Ember: A Smartphone Web Browser Interface for the Blind

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ABSTRACT

Ember is a smartphone web browser interface designed exclusively for the blind user. The Ember keypad enables blind users to type using their knowledge of Braille. The interface is intuitive to the blind user because the layout consists of a very few large targets and remains consistent throughout the application. The verbal command option provides another dimension for user-interface interaction. Five out of five users found that Ember verbal command navigation was easier than using a traditional web browser. Four out of five users found it faster to use the Ember tactile method of navigation compared to a traditional web browser. The learning rate for both the tactile and verbal command methods was faster compared to the learning rate associated with a traditional web browser layout. Finally it was seen that five out of five users found it significantly faster to use the Ember keypad compared to the QWERTY keypad.

Categories and Subject Descriptors

H.5.2. [Information Interfaces and Presentation]: User Interfaces – Graphical user interfaces (GUI), Input devices and strategies, Screen design, Voice I/0.

K.4.2. [Computers and Society]: Social issues – assistive technologies for persons with disabilities.

General Terms

Design, Human Factors

Keywords

Braille, Smartphone, QWERTY

1. INTRODUCTION

In the recent times touch interfaces have been integrated into almost every aspect of life, from ATMs to personal computers and mobile phones. The smartphone has become the most available and cost effective type of mobile phone in mainstream society. A smartphone not only has the features of a basic mobile phone but also has those of other consumer devices such as a media player, camera, GPS navigation, etc. The smartphone combines the functionality of many devices into one compact unit. It is important to innovate and provide functionality to all types of users, such as blind users, because the touch screen is so available and convenient. Though blind users are at a disadvantage because they cannot employ the traditional locate and touch paradigm that the touch interface uses, they can still use the interface in an effective manner [11]. This can be achieved by the extensive use of haptic and audio feedback and a specialized interface design. The major challenge faced was in creating an interface which was both quick to learn and easy to use. The design had to be intuitive to the blind user and this required insight, analysis and empathy.

Other methods which facilitate interaction with the web, like screen reading software and Braille readers do not provide the same availability or functionality. Braille is a writing system used by the blind and visually impaired. The devices do not support portability and are relatively expensive. Braille readers convert the text on the browser into Braille so that the user can read the text line by line. This provides a familiar set up for the user to interact with the webpage but it is not ideal when the user does not want to read every line on the page. There is no flexibility as to what the user chooses to take from the webpage. As shown in Table 1 the same problem is associated with screen reading software. With screen reading software the user's experience is limited to the web designer's attention to the compatibility of the page with the software. The layout of the page and other context may not be taken into account. A screen reader is limited to the computer only, so it is not portable. Ember hopes to eradicate these problems by providing a portable interface and taking advantage of the fact that the tactile method of interaction is what comes most naturally to the blind user.

It was found that blind users can use the edges of a mobile phone as bearings to locate specific points on the phone screen. With this in mind large buttons along the exterior points of the phone were created for back, forward, tools, home and audio input. The largest portion of the screen, the center part surrounded by the buttons, is used for text input. The user can touch any point in the middle of the screen and be able to initiate text input; locating a particular point on the screen is not required. The user can also choose to provide verbal commands through the audio input function at every stage of navigation and can also name bookmarks verbally. The QWERTY keypad is the most common modern-day keyboard layout. The QWERTY keypad is replaced with the braille keypad with audio feedback.

The key contribution here is the ability this interface provides to blind users with respect to navigating around the web on their touchscreen mobile phones. Traditional web browsers give more importance to the aesthetics and presentation of the webpage but this interface concentrates more on the functionality required by a blind user. The blind user needs to be able to locate buttons easily, be provided with feedback and have a more appropriate keypad for text input.

The rest of this paper is organized in the following manner. Section 2 outlines the effectiveness of related methods previously proposed and compares and contrasts them to the methods described in this work. Section 3 describes in a detailed manner the methodology and working of the web browser interface. Next Section 4 portrays the various successes and shortfalls of the implementation. The test conducted to evaluate the interface and the results are shown. Finally Section 5 and Section 6 will provide foresight into the work that can be done to overcome the faults found after conducting tests and to strengthen existing attainments further.

