Development of Interactive Multimedia Applications

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ABSTRACT

Multimedia is making an increasingly significant contribution to our informational society. The usefulness of this technology is already evident in education, business presentations, informational kiosks (e.g. in museums), training and the entertainment environment. Institutions, from grade schools to medical schools, are exploring the use of multifaceted electronic text books and teaching aids to enhance course materials. Through multimedia, teachers and students can take full advantage of the cognitive value of animation, audio, video and other data types in a seamless application. The Software Technology Branch at NASA Johnson Space Center (NASA/JSC) is taking similar approaches to apply the state-of-the-art technology to space training, mission operations and other applications. This paper discusses the characteristics and development of multimedia applications at the NASA/JSC.

1.0 INTRODUCTION

Multimedia embraces many technologies and disciplines including videography, music, signal and image processing, artificial intelligence, computer graphics, database and data communication. It is the fastest growing segment in the computer industry today. With incorporation of animation, audio, video and interactive navigational links, digital multimedia technology is changing the way computers are applied. For instance, computers are emerging as successful supplements to formal classroom instruction and as viable alternatives to expensive hands-on simulators and trainers. In education and aerospace training environments it has also become necessary to maximize resources. Whether these resources are in the form of instructors, materials, or time, all must be prudently allocated in a cost effective manner. Computerized instruction utilizing existing tools and developing technologies is being substantiated with a growing list of applications and increasing return on investment. Such applications can better stimulate human senses and draw closer attention than traditional systems.

All computer manufacturers support multimedia capabilities in one form or another. Companies like Apple Computers and Microsoft Corporation have released multimedia capable operating systems and Graphical User Interface (GUI) environments. Many other software and hardware vendors have also launched products for these environments that comply to the standards defined by international and professional organizations. Through

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these non-proprietary standards, products have become more homogeneous and can be utitized over a large sector.

In this paper, the characteristics and components of multimedia environments will be discussed. A summary of multi-platform development activities of interactive multimedia applications at the NASA/JSC's Software Technology Branch (STB) will be reported. The final section outlines the experiences gained from developing these projects.

2.0 MULTIMEDIA ENVIRONMENT

As the term implies, multimedia is the integration of several media in an interactive computing environment (Figure 2.1). Conventional media include audio, video, still-photographs and printed documents, whereas computerized media consist of test, graphics, animation, spreadsheets and navigational links. When combined with the computer's interactive capability, audiences need no longer be passive in a multimedia system because they can navigate through a maze of information based on an intuitive structure. They decide when to start, when to stop, which piece of information to retrieve, and where to go for pertinent data. Although the term multimedia is vaguely defined, it is obvious that multimedia is used to enhance the way messages are conveyed in a multi-sensory form. As a picture is worth a thousand words, time-sequenced pictures like video, combined with audio, transmit information more effectively. It is one of the most exciting things to happen with computers in many years.

