

BRaille TO GO - IN THE CONTEXT OF APPLICATION DEVELOPERS & SERVICE PROVIDERS

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ABSTRACT

The advancements and evolution in technology have touched all aspects of humanity. The average human has been able to successfully leverage the rapid improvements in the technological arena. However, disabled communities have been hugely marginalized in the technological revolution. This paper presents a state of the art mobile device that aims to target the needs of the blind community. The device supports both hardware and software extensibility, and thereby lays the foundation for future accessibility related solutions for the blind community.

1. INTRODUCTION

The environment surrounding us is a rich source of visual ‘cues’ which we have learned since childhood to ‘read’ to enable us to go about our everyday lives. However, partially sighted and blind individuals must learn to adapt their behaviors to live in a world designed by sighted people[1]. With the rapid advancement of technology and the decreasing costs of smart phones, the need for affordable, intuitive and innovative tools to aid visually impaired people is a dire necessity[2].

Over the years significant research and time has been spent to address the problems faced by the blind and to adapt existing hardware to be more accessible to the blind from a software perspective. Many efforts have been made to implement GUI frameworks to make existing applications more accessible, frameworks to attain accessible web presence, an IDE and SDK to create accessible applications, for e.g. the Accessibility API features introduced in the Google Android platform [3-5]. However, despite the success of these efforts, the need exists for a hardware solution designed specifically for the blind that integrates all the available software solutions on one platform.

This paper introduces a novel solution, b2g which aims to bridge this gap.

1.1 END-TO-END ACCESSIBILITY FOR THE BLIND

b2g is an innovative and multipurpose mobile computer targeting blind individuals. b2g provides a much needed eco system to build accessible mobile applications for the blind from both a hardware and software perspective. The open source software and hardware design of b2g encourages further enhancements and improvements to compliment and support future applications designed for the blind. The hardware could be improved further to reduce the cost or increase the features of the overall product. The hardware and specifications of b2g were designed under the guidance of the National Braille Press who clearly identified the needs, habits and behavioral patterns of blind individuals.

Both Google and Apple have provided support for accessible mobile applications from a software viewpoint but failed to introduce any hardware related accessibility features. b2g aims to address a social need and therefore does not charge any royalty for applications developed on the b2g platform making it more appealing to applications developers.



Fig 1: Braille to Go Device

b2g is equipped with state of the art technologies to support mobile internet access and navigation. A Braille keypad and a Braille display will allow blind users to access information using the familiar Braille system. b2g runs on the Google Android operating

system which provides a free, open source and fully customizable mobile platform.

1.2 HARDWARE OVERVIEW

The b2g device has been built using state of the art hardware components. A brief description of the hardware specification of b2g follows.

- b2g currently runs on Android 4.1 Jelly Bean and can always be upgraded to the latest Android version.
- The 1GHz ARM Cortex-A8 processor helps applications perform better.
- The display of the device includes a standard 20 cell Braille Display, with 8 dots per character.
- The nine key Perkins style Braille Keypad along with the five position navigation ring and two keys for Forward/Backward functionality facilitates easy input for the blind.
- The device is capable of connecting to any GSM network to make calls with download speeds up to 14.4Mbps using HSPA+.
- The 5 MP camera with LED flash is capable of capturing 1080p videos, making it perfect for object identification related applications.
- The sensors of the device include a 3-axis Accelerometer, digital compass and GPS to facilitate navigation based applications.
- The USB host port on the device provides a way to plug-in to another USB enabled device and perform additional configurations.
- b2g supports both Wi-Fi 802.11 b/g/n and Bluetooth v2.1, making the perfect guide for the blind to be connected for assistance at all times.
- The device has a 512MB of RAM, an internal microSD card slot of the OS and an External SD card slot for user data.
- There are inbuilt stereo speakers and a microphone plus a 3.5mm stereo out to connect headphones for audio feedback for the blind.
- The device has a vibration motor that enables haptic feedback for the blind.
- The device is powered by a Removable and rechargeable 5900mAh Lithium battery which provides a Stand-by time Up to 146hrs and a talk time of up to 8hrs(3G) and 12hrs(2G).
- All these components are built on a very compact circuit board and the dimensions of the device is 205mm x 112mm x 28mm and weighs only 550g.

1.3 UNIQUENESS OF PLATFORM

A major distinguishing factor of this device is its Google Android operating system. This opens countless avenues for software developers to design innumerable applications to support the device. Secondly, the hardware specifications are open source, thus enabling interested parties to work in collaboration to further improve the device.

