INVESTIGATING THE FUTURE OF SELF-SERVICE KIOSKS FOR VISUALLY IMPAIRED PATRONS AT BIBLIOTHECA

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Abstract

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A dissertation submitted to the University of Manchester for the degree of Master of Science, 2015

There is a growing interest in self-service kiosks in public places. The reason for this fast development is the advantages it offers to a wide range of the community. Touch-based kiosks are becoming popular and are commonly used as the main interaction model for self-services. These touch-based displays are considered to be visually intensive and continuous smooth surface. Touch-display kiosks are often considered hard to use for the people with vision disabilities. Bibliotheca is one of the worlds largest companies that produce interactive kiosks providing library-based solutions. The projects goal was to analyse the available data and demonstrate that touch-based kiosks can be designed to include the visually impaired patrons without compromising the user experience for non-visually impaired patrons. A prototype application based on speech synthesis and visualisation was developed as a proof-of-concept. This dissertation shows how a prototype application can be used to enhance the user experience for visually impaired patrons. We show further the technology decision and architecture to implement the application. Further, this dissertation explained an important part of the project, evaluation. The prototype application was tested on a panel of blind and visually impaired users and we evaluate how participants interact with the interface. We discuss in detail about the problems and their possible solutions to overcome the challenges.

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Chapter 1

Introduction

The term *self-service* can refer to the services or tasks that are performed by patrons[1] to complete without the help of another human being. Self-service [RH98] [MORB00] provides a cost-effective alternative to face-to-face customer services provided by the staff of an organisation, as people want better and faster services (without queuing for personalised custom service) while companies are looking to reduce their labour cost and maximise customer satisfaction. Self-service technologies are changing the way patrons interact with companies. Although they cannot replace personalised customer service, these self-service technologies are extremely flexible and helpful in providing a fast and reliable service. These technologies not only help employers to save on labour costs but also save office space too. Using self-service kiosks, the task of data management is shifted from staff to patrons (users), which lowers overheads for organisations that use self-service kiosks.

This shifting of data management to the patron also lowers companies, overhead costs as fewer customer service employees are needed to reply to patrons queries during busy hours. Employees can focus their attention on other activities besides the routine and manual tasks of checking books. Due to the changing environment and changing needs of patrons, the use of interactive self-service is in a good position to progress. Self service kiosks are widely used in a range of industries, including libraries, banking (ATMs), hospitals and railway stations.

Kiosks [RH98] [CLCW15] are a form of self-service technologies and human-computer interaction (HCI). A kiosk [cas15] is a computer-like device that is generally deployed

[1] Patron and User are alternative words refer to end users

in public places to give people self-service access to specific services or products. Typically, kiosks are placed in libraries, supermarkets, banks, hospitals (even now they can be seen in local surgeries for repeat prescriptions or other general enquiries) schools and airports. These kiosks provide self-service to those areas for which personal computers are not available or are not practical or cost effective. Kiosks may also provide access to the web (internet surfing, checking mails) or to various software applications. Unlike personal computers, kiosks may not provide all of the functionality of office computing (e.g word processing,web surfing), but a few task oriented services. For example, a library-related kiosk will only provide library services (borrowing and returning) and may not be available for web surfing. At the time of writing, kiosk deployment can often be observed in railway stations, shopping malls, airports or even in cafeterias.

These self-service technologies are deployed in situations where people can benefit from them directly, for example in hospitals where thousands of patients visit with different queries. This puts a lot of pressure on hospital staff to reply to patients queries. On the other hand, it becomes stressful for patients to wait in a long queue to have answer their general queries answered. A simple solution in the form of a kiosk can be used to reply to their day to day queries or allow them to do simple tasks. Another big advantage of a kiosk is that no additional staff are needed as kiosks provide access to information twenty four hours a day and seven days per week (twenty-four-seven) and do not need to be paid overtime. Kiosks come in many sizes and shapes and are often custom built for application in hospitals, train stations ticket kiosks, libraries etc. In spite of different structures, kiosks have several common features, like a shell or cabinet that holds a display, a central processing unit (CPU) and additional devices to do jobs.

Figure 1.1: An example of self-service kiosk sold by Bibliotheca.

These peripherals or additional devices help the kiosk to provide increased functionality. For example, a barcode reader is used in library kiosks for scanning books and cards. Similarly, a printer or credit card reader may be attached to a movie ticket kiosk. Special software is needed to make kiosks fully interactive. These software applications are designed to provide customised user interfaces, remote management functions and much more. Typically, three major categories [cas15] of software that run on interactive kiosks are operating system (OS) software, application software (custom made), and management software. Kiosks are designed to facilitate the provision of better customer service and user experience. They provide a friendly user interface for simple functions or tasks. For example, kiosks used in libraries help the patron to borrow or return books. As they are used by patrons of all age groups and all levels of education, then a well-designed interface can make them more effective and usable, Thus making access to information easier.

Touch screen kiosks [Saf08] [MXF13] are a modern form of kiosks. They provide input and output, both on the same device, and offer many advantages, like users completing actions in less time, no additional devices such as mice or keyboards being needed for input etc. The use of a touch screen can be seen in daily life, like smart phones and tablets, for which the user uses a finger to access the required application.

Bibliotheca [op15a] [CLCW15] is one of the world's largest companies that deal with interactive kiosks. They provide Radio Frequency Identification (RFID) based solutions. The main focus of their business is the public, private and academic library markets. They have offices in 11 countries along with 35 distribution partnerships across the world. A dedicated team at Bibliotheca is focused on developing and providing the very best software for interactive kiosks. The Bibliotheca team is focused on providing user friendly interfaces, so the maximum usability factor can be achieved. Kiosks produced at Bibliotheca are designed to be:

1. User friendly;
2. Comply with Disability Discrimination Act (DDA);
3. Integrate with Library Management System (LMS) providers;
4. Provide solutions that help and improve library services.

The software used for kiosks at Bibliotheca provides a customer service by giving the patron options for interact with the kiosk via:

1. a choice of languages;
2. a choice of color schemes;
3. a high visibility mode for users with vision issues;
4. management of library services (borrowing, return, payment etc).

The basic purpose of Bibliotheca kiosks is to enhance the user experience of the patron and overall usability of the product.
Todays technology-aware patrons want more innovation in self-service technologies in order to be served quickly and have product with better usability. However, there are a number of patrons who want these technologies to meet their special needs. The biggest challenge in designing an interface for kiosk is to provide maximum self-service *irrespective* of the individual patrons age, contact with technology, level of education, familiarity with the system and physical or cognitive abilities. However, it is hard to achieve the goal of universal accessibility, because designing a software application that provides input and output in multiple formats adversely affect the usability of the product. Nevertheless, small changes in a kiosk interface can make noticeable differences to usability [KR14].
Visual impairment (VI) is a term describing visual conditions. It can referred to a person who has low vision or poor eye sight and cannot be fully improved with the use of contact lenses or glasses. People with sight problems have a small focus area. Accessibility to touch screen kiosks can be problematic as the screen is one continuous surface for blind people or people with severe visual impairment (who can only sense light). Similarly, reading text can also be difficult for partially sighted patrons.

1.1 Research Scope of Project

This project is a result of the combined effort of the University of Manchester and Bibliotheca. The research questions tackled in this thesis are:

1. What are the main problems or causes that make kiosks inaccessible to visually impaired patrons?
2. What features can be added to achieve the maximum usability of library kiosks for people with low vision?
3. How do these features work in practice with real users?

The research aspect of this project is to determine the future of Biblioheca's library based self-service interface for visually impaired patrons. A prototype was designed to investigate possible solutions to these research questions, requiring a detailed analysis of available data. After sketching out the main areas of interest, a rough sketch based on information was made to implement the given recommendations. After that a final version of the prototype application was built, with enough modularity and flexibility to exchange or upgrade each component of the application.

1.2 Structure

This thesis is structured in the following way:
Chapter 2 provides the detailed scientific knowledge required for the project. This includes analysis of available data and related fields which is used as a foundation for the project. The background also provide details about the software engineering techniques used to complete the project.
Chapter 3 covers all phases of the design and implementation of the project. This chapter explains the details of the software system architecture and of the justification for the design decisions that were made after analysis. Chapter 4 explains all the steps taken for user evaluation. This also includes the results and limitations observed after completion of the process. The thesis concludes with the final outcome of the project and an outlook for future work, which includes the research questions which arouse during the process.

Chapter 2

Background

The study of and research into human-computer interaction (HCI) show how patrons can interact with computers more effectively and how technology can serve humans better. The major focus of human-computer interaction studies is on interfaces, as these act as a bridge between patrons/endusers and computer/technology. HCI is the study of humans may or may not use systems and applications. The use of applications and usability of products can be improved by focusing on computer interfaces. Interaction between humans and computers can occur in many ways and interfaces can facilitate it. The use of graphic user interfaces (GUIs) can be seen widely in today's applications like games, desktop applications, mobiles, web browsers and kiosks. In contrast to GUIs, voice user interfaces (VUIs) are not common in use. These are used in speech synthesis and speech recognition. The main focus of human-computer interaction studies is to provide satisfaction for the patron.

This chapter focuses on the background knowledge necessary for the project and provides the scientific background. As first section is based on information about Bibliotheca and its services towards library kiosks. The next sections provides the detail about related work, which already has done in this field. The last section talk about the software engineering process used for the project.

2.1 Bibliotheca:

According to Bibliotheca
"Bibliotheca is the worlds largest company dedicated to the development, deployment

and support of RFID based solutions, with particular focus on public, private and academic library markets. With offices in 11 countries across the world and distribution partnerships in 35 others, we are proud to hold almost 4,000 unique library customers with a deployed equipment range of well over 6,000 individual self-check units and over 400 automated materials handling (sorter) solutions. In satisfying this range of customers, Bibliotheca has deployed more than 200 million RFID labels and continues to supply in excess of 50 million labels each year." [op15a]

Bibliotheca has expertise in providing the library based radio frequency identification (RFID) [RFI15] products like self-service kiosks, solutions for the security issues, devices to help sort the large amount of books and many more innovative items. Bibliotheca radio frequency identification (RFID) equipment has been installed in different countries like the UK, Europe, the USA, Canada, Australia and many more. A large dedicated team at Bibliotheca works to develop software for the products like kiosks. This software should not only meet with patrons requirements, but should also provide functionality with complete satisfaction. Bibliotheca products and software completely meet the current needs and requirements of the industry. For instance, all their products meet the Disability Discrimination Act (DDA) [DDA15] standards and can be integrated with Learning Library Management Systems (LMS) [LMS15] providers. There is an ability to manage the library products from number of locations and to provide library services beyond just self-service kiosks. Bibliotheca teams are continuously seeking ways to provide best self-service to meets all of the physical and cognitive challenges of patrons. To achieve this goal, they have recently applied for WCAG[1] status [SLH15], " Are their kiosks are compliant with the needs of patrons with visual impairment?". Initially, the Bibliotheca team received a negative response along with the following guidelines in order to make the kiosks more accessible to visually impaired patrons.
These guidelines are:

1. Easy-to-read fonts to help visually impaired users to interact with kiosks.
2. Use of highly contrasting colours to help users to read text.
3. Ensure all interactive parts (e.g buttons or tiles) are very clearly defined.
4. Use of icons (where possible) can also make a difference.
5. Avoid any screen clutter that does not directly provide useful information.

[1]Web Content Accessability Guidlines

2.1.1 Liber8

Liber8 is a software application that is currently being used in Bibliotheca kiosks. All the data discussed in this section is provided by Bibliotheca. It is designed to give users or patrons a better self-service experience. It is a touch based application that allow patrons to navigate the product with a touch screen. The focus of Liber8 is to provide maximum user satisfaction to the patron. The feature of Liber8 which has enhanced the usability of the product is that its design is very simple and intuitive. It gives the user an ability to interact easily with the kiosk by avoiding any complexity. Figure 3.4 shows the main window which appear after the user has logged in. Three buttons are used to provide all the essential library services. They help the patron to get the required job done with minimal confusion and problems.