Table 1: Comparison of the strengths and weaknesses of Braille readers and screen reading software

Approach	Strength	Weakness
Braille Readers	Incorporates Braille and tactile ; familiar	Can only read one line at a time, bulky, no information about layout of the page
Screen Reading Software	Easy to use, knowledge of Braille is not a prerequisite	Effectiveness depends on the website developer, can be slow and inflexible

2. RELATED WORK

Ember extends previous research on the accessibility of touchscreen interfaces by providing a more suitable input method and navigation techniques which address the concerns expressed by blind users.

2.1 Implications for Design

The *Slide Rule* [1] research proposed ideologies that helped shape the design of Ember's interface. Blind users often carry a multitude of devices even though most devices overlap in function because a particular device may provide a suitable interface for certain functionalities but prove poor in another respect. The research showed that the difficulties blind users have include difficulty in learning where objects were located on the screen. Some informants also mentioned that they were afraid of making mistakes that could not be undone.

The *Slide Rule* incorporates various gestures, the L-select gesture in particular, to navigate through lists etc. Based on this feedback Ember was designed for the touchscreen mobile because the touchscreen can incorporate the functions of several devices into a single device. The interface should allow the users to interact with familiar layouts. Ember's skeleton layout stays the same throughout all navigation phases so the learning process is made easier. The *Slide Rule* research also showed that touchscreen interfaces must be easy to explore and minimize the need to find a particular point on the screen through trial and error. Ember's layout uses the edges of the keyboard as bearings, provides large buttons and a very large area to prompt text input. As the user passes over a button or text field with his finger, the label of the widget is read out to him. The need to pinpoint a specific area of the screen is almost negligent when the verbal command option is used. The consistent audio feedback and verbal command options make Ember's design functionally more apt then the *Slide Rule*.

2.2 Acknowledging the Need for a Different Method of Touch Based Text Entry

In [2], four different methods of text input were analyzed. QWERTY[3, 9], MultiTap[6], NavTouch[4] and BrailleType[5] were compared by testing their effectiveness across users of different genders, age, spatial ability, verbal IQ and Braille reading and writing in words per minute. The study aims to assess the advantages and limitations of different touch-based text-entry approaches, and to show that different blind users with different individual attributes can benefit from one method over another. The results showed that there was not a consensus on most methods except that BrailleType users collectively agreed that they would use the system.

BrailleType takes advantage of the capabilities of those who know the Braille alphabet. The touchscreen is divided into six large cells, each representing the dot positions. Users can explore painlessly as audio feedback is provided and double tap is required to select a target. By reducing the number of on screen targets, as compared to the QWERTY pad for example, less stress is placed on the blind user. Although BrailleType was the method which posed the least number of errors, there were still errors. The errors were mostly caused by the timeout mechanism of the keypad. The keypad did not allow experienced users to type faster and so the wrong letter was registered when the user tried to move on to the next letter. It made the process of text input very slow.

The Ember Keypad does not have this problem has there is no need for a timeout. The keypad is designed in the way that all the targets to be pressed at once and are registered simultaneously using multi-touch. The phone is held horizontally with the touchscreen facing away from the user such that they can use two hands simultaneously to type. Letters can be typed continuously in accordance to the user's comfort level. The letter is repeated to the user after it registers [12].

3. PROPOSED WORK

The aim of developing a smartphone web browser interface for the blind is to enable blind users to browse the internet comfortably and to still have all the features of a typical browser, such as bookmarks history etc., available to them. There are three innovative components of the Ember design that will be discussed: the interface, verbal bookmark search by name and the Ember Braille keypad.

3.1 The Interface

3.1.1 Layout

The layout of Ember as shown in Figure 1 and 2, aims to achieve larger target size and a less number of targets [14]. The targets must be easy to locate. There are five large buttons placed along the edges of the phone: forward, backward, tools, audio input and home. The user can use the edges of the phone as bearings. The large center space in the middle of the layout is the edit box. There is a large area that the user can touch to initiate text entry. This way the user is never forced to pinpoint an exact location on the screen. Although the layout is not comparable aesthetically to mainstream browsers, Ember is much more compatible to the blind user's needs. The user has the option to go back to the home screen from any point in navigation. The layout of the browser is in this format throughout the application so that the user can familiarize with it easily.

Using an assist app like TalkBack on the Android platform, the user can explore the interface without the fear of making a mistake. The name of the screen element is read out to the user when they touch it. Selection is done using double tap and scrolling is done with two fingers. Even menus are announced as they pop up on the screen. The combination of easy to locate target and audio feedback allows the user to adapt to the interface easily and explore with confidence [13].

