Augmented Cognition Technologies Applied to Training: A Roadmap for the Future

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Abstract

The military training community strives to meet ever-increasing expectations and challenges. One expectation is to support all levels of training from novice to expert. Supporting the full spectrum of training curricula, from basic knowledge acquisition in a classroom, or e-learning, to on-the-job-training with embedded training and mission rehearsal capabilities, are all of great importance to maintaining a qualified Fleet. Challenges to the delivery of training include: 1) increased operational tempo and mission complexity, 2) the perishable nature of higher order cognitive skills and team behaviours, 3) reduced availability of instructors and role-players, 4) system deployment and usability, and 5) costs including travel and leave costs of personnel while at “brick and mortar” schoolhouses (Lyons, Schmorrow, Cohn, & Lackey, 2002). An approach to addressing theses challenges is to apply advanced artificially intelligent computer assisted instruction technology, also known as Intelligent Tutoring Systems (ITS) (Chipman 2005), throughout the training continuum of delivery mechanisms. We propose that additional improvements could be realized across the training continuum by creating Augmented ITS capabilities that combine state-of-the-art ITS components with augmented cognition technologies, such as cognitive and neurophysiological sensing, and warfighter assessment gauges. This technology is currently being developed under DARPA’s Improving Warfighter Information Intake Under Stress Program, also referred to as Augmented Cognition or AugCog. The resulting Augmented ITS will add a new level of capability to blended training solutions.

This paper will provide an introduction and overview into the newly immerging field of Augmented Cognition for Training Superiority and Education. It is being presented as the 1st of seven papers in a session of the 1st International Conference on Augmented Cognition. Throughout the paper we propose approaches for inserting data from cognitive and neurophysiological sensing, and warfighter assessment gauges into the student model, expert model and tutor components of intelligent tutoring systems to create Augmented ITS. Brief summaries of on-going research in this area being conducted by our colleagues are provided for illustration. Notional examples of Augmented ITS applied to both individual and team training are also offered. Finally, we conclude with expected benefits towards addressing the challenges to military training and recommendations for future research.

1 Introduction

The military training community strives to meet ever-increasing expectations and challenges. One expectation is to support all levels of training from novice to expert. Supporting the full spectrum of training curricula (Figure 1), from basic knowledge acquisition in a classroom, or e-learning setting, to on-the-job-training with embedded training and mission rehearsal capabilities, are all of great importance to maintaining a qualified Fleet.

Schoolhouse/Lecture/Lab practice -- e-learning/ADL -- Virtual/M&S -- Live -- Embedded --On-the-job

Figure 1: The continuum of training delivery mechanisms utilized by the military.

Challenges to the delivery of training include: 1) increased operational tempo and mission complexity, 2) the perishable nature of higher order cognitive skills and team behaviours, 3) reduced availability of instructors and role-players, 4) system deployment and usability, and 5) costs including travel and leave costs of personnel while at "brick and mortar" schoolhouses (Lyons, Schmorrow, Cohn, & Lackey, 2002). An approach to addressing theses challenges is to apply advanced artificially intelligent computer assisted instruction technology, also known as Intelligent Tutoring Systems (ITS) (Chipman 2005), throughout the training continuum of delivery mechanisms. We propose that improvements could be realized across the training continuum by combining Augmented Cognition Technologies such as cognitive and neurophysiological sensing, and warfighter assessment gauges with state-of-the-art ITS, providing Augmented ITS capabilities.

The Navy has established several commands to address education and training. The Naval Education and Training Command (NETC) including the Human Performance Center (HPC) and Navy Personnel Development Command (NPDC) focus on the initial portion of the training continuum (individual training), with an innovative initiative called the Integrated Learning Environment (ILE). Fleet Forces Command addresses the other end of the continuum with collective Fleet Training once a sailor or marine is assigned, or deployed, with modeling and simulation (M&S) based, distributed training exercises that can include deployable, embedded and live training platforms. Success in maintaining qualified personnel throughout their careers is contingent on continuous collaboration between these organizations.