There is a custom micro-controller built in to operate the Braille Display and the Braille Keypad. The micro-controller, allows the Android system to perceive the keypad as a normal keyboard thereby saving power. When the device is on standby mode and the application processor is on sleep mode, this chip still listens to all the key presses and buffers the key presses and wakes the system. All letters are input using only six keys, therefore the chip is intelligent enough to recognize and guess the typed letters.

The standard power button found in an Android device is replaced with a slider switch. This slider helps a blind person to understand the current state of the device and lock/unlock the device via enabling or disabling the integrated keypad and display.

The rest of the paper is organized as follows. Section 2 explains the significance of the b2g device with regard to the needs of a blind individual based on a well-known conceptual framework. Section 3 highlights a few challenges faced by the developer community. Finally, section 4 concludes the paper and outlines future work.

2. CONCEPTUALIZING THE NEEDS OF THE BLIND

Adapting an existing product or a concept to cater to the needs of a blind individual has both its benefits and limitations. b2g aims to address those limitations by building a product designed exclusively for the blind from both a hardware and software perspective. When designing a concept or device to cater to the needs of a blind individual, identification of the key objectives to be met is crucial. In identifying these objectives one must take a deeper look at the needs of blind individuals. At present, there is a substantial gap between sighted and blind people. It was decided

to use a conceptual framework reflecting human needs to model this gap.

Herzberg's Two-Factor Theory [11] emphasizes on job factors that result in employee satisfaction and dissatisfaction. However, it is limited to professionals. Theory X and Theory Y [13] formulated by Douglas McGregor also covers only professional life. McClelland's theory of Needs / Achievement Motivation [12] states that human behavior is affected by three needs - Need for Power, Achievement and Affiliation. This seems to be a viable option to analyze the gap stated earlier, but the needs McClelland presented were less detailed when compared to Maslow's Hierarchy of Needs Theory [14]. Abraham Maslow states there are five levels of needs within each individual and the urgency of these needs varies.

In order to cover the wide spectrum of needs of a blind individual, Maslow's Hierarchy of Needs Theory [14] was chosen as the more suitable and applicable framework to explain the use and effectiveness of b2g. The succeeding sections below detail the needs identified at each level along with the possible solutions that avail them through b2g.

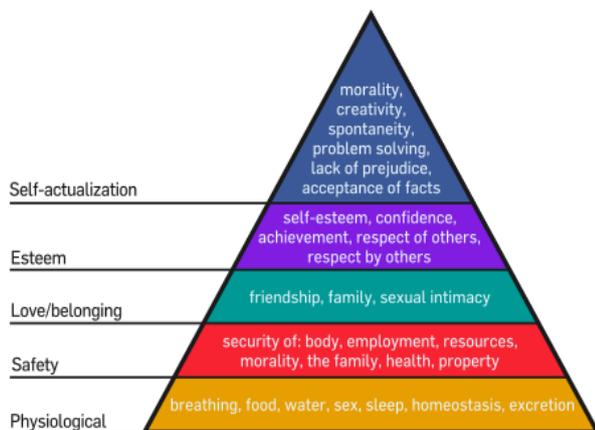


Fig 2: Maslow's Hierarchy of Needs

2.1 PHYSIOLOGICAL

Physiological needs are the most essential and basic physical requirements vital for human survival. Maslow believed that these needs are the most basic and instinctive needs in the hierarchy as all needs become secondary until these physiological needs are met.

Freedom is somewhat a luxury to the visually impaired. Their movements are constrained severely

due to lack of vision. This however can be overcome by a turn-by-turn navigation app. The app could be controlled by voice and the output would be in the form of text or audio. A highly accurate GPS receiver embedded in the device could further compliment this application. As per the research done by Bourbakis, N. G. and Kavraki, this application could be further improved to alert the user of the shapes of the objects in his pathway with the use of an inbuilt camera.

Another basic requirement that a blind individual is deprived of is the access and ability to read. With the invention of image recognition this scenario can be changed for the better. With the support of an application that recognizes sharp images using the 5 MP camera on the device, images are processed through the 1Ghz processor in real time. The output can be transmitted to the user via the Braille display or by via the text to speech converter.

2.2 SAFETY

At this level, the needs for security and safety become primary. Safety needs are important for survival, though not as demanding as physiological needs. People want control and order in their lives, so this need for safety and security contributes largely to behaviors at this level.

In a blind man's world, safety needs takes on a whole new meaning. Bramley et al., found that vision loss significantly increased risk of falls and/or accidents and injury in the home and there was a direct cost burden of blindness during the first year of managed care.

The first step to a blind person's safety is being able to identify obstacles and objects in the environment around them. Given that all tangible objects are tagged in a database e.g. Google Goggles, b2g can be used to scan the labels and read it out aloud or relay it in the Braille display to allow an individual greater freedom and independence in living and to improve their quality of life. Next step would be for the blind user to be able to remotely operate and control all daily appliances by b2g.[6]Enabling interoperability between devices in the future is a vastly active research area, in which the personal smart phone will play a pivotal role. b2g ascertains that the visually impaired society will not be excluded.