3.1.2 Navigation

Navigation is done by two means, by touching the appropriate button or by providing voice commands. On the long press of the audio button, the browser captures the voice command and moves to the corresponding activity on successful processing. This dual method of navigation is designed to provide the user with the most convenient method of interaction according to the situation they are in. For example if the user is in a library then they can use the touch method of navigation but if they are alone at home then the easiest method would be to just use verbal commands.

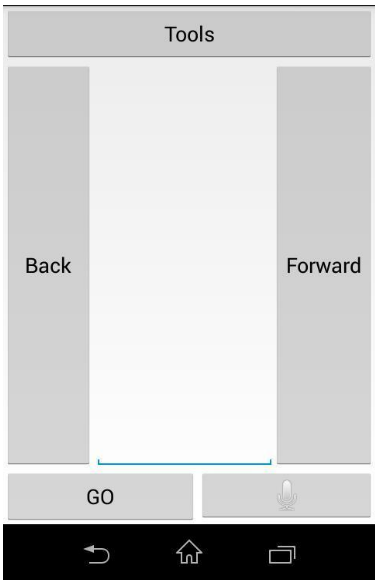

Figure 1: Screenshot of Ember home screen. The targets are placed at the edges of the screen and the text area is the largest section of the interface.

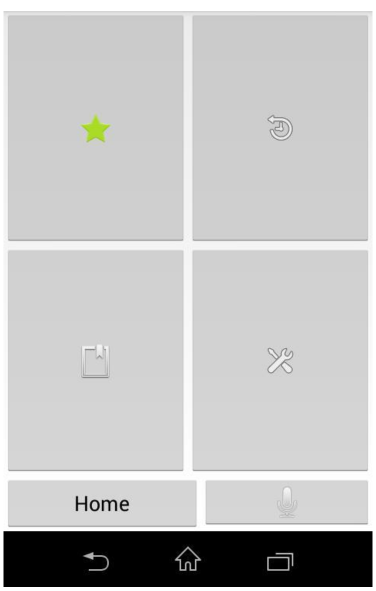

Figure 2: Screenshot of Ember Tools screen.

3.2 Verbal Bookmark Search by Name

A particularly novel feature of Ember is verbal bookmark search by name. When the user chooses to add a page to bookmarks they can name the bookmark. The user presses the audio input button and says the name of the bookmark. The audio input is converted to text and after text to speech processing the interface plays back the name of the bookmark to the user. The user can either choose to accept the result to cancel and record again. When the user wants to access the bookmark again, they just have to give the bookmark name as a verbal command in the bookmarks menu. They can also scroll through their bookmarks as in a traditional web browser.

3.3 The Ember Braille Keypad

3.3.1 Text Input

The Ember Braille Keypad integrates the blind user's knowledge of Braille with the requirement of having fewer targets on the touchscreen interface at once [7, 8]. The typical QWERTY keypad on a touchscreen phone has an overwhelming number of targets which can be difficult for even the most experienced blind user to use [9]. The buttons are small and it is extremely difficult to type without errors using a trial and error method. The Ember Braille keypad, like the BrailleType keypad , requires the user to map the Braille letter on the touchscreen instead of selecting a button for a particular letter[10]. The screen is divided into six zones so there are only six large targets the user has to handle. Unlike BrailleType, the Braille Keypad uses multi-touch technology to register multiple points of user interaction with the screen at a certain instance of time. This means that the user forms a letter by touching all required zones at once. For this reason there is no timeout mechanism as in BrailleType, reducing the number of errors caused by differences in user competency. The user is provided with audio feedback every time a letter is registered by the system.

3.3.2 Typing on the Go

The Ember Braille Keypad requires the user to engage at least three fingers on each hand. If the user is using the phone while walking i.e., the phone is not placed on a surface, then the user must hold the phone in a way that he can type comfortably. The phone is held with the screen facing away from the user as shown in Figure 3. This method ensures that the user is not uncomfortable and holding the phone in an awkward way.