The goal of the Integrated Learning Environment (ILE) is to improve and support job performance and mission readiness by providing high quality learning and performance support available anytime and anywhere. This will be accomplished by providing a single system for sailors to view and plan their entire career and advancement process. Sailors will be using elements such as the Navy Knowledge Online website, the Five Vector Model, and an individualized electronic training jacket (ETJ) tool to track their credentials and requirements for advancement (Human Performance Center, 2004).

An essential element of the ILE is migrating relevant areas of its classroom learning to web-based learning combined with modeling and simulation practicum experiences represented by "simulation objects" which could be enhanced with augmented ITS capabilities. This migration is expected to reduce the time and cost to educate and train sailors while increasing operational readiness by:

- Enabling prescriptive learning through reusable learning objects that can be combined "on the fly" to deliver individualized instructional curriculum, referred to as "my course."
- Increasing individual and mission performance by making knowledge available to sailors in the fleet when and where it is needed.
- Providing training according to a "the right sailor with the right skills in the right job at the right time for the right cost" approach.
- Emphasize learner control and responsibility.

In order to maximize the success and payoffs of the entire training continuum including those used by the ILE and M&S based training approaches, it is imperative that we understand and optimize the employment of these delivery systems. Such optimization can only truly be achieved by matching the individual's needs for learning to the time spent in training focused on targeted training objectives. It is this need to understand the individual's state of knowledge, skills and abilities, which we believe can be improved by the addition of augmented cognition technologies in training.

2 Background on Intelligent Tutoring Systems

Scope and Definition

The development of ITS began in the 1970s as an attempt was made to enhance computer based instruction (CBI). . The goal was, and still is, to combine highly individualized CBI with artificial intelligence (AI) methods in an attempt to produce the same kind of flexibility and learning effect that occur when a human tutor and student work together (Siedel and Park, 1994). In meeting this goal, the ITS would have the capability to assess what the student already knows, the curriculum that student needs to learn, and the appropriate instructional strategy and feedback format to be used. These decisions are made continuously and in real time. The flexibility of the system to make these decisions is what distinguishes ITS from CBI. Seidel and Park (1994) cite four features that are intrinsic to ITS that are impossible to include in CBI:

1. ITS can generate traditional knowledge, rather that select pre-programmed frames containing knowledge to present to the student.
2. ITS allow both the system and student to initiate instructional activities by applying AI techniques used to develop the computers natural language dialogue capability.
3. ITS can make inferences in interpreting the student's inputs, diagnosing misconceptions and learning needs, and generating instructional presentations.
4. ITS can monitor, evaluate, and improve its own tutoring performance by applying AI techniques commonly used in machine learning.

Components of ITS

By definition, an ITS must contain three essential components: the expert model, the student model, and the tutor (Figure 2). We, and our colleagues in this *Augmented Cognition for Training Superiority and Education* Session, propose various methods to "augment" all three components of ITS. The expert model consists of knowledge of the subject domain and is the basis for comparison of information received from the student model. Although all components of the ITS are integral to its ability to provide instruction, Anderson (1988) considers the expert model to be the backbone to any ITS, as the system could not function without domain knowledge. There are multiple options for encoding information into the expert domain. A black box model involves finding a way of reasoning about the domain that does not require codifying the knowledge that underlies human intelligence. Another option involves developing an expert system and requires the human expert knowledge to be codified and applied to the ITS. A more complex, yet powerful method involves incorporating a cognitive model, which authors such as Anderson (1988) and Zachary (1999) suggest is essential to producing high performance tutoring systems. We propose that representing cognitive state or warfighter assessment data (i.e. working memory load and attention) in the expert models of ITS, particularly when using cognitive models, will provide a deeper level of comparison and diagnosis of the student's knowledge with potential improvement in training effectiveness of the tutoring.

