Workshop on Computer System

User Interface for Visual – Impairment

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Abstract

This paper proposed a user interface for visual impairment to operate a computer using Braille input method. This system is focus on embedding the visual-impaired user enabling functions into the desktop operating environment for the visual-impairment. The proposed system can simultaneously display the context, which is inputted by the Braille input method, on the tactile Braille reading device, the computer screen with printed text and the audio device with voice. Moreover, the system can also detect the printed text, which was updated by other application program, on the screen and exports new content to blind system (tactile reading device and audio device) to remind the visual-impaired operator about this event. The major contribution of this paper is to enable the visual-impaired user to use their proficient Braille input method to operate the computer and the tactile reading device, simultaneously, without learning other input method. The performance of the proposed system has been evaluated by sightless users and has shown encouraging results.

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Keywords: User interface for the visual impairment, The supplemental Braille display instrument, The computer for the blind, Barrier-free technology, Linux.

1. Introduction

This paper is to study an integrated user interface of the desktop operating environment for the visual-impairment. A modular and systematical approach to design such a user interface system is elaborated in this paper.

Instead of designing an add-on application program, this research is focus on proposing a method to modify the user interface of the traditional Operating System to support the visual-impairment. The problem of designing a user interface as an add-on program is that only applications that follow the specification of this user interface can then accept input from this specific interface. To solve this issue, this paper attempts to integrate the proposed user interface into the Operating System kernel so that the blind can easily use most of applications.

By modifying the user interface of the Operating System, this research attempts to break through the barrier of the information acquisition for the visual-impairment by facilitate them using the computer. Using the Braille input device, the visual-impaired user can input characters through the keyboard. Furthermore, the audio pronunciation and the supplemental Braille display instrument enable the visual-impaired user to read the information from the computer.

This research uses the RedHat Linux as the experimental environment to develop the user interface for the visual-impaired user. In order to achieve the goal of integrating the user interface for the bind into the Operating System, this paper employs the kernel mechanism to mount the proposed user interface. Using this approach, the proposed user interface can effective accept the Braille input without creating overhead to the Operating System.

2. System Architecture

In this section, we present a schematic overview of the user interface for the visual impairment system proposed in this paper. The block schematic of the overall system is shown in Figure 1. There are three major capabilities to help the visual-impaired people read/write the files from/to computer: (1). The visual impairment can use the keyboard to input contents using the Braille code, the system will display them on the tactile reading devices first. The system is then translates these Braille code to Chinese/English context and display them on the computer screen and the audio device; (2). When the visual-impaired user moves the cursor on the screen, this system will scan the screen buffer and display the text information (a sentence or a line words) on the location of cursor on the tactile reading device and the audio device; (3). When any other applications update the screen buffer, this system will inform the visual-impaired user by displaying the newest content on the tactile reading device and the audio device.

With the help of these capabilities, the visual-impaired user can use the Braille input method to edit the computer text and operate computer applications. This system will automatically translate the user inputted Braille code into Chinese/English text and output to application program. In addition, because the system can display the content on the location of the cursor on the tactile reading device and the audio device, the visual-impaired user can move the cursor to edit text. That is, the visual-impaired user can know where the cursor moved in the context by touching the tactile reading device and hearing the voice from the audio device. Furthermore, in order to support the visual-impaired user to interact with the computer application program, such as the Internet chat, text game, etc., this system will automatic scan the screen buffer and display the newest content to the tactile reading device and the audio device.

3. The Braille and Chinese/English Input Mechanism

This section is to study a mechanism to help the visual-impaired people to use Braille input method to operate the computer and application programs. However, it is difficult for the beginner to master the complex rules when translating Chinese text into Braille and vice versa. Unlike English Braille, for example, a sentence is not translated letter by letter, and there is not a one-to-one relationship between the printed text and the Braille code. [1] To facilitate the production of the Braille code and encourage the visual-impaired user to use the computer, this paper proposed a new Braille-translation system to translates regular Chinese text into Braille and vice versa by using the translation rules and the dictionary table.

