an extent impossible to use, for instance webpage images, graphs and visual structures like tables. It was mentioned that Tables are specifically difficult since the screen reader can only really provide location making it difficult for conceptualization.

Its quite interesting to see how students interact with an SE. Out of those we visited, some students have never really interacted with browsers and the remaining few had difficulties with the page. Though it may be an age-related issue, since SEs are not a part of their curriculum yet, SEs are extremely useful in everyday life.

Memorizing key combinations is common as well. For student to proficiently write in Braille they must know contractions and spelling of the language. After that the user needs to know the keystroke combinations of the screen reader. Dont worry it gets worse whether the user is using a HumanWare product, BrailleSense, JAWS or and iOS device matters! Since each one of these devices may have different key commands for the same action. As a result the students must remember all the useful functions for each of the devices they require. This also forms a dependence on a single screen reader with a specific operating system.

SerpUI should avoid to introduce key combinations since its principles is to limit the cyberspace. Additionally, key combinations are <u>*hidden*</u> *options since a user needs to know they exist to apply them correctly.*
<u>Issues for Teachers:</u>

Forget the internet for a second, students can struggle in any aspect of school. During English they use a BrailleSense, for math they use a Brailliant with Braille Math contractions, and for browsing the web they use JAWS. Whats wrong with this picture? For starters, each student needs to be fluent in a wide selection of devices. But once you look deeper you start to notice that teachers have to get VERY creative on how to actually teach this content. How can you explain the intricacies of a bar graph to someone with total blindness? Or the coordination involved in sports?

SerpUI should aim to be platform independent so to overcome the gaps between the different technologies.
Teachers need teaching! Whether its for proficiency in JAWS or learning how to use Braille, it can often be difficult for teachers to find others that are willing to teach them how to use and understand these tools. Some even indicate that they had to spend their own money to recruit personal tutors.

SerpUI should also be easy to teach, so that the learning experience (the climb of the learning curve) is easy for both the teacher and the student.
By spending only a couple of days with these teachers it becomes more clear for how much energy is required. Teacher must have patience, technical know-how, and a strong level of commitment to their students. It often seemed overwhelming when going to meet these students and noticing that there is a team of teachers each responsible for a different portion of the child's learning.

The parents play an invaluable role in the child's development, from providing outlets for the child through extracurricular, to scouring the city in search of assistive devices from the Assistive Devices Program (ADP). There is an affirmative consensus from the teachers I met indicating the importance of a supportive home.

Appendices

Appendix A

Evaluation Content

A.1 Ice Breakers

For the time being, the ice breaker was tailored to the specific participants who attended the evaluation. Since it was known ahead of time that the participants are two young siblings, the ice breaker was a game to test how well they know each other.

“We’re going to sit in a circle and I will ask a question about one of you. Then we’ll count down from three and both of you will yell your answer! If you both say the same answer you get a point, if you say different answers your total doesn’t change! You’re working as a team and starting with 0 points. Your goal is to reach 7 points before I run out of questions! Got it?”

It was important to use their real names, which will be generalized to letters in this document, participants A and B.

1. What does **A** like better, cats or dogs?
2. What does **B** like better, birds or horses?
3. What is **A**’s favourite food?
4. What is **B**’s favourite board game?
5. Who is taller **A or B**?
6. Yes or No, does **A** like video games?
7. Yes or No, does **B** like broccoli?
8. What grade is **B** in?
9. Yes or No, does **A** like Basketball?
10. What is **B**’s favourite food?
11. What is **A**’s favourite sport?
12. What is **A**’s lucky number?

A.2 Qualitative Survey #1 - Pre

1. How old are you?
   (a) TEXT ENTRY
      i. Rationale: For participant sample data
      ii. Question Type: TEXT ENTRY
2. What grade are you in?
   (a) TEXT ENTRY
      i. Rationale: For participant sample data
      ii. Question Type: TEXT ENTRY
3. How good would you say your overall health is?
   (a) Excellent
   (b) Very good
   (c) Good
   (d) Fair
   (e) Poor
      i. Rationale: For participant sample data - VFQ25
      ii. Question Type: MEAN OPINION SCORE
4. ~~At the present time, would you say your eyesight using both eyes (with glasses or contact lenses, if you wear them) is excellent, good, fair, poor, or very poor or are you completely blind?~~
   (a) Excellent
   (b) Good
   (c) Fair
   (d) Poor
   (e) Very Poor
   (f) Completely Blind
      i. Rationale: For participant sample data - VFQ25
      ii. Question Type: MEAN OPINION SCORE
5. ~~How much of the time do you worry about your eyesight?~~
   (a) None of the time

(b) A little of the time
(c) Some of the time
(d) Most of the time
(e) All of the time
   i. Rationale: For participant sample data - VFQ25
   ii. Question Type: MEAN OPINION SCORE

6. Which of these computer systems have you used before?
   (a) Mac
   (b) Windows
   (c) Tablet (iPad)
   (d) Phone (iPhone)
   (e) Other
   (f) None of the above
      i. Rationale: To collect information about their existing technology
      ii. Question Type: MULTIPLE ENTRY

7. Which of these screen readers have you used before?
   (a) Jaws
   (b) VoiceOver
   (c) NVDA
   (d) Other
   (e) None of the above
      i. Rationale: To collect information about their existing technology
      ii. Question Type: MULTIPLE ENTRY

8. Which of these Search Engines have you used before?
   (a) Google
   (b) Bing
   (c) Yahoo!
   (d) Other (with text entry)
   (e) None of the above

   i. Rationale: To rank the commonly typed SE's (by this demographic)
   ii. Question Type: MULTIPLE ENTRY

9. Which of these computer devices have you used before?
   (a) Keyboard
   (b) Mouse
   (c) Speakers or Headphones
   (d) Monitor or Screen
   (e) BrailleNote Touch or Other Refreshable Braille Display
   (f) None of the above
      i. Rationale: To collect data on the type of devices and peripherals used by the sample group
      ii. Question Type: MULTIPLE ENTRY

10. ~~I want people to know that I am using an assistive device when using the computer?~~
   (a) Strongly Agree
   (b) Agree
   (c) I Don't Care
   (d) Disagree
   (e) Strongly Disagree
      i. Rationale: To gauge how comfortable the participant is with their technologies
      ii. Question Type: MEAN OPINION SCORE

A.3 Focus Group Questions

A collection of questions that can be used as focus group motivators to get children or students in the discussion.

