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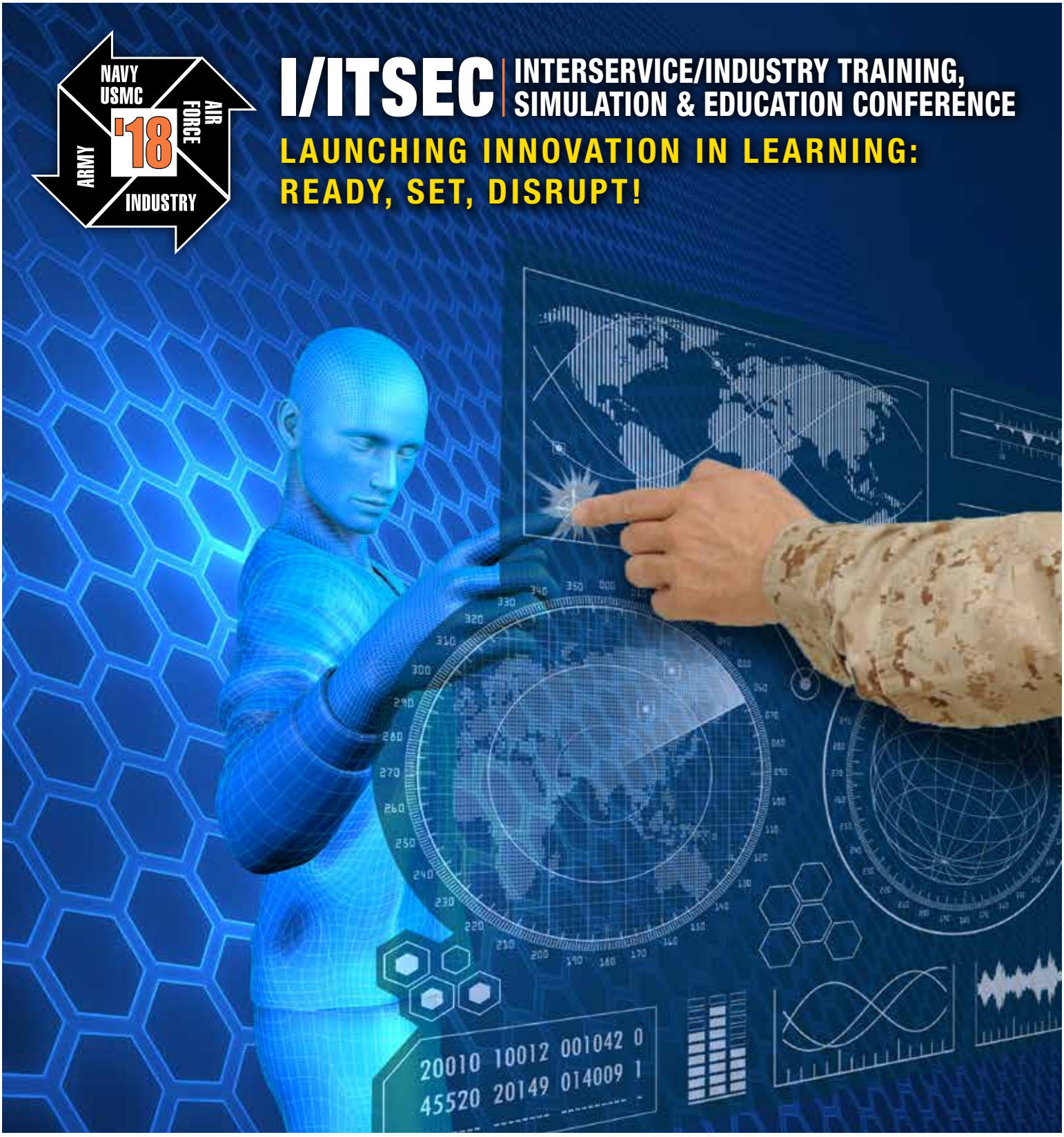

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FELLOWS

Lessons Unlearned: Barrier or Key to the Future?

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F1801

Those of us who work for the military in some capacity are well aware of the emphasis placed on lessons learned. Army's recognition of the importance of learning from past experience is embodied in the Center for Army Lessons Learned (CALL). CALL identifies, collects, analyzes, disseminates, and archives lessons and best practices … to facilitate the Army's … adaptation to win wars. There is great wisdom in the practice of reflecting on our experiences for building a better future in a complex world. When we truly learn a lesson, we incorporate it into our practices to advance our knowledge and capability, and to improve our simulation products. But what of lessons unlearned, those things we have tripped over, documented, forgotten and thus have tripped over again. Is there a role for them? What about our failures, the ones we hesitate to celebrate in papers and presentations? Are we neglecting a valuable resource? Enter the notion of superforecasting. In 2010, the Intelligence Advanced Research Projects Agency (IARPA) issued a Broad Agency Announcement (BAA) entitled Aggregative Contingent Estimation (ACE) with the goal of dramatically enhancing the accuracy, precision and timeliness of intelligence forecasts for a wide range of event types. Among the participants, a newly developed program, the Good Judgment Project (GJP), aimed at harvesting the "wisdom of the crowd" while simultaneously examining the performance of participating individuals. About 2% of the 250 individuals in the "crowd" emerged as superforecasters who beat the benchmarks by as much as 30%. That result would be of little interest, except that superforecasting capability can be trained. The thrust of this paper is an examination of how the thought patterns for superforecasters could influence how we work as program managers, technologists and trainers to improve our products and perhaps contribute to training more effective, agile military leaders. And, yes, unlearned lessons are telltale symptoms of not thinking like superforecasters. But imagine where we could take our industry if we could improve by only 10% our ability to make better judgments and assess more accurately potential futures.

EDUCATION

Advancing Capability: Designing Authentic Simulation-based Teaching, Learning and Assessment

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18123

Evidence indicates the successful use of simulation in learning contexts is not sufficiently matched with relevant theories of learning or application of good education practices (Shepherd 2017). The problem we address concerns closing this gap between theory and practice in a way that enhances both. The gap arises, partly, from the different speeds at which theorists and practitioners engage with their respective contributions. Leigh (2003) notes that knowledge generated through application (e.g. design and use of simulation and simulation-related equipment) is utilitarian, pragmatic and driven by time constraints. Conversely knowledge acquired through analysis and research (theorising) is concerned with verifying truth and exploring implications thus requiring longer time frames to produce relevant theories.

Tension between these two knowledges extends the gap rather than encouraging collaboration thus the problem remains real and constant. As a 'wicked' problem (Manning and Reinecke 2016) it lies within the Cynefin Domain of 'Complex' knowledge (Snowden and Boone 2007) where actions to address such a problem produce uniquely contextualised responses, while developing generalisable knowledge for use by both practitioners and researchers. For example Davies's (2017) model for evaluating simulation-based learning provides both a means for extending evaluation beyond the training environment to work contexts, and begins to address industry issues and demands (Jackson & Chapman, 2012).

Drawing on this research, and using a needs analysis approach, we identify emergent needs and scaffold related elements into a framework for designing and using simulation, uniting consideration of all elements of simulation from design to debriefing and evaluation. We are therefore modelling a way to combine 'research' and 'practice' using a rigorous, practical method and specifically applying its concepts to a way of assessing simulation-based learning.

Aligning Current VR/AR/MR Training with the Science of Learning

Jeffrey M. Beaubien, Ph.D. | Evan Oster | Janet Spruill

18036

Recent years have witnessed an explosion of interest in the use of Virtual (VR), Augmented (AR), and Mixed Reality (MR) technologies in training. To date, no fewer than 11 empirical meta-analyses have been published on these topics. This high level of research interest is largely due to the affordances that these technologies bring to the learning environment: sensory immersion, interaction, real world annotation, spatial visualization, and contextual visualization, among others (Appelman, 2005; Santos et al., 2014). Unfortunately, there is a considerable gap between the published literature on so-called "extended reality" training – which has been largely spearheaded by technologists and content domain Subject Matter Experts – and the larger science of learning community. With few exceptions (Cook et al., 2013; Zendejas et al., 2013), there has been little attention paid to established principles of instruction – such as schedules of practice, blended instruction, and individualized learning – on learning outcomes. Moreover, when these principles are addressed, they are often considered singly and in the abstract, rather than within the context of more holistic instructional approaches from the fields of human factors, education, and sports psychology. In this practitioner-oriented paper, we identify five holistic instructional approaches – visual orientation, desirable difficulties, contrasting cases, peripheral detection, and stress exposure – that are well-suited for use during scenario-based, extended reality training. For each approach, we provide graphical examples, theoretical justifications, and practical guidance on how to implement them. Finally, we identify common pitfalls that can degrade the effectiveness of extended reality training, along with practical guidance for avoiding them.

Assessing Character in Army Initial Entry Training

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18050

The U.S. Army must be prepared to respond rapidly to ambiguous and asymmetric threats especially when laws, rules, and regulations do not provide a clear, right course of action. Soldiers are trained to internalize and demonstrate a shared commitment to the Army Ethic, and act in accordance with the legal and moral foundation of the Army Profession (ADRP-1; U.S. Department of the Army, 2015a). The Army's strong commitment to development of agile and adaptive Soldiers inculcated in the Army Ethic continues during Initial Entry Training (IET), a sub-set of Initial Military Training. In IET, trainees not only learn and are assessed on technical and tactical skills, but also on character – how they live and uphold the Army Values in everyday activity. A key challenge is assessing character in a manner that facilitates Soldier development while also enhancing leader understanding of training effectiveness. This research showcases an assessment strategy and tools developed and tested for capturing and tracking character in Basic Combat Training (BCT), a component of IET. Specifically, trainee responses on peer evaluations and ethical decision-making questions based on videos showcasing the Army Values were digitally captured using audience response clicker technology. An Excel-based tracking tool was also developed to automatically store and analyze assessment data for insights into programmatic trends. A quasi-experimental study was conducted with three platoons as an initial test of the assessment tools. Preliminary findings indicate that instruction and technology interact to differentially impact learning outcomes (knowledge, critical thinking). Technology alone does not promote learning; as such, its implementation must be supplemented with instructional strategies that align with the primary learning objectives and instructor training on how to appropriately harness the tools to support learning. The assessment tool development process, study results, and practical implications (assessment tool integration, generalizability to other contexts) are presented and discussed.

Assessment of Flow, Immersion & Engagement on Game- Based Strategies for Kinesic Cue Detection

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18165

Military training may benefit from using game-based strategies to aid in instruction. This study evaluated Game-Based Training (GBT) by investigating a control condition and two feedback conditions: leaderboard and excessive positive feedback. Leaderboards produce competition using a ranking system. Excessive positive feedback praises correct behaviors. The control condition lacked a feedback strategy. Specifically, the GBT task involved detecting kinesic cues in a virtual simulation. Detecting kinesic cues, or non-verbal gestures that convey one's true emotions, help Soldiers interpret their environment. The kinesic cues trained in this study were aggressiveness and nervousness. The research investigated correlations between involvement and performance per each strategy; as well as correlations between game usage and involvement. A Kruskal-Wallis test was also conducted to assess differences in involvement between strategies. Involvement was operationalized as flow, immersion, and engagement surveys based on Likert scales. Performance comprised detection accuracy and response time in the kinesic cue detection task. Significant correlations were found between some select flow subscales and performance; and video game usage and the flow subscale of concentration on task. The Kruskal-Wallis test revealed the flow subscale of unambiguous feedback was highest in the excessive positive feedback condition. The research findings offer design considerations relevant to select flow states and their relation to performance. Unexpected flow outcomes suggest extrinsic motivation may have played a part in increasing performance within the excessive positive feedback condition. Additional considerations for GBT may be explored for educational applications. This research lays the foundation for defining which flow subscales map to specific feedback elements. As a limitation, the immersion and engagement questionnaires may require modification to increase sensitivity.

Developing an Intelligent Tutoring System for Robotic-assisted Surgery Instruction

Danielle Julian | Roger Smith, Ph.D.

18041

Robotic-assisted laparoscopic surgery is an operative innovation that has sparked global interest. Over the last decade RALS cases have rapidly increased with over 750,000 robotic procedures completed in 2017. Until recently, Intuitive's da Vinci surgical system has been the only FDA approved robotic-assisted surgical device for human procedures. Robotic procedures with the da Vinci require a specific, dedicated training due to the introduction of the technological components and psychomotor skills needed to successfully utilize this system. When a surgeon becomes interested in learning robotics there are limited avenues for training. Surgeons typically receive instruction on the necessary psychomotor skills in isolation from the cognitive and perceptual skills, and may only perform these skills in an integrated manner during a single day course.In this paper we discuss the development of a computer based Intelligent Tutoring System to train the cognitive and procedural skills needed to complete basic robotic suturing to novice robotic surgeons. This system could be used to bridge the training gap between online cognitive training materials and hands-on psychomotor skills training with simulators and robots. The tutoring system could provide novice and intermediate robotic surgeons with intelligent guidance in an easily accessible system to train the cognitive processes and procedural steps behind multiple fundamental robotic surgery skills, to include instrument control, suturing, knot tying, cutting, and sharp dissection. This web-based intelligent tutoring system would serve as a precursor to more advanced tutoring systems, which would reside within a 3D virtual reality simulator of surgery.

This web-based intelligent tutoring system was developed using the Generalized Intelligent Framework for Tutoring framework of tools. The cognitive and psychomotor content for the system was collected from multiple practicing robotic surgeons who performed each tutored task using a simulator and explained their actions, reasoning, and potential mistakes as they performed each exercise. This information was captured as video, instruction sets, and flow charts, which were reviewed for accuracy by surgeons and then encoded into an intelligent tutoring system using the Generalized Intelligent Framework for Tutoring tools.

Development of an Educational Platform for Simulation Developers

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18084

With simulators being used in numerous fields more often than ever, the demand for skilled engineers and software developers is high. To address this issue, an educational platform is needed to attract and train future simulation specialists. This paper provides insight into the modernization process of the platform, examples of usage in the teaching process and its effects.

The platform is based on a replica of SW-4, a Polish light helicopter, used for training purposes. The simulator is used by students and researchers at the Warsaw University of Technology since 2009. Throughout the years of operation, two problems limited its educational use. Firstly, the software was unique to the platform and required expertise to modify. This proved to be difficult for students not acquainted with this framework. Secondly, the rendering engine lagged behind its contemporary counterparts. As helicopter flights take place near the ground with low speed, an accurate representation of the surroundings is important. To resolve these problems, a choice was made to use off-the-shelf software, which not only allowed for easy modifications, such as implementing flight models, textures and training scenarios created by students but also contained a state-of-the-art rendering engine. However, this required custom middleware which would provide a means of communication between the hardware and the software, while also being backwards compatible. It was fully developed by the authors, as part of the modernization project.