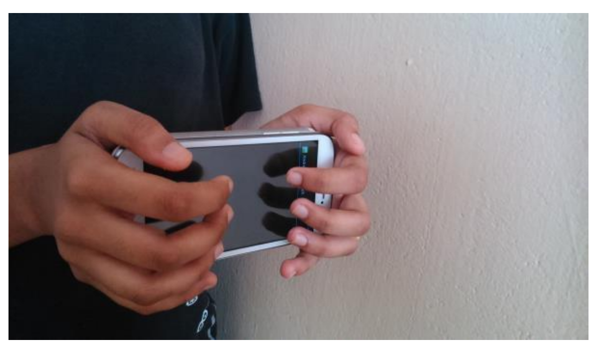

Figure 3: Typing on the go. This method of holding the phone will make typing on the Ember Keypad comfortable even while the phone is not placed on a surface.

4. RESULTS AND ANALYSIS

4.1 Testing Procedure

The Ember interface navigation and Ember Braille Keypad were tested by a group of thirteen blind adults who were Braille literates. Ember was tested against a traditional web browser. The Micromax A116 and the Sony Xperia C2104, as shown in Figure 4, were used in the testing process. To test the ease of navigation, volunteers were instructed to choose the menu, prompt the add bookmark activity, add a new bookmark and then search for the same in the bookmarks library. The volunteers were asked to perform the same navigation test three times for each of the web browsers. The difference in time between each of the three trials for each browser indicates the learning curve while the average time taken by each browser shows the overall complexity that the volunteers encountered.

The Ember Braille Keypad was tested by asking the volunteers to type the letters A, C, H Q and R in sequence three times. The time taken by the volunteer to successfully type all five letters was recorded. The letter “A” represents a letter with only one zone interaction, “C” represent two zone interaction, “H” three zone, “R” four zone and “Q” five zone interaction. The same test was repeated with the traditional QWERTY keypad. The comparison between the total time of each trial between both keypads represents the difference in complexity presented by each one.

The user’s improvement from trial to trial indicates the learning curve associated with either keypad.

Figure 4: Devices used in the evaluation; Micromax A116(left) Xperia C2104(right)

4.2 Results

Table 2: Comparison of navigation time. Navigation time shows the complexity presented by each interface. The Ember interface shows lesser average time.

		Average Time (Seconds)		
Sl. No	Audio		Tactile	
	Ember	Normal	Ember	Normal
1	206.667	207	137.33	154.67
2	189.33	196.667	138.67	142.33
3	193.67	198.33	164	161.67
4	206.667	214.33	144.33	149
5	203	206.67	132.33	138
6	211.66	200.67	132.67	129.33
7	206	206.67	133	139.67
8	201.67	209	133.67	138.33
9	195	204.67	132	138.67
10	203	206.67	130	145
11	200.67	211.67	133	150
12	206.33	208.33	125	145
13	203	206.67	132.33	139.67

Table 2 shows that twelve out of thirteen volunteers could on average navigate faster using the Ember audio navigation method than by using the traditional web browser. Ten out of thirteen users could navigate faster using the Ember tactile method of navigation compared to the traditional web browser navigation.

Table 3: Comparison of learning curve. The difference in navigation time between each trial indicates the learning curve. The Ember interface shows a decreasing trend whereas normal interface times are random.

		Time(Seconds)		
No of Trials	Audio		Tactile	
	Ember	Normal	Ember	Normal
1	210.61	202.53	137.4	135.6
2	210	211.07	135.8	141.8
3	200.07	204.23	134.2	137

Table 3 depicts how the learning curve for the Ember interface is less steep than the learning curve for the traditional browser. The average trail times for both audio and tactile navigation for the Ember and traditional browser interface show that the time required to complete the navigation test consistently decreased in case of the Ember interface but was random in the case of the traditional web interface.

Table 4: Ember keypad test for Complexity.

	Average	
SI No.	Time(seconds)	
	Ember	Normal
1	32.667	59
2	26	48.33
3	26	45.667
4	45.33	53.667
5	21.33	41
6	30	44.33
7	25.67	45
8	28	40
9	33.33	55.67
10	27	53.67
11	33	49.33
12	45	45
13	30	52.33

Table 4 shows the average time taken by each volunteer to successfully complete typing the letters A, C, H, Q and R on the Ember keypad and the QWERTY keypad. It is seen that the time taken to type using the QWERTY keypad is significantly longer in the case of all volunteers.