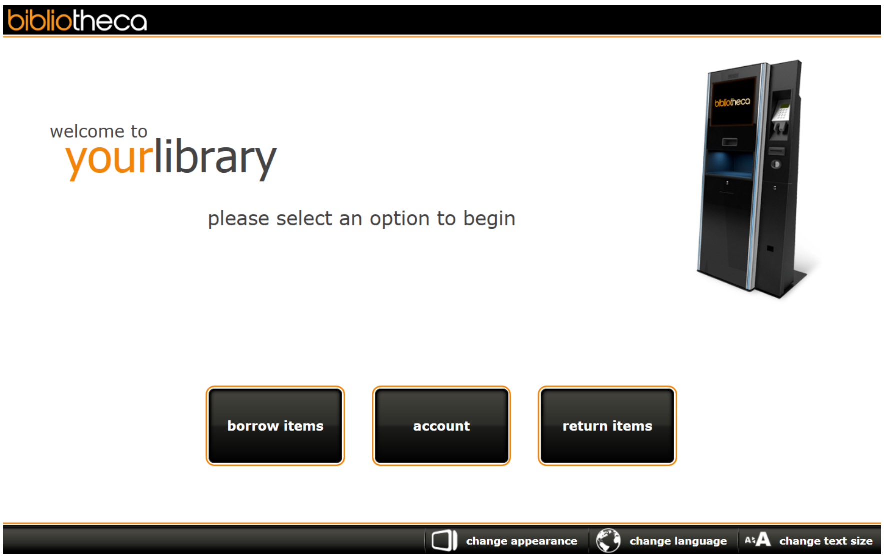

Figure 2.1: The simple user experience interface provided by Liber8. Three buttons enable users to borrow items, check their account and return items.

Liber8 provides the facility for a user to interact in their own language, for example, by pressing the *change language* button, shown in Figure 2.2, which switches language quickly. Figure figure 2.2 shows the options a patron has to choose from over 40 languages. Interaction with the computer regarding choice of language can make a huge impact on the usability of the product.

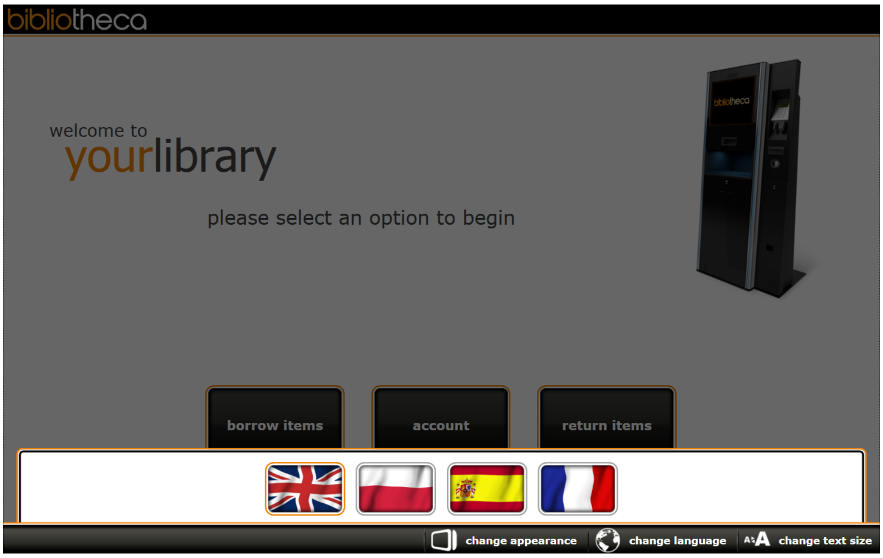

Figure 2.2: Language selection in Liber8; clicking on a flag switches Liber8 to the language of that country.

Liber8 also provides a feature for choosing the colour scheme of the application. There are eight different schemes are available to the user, giving them an opportunity to work in their desired environment. Not only does this enhance the user experience, it also facilitates those patrons who have difficulty in reading text in some colors like people with colour blindness who may not find it easy to work in specific colours, such as red or orange. Liber8 also gives an option to choose schemes that are specially designed to enhance the user experience of children, such as an ocean or jungle theme, as shown in Figure 2.3.

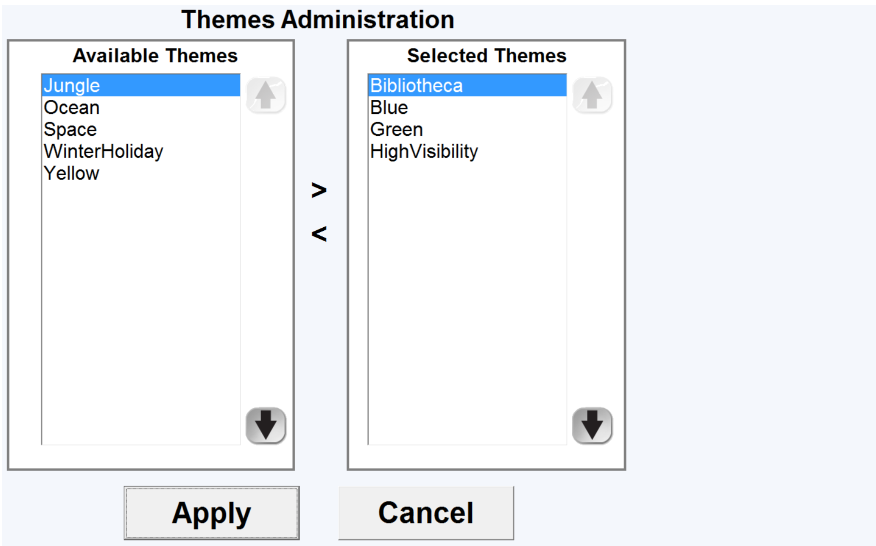

Figure 2.3: Theme selection in Liber8; clicking on a theme gives the user an opportunity to work in their desired environment.

A high visibility mode has been designed in Liber8 to target those patrons who have vision problems. This focuses on how people with sight problems can enjoy the maximum advantage from the kiosks. However, to access this mode, a patron has to come from the normal view by relying on normal sized features available in that view. As shown in Figure 2.4 the high visibility mode in the Liber8 application consists of a dark background and a large button size for better interaction.

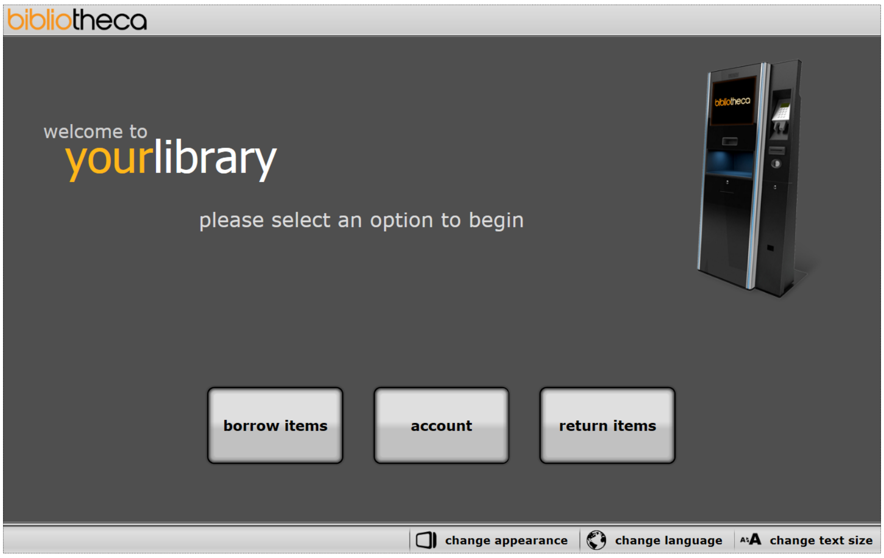

Figure 2.4: High visibility mode for patrons with low vision.

To enhance the user experience, Liber8 also provides a feature to change the text size. This feature enables a patron with low vision to use the kiosk too by enlarging the text size. Figure 2.5 shows the interface windows along with the bar used to enlarge the text size.

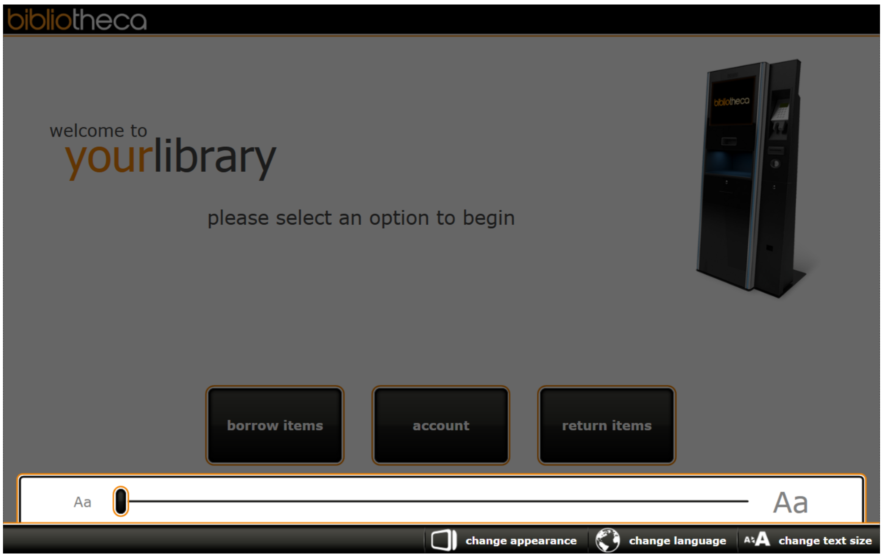

Figure 2.5: The text size bar in Liber8; The users slides over it from left to right to change text size from small to large.

Liber8 not only focuses on the user experience of the patron but librarians can also use all its features fully. It allows the library administration to configure the kiosk with customised features depending on the requirements of the individual library. As shown in Figure 2.6, the librarian or administration can choose how many functions should be available to the user.

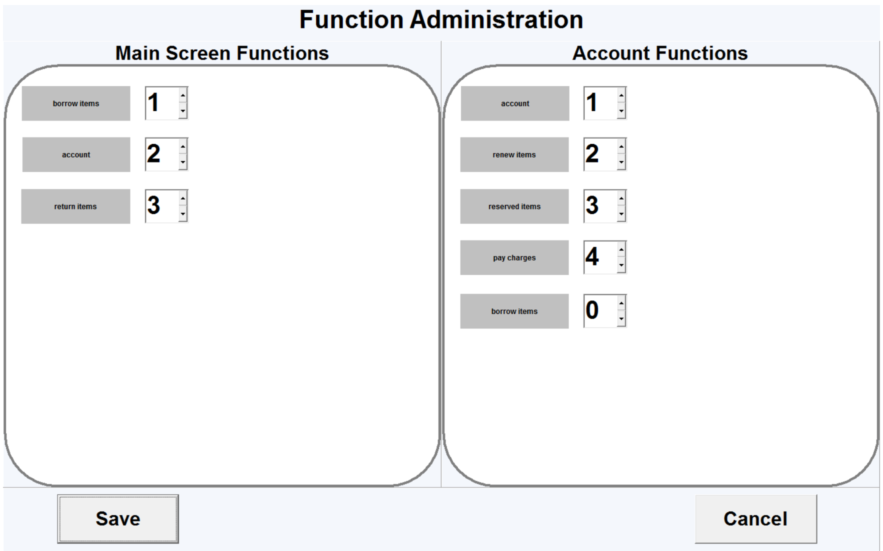

Figure 2.6: The interface window in Liber8 that allows the librarian to select what functions should be available to users.

2.2 Assistive Technologies

Some people have limited abilities because of impairments like hearing loss, sight or vision loss, physical or mental learning disabilities like dyslexia. Some efforts to support disabled users have been made but much more still needs to be done. The use of technology can help disabled users to complete their daily or routine work more independently and without additional support. It can be observed that much work has been done in computer science to assist disabled people with the use of technology [HS10]. For example, many mobile applications with speech or Braille input are available to make mobiles more usable for disabled people. Similarly, audio books facilitate acquisition of knowledge from books, speech is used to read or write messages and there are many other examples.

Nowadays, assistive technologies refers to technical devices like tools and equipment that help to improve the functional capabilities of physically disabled people. According to [SY10a], the term assistive technologies was first used in 1988 and may refer to software and hardware as well as electronic and optical devices, including hearing aids, optical glasses, wheelchairs and many more.

In this project, our study focuses on assistive information technologies that can facilitate human-computer interaction [NG99] (HCI) and communication or can provide access to information. These are related to software or hardware that helps people with special needs. Some studies have shown [SY10a] that it is hard to develop a universal assistive technology to improve communication and information for users with different disabilities. There is no single solution for multiple problems. Such systems are really developed like a computer system that helps both blind and deaf people to interact with each other independently. Figure 2.7 shows a conceptual model of assistive technologies that represents both multimedia input and multimedia output user interfaces. Although this model represents an ideal situation for assistive technology, it can be very helpful in designing the user interface for people with special needs.

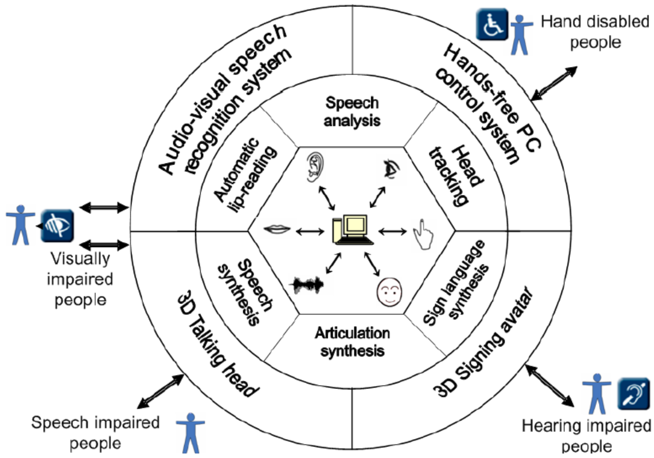

Figure 2.7: Reproduced from [SY10a], this shows the conceptual model for assistive technologies with multiple forms of input and output.

