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Life Sciences On-Line: A Study in Hypermedia Application

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ABSTRACT

The purpose of this study was to determine the feasibility of using a computer-based interactive information recall module for the Life Sciences Project Division (LSPD) at NASA, Johnson Space Center. LSPD personnel prepare payload experiments to test and monitor physiological functions in zero gravity. Training refreshers and other types of online help are needed to support personnel in their tasks during mission testing and in flight. This paper presents results of a survey of other hypermedia and multimedia developers and lessons learned by the developers of the LSPD prototype module. The paper also discusses related issues and future applications as well as recommends further hypermedia development within the LSPD.

Life Sciences Research

Rapidly emerging media-based technologies are providing online information aids for professional and technical workers in both the public and private sectors. At NASA-Johnson Space Center, attention is focusing on these tools for space program use. The Life Sciences Project Division (LSPD) is researching the application of online "job performance assistance" (Dona Erb, August 1987) to Life Sciences flight support personnel.

Life Sciences astronauts perform experiments for inflight missions on the Shuttle and planned Space Station *Freedom*. These investigations use special equipment modified for space flight to study human physiological and biological responses that occur in zero gravity.

Within the LSPD there is a perceived need for online, context-sensitive help such as training simulations or quick reference information during mission testing. In addition, a need exists for similar online reference tools for personnel working in other areas of the LSPD: development and testing, science monitoring, technical lab activities, office automation, and administrative tasks.

Purpose of Study

In response to these needs, an online prototype module, Life Sciences Interactive Information Recall (LSIIR), was developed. Interactive media was incorporated into a computer desktop workstation environment with which mission or payload specialist, scientist or engineer, and support or administrative personnel were already familiar. The aim of this approach was to focus the viewer's attention on the screen and manipulate content in such a way as to allow instant information transfer from screen to viewer.

The purpose of the study was to demonstrate the feasibility of providing an online interactive information recall system within the LSPD.

Hypermedia/Multimedia Tools

Hypermedia is the extension of hypertext, a term coined by Ted Nelson (Nelson, Literary Machines, 1987). Hypertext is non-sequentially, electronically stored writing. For example, a key word or phrase in a document can be highlighted on screen and "linked" directly to a picture – or another document. This link gives the user quick access to more information, without flipping through a paper manual, going to a library, or consulting a human source.

Online documentation and online help are not new concepts but context-sensitive linking and nonlinear selection are new capabilities of the emerging online information technologies. In addition, multimedia enhancements, such as video, 3-D simulations, voice, and animated text and graphics raise hypermedia to another level of training methodology. Hence, hypermedia combines information from different sources into one source, the computer.

These tools are now being used to develop appropriate online information and training media. The purpose of this approach is not to replace hands-on training methods or paper reference manuals but to amplify and augment these methods and materials electronically. The rationale for a multimedia-enhanced online system is that it increases visual information and allows the user to access all the information he needs on demand.

Issues

The new role of hypermedia as a learning concept and training tool raises some interesting and provocative issues:

Is a hypermedia/multimedia-enhanced system necessary? Hypermedia can provide online information without the addition of any multimedia resources. However, multiple media may provide the best presentation for topics that require the realism of photographs, the symbolism of diagrams, the simulation of operations, or verbal instructions.

Will online documents replace paper? The user's dependency on paper documents decreases as online documentation increases. Problems such as storing and updating paper documents, delays and inconvenience in document pick-up, or delivering too much or too little documentation are solved. Related materials no longer need to be limited to paper or stored and accessed separately from paper. Other media can be accessed with the document and appear as a window on the same screen.

What are its applications to education? The applications in education are well documented. An educational delivery system firm, Advanced Educational Concepts, used multimedia enhancements to convert a standard training area to a "projection" room by incorporating 3-D simulations, holographic projections, and interactive video. The system showed that students retain 25% of what they hear, 45% of what they hear and see, and 70% of what they do. Students in the IRIS project at Brown University reported that Intermedia (hypertext online referencing course) reinforced lectures and taught things not found in other sources. The EXVIS project at the University of Lowell recommended the use of icons with sound as well as visual parameters to represent several dimensions. This technique improved the performance of test subjects in analyzing scientific data.

