

MULTIMEDIA INFORMATION RETRIEVAL - REVOLUTIONARY RESULT OF TECHNOLOGY FUSION

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Abstract

In his 1992 article in Harvard Business Review, Fumio Kodama defined technology fusion as the "nonlinear, complementary and cooperative blending of incremental technical improvements from several previously separate fields of technology to create products that revolutionize markets."¹ This paper describes the design and application of a multimedia information storage and retrieval system that is the blending of digital multimedia, database management, and communications technologies. The resulting system has demonstrated the potential for dramatically changing the ways in which computer systems are applied to accomplishing work. As the multimedia capabilities of PCs become as common as math coprocessors are now, this new method of information management will blur the lines of distinction between training and work, and will add new dimensions of meaning to the concepts of "computer-based training" and "embedded training."

The Visual Information System (VIS) is a multimedia data management system with an intuitive, visually oriented user interface. Each node in the data structure may have multiple information elements that may be photographic, computer graphic, video, animation, audio, text and numeric. In addition, user-generated notes and tutorial programs may be attached to any node in the database, and initiated at the user's request. Database navigation may be accomplished either by linear traversal of the data structure, by directed search according to specified criteria, or by hyperlinks to other data records.

This paper will demonstrate applications of the VIS concept to aircraft systems (MH-53J PaveLow Helicopter) and electrical cable and connector repair, and will describe the system (hardware and software components) and how it works. The paper will conclude with a discussion of other potential applications that focus on why this startling new capability is important.

ABOUT THE AUTHORS

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INTRODUCTION AND OVERVIEW

The year is 1983. Charlie Chaplin is on television selling the IBM PC and AT. The PC Jr. emerges to address the home market, and Lotus 1-2-3 and Wordstar are the kings of the desktop. Mailmerge is an exciting capability and a 20-Mbyte hard disk is a big deal. . . .

The year is 1993. It is the age of digital multimedia, Quicktime, and Video For Windows. Electronic mail and networking are commonplace, as are cellular telephones, personal digital assistants, and telephones in airplanes. The arrival of Pentium is looming, and 486s can be purchased at WalMart for \$995. . . .

The year is 2003. Is our imagination robust enough to visualize the exciting results of another decade of development in computer and communications technologies? It seems clear that the applications supported by inexpensive desktop systems will continue to revolutionize the workplace as the engine of the information age.

This paper will describe a multimedia information management system that addresses information processing tasks of proficient users, as well as the training tasks associated with new users, or as may be associated with new procedures. The blending of improvements in digital multimedia and database management technologies with improvements and standardizations in computer systems and operating environments results in applications with capabilities that will change dramatically the concepts of Computer-Based Training (CBT) and Embedded Training, and will alter fundamentally the way computers are used to accomplish work. Maturation of the concepts illustrated here in combination with a continuing integration of computer and communications technologies could lead to information systems used on-the-job both to accomplish work and to manage continuous im-

provement training programs that account for individual learning styles.

MULTIMEDIA INFORMATION RETRIEVAL—HOW IT IS USED

Application Example—Aircraft Systems Database

One example of this type of multimedia information management system is a database system, illustrated in Figure 1, established for use by a USAF Special Operations Forces (SOF) aircraft support group. The Visual Information System (VIS) provides a centralized, on-line reference source for accessing system and component information on the MH-53J PaveLow helicopter, and was established to improve the productivity of experienced personnel in the group and to decrease the time required for new personnel to become proficient in their duties. To accomplish both objectives, the system must incorporate features that address the information management tasks of proficient users as well as the training needs of newcomers. The system was designed for use by the following types of users, each with their own unique job task duties, aircraft system areas of concern, and methods of accessing and referring to aircraft data.

- **Program managers'** principal job tasks are to set and communicate priorities, coordinate activities and monitor project performance. They must have a high-level understanding of the aircraft configuration and the interrelationships between aircraft systems.
- **Item managers** provide organizational accountability for supply, provisioning, installation, and maintenance of specific components or systems. They must have an in-depth knowledge of stock number history and parts usage and availability of the components and systems for which they are responsible.

