

INTEGRATING COMPUTER GRAPHICS
AND THE VIDEODISC: NEW INSTRUCTIONAL
TECHNIQUES POSSIBLE WITH IVIS

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TECHNICAL REPORT

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INTEGRATING COMPUTER GRAPHICS
AND THE VIDEODISC: NEW INSTRUCTIONAL
TECHNIQUES POSSIBLE WITH IVIS

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ABSTRACT

Digital Equipment Corporation has developed a new system for integrating computer graphics and the videodisc. This system is called IVIS, the Interactive Video Information System. The unique characteristic of this system is that it allows images generated by the videodisc to be overlaid with computer graphics of industry standard quality (resolution of 960 pixels horizontally by 240 vertically). This quality is achieved by converting the NTSC videodisc signal to RGB rather than using the more common technique of converting the RGB computer signal to NTSC.

The power of this integrated medium offers CAI course developers a number of new techniques for communicating information to students. This paper introduces some of these techniques, emphasizing CAI applications of overlaying. Controlling software is explained, including extensions to a graphics editor for specifying videodisc sequences. An IVIS CAI course on the installation and maintenance of a new printer is described, highlighting applications of the system's unique instructional features.

This paper has been submitted for presentation at the 25th International Conference on Computer-Based Instruction sponsored by the Association for the Development of Computer-based Instructional Systems (ADCIS).

SOME PROS AND CONS OF VIDEODISCS

As a storage medium for video images, the videodisc is unequalled. Not only can the disc store up to 30 minutes of prerecorded video per side, but each component image of that video can be displayed individually to yield over 54,000 still frames. These capabilities can make the videodisc an important instructional tool for all subjects that exhibit significant visual components.

Even with all of its advanced features and exceptional still frame capability, the videodisc is still not an appropriate medium for all types of visual displays. It is not, for example, a good medium for displaying large amounts of text or fine line drawings, because even the most rock solid image generated by the finest NTSC television cannot match the distinctly crisp lines that can be generated on an RGB computer display of even medium resolution.

Another problem with putting instructional materials on videodiscs is that the discs cannot be altered once they are pressed. (There has been much talk about "write-once" discs, but they are not yet economical.) This characteristic can make it difficult to revise instructional materials once they are tested, and to correct errors that pop up only after the disc has been in use for some time.

SOME PROS AND CONS OF COMPUTER GRAPHICS

Computer graphics, on the other hand, offer excellent resolution for many types of line figures. However, the natural images that are easily displayed from a videodisc are very difficult to produce by computer. While some computer graphic systems allow limited animation, the types of systems commonly used for CAI only allow the instructional designer to animate very small entities, such as a few special characters. Full screen motion of the type we are used to seeing on television is virtually impossible on systems commonly used for CAI today.

Unlike the videodisc, computer graphics are particularly well suited to displaying text on video screens in a large number of sizes, fonts, directions, and colors, with special attributes such as blinking, bolding, and reverse video. Most experienced CAI screen designers would agree that one should almost always use as little text on the screen as possible (illustrative diagrams are the preferred communication vehicle). When text is used, however, the screen resolution must be fine enough to allow that text to be read and understood easily.

Graphics stored on computer disks (or systems) are generally easy to update. If the graphic code itself cannot be patched, it is usually easy and inexpensive to generate new disks and distribute these to the system's users. This feature allows instructional designers to test their materials in final form and make revisions based on actual student usage. Most storage media for graphics software also make it possible to correct mistakes that are discovered only after the product has gone to the field.

THE BEST OF BOTH WORLDS

Digital Equipment Corporation has developed an integrated videodisc and computer graphics system that offers the best qualities of both of these media. This system is called IVIS, the Interactive Video Information System. The heart of the system is an option to the Professional 350 minicomputer that contains:

- a circuit for converting the NTSC signal generated by the videodisc to an RGB signal compatible with that produced by the Professional 350.
- a circuit that allows the video signal generated by the computer and that produced by the videodisc to be mutually synchronized, and
- a circuit for mixing the two synchronized RGB signals into a single signal (960 pixels horizontally by 240 pixels vertically) and displaying it on a medium resolution RGB color monitor.

The complete IVIS system also includes the base Professional minicomputer (including floppy diskettes, 10Mb of hard disk, floating point processor, and color graphics system), a computer floor stand, a videodisc player using an RS232 interface, a Digital VR241 color monitor (capable of displaying up to 8 colors simultaneously from a palette of 256), and optional printers.