As shown in Figure 2, the block schematic of the Braille and Chinese/English translation mechanism using the Braille input method. The Braille Input module read the Braille code from the keyboard. The Braille/Chinese Translator then translates the Braille code into phonetic symbols and uses the combination of these symbols combination to find the corresponded Chinese characters.

The Braille code uses a group of eight dots that are arranged in four by two matrix. [2][3] The Braille Input Module uses eight keys, i.e. “a”, ”s”, ”d”, ”f”, ”j”, ”k”, ”l”, and ”;”, on the keyboard to match these eight dots. By this way, the visual-impaired user can use these 8 keys to input the Braille code. These eight keys input algorithm for the Braille Input Module is shown by the following states:

Let

Φ = {W | W is the set of the pushing down keys}

Ψ = {S | S is the set of the set-free keys}

State 0: Waiting for a key to be pressed down;

If any of the eight keys is pressed down, change to State 1;

Else loop on State 0.

State 1: Waiting for the event of a new key is pressed down or a pressed key is released;

If another new key is pressed down then go to State 2;

If a pressed key is released then go to State3.

State 2: Recording the pressed and released keys to the sets Φ and Ψ.(?)

Go to State 1.

State 3: Erase the fields of Φ that the presses down keys were released;

If the set Φ is empty then go to State 4.

Else go to State 1.

State 4: Output the set Ψ and clear it;

Go to State 0.

The State 4 output the set Ψ to the Braille Output module and Braille/Chinese Translator in Figure 2, simultaneously. The Braille Output module then exports the Braille to the tactile reading device which enables the visual-impaired user to confirm his input. The Braille/Chinese Translator is followed by translates Braille input data to Chinese character and exports it to application program.

Since the Traditional Chinese Braille (or Mandarin Braille) is a phonetic symbols representation, [4][5] the Braille/Chinese Translator uses the Traditional Chinese phonetic input method to translate Braille codes into Chinese characters. As shown in Figure 2, there are three stages in the Braille/Chinese Translator : (1) it will translate Braille codes into Phonetic Symbols first, (2) these Phonetic Symbols is then input to Chinese phonetic input method module to find all of related Chinese characters with their pronunciation, (3) the user can then uses the tactile reading device to select correct Chinese character.

However, there are two problems must to be solved when translating the Braille code into a Chinese character:

1) The system must be compatible with many different Chinese-Braille input methods.
2) Because the Chinese Braille is phonetic symbols representation, there is more than one Chinese character having the same pronunciation. In another word, it is one-to-many matching between Braille and Chinese printed text.

This paper proposed an “antithesis table” to combine with the legacy “Chinese phonetic input method” to solve these two problems. The antithesis table is a table contains all of the legal combinations of Chinese phonetic transcription and their corresponding Braille code as illustrated in Table 1. As shown in Figure 2, when the Braille/Chinese Translator received keys from the set Ψ, it searches the antithesis table based on the Braille code and finds the corresponded phonetic symbols. The phonetic input method module read the resulted phonetic symbols and finds all Chinese characters that match this pronunciation for the user. Finally, the Chinese Words Selection module outputs corresponded Chinese phrases, which are stored in Chinese phrases hashing table, of each Chinese character to the Braille Output Module for the user. The visual-impaired user can then read these phrases from the tactile reading device and select correct Chinese character according to these phrases. The Event Control Module also output the Chinese character to the Screen Buffer Control module and the Voice Output module. Furthermore, if the translator received an English Braille code, it directly finds the corresponded English character and exports it to the Event Control Module.

