BUILDING A BRIDGE BETWEEN DATA FUSION TECHNOLOGY AND TRAINING TECHNOLOGY

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ABSTRACT

The modern Navy is confronted with a rapidly changing world order and it is essential that Navy personnel achieve the highest possible levels of proficiency on their assigned tasks. The Naval Air Warfare Center Aircraft Division, Warminster and Naval Training Systems Center are collaborating on an effort to develop an onboard trainer which will provide the AN/SLQ-32 operator with situation assessment training. To accomplish this, intelligent tutoring capabilities will be integrated into the knowledge base of an intelligent control architecture for data fusion. This design will provide the operator with an opportunity to practice electronic warfare skills and to receive guidance and feedback (via the computer) on his performance. The objective of this paper is to document the potential for data fusion technology to enhance onboard training.

ABOUT THE AUTHORS

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Commander Steven D. Harris received his commission in the USN Medical Service Corps in 1974. He holds an MS in Psychology. Prior to his assignment at the Naval Air Test Center and out-service training at Virginia Polytechnic Institute, he managed the Navy's voice-interactive systems and technology program at the Naval Air Development Center. CDR Harris developed the first artificial intelligence system, "DEMON," to be flight tested in an F-18, and has received wide recognition for his expertise in the application of advanced technology to crewstation design. His current assignment at Naval Air Systems Command is Program Manager, Simulation and Training Devices.

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INTRODUCTION

The modern Navy is confronted with a rapidly changing world order and it is essential that Navy personnel achieve the highest possible levels of proficiency on their assigned tasks. While technology has extended the range over which individuals maintain contact, the speed with which information can be shared, and the corresponding amount of information created, research addressing the behavioral demands on the users of these tactical systems has not been able to keep pace. Correspondingly, the training technology necessary for preparing these system users to perform their jobs or for assisting users in the maintenance of these skills lags system production. The objective of this paper is to document the potential for data fusion technology to enhance onboard training. Toward this goal we will first describe how computer technology is changing the operational environment, then discuss a data fusion technique known as KOALAS. Following this we will introduce training technologies with the potential to enhance key aspects of situational awareness in this new environment.

THE OPERATIONAL ENVIRONMENT

Modern combat systems can be characterized by their increasing dependence on computer technology to track, store, and process information. Unfortunately for the operators working within this environment, this shift to computer-aided information processing has not been accompanied by a reduction in the demands placed upon them. If anything, cognitive demands have increased on the system operator in that he is now responsible for overseeing the functioning of an "intelligent" associate.

Correspondingly, the missions these operators are now expected to complete have also become more demanding. Effective task performance by tactical operators and tactical equipment hinges on both competent situation assessment and selection of actions appropriate to the situation. Situation assessment and action selection involve two highly interdependent processes: deductive and inductive reasoning. Deductive reasoning is the forte of computers: it is the computer's ability to combine observable pieces of information in order make an inference. Induction, on the other hand, is something humans do quite well. It is our ability to draw conclusions based upon experience, motivation, and other non-quantifiable factors. In today's environment neither system (human nor computer) can perform these tasks alone.

Situation assessment requires interpretation of sensor data to detect, classify, and identify threat systems and platforms, and to assess the threat's capabilities against ownship and/or other friendly forces. Yet interpreting the sensor data is only half of the problem. Determining whether a particular airborne object is friend or foe may, under some conditions, depend solely upon the unknown pilot's intentions. And intentions, by their very nature, cannot be detected by sensors. Threat intentions are, however, extremely important in the context of situation assessment and for selecting an appropriate tactical action. The Iraqi engagement of the USS Stark (FFG-31) is a powerful example of the criticality of interpreting intentions accurately. The implications of the interplay between man and machine are crucial to designing operator-centered sensor fusion systems which exploit human capabilities for induction, while compensating for our limitations.

THE KOALAS APPROACH

Sensor fusion systems are intended to help by providing decluttered tactical displays to aid human operators in situation assessment and in maintaining situational awareness. To exploit the potential of sensor fusion in support of situation assessment, the Knowledgeable Observation Analysis-Linked Advisory System (KOALAS) was developed at Los Alamos National Laboratory as an advanced concept for the design of hypothesis-driven sensor fusion systems (Barrett & Donnell, 1991; Harris, Owens, Barrett, Parisi, & Becker, 1991).

The KOALAS approach is comprised of a taxonomy of intelligent control processes, an architecture for intelligent control systems that conforms to the taxonomy, and a methodology for development of intelligent control systems. The KOALAS taxonomy prescribes how human induction should be incorporated into the design of control systems. According to the KOALAS concept, the human operator controls the systems by intervening at two points: first, by controlling the operative situation hypothesis, and second, by controlling the actions recommended by the KOALAS system. The focus of the human operator's attention is on interpretation of sensor data to form a situation assessment and then selection of tactical action.