Visual Information System [MH53J]

Search Notes Preferences Admin Help

View 1 of 1

Zoom ? WUC ? Noun ? P/N ? NSN ? Top Level

MH53 J "Pave Low" Systems

History [WUC]

1.

Engines

Avionics

Airframe

Rotors

Instruments

Components
Engines and Relate
Avionics and Comm
Air Frame
Rotors
Instruments

WUC: 1. Noun: Top Level Systems P/N: N/A NSN: N/A

The screenshot displays a software interface for the Visual Information System (VIS) for the MH53 J "Pave Low" Systems. At the top, there is a title bar with the system name and a set of navigation buttons including 'Search', 'Notes', 'Preferences', 'Admin', and 'Help'. Below this is a search bar containing 'View 1 of 1' and a 'Zoom' button, followed by several filter buttons labeled '? WUC', '? Noun', '? P/N', and '? NSN'. A 'Top Level' button is also present. The main content area is titled 'MH53 J "Pave Low" Systems' and features a 'History [WUC]' section with a list item '1.'. The central part of the screen is a grid of five image thumbnails, each with a label: 'Engines', 'Avionics', 'Airframe', 'Rotors', and 'Instruments'. To the right of this grid is a vertical list of 'Components' including 'Engines and Relate', 'Avionics and Comm', 'Air Frame', 'Rotors', and 'Instruments'. At the bottom of the screen, a status bar displays 'WUC: 1.', 'Noun: Top Level Systems', 'P/N: N/A', and 'NSN: N/A'. A small grid of icons is visible in the bottom right corner of the main content area.

Figure 1. Top Level VIS Screen

- **Engineers** are responsible for evaluating system and component failure modes and assessing the impact of design modifications. They must have an in-depth knowledge of aircraft operations and system and component functions.
- **Equipment specialists** are responsible for functional and physical interfaces between subsystems and for the change activity associated with specific aircraft systems. They must analyze the statistical history of aircraft components in order to project current and future needs.
- **Contract specialists** must have an overall understanding of the aircraft systems to evaluate Statement of Work requirements. They must also visualize the items of a purchase request package.

The job tasks and information requirements of these individual user groups break down into the three basic aircraft configuration areas of interest shown in Table 1.

The VIS addresses these information needs by providing access to multimedia aircraft information that is stored in a logical hierarchical structure (the classic inverted tree structure) that allows a user to navigate freely through the aircraft data or to query on a specific system component. Information is collected and stored for each aircraft system from a variety of sources, and the system allows each individual user to associate annotations with any information node of the database. In order to address the special needs of newcomers to the organization, tutorials, guides and procedural job aids may also be attached to any information node of the system, and launched at the discretion of the individual user.

Application Example—Intelligent Computer-Aided Cable Repair System

A second example of the application of multimedia information retrieval is the Intelligent Computer-Aided Cable Repair System (ICACRS), illustrated in Figure 2. The objective of the ICACRS is to decrease the time spent by U.S. Air Force

Table 1. VIS User Information Requirements²

Job-Related Area of Interest	VIS Media Requirement	Media Requirement Rationale
System Operation and Function	<ul style="list-style-type: none"> • Motion video with audio • Animated diagrams with correlated audio • Engineering drawings • Text 	<ul style="list-style-type: none"> • See actual system in operation • Show/describe component function • Show component design • Present supporting information
Component Change History and Integration Affectivity	<ul style="list-style-type: none"> • Annotated photo • Static diagrams with correlated audio • Text • Statistical graphs 	<ul style="list-style-type: none"> • See actual system/component • Show/describe system interfaces • Present supporting information • Show visual change history
Configuration Ownership	<ul style="list-style-type: none"> • Annotated photo • Graphic charts • Text 	<ul style="list-style-type: none"> • See actual system/component • Show owner/aircraft relationships • Present supporting information

