BRAILLE DISPLAY TERMINAL FOR PERSONAL COMPUTERS

N. Sriskanthan, K. R. Subramanian
Nanyang Technological Institute, Singapore

ABSTRACT

Attempts have been continuously made to enhance the features of Personal Computers (PC) and to make them user-friendly so that handicapped people can access and use the PCs in their daily life. This paper describes an approach to design and develop a braille display terminal (BDT) which enables visually handicapped people to have real time interaction with the computers. The commercially available devices employing hardcopy braille printout or voice output have certain limitations on the speed of access and interaction. The terminal described in this paper essentially serves as a display monitor for visually handicapped. Hardware and software design and development are presented in the paper.

INTRODUCTION

The man-machine interfaces for personal computers are the keyboards and the video display units (VDU). The VDU provides a means of fast display of input and output (response from the computer). The visually handicapped people can practise 'fingering' on the keyboard and so be well-versed with the input device; however, they cannot use the VDU. They have to resort to the hardcopy braille printout or synthesised voice output from the computer. These devices have the limitations of interaction speed and accuracy. They do not have the flexibility of 'reading' the screen and making the necessary changes instantaneously. To receive and process the voice output, the person using the computer must be quite alert in listening. Also, the vocabulary of the synthesised voice is limited. Words with slightly different spelling but having similar phonotics may be pronounced in the same manner, resulting in incorrect interpretation. Character by character sound output is very slow for interactive use of computers. A soft braille display device, on the other hand, allows the users to 'read' the characters on their own pace and make on-line changes instantaneously. The device provides for immediate verification of input and output. Also, the wastage of paper is minimised as the contents of the screen is printed only when required at the end of the computer session. Such a direct braille display terminal (BDT) will greatly enhance the potential of computer usage by visually handicapped. A conceptual braille display system is illustrated by a block diagram in Figure 1. The development of such a system involves the design and building of a display terminal, hardware to interface to the PC and software for access and control. The system requirements and design approach are presented in the following sections.

SYSTEM REQUIREMENTS

1. A row of 80 characters similar to the one in the normal VDU shall be displayed. Three rows (lines) shall be displayed at any one instance, the first row being the user specified.

2. The display of row above or below the rows displayed shall be facilitated by a 'line up' or 'line down' key buttons respectively.

Contributed Paper
Manuscript received March 19, 1990

3. The braille characters shall be one-to-one translation of alpha-numeric text characters on the screen. Characters not specified by the braille code shall be represented by a word space.

4. Each character shall be represented by a 6-dot (3 x 2) or 8-dot (4 x 2) braille format. The spacing between the two adjacent dots in a character and between the characters shall conform to the user standards.

5. The reading of the braille display shall be by tactile means, i.e., by running the fingers across the display material and sensing the raised dots, just like reading a braille book. The protrusion (raising) of the dots shall be around 1 to 2 mm. The display material shall return to the normal position fast enough to display the subsequent rows specified by the user.

6. The BDT shall be interfaced with the IBM PC/XT or compatible computers. Hardware interface and software control shall be developed.

DESIGN CONSIDERATIONS

1. User friendliness - visually handicapped should be able to access the PC and control the output with ease and convenience. The number of gadgets to operate must be as minimum as possible.

2. Reliability and versatility - the BDT should be dependable and has the flexibility to interface with different types of PCs.

3. Transparency - the BDT control programs should not interfere with the user application programs.

4. Speed - the data transfer and conversion to the braille code should be fast and be controllable by the user.

5. Economy - a low cost device is required for the widespread use by handicapped people.

SYSTEM DESIGN APPROACH

A number of systems architecture alternative were considered.

Approach 1 - To build an interface between the composite video output of the PC and the BDT. The video signals are to be sampled, decoded and displayed. This approach has the advantage that the interface can be connected to any PC. There are certain problems in implementation such as digitizing the video signal, synchronisation and error correction. There is no user control of the display. The speed of the VDU display is different from the rate of character conversion to the braille code.

Approach 2 - To build an expansion card to be installed in the IBM PC/XT to interface with the BDT. The card retains part of the circuitry of the monochrome or colour graphic card. The video and character generator circuitry is replaced by an ASCII to braille converter and the BDT interface circuitry. This approach provides a dynamic display of the whole screen but does not allow the user control of displaying only the selected lines. It has similar drawbacks as in Approach 1.

Approach 3 - To build an interface card with address decode, RAM and microprocessor-based BDT controller. In this design, the display register must be polled continuously which informs the BDT controller as to when the PC is doing a screen memory write. The BDT does not do a screen memory read during this time. This approach also has the disadvantage that the screen display may change too fast for the BDT to capture as well as for the users to read. In approaches 1, 2 and 3 a Braille display terminal (BDT) with n x m character matrix is required, where n x m is the number of characters displayable on the full screen of the PC monitor (eg, 40 x 25).

