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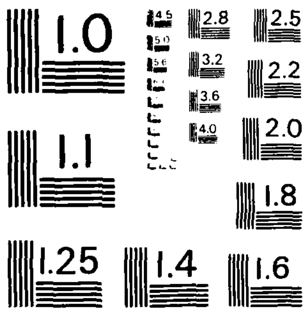

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DEVELOPMENT OF AN OPTICAL-DISC TRAINER: TRAINING ISSUES AND RECOMMENDATIONS

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A relatively new ocean surveillance system, the Inter-array Processor II, has been developed to an operational stage. Originally, training was to consist of on-the-job exposure to actual equipment with training manuals to guide the student. However, because of high equipment costs and limited availability, the feasibility of using a computer-based, optical-disc trainer as an alternative instructional delivery system is being investigated by the Naval Ocean Systems Center (NOSC). This report provides

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) recommendations to NOSC for the selection of the training scenarios, instructional delivery strategies, student/training system interface, and testing and feedback requirements, along with a discussion of the rationale behind the recommendations.

FOREWORD

This research and development was conducted under subproject PE 62759 (Human Factors Technology Development) and was sponsored by the Naval Electronic Systems Command (NAVELEX). The objective of this R&D was to provide training recommendations to the Naval Ocean Systems Center (NOSC) in support of its effort to test the feasibility of using optical-disc hardware in developing a portable operator training device.

The results of this work are primarily intended for NOSC and NAVELEX. They should also be of interest to instructional and equipment development agencies that are tasked with developing on-site operator trainers.

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SUMMARY

Problem

The integrated undersea surveillance system (IUSS), which is being developed to increase the accuracy and speed of acoustic target processing, is comprised of a number of detection, tracking, and reporting devices. One of these subsystems is known as the Inter-array Processor II (IAP-II). The design of IAP-II has recently stabilized sufficiently to allow the development of training materials.

The original training plan calls for on-the-job training using operational system equipment. However, because of equipment cost and availability restrictions, the feasibility of using a computer-based, optical-disc trainer as an alternate delivery system for operator training is being investigated by the Naval Ocean Systems Center (NOSC).

Objective

The purpose of this effort was to provide training recommendations to NOSC in support of their development of the optical-disc trainer.

Approach and Results

The following issues were addressed and recommendations made for each:

1. Training scenarios.
2. Instructional delivery strategies.
3. Student/system interface requirements.
4. Testing and feedback requirements.

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INTRODUCTION

Problem

Navy technical personnel tasked with performing ocean surveillance are required to be proficient at operating a variety of equipment included in the integrated undersea surveillance system (IUSS). IUSS is comprised of a number of detection, tracking, and reporting devices that are designed to increase the accuracy and speed of acoustic target processing. IUSS components are being developed, modified, and brought on station over a period of time. Initial training on these components is most often provided to personnel on-the-job, using actual system equipment. In many cases, this equipment is expensive, needed for performing operational tasks, and not designed to be used as an operator training device. The use of relatively low-cost hardware simulators is now being investigated as an alternative instructional delivery system for operator training.

One IUSS subsystem, the Inter-array Processor II (IAP-II), has gone through a number of system design changes. In the last few years, the design stabilized sufficiently to allow for the development of training materials. The original training plan called for on-the-job training using actual system equipment. However, because of the high equipment and operational costs associated with using an operational IAP-II system as an on-site training device, the feasibility of using a computer-based, optical-disc trainer as an alternate instructional delivery system is being investigated by the Naval Ocean Systems Center (NOSC). The optical disc will provide the images presently generated in real time by the IAP-II system and the computer will provide text allowing the student/operator to query the system, as well as give feedback. The training requirements for an optical-disc trainer need to be determined prior to the hardware development phase.