- What grade are you in?
- What is your favourite class at school?
  - Why is it your favourite?
- What do you learn/do in that class? (Get them to talk)
  - projects, field trips, assignments, groups...
- Do you also have a science class? (prime for 'Solar System')
- Did you have science in the years before?
- Did you like it?
- What did you learn in science class?
- Did you learn about the solar system?
- What do you know about the solar system?
- **Later on** we're going to use our computers to find out some things about the solar system! I'm going to help you with that as well
- What are some projects and assignments that your teacher gave you in a class? (prime for 'search process')
- Did you have fun working on it?
- When you start your project what do you do first?
  - Do you...
    * Go to your **teacher or EA**?
    * Go to the **library?**
    * Go to your **computer and go online**?
    * Go to your **parents**?
- Do you use a computer to work on it?
- Do you have your own computer?

- What kind is it?
  - Mac, windows...
- Do you use a screen reader?
  - Which one? JAWS, VoiceOver, NVDA...
  - Have you used more than one screen reader?
  - Whats about $< Option1 >$ is better than $< Option2 >$?
- Can you think of a project that you didnt need a computer for?
- How about one that you really needed a computer?
- Which one did you like better?
  - Why did you like that one better?
- Do you work on your computer alone?
- Does someone help you?
  - Who?
- How do they help you?
- If I was to give you a computer (Mac), Tablet (ipad), phone (iphone) which one would you like best? (priming for 'using laptops')
  - Have you used all three?
  - Why is $< Option1 >$ better than $< Option2 >$?
- Have you ever used Google?
  - Do you like it?
  - Why do you like/not like it?
- So lets say you have a question you'd like to ask Google how would you do that? (priming for 'SEs')
  - What device would you use from the options mentioned before (laptop, tablet, or phone)?
  - What would would be your first step?
  - Let's say that step doesn't work, what would you do next?
- What are some things you dont like about using internet?

- What is something that would REALLY help when using the internet? (be as creative as possible!)

What do I want to know?
1) Is it difficult to use your computer? 2) Do you feel like it takes longer for you to reach the same answer? 3) Do you enjoy using a computer/Google? 4) What things are missing when youre using Google? Idea: work them through the search process with questions

A.4 Qualitative Survey #2 - Post

1. Having the application keep track of my previous steps would be helpful...
   (a) Strongly Agree
   (b) Agree
   (c) I Don't Care
   (d) Disagree
   (e) Strongly Disagree
      i. Rationale: To evaluate the need for a 'Trail'
      ii. Question Type: MEAN OPINION SCORE
2. Information is more accessible with the new program I learned today...
   (a) Strongly Agree
   (b) Agree
   (c) I Don't Care
   (d) Disagree
   (e) Strongly Disagree
      i. Rationale: To determine how the participant compares the levels of accessibility from existing to new interfaces.
      ii. Question Type: MEAN OPINION SCORE
3. The new program was easy to learn
   (a) Strongly Agree
   (b) Agree
   (c) I Don't Care
   (d) Disagree
   (e) Strongly Disagree
      i. Rationale: To help evaluate the 'learning curve'
      ii. Question Type: MEAN OPINION SCORE
4. Which controller do you prefer?
   (a) Keyboard
   (b) JoyCon Controller
   (c) I don't know

i. Rationale: To evaluate preference of peripheral
ii. Question Type: MULTIPLE CHOICE

5. Is the new program fun to use?
   (a) Yes
   (b) No
   (c) I don't know
      i. Rationale: Can be used to gauge the overall usability of SerpUI
      ii. Question Type: MEAN OPINION SCORE

6. Would you recommend the new program to a friend?
   (a) Yes
   (b) No
   (c) I don't know
      i. Rationale: Can be used to gauge the overall satisfaction of SerpUI
      ii. Question Type: MEAN OPINION SCORE

A.5 Evaluation Results Notes

Notes from the video of the two kids M and Ie, ages 9 and 6 respectively.

- Questions about eye sight are out of place and should be removed
- M has used a Mac
- Ie has never used a mac
- Ie seems to have very little interaction with computers
  - **Main usage is with the ipad tablet**
  - Little use of phones and laptops
- M has used Talking Typer (Product for iOS devices)
- Ie and M are both familiar with Google
  - They were enthused when I brought it up
- For M, the purpose for using Google is to research facts for a class about plants
  - "to look up stuff"
- M has gone through a task retrieval in a school setting
- M has used a word processor
- No need for assistance when using a word processor, vision is good enough
- M has used peripherals like mouse, printer, speakers, ...
- Ie really likes the word "Mac", its easy to say and has a lot of meaning because of a couple of reasons:
  - Others in the room know exactly what it means
  - They have experience using it
  - Its a way of saying computer that's more user friendly
- **Ie does not know the difference between left and right**
- Ie can see the letter which would have been a better way of explaining functionality (instead of Left and Right)
- M was able to understand the structure of the webpage quite quickly

