micro-ordinateur pour machine a parler a l'usage des aveugles francophones" (From Written to Spoken, a Microcomputer Program for a Talking Machine for the Use of the French-Speaking Blind), *Le Francais Moderne* **48**, 225-245 (1980).
[7]R. Carlson, K. Galyas, B. Granstrom, S. Hunnicutt, B. Larsson, and L. Neovius, "A Multi-Language, Portable Text-to-Speech System for the Disabled," *Technology That Enables, Proc. Fourth Annual Conf. on Rehabilitation Engineering* (1981).
[8]C. Eldridge, "Braille Literacy and Higher Education," *Education of the Visually Handicapped*, 8-12 (Spring 1979).
[9]"A Typewriting Program for Visually Limited Children," *New Outlook for the Blind*, 56-62 (Feb 1969).
[10]J. Selby, "Undergraduate Days," *Blindness*, 100-102 (1971).
[11]J. A. Kutsch, Jr., *A Talking Computer Terminal*, Ph.D. dissertation, Department of Computer Science, University of Illinois at Urbana-Champaign (13 Jul 1976).

A BRAILLE WORD-PROCESSING SYSTEM

Robert E. Stepp III
509 E. White, Champaign, Ill. 61820

Robert E. Stepp III

More than secretaries and journalists, braille transcribers need word processing to help them be more productive. An inexpensive but full-powered braille word-processing system is described that can be used to transcribe both textual and nontextual (e.g., music or scientific) materials. Using a slightly modified Apple II personal computer, braille is keyed into the system. It is then displayed in the standard braille format on the screen, revised using a powerful text editor, and embossed by a computer-adapted Perkins brailler. High-quality braille is produced by the system without the frustration and delay of rebrailling an entire page when a mistake is made.

Introduction

The visually handicapped individual who has learned braille depends on ready access to braille materials. In the United States, braille is produced by both large braille printing houses (e.g., the American Printing House for the Blind) and individual volunteers working in their homes. The large printing houses handle the high-volume braille materials such as magazines and popular literary works. Low-volume and nonliterary work (music and technical texts) are handled almost exclusively by volunteer braillists. These 2000 or so individual braillists are collectively responsible for producing all braille music and most college textbooks, plus other scientific, mathematics, and foreign language braille texts.

Volunteer braillists produce braille in their homes on a mechanical braille embosser such as the Perkins brailler. This machine embosses raised dots directly onto heavy paper. Each braille page consists of 25 lines of braille with up to 40 braille characters per line. When a mistake of a single dot is detected, the entire sheet must be rebrailled. (If another mistake is made while copying the correct portion onto the new sheet, it too is ruined.) This extraordinary concern for perfection is necessary. Blind readers are very sensitive to even small "blips" (partially raised dots) on the page. Perfect braille pages are also required when using a thermoform duplication process, which copies entire pages of braille onto thin plastic. Much of a braillist's time is wasted rebrailling pages to correct errors.

Recently, progress has been made in developing computer systems that can automatically translate computer-readable text into what is called Grade II braille. A straightforward literary work can be typed into such a system by a secretary, and usable braille copy will be produced. Unfortunately, there is much printed material that cannot be processed by automatic translation. Many materials, including music scores, mathematical formulas, engineering equations, and foreign languages, can, however, be converted to braille and typed in braille form into a brailling machine.

A Braille Word Processor

A word processor is a computer system that absorbs text into its memory as it is typed on the keyboard, displays the text on a screen for proofreading, allows effortless correction of errors, and finally types out a perfect copy on paper. A braille word processor performs the same functions but with the input, display, and output in braille format. Since the braille format is unnatural to regular keyboards,

displays, and printers, three hardware extensions to the Apple II computer are necessary.

Braille Input. Braille is typed on a keyboard that has six keys and a space bar. Each key causes one of six possible dot positions in a braille character (cell) to be embossed. If the desired character has four raised dots, then four keys must be pressed simultaneously to type the character. This keying technique is quite unlike regular typing, in which only one key is pressed at a time. An extra circuit added to the Apple computer keyboard interface allows the simultaneous key pressing necessary for braille. The keys S D F J K L and the space bar are used to type braille. The system is designed to interpret any combination of S D F J K L pressed together as one braille cell.