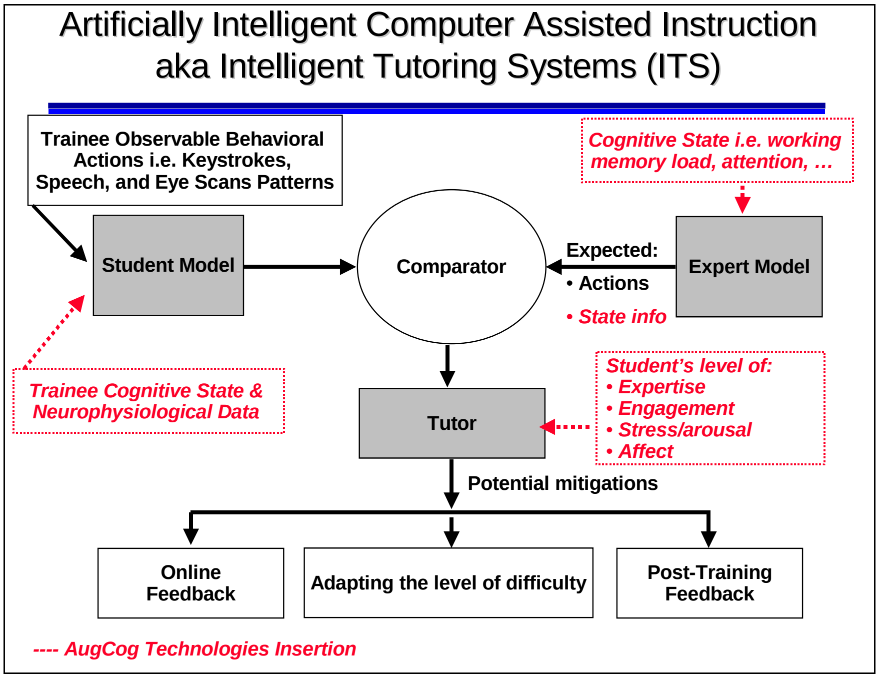

Figure 2: Intelligent Tutoring Systems and proposed "Augmented ITS" approaches.
(Adapted from Cannon-Bowers and Lyons (a.k.a. Nicholson), 1999)

The student model represents the current state of the learners' knowledge. The ITS assesses what the learner already knows during the diagnostic phase. During this phase, the ITS typically uncovers the student's cognitive state from his or her observable behavior (Van Lehn, 1988). There are several diagnostic techniques that are currently being used to assess the student model. The model tracing technique is the easiest and most widely used. This technique assumes that the diagnostic program has access to all of the student's significant mental states. This approach works by "delineating many hundreds of production rules that model curricular chunks of cognitive skill. A learner's acquisition of these chunks and departure from the optimal route is immediately remediated" (Shute and Postka, 1996). There are many other techniques used to construct the diagnostic module that is built in to the student model. They include path finding, condition induction, plan recognition and issue tracing. We propose that combining the trainee's cognitive state and neurophysiological data with the typical observable behavioural data represented in the student model will result in improved diagnosis and improved tutoring results.

The last component of the ITS is the tutor. This component encompasses the knowledge of teaching strategies to be employed during the learning process (Halff, 1988). After a trainee's knowledge has been assessed and compared to the domain knowledge in the expert model, the tutor must then make decisions regarding curriculum and instructional method, in order to bridge the knowledge gap. Although there are many mitigation strategies that could be employed, leading approaches include the delivery of real-time, on-line feedback, adapting the curriculum or scenario and post training debriefing in the form of a summary of performance. We propose that the selection and specific implementation of these strategies can be informed by the data provided through the augmented cognition technologies to effectively map the mitigation strategy to the student. For instance, a novice student may require more explicit, amplifying information in an on-line feedback message where as a more expert trainee could benefit from a simple notification of a mistake. Another area that could benefit from the sensing technologies is maintaining the trainee's interest or level of engagement. A foundational principle of the Augmented Cognition program is that based upon the Yerks and Dodson inverted U curve of human performance, there exists an optimum balance between human performance and a person's level of stress or arousal (Mendl, 1999). One goal of the adaptive human computer interface manipulations used by the Augmented Cognition teams is to maintain the operator at that peak of performance. We propose that the same theory could be used to drive adaptation of a training scenario or level of difficulty of the curriculum, striving to maintain a student at a peak level of learning.