The pilots confirmed a vast improvement in the fidelity of the simulator. An influx of students undertaking projects on the platform has been observed. With plans to introduce courses incorporating elements of simulation software development and engineering problems connected to it, these numbers will grow. Since commonly available software is used, the experience and knowledge gained by the students during their projects can be easily transferred to their future work environment.

ElectronixTutor: An Adaptive Learning Platform with Multiple Resources

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18064

The development of a complex, adaptive learning platform presents many challenges, particularly in difficult topics like electrical engineering that require deep understanding of technical concepts and their interrelationships. One approach to handling this challenge is to build a system that integrates an ensemble of adaptive intelligent learning environments as well as static learning resources (technical manuals, diagrams, simulations) so that the right resource is delivered to the right person at the right time. We instantiated this approach in a project funded by the Office of Naval Research with technology and learning standards guided by the Army Research Laboratory and Advanced Distributed Learning Initiative. The ElectronixTutor system was developed in an open-source learning platform on the web, instantiated on Moodle, with several intelligent tutoring systems (AutoTutor, Dragoon, LearnForm, ASSISTments, and BEETLE-II) that have demonstrated significant learning gains across various domains and depths of instruction. This paper focuses on three primary achievements, situated within the general development of the system as a whole. First, we describe the creation of a quantitative interlingua (learning standard) that is based on knowledge components in order to translate progress across learning resources into a comprehensive learner model. Second, we specify the procedures by which our recommender system evaluates and suggests items appropriate to the topic, depth, modality, and knowledge components for individual learners. We also describe other components of the system, including the user interface, in-person course integration, instruction calendars, and the learning record store. Third, we report an initial study that collects data from college students who learn about electronic circuits with the system. While the full results of this study are not yet final, the methodology and implementation into classroom settings demonstrates capacity for relatively easy adoption and expansion of classroom capabilities by offering coordination of multiple types of intelligent tutoring practice capabilities in a comprehensive learning experience.

Hey, This Is What Your Teacher Needs To Start With Online Lectures

Commander Geir Isaksen | Siren Frøytlog Hole

18056

As a part of a huge and overturning educational reform in the Norwegian Armed Forces (NoAF), a digital strategy is being enforced. For the educational sector, this means moving more of the instruction and learning activities online. To be able to do so successfully, the teacher/instructor/lecturer plays a crucial part. An important question is what kind of support and incentives are most effective to get teacher to develop and use more online lectures. What do they need in the planning, development and implementation of these video lectures? One of the challenges in this process is that the teachers often underestimate the workload and there is not enough time set aside on their part to map out their content, prepare and develop the script and learning material.

Through in-depth interviews with teachers at NoDUC, the ADL section investigated what kind of knowledge, support and training the teachers need to increase their motivation to developing video lectures. This paper will highlight the findings from these interviews and present them in context of relevant research and experiences from NoDUC's use of video lectures the last couple of years. Finally, the overall aim of the paper is to recommend a number of measures needed to be taken to ensure that teachers/instructors have the sufficient knowledge and motivation to produce and use online learning activities.

Learning Analytics with xAPI in a Multinational Military Exercise

Aaron Presnall, Ph.D. | Vesna Radivojevi

18196

As the truism goes, "You can't manage what you don't measure." However, assessing performance in training exercises has classically presented a measurement challenge, made more complex by the paucity of timely, relevant, comparable data on the training audience's performance. Even as the field of learning analytics becomes increasingly sophisticated, military training exercises continue to be assessed in largely subjective and superficial ways. In short, while we may know if the training was completed, it is difficult to objectively answer the basic question: did the exercise do any good?

xAPI is an emerging capability to support learning analytics, but until recently has remained largely untested as a solution for delivering comparable results across complex multi-platform asynchronous learning and performance data feeds at scale. Viking 18, a large multinational civil-military exercise, aspires toward full operational integration of Advanced Distributed Learning (ADL) as an integral part of the exercise experience, including the associated learning analytics supported by xAPI.

This paper presents a case study and lessons learned from the implementation of xAPI in the Viking 18 exercise. It also delivers a summary of the resulting Viking 18 learning analytics, including data from e-learning courses matched against quantitative observation data from the exercise management tool, with the aim of gaining insight on the relationships between training and performance against exercise objectives. As such, we crack open the door to aggregation of exercise performance data in support of operational and strategic planning. Analysis clearly suggests a pattern of enhanced training outcomes by units with higher rates of Introduction to Viking (pre-training e-learning) course completion.

BEST PAPER

Microlearning as a Corporate Learning Business Case

Anne Little, Ph.D.

18229

In order to meet compliance training requirements within the defense industry, government and commercial organizations must frequently subject their workforce to a dreaded annual training event. In these events, employees are expected to absorb material all at once in a passive training engagement; usually online. This approach breaks up workflows, takes time away from the mission, costs a lot of money, and may not be designed to support knowledge transfer. Both government and industry make this training decision in support of regulations which mandate training in a specific topic (i.e., sexual harassment/assault response & prevention, ethics, etc.). Unfortunately, this does not necessarily transfer to ensuring our workforce understands the mandated behavior associated with the topic. But, the approach persists because training engagements are easy to track and serve as evidence for compliance.

Each year, more content is added so the problem gets bigger. But, the risky viewpoint is that many organizations have equated being compliant with required training actions to mean their workforce is, therefore, exhibiting compliant behavior on the job—which may not be true. Additionally, compliance training solutions usually present a standardized body of knowledge which all members must review at the same level of detail. This approach assumes members have the same level of understanding and does not permit learners accelerating through material—even in content areas where the learner may actually be an expert. Worse yet, there may not be an opportunity within the event to address areas where the learner has a deficit.

In this paper, the author presents a transformational approach to organizational compliance training which uses microlearning assets targeted towards specific performance outcomes, performance assessment to validate workplace behavior, and strategic communications necessary to support the new paradigm for training and learning within an agency. Results of a recent enterprise-wide implementation during the 2017 training cycle, which substantially reduced overhead costs, are presented along with suggestions for implementation within government and industry organizations.

Migrating Nondigital Learning Events for xAPI Data Collection

Martin Bogan | Scott Bybee | Thomas O'Connell

18037

An estimated 70% of learning occurs informally, often outside a digital environment (e.g., ad hoc, self-learning, just-in-time), and generates learner experiences not captured by an Experience Application Programming Interface (xAPI). As a result, some learner data are excluded from evaluation, thereby skewing interpretation of training effectiveness. Capturing nondigital learning event data allows educators to better understand the learner's needs.

This paper reports the results of migrating Ground Control Station (GCS) familiarization nondigital training events into a series of digital training events. Using the ADDIE method—Analyze, Design, Develop, Implement, Evaluate—the master training task list (MTTL) for a Remote Piloted Aircraft training program was analyzed along with required proficiency levels for each training task. Analysis data were used to identify levels of interactivity, instructional methods, and media training effectiveness. This analysis provided recommendations on training events that could be migrated from nondigital to digital training.

Limited by time and budget, the selected method and media were assigned to training objectives before developing our prototype. Reading materials, a pretest, and virtual instruction (prebrief, lesson content, and postbriefing in a VR environment) followed by a test, were used to run a sampling of learners through a GCS familiarization lesson. Data capture requirements were based on interviews with instructors, site managers, program managers, and instructional systems designers. A subset of the data collected for this study was compared with results from a Control Group that uses traditional nondigital training events. Study results suggest that testing and lesson times can be reduced without compromising learning.

This paper presents a pathway to migrating nondigital events to a digital environment with captured xAPI data. Further, it proposes a strategy for use of xAPI profiles in addition to metadata, resulting in increased efficiencies, better learner engagement, and more useful learner data to apply adaptive learning technologies.

Mobile Assessment Technology in Army Schoolhouse Training

Elizabeth R. Uhl, Ph.D. | Courtney Dean | Krista Ratwani, Ph.D.

18114

In the U.S. Army Learning Concept for Training and Education 2020-2040, the Army recognizes the need for training/learning management improvements in order to enable education-based learning (U.S. Department of the Army, 2017). A mobile assessment tool called MLC SPOTLITE was developed for instructors of the Master Leader Course (MLC). This paper examines the usability and utility of MLC SPOTLITE as well as lessons learned from implementing new technology in the U.S. Army. MLC SPOTLITE was iteratively developed with input from and testing by MLC instructors, and was deployed on two-in-one devices. The development of MLC SPOTLITE aligned with several factors identified in previous research as facilitators of the use of technology to support the Army Learning Model, including an extensive front-end analysis, subject matter expert support, and editable software (Barnieu et al., 2016). The system streamlines the traditionally paper-based assessment process and allows instructors to digitally complete and sign course rubrics, and easily toggle between students. The majority of instructors found the system easy to use (94.8%), and all instructors agreed or strongly agreed that they felt confident using the system. Despite the need for such technologies to improve learning and education, there are significant challenges associated with using mobile devices in an Army setting. One challenge with using mobile technology is the variable access to Wi-Fi in Army classrooms. This paper explores and discusses some of the barriers that may prevent the wide-spread adoption of easy-to-use technologies. Without implementing mechanisms for overcoming such barriers, the role of technology in fulfilling the Army Learning Concept vision may be limited.

Novel Approach to Mass Casualty Triage Training and Competency Assessment

Teresa Riech, M.D. | Matthew Bramlet, M.D.

18230

Background: Efficient and precise triage of victims in a mass casualty scenario is critical for maximizing trauma resource utilization. Mass Casualty Incident (MCI) exercises are suboptimal for this aspect of medical training since they are extremely time and resource-heavy and yet only a limited number of participants actually perform rapid triage, while others are relegated to observation. The result is that only a fraction of participants are able to actually get direct competency training and evaluation. We sought to build a virtual reality (VR), competency-based mass casualty triage trainer for portable and scalable training.

Methods: Utilizing internally developed VR education software, (Enduvo, Inc. Peoria, IL), a mass casualty triage trainer was built within the VR environment. The educational objectives were to a) understand core tasks of MCI triage, b) describe standard patient classifications of MCI triage, and c) demonstrate rapid triage assessment of injured patients. Standardized patients (SP) were filmed on 30 second loops demonstrating relevant vitals for the range of triage categories. The expert in mass casualty triage principles interacted with the learner within the virtual environment, imported diagrams and images as well as the 2D filmed footage to create a customized VR learning experience.

Results: A VR experience was created that allowed individual competency training and evaluation for the primary Mass Casualty Incident objectives. The VR experiences consisted of 6 modules focused on the learning objectives with competency measures and a final mass casualty triage training simulation where the learner was timed as they triaged 12 victims. The experience included casualty presentation in video format as well as learning aids. A pilot group of 18 medical personnel demonstrated improvement in triage skills after completion of the training program.

Conclusion: VR holds the promise of creating more effective and efficient training in an asynchronous digital media format. This format allows for scalable distribution of training complete with competency training metrics to better meet the challenge of distributing specific triage expertise. This emerging training modality shows promise for training triage principles for a wide range of MCIs, including Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) events, which are difficult to simulate in conventional training exercises.

Rating Domain Analysis: Determining Ready Relevant Learning Point of Need

Judith Hale, Ph.D. | Christina Welch | Adrienne Read

18098

The Ready Relevant Learning pillar of Sailor 2025 is a transformational Navy initiative intended to accelerate the learning of Sailors for faster response to rapidly changing warfighting requirements. One goal of Ready Relevant Learning is to ensure every Sailor receives modernized training closer to the point of need to support assigned tasking.

Currently, accession Sailors' training is front-loaded with a large amount of content delivered after basic training and before their first deployment. Modernization efforts focus on distributing training out of the schoolhouse to the waterfront and operational environment, utilizing modernized delivery systems to simplify Sailors' access to training. The Ready Relevant Learning training paradigm supports a Sailor's career progression by providing training tailored to initial job demands and continuing skills development for subsequent tours and career milestones.

The Ready Relevant Learning content modernization effort includes the following analysis activities: Rating Domain Analysis and Media and Fidelity Analysis. Rating Domain Analysis and Media and Fidelity Analysis use consistent, repeatable processes and feed into the Functional Requirements Document to produce recommendations on content modernization and training timing. While all the activities work together, this paper will focus solely on the Rating Domain Analysis. The Rating Domain Analysis is a novel analysis methodology to answer the question of when exactly training should be provided. It involves identifying the work a Sailor performs in the Fleet and aligning existing learning objectives with those discrete tasks. This Rating Domain Analysis also identifies potential gaps in training, where work is performed on the job but no training content exists in support of that work, as well as areas of overtraining, where training content is being delivered that does not support work Sailors perform on the job. The paper will discuss the Rating Domain Analysis process, development and why the Rating Domain Analysis is a powerful tool to improve Navy training.

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Research to Training: Adapting a Sports Science Method to Improve Military Rapid Response Skills

Peter J. Fadde, Ph.D.

18213

This paper makes a connection between training rapid response skills in sports and training rapid response skills in military domains. In many rapid response skills, from baseball batting to close-quarters combat, performance consists of both psychomotor and perceptual-cognitive components – what you do and what you see. While psychomotor skills are routinely practiced, it is less common to train the perceptual-cognitive skills that performers use to almost instantaneously recognize key patterns in opponents' actions and thereby execute rapid and appropriate responses. Since the early 1980s, sport science researchers have studied perceptual-cognitive skills using the video-occlusion method in which video of an opponent's action is cut off partway through the action and participants must categorize the type of action (e.g., baseball pitch) and predict the outcome (ball or strike). Beyond its use in research, video-occlusion can be used to test and train the perceptual-cognitive skills of athletes and, potentially, warfighters. However, the journey from lab to field training can be rocky. This paper describes five phases of a research-to-training process that ultimately led to video-occlusion being adopted by a major league baseball organization for testing and training pitch recognition, which is the perceptual-cognitive component of baseball batting. The paper then describes a pilot video-occlusion application for training attack recognition as the perceptual-cognitive component of defensive tactics performed by law application or military personnel. Similar to video-occlusion in sports, law enforcement or military trainees view video clips of suspects' attacking motions (e.g., overhand strike, kick, gun reach) that are cut off early in the suspects' movement.

