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Effects of Visual, Auditory, and Tactile Cues on Army Platoon Leader Decision Making

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Abstract

Future U.S infantry capabilities, coupled with network-centric warfare concepts, will enable huge advancements in information distribution and display, and will provide a combat advantage. However, the distribution of large amounts of information, especially to the visual channel may result in information bottlenecks and cognitive overload. Utilizing other human senses such as audition and touch to convey information may help soldiers manage information, thereby enhancing their performance on the battlefield. In this paper, we describe our theory-based analytical approach that will identify techniques that aid information management and enhance situational awareness and decision making for operators of future Army Combat systems, specifically, the platoon leader in the infantry command and control vehicle.

Introduction

Modern combat represents a highly complex task environment that poses many significant challenges for soldiers. For example, during a combat situation, there are a variety of sources of information that a single soldier must attend to and comprehend, which becomes especially problematic when considering the high operational tempo, uncertainty, and stress of combat. In addition, technological advancements as well as the need to ensure that our forces are equipped for future conflicts have led the Army to invest in the development of Future Combat Systems (FCS). At the heart of FCS is the Command, Control, Communications, Computers, Intelligence, Reconnaissance, and Surveillance (C4ISR) system that will provide advanced communications and technologies to link soldiers with both manned and unmanned ground and air platforms and sensors. FCS-equipped units, therefore, must deal with a large amount of battlefield information.

The information provided by the C4ISR architecture is an important factor in maintaining situational understanding on the battlefield. However, “pushing” large amounts of information to the soldier may not enhance their situational understanding. Rather, there are certain pieces of information that are critical for soldiers to make adequate decisions and successfully complete their mission, and therefore, should be readily available. Another consideration is how information is presented to the soldier. Within FCS, battlefield information is digitized and conveyed to soldiers using an array of computer displays, which relies heavily on the visual modality. Traditionally, system designers use the visual modality as the main presentation channel, and other modalities are either ignored or used insufficiently, causing confusion and increased workload (Brickman, Hettinger, & Haas, 1999). In order to address the issues associated with information display for FCS systems, an Army Technology Objective (ATO) was developed. The ATO supports research focused on reducing the potential mental workload of soldiers who often perform multiple tasks simultaneously. A review of the literature on information processing suggests that Multiple Resource Theory

(MRT) may be a useful tool in designing interfaces for applications in which operators perform several tasks at the same time (Boles, 2001). The following section gives a brief discussion of MRT and how it was applied to this project.

Theoretical approach

A fundamental goal for ATO display investigations is to support soldiers in high workload situations. Display interventions have been particularly effective in situations where operators have multiple demands for attention. Multiple resource theory suggests a potential display solution: the distribution of tasks and information across various sensory modalities. Multiple-resource theory proposes that humans have a finite capacity for processing information (Wickens, 1991). For example, if an operator is asked to perform two concurrent tasks, the performance of one or both of the tasks may suffer because each task has fewer available resources than when each task was performed separately (Mitchell, 2000). Off-loading some of the information to other modalities can reduce dual-task interference, which should lead to more efficient processing and improve task-sharing performance (Sklar & Sarter, 1999). To a limited extent, the military domain has implemented a multi-sensory information presentation approach. For example, system designers are utilizing auditory displays, such as alerts, in addition to traditional focal visual displays (Nikolic & Sarter, 2001, Weinstein & Wickens, 1992, Bolia, D'Angelo, and McKinley, 1999). However, an operator may encounter situations in which their visual and auditory channels are both heavily loaded. In these situations, it may be beneficial to include the tactile modality (Sklar et al., 1999). Recently, tactile displays have been used as communication systems for pilots and astronauts to aid in spatial orientation by providing directional cues (Jones & Nakamura, 2003; Gililand & Schelgel, 1994) and as a navigational aid (van Erp, 2005; Elliott, Redden, Krausman, Carstens, & Pettitt, 2005).