maintenance personnel in identifying and repairing aircraft cable and connector components by providing an integrated resource for identification, technical documentation, and repair procedures on cables and connector components used in aircraft and test equipment. Multimedia information presentation capabilities provide the technician with connector and cable identification aids, technical specifications and diagrams, and step-by-step tutorials on the disassembly, repair, assembly, and test of connector/cable components. The utility of the ICACRS can be fully appreciated when one realizes that there are over 750,000 unique part numbers just within the Mil-Spec families of connector items. Commercial grade connector families add several hundred thousand more part numbers to the total that must be represented in the database.

The system will be used by personnel with a wide range of maintenance experience, from expert

technicians through entry-level maintenance personnel. The system is designed to accommodate this wide spectrum of users by providing the means by which experienced users may obtain data in a minimum number of steps; while an inexperienced or infrequent user may use additional features to obtain more detailed information. Tutorials can be used as refresher training for those tasks that are not performed frequently, and are valuable for the inexperienced and infrequent user. The tutorials also provide a mechanism for formalizing on-the-job training (OJT). For both Reservists and entry-level technicians, the system provides an electronic user's manual as well as on-line and context-sensitive help to assist them with their tasks. The ICACRS concept of applying multimedia information retrieval techniques to establish such an integrated resource is particularly appropriate for the anticipated migration in the Air Force to a two-level maintenance concept.