- M 'flew' through results when moving up or down
  - M seemed to enjoy the speed and responsiveness of SerpUI
  - Though unsure much of the results they read since the content is all text and generally seemed uninteresting
    - Introduce thumbnail feature - where the background of the tile is a thumbnail of the video/content
- It seemed like the participants were looking for information by familiarity, meaning that they would recognize Wikipedia if it didnt 'look' like wikipedia.
- Lots of false positives!
- M mentioned that it was good to have STT functionality since it made it easier to input text
- M would not check if his STT was correct he would just assume
- M is quoted saying "Its hard to use the Nintendo Switch Controller" as they were at the end of the session
- Too many buttons for Ie - this participant just cant understand the premise of this application
  - the mother explained that at the age of 6 they are not really expected to perform information based tasks. The extent of internet usage would be looking up videos and pictures.
- The mother indicated that the use of STT would be helpful for the younger age groups
- For the younger ages it seems like the final result is not interactive enough.
- Ie used the Joystick as a 'control' for YouTube since they thought that they can control the character in the video
- They required too much instruction. Not possible for them to just pick up a controller and learn it for themselves. **Bad Signifiers!!**

Appendix B

Literature Review - Tabular Format

B.1 Supplemental Material

The appendicies represent a detailed version of the written text above. Each Concept displayed in a Concept Matrix according to references that compose the section. The reader may utilize this categorical representation to focus on specific papers within a concept. At the bottom of each appendix section there is a list of all references found in the section.

Note that different readers may benefit from either of the two dualities. It is recommended to have a general research question or project direction when analyzing the text so to not be overwhelmed.

This section categorizes the concepts exemplified by each paper [58]. This will help the reader quickly reference articles that address relevant concepts.

B.1.1 Search Engines

Search Engines

Ref #	Products	Studies
[59]		“describe the main design issues affecting the user interface of a search engine when a sightless user interacts by means of a screen reader or voice synthesizer.” “the most important differences between a visual layout and aural perception”

[7]	Objective: - Introduce the concept of SSEB (Specialized Search Engine for the Blind) (abstract) Target Goals: - "to make visually disabled people able to keep pace with the changing World Wide Web and to improve the efficiency of their information searches." - Figure 3 captures the major elements of the Google SE results page [16] Jansen and Spink examined characteristics and changes in Web search from nine studies of five Web search engines based in the US and Europe (p2) [23] Topi and Lucas examined the effects of the search interface and Boolean logic training on user search performance and satisfaction the assistive search tool had a positive effect on performance satisfaction and confidence [13] Google made a beta function version of their search engine open to public use called Personalized Search... users could get the results most relevant to them based on what they have searched for in the past (p3)	

[60]		SE mentioned: Google, Yahoo, Bing, AltaVista, MSN Search, and Ice rocket → most of these SE dont exist anymore in 2014
[8]		- Important: "very few studies consider narrowing down the search space in the query formulation step" (abstract) - Introduces the importance of query specifications during the query step (ie. what type of document are you looking for?) (p1) - Only a fraction of retrieved documents are relevant (p1) - Figure 1: Shows PCA for information access in web SE (p2) Two types of searches: *Novice Searches*: "users do not have some prior knowledge to search specific information" (p2) *Expert Searches*: "users usually have this knowledge to search related information by some precise keyword" (p2) Search Space must be minimized → Avoid the feedback path in PCA is very important
[15]		Section 2: Short LR includes SE metrics accessibility Explains difference between implicit and explicit search

[13]		Discusses the level of brain activity required while using search engines
[61]	This VQA survey is similar to a Search Engine queries since it takes in a query tuple (question + image) and produces a single solution (most relevant answer to question)	
[10]	- WoW changes the SERP (search engine report page) so that it can be modified to form the user. (p2)	
[11]	VoiceApp: a complete speech-based web search engine	
[14]		Results: "participants overwhelmingly preferred the search engine method to the two browsing conditions" (abstract)
[17]		Common web applications: - search engines - news portals - e-commerce and a tourism portal
[12]	we use our previous findings to inform the design of a search interface [TrailNote] to support visually impaired users for complex information seeking.	

[18]		Objective: "describe the aspects to be considered when evaluating web search engines' accessibility for people with disabilities" (abstract) Findings: (abstract) Three steps of conducting accessibility assessment: 1. Preliminary review to quickly identify potential accessibility problems 2. Conformance evaluation to determine whether a website meets established accessibility standards → Mainly focused on W3C Web Accessibility Initiative's (WAI) evaluation model. 3. User testing to include real people with disabilities in a practical use Future Work: (abstract) "Conclusions about actual barriers of web search engines and criteria of satisfaction for people with disabilities do not exist as of yet; the model is not tested so far."

[20]		This paper also includes information on VI users and search engines since the subjects were required to collect online information on given tasks without specific guidelines or restrictions.
[3]		PCA: (p1) 1. Formulating a query for an information need 2. Inspecting search results to identify relevant results 3. Exploring potentially relevant pages to locate desired information * Users often revise queries and repeat these steps *

[16]		Prerequisites: "At the beginning of this research a preliminary study was performed concerning accessibility and usability of search tools and eight guidelines were formulated for designing search engine user interfaces" Objective: - "the derived guidelines were applied in modifying the source code of Google's interface while maintaining the same look and feel in order to demonstrate that with very little effort it is possible to make interaction easier more efficient and less frustrating for sightless individuals" - "the paper focuses on interface design and implementation." Includes results of survey on SE preference computer usage and query statistics (p567)

[19]		This article surveys how conformed are the common search engines to WCAG 1.0 compliance requirements. Results: "Of all tools analyzed only Google conformed to priority 1 of WCAG 1.0 [4] meaning that it satisfies a minimal level of accessibility (level A) whereas other search engines directories and meta-searches presented some priority 1 errors"

References mentioned in the Search Engines Appendix:

[15], [19], [16], [17], [11], [61], [14], [3], [59], [18], [60], [10], [20], [12], [13], [8], [7]

B.1.2 Navigation

Navigation, includes content for *Physical World Navigation* (PWN), helping its users navigate around physical spaces. Citations involving PWN are included to show how different modalities can be achieved for applications other than web navigation.

