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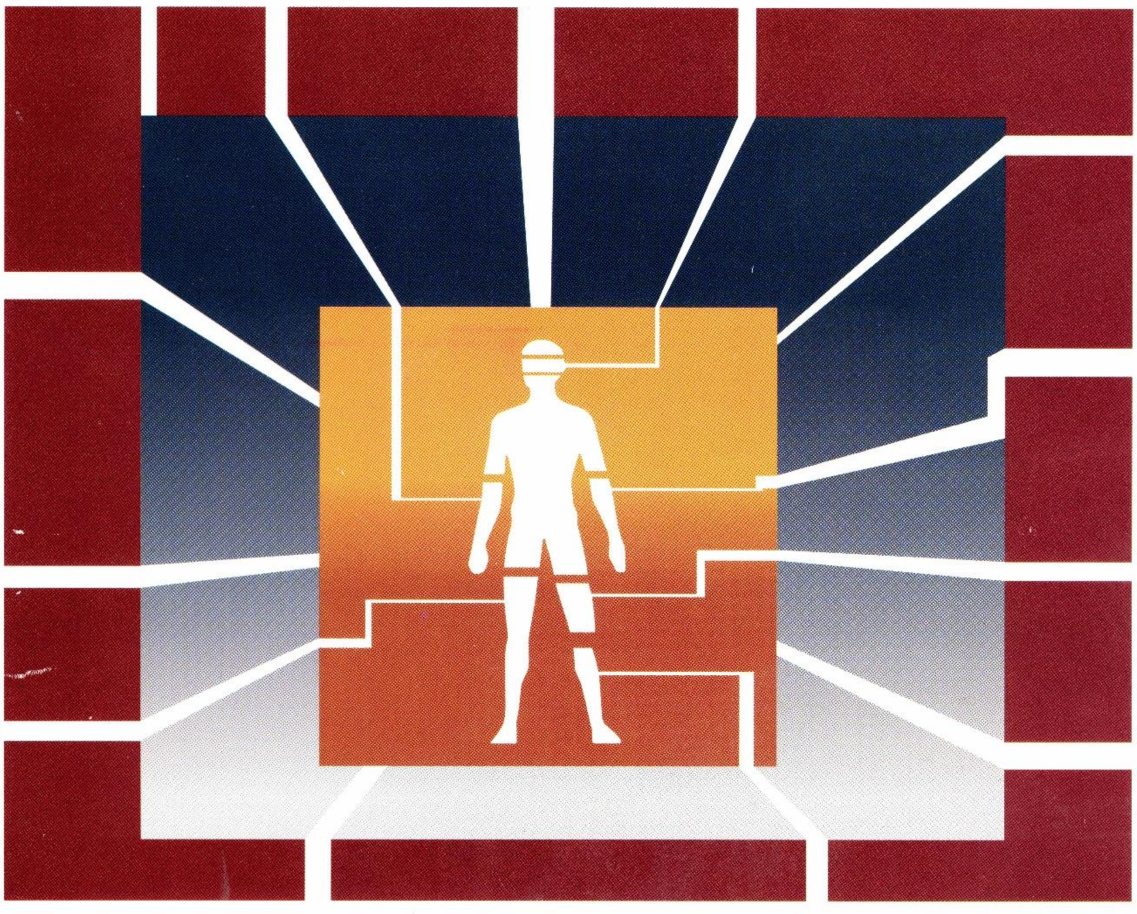

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VIRTAC, a Virtual Tactile Computer Display

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Abstract

The goal of the VIRTAC design is to provide an affordable means for a blind person to make use of the large base of publicly-released industry-standard software for the IBM PC/XT/AT compatible computer. The tactile display gives the operator the ability to explore text displays in a Braille mode and graphic displays in a direct tactile mode. The hardware includes a circuit board that occupies one expansion slot in the PC but requires no modifications to the computer or to the software being run on the computer.