Background

The Naval Electronics System Command (NAVELEX 124) tasked a contractor to develop training materials for use with the on-site IAP-II system. The instructional materials that were developed under that tasking consist of a series of training packets for use on the job and require the dedication of an IAP display console to conduct the training. They present all of the concepts and procedures necessary to operate the IAP-II. All of the hands-on practice requires the use of the actual equipment. The training is self-paced, expository instruction with limited requirement for instructor supervision/interaction. Each packet covers a different aspect of IAP-II operation, with some review as the series progresses to aid in the maintenance of operator skills. The packets are preceded by a reading assignment and require the operator to answer a series of open-ended questions about IAP-II operating characteristics. The operator then follows instructions to sign on to the operational equipment and perform the operations called for in each packet. Each packet supports operational procedures that are performed in real time using actual equipment.

There are both advantages and disadvantages to using the IAP-II system for training. Advantages include high task fidelity and minimized negative skill transfer. However, there are five distinct disadvantages that must be considered with the use of operational equipment:

1. Some critical operations cannot be performed because the console is "live" and thus capable of confusing the operational environment by sending training data that may be perceived as actual target data.

2. The range of practice situations the student can be exposed to is limited.

3. Operating in real time precludes demonstration of procedures that take too long and require too much computing power.

4. The costs associated with dedicating major on-site systems for training purposes can be prohibitive.

5. Perhaps most important in a training situation, it is difficult to monitor student performance and provide high quality, diagnostic feedback to the student when operational equipment is used as a training device. This difficulty is due primarily to an inability to modify the software in the operational device to support training requirements.

Use of a training simulator as an instructional delivery system can provide many benefits. Because the simulator does not involve any operational equipment, training does not interfere with equipment used for normal watches. The simulator allows practice on problems not normally found in routine situations, allows event time to be compressed for practice, and provides monitoring of student/operator performance. In addition, the costs are much lower. The benefits, especially the ability to monitor performance and give feedback, argue strongly for the use of a simulator.

The capability to simulate the system environment that is offered by the computer-based, optical-disc trainer could maximize the exposure of trainees to a wide range of problems for practice, reduce skill transfer problems, and limit use of dedicated on-site systems, as well as decrease the costs associated with building and maintaining training systems. However, to maximize the effectiveness of the optical disc device as an operator trainer, the operator training requirements need to be established and incorporated into the final system.

Objective

The purpose of this effort was to provide training recommendations to NOSC in support of its development of a computer-based, optical-disc instructional delivery system for IAP-II operator training.

APPROACH

Four training issues were addressed and recommendations given for each: (1) training scenarios, (2) instructional delivery strategies, (3) student/system interface requirements, and (4) testing and feedback requirements.

RESULTS

Training Scenarios

Selection Criteria

The IAP-II training package being developed will consist of approximately 30 training packets. However, at the time this project was initiated, only four were available for review. Because the purpose of this effort was to demonstrate the feasibility of using a relatively low-cost, computer-based optical-disc simulator as an instructional delivery system, it was decided to select the packet that incorporated the widest range of operator skills.

Recommendation

NOSC should use the IAP-II Training Packet 2 to demonstrate the performance of a low-cost, computer-based, optical-disc trainer as an instructional delivery device. Of the four packets, it has the largest number of representative procedures and requires the student to use all input devices. Further, the packet text and instructions need only minor modifications for use in the alternate instructional system.

Instructional Delivery Strategies

Alternate Strategies

IAP-II contains two CRT displays that can be used for alphanumerics and several types of graphic displays, as well as a keyboard, touch panel, and a trackball. IAP-II Training Packet 2 requires the use of all of these devices. Training requirements place additional demands on these resources and/or require additional hardware and software. There are a number of configurations possible in designing the simulator hardware. Five alternate strategies are summarized in Table 1. They include (1) an additional CRT devoted exclusively to text, (2) text windows on the operational CRTs, (3) hard-copy text, (4) auditory texts, and (5) adjunct information. For each strategy, it is assumed that a keyboard is available, as well as either a mouse or a touch panel and trackball.