Is it applicable to aerospace training? In the coming Space Station Era, information recall will no longer be limited to two or three day trips in space. Astronauts may be spending as many as 180 days in space. A simple pocket card or brief reference manual will not suffice. Storage space for larger documents may be unavailable. Messages and some instructions can be transmitted, but other information must be accessible from onboard systems. In another application, *Mechanical Engineering* magazine recently noted that a Macintosh running LabView 2 was used to pinpoint a fuel leak on the Space Shuttle *Columbia*.

Do the benefits outweigh the costs? How much user and developer time is saved? A pressing question is to what degree benefits justify development costs. Upgrades in multimedia hardware will speed and ease the tasks of the developer and user. Much of the software needed to develop an online training or information recall system is already available off the shelf, which means an online system does not have to be developed from scratch. Many HyperCard scripts (HyperTalk) are available through third party developers or shareware and can be used as is or with slight modifications for a new application. Many authoring packages, such as HyperCard, Macromind Director, and Guide have a low learning curve, at least to master the basics. Also, application updates like HyperCard 2.0 have added or improved features which can cut the developer's time in half and speed up processing and access time. Some types of training and information recall activities, such as simulations and trouble-shooting, may require a certain degree of user interactivity. Programming expertise may be required to implement some of them; however, others can be easily presented using interactive video. Multimedia hardware in the high-end range is now consumer-priced and therefore no longer cost-prohibitive for educators and contractors. The payback for development time and labor depends upon the amount of information required and selected for electronic access and the speed of information retrieval that can be built into an online system. In both aerospace and education, an easy updating procedure is important to keep content current. Additionally, in aerospace applications, a fast turnaround time for retrieving information is essential. If an online system can meet these requirements, it will pay for itself.

Objectives

The objectives of the study were: (1) to survey other users of hypermedia and multimedia tools in developing online training and information help systems for their employees or customers; (2) to produce a module (HyperCard stack) to serve as a training and memory aid that would run on a Mac SE or SE/30; (3) to review the end product (module) and evaluate its possible application to crew training or other types of online training within the LSPD.

Stack Development

The development team consisted of an instructional designer and a development programmer using two Mac's: an SE and an SE/30. A college student assisted in creating and modifying the graphics and sounds in the stack. Other resources outside the team were called upon as the need arose. Development of the stack extended from February to June 1990. The project was completed on time, including several modifications made as a result of the preliminary review. The stack was presented to LSPD and contractor personnel for review.

Hardware used in development included the Macintosh SE and SE/30 with an 80 Mb hard drive. The Mac SE's were connected to the Macintosh network to enable use of online utilities and provide copies to reviewers. This setup insured stack protection and and developer independence in producing segments of the stack. Software included: HyperCard 1.2.2 /1.2.5, the MacRecorder Sound System, MacDraw, MacPaint, Canvas, and Macromind Director. Both clip art and scanned photos were used; an Apple scanner was used to scan photos.

Content

The study focused on the production and demonstration of a prototype stack for refreshing the training and knowledge of LSPD users in the operation of an inflight instrument. The instrument was a flow cytometer used in a hypothetical payload experiment to measure cells in zero gravity.

The operation of the flow cytometer was divided into several sequential segments: (1) Introduction, (2) Equipment, (3) Procedure, (4) Configuration, and (5) Operation. The stack demonstrated a generic sampling of content vs. specific requirements for the purpose of the study. Procedures and operations were based on real-life experiments and considered to be representative of a typical usage of the inflight flow cytometer.

Concept

The flow cytometer was considered a good choice for creating a simulation of the operation for online viewing. It allows the user to step through the operation visually without using the real equipment. He can see the results of possible effects. In the event of an incorrect selection, the stack would branch to the correct action required. The stack "coaches" the user without having to set up the real experiment. Further, it "immerses" the user in the experiment without having to take time out to reference the hard copy documentation. Hence, protocol correctness can be ensured with online help and information.