4. The cursor control

The Display Area Control module in Figure 2 enables the visual-impaired user to move the cursor and scroll the display. When the visual-impaired user move the cursor on the screen, this Screen Buffer Control module will scan the Display Text Buffer and calculate the screen coordinate of the cursor. The scanned result is forwarded to the Braille/Chinese Translator module for it to display the information on the display area of the tactile reading device through the Braille Output module. Furthermore, the Screen Buffer Control module will also exports the sentence on the location of the cursor to the audio device.

In addition, this proposed system will synchronize the textual display between the tactile reading device and the Display Text

Buffer. Since the size of each Chinese Braille code is not a constant, it uses two or three Braille cells to present a Chinese character. On the other hand, English characters, punctuation marks, and numerals only required one Braille cell to present them. Furthermore, the movement on the display area of the tactile reading device is based on a Braille cell whereas the cursor movement on the screen is based upon a character or punctuations. Therefore, the cursor's moving step on the tactile reading device must be carefully controlled so that its movement is based on a character or punctuations. Without this synchronization, the cursor movement on the tactile reading device and the screen will be out of order whenever the user moves the cursor. This paper proposed a Braille access structure to synchronize the character on the computer screen text and the Braille code shown on the tactile reading device. The Braille access structure is showed as follow:

```
{   Braille_Length;
    Braille_Code;
    Position;    // The coordination on display area of tactile reading device
    }
```

Hence, the Braille Output module transfers all the characters which showing on the tactile reading device in this structure and save them in the Braille output buffer. When the system receives the cursor movement command from the keyboard, the Screen Buffer Control module scan the Display Text Buffer based upon the coordinate of the cursor and exports these texts to the Braille/Chinese Translator. The translator translates these texts to Braille codes and passes them to the Braille Output module. The Braille Output module analyzes these Braille codes to calculate the position and the Braille_Length value of a character corresponded to each Braille code. The position value is the coordinate of a character on the display area of the tactile reading device. The Braille_Length and position values of each character are saved into the Braille access structure which is stored in the Braille output buffer. The Braille cursor on the display area of the tactile reading device is then moved based on the saved values.

5. Spontaneous update of the tactile reading device

In order to support the visual-impaired user to interact with the computer application program, this system will automatic scan the screen buffer and display the newest content to the tactile reading device. The legacy Chinese system intercepts and recognizes the output characters of an application program. The results are then transform into Chinese fonts and display on the computer screen. Generally, these screen characters are stroke-based fonts and they are rendered as graphical mode pictures. It is difficult to recognize the characters from the graphical mode pictures on the screen. Although, we can use the pattern recognition technique to recognize characters from a screen image, however, this technology is not always successfully recognizing every character on the screen. In addition, the recognition process is difficult to be executed in real-time. Hence, this paper proposed another approach to resolve this problem.

In order to successfully synchronize the screen display and the tactile reading device, a new output function, called Display Text Buffer, is plugged into the Chinese system. Hence, after the legacy Chinese system recognizes output characters of an application, the results are transfer to Display Text Buffer before they are transforming into Chinese fonts as illustrated in Figure 3. Figure 3 shows the operational schematic of exporting Chinese characters to the computer screen as well as the tactile reading device and the audio device When an application program receives a character, the Chinese system will calculate the position of that character and output it to the computer screen and Display Text Buffer simultaneously. When an image is encountered during recognition, the image data is not stored in Display Text Buffer. Instead, it is replaced by a set of empty symbols as depicted in Figure 4(a) and (b). The Screen Buffer Control Module then can scans Display Text Buffer and read the text directly.

In addition, since the display area of the tactile reading device is much smaller than the size of the computer screen, a further refinement is required when output the result to the display area of the tactile reading device. During the execution, the Chinese system will synchronize the output on the screen buffer and the Display Text Buffer. When a text is updated on the screen, the Screen Buffer Control module will scan the Display Text Buffer and export lines of text to the Braille/Chinese Translator according to the location of the cursor and the size of the display area of the tactile reading device. Figure 4(c) illustrates the case when the display area is composed of 3 by 40 Braille cells. Since the length of Chinese Braille code is not fixed, these three lines of Braille codes will not have the same length when displayed on the Braille cells.
Hence, the visual impaired user can move the cursor to read the screen text by touching the display area on the tactile reading device to know the position of each character on the screen. As the result, the visual-impaired user can easily operate the computer like the normal user.