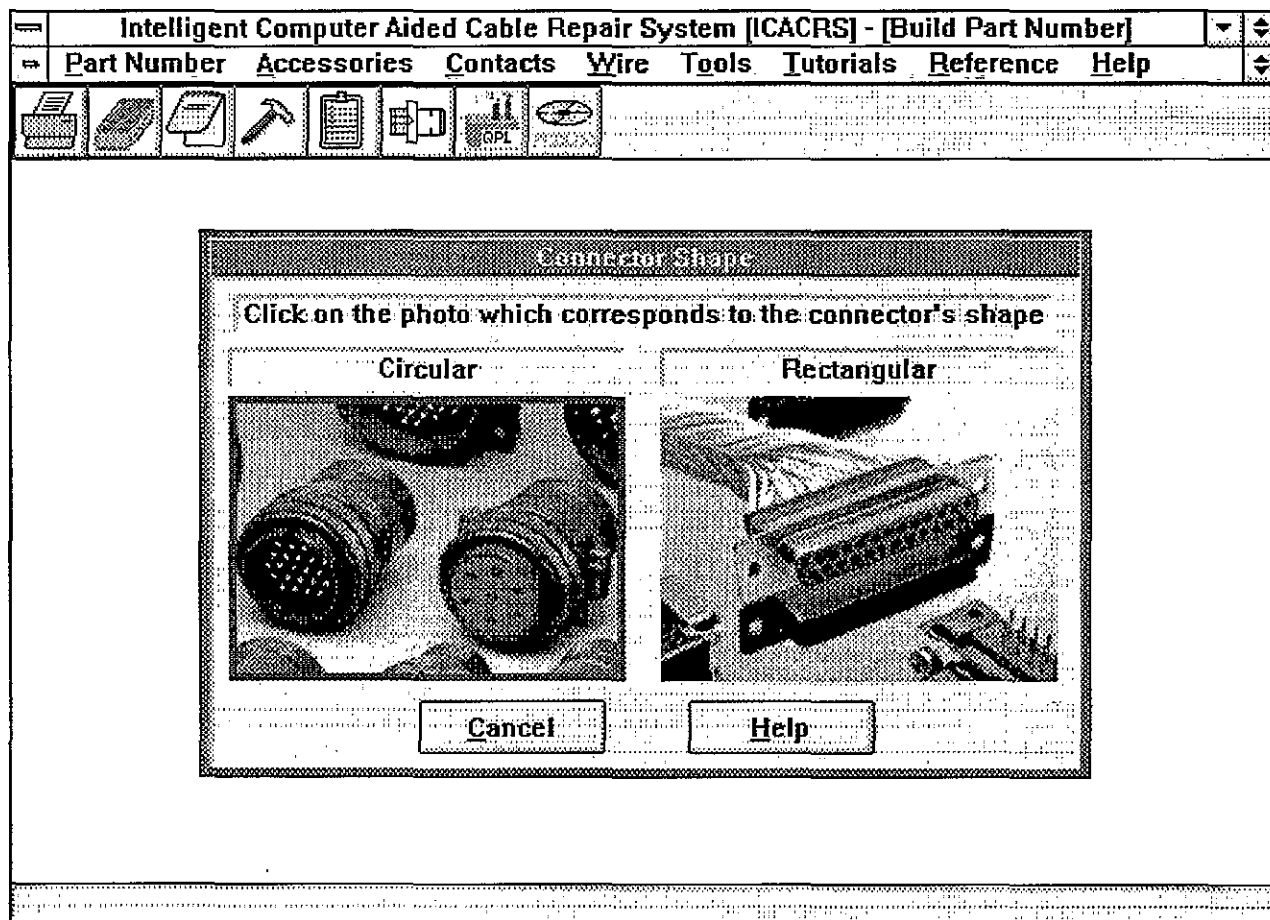


Figure 2. Intelligent Computer-Aided Cable Repair System

MULTIMEDIA INFORMATION RETRIEVAL—HOW IT WORKS

The VIS and ICACRS are powerful applications of multimedia database technology because they successfully blend the intuitive user interface standards of the Windows operating system with the information-rich presentation capabilities of multimedia data. Standard Windows interface characteristics simplify user interaction with the system to the point that database traversal and information retrieval become obvious. The resulting systems provide quick and efficient access to information and the ability to partition learning tasks into small, manageable, context-sensitive modules. The systems result from a blending of database, multimedia and computer technologies as described in the following paragraphs.

Database Structure, Navigation and Query

Using the Visual Information System as an example, the database is organized into an inverted tree structure of information nodes, as shown in Figure 3. This is no different from the classic database structure wherein each node of the tree has a single parent node, and may have multiple

daughter nodes. However, instead of being confined to alphanumeric records, each information node may have an unlimited number of data records, with each record consisting of a file of a specific multimedia data type. Thus, each information node may have a multitude of data elements that are text, images, video, audio, or any of the other multimedia data types presented by the system. Furthermore, information at a given node can be directly linked to another node by visual reference, providing powerful capabilities for database navigation.

Database navigation mechanisms that allow users to rapidly traverse to a specific information node from which a query may be launched can be summarized by the words traversal, hyperlink and history. Traversal implies that navigation may progress relative to present position by linear movement up and down the parent-daughter links of the hierarchy. This may be accomplished in several ways that are both textually and visually oriented, and provides an inherent browse characteristic in the system. Hyperlink implies the ability to move from the present position in the data structure to any other point that is unrelated in terms of direct parent-daughter relationship.