The KOALAS architecture provides support for human induction, incorporates an explicit model of the human operator's tactical situation assessment, and provides a context for the appropriate use of sensor fusion systems in the initialization and maintenance of that situation assessment. In the KOALAS model, the sensor, decision formation, and action assignment processes are defined to be deductive in nature. The interpretation process, however, entails induction on the sensor data to generate the operative hypothesis for subsequent decision making and action. The most important issue in the design of human-mediated equipment control is the definition of the human operator's role in the sensing, interpretation, decision making, and action processes of the control system being designed. Since sensing, decision making, and action processes in the KOALAS taxonomy are defined to be deductive, these processes can be largely (or wholly) automated; it is in these areas that machine intelligence offers greatest payoff in the control of multi-channel systems. The crucial human role in the system is in the interpretation process, a function that can be assisted, guided, or trained, but not automated.

COGNITIVE TRAINING TECHNOLOGY

The advances in sensor fusion technology will demand comparable advances in training technology to accomplish the goal of enhanced performance. Developing training for the operator's role as interpreter will not be as simple as applying tried-and-true training principles in another setting. Traditional training design principles (spaced versus massed practice, whole versus part learning, positive versus negative reinforcement) make few recommendations on "how to make people better diagnosticians, how to increase their available attention capacity, or how to help people create appropriate mental models for the complex processes under their control" (Howell & Cooke, 1989, p.125). Therefore new approaches for training these cognitive skills must be explored.

Developments in the field of cognitive psychology may have the most to say about how to train cognitive skills. Candidate techniques which may prove useful in training the equipment operator to perform in the evolving tactical environment include:

1) Automatic processing - Task performance can be increased by identifying behaviors that involve consistent cue-response relationships, then providing intensive practice on these behaviors. Within a tactical context, this strategy would focus on the psychomotor aspects of the task - the button pressing. The advantage of this technique is that by overtraining the routine elements of the job,

more of the operator's cognitive capacity can be freed up for use on non-routine activities (i.e., planning and decision making).

2) Mental models - The goal of this strategy is to help the trainee to develop an accurate mental representation of the system with which he is working. This mental representation enables the trainee to draw inferences and make predictions, in other words, to test hypotheses. Identifying the differences between the trainee's mental representation and the desired representation can be used to diagnose conceptual errors and provide corrective feedback while the individual is training.

3) Metacognition - This strategy concentrates on helping the trainee monitor what he does and does not know. The capability to self-monitor distinguishes proficient from non-proficient learners. Metacognition can be promoted through active involvement in learning (solving illustrative problems) and through the use of diagnostic feedback (what strategy the trainee used, why it did not work, what should have been done instead).

4) Expert systems - The objective of an expert system is to shape the trainee's level of knowledge to carry out complex operations. To accomplish this goal, the expert system must be able to diagnose the trainee's current level of knowledge based on his responses and provide feedback to the trainee to promote his understanding of conditions and outcomes.

BUILDING THE BRIDGE

Naval Air Warfare Center Aircraft Division, Warminster and Naval Training Systems Center are collaborating on an effort to develop an on-board trainer to provide the AN/SLQ-32 operator and supervisor with situation assessment training using a KOALAS based architecture. The AN/SLQ-32 is an Electronic Support Measures sensor found on many U.S. Navy ships. The device will be designed to be incorporated onboard ship as either a stand alone PC or as a software modification to future versions of the AN/SLQ-32. The idea driving this project is to allow the operator access to more information than is currently available, from which he can develop his own "mind's eye view" of the tactical situation. Concurrent with supplying this enhanced picture, training and evaluation of his performance will be provided by intelligent tutoring capabilities embedded in the KOALAS knowledge base. Thus, the operator will be able to practice his interpretive skills and to receive guidance and feedback (via the computer) about what actions are advised in different situations. This is the first known trainer which is based on an operational data fusion technique.

SUMMARY/CONCLUSIONS

This paper has described a sensor fusion architecture known as KOALAS which has the potential to provide a unique training opportunity for maintaining perishable skills. One of the current limitations of onboard training is the unavailability of instructional support for the trainees. By incorporating intelligent tutoring capabilities into the KOALAS knowledge base, a sensor fusion architecture can function also as an expert instructor. Because of the generic nature of the KOALAS architecture, an intelligent tutoring capability can be added to the knowledge base without modifying the basic architecture. A demonstration of this concept for electronic warfare training is in process.

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