The proposed conceptual model in Figure 2.7 shows a computer at the centre of the model that is able to see and hear users with the help of cameras and microphones. It can also produce output via a loudspeaker and touch screen. The second layer consists of visual, audio, synthesis and other methods and functions for automated processing. The outer layer represents the user interface, which acts as a communication bridge between humans and computers. The user interfaces are based on text to speech (TTS), machine text processing, speech synthesis, lip reading, gestures, speech recognition etc. There are some systems or technologies that are not covered in this conceptual model, like gesture recognition, brain reading, sign languages, eye tracking etc. The conceptual model shows that a user interface for assistive technologies must comply with the principal requirements of end users by being natural, effective, universal, friendly and reliable.

The model given is universal as it serves different categories of users with different physical and sensory challenges. For example, blind or visually impaired people can have output in audio, deaf people can rely on a sign and text based interface, physically disabled people can receive output via a hands free personal computer (PC) control interface and regular users can get information from multimedia (audio and visual) output. Assistive technologies [KR14] [GDBR15] act as technical devices, tools or services, whose sole purpose is to meet the social, technological and functional needs of people with an impairment. For visually impaired people, the use of sound or speech can make a big difference to their interactions with technology. There are many assistive technologies that are available to support people with low sight. Assistive technologies make technology accessible to people who cannot see or have reduced vision. For example, the term visual impairment includes more than a single condition and describes the different degrees of vision that different people experience. Thus, every single individual with a visual impairment needs a customised arrangement or setting to access resources using a computer. At present, these assistive technologies enable computers to talk and read documents, while can screens be made bigger for more visually impaired users. These technologies also provide assistance for Braille translation programmes, magnification devices and audio players for audio books in the required format. In spite of the advantages assistive technology (AT) offers to people with low sight, studies in Norway [SY10a] have shown that AT is rejected by severely visually impaired young people as a way of fitting into ordinary society. There are multiple reasons for this:

1. Users do not want themselves to be singled out or to appear different while playing games or accessing technology in a group.
2. They can find it hard to compete with their non-visually impaired friends as split views of graphics and text need more time and effort to get an overview.

The same study [SY10a] reveals the fact that it is hard for users to accept that they are not being treated as ordinary people. However, partially sighted people prefer to engage in information and communication technology (ICT) in the same way as normally sighted people. According to research [SY10b], the impact of assistive technology on patrons' level of activity and social involvement is directly related to usability. Assistive technology must reduce cognitive, physical and linguistic efforts and promote efficiency, productivity and satisfaction to achieve the highest level of usability.

The following section focuses on the most widely used available assistive technologies and their scope for use in kiosks to make them accessible to visually impaired patrons.

2.2.1 Screen Readers

Screen readers [LP04] are computer software applications that allow the conversion of displayed text into audio, enabling people with visual impairment or blindness to interact with computers. Screen readers provide information about icons, files, dialogue boxes and menus, and work closely with a computer's operating system. Screen readers are essential pieces of software that act as a communication bridge between technology and people with low sight.

How do screen readers interact with users? Screen readers typically rely on two methods to provide feedback to patrons or users.

1. Speech
2. Braille

In the first scenario, screen readers use a text to speech (TTS) engine that translates on screen text or information into speech. Users can hear speech via a speaker or headphones. A text to speech engine may come in the form of a software application or in the form of hardware that plugs into the computer. Screen readers also have the ability to provide information in Braille. However, to have output in Braille, an external hardware device, called refreshable Braille Display as can be seen in Figure 2.8 is needed.

Figure 2.8: Figure taken from [LP04] A refreshable Braille display device that can be connected to a personal computer or laptop to get output in Braille.

The device shown in Figure 2.8 consists of one or more rows of cells. Each cell can transform into a Braille character shape, so when the information changes on the computer screen, the Braille characters change too and provide fresh information directly from the computer.

Screen Readers and Different Languages: Screen readers have a primary language which matches the operating system language but they can also deal with different languages within documents. For example, if the text in a web page is *'as in French'*, a screen reader will change its speaking rate, accent and the pitch of the synthesized speech output to mimic a French style. The majority of screen readers support common languages like English, French, German and Spanish, but other languages too, like Chinese etc.

Screen Readers and Graphics: Screen readers are programmed to identify graphics on operating systems and common applications. When a screen reader finds a graphic, it gives output in the form of text. For example, if it finds the *'my computer'* icon on a display, it supplies the text *'My computer icon'* in the user's chosen output format i.e. speech or Braille. However, a problem arises when screen readers find an image that cannot be identified. Some screen readers provide an option for the user to label the image. However, in some cases of web page content, the text description appended to an image is provided by the website developer, as Shown in Figure 2.9

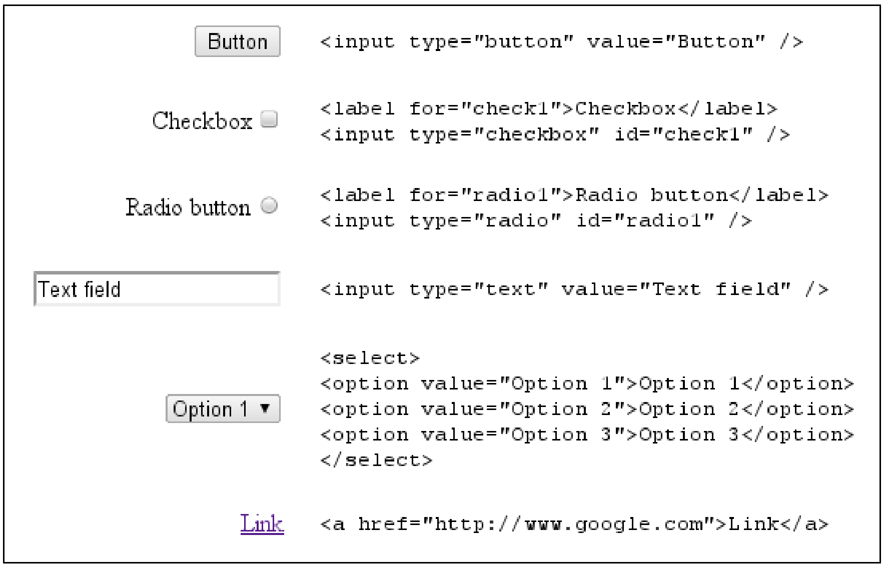

Figure 2.9: Standard [rea15] HTML controls that are accessible by keyboard and are generally understood by screen readers

Screen Readers and Web Pages: Screen readers work best with web pages as they are often well structured. Well structured web pages include paragraphs, headings, lists, tables, contents, image descriptions etc. All of this meta-data is available in computer language which allows a screen reader to access the required contents. For instance, when a screen reader finds a table in a web page, it will look for its column and row headings and communicate this information to users via their chosen format. Some of the most commonly used screen readers to access web can be seen in Figure 2.10

Screen reader	Creator	Supported platforms	License	Notes
95Reader	SSCT	Windows	Commercial	Japanese screen reader
Automatik Text Reader	Davide Baldini	Windows, Linux and Mac OS	Free and open source (GPL2)	Firefox plug-in with multiple speech languages.
BRLTTY	The BRLTTY Team	*nix, Windows console, DOS, Android	Free and open source (GPL2)	Available to download; part of most Linux distributions
BrowseAloud	Texthelp Systems Inc	Windows and Mac	Free for Users, Commercial	
Capture Assistant	Renovation Software	Windows	Commercial	Multilanguage screen reader
ChromeVox	Google	ChromeOS or, with a speech processor, Linux, Mac, Windows	Free	ChromeVox is a screen reader for Chrome and Chrome OS.
Microsurf	Microsurf	Mac, Windows	Free	Microsurf is a screen reader for Chrome.
Claro ScreenRuler Suite	Claro Software	Windows	Commercial	Provides a "strip" or "ruler" across the screen.

Figure 2.10: Commonly used screen readers, [BL08] their creator and supported platforms to access the web technologies.

2.3 Patron Analysis

To design an interface for an application, analysis of patrons about how to fulfil their specific needs can make a huge impact on product usability and patron satisfaction. As this project focuses on an interface to improve the user experience of people with low sight, the following section will help to understand the term "visual impairment" and its types, and it will also discuss the technology barriers and benefits for visually impaired patrons.

2.3.1 Visual Impairment

The term **visual impairment** is considered to be a wide term as it covers many different degrees of vision. Visually impairment person (VI) can be defined as: *a person with limited action and function of the vision system*. The term VI can referred to a person who has low vision or poor eye sight which cannot be fully improved with the use of contact lenses or glasses. People with low sight have a small focus area. According to the National Health Service (NHS), there may be about two million people in the UK living with vision problems, whereas around 365,000 people are registered as partially sighted or blind. The following graph shows disability statistics for the United Kingdom.

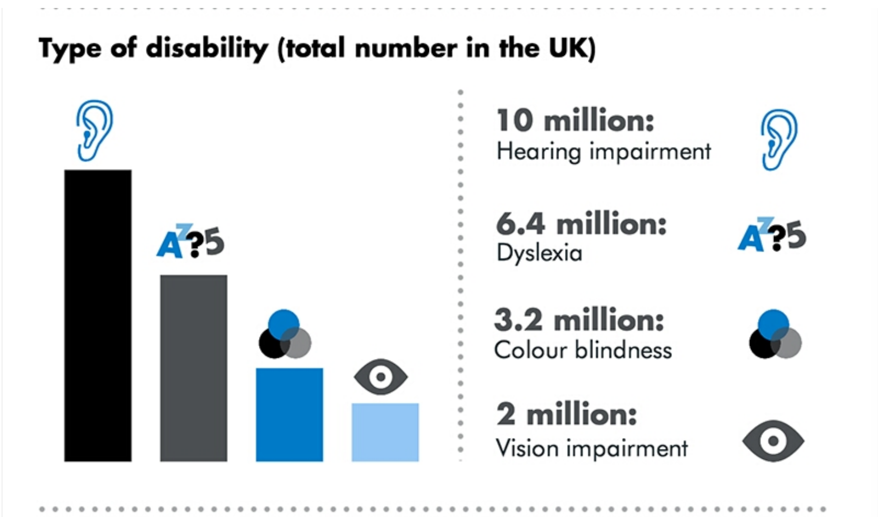

Figure 2.11: Figure provide United Kingdom(UK) disability statistics

Two areas are focused on while testing a person's eyesight or vision.

1. **Visual acuity:** This deals with central vision of the eye, used for instance in

reading books and watching television. A chart with letters on it is used to test vision and score is given against each observation. If a person is given a score of 6/60, this means they can read something from six metres away that a person with healthy eyesight can read from sixty (60) meters away.

2. **Visual field testing:** This deals with the field of vision and different tests or techniques are used to test this.

2.3.1.1 Types of Visual Impairment

The term visual impairment can further be broken down into two types on the basis of test results explained above in Section 2.3.1.

2.3.1.2 Sight Impaired

Sight impaired can also be defined as *partial* or poor sight. The term can be applied to people who have:

1. Poor visual acuity ranges between 3/60 and 6/60, with no issues regarding visual field.
2. Problems with both visual acuity (ranges between 6 and 24) and field (e.g. blurriness or cloudiness in central vision).
3. Good visual acuity but reduced visual fields.

2.3.1.3 Severely Sight Impaired

This type can also be defined as blindness, as the person cannot do any daily activity for which eye sight is needed. It can be further categorised into the following:

1. People with poor acuity ranges, 3/60, with full field of vision.
2. People with both visual acuity and visual field issues (visual acuity range (3/60 to 6/60).
3. People with better visual acuity but worse field of vision.

2.3.2 Technology Barriers and Benefits for VI Patrons

The advancement and adaptation of technology has brought noticeable changes to people's daily lives. Technology has the capacity to increase the quality of people's lives by providing an effective means of teaching and learning [Fug11]. Moreover, it would not be wrong to say that one's future success may rely on how one uses and accesses technology. However, this raises a very important question: Are these technologies [MFT05] equally accessible to people, irrespective of their sensory, physical and cognitive abilities? A survey in [Fug11] reveals that VI people use information and communication technology (ICT) less often than other people, while participants in the survey state that it was hard and challenging for them to use everyday technologies (web pages, kiosks, ATMs, mobile devices and elevators) and that they felt discomfort in doing so. It is therefore important to have detailed knowledge about the challenges, barriers and benefits for visually impaired people, when they interact with technology in order to provide products with maximum usability. We discuss some of the everyday technologies and their accessibility and usability for visually impaired users in the next sections.