Ref #	**Cyber Navigation**	**PWN**
[62]	The Buzzclip, developed by iMerciv Inc., is a PWN device that allow users to detect overhead obstacles at a range of distances. The device is small enough to fit in the palm of the hand and can be attached to practically any piece of clothing. The device is also flexible enough to fit on canes and can be hand-held. The impressive thing about the Buzzclip is it's discreetness and silence since all information is transmitted via tactile vibrations. This device can be considered as a Tactile User Interface (TUI) for PWN. Additionally, the device offers upper body detection not commonly accounted for when using canes and guide dogs.	✓

[26]	Findings: - users where disoriented as to where they were on the screen - "they did not know where the active window they were looking into" (p3) - "As stated by W3C the visually impaired became disoriented among windows due to the content spawning new windows without warning the user" (p3)	
[7]	- Table 1 includes VI difficulties for Navigation - SSEB may provide orientation navigation assistance and site maps to make users feel confident of where they are and what they are doing (p3) - Andronico et al. further verified some of these guidelines and principles... added shortcuts to make navigation faster (p2)	
[8]	- Baeza-Yates et. al. SE should use the concept of "relevance feedback" which feedback the retrieval results for the first round query as context of relevance	
[37]		✓

[28]	Issues with online navigation: - Navigating and filling in web-forms was reported as problematic task (p6) - Site timing out meant user lost their relative position (p6) - VI users want freedom on web and not to rely on sighted user (p6) - JavaScript auto-refresh feature is problematic (p6) Navigation Tactics: - "Participants also tended to want more feedback concerning the spatial location of images within a web page" (p7) - Gaining an overview of a web page can be a challenging process - VI use tab and arrow keys to manoeuvre the page Page Visualization: (p7) - Screen Reader Users (SRU) visualize a vertical list of points and links - No spatial perception - This would guide their methodology for searching the page - "A considerable demand was found to be placed upon short and long-term memory usage" (p7) - Expert users would 'speed-read' through a page to get an overview of its contents	

[29]	- AudioBrowser [24] allows users to navigate webpages while on the move (p4). System was built on evidence found in [53].	
[10]	- WoW provides the whole information by conveying it in one single browsable page	
[11]	Main objectives of the VoiceApp system: (p2) - "to adequately convey to users the logical structure and semantics of content in web documents" - "provide them with easy ways to select which parts of a document to listen to"	
[38]	Navigational Issue: - "leaving users uncertain as to what they have covered the information space [22]"	
[14]	Motivation: "To date no study has been conducted to examine how people with cognitive disabilities navigate in different content structures." (abstract) Objective: "an empirical study to investigate the impact of different search methods and content structures on the search behavior of people with cognitive disabilities" (abstract)	
[17]	- The requirements generated in this paper also highlight the need for user orientation while navigating pages	

[12]	- This paper also discusses TrailNote, an application that manages the search process for VI users	
[27]	- Focus on Multi-session search tasks (abstract) - "Multi-session tasks can be cognitively taxing for visually impaired users because the lack of persistence of screen readers causes the load on working memory to be high." (abstract) <u>Results:</u> - "discuss the strategies observed among participants to resume the search" (abstract) Introduce the concept of a Search Trail: - "The search trail as shown in Figure 1 automatically records the queries that the user issues and the search results that are visited during a search session." (p5) - "users reported that they took notes during the search process." (p9) - "they would copy the URL of the page in a text le" (p9)	

[20]	Objective: - "This project examines how visually impaired people search for web-based information" (abstract) Method: - "we investigated the search behaviour of 15 visually impaired and 15 sighted searchers while they completed complex search tasks online." (p1) - "Examples of complex searches include: planning travel to a previously unvisited country" - "gathering information on a medical condition" - "We studied 4 pairs of participants undertaking collaborative information seeking (CIS) tasks. Each pair comprised one sighted user and one visually impaired user who used a screen reader."	

[3]	Objective: (p1) - Examine the information consulted and time expended to make exploration decisions (PCA step 2) - Examine the time expended or cost of exploring webpages (PCA step 3) Findings: - "users leveraged page features to gauge the amount of effort that is required to explore search pages and made exploration decisions accordingly" (abstract) - "Users' desire to know additional page details varied based on their visual ability and the results' relevance" (abstract)	
[30]	Objective: - Homer Web Browser is a, "small self-voicing Web browser designed for blind users is presented." (abstract)	
[31]	- To use the Audio Hallway application, the user travels up and down the Hallway by head motion passing rooms alternately on the left and right sides.	

[51]	- This book discusses the lack of perception due to blindness when preceiving content online Note: because VI people cannot explicitly see the object online and they are forced to create implicit abstractions of these elements. → as a result: the internet must be restructured so that they are able to generate explicit differences between important components online	

References mentioned in the Navigation Appendix:

[30], [11], [29], [26], [3], [51], [10], [28], [20], [27], [31], [37], [8], [7]

B.1.3 Usability / User Interface

Usability / User Interface, includes content for *Physical World Navigation* (PWN)

Ref #	Products	Studies	PWN
[2]		Types of interfaces: (p1) - *Visual*: Graphical User Interface - *Audio*: Auditory User Interface - *Touch*: Tactile User Interface Interaction Principles of UIs: (p2) - *Availability*: The required parts of the application need to be available at the right time and should imply correct usage. Mapping between intended user actions and user operations required. - *Affordances*: Provide strong clues to the operation of things (e.g. knobs → turning, buttons → pushing). When used effectively the user knows what to do with no further instructions.	