Trainees learn to recognize advance cues, thereby increasing the speed and accuracy of their defensive responses. The paper concludes with recommendations for identifying military rapid response skills that might appropriately be trained using video-occlusion methods.

Simulation as an Emerging Literacy

Teresa Crea, Ph.D.

18118

This discussion paper argues that simulation training is a form of experiential learning that privileges a particular mind-body relationship: one that collapses the processing time between action and reflection. It proposes that when contextualized against the experimental neurobiological theories of Libet, Damasio and Varela, the simulation process is more analogous to how the brain and not the mind, cognizes and processes information across time. The case is presented for the need to review how we traditionally approach

pedagogy. It contends that the subjective, embodied and enacted nature of the simulation training experience reels in our body and our biology just as much as our mind.

This highlights a need to consider additional competencies and literacies such as sensemaking and a more granular real-time mapping of subjective navigation in order to interpret what is happening within a trainee. The paper begins with a review of key concepts relating to the processing brain and of the recent experimental neurobiological theories.

Next, it cites feedback from both a clinical simulation experiment and examples from the games industry to illustrate the principle of embodied cognition. Finally, it folds these understandings into some preliminary recommendations for the development of a new simulation literacy.

Teaching Modeling to Engineers in an Undergraduate Simulation Course

Vikram Mittal, Ph.D. | COL Robert Kewley | LTC Brett Lindberg, USA

18101

A significant challenge in teaching simulation to undergraduate students is to find a way to allow them to model a real world referent system within time and student skill constraints. Several research sources highlight not only the important challenge of model development (Garcia and Ceneno, 2009, Tako, 2011) but also the increased need for model development instruction among engineers (Grasas et. al., 2013, Saltzman and Roeder, 2013). One approach to this challenge is to use a general purpose discrete event simulation software package within the course, but this presents two challenges. Teaching the package to the students takes significant time, and the package introduces limitations which may restrict their ability to model certain real-world referents, particularly in the engineering domain. A conceptual approach to solving this problem is to use a model development paradigm that abstracts away the interface to the simulation infrastructure while still allowing the students to use the full expressive nature of a programming language. Two undergraduate courses at the United States Military Academy employed this strategy via the Discrete Events Specification System – Distributed Modeling Framework (DEVS-DMF) (Kewley et. al, 2016). The DEVS abstraction allowed students to think about their model as a simple state change function with defined inputs and outputs, and DMF allowed them to program in a cloud-based Jupyter Notebook using the Python language. Students in a combat modeling course employed a variety of models to understand drone jamming, and students in an engineering capstone project employed models to account for human factors in rifle marksmanship. The effectiveness of this approach was assessed through student grades, exit-interviews, and course-end surveys. These assessments showed an increased understanding of the model development process, and students also reported greater ownership of their models. However, this experiment also highlighted some weaknesses in their understanding of underlying methodologies and programming skills.

Technology-Supported Learning Environment and Self-Efficacy of Teachers

Chadia Affane Aji, Ph.D. | M. Javed Khan, Ph.D.

18031

The performance of students from the US on international assessments of math and science continues to be well below those from industrialized nations. Various challenges for this lackluster performance have been empirically identified.

Of these challenges, motivation and engagement are the most cited in literature. Active learning has been shown to positively impact student engagement with content. In this article, an innovative approach and its impact incorporating technology in the classroom, a research project funded by the National Science Foundation (NSF), will be presented.

The intervention consisted of a one-week long summer professional development for middle school teachers who were from groups underrepresented in Science Technology Engineering and Mathematics (STEM). These teachers were from two rural school districts with limited resources for a technology-supported active learning environment.

The participants learned how to use teaching modules for selected math and physics concepts using flight simulation software. The research design was a within-subject repeated measures pre-post design. Positive impact of the professional development on the participants' attitudes and self-efficacy were observed based on the post-workshop survey.

Training Command and Control in Search & Rescue - Adaptive Behaviors in Uncertain Conditions

Fredrik Forsman | Lars Axvi

18200

In any situation where there are shifting goals, there is a need for real-time adaptation. In critical situations in military or emergency operations, time is of the essence. It is crucial for success to get on top of the problem as quickly as possible and start acting faster than the situation develops, to seize and keep the initiative. By reaching such a state, proactive rather than reactive measures must be taken. Shifting goals require a radically different approach than stablegoals when it comes to the rationale for action. There is a known gap between work as done and work as imagined.Managers often have a too simplified model of how work is performed and thus many simulator training prostable are not living up to their potential. In this theoretical paper, the Cynefin Framework is being used to argue for different approaches to simulation design depending on the character of the situation depicted. Four situations are considered: simple, complicated, complex and chaotic. Simulation is a powerful training tool if used with thought. A thorough understanding of the area and system character of application is of crucial essence to be able to successfully develop simulator training. Complex system implies the need for adaption. Linear systems imply rule-based operations. If the solutions fit for linear systems are imposed on complex systems the ability to adapt is lost and in some cases to great risk to the operators on the field. To be able to tailor training to the task and to use simulation close to its full potential, it is of essence to understand the character of the real-life situation the simulation is aimed to prepare the trainee for.

Complex (uncertain) situations require adaptation which simulation can afford but too often is lost and forgotten in bureaucratic fulfilment of training curriculums.

A Serious Games Microservice Architecture

Prof. Alessandro De Gloria | Riccardo Berta, Ph.D. | Francesco Bellotti, Ph.D.

18159

Despite their potential, the market for educational serious games (SGs) is still limited, partly because of their high design and production costs. In this paper, we propose a microservice architecture for efficient development of SGs that we designed in order to support role-playing games. After describing the architecture and its modules (in-game chat, multiplayer support, conversational NPCs, score computation, etc.), the paper presents an application to the development of the Draweva game, a game to teach leadership skills. The goal of the game is to create awareness about the wrong pattern of "invisible silos" used in several big organization, in which managers and employees are aware only of their own targets and areas of responsibility, missing out on the opportunity to create synergies, supporting others in the achievement of their targets or to reach out to others to ask for help. This risk is represented in the game as a monster that players have to fight from different points of view. Data from a preliminary pilot have shown that using the proposed architecture allows a significant reduction in development time.

Moreover, creation of a network of very focused and specialized services over the game engine allows improving structured content organization, which is in turn expected to enhance maintainability and modularity.

Adapting Bayesian Networks to Predict Complex Systems using Small Datasets

Anastacia MacAllister | Eliot Winer, Ph.D.

18269

Increasingly commercial companies including Google, Amazon and Apple are using machine learning (ML) to predict customer behaviour and market trends. As these ML methods mature, they will continue to help improve commercial sector decision making, and potentially military processes as well. Reports suggest that the DoD alone could save $32 billion a year by increasing logistics and operational efficiency, savings that ML could help facilitate. Unfortunately, many ML methods require millions of known data points to train a system before its predictive capabilities can be realized. However, for many military processes, only relatively small data sets are available (i.e. hundreds to thousands of points). This paper explores a specific ML method, Bayesian Networks (BN), to function on problems with small amounts of known data. Specifically, this work investigates the feasibility of using Kriging and Radial Basis Functions to augment existing data available for training BNs. In addition, tuning BN parameters to increase network accuracy using Particle Swarm Optimization is also presented. Combined results from three different datasets suggest that pairing data generation and prior probability approximation can allow BNs to more accurately predict a system's outcome with small amounts of known data, potentially up to 80% or higher. Ultimately, as strategies outlined in the paper continue to develop they could help aid the implementation of BNs for a wide range of military processes. This would allow inefficiencies to be predicted before actual time, materials, and person hours are wasted.

Advanced RAID Technology Minimizes Network Traffic in Service Oriented Architectures

Mark Cuccarese | Paul Cooper

18258

It is important to maximize the potential of a Technical Reference Architecture (TRA) to handle large growth in both the number of users and technological advancements. This paper recommends a change to Redundant-Array-of-Independent-Disks (RAID) array technology to meet these goals by minimizing external network bandwidth (external to a RAID array). Existing cloud technologies are distributed, sharing resources such a Storage Area Networks (SAN), multi-core processors and thin clients (TCs). Virtual machines (VMs) and a hypervisor bring it together in a networked environment. A hypervisor is a minimal kernel with drivers for networks, USBs, VGA, memory and storage management. A TC is typically a personal computer with a network connection, processor, RAM, display but no storage. TCs frequently access more robust computing resources via web pages and web services, which run on one or more VMs. To provide data for a TC web service a VM requests data from "out-of-the-box" SAN storage. This results in a hypervisor request to retrieve the VM display data partition segment from the SAN as a block data file transfer back to the hypervisor. It is sent to the web service (via its VM) and received by the web based TC. Scaling up this hypervisor configuration can result in large network overhead. We propose combining the hypervisor with the SAN storage array hardware so the SAN is now "in-the-box". The hypervisor uses the internal SAN storage eliminating the block data transfers of the fiber channel RAID array and external network overhead. Tests will monitor network traffic from existing RAID storage and our proposed "in-the-box SAN". Network bandwidth analysis will demonstrate the network efficiency of the "in-the-box SAN". This paper focuses on our proposal of combining the hypervisor with the SAN storage array to reduce external network traffic.

Augmented Reality for Force Protection Systems

Sean S. Cullen | Richard Schaffer | Susan Harkrider | Christopher May

18091

The Night Vision and Electronic Sensors Directorate (NVESD) develops sophisticated, trailer-based, deployable surveillance sensors and operator stations used to monitor areas near sensitive and hostile work locations. Effective training for system operators is limited due to the expense of providing training targets in the live environment. In collaboration with NVESD, Lockheed Martin has developed a prototype embedded Augmented Reality training capability that enables the injection of realistic virtual training targets into the sensor displays. The system intercepts the sensor data prior to the sensor display computer, inserts virtual entities and effects, and forwards the results to the sensor display. The pros and cons of various insertion points and the challenges encountered when trying to synchronize video images with the sensor meta-data are examined. The system integrates the Night Vision Image Generator (NVIG) technology developed at NVESD into the rendering system to ensure virtual renderings match multiple sensor types, and sensor data along with instructor controls are used to blend entities with different environmental conditions. Finally, an innovative approach was developed to detect and mask video overlays that allowed virtual insertions to appear to be behind the overlays. The resulting prototype provides robust training capability with dynamic virtual insertions at a fraction of the cost of live training scenarios.

Authoring Tools for Free-Play Simulation-Based Troubleshooting Training

Eric Domeshek, Ph.D. | Sowmya Ramachandran, Ph.D. | Randy Jensen

18025

All training systems require definition of curriculum and creation of associated instructional materials. Simulation based training systems further require development (or at least integration) of a suitable simulation environment, and specification of challenge problems. Intelligent tutoring systems (ITSs), in addition, require logic for automated assessment, student/tutor interaction, and experience sequencing. Costs to create all these pieces can mount quickly, so it is important to provide authoring tools tied to general methods and code to speed content creation, reduce required levels of authoring expertise, and facilitate reuse.

This paper reports on authoring tool development and preliminary evaluation in the context of a simulation-based ITS employing novel mechanisms for tutoring troubleshooting skills. Major challenges included: (1) defining the data needs of the ITS, given it is neither a rule-driven cognitive tutor, nor an example tracing tutor; (2) mapping the system's complex data structures to consistent, supportive, tailorable user interface conventions so as to enhance tool usability and maintainability; (3) bridging between the desired unified authoring tool suite and useful commercial off-the-shelf (COTS) tools—e.g., for didactic instruction and simulation; and (4) designing for flexibility, so as to track evolution of the underlying tutor mechanisms and enable future generalization.

The example ITS trains Navy Information Systems Technicians to carry out troubleshooting and procedure-following tasks using virtualized computer networks as a free-play simulation environment. The tutor adds simulation instrumentation to gather information that feeds models of available actions and resulting states of knowledge. It then monitors student activity, hypotheses, and inferences, so as to provide contextualized, adaptive feedback and coaching.

The project was concerned with establishing a general framework for simulation-based technology troubleshooting applications, and had strong requirements for broad-spectrum authoring tools. We describe the project context, tutoring approach, authoring tools developed, authoring evaluation feedback, relationship to other authoring tool efforts, and lessons learned.

Automating the Training Feedback Paradigm with Intelligent After Action Review

Barry Clinger | Robert Burch | Jeremy Lanman, Ph.D. | James Todd

18275

There are emerging trends to support an enterprise approach for providing training capabilities to the Warfighter at the point of need. As needs increase for easy operation, mobile training, and force reduction, an enterprise methodology focused on providing intelligent assistance and automation to After Action Review (AAR) artifact generation is needed to advance the training feedback paradigm. In addition, a wider variety of capabilities must be provided to the instructor, allowing for opportunities to provide more focused training specifically tailored to training tasks. An Intelligent AAR (IAAR) concept addresses future needs relative to providing adaptive training for the AAR.

Intelligent Tutoring Systems (ITS) promise the ability to provide adaptive training focused on the specific needs of the trainee or team. ITS has provided that type of training in the past but usually at the cost of specialized ITS implementations each time. Many benefits can be realized through enabling an AAR to provide a common service oriented approach leveraging ITS as a reusable service. The approach allows a training system the ability to provide a cloud-based service that other actors can use to enable IAAR for any type of training. Such an approach must be capable of adapting to a wide variety of training systems and configurations to be a truly useful service in the larger enterprise. Our solution to this problem is the injection of optimized technology into the AAR process and toolset with focus on building an adaptive approach for representing training strategies and assessing trainee proficiency. We evaluated and prototyped various technologies and tools which may be appropriate for the development of an IAAR system. Specifically, we investigated technologies, tools, and algorithms to facilitate machine/adaptive learning, keyword spotting, object detection, intelligent tutoring, data analytics, and others for applicability to the use cases defined in an Army training domain analysis.

BEST PAPER

Beyond Ender's Game – Fusions of Simulations into Operational Interfaces

Peter Crane, Ph.D. | Alexandra Proaps | Patrick Benasutti | James P. Bliss, Ph.D.