1: Introduction

VIRTAC is a system designed to allow a blind computer user access to the large base of software available for the IBM PC/XT/AT compatible personal computers. The ultimate design goal is to provide an affordable means for augmenting a standard personal computer so that the blind user can work in the same hardware/software environment as his classmates or professional colleagues. Maintaining the common hardware/software environment is important because any design that relies on non-standard computers or special versions of software adds to the barriers that separate the blind user from the sighted user.

The specific goals of the VIRTAC design are to allow the blind user to:

1) use a standard IBM PC/XT/AT compatible computer;

2) use unmodified, standard software packages;

3) read the full text output of the computer as it appears on the normal video monitor (with rows and columns and other formatting preserved); and

4) interpret graphic displays that appear as monochrome (black and white) on the normal video monitor.

2: Virtual reality

A virtual reality can be created by using a computer to generate the set of sensory stimuli that would be produced if the objects and conditions in the computer's model universe physically existed. Very convincing virtual realities based on realistic visual and audio displays are now routinely generated by off-line processes for the entertainment industry. Less convincing, but very effective, virtual realities based on visual, audio and motion displays are routinely generated in real-time for high value applications such as aircraft flight and tactical weapon training simulators.

In the computer video display scenario, establishing a tactile virtual reality is orders of magnitude simpler than attempting to generate a virtual reality based on realistic visual displays. A universe consisting of only the information that is displayed on a computer video monitor can be exactly represented in a few thousand or a few hundred thousand bytes of computer memory. The tactile representation of this universe is sensed through a fingertip-sized window that reveals only a few bytes worth of information at any instant.

3: Tactile screen displays

3.1: The real full-screen tactile display

The VIRTAC design is an extension of the concept of "soft copy" Braille which, in its basic form, mimics the tactile appearance of embossed Braille characters through the action of small pins that can be electromechanically actuated to protrude above the surface of a display device. Stacking together enough pins and electromechanical actuators to mimic a full page of Braille text or one video monitor screen full of text would lead to a level of complexity that makes the cost of such a device prohibitive. However, such a full-page or full-screen display has the important advantage that the spatial

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relationships (of graphic displays, spreadsheets, tabular lists, etc.) that are clear to the sighted operator viewing the video monitor screen are preserved for the blind operator scanning the entire tactile display with a fingertip. In the process of moving a finger over the surface of the display, the blind operator builds a perceptual image based on two kinds of sensory data. The first kind is the textural information gathered by the fingertip. The second kind is the kinesthetic information from the arm and hand that provides the relative location for each bit of textural information gathered by the fingertip. It is essential that the fingertip roam the display surface if the surface is to be perceived accurately.

3.2: The virtual full-screen tactile display

Two key facts make it possible to avoid the complexity and expense of the full page/full screen tactile display:

First, the area of the fingertip used to roam the display surface is only a small fraction of the area of the full display surface. Therefore, at any instant, the sensory input to the fingertip is the same whether the display surface is fully populated with actuator pins or is populated with actuator pins only in the small fraction of the total display surface that is directly under the fingertip.

Second, the surface that is to be displayed (whether text or graphics) is exactly defined in the memory of the computer. Therefore, at any instant, it is possible to examine the memory of the computer and exactly determine the state of the entire display surface. Further, if the position of the fingertip on the display surface is known then the sensory input to the fingertip can be exactly determined. By using a small array of pins and mechanical actuators that remain under the fingertip as the fingertip is moved, the fingertip can be provided with the tactile sensory input that is appropriate for the location of the fingertip on the display surface.