6. The Implementation

The proposed user-interface for the visual-impairment is implemented on Linux environment with JMCE. The JMCE is a popular Chinese system on Linux. It intercepts keyboard input and the computer screen output of an application program. By scanning the keyboard buffer, JMCE transform the input into Chinese fonts and render to the screen in graphic mode.

This paper modified the input and output rules of JMCE on Linux to implement the user interface for the visual impairment. The input/output functional modules depicted in Figure 2 are embedded into respective device drivers. As shown in Figure 5, the Braille Input module and Translate Braille Code to Phonetic Symbols functional module are embedded in keyboard driver. User can use the hot-key to switch the input method among English, Chinese, English Braille, and Chinese Braille. In English and Chinese Braille input modes, our system will intercept the “up”, “down”, “left” and “right” keys to implement the Display Area Control module and synchronize the cursor movement between the computer screen and the display area on the tactile reading device. Furthermore, our system will also intercept “a”, ”s”, ”d”, ”f”, ”j”, ”k”, ”l”, and ”;” keys to read the Braille code and translate the resulted code into a Chinese phonetic symbol by searching the “antithesis table”. This phonetic symbol is then sent to JMCE Chinese phonetic input method. JMCE will output all of the detected Chinese characters with the same pronunciation to the Chinese Word Selection module. For each Chinese character, the Chinese Word Selection module is then searching the Chinese phrases hashing table to find its corresponded phrase and export this phrase to the Braille Output module. The visual impaired user can then choose the correct character according to these phases shown in the display area of the tactile reading device. The Event Control module will schedule the Chinese character output and cursor movement and transmit these events to the Screen Buffer Control module and the Audio Output module.

In addition, in order to exhibit the character on the display area of the tactile reading device, our system modifies JMCE output procedure by adding the function of exporting the text mode Chinese characters to the Display Text Buffer. This insures that the Big5/ASCII text in the Display Text Buffer is synchronized with the graphic mode text on the screen. The Screen Buffer Control can then simply scan the Display Text Buffer to export some text data (according to display size of tactile reading device and cursor position) back to the improved JMCE. The improved JMCE phonetic input method will output the corresponding phonetic transcription from the inputted Big5 code to the Braille Output module. Which will in turns transform this phonetic symbol into Braille code.

Finally, an experiment was conducted on Pentium II-233 with 64M RAM to verify the efficiency of the implemented system. A file that contains 170 lines of text and each line include a mixture of Chinese and English characters were created. By randomly moved the cursor within this text file in 150 times, the average time to export Braille code to the Braille output buffer upon detecting the cursor position is 11ms. This timing is smaller enough for the visual impaired user to fluently operate the computer.

7. Conclusion

This paper proposed an architecture and mechanism to design a user interface for the visual impaired user. The proposed user interface system enables the visual impaired user to operate a common desktop computer using the Braille input method without learning new input method or input hardware. Furthermore, this system allows the visual impaired user to read the screen text and, as a result, browse the Internet. The proposed system was implemented and is actually used in the Blind Information Center, Tamkang University, since April, 2002. It assists the visual impaired students in operating the computer and helps them study the courses of the computer science.

Significantly, the architecture of the user interface proposed in this paper can support multilingual environment by replacing the Chinese system with other language system. In addition, this proposed architecture of the Braille input model can be applied to the operating system of the wearable computing since it allow the user to manipulates the system with limited keys.

Reference

[1] Jiang Minghu, Zhu Xiaoyan, Xia Yang, Tan Gang, et. al, "Segmentation of Mandarin Braille Word and Braille Translation Based on Multi-knowledge", Signal Processing Proceedings, 2000, WCCC-ICSP 2000, 5th, International Conference on, Vol. 3, 2000, pp. 2070 – 2073.