Selection of the optimum strategy was based on three considerations:

1. The number and variety of things to which the student must pay attention, including the number of displays, the amount of information, the number of times the student must look back and forth between the displays, and the distance between displays, must be minimized.

2. Conceptually complex information must be presented in written form, particularly if the information must be referred to later (i.e., for review and study).

3. Oral information should be limited to short, simple instructions unless it is a repetition of material presented earlier in text format.

Of the alternative strategies listed in Table 1, number 2 offers the greatest number of training presentation modes and allows the student to examine the text in whatever mode desired. It calls for two CRTs with windowing capability for written text, a text handbook, and an audio text. Use of a text window allows the student to focus on the normal IAP display terminals for operator functions and training text without needing a third CRT. This precludes the need to look back and forth between the text on a third CRT and the normal displays.

Table 1

Alternate Instructional Delivery
Support Strategies

Strategy	CRTs--Number and Use	Presentation Modes	Student Input Devices
1	Two for normal displays One for training text	Text handbook Third CRT audio cue	Keyboard; track-ball and touch panel or mouse
2	Two for normal displays with windowing for text	Text ha[illegible]ook Audio [illegible]	Keyboard; track-ball and touch panel or mouse
3	Two for normal displays with windowing for text	Text h[illegible]book Audio [illegible], [illegible]ct cues	Keyboard; track-ball and touch panel or mouse
4	Two for normal displays with windowing for cues	Written text only	Keyboard; track-ball and touch panel or mouse
5	Two for normal displays	Audio text Text handbook	Keyboard; track-ball and touch panel or mouse

Strategy 2 includes the recommendation that the text should be printed as a handbook. This handbook would provide a number of benefits to the student. First, hard-copy text in handbook form would enable the student to read and review material specific to the frame of interest, as well as review text from previous frames. In past studies at NAVPERSRANDCEN,[1] [2] it was found that students take considerably longer to complete training when they cannot review the materials at their leisure. Second, allowing the students to retain the handbook following the course allows them to review the material when needed on the job, thus ensuring the availability of refresher training materials.

Finally, under strategy 2, it is recommended that audio text be used in two ways. First, it can be used to give short instructions (i.e., press specified button, look at specific area on CRT). Second, if the oral text is the same as the written text, the student can listen to the instructions/rationale while looking at the appropriate display. This would preclude the student from having to shift attention from reading to looking and would allow greater concentration on the display of interest. Because using audio only is not considered suitable for complex or long messages, it should not be used in isolation. With strategy 2, the student can use either or both of the presentation modes.

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[1]Hurlock, R. E., & Slough, D. A. Experimental evaluation of PLATO IV technology: Final report (NPRDC Tech. Rep. 76TQ-44). San Diego: Personnel Research and Development Center, August 1976. (AD-A029 384)

[2]Stern, H. W. Transfer of training following computer-based instruction in basic oscilloscope procedures (NPRDC Tech. Rep. 76-1). San Diego: Navy Personnel Research and Development Center, July 1975. (AD-A012 637)

Strategy 1 is considered the least desirable. Students would have to constantly switch their attention from the operational CRTs to the text screen. It might be possible to provide audio cues to overcome some of this problem, but it provides the least effective solution to the training problem. The other strategies are considered to be approximately equal in value except, possibly, for strategy 5, if it could be configured with cheaper CRTs not requiring the window feature. This would reduce the cost and might make this option attractive. There is no evidence that reading text from the CRT improves learning over reading text from hard copy. In fact, as noted above, CRT-only text may increase learning time.

Recommendation

The instructional delivery strategy selected should have the following:

1. Two CRTs with windowing capability for text display.

2. Written text, in hard-copy form.

3. Audio supplements to the text (desirable but not essential). If an audio supplement is included, the following criteria should be met:

a. Audio should be used only when the message is simple or when the message requires immediate action.

b. Audio should be an option to the student.

c. Audio text should duplicate the written text.

d. Audio text repetitions should be available to the student.