Approach 4 - To use the serial port of the PC. The transfer of data is via the RS232C interface in which the transfer rate is very slow, thus affecting the performance of user programs.

Approach 5 - To design a card to be inserted in the PC expansion slot (similar to Approach 2). Parallel information transfer takes place via computer's data, address and control bus. The user can specify the line to be displayed. The BDT control program, which is responsible for translating the screen data into braille codes, is activated only when the user initiates an interrupt command. In this method, the performance of the user program is not drastically affected.

Approach 5 has been selected in consideration of speed, user's ability to control over the contents to be displayed, cost and simplicity. One concern is that this system design is too system dependent. That is, the card developed can only be used in IBM PC/XT and compatibles. However, the design can be adopted and modified to develop suitable cards for other PCs.

BRAILLE DISPLAY CELLS

The computer braille codes as specified by the Singapore Society for the Blind are adopted in the design of the braille cells. The braille codes are illustrated in Figure 2(a). The recommended spacing between the dots in a character is about 3 mm, and between the characters is 10 mm. The design specifications for the braille display cell are set as follows:

1. The cell dimensions are shown in Figure 2 (b).
2. When a pin is activated, it should be raised by 1 mm (the required protrusion for a dot on the display material).
3. The pin movement is electro-mechanically controlled using relays.
4. Current through the relay coil should be minimum, recommended not to exceed 5 mA.
5. To accommodate a large number of cells in a small size display terminal, miniature relay coils should be used.
6. The input signal to the cell is to be TTL and digitally latched. If the current flowing is prohibitively high, a scanning approach can be used. In the scanning method, a capacitor included in the relay or logical control circuit is charged while the relay is activitated. After the current ceases, the charged capacitor will keep the relay activated. The capacitor has to be periodically charged to maintain the relay activated.

SOFTWARE DESIGN

The BDT control software is required to read three lines from the video monitor starting from the specified line number and convert them into braille codes to the BDT for display. The software is a Terminate-and-Stay resident program in the PC and does not affect the execution of user application programs. The control program has four main functions: initialisation, input, process and output. The initialisation of the terminate-and-stay resident program is done by interrupts from the BDT. The input and output functions are performed by direct access to the BDT ports. The function of the process is to convert the ASCII characters obtained from the screen buffer into braille codes. The output module controls the BDT in order to display the codes in the correct sequence.

SYSTEM IMPLEMENTATION

The braille display system consists of a control unit, a display terminal and a keypad. As it would be convenient for users to minimise the number of devices to be accessed, the special keypad required to issue commands to the display control unit is integrated with the normal PC keypad. Thus, the hardware cost is minimised while making it convenient for handicapped users.

The electro-mechanical BDT comprises:

(a) a 40-cell unit which displays 40 characters at a time.

(b) 2 separate cells to display the 2-digit cursor line number.

The top view of a cell is illustrated in Figure 3. All the cells, which are identical, are connected together in parallel by a common bus to the interface circuit, as shown in Figure 4. It consists of four main sub-circuits: (a) power supply, (b) control, (c) cell driver and (d) cell select. A double-sided PCB is used to accommodate all four sub-circuits in the control unit. The PC address decode and buffer sub-circuit is fabricated as a card to be plugged into the IBM PC expansion slot. Larger units can be built utilising similar design techniques and control circuits. The terminal is configured to display 40 characters at a time. An 80-character line is displayed by dividing it into two 40-character lines. The first 40 characters and the line number will be displayed first. The subsequent characters will be displayed on the user request. The line break is identified by means of a special character. If 80-characters are to be displayed in one line, a small modification to the software and an 80-character wide BDT are required.

The software is implemented with the assembly language programming. Microsoft 8086 Macro Assembler version 4.0 and Microsoft 8086 Object Linker version 3.05 are used. The braille display system (BDS) software has two main programs, the Install program and the Control program. The install program installs the control program into a portion of the system memory and reserves that area. The control program controls the display on the BDT and allows the user to read the contents on the screen as conveniently as possible. The software is grouped into modules as shown in Figure 5. The functions of each module are listed below:

INSTALL : Installs the Control program into a portion of the memory and initialize the BDS.

ACTIVATION : Allows for keyboard activation of the Control program through some designated hot-key.

DISPLAY CURRENT : Displays the line where the cursor is currently on.

DISPLAY UP : Displays the line just above the current line.

DISPLAY DOWN : Displays the line just below the current line.

DISPLAY SCROLL : Displays the whole screen by scrolling line by line.

DISPLAY AUTO : Automatically scrolls the whole screen, line by line.