Braille Display. During editing and proofreading, braille text is displayed on the screen of the computer system in a format identical to a braille page. Each braille character is presented as a 2×3 pattern of dots. The screen holds up to 22 lines of 40 braille characters each. Braillists proofread their work visually. The braille computer display is much easier to read than the all-white embossed paper output of a regular brailler. The braille character display on the Apple II computer is accomplished by installing a small circuit module that contains a braille character generator. This gives the Apple II the ability to display all 63 braille cells in addition to regular (ASCII) characters.

Braille Output. The final output from the word-processing system must be embossed braille. Commercial computer-controlled braillers are very expensive ($20,000 and up) and bulky. A computer-controlled brailler the size and price of an electric typewriter was designed and fabricated, using the mechanical Perkins brailler as a major component. The working prototype produces high-quality braille at a rate of eight braille cells per second (one page every three minutes). The computer interface to the Perkins brailler is housed in a 1.25-inch extension to the base of the brailler. A flat cable coming out of the right side of the brailler connects to a communication board that plugs into the Apple computer.

These three enhancements to the Apple II computer, plus a powerful braille text-editing program, constitute the braille word-processing system. The system is small enough and inexpensive enough to be placed in the home of the volunteer braillist.

Operation of the Braille Word Processor

Most work is performed by interacting with a powerful braille text editor (the same editor can be used in regular mode, if desired, to handle alphanumeric text). The system uses a simple command language that is consistent and easy to learn. To enter a braille document, the user brailles the letter I (the INSERT text command), and the system prompts with ?. The braille text is then typed by striking any combination of the six keys: S D F J K L. An empty cell is entered by pressing the space bar. The system interprets the combination of keys pressed together as one braille cell, and that cell is displayed in braille on the screen. If an error is made in entering a line, the backspace key may be used to reposition the cursor, and the cell may be retyped. When a line of braille is complete, the RETURN key is pressed to advance to the next line (another ? sign prompt is given). Two consecutive RETURN's terminate the insertion of text.

After the braille text has been entered, editing commands make it easy to adjust the text and correct errors. The system can perform high-speed searches for strings of braille cells and can do local and global substitutions of one string of braille cells for another. Additionally, the powerful Modify command allows corrections for one line of braille to be entered by typing the corrections underneath the incorrect portions of a displayed image of the line (it is not necessary to reenter the correct portions). The Modify command can also be used to reposition the braille text on a line. This is very useful in brailling music, where one part must line up with another part or with the words of a song.

When corrections are complete and an embossed copy is desired, a command causes the braille text to be transmitted to the modified Perkins brailler, where it is embossed at a rate of one page every three minutes. Braille texts may be stored on diskettes indefinitely and retrieved as needed for further revision or to emboss additional copies. With widespread use of braille word-processing systems, the diskettes themselves could be exchanged between braillists to allow them to share their resources. For example, computer-controlled braillers might be concentrated at one location. Individual braillists could mail diskettes produced on individual braille word-processing systems to the central location for embossing as needed to serve the requests that come in. The diskettes could be stored in the library rather than the bulkier paper copies.

Conclusion

Experience with the prototype braille word-processing system, in the hands of an expert music braillist, has shown that it greatly increases the productivity of the braille transcription process. Copy mistakes are a thing of the past. Word processing also facilitates experimentation with alternative approaches to brailling a complicated passage. With little additional effort, several different solutions may be tried, and one eventually selected. With word-processing systems, braille transcribers will be able to meet many more needs of the visually handicapped than they can today.

ACKNOWLEDGMENTS — This project would not have existed without the help and advice of Mrs. Edward J. Krolick, Vice Chairman of the Braille Music Committee of the National Braille Association. Her enthusiastic interest in advanced technology for producing braille continues to be indispensable.