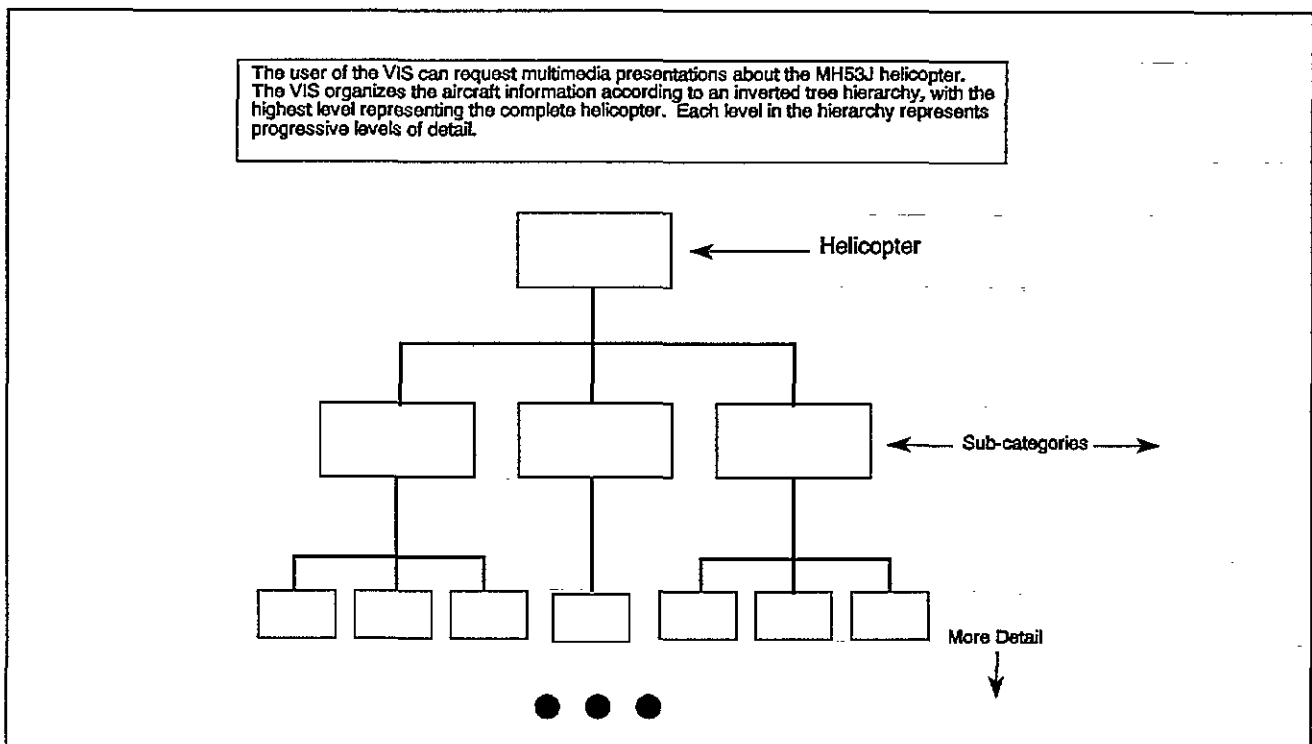


Figure 3. VIS: Structure of Visual Data³

Hyperlink is accomplished primarily by searches which may be directed to a specified part number, nomenclature (proper name), stock number or work unit code. Hyperlink may also be accomplished by a text search to localize into a specific area (i.e., "radar"), with the exact information node then being selected from a "short list" of candidates. Finally, hyperlink may also be accomplished by defining regions of images as "hot spots" that provide a visual hyperlink to other information nodes of the database. History implies the ability to return to any previously visited information node. This is accomplished by keeping a history log in a window of the screen, and permitting direct return to an information node by double-clicking on its designation in the history window.

Database query is accomplished directly from the desired information node, and is illustrated in Figure 4. The fundamental data elements associated with the node, such as the name, part number, stock number, work unit code and primary image view, are displayed immediately on the screen.

Additional image views of the subject of the node can be accessed immediately using the image bar. The existence of additional information elements is indicated by the appearance of various Multimedia Information Retrieval buttons. These buttons appear at a given information node only when information of the type indicated exists. A mouse click on the appropriate button will cause the presentation of information as indicated in Table 2.

Multimedia Data Types

The defining feature of the VIS and ICACRS is the ability to store, retrieve, and display data of many types, including:

- Text (ASCII)
- Digital Audio (.wav and compressed)
- Digital Video (.avs, .avi, .qtw--hardware and software)
- Animation (.flc)
- Tutorials (Authorware, Toolbook)
- Graphics (.bmp, .wpg, .pcx, etc)
- Photos (.bmp, jpeg compression, others)