[2] Jan Mennens, Luc van Tichelen, Guido Francois, and Jan J. Engelen, "Optical Recognition of Braille Writing Using Standard Equipment", IEEE Transactions On Rehabilitation Engineering, Vol. 2, No. 4, December 1994.

[3] J. Brabyn, "Electronic Braille Technology for the Blind", in Proc. Ninth IEEE Annu. Conf. Eng. Med. Biol., 1987, pp. 1791-1792.

[4] "Chinese Braille Code Self-Study Manual", National Central Library Taiwan Branch, R.O.C. 1997.

[5] Teng Weimin, Li Weihong, China Braille, China Press, 1996.

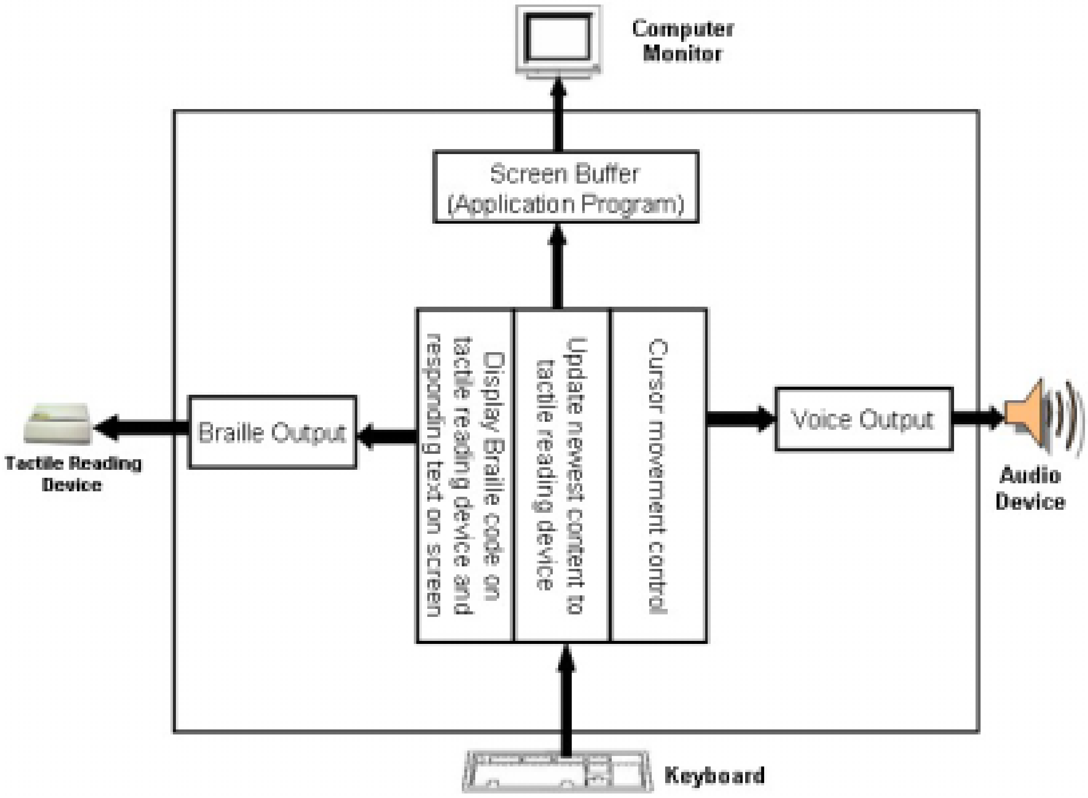

Figure 1 The block schematic of the user interface for the visual impairment

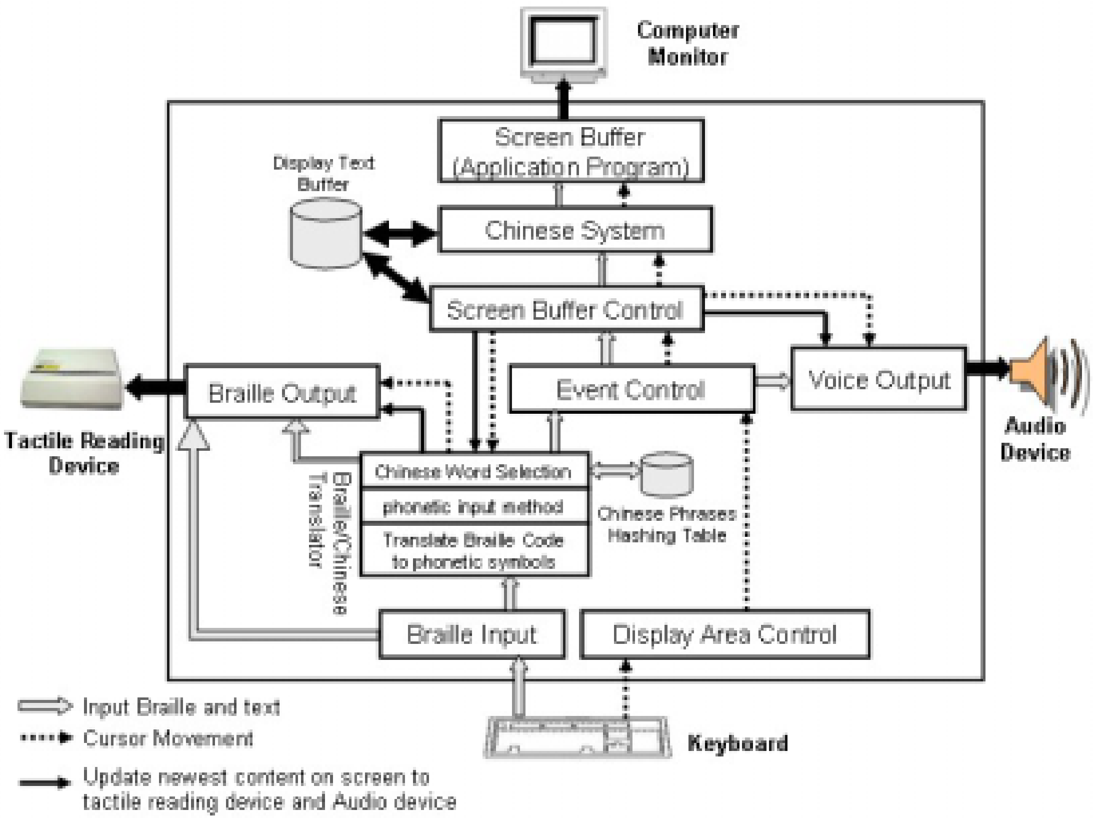

Figure 2 The system architecture of the user interface for the visual impairment

Table 1 The sample of the antithesis table

Phonetic Symbols	Braille Code	Phonetic Symbol keys on keyboard
ㄐㄧ	K*	ru
ㄍㄜ	K!	ek
. .	. .	. .