We include a review of our colleagues' specific research efforts exploring several implementations of these concepts for augmenting ITS in section 4 below. However, we will first provide an overview of the augmented cognition technologies that we keep referring to from DARPA's Improving Warfighter Information Intake Under Stress Program, also referred to as Augmented Cognition or AugCog.

3 Augmented Cognition Technologies

New and established neurophysiological sensor technologies, coupled with sophisticated cognitive modeling software, have the potential to provide additional capabilities to traditional ITS approaches employed in existing and emerging human-centric training solutions such as scenario-based training in virtual environments (Lackey, 2004) or web-based training. An impressive collection of cognitive state detection and physiological sensor technologies and tools are currently under investigation by the AugCog researchers (see Table 1). These tools are being investigated to determine which individual technology or combination of technologies contributes to the development of Warfighter Assessment Gauges. Though initially being applied to adaptive human computer interaction (HCI) configurations for operational domains, applying these Warfighter Assessment Gauges to training environments will allow for experimentation to determine the level of contribution each cognitive state detection tool and physiological measure can provide within an augmented ITS.

Cognitive State Detection & Physiological Sensor Technologies	
Cortical blood oxygenation	Interbeat Interval
Cortical blood volume	Respiration Rate
Event related optical signal	Galvanic Skin Response
Neuronal patterns	Posture
Neuronal firing signatures	Eye fixation duration
Frequency of neuronal population firing	Eye gaze location
Sync/Desync of neuronal structures	Pupil dilation
Error related negativity	Mouse Pressure
P300	Rate of task completion
Heart Rate	Error rate

Table 1: Detection and sensor technologies of interest to AugCog (Schmorrow et al., 2005)

The AugCog teams are each working with various combinations of the above sensors to develop Warfighter Assessment Gauges for:

- Attention,
- Verbal Working Memory,
- Spatial Working Memory,
- Memory Encoding,
- Error Detection, and
- Autonomic Activity

The gauges are based upon data output streams from combinations of sensors, simultaneously captured from an individual in real-time. The resulting capabilities have resulted in the ability to address the four cognitive bottlenecks depicted in Figure 3. Sample mitigation strategies follow in Table 2 and are paired with task environments investigated by the four AugCog research teams.

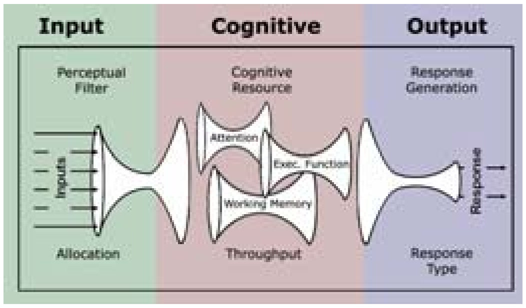

Figure 3: Cognitive bottlenecks (Schmorrow, et al., 2004)

Cognitive Processing Bottlenecks	Sample Task Mitigation Strategy	Task Environment
Attention	Task scheduling strategy based on priority, time and operator readiness	Dismounted Soldier
Working Memory	Alert delivery strategy based on verbal vs. spatial workload of operator	Aegis Command and Control Supervisor
Executive Function	Bookmark cueing strategy based on independent or dependent task context switching	Unmanned Vehicle Controller
Sensory Input	"Sensory shortcut" strategy based on available input channels	Command and Control Vehicle Operator

Table 2: Processing bottlenecks addressed by AugCog

AugCog efforts to mitigate cognitive bottlenecks have provided compelling tools to improve Warfighter performance with computer assisted adaptive HCI in these operational environments. The expectation, based on this success, is that these technologies will also support the improved implementation of computer assisted instruction by improving the effectiveness of training mitigations such as on-line feedback, adaptive scenarios or level of difficulty in curriculum and post training after action review.

4 On-going research in Augmented ITS

This paper is striving to provide an introduction and overview into the newly immerging field of Augmented Cognition for Training Superiority and Education. It is being presented as the 1st of seven papers in a session of the 1st International Conference on Augmented Cognition. The following is a brief summary of each of our colleagues' research approaches towards achieving the Augmented ITS capability described above. The first summary of Campbell and Luu describes an approach for augmenting the Student Model of Figure 2. The remaining researchers provide various approaches or examples of augmenting the Tutor Module of the ITS.