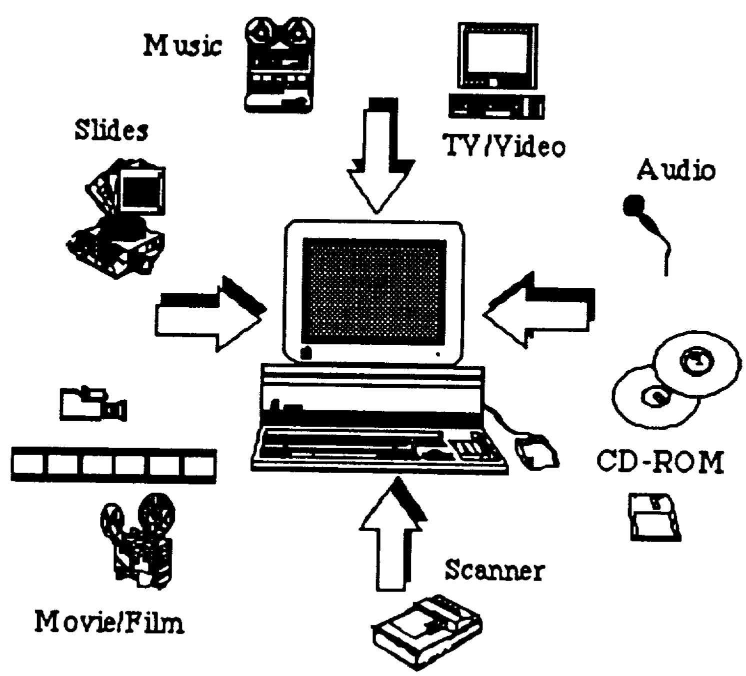

Figure 2.1 A Multimedia Environment

A multimedia software environment generally consists of two levels: viewing and authoring. Viewing refers to accessing a pre-composed system interactively without the capability to make modifications. Authoring involves organizing, mixing, and matching different forms of media; generating links for navigation; designing user-interfaces; and, creating error handling routines. Scanning devices are used to scan in photographs and flat documents, while appropriate digitizing devices are used to convert audio and video data from analog to digital forms. Of all the included media, video is the most elaborate, complicated, and intriguing. It is composed of sequences of video frames or images which are stored and replayed in rapid succession. The National Television and Standard Committee (NTSC) format used in the United States displays thirty frames per second. Thus, video documents containing a wealth of information, such as sound and still and motion images, demand greater system resources. Many computer hardware and software companies, including consumer electronic companies, have released desktop multimedia products with the necessary components and capabilities.

2.1 Trends

Available components include single chip solutions for video encoding (i.e. frame grabbing), display, and compression/decompression (CODEC), respectively. With these components, high-resolution displays are common to today's computers. They can now display up to 1280 by 1024 resolution and show 24-bit color photo-realistic images, at a fraction of the cost of earlier high-priced graphics workstations. Also, a single video overlay board (e.g. NTSC to VGA) can display a live television window on a computer, and can capture and compress video data on a hard disk. As a result, these capabilities allow software vendors to develop and market authoring tools (e.g. Authorware's *Authorware*), non-linear video editing software packages (e.g. Adobe System's *Premiere*), and video special effects systems (e.g. NewTek's *Video Toaster*). In addition, mass media companies are trying to establish their presence in the new media frontier. For instance, the Wall Street Journal reported that Turner Broadcasting System, Inc. is creating interactive news documentaries using the company's Cable News Network (CNN) footage and interactive games based on characters from its Hanna-Barbera film library to be used on CD-ROMs, i.e. compact disk-read only memory. As shown in Table 2.1, many similar *titles* ranging from children books to instructional materials are already on the market.

Title	Description	System
Amanda Stories	Children adventures and stories	Mac/PC
Beethoven: Symphony No. 9	Interactive classical music entertainment and lesson	Mac/PC
I Photograph to Remember	A still image essay the works of Pedro Meyer, a renowned photographer	Mac/PC
Columbus: Encounter, Discovery and Beyond	An interactive multimedia lesson of Columbus' voyage to the new world	PC
Microsoft Bookshelf for Windows	A reference library includes an encyclopedia, a dictionary, a thesaurus, a world alamanac, an atlas and two books of quotations	PC
The Virtual Museum	An interactive electronic museum where users can move from room to room and select any exhibit for more detailed examination	Mac
The Madness of Roland	The world's first hypermedia novel with digital video	Mac

Table 2.1: Commercial multimedia publications

As these data types demand increasing storage space, manufacturers have responded with winchester (hard) disk drives that are smaller in physical size, but greater in capacity. It is not uncommon for new PCs to have 2 billion bytes (GB) of storage. Distribution medium for developed applications also needs to be more efficient and economical. CD-ROM, for example, can store up to about 650 million bytes (MB), and yet, each disk costs as little as a box of floppy disks to produce. The greater the number of disks produced, the less expensive per disk is the production cost. In comparison, a box of ten diskettes can store approximately 15 MB. Then, there are magneto-optical drives (~1 GB), 3.5 inch *floptical* drives (~120 MB), 8 mm backup tapes (2.3 GB), and digital audio tape (DAT) (8 GB).

It is now obvious that the multimedia industry has enjoyed an exponential growth within the last few years. In fact, it is considered to be one of the fastest growing industries. However, the growth could have been much greater if there were open standards for this technology. A lack of standards has resulted in proprietary systems that are costly and incompatible. This is the main reason that multimedia technology did not reach the mainstreams until recently.

So, what standards exist today, and what are needed in the future? The raster display technology of the past decade is one of the forerunners to the current multimedia realm. Digital audio has also become a common data type on computer systems from Apple Computer, Commodore Computers, Sun Microsystems and PC vendors. Most importantly, as of 1992, video data is becoming more common on systems like Macintosh and PCs. This is primarily due to the fact that there are currently three non-proprietary digital video CODEC standards: Joint Photograph Experts Group (JPEG) standard for still image compression; the Consultative Committee on International Telephony and Telegraphy (CCITT) Recommendation H.261 for video tele-conferencing; and, the Moving Pictures Experts Group (MPEG) for full-motion video compression on digital storage media (DSM). Table 2.2 lists the experimental compression ratios that JPEG variant coders can achieve and the resulting image quality [2].