		- *Constraints*: Minimize the number of possible actions and give information about the correct usage of UI elements. - *Natural mapping*: If the relationship between controlling elements of an application and their results are natural to the user, it simplifies the learning process of the application and assists in recall. Natural mapping depends on physical analogies and cultural standards, and is therefore subjective to different user groups. - *Conceptual models*: By interacting with an application the user builds up a conceptual model of it. If this model is equivalent to the task model of the application it allows the user to predict the effects of their actions. - *Feedback*: Information about the result of their actions are sent back to the user and enables immediate control of the input.	

[44]		Objective: - "aims to evaluate the usability of a university website by visually impaired students" (abstract) Results from Survey: (p4) - Majority use Internet Explorer as preferred web browser Findings: - require library staff to get started (p5) - find computer - start computer - digitizing printed material they wish to read	
[42]	- Watch YouTube to learn something new - Read Wikipedia for quick facts "This paper highlights the Mg Sys Visi system that has the capability of access to World Wide Web by browsing in the Internet checking sending and receiving email searching in the Internet and listening to the content of the search only by giving a voice command to the system."		

[7]		- Classification of difficulties for VI users: (Table 1) - "Leporini et al. proposed three guidelines for user interface design" (p2) [18 21] Although Google has a simple user interface and often is highly accessible it may be further improved to simplify interaction for visually impaired people when using screen readers	
[8]		- On mobile devices Google displays more results with less description (p2) → good for quick overview and avoidance of repeating query entry <u>Results</u> : (p3) *Create a two step query formulation:* 1. users to provide some keyword(s) as the queries 2. users to select what kinds of retrieved documents they really want (ie. PDF website news images ...) (Step 2 is optional (p3)) - Table 1 (p4) → specifies which information is important when asking a user to commit to a specific query specification (ie. Images: Size, Content Type, File Type, Colouration ...)	

[15]		Important quote - "[13] pointed out that increase in cognitive activities required by a search tool reduces the chances of finding information" (p2)	
[40]		- Problem Summary: Large computer-based webpages are too large to be viewed on small form factor devices like "handheld computers personal digital assistants (PDAs) and smart phones". Process - Two Step: - "Page Analysis - analyzes the structure of a give web-page" - "Page Splitting / Auto-positioning - splits the webpage into a two-level hierarchy" Note: "For a web-page not suitable for splitting an auto-positioning method (or scrolling-by-block) is used to provide a similar user experience."	
[48]	AlterEgo: HCI technology where the user must only mouth the intended words so that the electrical stimulus is sent to the muscles. This allows the user to interface with the computer without a sound.		
[13]		Explains the comparison between *Net Naive* (new internet users) and *Net Savvy* (internet users with prev experience).	

[46]	EasySnap, VI photographer application: - "an application that provides audio feedback to help blind people take pictures of objects and people and show that blind photographers take better photographs with this feedback." - Allows VI users to take, share (face-to-face or via social media), and browse pictures without the need to see. (p3)		
[25]			
[41]		132 Total participants in survey: - 81 total VI were as likely to use a smartphone or tablet as those with low VI - 59 of smartphone users found speech was helpful - 51 camera and screen as a magnier - 48 used an e-book reader	
[37]	Focus: "This chapter focuses on web-based tactile and audio-tactile maps for blind and visually impaired users developed within the Mapping for the Visually Impaired project"		✓

[36]	Objective: - “In this paper we present KAI (Accessibility Kit for the Internet) that considers both the user and the designer.” - “ KAI includes a mixed audio/touch browser (WebTouch) that enables selective reading of contents.” Secondary Objective: - “KAI is based on a new language BML (Blind Markup Language) that helps authors to develop better structured pages.”		
[43]		Issues with online accessibility: - “most of the browsers used to surf the net are thought to be managed by users without visual disabilities” Objective: - “Our research group has developed such a tool called KAI (Kit for the Accessibility to the Internet)” - In this paper we focus on WebTouch and its two modalities for surfing the net: voice and tactile skills.	

[35]		- GUIs are widely regarded as a major advance in human-computer interaction. - Their heavy dependence on visual cues for input and output presents a significant problem for visually disabled patients. (p3) → as a result the internet will only become more visual (which it has since 2005) New developments on tools: (p8) - W3C: Web Content Accessibility Guidelines which have become an international standard for creating universally accessible Web-based products. - Improvements for replacements of computer mouse - a target mouse that provides auditory assistive feedback when the pointer enters or exits a target region	

[28]		<u>Reasons to not download files</u>: - security - file may contain virus - lack of training to download and interpret files - fear of system settings to be altered <u>Time before info overload</u>: (p8) - Less experienced users: 0.5 to 4 hrs - More experienced users: 5 hrs to entire day - Partially sighted user: vary due to eye condition (ie. eyestrain) - "voice of a screen reader could be overloading in itself" (p8) Note: CAPTCHA programs could never be resolved by VI users (ie. Anti-bot software) <u>JAWS</u>: - Not enough training from IT or VI users - Most users felt that training by a JAWS pro would be very beneficial (complex UI) - JAWS according to users in the study is "the best on the market" (p5) - "difficult to scan a page using JAWS" to gain overview of web page or locate an item of interest	

[10]	- "spatial representation is processed by an amodal system" (abstract) → implying that when perceiving something we see it as whole (amodal perception) WoW outputs its results "in a top-down hierarchical sequence starting from the greatest ranking level website to the lowest in several results pages"		
[38]		Objective: "investigate how to present search results through a conversation over a speech-only communication channel where no screen is available" (abstract) Advantages of speech-only systems: (p1) - operating machinery [6 7] - no screen or keyboard is available [24] - users are on the move [16 21] - using wearable devices [5]	
[17]		Objective: "This paper presents Web design requirements that can improve the accessibility of such websites for PWDs [People with Disabilities] particularly the blind." (abstract)	