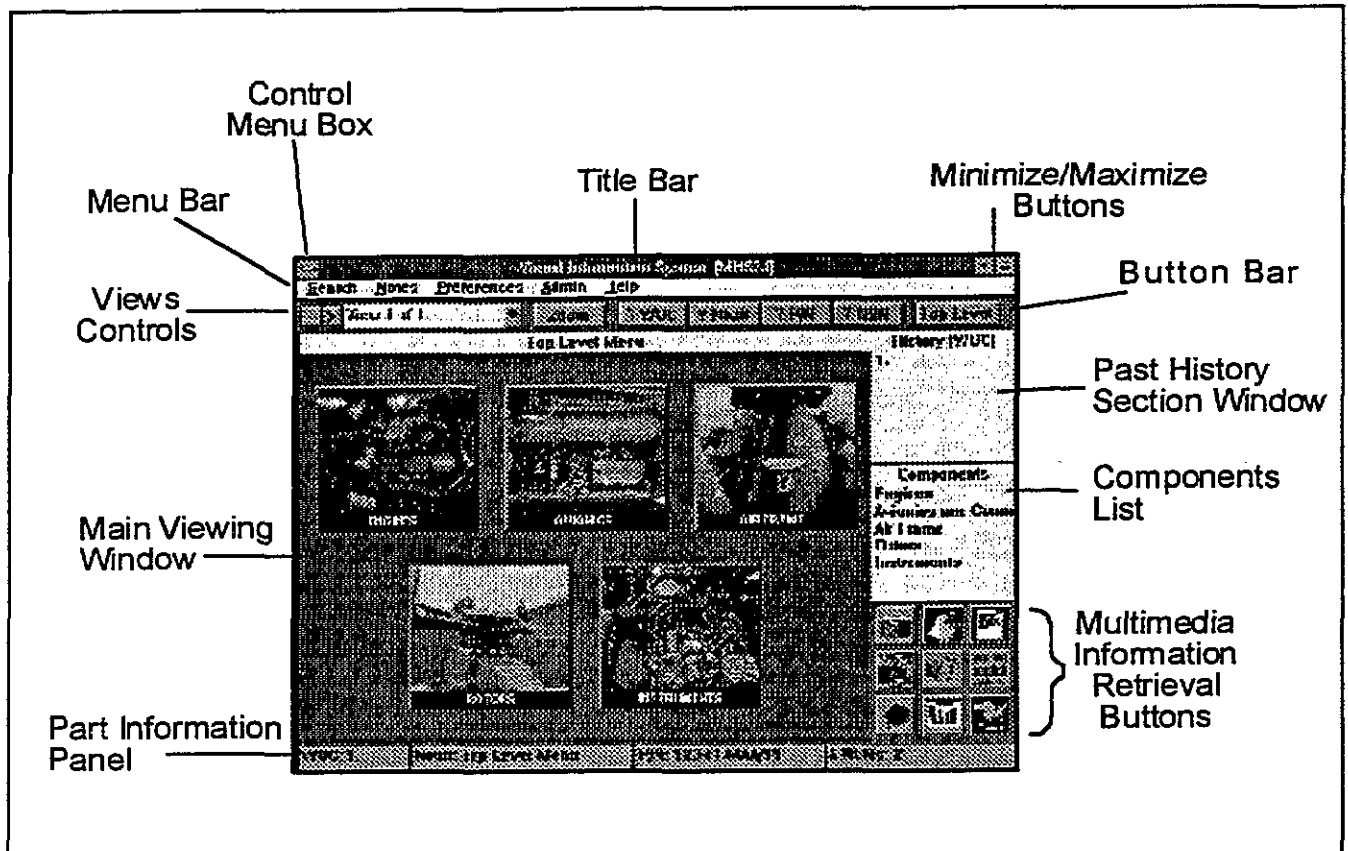











Figure 4 Database Query

Table 2. Multimedia Information Retrieval Buttons

BUTTON NAME	ICON	LOCATION	FUNCTION
Media Info	Camera 	upper left corner	gives info about an image in the main viewing window
Notes	"Stick-on" note 	top row center	indicates a note is associated with this node
Text	Document 	upper right corner	indicates a text file is associated with this node
Video	Clapboard labeled "video" 	center row left	indicates that motion video is associated with this node
Audio	Loudspeaker (an "X" appears when the icon is clicked) 	center row center	indicates that a sound file is associated with this node
Animation	Flowchart labeled "animation" 	center row right	appears whenever an animated file is associated with a node
Tutorial	Mortarboard (cap and tassel) 	bottom row left	means that there is a tutorial associated with the current node
Change History	Bar graph 	bottom row center	gives data about the change history of a part
Ownership history	Map labeled "owner" 	bottom row right	shows a map of the U.S. with the year each ALC was responsible for the part

Each data type requires an editor or other interface and, in most cases, driver software. Simplified management of so many different data types and the ability to easily add new data types to the list are made possible only by strict adherence to the standards and conventions of the Windows operating system. For example, the VIS contains two types of video files—Video for Windows (.avi) and DVI® files (.avs). These video files are displayed to the user through a common interface but have different drivers and hardware requirements. The choice of file type may be made by the system administrator and should be based on frame rate and image quality requirements of the application. DVI files (now known as "Indeo") are played through specialty hardware (Intel's Action Media II board) that can produce 30 frames-per-second video at one-quarter VGA resolution. Video for Windows has a smaller native screen resolution and variable frame rate but is software only. Both video types, however, are played on a screen with a television set visual metaphor, as shown in Figure 5, with controls that are common to VCRs. From the user's point of view, the file type is not known and is irrelevant. QuickTime for Windows video files (.qtw files) or other standard video file formats can be added easily so long as Windows can accept the driver for the file type.

For text, a simple editor has been written so that the data administrator, with proper privileges, can easily make edits but an ordinary user can only make limited changes (by means of the "Notes" utility on the Multimedia Information Retrieval button pad). For most other data types, a custom interface has been designed but with reliance on third-party software drivers such as Animator Pro, Authorware Professional, or PhotoStyler. In this way, users are provided with access to visual information quickly and easily in a standard format, but system administrators may use the Windows-compatible editing or composing tool of their choice. Adding new data types requires only installing a new Windows-compatible driver.