Design

An "online help" stack was envisioned that would cover all the critical information a user might need during testing or in flight. It was assumed that (1) the training task involved more than seven items to be recalled, (2) the training protocols could be changed, and (3) testing and feedback reinforce learning and reduce errors in performance.

Simulation and walk-through sequences were incorporated into the stack. A storyboard was drafted to show the sequencing of content based on the flow cytometer used in flight. The original screen maps were used as building blocks which changed as the stack began to take form. A user navigation map was added later (see USER NAVIGATION MAP on the next page). Enhancements based on design modifications and preliminary review removed some of the "flat" storyboard quality of the finished product. These enhancements were created primarily with HyperCard and MacRecorder. Macromind Director was used to "smooth out" the opening and closing screen animations. Graphic windows were created as placeholders for scanned photos or video clips using tools that would be acquired later. Voice overlays and other sound and graphic segments were modified to simplify or clarify the user interface.

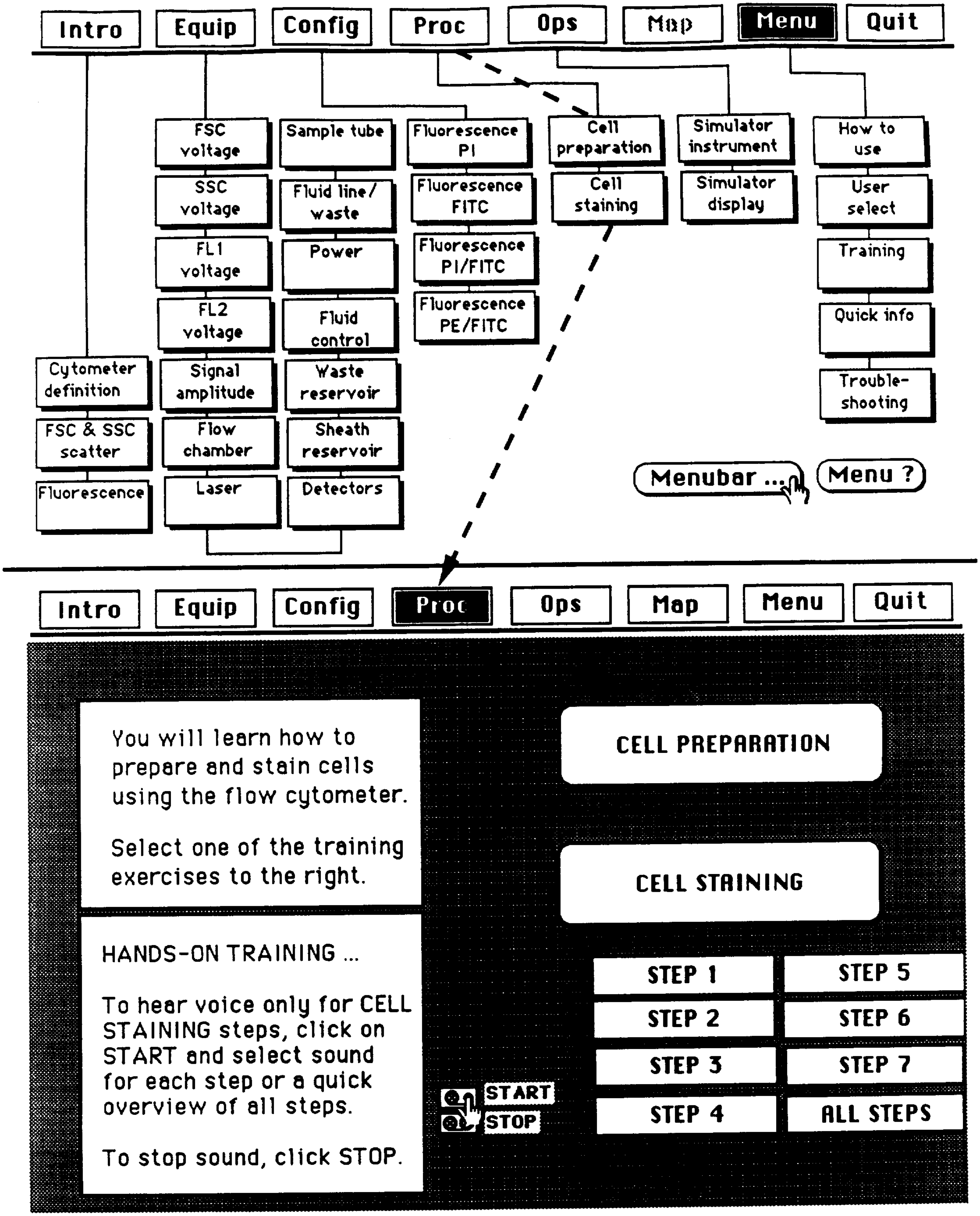
Since the end product was delivered to Mac SE users for review, still video and camera enhancements would have displayed with a very low resolution at best on the normal Mac SE black-and-white monitor. Full motion video and 3-D graphics are more effective on a Mac II or computers with compatible platforms.