Even amidst a city of people, the blind don't feel secure to travel independently as even a flight of steps could be a hazard to their safety. Similarly to what is mentioned in Ito and Fujimoto et al. (2012, p. 60 to 63) [7], b2g could be used as a tool for the blind to perceive their environment and an assistive tool for the locomotion of the blind. The hardware of b2g supports the configuration of external IR sensors that could be used to provide auditory and haptic feedback to the user when an object is near. This would be instrumental in providing safety to the user by alerting them if an object is in front of them and prevent any collisions and to also identify approaching objects. Many useful applications could be built based on the feedback received from the sensor to help users perceive the distance to an object. Although there are several devices that help the visually impaired identify the distance to objects, the advantage of b2g is that, it is portable and one-handed so that it can be carried around easily by users. Furthermore, the app could be used to alert the user when there are a flight of steps ahead by providing auditory feedback indicating whether the steps are ascending or descending. The app could then guide the visually impaired user when traversing each step. For e.g.it could provide auditory feedback such as 'step up' or 'step down' and 'final step' to indicate the last step. A flight of steps may not seem a safety hazard to sighted people. However, for a visually impaired person it could be a major hindrance to their physical safety. Being able to identify when there is flight of steps ahead and a real time guide to inform them when they climb/descend those steps could be of extreme use to them. Furthermore, blind people need to be alerted when walking over ground that is not leveled, so that they can consciously slow down their pace and keep their feet steadily. This need could be overcome by a suitable application used on the b2g device.

2.3 LOVE AND BELONGING

Maslow described these needs as less basic than physiological and security needs. At this level, the need for emotional relationships drives human behavior. Relationships such as friendships, romantic attachments and families help fulfill this need for companionship and acceptance, as does involvement in social, community, or religious groups.

Social Networking has now become a mainstream way of connecting to people, widely used throughout

the world. However, not much effort has been made to ensure social media is accessible to the blind. b2g can be used to design intermediate applications which will use speech, the Braille Keyboard and Braille display to ensure social networks are accessible to the blind. This would guarantee that the blind can connect with their loved ones and would increase their sense and feeling of belonging in society.

A major frustration for blind individuals is the thought of being lonely. They long to be able to chat and email friends and family. Several attempts have been made to design mobile applications that are user friendly for the blind. However, these have certain limitations which prevent them from being used independently by blind users. b2g can be used effectively to address these limitations to design chat and email applications that are user-friendly for blind individuals.

The gaming industry has evolved rapidly with technology. Upon realizing that the future of gaming is mobile, many traditional games are being redesigned for mobile devices. However, gaming has been considered to be virtually impossible for the blind community given the lack of means to get their input and display output. b2g aims to resolve this setback for the blind community. Game developers can leverage the fast Braille keyboard and the twenty letter display together with audio and haptic feedback.

A valuable and useful initiative in the current state would be to design a framework or API to develop games for blind people which could then be used by the Android Developer community.

2.4 ESTEEM

All humans have a need to feel respected, accepted and valued by others. This includes the need for things that reflect on self-esteem, personal worth, social recognition and accomplishment.

One of the main factors that affect the self-esteem of a blind person is the loss of independence. The loss of flexibility and spontaneity,[1]and always having to rely on someone else leads them to believe that they are unable to achieve the success enjoyed by others. Furthermore, society has a preconceived notion that the blind cannot accomplish day-to-day tasks and therefore cannot lead a normal life.

The key to achieving self-esteem is by providing the same opportunities and experiences for the blind as those provided to sighted people. At present such an endeavor seems impossible because, technology has not been used effectively to help empower the blind. The methods for educating blind students varies on a continuum from mainstreaming in public schools, to attending schools for the blind where students live on campus during the school year. For those who had attended specialist schools or a specialist unit within a mainstream school, the move to university, with a much lower level of support, can be a difficult change. There is a need for consistent support to be provided to blind and partially sighted students making this transition. The lack of understanding from others about the repercussions of having visual difficulties make life even more challenging for the blind (Wang and Boerner).