4. Student input devices, including keyboard, touch panel, and trackball.

Student/System Interface Requirements

Instructional Issues

As indicated previously, the IAP-II console contains two CRT displays that can be used for alphanumerics and several types of graphic displays, a keyboard, a touch panel, and a trackball. The computer-based, optical-disc training simulator is being designed to emulate the actual console as closely as possible. Since the original and the simulator systems are both designed to minimize the number of operator responses to achieve a given display, the main inputs must be made through the touch panel and trackball. The keyboard is activated only when needed, thereby reducing the amount of typing required of the operator. Since the student will use all available spaces in the touch panel at some time during Packet 2 training, some other means of allowing the student/operator access to training text and other aids is needed so that he or she can easily move through the training material.

Originally, Packet 2 was a paper workbook intended to be used with live equipment; however, the optical-disc trainer will have the Packet 2 text available on one CRT and an option for a paper copy. Student actions are directed at all times in Packet 2 for both versions. Most entries are made through the touch panel, which is the normal mode of system operation. The keyboard is used to enter the operator's name, array number, time/date group, beam number, and beam frequency. The trackball is used to position the cursor. For training purposes, some means is needed to allow the student to manipulate training text independent of the normal displays. The student will normally progress from frame to frame in a linear sequence, but some student flexibility is desirable. A provision is necessary to allow for the student to move forward or backward a few frames or to repeat a section of the training.

Student Interfaces. The way students interface with the training system is critical. They must have a minimum of choices that are clearly marked. One possibility for the future would be the addition of another touch panel. However, at this time, the best interface can be constructed with the keyboard.

The student must be able to control the following five variables: (1) frame duration, (2) training entry point, (3) training exit point, (4) review (single frame and section), and (5) access to "help." Control of these variables requires software to allow student access to a selected set of keys that remain constant for each variable. For example, if arrow keys are available, they can be used to move forward and backward in the text when the student wants to review. They should be keys that are not used normally so that they can be relabeled with the appropriate term. The text must be linked to the nominal display functions, but some provision is needed to allow the student to move forward or backward a few frames of IAP-II displays without changing the text. This is necessary to provide feedback to the student on the consequences of the action performed. For example, when some touch panel action is performed, the IAP-II frame should be advanced while the text is held constant. When the student is satisfied with the result, a keyboard function will allow advancement to the next text frame describing the required action and any comments on the action. To aid in ensuring the correct touch panel response, the correct square should be blinking. The student should be able to toggle off both the blinking touch panel and the text to allow self-testing of procedural knowledge.

Advance organizers. The training packets provide little advance information as to what is expected of the student. The current packet includes material within the packet that is used as a review of the completed lesson. This material could easily be moved to the beginning of the training and thus provide the student with an overview of what is expected in that lesson.

Menu. At least one line at the bottom of the CRT should be reserved to present a menu for the special keys. Another menu is needed to mark major points in the training exercises, such as the advance organizers. This allows the student to jump out of the normal sequence to review the overall objective or other information that might be needed. If the student does not complete the lesson in one session, some means of returning to the break point is needed. One way to do this is to provide a menu of the major and semi-major procedures in Packet 2, which would allow the student to return to the approximate stop point. Menu selection should be either by moving the curser, as in normal IAP operation, or by keyboard press of the first letter of the selected menu word.

Text delivery and student control. Text will be presented in the bottom half of the right-hand CRT at all times. In most cases, this will not interfere with normal screen functions. However, on a few frames, the text will have to alternate with the screen graphics. This should be under student control. Advance organizers could use the whole CRT, if necessary.

The simulator should be supplemented with a written text that gives the procedures for equipment operation. When there is no provision for the student to retain a copy of the procedures, they tend to take copious notes for review at a later time. The hard copy also ensures that the student gets the correct procedures for later use in the fleet.