Modes

The software selected to create the stack, HyperCard, is an authoring toolkit primarily used for training and presentation applications. It allows the author to create and run a program, or stack, in several modes: programmer and user. While the stack is being created, the author is functioning not only as author but also as user so that every segment constructed can be tested, as well as modified, at the user level. There are five user levels: browsing, typing, painting, authoring, and scripting.

Programmer Mode

In this mode, the programmer authors and edits the stack using the authoring or scripting user levels. The authoring level is selected to link one card in the stack to another card, usually in sequence. At this level, scripting cannot be done using the built-in HyperTalk scripting



Example "Link" from User Navigation Map

language (similar to but simpler than higher level languages such as Pascal or 'C'). At the scripting level, the programmer can use HyperTalk 's English-like functions which allow rapid cross-linking of information segments. At this level, the author-user can use the features of HyperCard to their fullest potential.

Normally, a stack is tested by the user in the run-time mode at the browsing level. In the case of the flow cytometer stack, the user level was set at the typing level because the type command was used to create running type, as in the trouble-shooting exercise, which provides user prompts and feedback.

User Mode

In the run-time mode, the stack is password-protected inside the stack. The password protection ensures that, at the browsing, typing, or painting levels, the user can navigate through the program but cannot access or change any of the HyperTalk scripts that control the links between the cards in the stack. If a user wishes to view or edit the scripts, he must select the Apple command key to get the full menus, pull down the File menu, select Protect Stack, enter the password, and select the Scripting user level in the dialog box. At the Painting level or above, the user can alter any of the graphics created or imported.

Interactivity

The mouse was used as the primary input device. Keyboard input was required in the data acquisition segment (Operation simulation) only if the user needed to change parameters after answering the user prompts. Various levels of interactivity were built into the stack. At lower levels, information is retrieved with minimal participation from the viewer. At higher, more complex levels, such as training simulations and procedural steps, more user control should be provided. The developer's selection of a particular level should be determined by the user's purpose and requirements, such as learning , reviewing , or recalling the material.

Size

The run-time stack at the end of the project contained 1.7 Mb. It was determined that graphics, animations, and sound added to the module's size along with scripting and deletions. Compacting the stack removed extra space and helped speed up navigation. The stack also varied in size when the Trouble-shooting exercise was accessed by the user. A copy of the stack was placed in a folder with HyperCard and Macromind applications on the network server for review.

Approach

The approach used to set up the stack for computer screen viewing was to provide a two-way "task mirror" that would both reflect the task being performed and reveal the information the user needs to accomplish the task. With these options the user would be able to (1) step through the simulated task in a training session, or (2) quickly recall the specific items needed to complete or troubleshoot the task. This open-ended approach provides a refresher of previously mastered information, updates old information, and allows the user to learn less prioritized or infrequently performed tasks.

Hence, the computer serves as a "trainer" or simulator. It provides the user with different sets of information to change variables during a training exercise or make alterations to procedures and configurations. The user can point and click the mouse cursor on these various sets of information, via icons (buttons, pictures, or text), and link instantly to another desired set of information. It is similar to flipping to the index or table of contents and then to the first page of a section in a paper document, then flipping again to the specific page, and finally using eye and finger to move down the page and locate the lines that contain the information needed. In comparison, online linking takes less time.