The Professional 350 IVIS option can operate in four modes, each with a unique application in course presentation.

- Professional 350 mode -- all capabilities of the Professional 350 are available to the developer (including lower resolution/greater color selection). However, when the IVIS option is switched from this mode, the screen will roll until synchronization is acquired.
- Synchronized Professional 350 mode -- all eight colors are available to the user and display from the videodisc source is not possible. This mode is used for extended computer-based instruction sequences that wish to use the

eighth color but that need to convert to IVIS mode without the roll associated with the first acquisition of synchronization.

- Video mode -- the signal coming from the video source is displayed directly on the monitor with no switching between graphic and video sources. This mode is used when all the information is coming from the videodisc.
- IVIS mode -- one of the eight colors (selected from the 256-color palette) is designated as transparent, allowing both graphic and video images to be displayed on the screen simultaneously.

In IVIS mode, the screen can be completely devoted to the videodisc by setting the background color to transparent. With the screen background set to any other color, only the computer-generated text and graphics are displayed. To overlay computer graphics onto a videodisc image, the screen background is first set to transparent, allowing the video image to show through. Other graphics are then drawn on the transparent background in any of the remaining seven colors, effectively blocking out the video at those points and simultaneously displaying their information.

THE IVIS HARDWARE

A simplified block diagram of IVIS is shown in Figure 1. Experiments with converting the computer-generated signal to NTSC resulted in intolerable visual quality. Colors bled into each other and shifted in hue and saturation, and the system was not able to display lines with single pixel widths. Industry standard text displayed 80 characters per line was illegible. Digital's engineers therefore converted the NTSC videodisc signal to RGB even though this approach is more difficult and expensive (though straightforward).

The real difficulty in building a system of this type is in the synchronization of the two video signals. Computer terminals and computer graphics subsystems are virtually never designed to be synchronized to external sources. With industrial quality videodiscs or video tape, it is reasonable to vertically synchronize the video source to the computer. However, if horizontal synchronization with an accuracy of less than one-third of a pixel is desired, a timebase corrector would be needed. It becomes a more attractive alternative to synchronize the computer to the video source than to require the expensive equipment needed to do it the other way. IVIS chose this route.