2.3.2.1 Web Pages and Accessibility

[SPAS98] revealed that generally, it seems the majority of web pages are accessible to VI users with the help of screen readers or assistive technologies. However, in practice, [MFT05] study denies the above statement as it seems some websites are hard and challenging or even inaccessible for VI users to interact with them. For example, it is almost impossible for VI users to book railway tickets online. The same study also completely rejects the general conclusion that some web pages are accessible to VI users as the presence of inaccessible electronic forms and documents makes them inaccessible to users with visual impairment.

2.3.2.2 Online Banking and Accessibility

Online banking [WWSB01] is a modern way to manage bank accounts and transaction. It does require security, registration and authentication, which are more complicated than other processes found in network services. To use online banking, a code generator is commonly used for double security checks or authentication. This device is inaccessible to screen readers. For the sake of argument, if this authentication issue solved by with the help of someone else, still VI users may still be afraid of making mistakes, due to poor accessibility. Also, to run and manage an online bank account, it is necessary to read information on paper bills. So it would not be possible for VI users to complete online bank transactions without help from someone else.

2.3.2.3 Self-Service Terminals and Accessibility

Self-service terminals like public kiosks, ATMs and ticket machines help to transfer services from humans to machines. Study [Fug11] shows that these technologies in their current forms are often difficult and sometimes inaccessible, for users with vision problem. Modern kiosks and ATMs with touch screens make it more challenging, as touch screens are a single continuous surface for interacting with machines. These technologies are harder to use in public places for visually impaired users if there is a long queue behind them waiting for their turn. ATMs are considered to be less [Fug11] inaccessible, compared to other self-service technologies, as in most places mode of input is a keypad and sometimes Braille input is also available for VI users. However, modern touch screens ATM systems are still a big challenge for VI users.

2.3.2.4 Mobiles Devices and Accessibility

In today's modern world of technology, mobiles are one of the most commonly used devices and are common among VI users too. Mobiles have had a huge impact on the lives of VI users and have made them less dependent on others for communication. The study [AFCD10] reveals that this technology has its own challenges. Although the use of Braille, text to speech (TTS) and speech synthesis has made them accessible to VI users. There is a small number of mobile devices available in the market that are usable for VI users or suitable with TTS [Fug11]. It is difficult for VI users to test mobiles font sizes or other feature in the shop without the availability of proper assistive technologies, and therefore to make the right choice. However, it is also a fact that [Fug11] devices like GPS, smart phones, notebooks with built in assistive technologies help to make it easier for VI users to interact with other people.

2.3.2.5 Conclusion

There are alternatives to these technology challenges, discussed in [Fug11] and further initiative can be taken to solve these problems. For example, online web booking services can be installed on VI user's mobile devices as they are more accessible and easy to use in the user's familiar environment. Training on how to interact with technology on multiple platforms can overcome day to day challenges. The study [Fug11] proposed the six research areas that could help to develop technologies that meet with VI user's requirements.

1. There should be continuous development, with corresponding tools, to make services accessible.
2. The authentication and registration processes should be designed in such a way as to be accessible to VI users too.
3. Learning materials need to be interactive and accessible.
4. Web services should be accessible on mobiles too for better accessibility.
5. Social network services and web tools must be accessible.
6. There should be more accessibility on the internet.

2.4 Extra ordinary Human Computer Interaction

Humans are different [NG99] in term of their physical cognitive and sensory abilities. All humans are different in term of their skills, education, cultural mores and abilities. Similarly, an obvious difference exists between children, adults and older people. In addition, some people are classified as disabled or people with special needs. Many such people who are placed in physical or cognitive impairment category are in the workplace or could partake in employment. Hence, people are very diverse [Edw95] in their abilities and due to better healthcare and improved lifestyle, there is likely to increase in people with the diversity of disabilities in the workplace. When it comes to technology and work, it is important to address the needs, characteristics and wants of peoples with disabilities and people comes under other categories such as temporary visual, physical and sensory impairment [PN07].

Human-Diversity and Technology It is important to consider all the characteristics of the potential user including users with special needs when designing a technology for the use of public or workplace. Study [NG99] shows age and gender have a significant effect on (HCI) human-computer interaction. Not all disabilities do directly affect the technology required at the work environment. But some disabilities like vision or dyslexia impairment may be able to relate directly with technology use at public or workplace. Some studies [NG99] [Edw95] reveals that human- computer interaction (HCI) have a seriously concerned with access to the computer for the people with special needs or disability. In practice, progress in this field is slow. Facts show [Fug11] that technology design and access primarily based on 'norm' users rather than users who are disabled. This routine also reflects in research papers, where very few papers consider people with special needs under the category of potential users.

Study [NG99] reveals an important fact that designs which deals with the needs of people with disabilities can produce a better design for all potential users. However, a certain group of engineers do not prioritise their design on the base of ease of use.

There are many examples which are directly related to human-machine interface. For example typewriter (developed in 1880) that enable blind to write, television caption for people with hearing impairment etc. At the time of writing, web pages have been made to give access to blind people by replacing graphics with text. These pages can also be converted into synthesised speech to convey the information on the page.

Disabled Person Characteristics The term disabled can be very controversial, for example, there are many people with severe hearing loss may not consider themselves to be disabled. Similarly, people with the low sight that can be corrected with spectacles do not come under term 'visually disabled', even without their spectacles their ability to see is same as someone who is visually impaired. Similarly, there could be temporary, by accident disability cases [NG99]. Factors like fatigue, stress, noise level or combination of these can cause change in person cognitive ability during work for all the reasons explained above, people do not consider themselves disabled but their ability to operate standard equipment may reduce. To address these issues, designers should take into account patron's needs [Mag01], especially when designing a technology that will benefit people at public or workplace.

2.5 Interface Design

The following section deals with research that contributes to an understanding of what should be considered when designing an interface for an application and of how we can provide a better form of interaction for people's needs. To design an interface, it is essential to understand the user's requirements and needs in order to deliver an application with maximum advantages and usability. The study of human cognition deals with human behaviour under different circumstances. It covers human behaviour, perceptions, short and long term memory, understanding of language and speech etc. Cognitive studies insist that if a product does not satisfy the user, then it does not fulfil the complete purpose producing it. The distance between cognitive science and the design engineer is considered to be one of the most significant human factors in designing an interface. It is assumed that interface design is based on the designers theoretical or individual understanding, while a cognitive approach to interface design is not a simple approach. This is because cognitive studies does not only consider the issue from the perspective of designers and engineers, but also from the point of view of neuroscience. According to research by [Mag01], many factors like colour, location and texture affect the usability factor of a product. It proposes that usability can be achieved through simplicity so that users can easily find what they need.

2.5.1 Usability

This project focuses on how the usability of kiosks can be enhanced or how to improve the interface to meet patron's needs. The focus is also on patrons with low or poor sight. Study and research shows that the use of speech can make a difference to an interface for partially visually impaired people. According to the RNIB [RNI15]:
" The addition of speech and Braille input to an application can even make blind people interact with an application".
The desire to design a better interface for the human interaction system has set new challenges for designers as new methods are being encouraged for the design of an interface that fulfils the user's requirements. Questions are being raised as market is being hit by more and more applications. Designers are also considering and showing interest in traditional user centred design (UCD) or human centred design (HCD). They are willing to look for new design methodologies for applications and software that are suitable for patron's needs. In most past cases, in research into interfaces for human-computer interaction, user's are taken to be ordinary people with average abilities. Most researchers [Edw95] [NG99] consider only one model of the user with a lack of deep knowledge of the actual needs and requirements of that model. Contrary to previous approaches, at worst most interface software applications give the an impression they are designed only for patrons aged 25 who know almost everything about computers and who could even be called experts. A change in vision is needed which sees that the disability factor can make a difference with designing an interface for people with disability. Disabled people should be treated as people with extra needs.

2.5.2 Sound Based Interfaces

Sound is an important and effective means of communication. The advantages it offers can be used to enhance the usability of applications for visually impaired patrons. The use of sound, or non-speech, can be observed in computers when an alarm sound is produced to warn if battery is low, in medical equipment such as the beeping sound of ultrasound machines, in industry when machines sound warnings or indicate malfunctions. Research by Karpov and Ronzhin [KR14] shows that the addition of sound to an interface can improve the user experience of the end user but can also help patrons with low vision to interact with it more effectively. The use of speech in an interface acts as assistive technology for patrons with low vision and helps them to navigate the application to achieve the desired service easily and independently. It not only benefits the patron with a sight problem but also helps those whose focus is not on the application or whose focus is divided. A graphic user interface (GUI) with audio allows more natural communication between humans and systems. Sound can give a patron the choice of the best sense instead of only relying on vision. However, use of multiple media in interfaces is still in its early stages. One major reason for using sound with graphics is to facilitate more models of users. Another motivation behind this is that user's eyes may not be able to do everything. For instance, if a patron's focus is on one part of a display, then there is a possibility they may not focus on another part of the application at the same time. In contrast to this situation, visually impaired patrons can have the full benefit of audio to do the job.

2.6 Software Engineering Process

The software process Kanban [GM03] has been used for this project. Kanban is another methodology or technique to implement agile. Generally, scrum and Kanban similar to each other, but both are different [AL15] frameworks. Kanban offers more flexibility as compared to scrum. Kanban provides flexibility in planning that was a key requirement for this project. Scrum focuses on do as many jobs as possible from a backlog. A backlog is a list of pre-defined tasks and has been defined at the beginning of each sprint.

Scrum based on regular fixed-length sprints (usually 2 weeks). Scrum also focuses on not to make changes, once sprint has been started. Contrary to scrum, Kanban concept based on continues flow. Kanban increases the velocity of work and keeps minimise work-in-progress. The Kanban priority is to finish the work as soon as possible, once it's started. Kanban sprint length is variable. This mean sprint length is not fixed and it also welcomes changes. Kanban board have a loose collection of tasks called "To-Do" column, sorted by priority as shown in Figure 2.12.

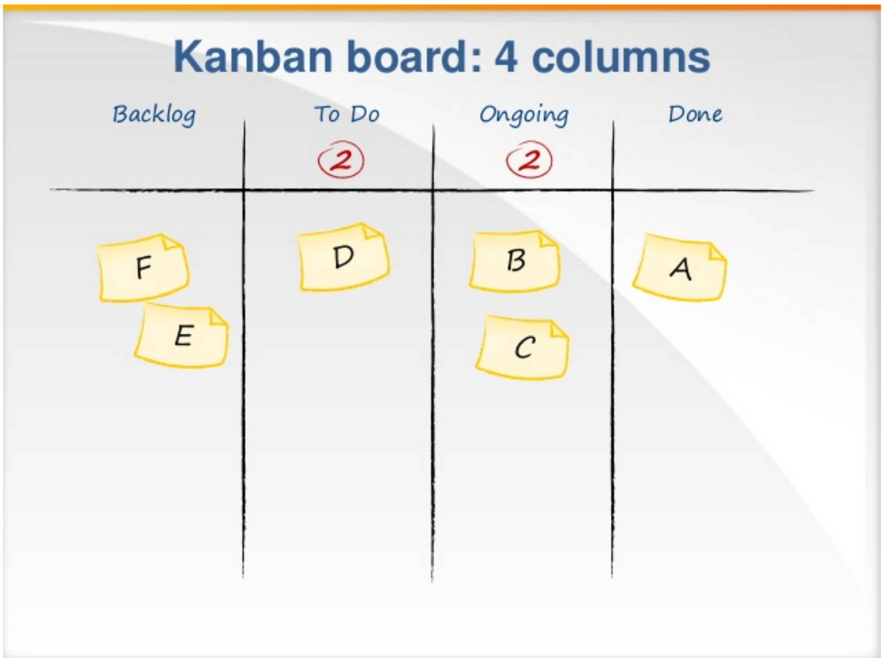

Figure 2.12: A presentation of Kanban Board taken from [op15b] that shows jobs division in To-do, Ongoing and Done columns.

The Kanban is a practice of continuous improvement and continuous delivery. Continuous delivery makes sure that there should be some features delivered at the end of each sprint. Another important feature of Kanban is informal and quick feedback from the patron. This allows getting feedback on done work and allows conclusion or changing for next sprint. Review cycle for this project was up to one month. At the end of each cycle, it was necessary to amend the process in the light of valuable feedback. The standard sprint length was set for two weeks. But in case of certain events (like exams) had prolonged to three weeks.

2.7 Background Summary

This chapter provides the concept of self-service prototype application in a wider research context. The chapter showed for the application, touch-display kiosks accessibility for the visually impaired patrons, can be connected to the already done work in different fields like web accessibility, mobiles, tablets etc. A major requirement for this project was to fulfil the real-time needs of visually impaired users without compromising the user experience for non-visually impaired users. The references provided in this chapter, explain the related work, meet with the same challenges. This chapter also guides about the basic user interface principles and design guidelines for the designer to develop applications, which require extraordinary human-computer interaction. This chapter concluded with the software process Kanban, which has been used for the implementation of prototype application.