Text changes and student actions will be under separate control, but they need to be linked by some software connection, a frame numbering sequence, or both. This means the student will have to advance the IAP-II frame separately from the training text frame. This should be limited to a few frames. Some means of linking the nominal IAP-II frame and the corresponding text frame has to be provided. This is necessary if the student becomes confused or if the student desires to jump out to another part of the text. This is probably the most difficult implementation issue and may require revision during development and during the pilot test phase.

Error and help messages. Error messages are under software control. For this initial effort, two kinds are needed: (1) a simple message that the wrong function was selected, and (2) an answer-judging routine to display a message when an incorrect answer is typed in or the trackball is slewed to the wrong position. In both cases, the correct button press, data entry, or cursor position can be reiterated in the lower-right CRT, perhaps with reverse video and audible beep to ensure student attention.

Help messages are under student control. The menu needs a provision for help. These messages will be displayed in the same area reserved for text. As with error messages, two types are required: One to provide students with explanations for student interface mechanisms (e.g., control keys, directions for returning to previously seen text for review, and terminology definitions) and the other, to provide expanded explanations of operations and terms or offer brief tutorials on related topics.

Recommendation

The student/system interface selected should have the following characteristics:

1. Student actions should be input via the keyboard.

2. Video text delivery should be placed on the lower half of the right-hand CRT.

3. Student progress should be linear, with no provision for "free play."

4. The bottom row of the right-hand CRT should be reserved for a menu.

5. Correct touch panel choices should blink.

6. Student should be able to toggle off text and other student prompts.

7. Two types of error messages--"wrong function" and "incorrect answer"--should be provided to the student.

8. Students should be provided with interface explanations via student-controlled "help" messages.

9. To ensure coordination, some provision needs to be developed for linking display frames.

Testing and Feedback Requirements

Issues

Assumed level of knowledge. Packet 2 assumes some prior experience with the IAP console and requires preliminary study of reference materials. Some general questions are asked before the student signs on the system. Provision needs to be made for pretesting and for periodic reviews of student progress.

Packet 2 presently provides open-ended pretest questions and one short review question. These questions could be modified with minor effort to provide an interactive review for the students, but additional material needs to be added to inform them of their progress. There is also considerable pretest and review material in Packet 1 that should be understood by the student prior to undertaking the training in Packet 2. If the student does not have the basic skills and knowledges that are aquired through Packet 1, poor performance in Packet 2 might reflect this lack of skills and knowledges rather than the simulation's training ability.

Performance measurement. Student performance levels should be assessed at the start of training to build a data base that can be used to identify entry-level students and to adjust training progression. Progress tests should be an accurate reflection of the performance required. For example, in Packet 1, the student is asked to list the parameters of the "initial target state." These parameters do not need to be memorized because the IAP-II console prompts the operator for the values. Without performance measures, evaluation of a computer-based, optical-disc training sytem is limited.

Prompting. Training should be designed to provide heavy prompting at the beginning, with decreased prompting as the student progresses. Training Packet 2 is designed to prompt the student. As the student becomes more familiar with the sequences, the prompts should fade. For this pilot study, a temporary solution for the problem would be to allow the student to toggle the prompts as necessary. The feedback or error messages should be available at all times and not under student control. The student should perform the task as it is performed on the job and performance should be assessed based on job criteria.

Student trails. As mentioned previously, the student will progress through the training Packet frame by frame. This means the information will be presented in a linear sequence. However, since the student will be allowed to repeat difficult frames and whole sections, a student audit trail is needed to provide a record of student progress through text passages. This will allow determination of difficult operations. Since later versions of the training will allow for branching, a provision for auditing these trails can be developed now, if time permits. For this study, the following summary data are desirable: (1) total time, (2) time for each task or objective, (3) correct response rates for each item on the first attempt, and (4) number of incorrect responses to each item.

Recommendation

The list of testing and feedback requirements should include the following:

1. Pretesting is required to establish minimum entry level.
2. Testing of all objectives is needed to assess student proficiency.
3. Prompts should be made available to the student when requested.
4. Error messages should alert students to incorrect performance.
5. Data on student study time and responses are needed.

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