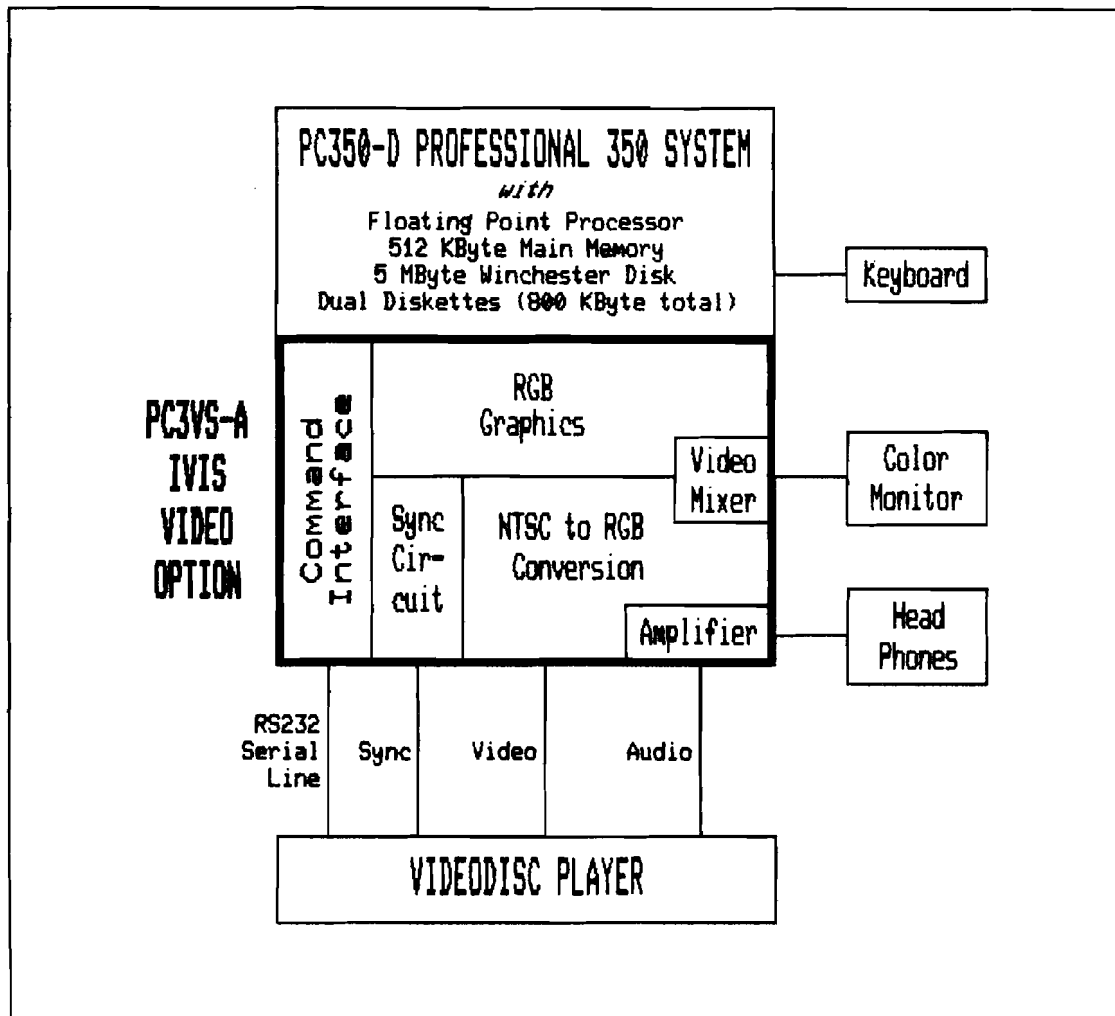


Figure 1

IVIS BLOCK DIAGRAM

Even though the visual qualities of IVIS graphics and video are both excellent individually, the system's "pièce de résistance" is its ability to overlay the former on the latter. IVIS implements overlay like a chroma key. That is, one of the eight available Professional 350 colors is defined as transparent. (In non-mapped applications the transparent color is black, in mapped applications, color 0 is transparent and the other 7 colors can have any value selected from a palette of 256.) The video switcher compares each pixel from the bit-mapped memory to the transparent value as it is taken from the memory for display. It displays the contents of the bit-mapped memory for each non-zero pixel. When it finds a transparent pixel, it displays the corresponding value from the videodisc for a pixel's duration. With a bit map of 960 by 240 pixels being refreshed at 60 times per second, this means that the decision about which video source to display is made approximately every 60 nanoseconds.

The ability to overlay was an immutable design goal from the beginning of the project. Instructional designers conceived of a large number of applications for overlaying, and felt that this feature was critical to the system's success. Some typical uses of overlaying are:

- highlighting specific components in shots of a complex device by outlining or pointing to them,
- drawing hidden data paths to show how pictured components interconnect,
- adding orientation information at the top and bottom of the screen,
- "lighting" different LEDs on the same shot of a control panel while the meanings of these LEDs are described,
- providing student control features on the screen during a video sequence,
- using composite video images as menus and allowing students to indicate their choices by moving the cursor to different areas of the image,
- using the video image to hold a number of smaller images and displaying only those applicable to the subject being discussed,
- implementing exercises that ask students to identify or sequence specific components by pointing to them, and
- correcting slightly erroneous video information by blanking out the incorrect screen area, overwriting the error, displaying explanatory text, or programming around the error and ignoring the video.

THE IVIS SOFTWARE

The entire system is, of course, tied together with controlling software. The approach to the software problem was to extend the graphics editor described at the 1980 ADCIS Conference [1]. This software allows a developer to control screen color easily and to generate graphics using editor commands or GIGI's firmware graphics language, ReGIS. The graphics editor has also been extended to allow control of the videodisc. About a dozen such commands have been implemented, the main ones being:

- **LOAD** to spin up the videodisc and establish communication between the player and the GIGI,
- **FIND n** to search to videodisc frame number n while blanking the screen,
- **PLAY TO n** to play the video segment between the current frame and frame n and then pause on frame n (playing can be either forward or backward),
- **AUDIO [1|2] [ON|OFF]** to turn the two audio channels on and off, and
- **WAIT** to cause the host system to cease further output to the terminal until it receives a signal from the videodisc indicating that playing of the last requested videodisc segment has been completed.

The IVIS hardware works with any NTSC video source, but non-videodisc sources would require different controlling software. Examples of the ways in which these commands can be used and integrated with computer-generated graphics are presented in the next section.