4: VIRTAC

VIRTAC's virtual tactile window is implemented by electromechanically actuated pins in a rectangular tactile array comparable in size to the sensing area of the fingertip. The array is mounted in a handrest similar to a computer "mouse" that allows the computer user's hand to push the handrest around on a horizontal surface while the user's fingertip senses the state of the tactile array. The user's fingertip moves within a display rectangle that is logically equivalent to the rectangular screen of the computer video monitor, which is logically equivalent to the video memory within the computer. (See figure 1)

A measuring system determines the position of the user's fingertip within the display rectangle and makes this information available to a control microprocessor that has access to the information contained in the video memory within the computer. The control microprocessor determines the position of the fingertip within the display rectangle and reads the data from the corresponding

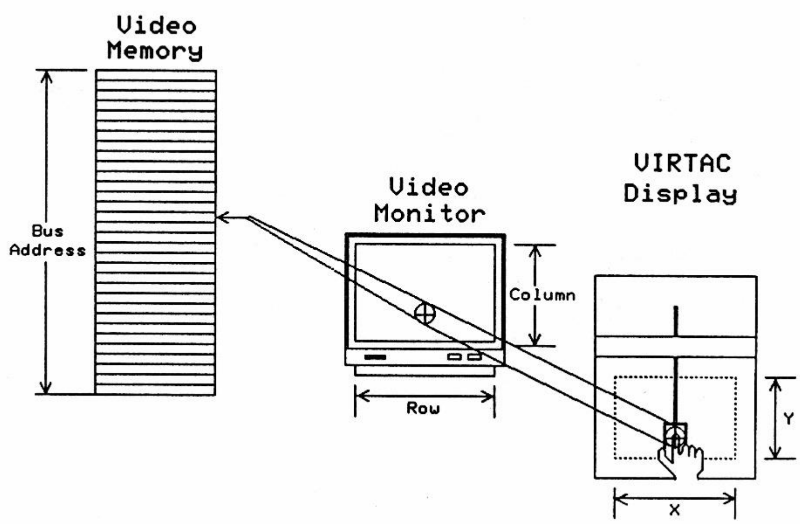

Figure 1: The three coordinate frames used in the VIRTAC System.

location in the video memory. Depending on the operating mode selected by the user, the control microprocessor generates a Braille character to represent a text character, a textural surface to represent a graphic figure or a textural pattern to represent some status information. The control microprocessor then commands the electromechanical actuators to put the tactile array into the proper state.

An important feature of the VIRTAC design is that the activities of the VIRTAC system do not require the cooperation of the personal computer or of the software running on it. Figure 2 shows the basic architecture of the IBM PC family of computers. In this architecture, all data transferred between the CPU and any of the peripheral devices (including the Video Output Controller) are transferred via the expansion bus. Since this is a parallel bus structure, all of the bus data, address and control signals are available to every device on the bus. Every device is free to make whatever use it can of the bus signals.

Note, in Figure 2, that information from the IBM PC Expansion Bus flows into the VIRTAC Controller board but no information flows from it back onto the PC bus. The Controller board can monitor all of the activity on the PC bus without making any demands on the CPU or on the software that the CPU is running. The display memory in the Video Output Controller occupies a fixed, well-known set of PC bus addresses so the Controller board is able to monitor the data transfers on the bus and determine when and what data have been sent to the display memory. Any data that are determined by the VIRTAC Controller to be enroute to the Video Output Controller are simultaneously written into a dual-ported RAM in the VIRTAC Controller. The control microprocessor has access to the contents of the dual-ported RAM, which are an exact copy of the display data in the Video Output Controller. The architectural schematic in Figure 3 is presented as an aid in understanding how the control microprocessor interacts with the PC bus monitor hardware and the tactile display hardware.