In summary, there are challenges involved in conveying battlefield information to the soldier in a manner that enhances their ability to manage the information and in turn, increases their situational awareness. Research cited above suggests that multi-sensory information display may be an effective technique for enhancing the information management and situational understanding of soldiers. Therefore, the goal of this project is to use the principles outlined in MRT to guide development of displays for presenting critical information to the platoon leader, thereby increasing system performance. Results of this project will support development of display design guidelines that will transition to FCS developers.

Objectives

The first objective of this project was to identify a preliminary set of critical information requirements (CIRs) for the five crew positions in the Infantry Platoon leader vehicle (IPLV): Driver, Vehicle Commander, Platoon Leader, Robotics NCO, and Medic.

A second objective was to build a task-network model of the IPLV, which would identify periods of high mental workload experienced by crewmembers during the modeled mission. In addition, the model would indicate the modality and interface used to display current CIRs.

Finally, recommendations for simulator studies and experiments were made, based on the model output and MRT. These experiments will investigate alternative modalities or methods of presenting CIRs to the crewmembers to reduce workload, thereby increasing system performance.

Methodology

Critical information requirements are the pieces of information soldiers need to make appropriate decisions and successfully complete their mission. Job analyses, questionnaires, and SME interviews were used to obtain a preliminary set of CIRs. In addition, information derived from the job analysis helped identify a set of tasks for each crew position within the IPLV.

Next, a task-network model of the Infantry Platoon Leader Vehicle (IPLV) using the Improved Performance Research Integration Tool (IMPRINT) was developed. The IMPRINT model simulated tasks performed by the five crewmembers in the IPLV. The purpose of the model was to identify when crewmembers experienced high mental workload. A subsequent analysis of the model data identified tasks associated with the high workload and the modalities associated with these high workload tasks (Mitchell, Samms, Glumm, Krausman, Brelsford, & Garrett, 2004). The platoon leader was the primary focus of the analysis. Results of the IPLV model indicated that the platoon leader experienced high workload when visually scanning the tactical display, monitoring remote operations, and receiving and comprehending digital messages.

Project personnel conducted Subject matter expert (SME) interviews to help verify tasks and functions included in the IMPRINT model and to identify critical information associated with the high workload tasks. Several pieces of critical information were derived from the interviews including: main routes of advance, known obstacles, objectives, limits of advance, sectors of fire, friendly and enemy locations, phase lines, course of action, status and location of unmanned assets, location of support assets, casualty evacuation routes, casualty collection points, danger areas, and urban areas.

Finally, based on the results of the IMPRINT model, SME interviews, and the principles of MRT, it was determined that a simulation study be conducted that examines the effects of multi-sensory information presentation on platoon leader performance. More specifically, how using alerting mechanisms such as visual, auditory, and vibro-tactile affects the platoon leader’s decision making. The following section provides a description of the simulation platform that will accomplish the goals of this effort.

Platform description

The M-Body Agent Enabled Decision Group Environment (AEDGE®) simulation platform was developed by 21 Century Systems Inc. (21csi) under an Army TACOM-ARDEC sponsored Phase II Small Business Innovative Research (SBIR) Program. The platform, originally developed as a tactical decision support system platform, was modified to fit the requirements of this program and to represent the functionality that was necessary to simulate platoon operations. M-Body AEDGE® provides several unique capabilities: (1) it provides that generate specific audio, visual, and vibrotactile cues for attention management, and an option for both unimodal or multimodal presentation, (2) it provides a data collection capability that considers the command and control decision making aspects for Army platoon leaders, allowing the capture of extensive simulation events and human interactions, (3) it provides a capability to modify mission scenarios based on the research question.

The platform consists of two interconnected workstations with 17-inch flat panel monitors, and a 48-inch flat panel for 3-D graphics (Figure 1). Each station can provide users with 2-D and 3-D map views with grid coordinates, communications via voice and text messaging, visual, auditory, and tactile cues, vehicle movement, terrain information, mission-specific icons and graphics, and UAV views (Figures 2 and 3). Stations are reconfigurable depending on the positions simulated and information required.