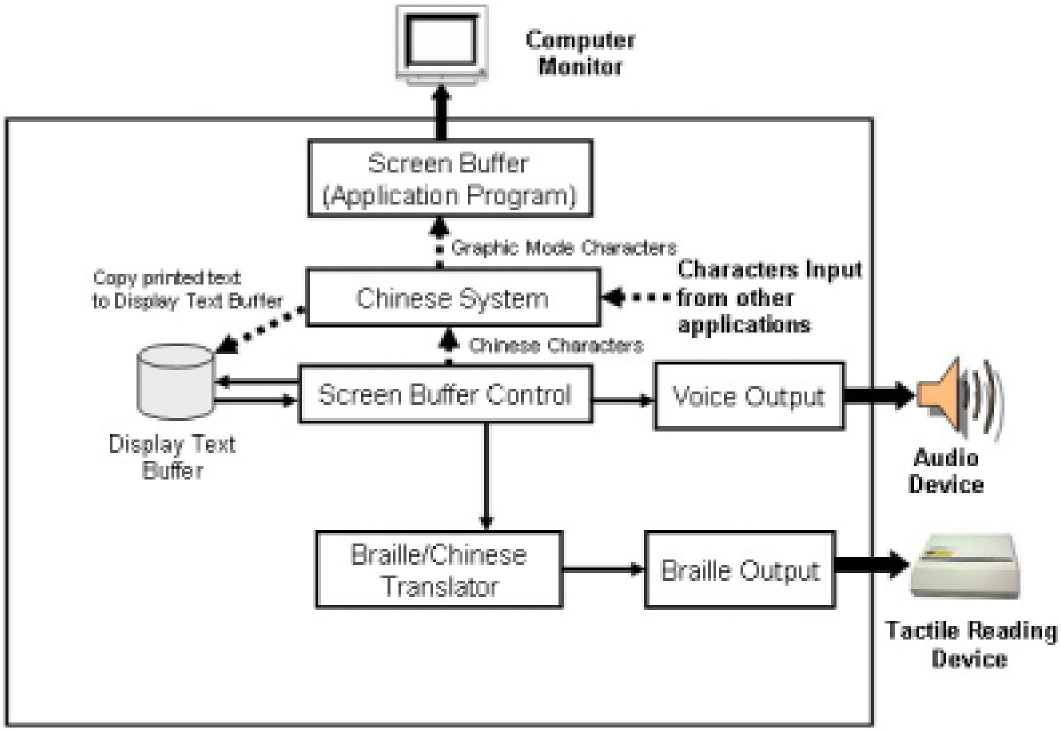

Figure 3 The operational procedure of exporting Chinese characters to the tactile reading device and the audio devices