Bits/Pixel	Image Quality	Ratio
0.1	Recognizable image	160:1
0.25	Useful image	64:1
0.75	Excellent quality	22:1
1.5	Near original	11:1
8	Lossless JPEG	2:1

Table 2.2: JPEG Compression Ratios

Intel Corporation is one of the pioneers in the digital video compression arena. Intel's Digital Video Interactive (DVI) provides powerful CODEC capabilities with a programmable processor. DVI allows application developers to choose CODEC algorithms for better image quality; more simultaneous video operations, such as scaling motion video to a re-sized window or increased flexibility to support special needs of embedded applications; or any combination of the above. A key new feature of the components is their ability to compress or decompress JPEG images in near realtime. IBM Corporation is aggressively supporting this technology in its ActionMedia product line. NewVideo Company is another vendor actively developing DVI boards for Apple Macintosh systems.

Finally, Apple Computers has released a Macintosh system extension called QuickTime that allows temporal data types, such as audio and video, to be integrated into applications without special hardware. This extension can be used along with the above CODEC standards as long as the software interface conforms to QuickTime protocol. With it, video messages can be embedded in electronic mail, spreadsheets and presentations.

3.0 DEVELOPMENT ACTIVITIES

The use of various forms of media in computer applications has been in place at the Software Technology Branch (STB)for several years. However, the applications developed today utilize more multimedia capabilities by incorporating audio and video which was not feasible in the past. The following sections describe the to-date activities of developing multimedia and related applications at NASA/JSC.

3.1 Multimedia

The Automated Information Center (AIC) project is an interactive multimedia tour of the NASA/JSC Information Systems Directorate Products Center (IPC). The IPC is a facility dedicated to providing computer-related hardware and software products for sale and loan, information searches, product demonstrations, monthly newsletters, and many other services to the JSC community. The AIC system was developed to provide IPC customers with on-demand access to information about the IPC and its products and services. Also, to lessen the IPC staff's burden of continually being asked questions by customers about general operational topics. By automating this task, the IPC staff will be able to provide more individualized assistance to customers requiring detailed information, as well as being allowed greater freedom to accomplish day-to-day activities. This system was built as a fully automated multimedia environment utilizing state-of-the-art personal computer components and software in a kiosk-style booth at the IPC facility (Figure 3.1).

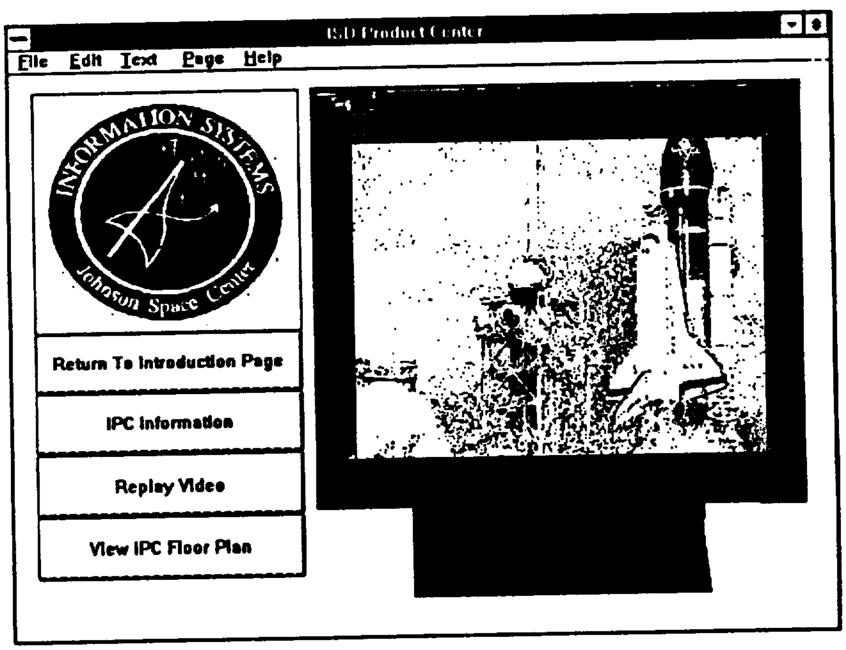

Figure 3.1: Automated Information Center's digital video screen

The general system configuration includes a generic 486 PC with Microsoft Windows, digital CODEC boards, an audio board and a CD-ROM drive. In the application, the user is presented with a touch screen interface and menus to invoke general information about the IPC and detailed descriptions about the IPC services, products and activities. The user could choose either of these paths from the initial screen. The upper portion of the screen contains general navigational buttons. Upon selecting certain buttons, the user receives audio and video explanations, schedules of events, software and hardware catalogs, and floor plan information. The user can also try out some on-line software or can view software demonstration videos.