18235

Advances in Augmented Reality are turning "train like you fight," into "fight like you train," where simulation and synthetic imagery can be inserted into battlefield operations to remotely operate systems with enhanced situation awareness and decision making. VR Rehab with Old Dominion University and Lockheed Martin, in collaboration with the Army's Natick Soldier Research, Development and Engineering Center (NSRDEC) have developed Fused Augmented Realities with Synthetic Vision (FAR/SV) which merges simulated terrain and graphics into operational interfaces. This paper will describe FAR/SV successful R&D investigations enhancing the situation awareness and decision making by warfighters controlling small unmanned aerial systems and small unmanned ground vehicles under OSD/NSRDEC sponsorship. This paper describes the foundational science, agile development efforts to overcome challenges, and data from empirical studies of usability and mission performance. Two successful FAR/SV innovations are presented. First, to overcome long-standing problems of 'looking through a straw' high-magnification viewing, we surround the actual live/sensor view with a correlated 3D synthetic vision wider field of view for enhanced situation awareness. Second, to overcome degraded visual conditions, we semi-transparently blend the actual live/sensor view with the underlying correlated 3D synthetic vision terrain. Additional operational benefits derive from our FAR/SV interface innovations where users perceive they are adding 2525 icons and other annotations directly to the video/sensor imagery; where 'under the hood' we are anchoring the icons and annotations persistently to our underlying correlated 3D terrain. FAR/SV supports its use as a standalone App running under Windows or Android, as well as an add-on module for existing video and sensor imagery viewing applications.

Blockchain Applications in Distributed Simulation

Roger Smith, Ph.D. | Danielle Julian

18039

We investigated the operational capabilities of blockchain and several other distributed ledger techniques that are being used in cryptocurrencies. Our objective was to characterize the capabilities of the techniques and their limitations as they apply to distributed healthcare and simulation applications. This paper reports on the capabilities that appear to be applicable to distributed training simulation. It also discusses the limitations of these techniques which may impact practical applications.

Blockchains or distributed ledgers lend themselves most readily to services like the distributed network loggers and After Action Review systems that are used in networked simulation events. The logger applications record the stream of messages that have been exchanged between simulators, while AAR applications analyze and replay the data to provide feedback to the participants. In addition to logging messages, a blockchain adds features that are important in currency exchanges, such as partial anonymity, security against forgery, distributed validation, immutability of recorded transactions, and public access to the log. These features require computer resources for hash functions, encryption, and network communication, which can result in slow transactions and limitations on the size of the chain that maintains the ledger.

After investigating multiple distributed ledger techniques, our conclusion is that the core features of blockchain are not useful for replacing existing services in distributed simulation. This conclusion is derived from the fact that blockchain was created to enable the processing of valuable data between participants who do not trust each other, and within a system that was previously highly inefficient and costly because of the convoluted mechanisms needed to prevent fraud. Distributed military simulation systems are composed of nodes that are trusted and which have been configured for performance in the absence of internal network threats. Therefore, the core advantages of blockchain are not applicable in this environment. However, the components of blockchain may provide secure, verifiable identifiers for network participants and indices across multiple legacy data storage services, which may be useful new services for simulation operators and sponsors.

Building a Human-Machine Teaming Training Testbed

Julia L. Berger, Ph.D. | Kent C. Halverson, Ph.D. | Eric Watz | David Malek

18112

The Department of Defense faces increasingly complex mission sets, demanding unprecedented warfighter performance and flexibility in unpredictable situations. Autonomous intelligent agent (AIA) technology promises to significantly relieve these demands, in both training and operational settings. In the future, warfighters and AIAs will work jointly as part of mixed human-machine teaming (HMT) environments, wherein AIAs will routinely assess warfighter cognitive states to optimize learning, task management, feedback delivery, and performance. To meet the desired future state, training must equip humans with HMT skills necessary to optimize this collaboration. Learning environments must allow humans to experience authentic scenarios with HMT interactions that can be measured and assessed to provide real-time and after-action feedback.

To ensure HMT skill acquisition and retention, the AIA should meet the following system requirements. It needs to operate autonomously in complex environments, be adaptable, and be able to enhance learning by delivering strategic workload-based personalized feedback.

One way of achieving the aforementioned goals is by engineering a testbed that would meet the said system requirements and would train operators to interact with AIA and human teammates. The envisioned testbed would represent a fully deployable live, virtual, and constructive training system featuring integrated inner-loop (during the training scenario) and outer-loop feedback (after the scenario) capabilities along with a multi-modal measurement suite. The testbed would serve dual purpose – one for realizing operational training needs and the other for conducting within-subject multi-trial scenario-based studies to examine whether or not the presence of AIA impacts warfighter performance. Consistent with a growing body of literature which suggests that human performance tends to improve with an addition of an AIA (e.g., Mercado et al., 2016; McKendrick et al., 2014), we predict that warfighter performance will improve when AIA is present. While the research potential of the testbed is limitless, we offer several future research directions in this paper.

Cloud-Based Modeling and Simulation Study Group

COL Robert Kewley, USA | Chris McGroarty | Joe McDonnell, Ph.D. | Keith Snively | Scott Gallant | Jonathan Diemunsch

18256

Cloud computing brings many benefits to information technology including cost savings, improved productivity, reduced maintenance, increased availability, and better user experiences. The North Atlantic Treaty Organization (NATO), the United States, and several member countries have introduced policies emphasizing a cloud-first approach for information technology. This move towards cloud computing has highlighted both benefits and struggles within defense programs. Modeling and Simulation (M&S) programs must address our unique constraints, objectives, business models, and policies in our use of cloud computing.

In order to better understand the implications of cloud computing to M&S, the Simulation Interoperability Standards Organization (SISO) has established the Cloud-Based Modeling & Simulation (CBMS) Study Group (SG), which began in November 2016. The purpose of this study group is to identify and document existing M&S cloud activities, best practices, lessons learned, and potential standards in order to facilitate adoption by other practitioners. Cloud computing requires new technical architecture patterns for processing, communications, user interfaces, security policies, licensing considerations, and management, which is more than just moving legacy applications into virtual machines to execute on a remote server.

This paper highlights findings from nearly two years of discussions, development, demonstrations, and lessons identified from applying key cloud concepts to M&S applications. The group's activities are organized around twelve focus areas for examination and building knowledge and technology products as proof-of-concepts. The group has demonstrated working, composable services patterns, including deployment, orchestration, execution, and management of M&S services. We will present results from the group's efforts including the successful composition and implementation of services within the cloud along with important considerations when executing simulation within the cloud.

Data Science Challenges: Cut Your Time in Hack!

Joe Rohner | Kaye T. Darone

18158

The increasing velocity and variety of data generated by the Department of Defense and used by the modeling, simulation, and training community demands holistic data science approaches performed in near-real time. How can you discover multiple innovative, unbiased, cutting-edge solutions in just three days? Host your own Data Sciencan Hackathon challenge! Data Science Hackathons are events that have been successfully used by the US Army and US Navy to incorporate external open-source tools coupled with super-smart data scientists to solve challenges impeding their success. Data Science Hackathons are designed to leverage cutting-edge data science tools, cloud computing environments, and resources from industry and academia to help solve an organization impeding computing problems. These events scale a data science workforce in a very short period of time to focus on challenges impeding a mission's success. This enables new perspectives on complex

problems with crowd sourced approaches and solutions, with little cost to the sponsoring organization. As a beacon for talent, Data Science Hackathons also serve as catalysts to accelerate and transform how enterprises engage problems and provide 365 days' worth of work in three days. Our presentation will end with an overview of the 2017 I/ITSEC's hackathon, sponsored by US Army TRADOC G-2, where contestants successfully processed 288 unstructured data files (video, text, audio) in less than 4 hours, beating the baseline processing time by a factor of three, and used topic modeling to extract the true value from this corpus of information. US ARMY TRADOC G-2 will share how their organizations have implemented the participant's solutions and how their organization has changed as result of the event.

Data-driven Training Development: Deriving Performance Constraints from Operational Examples

Randy Jensen | Sowmya Ramachandran, Ph.D.

18324

Many modern operational performance environments produce significant data artifacts that collectively constitute rich libraries of decision-making examples. For domains where expert decisions are guided by constraints, there is the potential to automatically derive the constraints themselves from expert performance data. This paper discusses a data-driven machine learning approach to modeling constraints, implemented in an authoring tool coupled with a simulation-based training environment for satellite planners. In this domain, the planner's task is to create a 7-day schedule of requested satellite contacts, while meeting a range of specialized planning constraints which vary for different satellites with different missions. The training goal is to assess planners' decisions in simulation-based scenarios and provide feedback, which requires automated performance assessment measures with knowledge of planning constraints. For this application, the authoring tool provides a utility to directly process operational source data, in this case consisting of archived records of satellite requests from previous periods. This produces derived constraints, which authors then review, edit, and annotate as needed before linking the constraints to runtime assessment mechanisms for exercises. Beyond the initial focus on generating automated assessment with this data-driven approach, the development process uncovered other useful applications for the ability to derive constraints from operational data. For example, one phase of the satellite planning process involves deconflicting one's own satellite support requests from those involving other satellites that may be seeking to simultaneously use the same resources, such as a specific ground antenna. In order to support individual training for this task, an automated agent was created to produce realistic simulated conflicts with the planner's requests, based on constraints mined from operational data. This research also helped to uncover drawbacks in the data-driven approach for some domains, so this paper discusses applicability and limitations in more general cases beyond the initial satellite planning application.

Deep Learning Applications for Modeling, Simulation, and Training

Tim Woodard | Mike Enloe

18315

With the explosive growth of Big Data and the emergence of general purpose computing with graphics processing units, Deep Learning has seen rapid adoption in many industries including healthcare, finance, entertainment, architecture, engineering, social media, speech recognition and translation, retail, advertising, high-performance computing, robotics, and transportation. Deep Learning is a rapidly growing class of Artificial Intelligence which has shown tremendous promise for solving heretofore intractable problems.

To date, the adoption of Deep Learning techniques has been somewhat limited in the Modeling, Simulation, and Training (MS&T) community. However, there are many possibilities for leveraging the work from other industries for the benefit of MS&T. Much of the active research in Deep Learning has direct relation to problems faced by the MS&T community, including image classification and segmentation, texture synthesis, physically-based material generation, ray tracing, style transfer, natural language processing, gaze tracking, character animation, and human behavior modeling.

In this paper, we will first provide an overview of Deep Learning concepts and how it fits into the broader contexts of Artificial Intelligence and Machine Learning. We then present the state-of-the-art in Deep Learning, including convolutional neural networks, generative adversarial networks, and phase-functioned neural networks. Finally, we discuss some of the ways that advancements in Deep Learning can be applied to meet current and future requirements in MS&T.

Deep Learning: Measure Twice, Cut Once

Robert F. Richbourg, Ph.D.

18048

Many in the industrial and defense communities are expecting current artificial intelligence technologies (deep learning and deep neural networks) to solve a wide array of problems. Others are deeply concerned that adversaries investing heavily in these technologies will produce highly autonomous and adaptive weapons that will overmatch any known defenses. This reaction is not surprising given that deep neural networks and deep learning systems have been remarkably successful at tasks long believed to require high levels of (human) intelligence. These technologies are enjoying great success because of two enabling developments. The availability of large amounts of appropriately labeled training data and the continued growth in sheer computing power permit the decades-old neural network technologies to reach surprising performance levels. These success stories beg answers to questions about the limits of performance and potential. This paper describes artificial intelligence in its historical context of boom and bust cycles. The AI discipline has a 60-year record of heightened expectations fueled by remarkable achievement that were soon followed by disillusionment ("AI Winters") when the technologies failed to generalize to wider application. The paper also develops parallels between the current deep neural network requirements for success and those of previous intelligent technologies that were once inspiring but have now been largely retired. Finally, deep neural network technologies have known limitations that should be publicized along with their success stories to frame and temper expectations. The paper promotes awareness of these limitations to foster a rational appreciation for potential. These artificial intelligence technologies can certainly contribute to advancing automated capabilities, but their contribution is not without limit, so careful planning and preparation should precede action.

Evaluating and Infusing Participants' Stress Levels in Dynamic Training

Richard E. Cleveland, Ph.D. | Jonathan C. Hilpert, Ph.D. | Andrew E. Cleveland

18060

High-stress incidents (e.g., asymmetrical tactical and/or combat situations) can trigger autonomic nervous system (ANS) conversion from parasympathetic (PNS) to sympathetic nervous system (SNS) functioning. To mitigate adverse effects associated with this conversion many organizations employ stress inoculation training and simulation exercises to prepare operators. Previous studies have assessed stress during these exercises through cortisol or heart rate (HR) measurement. Cortisol measurement can be costly, resource intensive, and time sensitive. Heart rate, while providing information regarding physical stress level, may fail to adequately capture participants' cognitive stress. This paper reports preliminary findings of a case study designed to assess active stress during a tactical stress inoculation training incorporating electrodermal activity (EDA) measures. The case study utilized disruptive technology (i.e., innovative hardware) in biophysical measurement. A review of pertinent literature is provided followed by an outline of the reactive shooter operator training curriculum. Empirical evidence is then presented underscoring three important considerations for law enforcement and/or military training and simulation. First, the ergonomic aspects of the hardware are conducive for dynamic training modalities (i.e., stress inoculation) allowing instructors to incorporate participant stress and response within instructional delivery. Second, the technology is able to provide consistent, accurate measurement of participant HR and EDA. Third, statistical analysis of participant HR and EDA data demonstrate discriminant representations of physical stress (HR) and cognitive stress (EDA). Limitations and implications for subsequent project stages, training and evaluation recommendations, and a presentation of multiple hardware options for HR and EDA measurement are discussed.

Exterior Attribute Extraction and Interior Layout Speculation of 3D Structures

Ronald G. Moore | Matthew J. Reilly | Tony Pelham

18243

Automated collection-to-construction of terrain databases is a critical capability envisioned for future U.S. Army training systems. The challenge is how to automatically produce terrain data that supports both visual rendering and simulated reasoning with content sufficient to train ground forces in dense urban environments.

The process of automated terrain construction begins with surface capture. Drones and ground-robots are deployed, capturing large amounts of raw surface data. Processing the surface data yields point clouds or 3D polygonal meshes, providing an initial 3D terrain model, typically with very high point/polygon densities and large raster memory requirements. While certain applications may be able to utilize these terrain models directly, most visualization applications, require additional processing to generate well-formed model geometry, sharp textures, door and window apertures, and material classifications. This additional processing, performed on the point cloud or 3D polygonal mesh, extracts point, line, and polygon feature geometries along with descriptive feature attributes (e.g., height, roofline, roof-type). A bare earth elevation model is generated to provide a ground surface in which to place the extracted 3D features. The final enabler of the terrain construction process is the automated generation of 3D models from the feature and attributed data.