Format

Three user paths (USER MENU) link the user to online training and information: Training Session, Quick Info, and Trouble-shooting. "Training Session" provides a full, walk-through session for a first-time viewer. "Quick Info" allows the user to find information on demand without going through any learning exercises. "Trouble-shooting," represents a knowledge base of built-in maintenance and repair information in the event of a malfunction or in cases where the user needs to change procedures or configurations.

A list of information segments presented in a hierarchical order was added at the top of the screen (MENU BAR) for user navigation through the stack. The menu bar also contains a navigation flow chart (USER MAP) showing the location of the user within the stack. The icons on both the menu bar and the user map are clicked to go to any training activity or information set desired. Hence, the navigation map allows the user to browse or search through a linear sequence of information -- non-sequentially -- from anywhere in the stack.

Consistency was maintained in the placement and type of icons and buttons used to link to other cards in order to reduce user "slow-down" in navigating through the stack.

Implementation Considerations

Many factors can affect the implementation of online modules within the LSPD, such as:

- Portable vs. fixed computers for workstations
- Cordless input devices (i.e. touch screen and voice command) vs. the mouse and keyboard
- Computer access time related to user needs
- Trainer or expert input on training protocols and information requirements
- User feedback on training and information needs

Hypermedia requires further investigation within the LSPD as a computer-centered medium for a user information workstation. Results of providing information on line in ground testing situations would be aimed toward the Space Station Era.

Specific inflight implementation problems that should be addressed are:

- Effect of visual disorientation on computer screen proportions
- Effect of light conditions and viewing angles on computer displays
- Distortions in computer sound and voice command
- Onboard storage vs. transmission of online information
- Use of online assistance as a stand-alone system or with paper references

Conclusions

The flow cytometry prototype module demonstrated how an interactive information recall module could be applied in a scientific and engineering work environment to refresh knowledge acquired in training or provide an orientation to a new task. A hypermedia approach to development provided the best user interface and quickest access to information needed. The integration of multimedia, including video, animations, 3-D simulations, knowledge bases, sound, and more interactive input devices could not only increase visual information by transforming and enhancing online displays but decrease time spent in review.

Evaluators recommended the stack for further development and rated features such as the user interface (navigation map), graphic zoom-in's, and walk-through steps (without the voice) highest in user value.

Survey Results

A survey was conducted to determine the type of hypermedia/multimedia-based online training and information retrieval projects which are in the planning stages or under development by other individuals or organizations. Respondents were mostly from the Southwestern U.S. Several participants also provided other contacts who were involved in similar projects. Approximately half of the respondents were currently working on a hyper/multimedia project. Most products were used to train or provide online help and job support or quick information interchange. Most projects were ongoing; independent development lagged behind commercial development. Target users included company personnel, management staff, NASA, medical staff, educators, and researchers. Both Macintoshes and IBM's as well as mainframes were used in development. HyperCard, SuperCard, Macromind Director, Guide, APDA (Apple Programmer Development Association) products, and desktop publishing applications were used. Most respondents were or would be integrating expert systems. Most were willing to demonstrate their products and participate in a hypermedia work group.

Lessons Learned

Numerous design and user interface changes were made to enhance the stack. In addition, HyperCard 1.2.2 and 1.2.5 were lacking in features that would have improved the stack. The main lessons learned from stack development are described below.

- Macromind Director enhances graphic displays and animation. Director also shows a shift in data displays when parameters are changed by the user.
- Selecting scenarios to show a sequence of location or events from the actual work environment add real-life perspective to graphics.
- Sound can be turned on or off.
- Voice should be used sparingly to emphasize critical information or to give warnings, or in cases where the work or training area is not adjacent to the computer.
- Short sound clips are more effective than long soundtracks (music).
- Special effects focus user attention when a change occurs.
- Successive steps on the screen can occur automatically or be user-selected.
- A navigation map should be placed in the background of the stack, not on the cards.
- Mac SE processes large HyperCard stacks more slowly than the Mac SE/30 or Mac II.
- HyperCard is ideal for creating storyboards, such as creating placeholder "windows," stick figures, and pseudo animation for video and simulations.
- For running type to work in HyperCard (as in the Trouble-shooting exercise), the user level for the run-time program must be set to Typing.