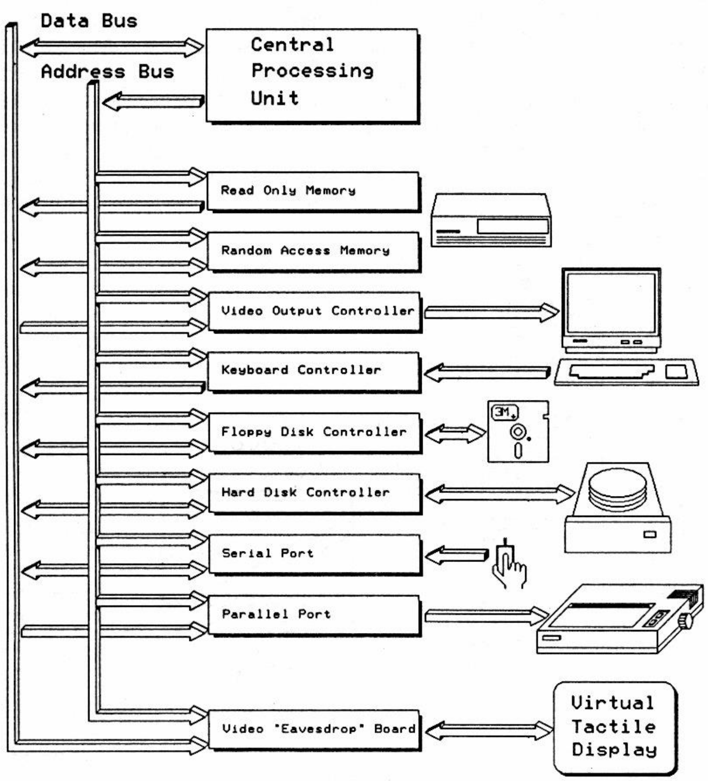

Figure 2: The architecture of the PC/XT/AT Expansion Bus.

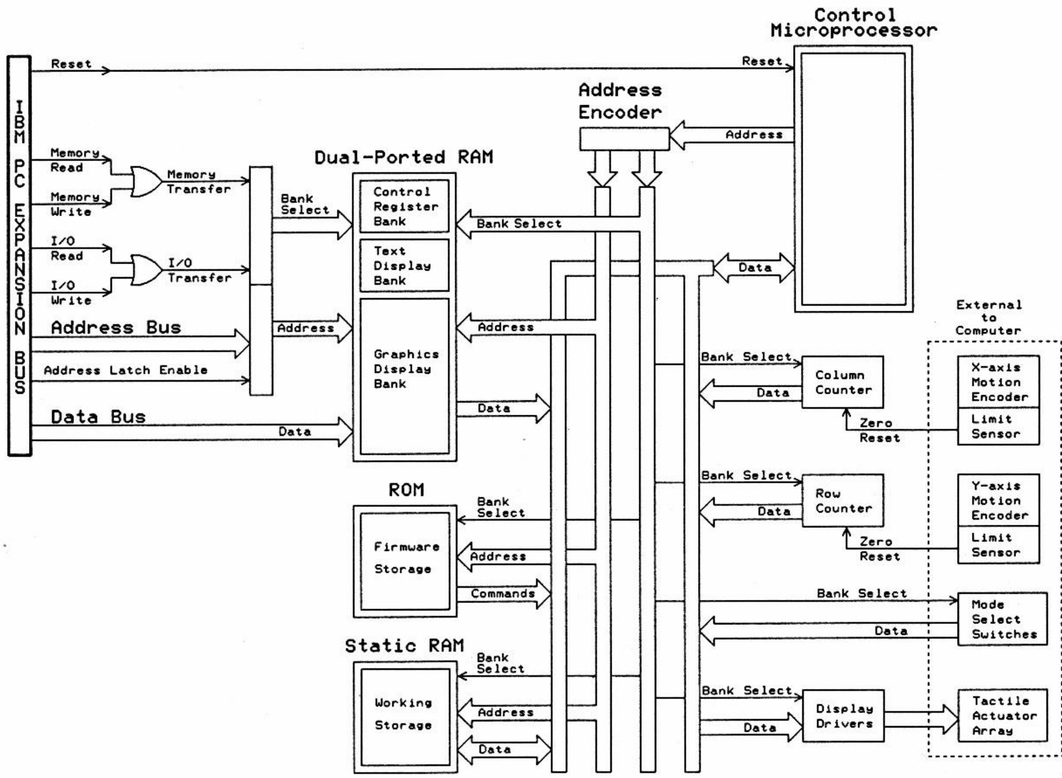

Figure 3: The architecture of the VIRTAC System. Except for those labeled as external, all components are located on the VIRTAC Controller Board, in the personal computer.