Based on this system, STB is exploring potential development of a very large scale multimedia information retrieval system for the NASA/JSC's Public Affair Office and the U.S. Navy's Informational Survivability Management System (ISMS) for advanced damage control.

3.2 Hypermedia

A hypermedia product, called Hyperman, was designed and developed by STB. Hyperman is a software tool which enables the users of technical manuals to have rapid on-line access to documentation with a full range of hypermedia capabilities. With Hyperman users can parse documents in their native word processing format and display these documents on a UNIX platform employing X-Windows with the Motif Toolkit as shown in Figure 3.2. Hyperman is able to display a broad range of media, including text, equations, tables, graphics and audio.

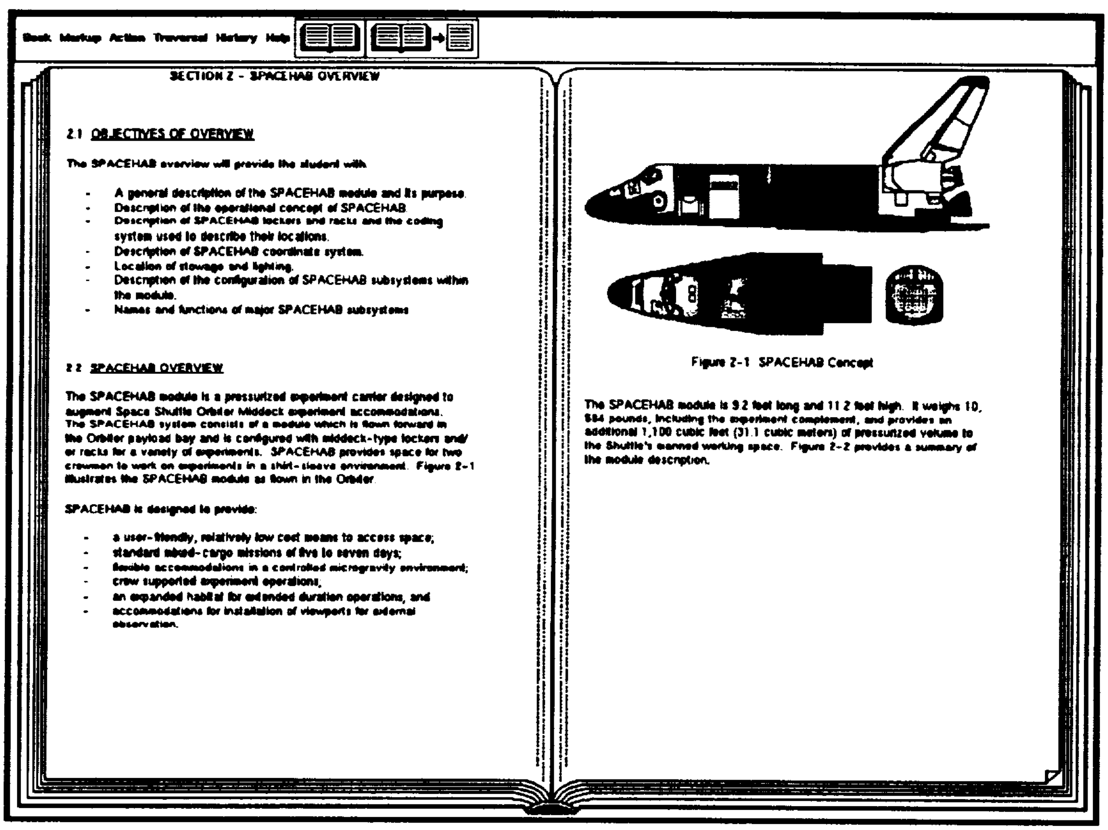

Figure 3.2 Hyperman's on-line documentation

Hyperman was created with two separate configuration options. The first option creates a stand-alone hypermedia tool. The second option creates a "help-system" version of Hyperman. In the second configuration, Hyperman can exist within another host software tool. When the user has a need for on-line help, Hyperman can provide context sensitive help based on the users current location in the software.

Hyperman employs a number of techniques to provide for easy transition between the user's paper and electronic document domains. These techniques include; electronic highlights, electronic notepads, full text search, hyper-links, preservation of the look of the book from paper to screen , and easy access to the UNIX environment. This access to the UNIX environment means that applications and processes, including the attachment of video, animation and audio to Hyperman text and graphic objects, can be started from within Hyperman which will augment the users comprehension. Hyperman's parsing preserves not only the text and page formats but all of the formats to the text including bold-facing, underlining, scripting, subscription, and italics. These capabilities are encased in a Graphical User Interface (GUI) which attempts to make the task of document management, information retrieval and diverse data integration easy.