[45]		Objective: “This study examined the usability challenges and emotional reactions blind college students experienced in accessing educational materials and communicating with professors and colleagues through online technologies.” (abstract)	
[12]	Objective: “redesign the spelling-support mechanism using nonspeech sounds to address previously observed diculties in interacting with this feature.” Findings: “the search interface was effective in supporting participants for complex information seeking and that the proposed interface features were accessible and usable with speech-based screen readers.” (abstract)		
[16]		This paper identifies the accessibility and usability issues (with references to other papers) (p123)	
[30]	This paper presents the Homer Web Browser (p1) → this application can be classified as an AUI Five main modules: *Input* → Voice, keyboard and mouse *Output* → Speech and non-speech sounds indicating location of pointer (mouse) (p3)		

[31]	Objective: "Audio Hallway a virtual acoustic environment for browsing collections of related audio files" (abstract) Note: This paper presents the notion of creating a new (virtual) world for the user to interact with the search process and relevant information		

References mentioned in the Usability Appendix:

[15], [16], [17], [40], [35], [41], [30], [2], [42], [46], [48], [36], [43], [10], [44], [28], [45], [12], [31], [37], [13], [38], [8], [7]

B.1.4 Information Accessibility

information accessibility, includes content for *Physical World Navigation* (PWN)

Ref #	Products	Studies	PWN
[44]		- VI users need to be informed of "opportunities and events taking place on campus" (abstract) - date related info was most difficult to acquire (generally displayed in a visual format; calendar) (abstract) Difficulties encountered with school site: (p5) - Complexity of course registration - Irregular reading order of the links at homepage - Irregular listing of the announcements - Failure to read visuals (posters etc.) - Lack of direct access from web page to the target link	

[26]		Objective: - to explore the challenges faced by the visually impaired learners in accessing virtual learning environment - to determine the suitable guidelines for developing a voice recognition browser that is accessible to the visually impaired - Developers are too esthetic oriented (p1) → "Their main purpose is only to make their applications look fantastic and impressive" Findings: - "most of the existing web applications are not accessible" (p2) - "the user could not understand or grab the idea of information effectively"	
[42]	Includes translator that has the functionality to convert html codes to voice; voice to Braille and then to text again Results: - System can be used for other users of specially needs like the elderly and the physically impaired learners (not just VI).		

[7]	- The objective of this paper was to design an accessible user interface for blind people the Specialized Search Engine for the Blind (SSEB) (p3) - "a minimum requirement is to ensure that everyone can understand the contents of any Webpage." (p1)		
[40]	Solution: Compartmentalize each Web page to a grid of thumbnails that can be individually accessed to reveal the data in detail.		
[48]	AlterEgo allows the user to request and receive information discreetly		
[37]	- "production of maps for people with special needs poses new challenges" - this article focuses on the access of physical world maps for people with VI		✓
[36]	KAI includes 2 components: - BML - WebTouch (more info on this in "Macias - 2004 - WebTouch...")		

[43]	Issue with online accessibility: - “the inaccessible design of the pages” Components of KAI: → BML - a new markup language with accessibility features called Blind Markup Language → WebTouch - a multimodal browser taking blind people into special consideration		
[35]		Accessibility achieved by: - translating the visual screen display into → auditory output (e.g. screen reading software with speech synthesizers) → tactile output (e.g. Braille display that echoes the screen display) → or a combination of the two modalities (p6)	

[28]		- Generally no ALT Text (p7) - Some would copy and paste content to word processor to be analyzed later (p7) - Afraid of forgetting information! (p7) Note: The user is exposed to so much useless info that the are forced to listen and analyze carefully. (overload) - Less experienced blind users would send emails to friends and would visit websites recommended to them by friends ("blind-friendly sites") (p5) → Websites shouldn't be 'blind-friendly' accessibility to information is something everyone should be able to do equally	
[49]	- This paper focuses on the use of electronic mobility devices in the physical world for obstacle detection orientation wayfinding and navigation systems - BrailleNote GPS was found to be useful for the users to assist in learning a new space, therefore, Nonuse of the device (BrailleNote GPS) was noticed once the subject became familiar with the space		✓

[29]	- This paper covers existing technologies that integrate the user to the physical world (ie. navigation, obstacle detection, space perception...). - Also applications that aid navigation in the virtual world by compartmentalizing a webpage (AudioBrowser only).		✓
[10]		-"sonication method offers an effective tool able to transmit graphic information" (abstract) - it is not enough to make a webpage accessible but also usable for those who do not interact with it naturally (p2)	

[11]	VoiceApp enables to access and browse Internet by means of speech (abstract) <u>Three components</u>: (Abstract) 1. Voice Dictionary: allows the multimodal access to the Wikipedia encyclopedia 2. Voice Pronunciations: developed to facilitate the learning of new languages by means of games with words and images 3. Voice Browser: provides a fast and effective multimodal interface to the Google web search engine <u>Conclusions</u>: (p9) - creates a markup language to include relevant voice information from the webpage (VoiceXML)		
[38]		"it is difficult to convey large amounts of information via audio without overloading the user's short-term memory [14 18 21]"	
[39]	*Reference* [4] in this paper, The Web Access Project, developed methods for adding captions and audio descriptions to movie clips		

[53]		"A study in 2008 found that five of the most popular social networking sites were not accessible to people with visual impairment (122)." (p185)	
[14]		Note: Though this article targets cognitive disorders the idea of preferring a format different than the standard is important to consider	
[17]		<u>Suggested Requirements</u>: (p8, p9, p10) - a text only version of the website - text alternatives for visual elements - meaningful content structure in the source code - skip navigation link(s) - orientation during navigation - to avoid the feeling of disorientation - ensure (tables frames and forms) are accessible - test the website with keyboard only access - use or convert documents into standard formats - expand abbreviations and acronyms the first time they appear on a page.	