This paper reports on research which expands automated extraction of attributes from images through deep-learning and image processing techniques, identifying structural dimensions, apertures (e.g., doors, windows), appendages (e.g., A/C-Unit, chimneys), colors, and materials. From this set of enhanced attributes, geo-representative 3D models are procedurally generated. In addition, from the same set of enhanced attributes, geo-representative building-interiors are speculated and procedurally generated. This paper details these image processing and deep-learning techniques, describes the enhanced feature attributes that are extracted, explains the methods for interior speculation, and details the techniques for procedural 3D model generation. The paper provides lessons-learned and recommends a new standard for procedural model generation.

Human-Like Auditory Detection Capability for Intelligent Virtual Agents

Hung Tran

18009

Intelligent virtual agents (IVAs) represent important components in simulated real-world environments. Significant IVA progress has been made in diverse applications, such as entertainment, gaming, telemarketing, and recently, in military training. The use of IVAs for training is mainly in task collaboration where virtual agents interact with each other or with human users. Typical usage of IVAs in military training is virtual warfare scenarios. IVAs with perceptual capabilities, such as vision or hearing, tend to produce results that are more realistic and, consequently, can improve training task performance. Research and development on perceptual models for IVAs focuses largely on visual perception. However, auditory perception represents one of the most fundamental perceptual aspects for human-like behavior in a virtual environment because it improves situational awareness by extending the information and feedback envelope beyond the field of view. Therefore, in an event of auditory detection, IVAs should be able to react to other virtual entities or humans participating in a same virtual scenario.

In this paper, we will present a perceptual model to predict the auditory detection capability of IVAs. Our study will describe the foundation of this perceptual model, which is based on the auditory filters of the human hearing system. We will also present the simulation framework that was used to implement this perceptual model.

When comparing the predicted and observed auditory detection capabilities, the simulation results showed a slight overestimation for the predicted detection thresholds. This overestimation indicated, for the same test conditions, the IVA's detection capability is generally less sensitive than the human hearing capability. Nevertheless, the model proposed in this paper represents a highly promising method for prediction of auditory signal detection capabilities of IVAs.

Impact of Popular Media on the Potential of Educational Games

Jennifer McNamara | Victoria Van Voorhis

18322

Research has demonstrated that playing games can positively impact educational results, both from playing games designed to achieve educational outcomes and tangentially from playing entertainment games. There has been a pervasive barrier to adoption of learning games rooted in concerns related to negative effects associated with entertainment video games. The game industry has been the subject of criticism for employing design practices linked to a number of potential negative outcomes among players including fostering gaming addiction, contributing to negative cognitive effects from too much screen time, and real-world carryover effects from exposure to violence and negative depictions of women in games. Popular media outlets have leveraged current events to sensationalize these concerns increasing the attention they receive potentially increasing barriers to the adoption of games for learning.

Because educational games leverage many of the same design elements as their entertainment counterparts, it is understandable for funders, educators, and parents to be concerned that common issues may impact learners. Beyond the popular media portrayal, there are volumes of research on gameplay and its associated real-world impact on players. Makers of learning games have an obligation to understand the current literature and to both

educate potential users of educational games on the positives and negatives of their adoption and to reflect the known best design practices in creation of learning games.

To equip the educational games community to achieve these goals and ultimately limit negative impacts on the potential of learning games, this paper surveys current research on positive and negative effects of gameplay and provides design recommendations for educational games.

Interspecies Animation System for Human and Quadruped Characters

Tyler Ricks

18198

Many modern simulations struggle to implement human and animal characters into their solutions, due to the challenges of rigging and animation that differ greatly between species. Multiple obstacles challenge implementation, including sorting out different world spaces, integrating disparate toolsets, and addressing design requirements. Certain solutions, such as motion capture, are sufficient for most needs for humans, but are almost useless for certain animals. Although some video game solutions offer support for animal characters, differences between the gaming and simulation industries are often so great that using third-party software solutions in simulation environments is expensive, time consuming, and removes the ability to control animations within the simulation runtime.

This paper describes how an animation system was created that allows for human and quadruped characters to the built for simulation. The solution allows for input of animation data from game resources, motion capture, or keyframe animation techniques common in the animation industry. This process is enhanced by the fact that it allows for the full use of available modeling, rigging, and animation toolsets. This is important for the simulation community because it grants full access to a wide variety of animation resources, greatly lowering the cost of implementing many different species into existing or future databases.

This paper describes the features and advantages of such a system, which allows for direct control of animated humans and animals in the simulation environment using standard simulation controls, as well as offering host control of the characters directly. It compares the processing load put on systems using older systems and techniques. Finally, future potential developments and possibilities are explored.

Machine Supported Entity Resolution in the Cyber Domain

David A. Noever, Ph.D. | J. Wesley Regian, Ph.D.

18168

The intelligence community has prioritized training of new analysts to identify nation-state actors and its curriculum hinges on new data-driven methods for seeking and tracking malicious behavior in geographically uncertain landscapes. A key cyber challenge is to construct and understand networks in which nodes of actors, events and organizations share linked relationships. To automate building such networks, we investigate large-scale, multi-label classifiers for finding key entities, both named (persons, organizations and locations) and unnamed (web addresses, malware hashes, and dates). We evaluate machine learning methods on two novel datasets describing advanced persistent threats (APT) and their common attributes (countries, groups, tactics, and targets). One dataset employs crowd-sourced entity tags from human-curated cybersecurity reports. The second one automatically mines 10 years' worth of APT reports totaling nearly 6,000 pages. The core mission centers on natural language processing of complex narratives, often dominated by inconsistent foreign or technical terms. With 97% accuracy, we automate the identification of new threat reports responsive to APT nation-states, as distinct from general web reports on vulnerabilities, blogs, and data feeds. We bootstrap from a small subset of human-scored APT reports, generalize the rules implicitly applied to each country, and provide simple decision trees with 91% accuracy that might aid an intelligence analyst to sift through large and continuously updated repositories. If the training challenge often begins with learning the domain-specific vocabulary, we find novel APT ontologies that both supplement existing teaching resources and automate any manual steps to free up the analyst for new kinds of more complex data mining and discovery.

Man-Machine Interoperation in Training for Offensive Counter Air Missions

Patrick L. Craven, Ph.D. | Kevin Oden, Ph.D. | Kevin Landers | Ankit J. Shah | Julie A. Shah

18305

The application of an artificial intelligence (AI) agent developed via Machine Learning (ML) was investigated for the purpose of automatically interpreting the execution of a simulated Offensive Counter-Air (OCA) missions flown by experienced fighter pilots. The agent demonstrated the ability to interpret the behaviors of human pilots flying missions in a synthetic task environment (STE) using a realistic desktop flight simulator to provide segmented behaviors useful to commanders in a mission debrief.

The objective was to be able to automatically parse the mission execution in order to ultimately build more effective technology tools for commanders. First, we defined the framework for a machine-learning capability to automatically decode mission execution. Next, we developed a realistic military flight scenario. We then developed a synthetic task environment (STE) in which two experienced fighter pilots flew a two-ship strike package, and we collected mission data as they performed several missions. This data included not only the behaviors of the aircraft and other scenario objects, but also the mission segmentation commonly performed during mission debrief. Data was extracted from the STE that is consistent with what can be extracted from a live aircraft, and following the missions the pilot's segmented the mission into distinct phases. Finally, we trained the ML model to perform the mission segmentation, and it learned to classify different parts of the mission into their respective phases.

The results showed similar classification accuracy for Linear SVM, random forest classifiers and feed forward neural networks (~ 75% accuracy). LSTMs and Kernel SVM performed more poorly, on average, but inconsistently demonstrated high classification accuracy for certain runs. Overall, the results demonstrated that mission phases could be correctly classified a majority of the time using snapshot techniques. Future work will expand the techniques to include time-series models that can better account for phase inertia.

Modeling Battle Drills for Computer-Generated Forces using Behavior Trees

Per-Idar Evensen | Håvard Stien | Dan Helge Bentsen

18081

Modeling realistic human behavior, including decision-making and creativity, is the hardest and most complex challenge in combat simulation. Behavior trees (BTs) are a relatively new and increasingly popular approach for developing behavior models for artificial intelligence (AI) and intelligent agents. The approach has become especially popular for creating behaviors for non-player characters (NPCs) in computer games, robots, and autonomous vehicles. The first high-profile computer game that used BTs was Halo 2 from Bungie Software, which was released in 2004.

BTs are represented as directed trees with a hierarchy of control flow nodes and task nodes that control the behavior of an agent. The control flow nodes are interior nodes and contain decision logic for flow control. The task nodes are leaf nodes and contain conditional tasks that test some property in the simulated environment (or the real world in case of robots and autonomous vehicles) or action tasks that alter the state of the simulation (or the real world) in some way.

What makes BTs so powerful is their composability and modularity. Task nodes and control flow nodes are composed into sub-trees that represent more complex actions, and these actions can be composed into higher level behaviors. Task nodes and action sub-trees can be reused, and different sub-trees can be developed independently of each other.
In this paper we will give an introduction to BTs based on available literature and discuss the possibilities and limitations of employing this modeling technique for creating behavior models for computer-generated forces (CGF) in combat simulations. Furthermore, we will give a concrete example of how to create a BT from a textual description of a battle drill (from a field manual), and provide tips and tricks on how to create BTs in general. Finally, we will summarize our experiences from working with BTs.

Multidisciplinary standard-based architecture for underwater autonomous systems

Alberto Tremori, Ph.D. | Arnau Carrera, Ph.D. | Pilar Caamaño | Thomas Mansfield | Giovanni Luca Maglione, | David Solarna | Robert Been

18160

This paper describes the research conducted by NATO STO CMRE (North Atlantic Treaty Organization Science and Technology Organization Centre for Maritime Research and Experimentation) on the development of an architectural framework based on standards that bridge the Robotics, Command, Control and Communication (C3) and Modelling & Simulation (M&S) communities.

The use of autonomous systems in real operations, in particular in the underwater domain, requires preliminary phases of testing (Does it work?) as well as experimentation and analysis (How does it work?) under accurate and realistic scenarios. CMRE is answering these questions with interoperable M&S. This work uses interoperable M&S to fill a cultural and educational gap in the underwater autonomous system operational communities, preparing the way for new concepts such as serious gaming for the analysis of the human decision-making process and “M&S-based training environments for robotics”, by including machine-learning algorithms in the loop.

CMRE’s work has addressed the development of multi-layer interoperable High-Level Architecture (HLA) federations to support operationally relevant research and engineering activities for cooperative and collaborative teaming of autonomous systems in the maritime domain. The use of HLA federations also enables Live, Virtual and Constructive simulations following the Distributed Simulation Engineering and Execution Process (DSEEP) standard.

To date, the federations consist of ROS (Robotic Operating System) based underwater autonomous systems (hardware- and software-in-the-loop), virtual simulators to display and manage interactions among assets, and federates for the environment, communications, dynamics as well as mission-specific federates. Furthermore, the architecture supports over-the-internet distributed experiment, embracing the Service Oriented Architecture concept.

The paper presents the result of the work done to support the experimentation on autonomous collaborative algorithms for Autonomous Underwater Vehicles (AUV) for Mine Counter Measure (MCM). Currently the team is focusing on Anti-Submarine Warfare scenarios and on the design of new application of Augmented and Virtual Reality for surface and underwater to enhance situational awareness by the integration of multiple layers of information.

Securing Distributed Simulation and Training using Blockchain Technologies

Shawna Boucher | Mohammed Elshennawy | Spencer Frazier | Joshua Jacobs | Heather Kurtz | Benjamin Noble

18195

Modern simulations and distributed training methods such as BYOD (Bring Your Own Device) pose unique challenges of security and data management. Problems in the space include: maintaining a common and standardized ledger of trainee data, securing individual BYOD hardware, securing application communications, a standardized delivery of training content.

Using blockchain technology can address these challenges. Blockchain technology is defined as a distributed ledger of transactions made practically immutable by algorithmic consensus of encrypted data across multiple nodes on the network. It is possible to create blockchain records of simple transactions or advanced, Turing-Complete, computation (smart contracts). Smart contracts are open, trustless pieces of code which are deployed in a distributed system and computationally verified. Combining these smart contracts with advances in homomorphic encryption and cryptographic signing would allow system designers to address the aforementioned challenges in flexible ways appropriate to the training domain.

There are drawbacks and limitations to consider with blockchain technology as well. An immutable ledger comes with a large data footprint due to ever increasing historical data. Participating anonymously is often considered an important feature of blockchain; however, this anonymity may not be desired for access-controlled environments. Energy requirements with a traditional blockchain can be significant. There are several emerging techniques to address these issues such as ledger pruning, closed access blockchains and energy efficient algorithms.

We’ll explore these technologies in greater detail and then review the existing implementations and assessments of these techniques along with their drawbacks to validate their potential. Design recommendations will be provided to existing training solutions based on blockchain technology and finally, we’ll audit our recommendations to quantify the value these technologies would add in terms of security and auditability.

Simulation of In-Theater VLF Communications to Unmanned Underwater Vehicles

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18199

Autonomous unmanned underwater vehicles (UUVs) are able to perform missions that would be unsafe or impossible for manned submarines. These missions include but are not limited to mine counter measures (MCM) and collection of intelligence, surveillance, and reconnaissance data (ISR). The parameters of these missions occupy an important trade-space between

stealth and communications. The operational tasks required of UUVs fall into two general categories: patrolling a region to gather data, and transporting data out of the operational region.

Radio waves are absorbed by sea water - only the lowest frequencies penetrate down to a depth that is useful for UUV operations. Low frequencies require large antennas and high power to transmit efficiently. Radio communications from shore facilities to underwater vehicles are thus restricted to the VLF band (3kHz – 30kHz), or lower, and are not used for underwater to above surface return communications because of these limitations.

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This paper presents simulation results of in-theater VLF communication with UUVs. The simulation integrates several models of communications among vehicles and incorporates all significant propagation and network effects. The simulation results can be used by command staff to investigate the range of mission scenarios over in-theater VLF is practical.