INSTRUCTIONAL TECHNIQUES

The first course developed for IVIS was designed to introduce DEC Field Service Engineers to a new series of printers. These printers are similar in some respects to printers with which the engineers should already be familiar, but they have a number of new components and features. Due to the prior experience of the target population and the existence of well-documented troubleshooting job aids, it was felt that students could learn all they

[1] Moreau, Ken, and Jesse M. Heines, 1980. "Creating Graphic Displays on Non-Graphics Terminals," 1980 ADCIS Conference Proceedings.

needed to know to install and maintain these printers without actually working on them, providing they had adequate instruction. These factors and the strong visual component of the device itself led to the selection of this course as the first real IVIS application.

The course begins with an overview of the printer series, pointing out the salient features and describing the major components. This overview provided the opportunity to use straightforward techniques to highlight specific components as they were being described on the audio track. A picture of the entire device was displayed, and each component was either outlined or pointed to as it was discussed. At times part of the videodisc picture was masked to direct the student's eye to the relevant components. This was done by overwriting part of the transparent background with a block of a different color, usually black. Note that black, the normal dark background color of the screen, is a valid color just like any other. It still blocks the videodisc signal effectively even though it appears that nothing has been written.

Once an entire set of components had been described, it was often valuable to display a diagram showing how they interacted. An audio track to serve this function was recorded on the videodisc, but corresponding video had not been shot. The plan was to draw the diagram solely with computer graphics and play the videodisc audio track while the diagram built up on the screen. Using the WAIT function described above, display of the diagram could be synchronized to the audio track. (The graphics generally came up faster than the narration that was describing them.) This use of sound alone proved to be so effective that computer graphics were often substituted for video sequences that actually were on the disc but that were to be of inferior quality. Note that by using the AUDIO command described above to switch from one audio track to the other, course developers were able to make use of the entire 60 minutes of audio available on one side of the disc.

One requirement was to show actual video of a pair of switches so that students could locate them on the printers, and then simulate various switch positions as an exercise. In this instance, video showing the switches was first overlaid with computer-generated graphics, and then the switches were redrawn in a larger size. This technique allowed visual continuity to be maintained after orienting the student to the component at hand. Again, IVIS made it possible to take advantage of the best features of both the videodisc and the computer graphics media.

Several video menus were planned for the course. These consisted of nine blocks arranged on the screen in three rows of three. The eight peripheral blocks were filled with pictures of various printer components, and the student was directed to use the terminal's arrow keys to move the cursor to the picture of the component he or she wanted to study. (The middle block contained

other options, such as returning to the main course menu and exiting the course.) The matrix of video pictures was composed with standard video editing equipment and stored on a single frame of the videodisc. Using the FIND command described above, it was easy to get to this frame whenever the menu was desired.

One of the most fundamental tasks that Field Service Engineers had to learn about the new printers was how to assemble and disassemble them. This was presented with a standard video sequence, but we thought that retention would be enhanced if students could step through the process under their own control. We therefore implemented an exercise using the STEP command described above that worked as follows. A picture of the fully assembled printer was displayed. At the left of the screen a list of parts was displayed. Each part name was printed in green. To remove the next part in the disassembly procedure, the student pressed the down arrow key. The videodisc advanced to the frame showing the printer with this part removed, and the color of the part name was changed from green to red. The student could continue removing parts in this manner or put parts back by pressing the up arrow key. He or she could spend as much or as little time as needed to gain familiarity with each of the parts and their assembly and disassembly procedure.

ADDITIONAL TECHNIQUES TO EXPLORE

The techniques described above represent a fair sampling of the IVIS capabilities explored to date. Some techniques work better than others, but it appears that all techniques have applicability in certain unique situations.

The videodisc for this course was pressed before the computer materials were developed. While video was shot to allow for a large number of combination techniques (such as the menus described above), new techniques were created when some computer materials proved difficult to implement because the video had not been shot with those techniques in mind. For example, it might have been nice to have more close-ups of the switches described in the previous section so that the simulation could have been done by overlaying on actual pictures rather than redrawing the switches. Closer attention could also have been paid to the angles from which the printer was shot to achieve greater visual continuity between those images and the computer-generated diagrams.

All-in-all, this attempt at using IVIS turned out to be an extensive learning experience. More up front planning is being done on courses currently in development, as the parameters that are most likely to get out of control during the development cycle have now been identified.