An issue for students was the time delay in obtaining materials in a suitable format. Also the actual studying took longer because of the time taken to read materials. As mentioned in Rnib.org.uk 2009 [1] Assistive and adaptive technology could help the blind children in numerous ways. For e.g. instead of printing Braille textbooks, the b2g could be used to read normal books and translate it to Braille on the refreshable Braille display. This could be both cost and time effective and ensure blind children have access to the wealth of information out there. As education tends to become more digital and online, web accessibility is vital for ensuring blind children can enjoy the same benefits enjoyed by sighted children [9]. Educational mobile apps may play an important role in the future. Existing screen readers could be further improved by allowing the blind user to navigate across the html elements that comprise a web page. For instance existing screen readers, employ a top-to-bottom approach. This might not suit web browsing as one often needs to skim through multiple search results to select the most appropriate result. Screen readers should be able to provide this flexibility to blind users. The function keys of the b2g device complement this need well by allowing to be mapped to a specific element of a web page.

Mashups which traditionally relied on making the interface more accessible can now make use of the underlying hardware of b2g to make existing sites more accessible. With regards to the working age, blind and partially sighted people's employment is a huge issue. In individuals whose onset of sight loss occurred early in their lives, they were more likely to

be employed if they had high educational achievement. Conversely, those who had low educational achievement were more likely to describe themselves as "long-term sick or disabled", thus staying out of employment [1]. However, this can be prevented by providing the suitable applications needed by employers such as Braille calendars, note taking applications etc. Likewise building the self-esteem of a blind person is centered on liberating him with the relevant tools and technologies to live an independent life. Trivial dependencies like not being able to shop alone and purchase required items can be a major source of frustration. However, a simple mobile application with an eyes-free barcode scanner or RFID/QR reader coupled with an Optical Character Recognition (OCR) Engine can be of immense use to a blind shopper. Accessible shopping systems based on teleassistance[2] aim to implement their systems in the form of smart phone applications in the future. In such a scenario, b2g would be a far more user-friendly client enabling blind individuals to obtain help from sighted individuals in remote locations by transmitting images, video and voice over wireless connections.

Recent developments in Autonomous parking controlled by a user's smart phone spear headed by Volvo [10] imply that the future of automotive related technologies will be centered on the smart phone. This indicates that blind individuals need to be in full control of their smart phones to benefit from future autonomous driving solutions. b2g is intended to cater to this requirement, by replacing the touch screen with the Braille input keyboard.

Mobile Banking solutions and the usage of smart phones as a payment device is gaining wide popularity. The use of function keys in the Braille keyboard in the b2g would reduce the probability of error that could be made when interacting with these highly sensitive and critical financial applications.

2.5 SELF-ACTUALIZATION

"What a man can be, he must be," Maslow explained, referring to the need people have to achieve their full potential as human beings. Self-actualizing people are self-aware, concerned with personal growth and less concerned with the opinions of others.

In the context of a blind individual, the ultimate goal

would be to reduce and eventually eliminate the gap between blind and sighted individuals. The gap could include the inability to perform certain day-today mundane tasks, the outlook and sensitivity from society towards blind and visually-impaired individuals or even the perception of oneself. Achieving the needs in the preceding four levels will ultimately assist a blind individual realize self – actualization.

3. CHALLENGES AND RESTRICTIONS

Mobile applications for the b2g device need to be designed from an entirely different outlook and perspective. The application would be most effective if the design and navigation of the application is supported by the b2g hardware. The device works well with list based applications but need not be limited to these types of applications. However, one may need to ration and design a simplistic user interface to ensure maximum user friendliness.

A handful of existing applications have been tested on the b2g. While some of them have worked seamlessly on the device, some applications faced difficulty when navigating through the user interface. The layouts of some existing applications were not supported on the b2g. Trivialities such as the tab order of an application can have a huge impact when accessed from b2g.

The Google Accessibility API coupled with applications such as Talkback and Brailleback play a pivotal role in the usability and accessibility of the b2g. However, the accessibility API is based primarily for touch- based android devices. This introduces a gap when trying to leverage the accessibility API for b2g.

The Braille display of the b2g device can be used with ease by blind individuals familiar with the Note taker device. However, navigating through applications using the shortcut keys may pose a slight learning curve for a novice user. The concept of the homepage and various applications with different navigation logic and behavior needs to be well understood and absorbed to make complete use of the device. This may be a significant challenge for individuals who are blind from birth. However, the learning curve of the device depends solely on the

novel and thoughtful applications developed for the b2g.

4. CONCLUSION & FUTURE WORK

The key defining factor of b2g is that it provides a platform for continuous improvement and innovation. There is provision to include Ultrasonic sensors in b2g in the future, if it provides better accuracy in the identification of objects. Given that blind individuals are more sensitive to haptic feedback, the number of vibration motors integrated in b2g could be increased in the future. These motors could then be used to interact with the blind individual by providing varied levels of vibration. The display of b2g could be further improved to consume less battery life. Based on the needs identified b2g has been designed to be a fully integrated assistive agent for the blind, liberating a blind individual and reducing the gap between a sighted and blinded individual.

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