- Setting a password and the user level to Browsing or Typing to prevent the user from changing screen objects or scripts (vs. the more dangerous practice of protecting the stack and locking out the developer as well as the user).
- Writing a script to automatically compact a stack. Compacting a stack eliminates free space (the number of bytes added to the stack when a new action is performed). This saves disk space.
- Shortcuts in scripting (thanks to a reduction of the developers' learning curve and HyperCard version changes) were responsible for speeding up online information access time:

  - "Send mouse up to card button..." automatically points and clicks.
  - Visual effects work in color mode on Mac II in HyperCard 2.0.
  - Characters in text fields can now be underlined, bolded, resized, and restyled individually within the field to make sections like the Introduction more readable.
  - "Set hilite to true/false" for each object to stay highlighted until another button was clicked is now a button function called "shared hilite."
  - "Put [literal or variable] into card field of card" does not have to be repeated because text field can be put in the background of the stack, not on the cards.

These new features can save a substantial amount of time spent in scripting and thus speed up processing and information access. One example is creating one background card and one line of 'set' and one line of 'put' instead of multiple lines for a set of cards with minimal changes resulting from user interactivity. This type of activity occurs in the Operation and Acquisition segments of the flow cytometer training simulation.

Recommendations

The LSIIR hypermedia prototype in this study proved a concept for an online help system that could not only save time and error when critical information is needed but also decrease turnaround time in obtaining information and increase the performer's productivity.

The users who would most benefit from a hypermedia-based system are LSPD mission end users, such as astronauts and PI's, and LSPD engineers and scientists. Other groups that could benefit from such a system would be contractors, support personnel, and visitors to the LSPD.

Ongoing development should include online systems for:

- Electronic documentation and information
- Electronic training and review

Module concepts that derive from this research include a desktop referencing system as well as an online help system.

A desktop referencing system would include an LSPD module with a "Q & A" display version for visitors and a more comprehensive version for LSPD personnel; an online LSPD guide of the branches: SE, SE2, SE3, SE4; and a search and retrieval front-end program for viewing documentation on line. An online help system would continue development of training and review modules for flight support personnel, such as a Flow Cytometry series, including a FlowCytoMETRIC module, which instructs the user in how to calibrate the flow cytometer based on different sets and tests and a FlowCytoEXPERT module which provides the user with a knowledge base for trouble-shooting the flow cytometry equipment ("stacks-in-racks"). Instructions in analyzing data, reading histograms, and explaining technical symbols and expressions for technical monitors and principal investigators could also be put on line.

Future Research

Research that should be continued or initiated within the LSPD includes:

- Integration of expert systems into online help systems
- Indentification of state-of-the-art multimedia technologies
- Cost/benefit of online vs. paper documentation
- Evaluation of training and information needs
- Research vs. non-research tasks performed in flight
- Study of flight and payload training requirements
- Investigation of other hypermedia/multimedia research

References

Beeman, William O. et al., "Hypertext and Pluralism: From Lineal to Nonlineal Thinking," (IRIS Project), Hypertext '87 Papers, 1987

Betts, Kellyn S., "Macintosh Seeks Engineering Muscle," Mechanical Engineering, vol.112, No. 7, November 1990

Erb, Dona M., MITRE Working Papers, The MITRE Corporation, August 1987-June 1989

Nelson, Theodor H., Literary Machines, ed 87.1, The Distributors, South Bend, Indiana, 1987

Rice, J.W., survey respondent, Advanced Educational Concepts, Inc., Houston, Texas

Williams, Marian G. et al., "Computer-Human Interface Issues in the Design of an Intelligent Workstation for Scientific Visualization," (EXVIS Project), SIGCHI Bulletin, vol. 21, No. 4, April 1990

Session 2

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