A joystick, keyboard commands, or voice commands control the movement of vehicles in the simulation. Communications are accomplished via text messaging, or verbally, using a headset. Alerts (visual, auditory, and vibrotactile) signal important incoming information or threat location. A pull down menu allows selection of desired alert type.

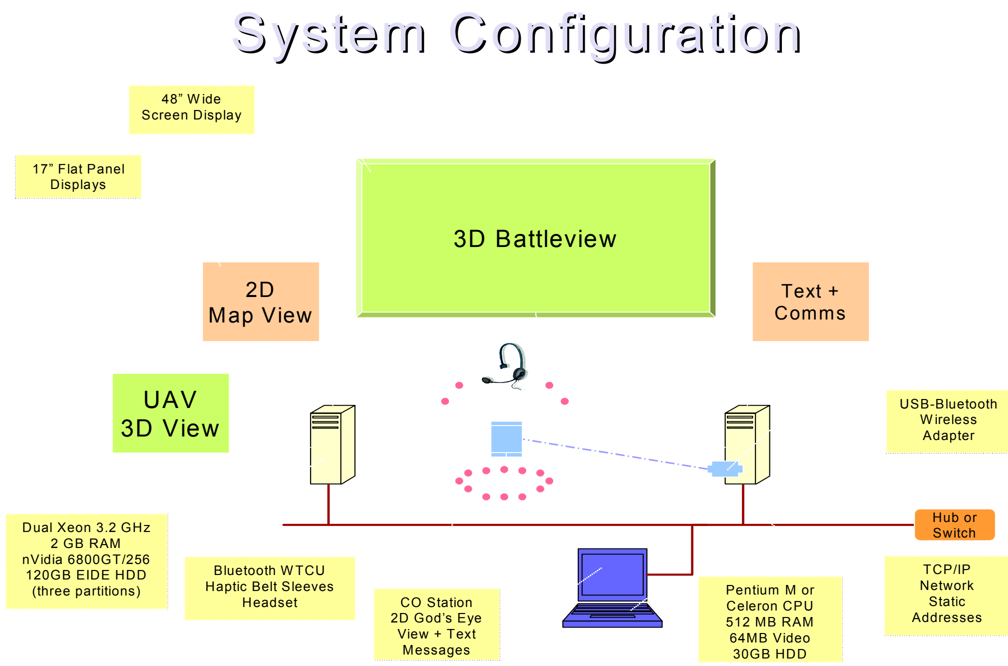

Figure 1. Diagram of M-Body AEDGE research platform configuration

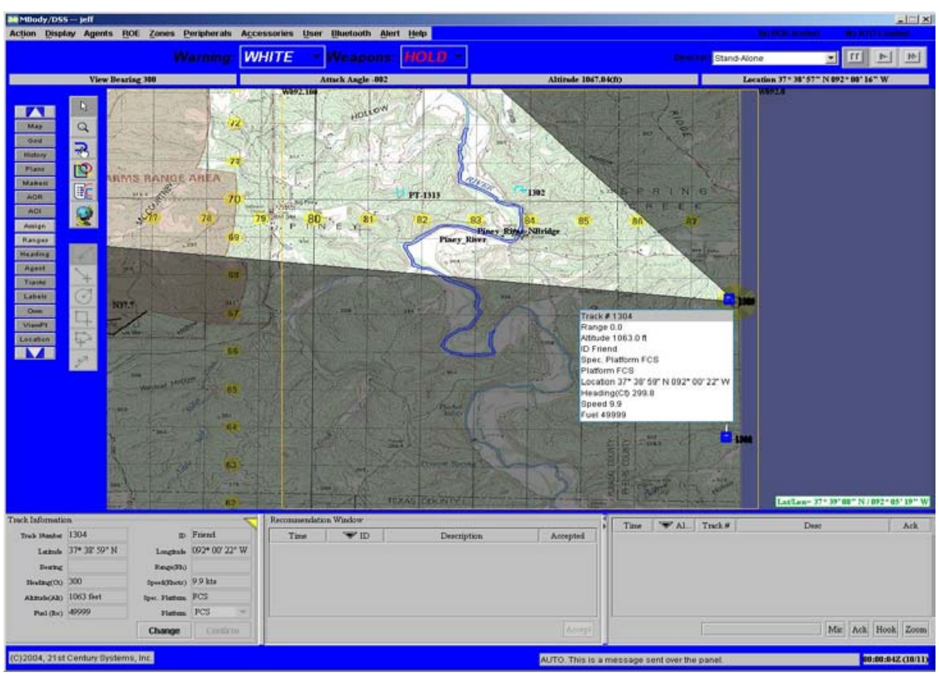

Figure 2. 2D map display

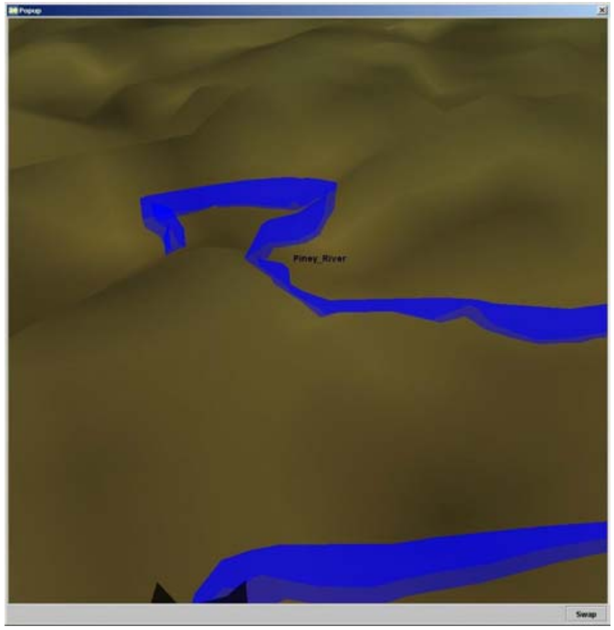

Figure 3. UAV display

The capabilities of the M-Body AEDGE make the platform a powerful tool for studying various aspects of situational understanding and display design. The following section provides a brief description of the proposed research in support of the Army ATO.

Proposed research

The effect of alerts on the decision making of a platoon leader during a mounted attack mission is the focus of this effort. The M-Body AEDGE platform will present the platoon leader with three movement-to-contact scenarios, which include 2-D and 3-D map views, voice communications, and digital messaging. Scenario roles and tasks reflect anticipated duties and the tasks included in the IMPRINT model such as communications, monitoring the battlefield, and observing UAV operations. The scenarios are (a) equivalent in tasks and workload and (b) different in surface features, to minimize recognition and practice effects.

Visual, auditory, and tactile alerts will signal the platoon leader of incoming information. Critical decision events will occur several times during each scenario. Structured interviews of active-duty captains and platoon leaders with recent combat experience identified the decision events. They were further crafted to represent and distinguish levels of decision making performance, that is, decisions can be easily recognized as effective or ineffective. For example, the platoon leader may receive a message that indicates there is a danger area ahead, so he may decide to change course.

During scenario performance, the software creates a data log, which will include the time each communication is sent, the time it is opened, and the subsequent action that is taken. Observer-based ratings of performance and subjective evaluations of alerts by the participants will be recorded and analyzed. Measures will include decision time and accuracy.

Future work will explore multi-modal options and the use of visual, auditory, and tactile alerts to provide information on threat location to the platoon leader. Additional topics may include the use of redundant alerts and using the tactile modality to convey messages rather than just alerts.

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