4.3 Analysis

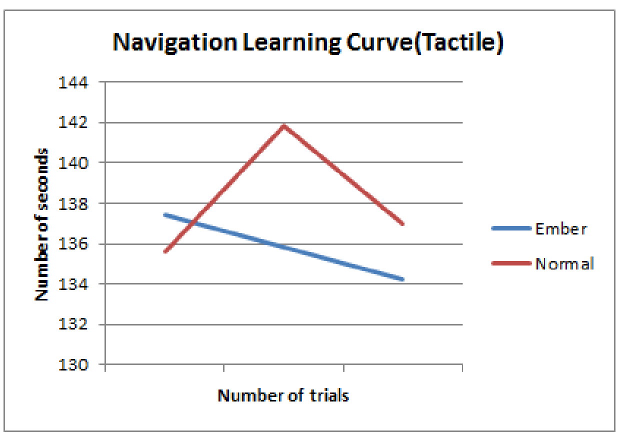

Figure 5 : Navigation Learning curve (Ember v/s normal browser - Tactile)

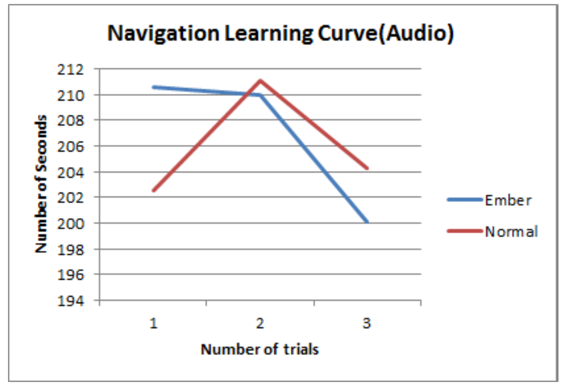

Figure 6 : Navigation Learning curve (Ember v/s normal browser - Audio)

The consistent downward slope presented by the Ember interface in Figures 5 and 6 clearly shows that the volunteer's performance improves significantly with every trial. The traditional web browser shows random results with the slope showing an upward trend and downward trend over the three trials. The Ember curve in the tactile navigation map has a consistent downward slope but the slope drastically increases from trial two to trial three in the audio method of navigation graph. This indicates that audio method of navigation is even easier to get accustomed to than the tactile method.

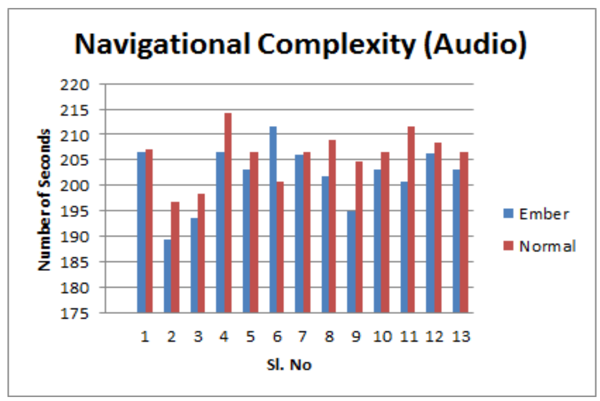

Figure 7 : Navigation Complexity evaluation (Ember v/s normal browser - Audio)

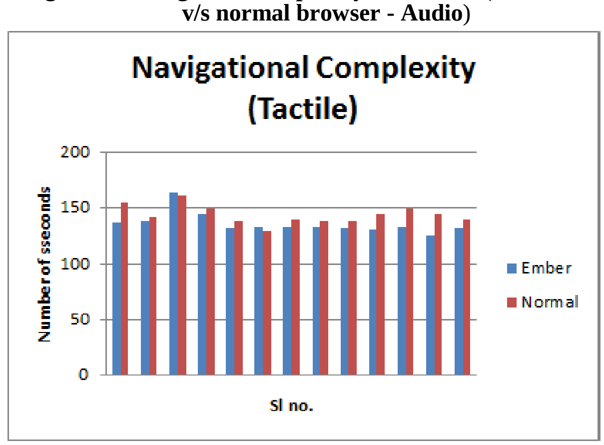

Figure 8 : Navigation Complexity evaluation (Ember v/s normal browser – Tactile

Figures 7 and 8 show that the time taken to perform the navigation test was almost always longer in the case of the traditional web browser compared to the Ember interface. It is also seen that the time taken to complete the audio navigation test is more than the time taken to complete the tactile navigation test. Tactile navigation is faster than verbal command navigation.