DISPLAY NUMBER : Display the line number requested by the user.

FUTURE DEVELOPMENT

The electro-mechanical BDT operates well and fulfills the requirements satisfactorily. However, it is not found to be very cost-effective for widespread use. A terminal employing thermo-plastic material to display the Braille patterns is proposed. Using the property of thermo-plastic material (expand on heating and contract on cooling), it is possible to construct Braille cells as shown in Figure 6. An investigation is being carried out to identify a suitable material for this applicaion.

CONCLUSION

A fully functional Braille Display Terminal has been developed for the visually handicapped people to access IBM personal computers and work with them. Hardware and software design required for the fabrication of control circuitry, Braille character conversion modules and Braille display terminal is described.

ACKNOWLEDGEMENT

The contributions of Ow Weng Kee, Teo Hang Yeong, Joseph Noel, Lee Chee Kit, Peter Chan and Huan Boon Kean towards the design and development of the BDT are gratefully acknowledged.

REFERENCES

1. Tom Kihlken, "Communications And Video Setup With Setmode", PC Magazine, July 1988.

2. Al Stevens, "Writing Terminate-And-Stay-Resident Programs", Computer Language, February 1988.

3. Peter Norton, "Inside the IBM PC: access to Advanced Features and Programming", Robert J Brady Co, Bowie, Maryland, 1983.

4. "Uses of Computers in Aiding the Disabled", Proceedings of the IFIP-IMIA Working Conference on Usage of Computers in Aiding the Disabled, edited by Josef Raviv, published by North-Holland Publishing Co, Amsterdam, 1982.

5. William Schiff and Emerson Foulke, "Tactile Perception: a source book", published by Cambridge University Press, New York, 1982.

6. Leslie L Clark, "A Guide to Developing Braille and Talking Book Services", IFLA Publications, 1984.

7. Richard Dufton, Proceedings of the International Conference on Sensory Devices For the Blind, published by St. Dunstan's, London, 1966.

8. Glenis Moore, "Literacy and computing for the blind", Electronics & Power, July 1966.

9. Ware Myers, "Aid the Handicapped", IEEE Micro, February 1982.

10. Michael Hyman, "Memory Resident Utilities, Interrupts, And Disk Management With MS and PC DOS".

(Diagrams are on the next page)