Taming the Terminator

Robert Lutz | William D'Amico, Ph.D. | Reed Young | Kristine Ramachandran | Christopher M. Eaton | Derek Kingston

18065

Innovations in machine learning, artificial intelligence, and other supporting technologies have significantly advanced the state-of-the-art in terms of the capabilities provided by autonomous unmanned aircraft systems. However, autonomous systems pose special challenges for live tests on DoD test ranges, in that the methods and infrastructure used to verify requirements for traditional military systems are inadequate to accurately measure the performance and behavioral characteristics of aircraft controlled by an on-board autonomy engine. The Safe Testing of Autonomy in Complex Interactive Environments (TACE) system provides an on-board "Watchdog" processor that automatically detects unsafe behaviors stemming from an autonomy-generated instruction or from user-defined platform/test range limitations during live tests. If unsafe behavior occurs, then the Watchdog unilaterally assumes control of the autopilot as needed to mitigate or remediate the sensed hazard. TACE also provides a ground station for test monitoring and control and a sophisticated live-virtual-constructive (LVC) infrastructure for stimulating autonomous system behaviors of interest.

This paper focuses on Strategic Capabilities Office (SCO) and Test Resource Management Center (TRMC)-sponsored improvements of TACE capabilities and transition of TACE to "early adopter" test ranges. More specifically, this paper will 1) discuss the integration of TACE with the NAVAIR GUARDIAN system (resulting in a TRL 6 ground-based sense-and-avoid system for collision avoidance and airspace de-confliction), 2) discuss the SCO-led integration of TACE with AFRL's Unmanned Systems Autonomy Services (UxAS) (resulting in a hardware agnostic test tool for ranges to safely evaluate a wide variety of autonomous systems from across the DoD on low-cost platforms), and 3) discuss ongoing efforts to transition TACE to the Edwards Air Force Base (EAFB) test range.

Tanks Don't Tweet: Implementing Information Warfare Simulation

James Kearse | Keith Ford, Ph.D.

18154

Information effects such as psychological operations, computer network operations and the use of media as an influence tool are of increasing importance to military users. However, current modelling and simulation environments have a limited representation of these aspects, having evolved to represent the physical environment and physical warfare effects. Human role players are often used in exercises to simulate information effects but this is expensive and does not consistently provide an accurate and detailed representation of the information environment. As a result, commanders are not currently able to deploy information warfare effects using information available training systems. Future simulations must be able to provide improved representations of operational environments including information effects such as disrupting communications or networks, spoofing messages and the use of social media for information operations purposes.

Under funding from the United Kingdom Ministry of Defence, Defence Science and Technology Laboratory (Dstl), Thales UK have undertaken research as part of the Synthetic Environment (SE) Tower of Excellence1 into the implementation of information warfare within simulation. In order to investigate information warfare effects, the team developed a test-bed using off-the-shelf components. The test-bed has been used to investigate a series of use cases based around information operations and media operations scenarios.

As well as discussing the experimentation and the practical consequences for integrating of information warfare into Simulation and SEs, the paper considers the implementation of Information Warfare in the context of MSaaS. The MSaaS concept, as developed within NATO Modelling and Simulation Group (NATO MSG) 136, promotes the delivery of simulation capability as services with well-defined functionality and interfaces. The results from the research shows that this approach is desirable when simulating information warfare effects as it enables physical, network, information and cognitive effects to be managed independently in an extensible open framework.

Recommendations for the practical integration of information warfare services into current simulations are also provided.

Temporal IR Energy Maps for Synthetic Virtual Training

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18255

State-of-the-art Command, Control, Computers, Communications, Intelligence, Surveillance and Reconnaissance (C4ISR) requires affordable and timely generation of imagery to enable training that responds to requirements of the future flight. This capability needs to render realistic visible and infrared (IR) representations, in real-time, accurately mimicking real sensor capabilities and limitations, and generate plausible run-time, views that accurately simulate the intel sensor models used for analysis during mission training scenarios. Accomplishing this requires both synthetic terrain and material mapped data plus the ability to alter that data to develop new, what-if scenarios. This work describes a synthetic terrain generation and runtime process which can rapidly create many, variable, realistic, sensor-enabled environments tailored to specific training objectives of operators and analysts. We mimic a physics-based sensors model to accurately simulate the data and environments intelligence officers will use to analyze and exploit synthetic imagery in real-time. This simulation process allows for more robust training than only reviewing pre-recorded past scenarios. We describe our work to demonstrate the feasibility of creating plausible visible and IR "artifact free" temporal energy maps using procedurally generated techniques. We pre-bake visible and IR lighting, and simulate the sensor in real-time using a commercial-off-the-shelf game engine (Unreal4). This capability allows production of such maps to be performed without the need for fly-over imagery. This allows for better training and mission planning since trainees train on simulated situations instead of merely watching prerecorded videos.

The Application of Automation Systems for Training – Implications of Trust

Emily C. Anania | John Killilea | Beth Atkinson

18019

Interactive automation has the potential to decrease the resources needed for effective aviation training systems. Currently, some training environments require instructors to monitor and train multiple individuals at once, while simultaneously acting as fellow crewmembers in the scenario. This creates high workload for instructors and decreases the efficiency of training and the quality of feedback. Leveraging automation to support instructors can reduce manpower requirements, time demands, as well as enable cost savings.

However, experience with new automated systems (positive or negative) influences instructors' trust in the technology, and therefore, future use and reliance on the system. For example, the instructor may become over-reliant on the automation and miss important aspects of the training. Conversely, they may underutilize the system, thereby increasing their workload. Trust will also influence trainees' usage of automation, altering the way each individual trainee interacts with the simulation and impacting the fidelity of the training received. This paper will expand on these potential issues, their effects on instructor and trainee behavior, and the subsequent implications for assessment of training. A protocol for measuring trust in automation within a training session will be suggested and outlined.

Lastly, the authors will provide an overview of a use-case Navy effort to develop synthetic, autonomous agents for P-8A crewmembers. The effort's technology will allow trainees to interact with simulated crewmembers, enabling instructors to focus on instruction and performance assessment. This paper will detail how potential issues with trust in automation are being addressed within this applied context.

Three-Dimensional Immersive Diagnostic Tool for Spatial Egocentric Ability

Maria Kozhevnikov, Ph.D. | Michael Kozhevnikov, Ph.D.

18148

The goal of this study is to design and validate an innovative diagnostic tool to assess egocentric spatial ability, which is the ability to perceive and manipulate objects in space using a self-to-object frame of reference (e.g., imagining a change of perspective). This is important for successful navigation in large-scale 3D space, teleoperation, robotics, dentistry, and surgery. In contrast, allocentric spatial ability is the ability to imagine rotation of objects from a stationary perspective (e.g., mental rotation), and it predicts success in science and engineering. The existing assessments of spatial ability, usually administered in non-immersive environments, where an observer views himself from outside the screen, assess primarily allocentric spatial ability.

We designed an immersive 3D Virtual Reality Perspective-Taking Ability (3D VR-PTA) task, in which participants were shown an array of objects, asked to imagine taking the perspective of an avatar within the scene, and then asked to indicate the direction to a target object from this imagined perspective. In Experiment 1, 13 participants were administered 3D VR-PTA along with the two-dimensional (2D PTA) and 3D non-immersive (3D PTA) versions, and a number of allocentric spatial tasks. The analysis of pointing accuracy pattern suggests reliance on the egocentric system while encoding and manipulating stimuli in 3D VR-PTA vs. 2D PTA. In Experiment 2, 36 participants were administered 3D VR-PTA along with non-immersive spatial tasks (mental rotation, paper folding, 2D PTA) and real-world tasks where they were placed in a new real-world environment and tested on pointing direction tasks, shortcut finding tasks, and path integration tasks. 3D VR-PTA was found to be the best predictor of navigational performance followed by 2D PTA, while all other allocentric spatial ability tasks did not predict real world navigational performance.

Using Novices to Scale Up Intelligent Tutoring Systems

Andrew M. Olney, Ph.D.

18028

Intelligent Tutoring Systems (ITS) simulate the behavior and pedagogy of human tutors. Several meta-analyses have found that ITS are generally as effective as human tutors at promoting learning. Unfortunately, ITS are extremely expensive to produce, with some groups estimating that it takes 100 hours of authoring time from AI experts, pedagogical experts, and domain experts to produce 1 hour of instruction. The expense of creating ITS seems to be the largest barrier to scaling up ITS for widespread adoption. Some groups have created specialized authoring tools to address this problem. However, these authoring tools still require experts to use them. We have developed an alternative approach that replaces authoring tools with a new learning environment and replaces experts with novices. In our approach, novices read static content like books and web pages together with a virtual student who proposes summaries, questions, concept maps, and predictions about the content being read. The virtual student combines AI with the corrections of previous human novices to continuously improve its summaries, questions, concept maps, and predictions. Our previous research has shown that by correcting errors that the virtual student makes, human novices learn the content better than reading alone. Moreover, by correcting errors, human novices implicitly author the content needed to create an ITS. Our current research has created the infrastructure to implement this approach in the real world and has evaluated this infrastructure by generating over three thousand tutoring modules from the Navy Electricity and Electronics Training Series. The tutoring modules run on a previously developed ITS for electronics that tutors students by holding a conversation in natural language.

Virtual Reality Application for Enhancing Risk Assessment Skills

Robert J. Slezak | Nir Keren, Ph.D. | Tor Finseth

18280

Conducting risk assessment on systems require a deep understanding of all aspects of the system. When training novices to conduct risk assessments, they need to form a strong understanding of the system, its relationship to the environment, and how it operates. The term mental model is used to describe this understanding. Novices, who are provided system design in a 2D format, may struggle to form a mental model for the system and, thus, may fail to embrace risk assessment processes.

Training novices can, therefore, be a significant challenge. This paper presents a 3D, full-scale, highly interactive VR application titled Collaborative-VR (CVR) that was created with the hope it will allow novices to form a high level metal model for the system. Since risk assessments are done in teams, CVR was created to allow multiple users to work in the virtual reality environment and build systems with the hope that this experience will create the desired shared mental model that they need to effectively conduct risk assessments on system.

CVR was implemented in a Risk Assessment course at Iowa State University. Students worked in teams in a full scale, virtual reality model of the International Space Station, where they were required to design a system to solve a problem and conduct risk assessment techniques on the system based on the life cycle of the project.

Observations from a pilot study that indicated that students struggled forming robust representation of the systems and, subsequently, gained limited success in assessing systems risks. These observations and understanding CVR limitations will assist in further design features of CVR to overcome these limitations; further assessment of the capability of CVR to serve for forming strong, team shared mental models, will follow the implementations of the proposed improvements.

Visual Training Aids for Accelerating the Learning of Intuition

Aaron Novstrup | Sarah Lee | Terrance Goan

18197

Intuitive decision making (IDM) processes allow warfighters to synthesize great quantities of information at the speed required to act intelligently in highly complex, uncertain, and time-constrained tactical situations. A driver on combat patrol, for instance, does not have the time to consciously deliberate over the warning signs of an ambush, but must instead rely on the more immediate sense of intuition. Unfortunately, effective IDM only emerges through extensive experience, which for a warfighter operating in the real world can be both costly and life threatening.

This paper reports on the effectiveness of perceptual augmentation for accelerating the acquisition of the situation recognition capabilities essential to intuition and for improving IDM. In two human studies (n=24 and n=60) involving a naturalistic, rapid situation categorization task (cf. Smith et al., 2017), we evaluated visual training aids designed to implicitly a) direct focus to the salient features of the situation, b) broaden attention to non-redundant perceptual inputs, and c) surface information from working memory that would otherwise be less accessible to IDM processes. Effects are measured by comparing subjects receiving visual assistance to those not.

Our findings suggest that it is possible to accelerate pattern learning by augmenting perception with stimuli that communicate information otherwise available only in working memory and by drawing attention to significant contextual cues. We also demonstrate that perceptual attention can be manipulated with subtle cues, apparently outside of conscious awareness—a capability that may prove essential in developing simulation-based implicit training methods that trigger the subconscious cognitive pathways hypothesized (Luu et al., 2010; Reber, 2013; Wan et al., 2011) to be associated with IDM. Finally, we find significant differences between intuitive and more deliberate subjects in how they allocate attentional resources (specifically eye gaze), raising the possibility that further study of the attentional behavior of rapid decision makers may lead to improved methods for cultivating effective IDM.

HUMAN PERFORMANCE ANALYSIS AND ENGINEERING

A Maintenance Domain Experiment of Efficiency, and Precision Comparing Augmented Reality and Traditionally Cued Procedures

CDR Christopher Angelopoulos, USN | Rudolph Darken, D.Sc. | Perry McDowell

18285

Combat lethality depends on viable and repeatable maintenance processes. Technological advances have increased the complexity of maintenance communication. The technical manual, while essential, is not the optimal communication medium for all types of information. Augmented reality (AR), which is the overlaying of contextual computer-generated information upon the real world, is a candidate to mitigate complexity because intuitively AR appears to provide a better method of communication. Yet little is known about the efficiency, precision, and variability of AR compared to traditional methods. This research studied the effect of augmented reality cued (ARC) maintenance procedures on human efficiency and precision. Participants performed two sets of tasks in two conditions, one AR and one traditional (control), enabling a pairwise comparison. The first task set directed participants to place simple “erector-set”-like parts in specific locations and the second task set used such parts to construct a more complex object. In the control condition, participants used a technical manual. In the AR condition, an AR head mounted display presented the same information in a visual form. The AR condition consisted of virtual guides projected in real 3D space via a Microsoft HoloLens. Instructions in both task sets guided participants through decomposed maintenance procedures that induced absolute, cumulative, absolute referential, and complexity errors. Results indicate that the assembly procedure is statistically more efficient and precise within the AR condition. ARC placement actions of small parts are statistically more efficient and generally at least as precise.

Assessing Intuitive Decision Making with Cognitive Neuroscience-based Methods

Lisa C. Lucia, Ph.D. | Jeffrey M. Beaubien, Ph.D. | E. Webb Stacy, Ph.D. | CAPT Ronald Steed, USN (Ret.)

18110

Many military jobs pose complex perceptual-cognitive challenges, such as detecting potential collisions among vehicles that are operating in close physical proximity. These situations require rapid and intuitive decision making. Unlike deliberate decision making, intuitive “hunches” are largely automatic and do not require working memory (Evans, 2003; Evans & Stanovich, 2013; Kahneman, 2011). As a result, cognitive neuroscience-based methods such as Diffusion Modeling (DM; Wagenmakers, 2009) and electroencephalography (EEG) are well-suited to the study of intuitive decision making. Previous research by Lucia and colleagues (2017) provided support for a generalized neurological “signature” of intuitive decision making (Luu et al, 2010). This signature held for two different decision tasks, both of which used briefly-presented static imagery as the decision stimulus. In the current study, we examine the generalizability of this neurological signature with a new sample of 22 submariners who performed a similar decision task, but which used brief motion pictures as the decision stimulus. We also analyze the response time (RT) and accuracy data from both studies using DM. Unlike traditional methods for analyzing RT and decision accuracy, which treat them as separate dependent variables (Luce, 1986), DM combines them to model the underlying cognitive processes: processing speed (Delta), response caution (Alpha), stimulus encoding (Tau), and response bias (Beta). While some of the findings generalized across the two studies, others did not. Differences may be due to the type of decision stimuli used: static imagery vs. motion pictures. In some cases, however, the EEG results were able to reliably differentiate experts from novices even when the behaviorally-based measures did not. The paper concludes with practitioner-oriented guidelines for using EEG and DM methods to study intuitive decision making.