[45]		Findings: "Schmetzke (2000) found that 23 out of 24 university websites audited in the United States did not comply with Web Accessibility Initiative guidelines (WAI 1999)." "Zaparyniuk and Montgomerie (2005) and Sloan Gregor Booth and Gibson (2002) conducted audits on web resources for 311 higher education institutions in Canada and in the U.K. respectively. They found that the educational resources 20 for academic staff and students contained design errors that seriously hindered accessibility and usability for individuals using adaptive software to access information." (p3)	
[16]		This paper identifies the accessibility and usability issues (with references to other papers) (p123)	
[6]	An Act set out by the government of Ontario (Canada) detailing the standard required for ensuring an organization's product and services are accessible. The government of Ontario has set a goal to make the province fully accessible by 2025.		

References mentioned in the Information Accessibility Appendix:

[6], [16], [17], [40], [35], [11], [29], [42], [14], [26], [48], [36], [43], [10], [44], [28], [45], [49], [37], [38], [53], [39], [7]

B.1.5 Latency

Latency

Ref #	Products	Studies
[44]		Table 6 captures latency by showing how much time each participant spent to complete each task
[8]	Findings: "mobile users can spend less time to browse many irrelevant documents" (p1)	
[48]	AlterEgo: a non-invasive, non-vocal, HCI Allows the user to input content to the computer at a faster rate	
[46]	EasySnap, VI photographer app Major point: They are able to learn how to use the application very quickly [abstract]	
[11]	Note: The importance of Wikipedia as a source of quick information access	
[27]	This paper introduces a product called *Search Trail* - In order to reduce the time it takes to resume the session or a search, the user may revisit parts of the trail in order to resume (p12)	

[3]		This paper is regarding speed of access Results: Show that blind users take MUCH longer to explore SE and webpages than sighted users (Table 2 p4)
[16]		This paper also considers the importance of a more efficient and quick user interface that reduces the latency in search engines
[51]		This book addresses the lack of preception for VI users → in order for a VI user to create explicit perception of these online object they must spend significantly more time doing so

References mentioned in the Latency Appendix:

[16], [11], [3], [46], [48], [51], [44], [27], [8]

B.1.6 Discreetness

Discreetness subcomponents (user voicing & audio feedback)

Ref #	Products and Studies
[42]	The Mg Sys Vigi system is a web browser that accepts voice commands reducing its discreetness
[26]	Note: This study focuses on Voice activated browsers which excludes discreetness
[48]	This paper presents a wearable technology that allows the user to communicate with a comupter without actually speaking → the device picks up the signals from the brain to the vocal cords and forms the intended words on the computer Information can be relayed back via headphones thus ensuring a discreet experience
[52]	The BrailleNote developed by Humanware[52], is a braille display capable of: entering text through large buttons, and reading with a single line of refreshable braille displays. The unit houses USB and auxiliary sound as ports, as well as bluetooth capabilities with long battery life. The OS is available in different lanuages. The device is also available in several lengths that modify the length of the readable braille row.

References mentioned in the Discreetness Appendix:

[42], [52], [26], [48]

B.1.7 Emotional Implications

Emotional Implications

Ref #	Products	Studies
[44]		Intro: (p2) - "Usable products and contexts make people happy" (p1)
[26]	Application: Voice Acitivated Browsers Findings: Visually impaired learners feel disappointed (p3)	
[8]		This paper claims that, there is a sensitive amount of time until the mobile user becomes frustrated (p2)
[54]		Discusses the emotional implications and dependance of visually impaired people
[13]		Findings: Discovers that increased brain activity of the Net Savvy users vs less activity in Net Naive while completing a google search → suggesting that computer usage is unnatural if the brain has to modify its activity
[55]	This paper includes social media platforms such as Twitter	In the context of social media, this paper displays how influential specific groups of people are and what are the demographics of their follower base
[46]		Sharing pictures and videos through social media has positive effects on people and their social circles

[25]	This paper includes data on technologies such as VoiceOver and iOS on the social media platform Facebook	Findings: - Comparing the Facebook social networks of visually impaired users (VoiceOver Sample) vs. visually functioning users (iOS Sample) → Found strong similarities between the two in both network density size and usage - VoiceOver sample group found to receive more feedback from others online
[41]		The most frequently cited reason for NOT using these devices included: 1. Cost 2. Lack of Interest
[28]		- "Half of the participants felt that they were missing out on a perceptual experience which they thought that the fully sighted community experience when viewing images" (p7) - "Navigating the Internet using a screen reader was reported to be a frustrating experience due to the lack of feedback received" (p5)
[29]	Mobile Assistive Technologies (MATs)	- Motivation for creating MATs is to help the user "help individuals feel less stigmatized or labeled" (p2)

[53]		"Online communities can be particularly empowering for those with hearing or visual impairments or autistic spectrum conditions (105) because they overcome barriers experienced in face-to-face contact." (p184)
[45]		This paper also studies, "the emotional reactions blind college students experienced in accessing educational materials and communicating with professors and colleagues through online technologies." (abstract)
[27]	This paper introduces a product called *Search Trail* The use of the *trail* allows the user to know that their session is saved thus increasing confidence in the program	
[16]		This paper also address the need for less frustrating user intefaces that are user-oriented

References mentioned in the Emotional Implications Appendix:

[16], [41], [29], [54], [26], [46], [44], [28], [45], [27], [13], [8], [53], [25], [55]

B.1.8 Visual Question Answering

A sample of Visual Question Answering suveys

Ref #	**Studies**
[63]	VQA - might be useful for image to text descriptors of online visual media
[64]	VQA
[61]	VQA

References mentioned in the Visual Question Answering Appendix:

[63], [61], [64]