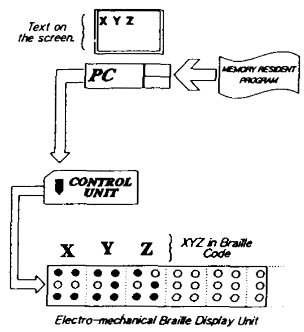

Figure 1 Braille Display System

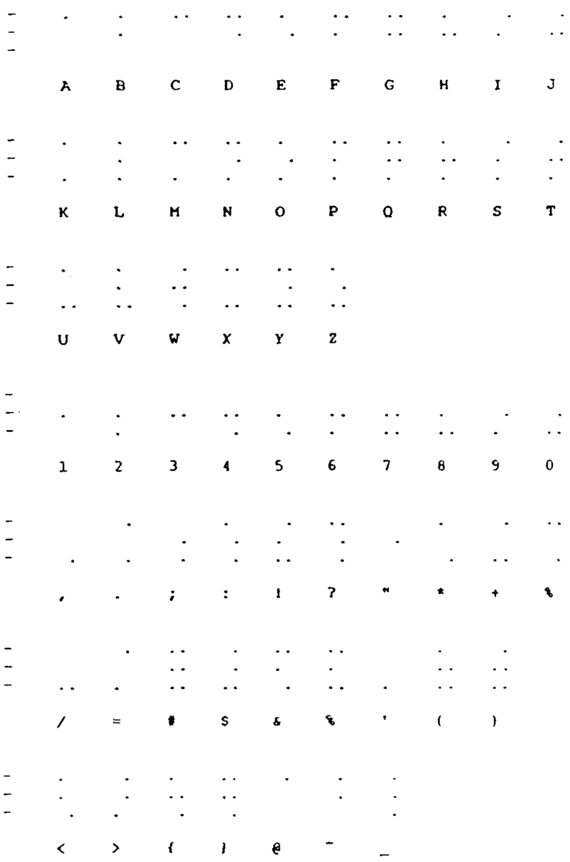

Figure 2(a) Braille Codes

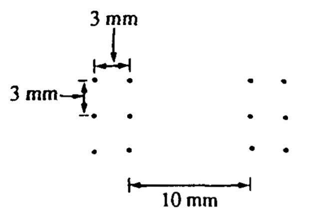

Figure 2(b) Braille Cell Dimensions

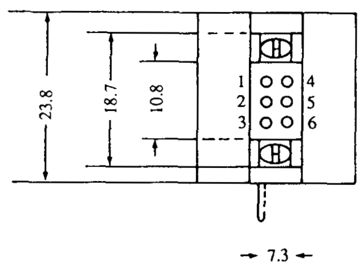

Figure 3 Top View of One Braille Cell

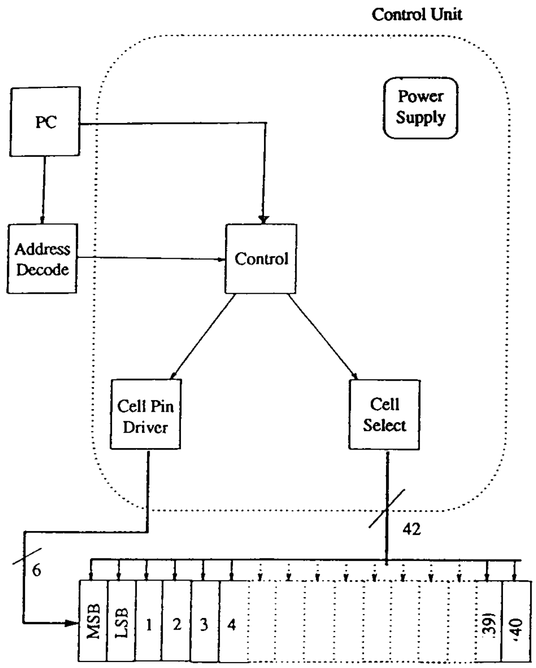

Figure 4 42-cell Braille Display System Hardware

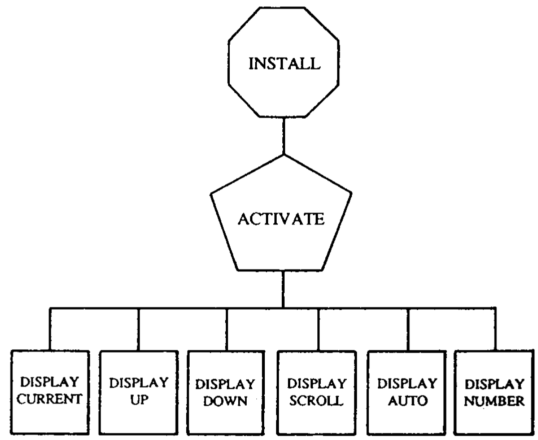

Figure 5 Software Functional Modules

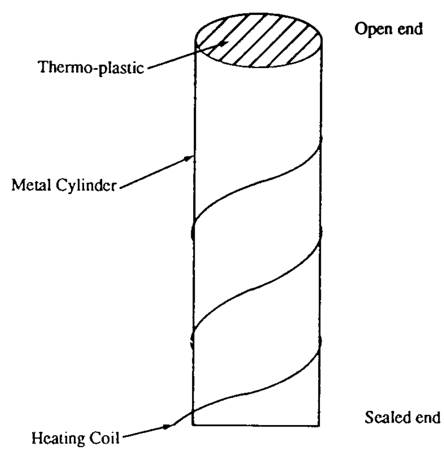

Figure 6 A view of a Thermo-plastic Braille Pin

Mr Nadarajah Sriskanthan is a Senior Lecturer, School of Applied Science, Nanyang Technological Institute, Singapore. He received the BSc degree in Electrical Engineering from the University of London and the MSc degree in Electronic Equipment Design from Cranfield Institute of Technology, U.K. in 1972-78 respectively. He worked as Senior Test Engineer with Plessey Radar from 1972-76. From 1978-82, he was Design Engineer at Philips, Crogdon, From 1982-84, he worked as Research Officer at Cranfield Institute of Technology. Since 1985, he has been lecturing at the Nanyang Technological Institute, Singapore, in Computer Inter facing Techniques. His research interests are in developing computer interfacing hardware and software, particularly in the application of Computer Graphics, Videotext, Multiprocessor and Control.

Associate Professor Regu Subramanian is with the School of Electrical and Electronic Engineering, Nanyang Technological Institute, Singapore. He received B.Eng (EE, First Class Honours) degree from the University of Madras amd M.Sc (EE) from University of Alberta, Canada. During his employment with Alberta Government Telephones from 1969-76, Regu acquired an extensive and broad experience in telecommunication networks and systems. From 1976-84, Regu was with Bell-Northern Research Limited, a renowed communications research organisation in Canada. He conducted systems research in telecommunication network characterization, evolution, strategic planning and fibre optic applications. He is a member of IEEE, IEE, and IES. He is a Chartered Engineer and a Professional Engineer. The areas of his current research interests are Communication Systems, Computer Communication Networks and Fiber Optic Communications.