Boosting Cognitive Capabilities through Enhanced States during Gaming

Maria Kozhevnikov, Ph.D.

18149

We report on the existence of enhanced cognitive states - states characterized by dramatic temporary improvements in focused attention, as measured by an attentional blink task. In Experiment 1, significant attentional improvements were exhibited by participants who played action video-game (First-Person Shooter), and whose skills matched the level of the video-game (optimal challenge), but not by those who were over challenged or under challenged. Furthermore, using EKG (electrocardiography) methodology, we showed that arousal, indicated by withdrawal from parasympathetic activity and activation of the sympathetic nervous system, is a necessary physiological condition underlying the enhanced cognitive states. In Experiment 2, we showed that participants who played high-arousal collaborative physical puzzle game (such as Escape Room, in which a team of players solve a series of puzzles meeting certain criteria) exhibited similar enhanced cognitive states to the group of FPS video-gamers who were optimally challenged in Experiment 1. In contrast, participants who played a low-arousal computerized puzzle game, such as Tetris, did not exhibit such attentional enhancements, despite their active engagement in the game.Overall, the findings provide the experimental evidence for the existence of the enhanced cognitive states through high-arousal gaming experiences. In particular, the results suggest that the observed attentional enhancements cannot be simply due to the activity of gaming per se, but might rather represent an enhanced cognitive state resulting from specific conditions (heightened arousal in combination with active engagement and optimal challenge), resonant with what has been described in previous phenomenological literature as “flow” or “peak experience”. The enhanced cognitive states are expected to be universal across domains that involve first-person focused attention activities (e.g., painting, drawing, meditation). The finding of this research suggest practical ways for consciously accessing latent resources of our brain to temporarily boost dramatically our cognitive capacities upon demand.

Development & Assessment of a Human Patient Simulator Gender Retrofit Kit

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18266

Tension pneumothorax is one of the leading causes of preventable death on the battlefield, second only to hemorrhage. The condition occurs when a chest wound allows air to fill within the pleural space, a small area between the lung and the chest wall. If left untreated, a tension pneumothorax can rapidly progress to cardiovascular collapse, respiratory failure, or even death. Soldiers are trained to perform a Needle Chest Decompression (NCD) procedure to allow the accumulated air to escape. Unfortunately, patient gender impacts the success of the procedure. A recent study found that female casualties had a higher mortality rate after a traumatic injury when compared to males. Ingrained societal taboos often interfere with combat medics from properly examining a female for a chest wound to rule out tension pneumothorax. Most Human Patient Simulators (HPSs) utilized by the U.S. Army at various training centers are currently configured only as male casualties. The U.S. Army Research, Development and Engineering Command Simulation and Training Technology Center (RDECOM STTC) identified a need from the user community to develop female-centric training experience to train medics to perform a Needle Chest Decompression (NCD) on female casualties. This paper will describe the research and prototype development conducted to satisfy this requirement, which offers accurate female anatomy and compatibility with existing HPSs. Additionally, the paper will summarize the results of usability studies along with participants provided feedback. Preliminary analyses indicate that the prototype was well received and that it provides trainees an opportunity to practice assessment of female casualties during training.

Evaluating Augmented Reality Assembly Instructions Delivered via Microsoft HoloLens

Melynda Hoover | Jack Miller | Stephen Gilbert, Ph.D. | Eliot Winer, Ph.D. | Paul Davies

18272

To keep up with the maintenance demands of a dynamic fleet of equipment, military personnel are constantly learning new repair skills. However, this constant training can be time consuming and cost prohibitive. In fact, United States Military spending on operation and maintenance equaled $200 billion in 2015. One method of reducing these costs is to employ more efficient methods of delivering work instructions, such as Augmented Reality (AR). Studies on the use of AR work instructions have shown reductions in task duration and errors by as much as 50%. Although previous research has confirmed the advantages of AR over traditional 2D work instructions, little research has been conducted to evaluate the advantages of emerging AR hardware, such as the Microsoft HoloLens for delivering maintenance and assembly information.

This paper presents the results of a comprehensive user study comparing four work instruction delivery methods. Users were asked to perform a mock wing assembly task with work instructions using one of 4 methods: 2D instructions on a desktop computer, 2D tablet instructions, AR tablet instructions, and AR instructions on the Microsoft HoloLens head-mounted display (HMD). Results of the study showed that viewing the AR instructions using the HMD yielded faster assembly times than the other three instructional methods. The study also showed that users made very few errors when using AR methods in general. However, net promoter scores (a measure of user satisfaction) and qualitative feedback from the users showed that some improvements in comfort and 3D registration may be necessary before the HoloLens can be successfully employed for widespread military maintenance use. Despite this subjective feedback, the HoloLens HMD has the potential to provide warfighters with quick access to work instructions that will decrease the need for expert assisted training and increase readiness of military equipment.

Human-Agent Teaming: State of Assessments and Selected Issues

Grace Teo, Ph.D. | Lauren Reinerman-Jones, Ph.D. | Maartje Hidalgo | Clayton Burford

18283

Progress in computing and robotics technologies has fueled research in Human-Agent Teaming. More than before, robots, machines, and systems are seen as viable agent teammates that work alongside humans as force-multipliers to enhance performance, to ensure safety, and to improve efficiency. However, even as the demand for research and development in HAT by both the military and industry continues to increase, there is a growing concern over the current and foreseeable future challenges with assessments in this relatively new domain. For instance, it is difficult to compare results of assessments that are purported to examine the common HAT construct relationships, such as that between reliability and workload, but use different definitions and measures for the constructs. Moderation of the effects of multiple HAT innovations by contextual factors is also not well understood because many assessments have been done using various tasks and testbeds. All this constrains the extent to which study findings can be generalized, and the establishment of knowledge base about the critical factors and relationships in HAT. In this paper, analyses were conducted on the metadata of 74 HAT research studies from ten researchers from military labs. Results show patterns and trends in the metadata that illustrate which constructs tend to be examined together, which measures seem to cluster, and which constructs had the most and least diverse measures and definitions. Implications of these findings on assessment quality and the utility of assessment outcomes for informing a variety of critical decisions are also discussed.

Managing Learning and Tracking Performance across Multiple Mission Sets

Eric Watz | Peter Neubauer | John Kegley, Ph.D.

18304

Live and simulation-based training systems are data-rich environments with a wealth of human-performance measurements. Knowledge Management Systems (KMS) that fuse multiple data sources to predict current proficiency and future training needs are essential to managing localized and longitudinal learning goals for individuals, teams, and teams of team. This is the foundation for adaptive proficiency-based training that improves training efficiency and effectiveness. A KMS can take many forms but fall into three distinct categories of technology and capability. This paper illustrates three primary categories of managing learning that apply to the majority of KMSs available today. Recent advances in training technologies along with lessons learned from implementation in the simulation and live operations domains have made it possible for the Air Force Research Laboratory (AFRL) engineering and research teams to execute advanced capture, processing, and visualization of training research data. This paper delves into some challenges that exist to measuring, tracking, warehousing, and tracking proficiencies across human performance data sets within the U.S. Air Force (USAF) tactical domains. These challenges include tailoring assessments by domain, strategies for handling the ever-increasing complexity of training in live, virtual, and constructive (LVC) environments, and the need for operationally-relevant and scientifically-based methodologies and practices when measuring and tracking training. This paper draws upon lessons learned from implementation of an enterprise Knowledge Management System and looks at the way forward in terms of performance measurement, data storage, and proficiency prediction.

Objective Stress Monitoring for Live Training Exercises

Zach Huber | Brent Winslow, Ph.D. | Joanna Chiang | Mark Dranias, Ph.D. | Ajmal Aziz

18105

A primary goal of live and virtual training exercises for military forces, medical practitioners, and first responders is to develop readiness in a controlled, realistic environment. Once basic skills are learned, training transfer of complex skills from exercises to a high stakes, high stress environments increases when training exercises closely mimic the stress and tempo of operations. Objectively quantifying stress in real-time would provide key data to influence and evaluate immersive training exercises. The community has investigated a number of physiological-based indicators, many of which utilize lab-based equipment that limits the ability to use such approaches in military and first responder training exercises. A stress classifier was created to allow user physiological state to be monitored and classified in real-time in an ambulatory environment, and indicated high stress classification accuracy in healthy adults and those undergoing cognitive behavioral therapy for Post-Traumatic Stress Disorder (PTSD). While the stress classifier has been assessed using both healthy and clinical populations, the ability to extend its capabilities to military and first responders was required to determine classification accuracy and ruggedness in training and operational environments.

Field data collection events in collaboration with the Department of Homeland Security (DHS) First Responders Group and naval firefighter training with the Surface Warfare Officer School (SWOS) provided context relevant data to evaluate real-time stress measurement accuracy and reliability. Results from field studies in each of these two environments will be presented, along with a discussion of the findings, challenges and next steps for this technology. This paper will also summarize the unique ruggedization requirements for physiological-based algorithms and associated hardware, as well as related technologies for immersive training communities.

Reliability requirements for augmented reality in visual search tasks

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18247

In military operations, quick and accurate target detection and identification is critical for mission success. Augmented reality (AR) technologies can aid target detection and identification by layering digital imagery atop a Soldier's field of view to increase situational awareness. These systems are rarely perfect, however, and in some cases unreliable AR may actually interfere with performance. This investigation focused on the capacity for unreliable AR to impair performance. We showed participants a series of 2D simulations where highly-visible AR cues were superimposed over tanks placed randomly in a grassland environment. The reliability of these cues varied (from 25% to 100%) throughout the experimental session, as some valid targets were erroneously un-marked (false negatives) while some invalid targets were erroneously marked (false positives). Participants were asked to search for the vehicles while being assisted by the AR; search accuracy and response time were analyzed, and participants provided feedback regarding their mental workload and trust in the AR. We found the expected negative relationship between unreliability and performance, but also found that AR false positives were more damaging to performance than AR false negatives. Unreliable AR also hurt performance more when marking vehicles at greater distances. Further, although error type and target distance had powerful effects on participant performance, they had less of an impact on subjective trust and workload, suggesting that Soldiers using AR might not be consciously aware of how their own performance changes as a function of AR properties. In summary, unreliable AR hurt performance differently depending on the type of errors produced by the system, and impaired some aspects of performance but not others. These results carry important implications for how AR is designed to improve performance on the battlefield.

Smart Simulation for Decision Support at Headquarters

Ariane Bitoun | Yann Prudent | Antony Hubervic

18246

While serious games are being widely adopted by NATO and partner nations, their use is currently limited to training and operations planning. In this paper, we explore new methods that use simulations for decision support during the execution of military operations.

During this phase, the commander makes decisions based on knowledge of the situation and the primary objectives. We propose here to take a simulation containing smart and autonomous units, and use it to create new kinds of decision support tools capable of improving situation awareness, and consequently the quality of decisions. The breakthrough behind this initiative is the realization that we can provide HQ decision makers with access to a version of the information that smart simulated units use to make decisions.

To ensure the approach was sound we first studied decision-making processes, and analyzed how situation awareness improves decision making. After analysis of the decision-making processes at various headquarters, and the types of decision criteria employed, we are able to produce innovative information, computed by the simulation, and fed by the command and control system. We then propose a prerequisite architecture, and describe the first results of our proof of concept work based on the SWORD (Simulation Wargaming for Operational Research and Doctrine) simulation.

The Effect of Work Experience on Risk Assessment Skills

Jennica Bellanca | Brianna Eiter, Ph.D. | Jonathan Hrica | Terry Weston | Robert Weston

18126

Identifying and assessing the risk of hazards is critical to avoiding accidents and injuries. However, studies indicate that workers have difficulty accurately assessing risk (Carter & Smith, 2006) and that there is a lot of variability in how people define and perceive risk (Perlman, Sacks, & Barak, 2014). Specifically, it has been reported that untrained workers tend to only consider severity as opposed to both the severity and probability of an accident occurring when assessing overall risk. Between the fourth quarter of 2013 through 2016, 72 mineworkers were fatally injured at metal/nonmetal mines in the United States (MSHA, 2017). A significant portion of these fatalities appear to be linked to a lack of task and site experience, with 22 fatalities involving mineworkers performing an activity with which they had less than one year experience, and 20 fatalities involving contractors. The focus of this research effort is to expand our understanding of how mineworkers with varied experience and employment backgrounds assess the risk of worksite hazards. Initially, researchers at the National Institute for Occupational Safety and Health (NIOSH) collected hazard recognition and risk assessment data from 24 mineworkers, 13 safety professionals, and 14 students while performing a simulated workplace examination in NIOSH Pittsburgh's virtual immersion and simulation laboratory. Researchers then packaged four hazards from the laboratory study into a risk assessment training module, specifically looking at severity, probability, and overall risk. Researchers used the training module to collect risk assessment data from over 1,200 mineworkers during mandatory, annual refresher training. The training data collection provided a larger, more general sample that specifically included contractors. This paper compares risk assessments from the laboratory and training data, and it reports on the differences between risk components, groups, and experience in order to identify future training needs.

Total Learning Architecture: Moving into the Future

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18224

Increasingly, the defense community requires a continuous, adaptive learning enterprise that delivers the right training, education, and just-in-time support, in the right ways and at the right time. The Total Learning Architecture (TLA), now in its second iteration of development, is intended to help meet that vision. The TLA is a set of internet and software specifications being developed to create the interoperability backbone of this future learning ecosystem. The products derived from this project include technical implementation guidelines, Application Programming Interfaces (APIs), middleware, and data model descriptions that help training, education, and personnel management technologies seamlessly communicate through integrated coherent systems.