Detection of Slips versus Mistakes (Campbell & Luu, 2005)

Campbell and Luu are performing research, under ONR's Virtual Technologies and Environments (VIRTE) Program, to investigate the feasibility of using neurophysiological indicators, particularly error-related negativity (ERN), when interpreted in conjunction with performance data, to support improved automated diagnosis in a simulation-based ITS. Their concept is that ERN signals have been used to identify when a person recognizes immediately that he or she has made an error. This situation corresponds to a behavioural "slip" in Norma's (1981) discussion of error types, and does not reflect a true mistake indicating an underlying misconception or knowledge gap, which would require the same type or amount of instructional remediation. They propose to first use the ERN response slip data to filter the student performance data set being feed into a student model to increase the amount of variance accounted for by a mathematical model of performance data. Once this is demonstrated, the next step is to evaluate the impact of incorporating this neurophysiological analysis into an augmented ITS in a simulation based training system.

Detection of transition from Novice to Expert (Cohn, Kruse, & Stripling, 2005)

The goal of most training and educational sessions is to move a novice's behaviours and patterns of knowledge and reasoning towards those of the expert's. As discussed previously, typical ITS assess the trainee at the outcome/behavioural level. Another team of scientists under the VIRTE Program are investigating the hypothesis that there are detectable, reliable and repeatable behavioural and neuro-physiological measures that distinguish experts from novices in complex training tasks. They propose the use of continuous collective performance measures, or a "Performance Template", that incorporates both behavioural and neuro-physiological measures. Through the use of these collective measures the goal is to gain the capability to track a trainee, in real time, through the stages from novice to expert using technologies sensitive to the dynamic nature of learning in the brain. If successful, an augmented ITS can be realized in which it will be possible to assess where a trainee is cognitively in the training process and to then move trainees more efficiently and effectively through the training curriculum.

Mitigating Barriers to Sympathetic Teaching and Testing (DuRousseau, 2005)

This effort focuses on the barriers to sympathetic teaching and testing, and addressing those barriers by developing and using a Learning System Developer's Kit (LDSK). DuRousseau describes the process for combining cognitive state assessment algorithms with off-the-shelf computer-adaptive teaching (CAT) software capable of intelligently managing the delivery of instruction. In addition, tools to facilitate the design and test of applications which are capable of manipulating content, timing, style, and form of multimedia stimuli in real-time based on measures of executive control within the human brain are described. A summary of recent work focused on the computer-adaptive testing architecture and analytical methods of the LDSK is included.

Cognition monitoring for pedagogical diagnosis and intervention (Mathan & Dorneich, 2005)

Cognitive tutors, a.k.a. ITS, are used to monitor student behaviour dynamically, and using model tracing techniques, intervene when student behaviours are not consistent with strategies determined to lead to successful task performance. Anderson and Gluck (2001) have noted that ITS have several limitations when compared to live instructors, specifically with respect to the ability to detect cognitive and affective states. However, Mathan and Dorneich propose that the use of neurophysiological sensors to detect cognitive and affective states could be used to effectively augment ITS to enhance the diagnostic process in the Tutor Module, thereby more closely linking student performance and skill level with appropriate automated training interventions. Implications for ITS interventions can be more closely linked to skill maturity level, producing more efficient training.

Physiologial self-regulation training (Pope & Prinzel, 2005)

One challenge of long-duration space flight is cognitive skill maintenance. Pope and Prinzel have developed RESTORE, physiological self-regulation training technologies that can be embedded in engaging/entertaining tasks and adapt the task scenario based on physiological signals derived via EEG to modulate parameters of the task to optimize skill maintenance. These scenario-adapting approaches are proposed to be applied to other operational and training domains, such as submarine operations, to maintain and reinforce cognitive readiness and monitor and maintain effective mood states.