Hardware and Software Components

Multimedia information applications such as the ICACRS and the VIS can be run on 386 machines with 20 MHz clock rates and 4 mB of RAM. However, the applications function best in a 486-33 environment with 8-12 megs of RAM. System

disk requirements vary with the application. For video-intensive applications or for applications involving thousands of images, high storage capacity hard disks (500 mB or more) are recommended. Video capture and playback accelerator boards are also recommended for applications requiring users to view a lot of video.

As for future possibilities, recall that in 1983 20 Mbytes of disk was an astounding amount of storage space, and AT stood for advanced technology. With disk storage densities continuing to increase and the next generation of processors already becoming available, it would seem that the tools to support even more sophisticated applications are rapidly becoming available. No specific recommendations are made at this point because hardware is changing rapidly. New video accelerator boards are coming into existence monthly and should be researched carefully. However, Video for Windows has emerged as a clear industry standard for multimedia PC computing and has been included for that reason. Hardware acceleration combined with Video for Windows makes quarter-screen, 30 fps video possible on a 486 platform, and a Pentium platform may well provide software-only 30 fps video.

CONCLUSION — WHY MULTIMEDIA INFORMATION RETRIEVAL IS SO IMPORTANT

The multimedia applications described here are only examples of the truly revolutionary information management applications that are rapidly becoming reality, and will change the way computer and communications technologies are used to accomplish work. These applications are remarkable for several reasons. First, they reduce the information-retrieval overhead on students and other users; they are intuitive and efficient. Second, they allow for true continuous improvement. In other words, when does the user stop working and begin training, and vice-versa? The boundary between the two activities is so subtle it is almost nonexistent. Finally, the ability of these applications to integrate with other Windows products and tools provides maximum flexibility and personalization, with a standardization that makes information accessible by more people. Combine all of these concepts with such things as ISDN (Integrated Services Digital Network), wireless LANs (Local Area Networks), cellular communications, and