Chapter 3

Design and Implementation of the User Interface

The user interface is one of the important components of an application. Chapter 2 explained the importance of the interface in any application. It acts as a bridge between user and service provider. The user interface is the part that conveys information to the user. To serve a wider range of patrons, technologies should be well-established and reliable. It is important to know that the best results and statistics cannot be achieved if the application is not presented in an appropriate way.

This chapter presents in detail the design and development process of the user interface for library kiosks. First part explains the concept and design of system architecture. Second part of chapter explains the decision taken toward technology selection and implementation. Next part of chapter explains the reasoning behind the colour contrast used for the interface. This is followed by section which explains the font and button size, designed for visually impaired users. The last section explains the use of speech in the prototype.

3.1 Design and Concept of System

The user interface of the prototype does have same number of options (Borrow,return,account) as in Liber8 application at Bibliotheca, but with complete changed visualisation and addition of speech synthesis. The proposed prototype was not entirely planned before the start of implementation. The final outcome software application is the product of software engineering and had been achieved from an agile approach that focuses on iteration. This section will provide the details about software engineering process and its architecture. The following part will provide some basic information about the agile design and its relation to Kanban methodology.

3.1.1 System Design

The system design of the project is closely related to the agile methodology Kanban. Initially, the concept of system design was not specified but builds iteratively. **YAGNI** Principle ("you aren't gonna need it") had been used for this project, as only the required parts which necessary, were designed. This methodology leads to some refactoring throughout the project, but it helped also to reduce the number of unwanted features. System design of the project was consistently reviewed and amended to keep code simple and clutter free.

3.2 Technology Selection

Although there was no recommendation or restriction by Bibliotheca, a careful research has done for the selection to choose the right technology. The following section describes the available technologies that were considered for the design of the prototype user interface and explains their advantages and disadvantages.

3.2.1 NetBeans IDE

NetBeans is an open source integrated development environment (IDE[1]) that is used to develop web, desktop and mobile applications. It support various languages like Java, HTMLS, PHP and C++, and can be extended to support many other languages. It runs on multiple platforms such as Mac, Linux, Windows and other Unix-based systems. With NetBeans swing GUI[2] builders, java desktop applications create a professional user interface. Although GUI features are provided in NetBeans, the use of speech synthesis could be challenging for the first time as ISAPI (A free Text-To-Speech) for files needs to be added to the NetBean directory. To conclude, the use of NetBeans technology may require the implementation of all or some parts of User Interface but the addition of audio or speech could be challenging. Since this project had a short

[1] Integrated Development Envoirnment
[2] Graphic User Interface

time-span, the use of NetBeans IDE would have meant a lot of effort compared with the benefit it offers.

3.2.2 Visual Studio

Visual Studio is a development tool used to develop mobile, Windows and cloud applications. Visual Studio enables a developer to create multi-platform applications for Windows, Android and iOS in a single integrated development environment (IDE). It has options to write code in C#, C++, JavaScript, Visaul Basic, F#, python and many more. There are thousands of extensions available in Visual Studio, from gaming to PHP.

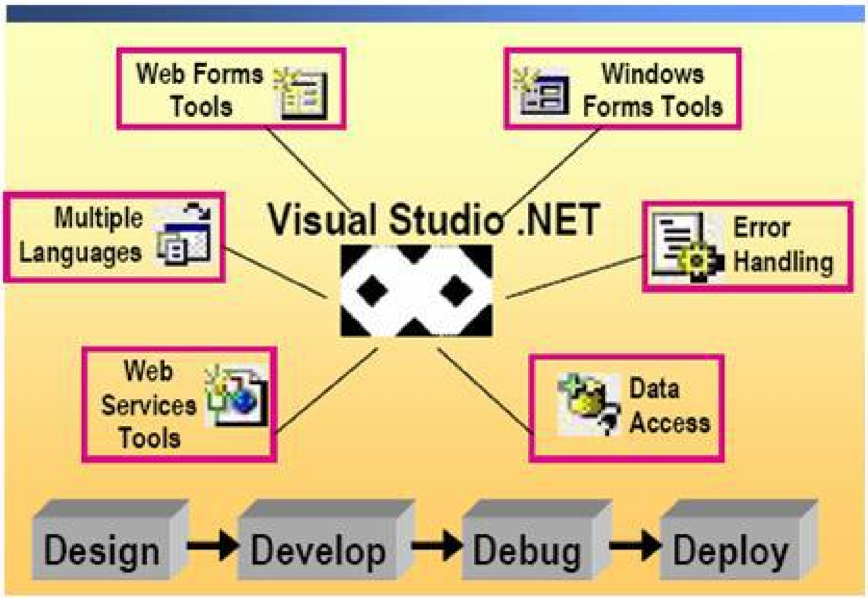

Figure 3.1: Figure reproduce from [oMn15] shows the Visual Studio features it offers to developers.

Visual Studio has the ability to manage complexity and resolve issues more quickly with the use of intellitrace. Also, microsoft developer network (MSDN) subscription provides much benefit for developing and testing software. Visual Studio Enterprise-grade solutions provide maximum support for work on large and complex projects.
It would be possible to implement this project in a number of programming languages, and a few have been considered and analysed for suitability for the project. C++ and C# were two of the best candidates for implementations in the project. From a syntax point of view, both languages are quite similar. In spite of similarities, the two languages have their strong and weak points. C# has the advantage of automatic memory and

safe coding conventions, but still relies on the .NET framework which can make it slower than C++, which has a binary compiler. C# was selected to implement the prototype application.

Visual Studio 2012 was chosen for the project after careful consideration. The next decision was to choose between Window Forms (WF) and Window Presentation Forms (WPF). Both have their advantages as Windows Forms is older, more procedural and more tested as compared to WPF.[3] In cotrast to Windows Forms, WPF is new and declarative by nature. As the project is about designing an interface that enhances the user experience for people with low vision, WPF is considered as the best choice on the basis of the following advantages:

1. Because it is new, WPF meets current standards.
2. Use of XML[4] makes it easier to create and edit the graphic user interface (GUI).
3. WPF allows the work to be split between designer and programmer.
4. It has a choice for making user interfaces for both Windows and web applications.
5. It allows data binding for clean separation of layout and data.

With the consent of all stakeholders, Visual Studio was chosen for the prototype application. Another major reason to choose Visual Studio was the technology help available from Bibliotheca team.

3.3 User Interface Prototype

Following to the decision to use Visual Studio with the combination of Windows Presentation Forms, development on the prototype was started. The user interface design was kept to basic and simple to make it more accessible for the visually impaired users. It is also important to notice, proposed prototype also accessible to normal users too.

3.4 Implementation

The project had not pre analysed user interface features. The entire progress had been made with sprint to sprint after getting feedback from users. And prototype functionality had been improved and extended till the date of project submission. Visual Studio

[3] Windows Presentation forms
[4] Extensible Mark-up Language

MVC[5]architectural pattern separate the application into three components and gives an choice to work on user interface without effecting the other parts of application as can be shown in Figure 3.2.

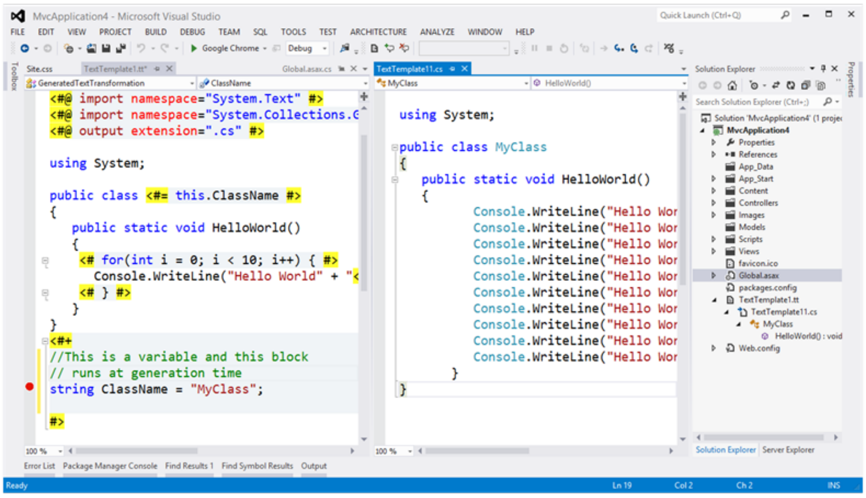

Figure 3.2: The Figure shows Model View Controller architecture in visual studio development environment

3.4.1 Libraries

The Visual Studio libraries had been used for user interface components are **windows.media, windows.imaging, windows.navigation and speech.synthesis** as shown in Figure3.3. These all libraries are part of Visual Studio and provided by manufacturer.

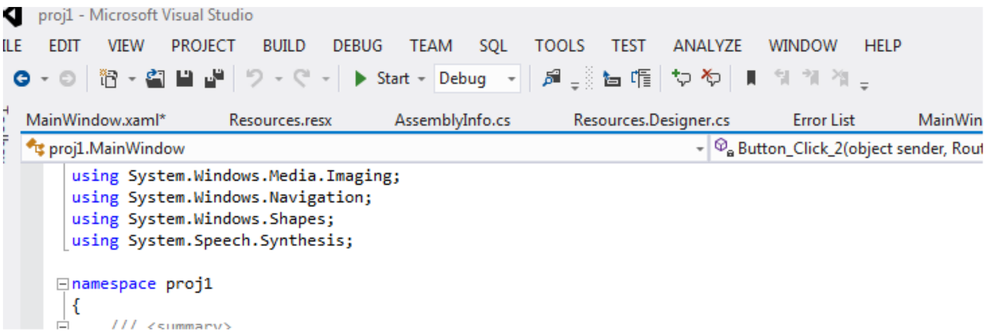

Figure 3.3: Figure shows the libraries used in the prototype for User Interface components and audio

[5]MVC=Model View Controller

3.5 User Interface Components

The Liber8 interface, originally have a white background, Black and white colour combination on buttons, small size button and smaller font size as can be seen in Figure 3.4.

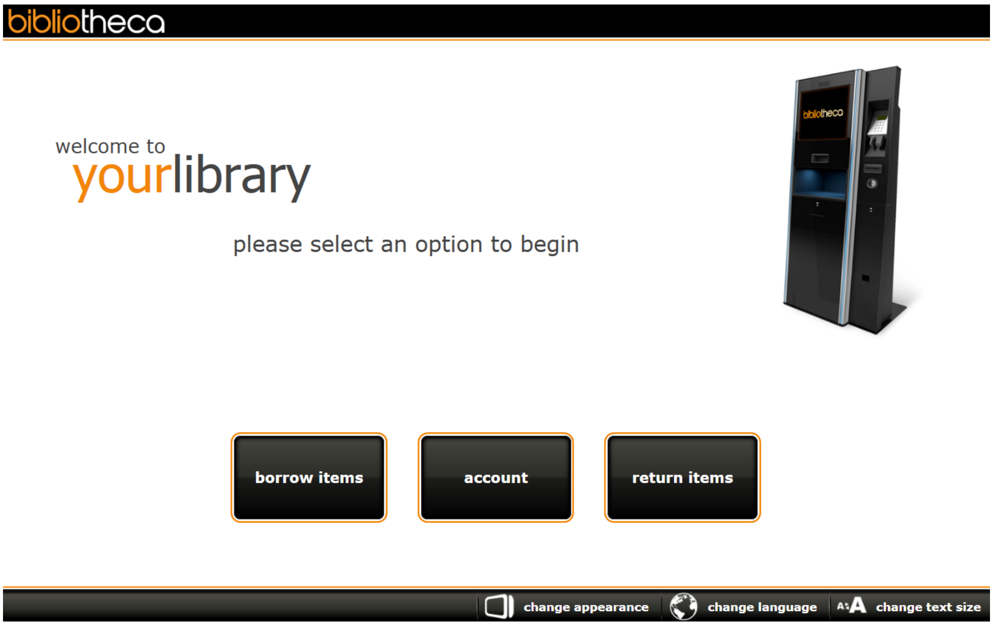

Figure 3.4: Liber8 interface with white background, smaller font and button size.

Based on thorough research and information derived from visually impaired users, Following area's were discovered on Liber8, which could be act as access barriers for VI users in access library kiosks. The areas are:

1. White background
2. Small font size
3. Small size button
4. Colour combination of an interface
5. Only emphasis on text for Human-computer interaction

3.5.1 Use of Graphics

Based on the guidelines, prototype implementation was started. A dark background had been used for the application as show in Figure 3.5. The prototype application has large buttons size and font size to make it accessible for the patrons, which use big font keyboard for the computers. A simple designing approach has been used for the application to make it clutter and confusion free for the VI users.