B.1.9 Technologies & Compliances

Technologies & Compliances

Ref #	Technology	Compliance
[44]	Technologies: - JAWS (with headset) - Windows-Eyes	W3C
[26]	Technologies: - screen reader or screen magnifier - JAWS → "JAWS has limitation to describe images"	W3C
[42]	Mg Sys Visi: specialized voice recognition browser - originally designed and developed for the visually impaired learners System Composition (5 modules): - Automatic Speech Recognition (ASR) - Text-to-Speech (TTS) - Search engine - Print (Text-Braille) - Translator (Text-to-Braille and Braille-to -Text)	
[7]	Technologies: - SSEB - Screen Readers: JAWS or Big Eyes - Personalized Search	WCAG 1.0 (p2) → Verifiers considered that guidelines nos. 1, 4, 6, 12, and 14 were essential and should be given the highest priority

[65]	Assistive devices for VI: (Table 1 p2) - Long cane - Hoople - Guide dog - Human assistant - Laser cane - Mowat sensor - Sonic Guide - Nottingham Obstacle Detector - NOMAD - Tactile displays/maps/arrays - Personal guidance system - MoBIC - Atlas Strider - Talking signs - Auditory beacons - Electronic strips - Motion detectors - Pressure detectors - Bar code readers - Beacons - Braille/Auditory compass - Vision enhancing devices (monocular) - Infrared detectors ... continued on next page ...	

...	Physical Barriers in Navigation: (Table 2 p3) - Pavement furniture - Cars parked on pavement (sidewalk) - Inability to read visual cues (e.g. street signs) - Construction/repair - Irregular uneven or broken surface - Crowds of people - Steps - Traffic lights without audible or pedestrian sequence - Weather - Lack of railings - Imperceptible kerb cuts (dropped kerbs) - Elevators - Distance - Door location - Door handles - Nonstandard fixtures (shop front rails baskets and stalls) - Traffic hazards - Surface textures (lack of) - Overhead obstructions (overhanging signs cables vegetation) - Lack of cues (e.g. uniform open space) - Gradient List Source: Golledge and Stimpson (1997 p. 493).	
[48]	AlterEgo	
[25]	Mentioned: - VoiceOver - Facebook	

[41]	Mentioned: - Smartphone - Tablet - Camera as a magnifier - e-book reader	
[35]	Technologies: (p7) - JAWS, by Freedom Scientific - outSPOKEN, by ALVA Access Group - HAL, by Dolphin Computer Access - IBM Home Page Reader, by IBM - Narrator, by Microsoft Corp. Common assistive technologies: (p7) - Screen magnifiers - Screen readers - Braille displays	W3C
[28]	Technologies: - JAWS (p5) - Windows Eyes (p5) - Supernova (p5) - ZoomText (p5) - Brailler (p7) - Dictaphone (p7) - Screen Readers	Web Content Accessibility Guidelines 1.0 (WCAG) → Studies (p2) show that these guidelines are insufficient.
[49]	Technologies: - BGPS - BrailleNote GPS - UC - Ultracane - TTTP - Teletact and Tom Pouce - SP - Sonic Pathnder - LC - Laser Cane - No longer available Products: - MS - Mowat Sensor - SG - Sonicguide - PS - Pathsounder	

[29]	- Mobile Assistive Technologies (MATs) are devices used to sighted users as to escape the stigma of traditional assistive tool (ie. cane, screen-readers, walkers, guide dog...) (p2) - Table 1 includes a list of assisted device, their intended usage, and their platform of operation.	
[10]	WoW (WhatsOnWeb) is: - "an application tool based on new graph visualization algorithms" (p2)	
[38]	Technologies: - interactive information retrieval (IIR) (abstract) - Spoken Conversational Search System (SCSS) (abstract) - screen readers	
[39]		WCAG 1.0: - contains 14 significant guidelines (p1 intro) - intended for all web devs
[53]	DEFINITION: "An *assistive technology device* can be defined as "any item, piece of equipment or product whether it is acquired commercially modified or customized, that is used to increase maintain or improve the functional capabilities of individuals with disabilities" (59)." (p105)	
[17]	Technologies: - Job Accessibility with Speech (JAWS) 8.0	

[45]	Technologies: - JAWS (p3) - Braille displays (p3) - Window-Eyes (p3) - Magic (p3) - Zoom Text (p3)	W3C (p3)
[12]	we particularly focus on implementing TrailNote → a tool to support visually impaired searchers in managing the search process Technologies: (abstract) - JAWS - VoiceOver - Window-Eyes - Search Trail (as mentioned in previous papers) - TrailNote	
[18]		W3C Web Accessibility Initiative's (WAI)
[20]	Mentioned: - Screen Readers	
[16]	Technologies: - JAWS (along with its theory of operation) (p8) → "JAWS is a fairly complex program itself requiring considerable knowledge to be used with maximum proficiency"	
[19]		WCAG 1.0

[47]		Objective: "This study raises awareness about issues of access in higher education" (abstract) Web Compliance: (p1) 1. Priority 1 (Single A) 2. Priority 2 (Double A) 3. Priority 3 (Triple A) → full compliance and accessibility - Accessibility Tips for Web Page features (found in Appendix A)

		Results: One (1) university website (of 12) achieved *Triple A Compliance* → "Studying this institution's implementation process we propose that other institutions might emulate this exemplary model to achieve greater website accessibility for all constituents" (abstract) Number of compliant sites: (p3) None - 4 Single A - 6 Double A - 1 Triple A - 1 Mentioned: - WCAG (p1) - "The United States' Section 508 by law requires U.S. government websites to be accessible." (p1) - The Wayback Machine, an Internet tool has the utility to note changes among archived versions of websites (p4)

References mentioned in the Technologies & Compliances Appendix:

[19], [16], [17], [35], [41], [29], [42], [47], [26], [65], [48], [18], [10], [44], [28], [45], [49], [20], [12], [38], [53], [25], [39], [7]

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