3.3 Intelligent Computer-Aided Training (ICAT)

Expert system technology has been used to develop autonomous training systems for use by astronauts, flight controllers and NASA engineers in learning to perform a wide range of procedural tasks. STB has developed many ICAT systems based on this technology. The Payload Deployment ICAT (PD/ICAT) and Center Information Systems/Computer Operations ICAT (CISCO/ICAT) are examples of such applications developed on UNIX/X-Windows and Microsoft Windows environments, respectively. The Active Thermal Control System (ATCS) ICAT for Space Station Freedom training was developed on the Apple Macintosh environment. It incorporates extensive multimedia in the form of scanned color photographs, animated graphics, digitized audio, and QuickTime digital video to engage the trainee's interest and to present a variety of concepts and system functions in a simulated real-world environment.

Audio and video are significant elements in many subject areas. Flight controllers rely heavily on audio information received via their headphones, and astronauts must train for many tasks requiring visual inspection. Yet, audio and video elements have been omitted from most ICAT systems because they are system dependent. Integrating Apple's QuickTime software into the ICAT development environment offers three major advantages: it eliminates the cost of specialized hardware, it speeds development time and reduces maintenance costs, and it enables the cross-platform portability of the ICAT development environment.

Using interactive graphics of display screens, high resolution photographs of equipment and control panels, and full-motion video of operation and maintenance procedures, ICAT systems are being developed to supplement and potentially replace large, expensive part task trainers and provide "on-demand" training wherever and whenever it is needed.

3.4 Virtual Environments

Virtual Environment technology, which is generally referred to as *virtual reality* or *artificial reality*, has the potential to provide an intuitive human-computer interface of unprecedented power (Figure 3.3). The STB is exploring the use of this technology for training as an adjunct to its ongoing work in ICAT. Virtual Environments (VE) can *place* an individual into any scenario that can be copied or imagined. The use of VE for training is obvious. Crew members can experience a virtual cockpit or an Extravehicular Activity (EVA) and both develop and be trained in new procedures. Payload specialists can learn to operate virtual instruments before they are built or flown. The key to VE is the *immersion* of the user in another world. The ability of VE to cause the *suspension of disbelief* is a power argument for the infusion of VE technology into NASA's training program.

Figure 3.3: A VR system in use at NASA/JSC

The STB is actively pursuing a number of applications projects that will utilize virtual environment technology. Among these projects are training for Space Shuttle EVA, Space Station Freedom operations especially those that are cupola based, and Hubble Space Telescope repair and maintenance. In addition, STB is working jointly with Marshall Space Flight Center to enable personnel at the two centers to simultaneously share the same VE, eliminating the usual constraints of location from joint training activities. Finally, prototypical science laboratories are being developed to enable students to observe physical phenomena not available in typical student laboratories.

4.0 CONCLUSION

Multimedia technology is in a very dynamic growth period with industry standards being defined and technical advancements with hardware occurring in many cases faster than new products can be released. Applications are being developed to exercise these available technologies. Software is reaching cross-platform capability status with peripheral component interface utilities and more extensive capabilities and functions incorporated into products. As multimedia system and component costs decrease, these systems will become attainable by a wider group for varied implementations.

Although multimedia is here today, the technology is still in its infancy. Mixing and matching peripherals with existing peripherals bring up conflicts and incompatibilities. On a distributed network, transferring multimedia data can decrease the network throughput and efficiency dramatically. The STB is actively pursuing many avenues to overcome these deficiencies. Many multimedia data types are quite portable now. Animation, audio, graphics and images, spreadsheets and text data can easily be transported between hetrogeneous platforms. What is needed most at this time is non-proprietary software video compression and decompression capabilities such that the applications developed can be delivered without
requiring costly hardware add-ons. More research and development needs to be done to incorporate search and indexing, knowledge capture, and higher bandwidth networking for distributed capabilities.

As important as the hardware and software technology is the skill level of an integrated development team. This team of creative professional technical and artistic people from various disciplines is necessary for a worthwhile product. With a good design and creative skills, a multidisciplinary effort of computer engineers, graphics artists, a producer or manager and other relevant personnel can conquer the risks and barriers. It will also result in a high-tech *masterpiece* application and yield high pay-offs. In conclusion, to meet the demands of our informational society, the full potential of this revolutionary digital technology must be continue to be realized and utilized.

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VISUAL COMMUNICATION IN MULTIMEDIA CYBERSPACES

This paper was withdrawn from presentation