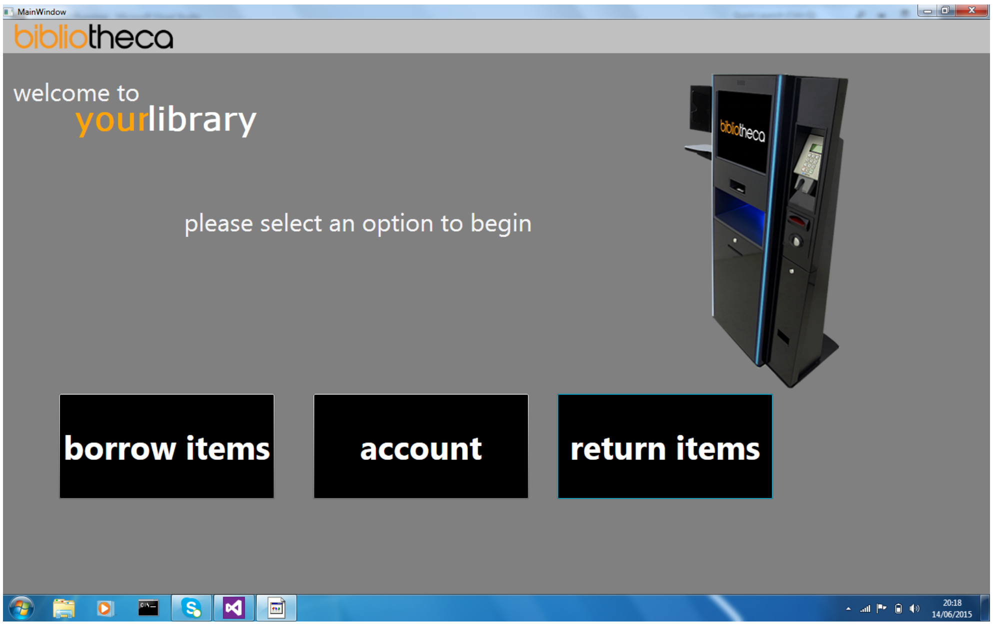

Figure 3.5: Prototype application interface with the dark background, big buttons and big fonts.

3.5.2 Speech Synthesis Use

For this application, instead of only relying on interface visualisation, second communication medium, audio also has been used to make it more accessible for VI users. To make it happen, speech system library from WPF[6] service manager has been used. Furthermore, text on each button has added. This text translated into audio, when a user clicked on button to access a library service, which make it easy to interact for VI users. This setup allows a quick communication between kiosk and VI user. Figure 3.6.

[6]Windows Presentation Forms

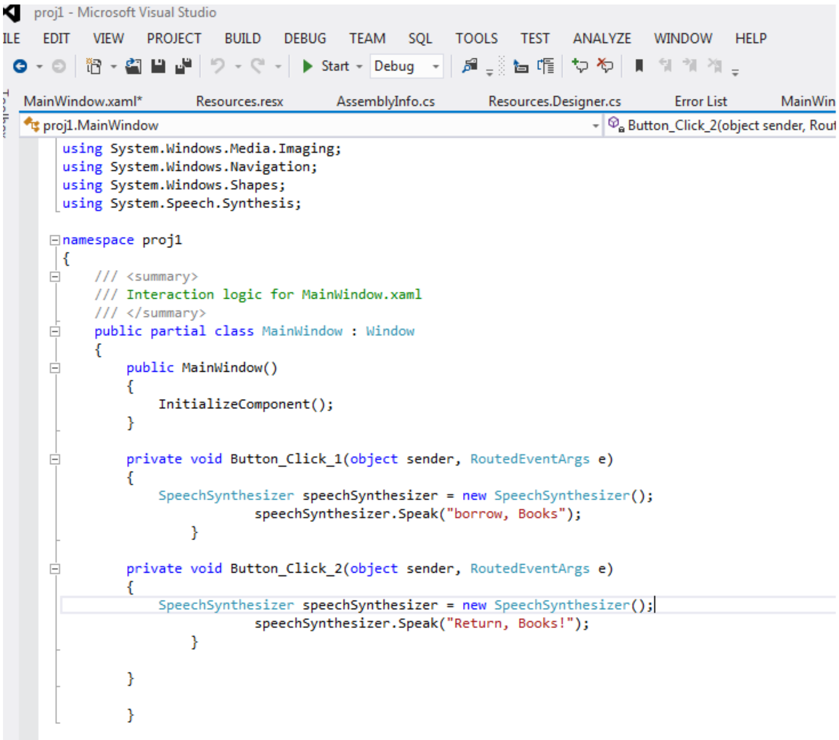

Figure 3.6: Application code snippet used to convert text into speech for each library service.

3.6 Summary

This chapter explained the entire implementation of the user interface prototype. The first part of chapter describe the system design and technology. It also provides the justification for choosing Visual Studio and WPF. Last part of the chapter explains the visualisation of user interface and use of speech synthesis in prototype application.

Chapter 4

Patron Evaluation

User evalution of software is considered to be an important part of any project as it reveals the usability of the product and it was very informative for this project too. Feedback got from VI[1] users decide the success of the project. This chapter provides detailed information about the user evaluation. As this project focuses on the interface, the evaluation or user testing therefore had a major impact on the final result. A major issue we had to face during this phase was to find as many end users as possible with visual impairment. In our experience, it was very challenging to find large numbers of visually impaired users who were willing and able to participate in our study. In our experience we have found that some of users had never used kiosks before. The major reason behind this is that current library kiosks are completely inaccessible to visually impaired users, so they do not use them and rely on the help desk or other resources (including the web and the local services, Henshaw's). Another major reason for not finding visually impaired users is that many services specific to visual impairment or vision, such as the Royal National Institute for the Blinds UK (RNIB) library in Manchester [RNI15], have been closed due to government benefit cuts.

4.1 Participants

In total our prototype application was used by fifteen people. These were classified as follows:

1. five users were visually impaired;

[1] Visually impaired

2. two users were blinds;
3. eight users had no visual impairment, but used dark glasses to simulate visual impairment.

A group of users with no visual impairment can be assumed to have familiarity with or knowledge about touch screen technology and kiosks. The seven users with visual impairment (VI) can be assumed to be computer literate but some of them were naive in terms of interaction with kiosks or touch screens.

4.2 Task

All participants were asked to complete common library tasks like borrowing and returning items. In some cases they were instructed to choose a specific option. A person familiar with computer technology and library kiosks would be able to complete the process of borrowing or returning books within minutes. This depends upon the option selected and the number of books he or she is borrowing or returning. After this, a number of questions were asked in order to get their feedback on each component and on further assumptions and features.

4.3 Set-up

Instead of an actual kiosk (normal screen size, 19 inches), a touch screen of size 21.5 inches shown in Figure 4.1 (54.6 cm) was used. Use of real kiosks was not feasible for the evaluation since this was conducting at various places, (such as Manchester Central Library, the University of Manchester and the Bibliotheca office in Cheadle Hulm), and it was not possible to carry a large kiosk from place to place for the user evaluation. Nor was not possible to get all of the participants in one place.

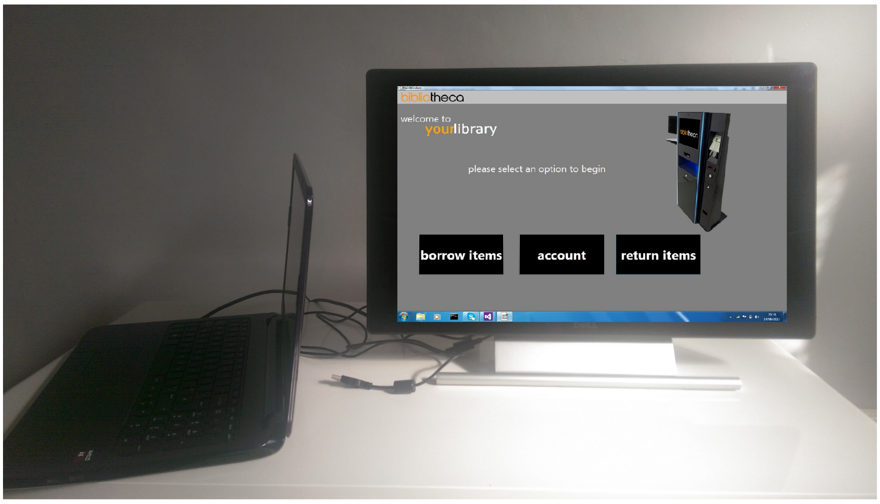

Figure 4.1: The apparatus used for user testing; a large touch screen (54.6 cm) and laptop for audio.

The screen was attached to a laptop running the prototype application. Built-in speakers on the laptop were used to play audio. Both kinds of apparatus were located close to each other so users could hear the audio clearly.

4.4 Procedure

Each user was given a brief introduction, except those who already knew about the kiosk use. Their time for completion of the task was recorded. The evaluation procedure was conducted in multiple location, including the University of Manchester, Bibliotheca offices in Cheadle Hulme, Manchester Central library and Levenshulme Library. At each location, the same apparatus was used to complete the analysis. All the sessions held in libraries gave an opportunity for users to compare a real working kiosk with the proposed prototype software.

4.5 Results

All participants successfully completed the tasks without any training. Participants with visual impairment and no experience of touch screens took longer than participants familiar with touch screen interaction. The graph below shows that the time differences between the three user categories are relatively small. The participants with no visual impairment completed the task faster than those who were visually impaired. One reason for this could be that all participants aged 14-36 were computer literate and already knew how to use a kiosk. This group of users were more familiar with touch

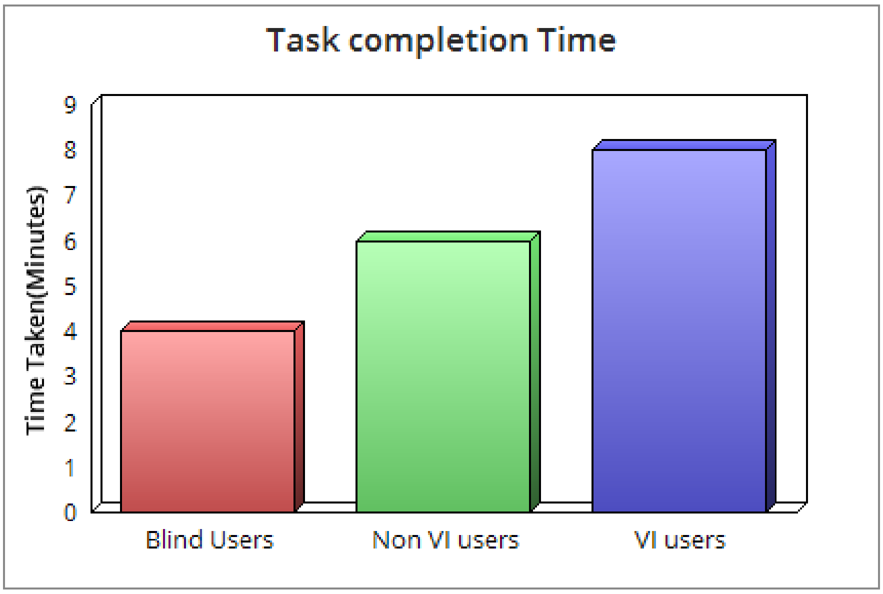

Figure 4.2: Chart comparing the times taken to complete a given tasks for blind, visually impaired and non-visually impaired participants

screens and felt free to explore the interface, compared to the participants with visual impairment who were familiar with computers but less confident with kiosks or task oriented interaction. For some participants, it was hard to understand the features and the interface that our prototype application offers. It took time for them to understand what they actually had to do. Initially, some participants clicked on the instruction text, as shown in Figure 4.3 rather than clicking on the button and waiting for an action.

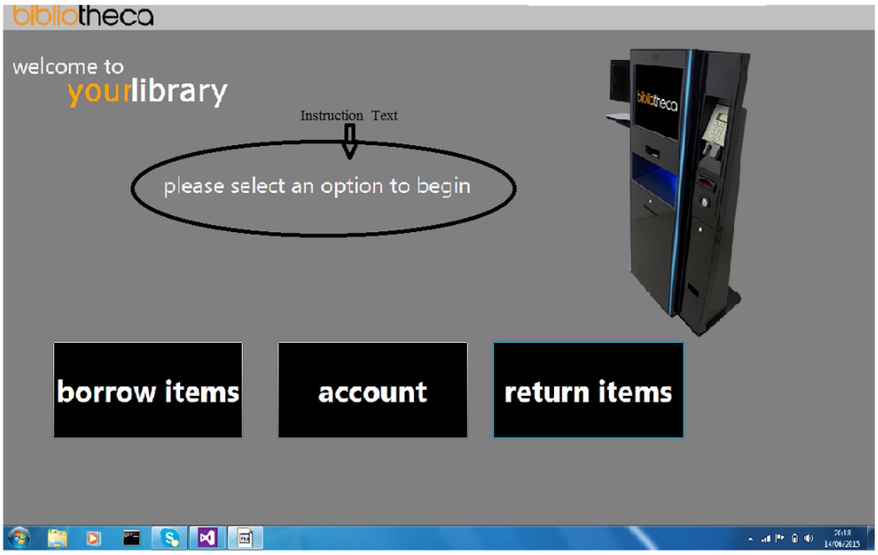

Figure 4.3: A user clicks on instruction text in the middle of the screen, instead of buttons that can be seen below.