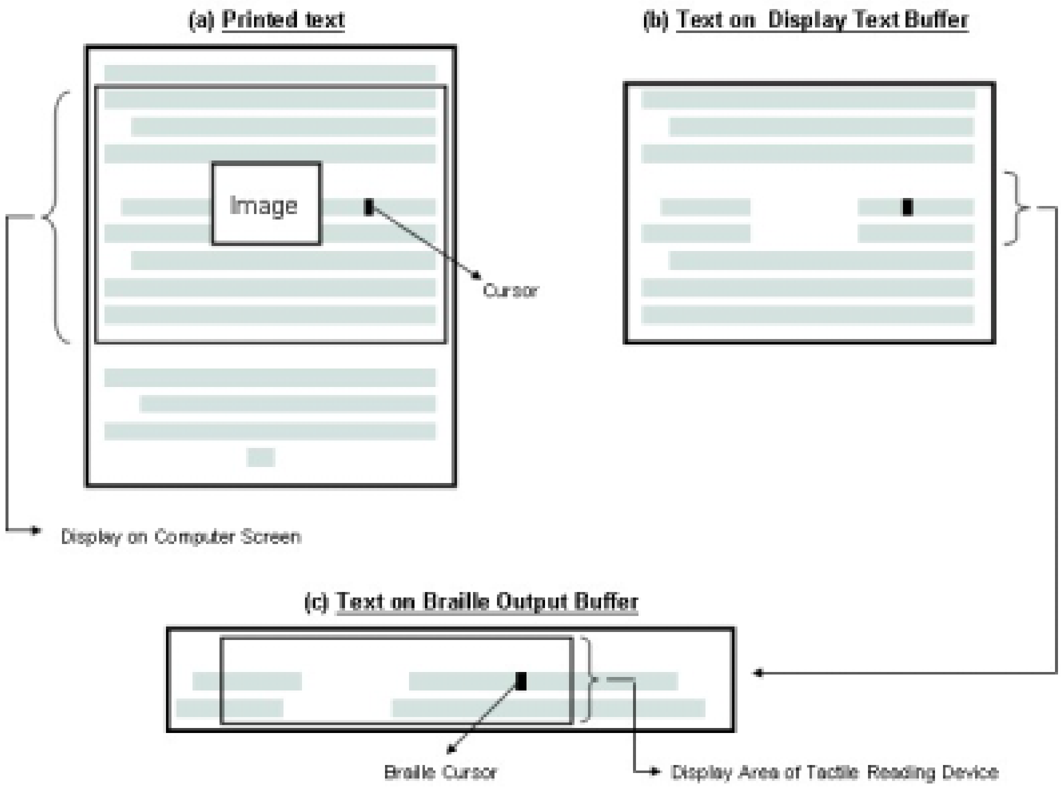

Figure 4 (a) The text showed on the computer screen (b) The text stored on the Display Text Buffer (c) The system will transform 3 lines of text from Chinese/English to Braille based on the cursor location and the display area of the tactile reading device

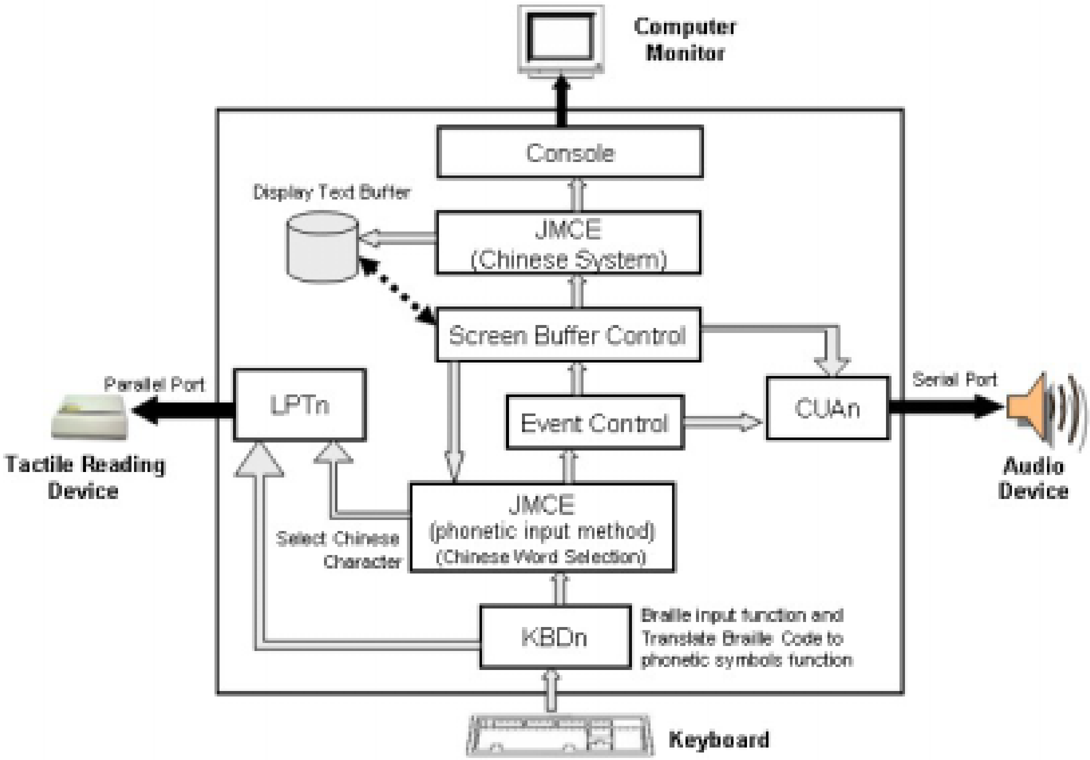

Figure 5 The implemented on Linux