Potential predictors of errors in shooting judgment and cognitive performance by law enforcement personnel during a stressful training scenario. (Meyerhoff, Saviolakis, Burge, Norris, Wollert, Atkins, Speilberger, and Hanson, 2005)

Significant military research has centered on performance during stressful situations. This work adds to this body of literature by investigating the relationship between stress induced elevated arousal levels and performance. The authors describe a study in which the arousal level of police trainees was assessed after they completed a highly stressful interactive scenario. Although stress induced elevated cortisol levels have been linked to poor performance in a previous study, the results of the current study did not follow that trend. However, the results did suggest that another indicator of arousal, increased heart rate, appears to be linked to performance. The authors then discuss whether these indicators of arousal can be used as possible predictive measures of performance decrement, as well as the development of measure to keep arousal levels balanced during stressful situations. This research could have implications for accounting for levels of stress within an augmented ITS.

5 Aviation Simulation-based Training System Example of Augmented ITS

The following examples, previously mentioned in AugCog International Quarterly (2005), provide insight into the potential impact AugCog technologies through Augmented ITS can have on individual and team training.

Individual Training
The achievements of the AugCog program make it possible to more than imagine, but to speculate what future military training will look like in the next decade. A young Lieutenant seeking additional Naval Flight Officer (NFO) training serves as an illustration. LT Thompson, Air Control Officer (ACO) - Air Wing 5, climbs into his NFO E-2C Hawkeye training simulator to practice tracking and communication skills for an upcoming qualification check. As part of his pre-flight routine, he dons his helmet and safety harness. Integrated into his gear are various cognitive and physiological sensors. From sensor data being fed into the student model and tutor module of the augmented ITS, the NFO simulator automatically alters the scenario on the fly to challenge the ACO's weaknesses and provide extra practice events where needed. LT Thompson's instructor gains deeper understanding of the Lieutenant's intentions, actions, workload, and ultimately his performance in real time from the Warfighter Assessment Gauges being displayed on the instructor's operator station. The increased awareness of the instructor will allow for improved during action feedback and assessment, as well as a more detailed after action review specifically tailored to the Lieutenant's needs. Integration of AugCog technologies into the ITS results in two valuable improvements: a truly individualize training experience for the Lieutenant, and value-added tools that facilitate an instructor's ability to efficiently and effectively enhance individual readiness.

Team Training
An exciting opportunity for the training community is the development of an AugCog sensor suite capable of measuring comprehensive team training performance. This capability involves monitoring team members' mental workload through the use of cognitive and physiological sensors. The ability to capture such data provides an opportunity for an ITS to facilitate training of teamwork skills such as proper communication and back-up behavior between teammates. Team back-up is appropriate when teammates have the responsibility to recognizes one another's workload and step in to cover or reallocate the distribution of tasks when feasible. Additionally, identification of specific scenario events which contribute to the onset of mental overload by the Warfighter Assessment Gauges can provide instructors with much needed insight into team performance.

Extending the example above, LT Thompson, an ACO, returns to his E-2C training simulator for an Air Wing training event that includes members of his immediate team – Combat Information Center Officer (CICO) and Radar Officer (RO) and several F/A-18 Sweep and Strike air assets. During a difficult Dynamic Strike simulation exercise, AugCog sensors track the workload of the three E-2C flight officers. These sensors indicate that LT Thompson's workload level crosses the productive threshold during the middle of the training scenario. At the same time, the sensors indicate that the RO is the best candidate to relieve a portion of the ACO's tasking. Rather than continue to overwhelm his teammate, as part of the established crew contract and his expected teamwork skills, the RO should assume responsibility for monitoring incoming verbal communications and hooking new tracks. If this is not observed by the Team Tutor module, the ITS will provide immediate feedback to the RO notifying him of his teamwork responsibilities and recommend that he provide the needed back-up to his teammate. This allows the ACO to focus on providing outgoing verbal and digital communications to the Sweep and Strike assets until sensors indicate that he is cognitively prepared to recover all of his primary tasking. By incorporating AugCog's cognitive and physiological sensor technology for this training event, individual and team performance is monitored in order to train productive team skills and improve overall team performance.