This also took a fraction of time. About half of the visually impaired participants had difficulty in hearing the audio as they selected specific options and clicked more than twice to hear the sounds clearly.One possible explanation for this could be that the audio came from the laptop while they were selecting buttons on a separate touch screen monitor. Even though both apparatus were close to each other, the laptop speakers did not always face the participants because desk space was limited in some test locations. This suggests it would be better if headphones were connected, which would also reduce noise.

Participants with partial visual impairment found it easier and felt more confident to select library services on the prototype as compared to selecting them on a library kiosk, where the button text and colour are hard to see. Overall, the majority of participants completed the task on their first attempt. When patrons used the interface for a second or third time, it was easier for them to select the required option, as they became familiar with the interface and became more capable in interacting with the kiosk effectively and quickly. One interesting suggestion made by one of the blind participants was that the touch screen could be easier to use if it was in a more reclined position (like an ATM) rather than vertical. Generally, the reaction and remarks from participants during the evaluation were very positive with words such as **nice** and **really good idea**. Some visually impaired users pointed to the fact that **it was the first time they had used a library kiosk** and that it could be useful for them for borrowing audio/video items, while they can do library tasks without the need for help from staff. Most participants seemed satisfied with our colour combination and background colours. However, one participant with visual impairment suggested that the instruction text colour should be darker than it is on buttons, can be seen in Figure 4.4 and Figure 4.5

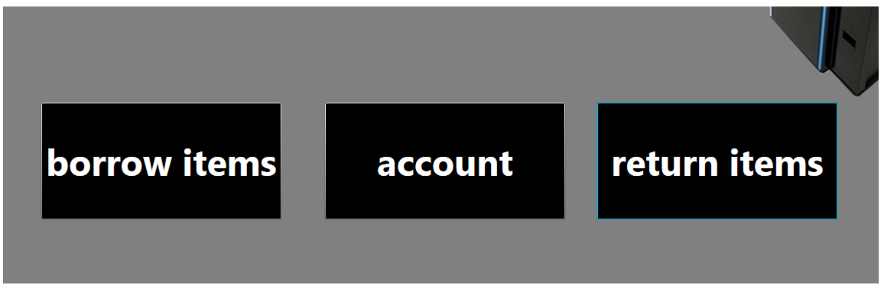

Figure 4.4: Black and white combination on buttons has been used to make it more in readable form for visually impaired users.

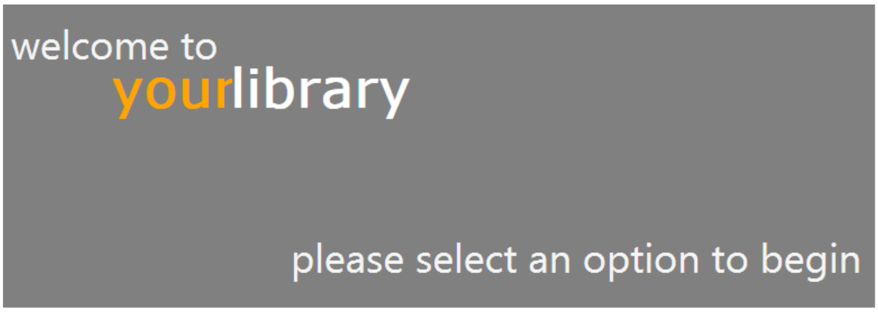

Figure 4.5: One participant found grey and smoke white colour combination confused, which has been used for instruction text.

4.6 Summary of Questions

The following section will summarise the results from the question asked of the participants during user testing. The questions asked after testing session were:

1. Do you think the application with the change visualisation enhance the kiosk usability?
2. What user interface component, you think is good or helpful in accessing library tasks?
3. Do you think audio or speech does make a huge impact for accessing kiosks?
4. Would you prefer to use kiosk for library tasks, if it is easy to access?
5. Do you think social media interaction on library kiosks can be advantageous? Why and why not?
6. Do you think kiosk can also helpful to access or downloading the audio books for visually impaired patrons.
7. Which user interface component in prototype does not make a big difference for you?
8. Part of the application, you like most?
9. Part of the application, you dislike?
10. Any further recommendation, you would like to see in application.

4.6.1 Usage

The first question was about whether participants would use this application and how often (regularly or occasionally). Most users showed very positive response and stated that they will definitely give it a try. some of users stated that if it is accessible to them, they would definitely give it a try as the currently installed kiosks are not compliant with their basic needs. One of the users stated that a major reason for not using this is the traditional borrowing book system as users with visual impairment need audio or other book formats to access information. When asked for what services they would prefer to use this application, some of them answered that they would use it, or preferred it for borrowing audio books or CDs. Graph 4.6 shows the patron response towards the kiosk usability.

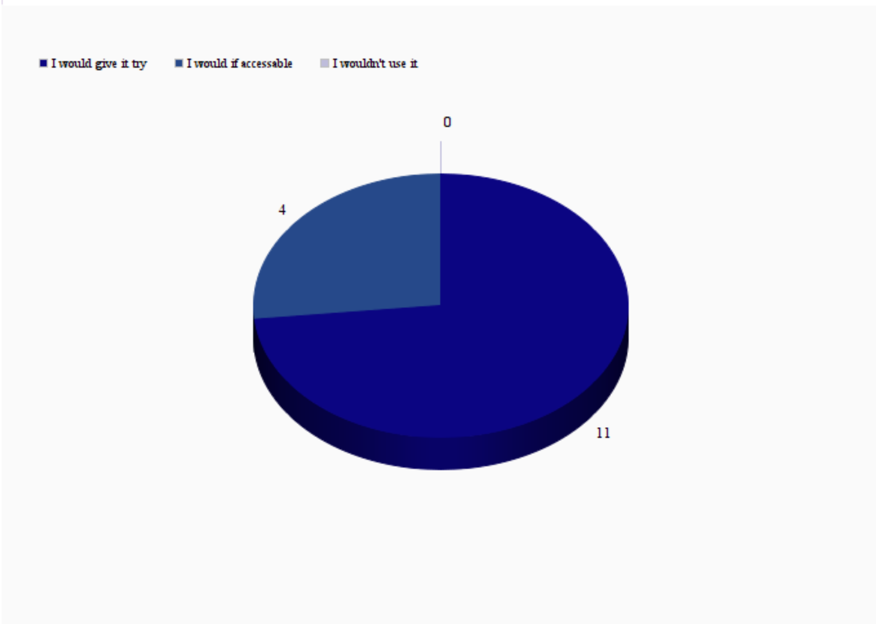

Figure 4.6: Chart shows patron response on use of kiosk in proposed environment

1. I would give it a try 11 (70 percent)
2. I would use it if it is accessible 4 (30 percent)
3. I would not use it 0 (0 percent)

Why would/ why would not use it? As prototype seems interesting to use and offered reasonable advantages such as time saving, less reliability on other persons, give you independence to work on your own and in ease. some responses were 1) I would use it If it is in accessible mode such as there should be additional peripherals (headphone to avoid noise) to use it. 2)I would definitely give it a try as it seems easy to use and interesting. 3) I found it very good as i never use it before and completely new way to access library.

4.6.2 Graphics or Visualisation

Although the major emphasis of the project was on speech synthesis, users with partial visual impairment were asked about the colour contrast and text size. They were asked whether these changes made their interaction easy or not. Most of them stated that it was easier to read with a dark background instead of white or light background. Only one participant gave a different opinion. He stated that, instead of dark background, the instruction text should be in a darker colour with a light or white background. Most users gave satisfactory remarks on this. Graph 4.7 based on questions asked about prototype graphics or visualisation. It shows patrons response on each component of user interface.

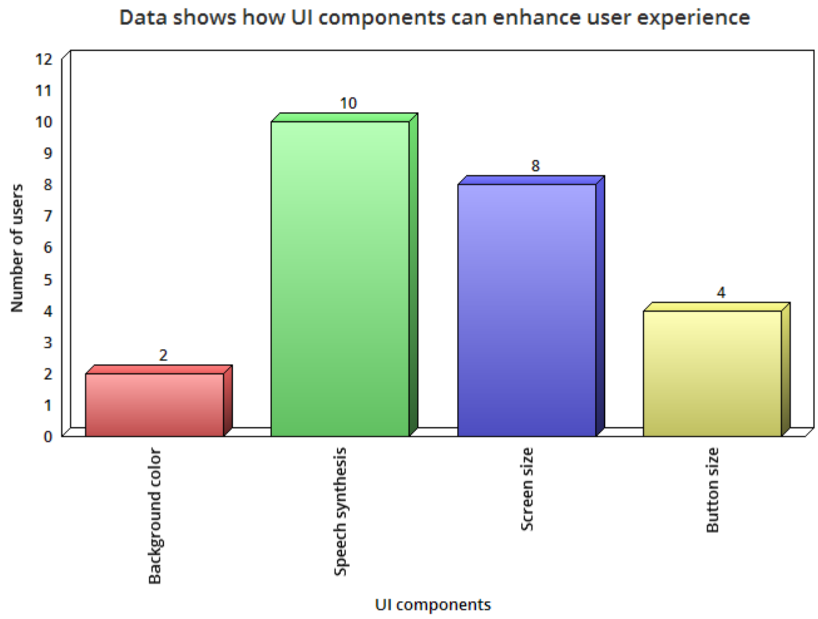

Figure 4.7: Graph shows patron response on each component of user interface

Patrons had been asked individually about the color combination, button size, screen size and use of audio in user interface. As graph 4.7 shows majority of patrons approve the use of audio in user interface and shows that these changes help to improve their kiosk usability.

4.6.3 Social Media Integration

Bibliotheca is planing social media integration (use of Facebook, Twitter) on self-service kiosks. When users were asked if they would like to use these on kiosks, eleven out of fifteen users responses were negative as they were not sure about it. One justification for this could be, that there interaction with kiosks relies on speech synthesis and so they may not like to use social media in public places. One of the users stated that he uses Facebook on his personal computer with special software (like a screen reader), so the use of speech synthesis only may not fulfil the task as required.

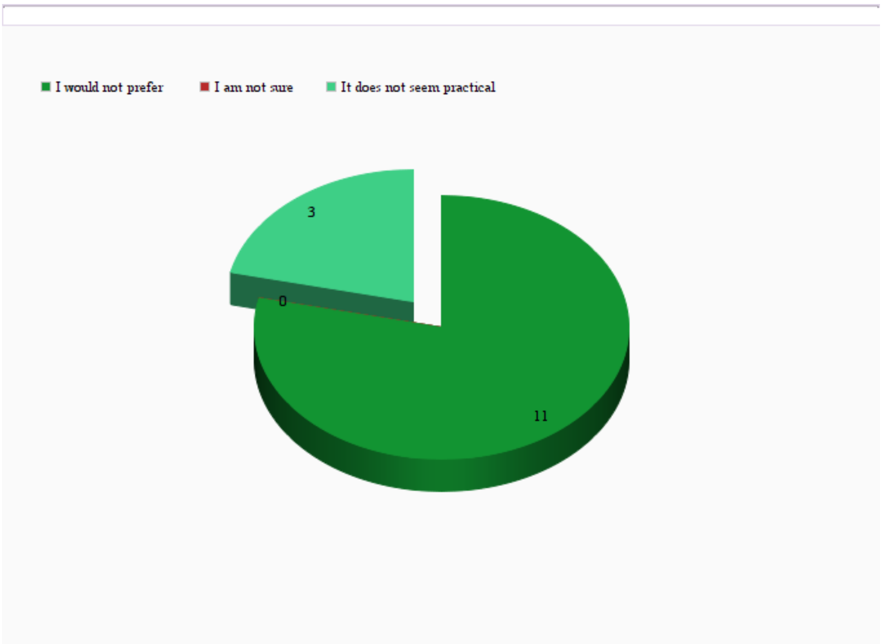

Figure 4.8: Graph shows patron response on social media integration

Graph 4.8 shows majority of patrons dislike the idea of social media integration on public kiosk. Response were like 1)I would not like to use face book or Twitter on public place as kiosk are installed in open places. 2) It does not appeal me and I found no use of it. 3)It seems difficult to me use in public. 4) It does not seems practical as it may need screen reader that will make it more hard to accessible.