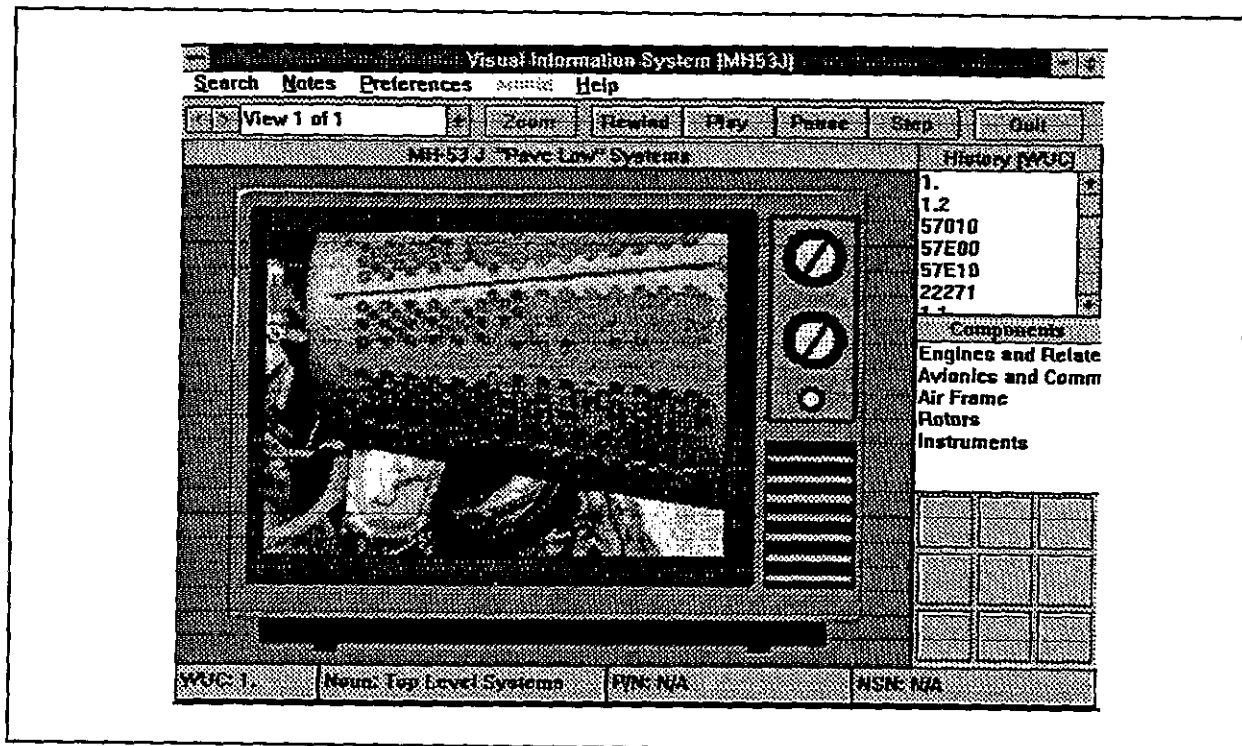


Figure 5 Video Screen

another decade of computer and communications technology development, and imagine the endless applications. . . .

- Multimedia magazines delivered daily via wireless network
- Multimedia E-mail and conferencing
- Multimedia presentations, proposals, and dissertations
- Multimedia merchandising, retailing, and advertising
- Entertainment such as interactive storytelling for children
- Technical documentation such as Interactive Electronics Technical Manuals (IETMS)
- Multimedia references including the I/ITSEC conference proceedings. At last, we will be able to prowl the exhibit floor and still experience the paper presentations!

Finally, imagine the powerful combination of this information technology with the organization concepts of Total Quality Management (TQM), focus groups, Statistical Process Control (SPC) and other developments. The potential for changing both the way computers are used to accomplish work and the concept and conduct of training is powerful.

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