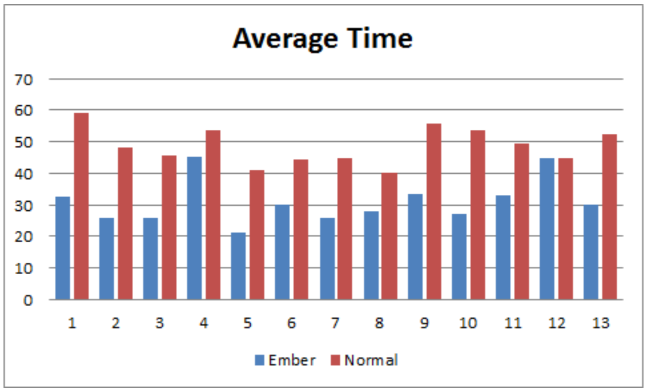

Figure 9 : Complexity evaluation (Ember v/s normal browser – Ember Keypad)

Figure 9 shows that the time taken to complete typing the sequence of letters is significantly less in the case of the Ember Keypad compared to the QWERTY keypad.

4.4 Discussion

After testing and analysis it was found that the volunteers found it easier to use the Ember interface compared to a traditional web browser. The analysis showed that with the use of the Ember keyboard it took them lesser time to input text. The Ember interface was found to be more accessible than the traditional smartphone web browser in terms of navigation and text input. The navigation through Ember was made easier with the use of speech input and audio feedback at every stage. The complexity of navigation (for both audio and tactile navigation) as well as the learning curve was smoother in the Ember interface compared to the traditional browser.

The volunteers required a period of time to get accustomed to the Ember interface. It was seen that the exploration phase was relatively simple and quick when compared to the traditional web browser. A few volunteers commented that the traditional web browser was intimidating and would require a lot of practice to master. When asked which feature they appreciated most about the Ember interface, the volunteers concentrated on the ease they felt while locating targets and the constant audio feedback.

It was seen that the volunteers faced difficulty with the QWERTY keypad. They found the targets too small and locating individual letters cumbersome. On average the volunteers took about one to two minutes to get accustomed to the Ember Keypad. They were comfortable with the Braille based entry. The Ember Keypad still faced errors mainly due to asynchronous selection of targets. If the volunteer intends to type a certain letter then he must select all the required targets at the same time. The volunteers faced trouble typing the correct letter if they showed hesitation while in the process of typing the letter. This delay caused the keypad to register the wrong letter. The volunteers also had a difficult time with the spacing of the targets in the Ember Keypad. It was difficult for them to determine the distance they needed to maintain between their fingers.

The feedback given by the volunteers was overwhelmingly positive. The volunteers stated that it was very easy to understand and would be extremely useful with a little practice. Furthermore, one volunteer stated that the Ember Keypad would be an enjoyable and easy way to learn braille. The ophthalmologists consulted during the testing process understood Ember's design easily. They found the principles with which the interface was designed to be clear.

5. CONCLUSION

The Ember interface provides blind users with the ability to use a smartphone web browser with confidence. The layout ensures that they find it easy to locate targets. The user will feel in control at all times because they will receive continuous audio feedback from the interface. The interface does not compromise on features provided by a traditional web browser such as bookmarks, history and saved pages. Ember enhances the experience by allowing the user to name and search for bookmarks or saved pages verbally. The Ember keypad facilitates faster and more accurate text input.

6. FUTURE WORK

Ember is still in its nascent stages and can be improved upon in a number of ways. More features such as gestures can be added to the interface to make it more accessible, gestures to begin search, open ember keypad, scroll lists easily. A few smartphones could also incorporate air gestures for better navigation between pages. The comparison of the Ember Keypad to other braille input methods would be a more appropriate comparison to test its usability further. As one of the volunteers had suggested, creating a Ember Keypad exclusively for teaching braille would be a rewarding extension of the project.

Ember as of now does not include a web reader, a read aloud application that would read the results of a search or listings aloud, including such a feature would make Ember more handy and easy to use.

The Ember keypad has been designed for English braille, other languages can also be incorporated effortlessly in future with features that could use gestures to input text.

7. ACKNOWLEDGEMENT

The completion of this work would not have been possible without the support and cooperation of the Mobility Training Centre for the blind Attavar Mangalore, Dr. Govindraj at Prathibha Eye Hospital, Mitra Jyoti Bangalore, a charitable trust that aims to support the blind, and finally Mr. Sridhar G. Domanal for his constant support.

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