4.6.4 Likes, Dislikes and Recommendations

The last questions were about the users likes, dislikes and suggested features. There were negative responses about the absence of additional devices like headphones to avoid noise in public places or libraries. Some negative remarks concerned the apparatus used for the evaluation process. As one user stated the touch screen should be reclined. Most users disliked the idea of social media integration on kiosks. Almost all of the participants liked the use of speech synthesis. Users openly stated that the use of speech made them rely less on the appearance or text. The final question was asked about recommendations or features the users may wish to add or change in the prototype application. Most of the participants stated that there should be access to an audio library, so they can download audio books.

4.7 Conclusion of Patron Evaluation

The prototype application in the current form seems to attract user attention. Users have shown their interest in and willingness to use the kiosks, but the work presented was limited. Some of the issues like additional devices and screen position can be solved with little effort. However, other features like integration of social media or the web may not be so that easy to implement for blind or visually impaired users on the kiosks. It is obvious from the statistics that speech synthesis enhances the usability factor for blind or visually users.

It is important to keep in mind that a very small group of visually impaired people took part in the evaluation process and that a major reason behind this is that current library kiosks are completely inaccessible to visually impaired users. In addition many organisations and institutes (RNIB library[2]) have been closed due to government cuts that make it a challenging task to find people with visual impairment.

There are certain issues which are not addressed in this project; for instance it may be problematic to swipe a library card for patrons with severe visual impairment (as they

[2]Royal National Institute for the Blinds

can only sense light). Similarly, another developing issue was the location of kiosks for users not familiar with a given library location. Although these issues could be solved with the help of special pathways to kiosks or library staff providing guidance for the first time.

Another possible option is the use of screen readers to complete the library tasks. One justification against this would be that screen readers convert all the text on the screen into speech. This may not fit on Kiosks as service button should produce audio when it is clicked by a user. While VI users also use different kinds of screen readers with the different speaking rate (number of the words per second or more). On contrary to this, screen reader use on kiosk may confuse the people with no visual impairment.

Another possible option is the use of gesture to complete the library tasks, in addition to speech synthesis. One argument against this would be that, while patrons in this project successfully interacted with a computer without any training, with gesture they may need prior training, which could be confusing as there would be more options available despite there only being three basic library services.

4.8 Summary

This chapter describes all of the steps taken in the evaluation of the prototype application. It shows that a satisfactory result was achieved and the project can be said to be a successful prototype application for providing library kiosk accessibility to patrons with visual impairment. There had been problems but proposed solutions are also mentioned in this chapter. The summary of questions gives an overview of the feedback from patrons.

Chapter 5

Conclusions and Future Work

This chapter based on the key aspects of the dissertation. First, Section 5.1 summarises the result and findings of this project. This is followed by an outline of possible future work that can be carried out and problems that arouse during the project.

5.1 Conclusions

This project has explored the use of speech synthesis and graphics to make touch-based library kiosks accessible to patrons with visual impairment. The project focus was to achieve this goal without sacrificing or affecting the user experience of *normal* patrons. Self-service kiosks have gained an important place in self-service technologies (SST) and are likely to continue to become more important because of the advantages they offer. This project has proved the feasibility of kiosks for visually impaired users of a Windows prototype application that offers accessibility for people with visual problems. We have developed a prototype application that is a result of analysis of data made available by Bibliotheca. The data provided was enough to extract interesting information.

Implementation of the prototype application serves as a proof of the concept and achieved with a minimal amount of work. We had to analyse the existing work on self-service, accessibility, user interfaces, human-computer interaction and extraordinary HCI[1]. This dissertation is based on all the available and proposed user interface features that are documented in this report. Technologies needed for the implementation had to be portable and flexible. It is shown that Visual Studio, in combination with WPF[2] and speech synthesis, prove to be reasonable choices for the project. Although the project execution was on a single device (touch screen), it is possible to execute it in different environments as Visual Studio offers a choice of multiple platform environment.

Based on background research and data analysis, a simple prototype application was implemented based on user interface graphics and audio input (speech synthesis), which allows a visually impaired user to select from **borrow, account and return** options. Speech synthesis or audio input acted as a main method of interaction with kiosks for severely visually impaired or blind users. The experimental evaluation of the prototype showed that all the participants managed to complete library tasks in less than five minutes on their first attempt. This include all groups, i.e visually impaired, blind and non-visually impaired users.

The designed user interface is simple and easy to use, and evaluation of the prototype showed that almost all participants complete tasks without any prior training. The result obtained shows that use of speech synthesis and graphics along with smaller changes to self-service kiosks, can make a big difference for visually impaired patrons. The interface designed for people with extraordinary needs should rely on a simple approach and be free of clutter as a lot of information can make the system more inaccessible. Moreover, the audio or speech language should be simple and easy to understand.

[1]Human computer Interaction

[2]Windows Presentation Form, choice in Visual Studio to create best User interface design

5.2 Future Work

This project has revealed further interesting research topics that could serve as possible future projects:

Use of Gestures: One interesting topic lies in the area of gestural input. This project focuses on the use of speech as the input mode, but the use of gesture can be further explored, tested and verified to ensure usability when it comes to serving large number of patrons. As library kiosks have to deal with a wide diversity of patrons, gestural input can provide reliability with the same performance and responsiveness.

User Interface Visualisation: The graphic component of this prototype is limited to three (3) menus options, i-e *borrow, account and return*. However, the real world often has more options, such as more menus on the account screen for management of accounts. One approach is to accommodate such problems, but to make the screen clutter-free and stick to basic library options. However, the effectiveness of such schemes needs to be analysed, tested and verified via a large audience. Similarly, use of icons (as explained Section **??**) rather than text could be another option.

Speech Recognition: Speech recognition is another interesting area which could be further explored, tested and verified after careful analysis and research. This area could also address the needs of modern users who want more advanced self-service kiosks while also helping visually impaired patrons to interact with kiosks more efficiently.

Social Media Integration: The user evaluation in this project gave a negative response for social media integration with kiosks. As the users did not think that it would be easy for them to use or felt that they may not have complete accessibility as on their personal devices (phones or laptops). However, it is also a fact that social media integration is one of the key factors for the success of modern applications. This is especially true of those self-services terminals which have large number of users. It could be challenging and interesting to find out how a kiosk can also be accessed by all types of user irrespective of their sensory, physical and cognitive abilities.

Pilot Phase: The user evaluation gave valuable information about the users' **opinions** of the application. This project was evaluated by a very small group due to problems in finding users (as explained in Section 4.7). However, it is necessary to extend these tests on a large scale if the existing work continues. This pilot phase could be based on large number of users (hundreds of users) and can be run on actual kiosks rather than in a simulated environment. This study could provide valuable information that can be used for further development of the prototype application.

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Appendix A

Data File Extract

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Documents;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Imaging;
using System.Windows.Navigation;
using System.Windows.Shapes;
using System.Speech.Synthesis;

namespace Vp_project
{
<summary>
```

```
Interaction logic for MainWindow.xaml
</summary>
public partial class MainWindow : Window
{public MainWindow()
{
InitializeComponent();
}
private void Button_Click_1(object sender, RoutedEventArgs e){
SpeechSynthesizer speechSynthesizer = new SpeechSynthesizer();
speechSynthesizer.Speak(" Borrow items !");
}
private void Button_Click2(object sender, RoutedEventArgs e)
{
SpeechSynthesizer speechSynthesizer = new SpeechSynthesizer();
speechSynthesizer.Speak(" Account details!");
}
private void Button_Click_2(object sender, RoutedEventArgs e)
{
SpeechSynthesizer speechSynthesizer = new SpeechSynthesizer();
speechSynthesizer.Speak("  Return items!");
}
private void Button_Click_3(object sender, RoutedEventArgs e)
{
this.background = System.Drawing.Color.DarkBlue;
}
public System.Drawing.Color background { get; set; }}}
```

```

<Window x:Class="Vp_project.MainWindow"
xmlns="http://schemas.microsoft.com/winfx/2006
/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
```

```
Title="MainWindow" Height="800" Width="1100" Background="Gray">
<Canvas>
<Label Content="welcome to" VerticalAlignment="Top" Height="55"
Width="207" FontFamily="Ebrima" Foreground="WhiteSmoke"
FontSize="36" Canvas.Left="10" Canvas.Top="75"/>
<Label Content="library" Height="71" Width="179"
FontFamily="MS Reference Sans Serif"
Foreground="White" FontSize="48" FontWeight="Bold"
Canvas.Left="205"
Canvas.Top="109"/>
<Label Content="your" Height="93" Width="118" FontSize="48"
FontWeight="Bold"
Foreground="Orange" FontFamily="MS Reference Sans Serif"
RenderTransformOrigin="0.5,0.5"
Canvas.Left="99" Canvas.Top="109"/>
<Label Content="please select an option to begin" Height="71"
Canvas.Left="259"
Canvas.Top="265" Width="532" Foreground="WhiteSmoke"
FontFamily="Ebrima" FontSize="36"/>
<Border BorderBrush="Silver" BorderThickness="26"
Height="49" Width="1800"
HorizontalAlignment="Stretch" >
</Border>
<Image  Source="C:\Users\Aysha\Documents\Visual Studio 2012
\Projects\Vp project\BibliothecaDark.PNG"
HorizontalAlignment="Left"
Height="49" Margin="0" VerticalAlignment="Stretch" Width="337"
RenderTransformOrigin="0.473,-0.034"
Canvas.Left="10"/>

<Button Content="borrow items" Height="155"
```

```
Canvas.Left="81" Canvas.Top="545" Width="316"
FontSize="48" Background="Black" Foreground="White"
FontWeight="Bold" Click="Button_Click_1"/>
<Button Content="account" Height="155" Canvas.Left="452"
Canvas.Top="545" Width="316" FontSize="48" Background="Black"
Foreground="White" FontWeight="Bold" Click="Button_Click2" />
<Button Content="return items" Height="155" Canvas.Left="808"
Canvas.Top="545" Width="316" FontSize="48" Background="Black"
Foreground="White" FontWeight="Bold" Click="Button_Click_2" />
<Image Source="C:\Users\Aysha\Documents\Visual Studio 2012
\images\kiosks\40004.png"
Height="617" Canvas.Left="960" Width="299"/>
</Canvas>
</Window>
```

Appendix B

Project Timeline and Kanban

Software engineering process ' Kanban' fits well with the project. It helped to simplify the time management. However, certain engagements such as coursework deadlines, exams and write up reports slow down the project. Kanban sprint length flexibility helped to prevent these interruptions.

B.0.1 Project Timeline

The original project period spanned almost eight months, from February to the beginning of September. however, due to unseen circumstance, project deadline extended to 2nd of October. This was a challenging deadline for the project to be completed. The project had a diverse work capacity. Project progress was slow in the first half (February to the end of May) because of lectures, coursework, and exams. However, the second half (June to September) was fully utilised to work on the project. The project had five major phases, with a milestone at the end:

- Start and Initial research.
- Implementation phase 1 (Initial draft).
- Implementation phase 2 (Final draft).
- Evaluation and re-factoring.

- End phase.

B.0.2 Gantt Chart

A Gantt chart was designed at the start of the project. However, it was really hard to follow the Gantt chart in an agile or iterative project. The major reason behind this, it is impossible to combine the lean and agile approaches in a project. Since, for this project term 'management' refers to the combined effort of the academic supervisor, Bibliotheca supervisor and the readers of reports and the dissertation. Figure B.1 shows the Gantt chart that has been agreed upon at the start of the project. The project based on the five milestones, which were required to accomplish the following tasks at the given dates:

Initial Report Deadline (March 12)

- Data analysis at Bibliotheca
- Initial literature review
- Stakeholders consent on project scope

Progress Report Deadline (May 8)

- Software application analysis at Bibliotheca
- Perform background research
- First implementation of user interface prototype
- Write progress report

Re-factoring of prototype application (July 10)

- Perform most of background research
- Finish core functionality of user interface
- Start user evaluation

Plan project end (September 10)

- Stop implementation and user testing
- Dissertation layout

- Start of buffer period

Dissertation deadline (October 2)

- Final application ready
- Hand-in dissertation (two copies; printed and bound)

B.0.3 Conclusion

This chapter provides the details about the project timeline and management. This justifies the time flexibility provided by Kanban framework. It also proved that prioritisation of tasks could play an important role in project development. Further, it explains about the project milestones, which has been achieved.

Activities	Jan	Feb	March	April	May	June	July	August	Sep
Project background									
Subject research									
Initial report			M1						
Deep Research									
Patron Analysis									
Progress report					M2				
Sys requirements									
Sys specification									
Project design and start dissertation									
Implementation									
Coding									
Testing								M3	
Evaluation								M4	
Proof reading									
Final dissertation									M5

Figure B.1: Gantt chart designed at the start of the project, showing project timeline estimation.