6 Current capabilities and future directions

The promise of augmented ITS capability will be of no consequence if they fail to deliver effective training defined by a demonstrable improvements in task performance, skill maintenance or other relevant training outcome. To achieve full potential there are several capabilities that must be effectively designed and developed. First, trainee cognitive state must be effectively assessed in real-time. Several efforts currently underway under the DARPA Improving Warfighter Information Intake Under Stress Program are focusing on this problem. One team led by the Boeing Company (Barker, 2004), for example, has developed a closed-loop system for augmenting cognitive performance of Unmanned Aerial Vehicle operators. They have demonstrated real-time measurement of verbal working memory, spatial working memory and executive function using a combination of EEG, pupilometry and functional near infrared (fNIR). Russell (2004) has developed a neural–net based EEG signal processor for this team that can classify EEG activity in real-time, and which feeds into cognitive state classification software that computes relative activity levels of various types of cognitive activity. This team has also developed software that modulates the user interface of the UAV operator, based on cognitive state data, to optimize cognitive processing throughput. In this example, the user interface alternates between relatively textual (verbal) and graphical (spatial) displays to take advantage of relative surpluses in verbal and spatial working memory capacities. They have demonstrated significant improvements in operator task performance under augmented conditions (AugCog International Quarterly, 2005).

Although the Boeing work is an example of adaptive HCI in an operational environment, the application readily transfers to the training domain. The components developed by this team are the same fundamental components that would be required in an augmented ITS: real-time cognitive state measurement and classification, software to modify the interface or task based on cognitive state, and metrics that provide assessment of operator or trainee performance.

Other related efforts are underway under DARPA, ONR and OSD sponsorship to address the usability and ruggedness of the sensor technologies such as non-contact EEG electrodes, wireless electrodes, new optical sensors, and miniaturization of fNIR systems. These initiatives have the potential to provide the components for deployable, maintainable and reliable augmented ITS training systems. However, much research remains for the future, particularly with respect to implementation techniques for augmented ITS as well as training effectiveness evaluations of such systems.

7 Conclusion

We have proposed that improvements could be realized across the training continuum from e-learning to deployed training by combining Augmented Cognition Technologies such as cognitive and neurophysiological sensing, and warfighter assessment gauges with state-of-the-art ITS, providing Augmented ITS capabilities. It is our premise that the realization of these capabilities will be useful for addressing the many challenges currently faced by the military training community.

We predict that the techniques described in this paper will optimize the effectiveness of ITS training systems and be key enablers for providing the individualized and tailored training required to overcome the challenges of increased operational tempo and mission complexity. Such optimization will make the most of every training opportunity, providing the basis for streamlining the training pipeline in an attempt to combat the general high costs of training.

Consequences of increasing operational tempos in today's military environment include reductions in the availability of instructors, teammates or other role-players for training scenarios. For a sailor deployed aboard ship for six months, the non-availability of instructors or teammates could result in significant degradation of perishable higher-order cognitive skills and team behaviours if there were not tools available for skill maintenance. The advent of augmented ITS coupled with realistic synthetic teammates (Schaafstal, 2001) in deployable trainers should provide significant improvement in skill maintenance and refresher training capabilities.

The reduced reliance on live instructors resulting from the implementation of augmented ITS provides new opportunities for cost savings through deployed training. However, deployment of trainers with this technology will place new requirements for the reliability of the system components. The sensor, state monitoring, and adaptive control technologies emerging from the field of augmented cognition must still undergo significant development to become sufficiently rugged, small and reliable before such systems can come into widespread use. Additionally, to capitalize on true cost savings one must consider the return on investment. Certainly there will be cost saving benefits of reduced reliance on live instruction and live teammates, both in terms of manpower and infrastructure. However, if these savings are offset by significant costs related to development, procurement and maintenance of new automated augmented training solutions, the question of their value will remain. Nevertheless, it is encouraging that efforts are being made, by programs such as DARPA's Augmented Cognition, to address issues (i.e., technology maturation and deployability) that are critical to future training capability, so that the time horizon to the widespread availability of affordable and deployable augmented training systems should be significantly shortened.

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