Spiral-1 of the TLA research and development project focused on developing an initial set of 10 APIs consisting of candidate specifications as well as protocols developed specifically for the initial development cycle. During Spiral-1, community stakeholders provided feedback on the functionality of the written specifications, and end-users (active duty personnel) interacted with a prototype reference implementation created from the specifications. Findings suggested that users could learn effectively through this system and data were efficiently shared between devices and a central learning record store; however, the documentation was overly complex and too idiosyncratic.

Spiral-2 of the TLA research and development project is focused on the identification, incorporation, and evaluation of additional candidate standards and specifications, drawn from recognized international standards and specifications. This paper summarizes the updated state of the TLA Spiral-2 development process, the TLA's current set of recommended specifications, assessment efforts, and ongoing developmental planned.

Uncanny Avatars in Virtual Aircraft Environments, How Best to Represent

Rob Lechner | Shawn Burke | Elizabeth Biddle, Ph.D. | Claudia Hernandez | Mike Eakins | David Metcalf, Ph.D.

18030

With the recovery of the global economy, commercial aviation travel has dramatically increased over the last several years and continued growth is projected at a rate of 6.5% per year. Aircraft manufacturers have an unprecedented backlog of commercial aircraft orders to meet the demand. This, in turn, is causing a surge in the demand for civil pilots to fly these new aircraft with a total of 637,000 new pilot jobs projected over the next 20 years. The increase in pilot demand will stress current commercial training system facilities. With technology advances in head-worn augmented reality and virtual reality systems (AR/VR), the potential exists to leverage this technology to increase training throughput. However, the question arises as to what will be acceptable to federal aviation regulators and aircrew in-training.

There has been recent emphasis on flight crew coordination competencies being factored into refresher and type rating training. Three specific competencies: Communication, Leadership and Teamwork, and Workload Management, are prominent areas where AR/VR technologies can be utilized. In an AR/VR environment, the question arises as to how best to portray a human avatar to provide the second crew member. Previous research in the use of avatars for human stimuli theorizes that avatars with high human-likeness may evoke feelings of eeriness in the human observer (Borst & de Gelder, 2015).

This paper presents an experiment that was performed to study the best representation of a pilot avatar for the purposes of competency-based training. The study utilized 4 different avatar representations portrayed in a virtual 787 cockpit displayed in an HTC Vive headset. Sixteen personnel with various piloting experience went through a within subjects experimental design with two factors. The two factors were realistic vs. abstract representation and full body vs. partial body. The results of the study are presented herein.

BEST PAPER

Validation Affordances: Keeping the Eye on 3D Virtual-Simulation Baseballs

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18143

A persistent challenge to technology-enhanced learning is a general need for evidence-based ecological validation protocols?especially as it pertains to transfer-of-training for serious video games and virtual simulators. It is often missed that the critical objective in achieving ecological validity in virtual simulation trainers is not necessarily to maximize realism but to optimize training by targeted and deliberate stimuli, and that validation must be against operational simuland referents as well as affordance referents. That is, validation must ensure not only that the body of knowledge of real operational environments being simulated (i.e., simuland referents) is properly selected, specified, and codified in computable models but also that quality measures of human sensory detection instigated by virtual environments are consistent with those afforded by corresponding real/live simulands (i.e., affordance referents). In this first-of-its-kind exploratory pilot study, a part-task hybrid simulation-couple paradigm (i.e., virtual simulator in tandem with mechanical simulator counterpart) was implemented to garner and establish oculomotor affordance referents relative to ecologically-valid 60-mph live fastballs in the baseball batting task as well as to instigate and measure horizontal eye movements relative to corresponding virtual fastballs. Results indicate virtual fastballs in full-size 3D stereo theater afford similar overt attentional responses as live fastballs at modest speeds but not at faster speeds. Onset times of catchup saccades, succeeding smooth pursuit, while observing off-center incoming virtual fastballs, lagged those while observing live fastballs?suggesting possible accommodative-vergence impairment induced by the fixed focal

plane of 3D stereo display. Results offer nominal evidence of limited ecological validity for 3D stereo virtual environments involving horizontal eye-movement tasks while observing objects moving in depth?demonstrating the relevance of affordance referents in selective ecological validation of virtual stimuli.

POLICY, STANDARDS, MANAGEMENT, AND ACQUISITION

A Capability Maturity Model for Flight Training

Jean-François Delisle | Stéphane Ouellet | Derek Linders

18298

The aviation industry invests heavily in technology to ensure training quality and compliance with flight safety regulations. At the same time, the steady growth of air travel is driving the demand for pilots. Maintaining pilot throughput without sacrificing the quality of training is a major challenge facing the industry. A methodology for improving training could potentially benefit flight training organizations by identifying areas for process improvement.

We propose a Flight Training Maturity Model (FTMM) derived from the Capability Maturity Model Integrated (CMMI) published by the Software Engineering Institute (SEI) at Carnegie Mellon University. Initially developed to improve the performance of military software projects, the CMMI is a reference model designed to evaluate and improve the software development lifecycle process. Maturity models are not new and they exist for many disciplines. Relevant models include (Wagenstein, PMI, 2006) in education and training (Marshall 2012) in eLearning, the Federal Aviation Administration Integrated Capability Maturity Model (FAA-iCMM) and (Ibrahim, 2000) in system engineering. We believe the flight training process can benefit from an adaptive training approach based on competencies. Adding a competency-based approach to the maturity model was studied by (Gillies & Howard, 2003) for change management in healthcare, but can benefit the aviation sector as well.

In our paper, we derive from the CMMI's five-level maturity scale an analytical framework for flight training that defines key performance indicators (KPIs) for each key process area, in order to evaluate organizations. The KPIs target the training processes, participants, learning environments, and technologies involved at each maturity level. Using existing training center programs and industry standards, such as the Analysis-Design-Development-Implementation-Evaluation (ADDIE) instructional system design framework and the FAA–Industry Training Standards (FITS), we identify process areas that can be compared with valid KPIs for corresponding maturity levels of different flight training organizations.

Achieving Full Potential through Evaluation Policy that Disrupts Status Quo

Miriam Plaza | Pamela Bishop | Marie H. Prosper | Klainie Nedoroscik

18292

Program and training evaluation is not only a widely acknowledged best practice, it is a mandate for federal agencies. However, the U.S. Government Accountability Office (GAO) recently found that only 30% of the 27 agencies surveyed consistently implement a formal process for evaluating the impact of training on the agency's goals and mission, and most do not gather the information they need to appropriately manage their training programs. Without proper evaluation, program and training investments risk failure, waste, or loss of funding. Unfortunately, evaluation is often overshadowed by a focus on training acquisition, production, and execution. Additionally, evaluation needs are often not included in budget calculations. Evaluation resources are often scattered across agencies, and relatively few personnel have the expertise required to successfully shepherd their organization through the process of developing and maintaining an effective evaluation system. Program and training evaluation comprises far more than the smile sheets that have come to dominate perceptions about the science. It involves a comprehensive, systematic approach to making defensible decisions based on credible information about programs, their processes, their outcomes, and the systems in which they exist. This paper examines guidance provided by federal regulations, GAO, the Office of Personnel Management, the Department of Defense, the American Evaluation Association, and academic and industry publications to present an organized, condensed set of 12 program and training evaluation standards for federal agencies. This paper fills the need in literature and practice for a repository of recommendations from across agencies and industries. The standards will help organizations develop or evolve program and training evaluation practices that align with expectations for federal agencies. The paper concludes with recommendations for incorporating evaluation-supporting requirements into federal acquisition processes.

An Agile ISD Process to Develop a Medical Simulation

Susan Dass, Ph.D. | Victor Cid

18116

The Bethesda Hospitals' Emergency Preparedness Partnership identified a need to design training systems for hospital emergency management scenarios. As part of this partnership, the National Library of Medicine was challenged to develop an engaging, learner-centered simulation to specifically address hospital procedures for highly infectious diseases (HIDs) for multiple healthcare roles. A cognitive task analysis was used to collect the rich psychomotor, procedural, and cognitive data necessary for the design of a serious game for handling HIDs. Based on that data, a proof of concept prototype was developed in Second Life. That success has led to continued development. In this paper, we discuss the use of a novel Agile ISD process used to develop a new prototype using Unity 3d as the platform. An agile process was explicitly followed for this project to accommodate the limited budget that had abundant project visions. It was anticipated at the outset that the project would likely require continuous project re-scoping and refinement of product requirements that would need to be addressed smartly and efficiently. Furthermore, questions about fidelity in terms of visual representation as well as instructional integrity would still need to be addressed simultaneously. The project was conducted within a flexible contract environment that accommodated the anticipated re-scoping and refining during development. An overarching vision statement helped keep the product development moving forward with evolving requirements. The agile sprint process was invaluable for iterative reviews throughout the development process which afforded changes and redirection. However, usability testing revealed a significant change that was not noted as part of the iterative review process. This paper will briefly describe the Agile ISD process, show how it was applied to develop medical training on doffing personal protective equipment, share lessons learned, and briefly discuss flexible contract environments.

Building Bricks for Simulation: from Flexibility to Consistency

Lieutenant-Colonel Eric du Pontavice

18069

In a time of financially constrained resources, the French Army has tried to optimize its simulation effort by using a "building brick" approach. This modular concept allows a streamlined training process, while simultaneously saving resources with re-usable simulation modules.

Legacy simulation systems linked with their parent weapon systems had a tendency to use multiple simulation engines, therefore producing multiple simulation environments: virtual terrain and objects. Digitization of the battlespace has then added another complexity layer when command and control (C2) systems were not natively designed to be connected with simulation systems.

This paper first explains the operational readiness preparation cycle of the French Army and its consequences on the French classification of simulation. It then moves to the procurement regulations and process, and to the shared responsibilities in the development of simulations. What is really complex and not urgent (simulation engines, after action review, etc.) must be contracted with industrial partners, while what is simpler but urgent or classified should be developed by governmental agencies.

This paper then describes how two middleware have been developed by the French Army and actually provide key capabilities. A dedicated C2-simulation gateway allows connections between simulation engines and evolving C2 systems, even if the upgrade cycle of such systems is not usually compatible with industrial contracting and development timeframes. On the pedagogical side of things, a simplified administration system allows wide and simple access to simulation resources throughout the Army bases and schools.

Together with two simulation engines, these two government-issued "bricks" are actually at the core of the French Army simulation "system of systems".

This paper finally shows that even if actual gains are difficult to measure, the lessons learned thus far strongly suggest continuing towards more flexibility through adapted models and connectors."

PSMA

Can we talk? Semantic Interoperability and the Synthetic Training Environment

Paula J. Durlach, Ph.D.

18093

Future cloud-based, service-oriented training environments, such as the Army's planned Synthetic Training Environment (STE), are expected to consume authoritative data sources for terrain and simulation models, and to stimulate and consume data from mission command systems. This paper describes the envisioned capabilities of the STE in general, and the training management tools in particular. STE is anticipated to be supported by training management tools that will use unit training records and plans to help automatically or semi-automatically tailor STE training exercises to the unit's current training needs. At issue is how these adaptive training management services will exchange data with other STE components. The paper argues that semantic interoperability will be required. A review of existing and developing data exchange standards in the modeling and simulation domain and in the adaptive training technology domain suggests they are unlikely to support the semantic interoperability required. It is suggested that the National Information Exchange Model (NIEM) may represent a possible method of providing that level of interoperability. NIEM, which is federally governed, allows communities of interest to establish a common vocabulary and to use it to create standardized machine-readable information exchange packages. These data packages use World Wide Web Consortium (W3C) Extensible Markup Language (XML) schema or NEIM-Unified Modeling Language. In 2013 the Chief Information Officer for the Department of Defense (DoD) issued the "NIEM first" memorandum, which directed that the DoD shall consider NIEM first for their data exchange standards. A MilOps community of interest has used NIEM successfully to exchange information with coalition partners. Of additional relevance, work in the geospatial community has demonstrated the combined use of NIEM, intelligence community security specifications, Open Geospatial Consortium web services and Geography Markup Language-aware clients to support information exchange among authorized users. The paper recommends that STE proponents consider reuse of and building upon prior NIEM work to support the semantic interoperability required among the models, simulations, authoritative data sources, and training management systems that will make up the STE.

Defining Virtual Training System Requirements for Foreign Military Sales

Michael Coleman | Ronald Brabant

18038

The United States (U.S.) Department of Defense (DoD) offers a "total package approach" to partner nations that purchase defense articles and services through the Foreign Military Sales (FMS) program. A total package approach includes training, maintenance, operations, and sustainment. While success of the total package approach relies on definition of robust requirements in a partner nation's Letter of Request (LOR), increased stakeholder participation during FMS case execution often results in realization of additional requirements. Unique requirements for a virtual training system may result from differences in concept of operation of the weapons platform, training objectives, and concept of operation and sustainment of the training system within a customer's regulatory environment. This paper aligns definition of a partner nation's unique virtual training system requirements to DoD guidance for building an LOR, and presents implications of implementing these requirements within cost, schedule, and U.S. regulatory constraints of an FMS case. In conclusion, the paper recommends that partner nations prudently define unique, robust requirements for an FMS virtual training system, that DoD exercise due diligence in evaluating partner nation requirements, and that industry partners maintain awareness of unique partner nation requirements for FMS virtual training systems.

Lessons Learned from Distributed Virtual Air Refueling (VAR) Integration

Jonica Tramposch | Christian Schwindt

18005

Aerial refueling over a distributed network requires players across multiple time zones to recreate a virtual world that has stringent temporal and spatial threshold tolerances. Such capability enables a coalition of forces to participate in quality training at a small fraction of the cost and logistics time of a live exercise. Until the Mobility Air Force (MAF) Distributed Mission Operations (DMO) Program, such precision had not been achieved. In 2017, multiple Mobility Air Force platforms embarked upon testing the efforts made thus far in achieving this Distributed Virtual Air Refueling capability. Years of preparatory work and standards development preceded this effort; yet, when theory met practice in 2017 many valuable lessons were learned. This paper discusses the most important lessons learned from the VAR effort. Advice on what to require, avoid, and when to address the following topics is given: physics model fidelity, data self-consistency and accuracy, objective and quantitative test results and analysis to enable correct root cause determination, ways of dealing with legacy code and when to refactor, contract and acquisition strategies, and subject matter expert support required to ensure success. Incorporating these lessons into future efforts will improve the efficiency and success of creating a precise virtual world that serves as a capable battle space for complex, distributed training.

BEST PAPER

Leveraging Science and Technology to Launch Innovation in Learning

Kendy Vierling, Ph.D. | Sae Schatz, Ph.D. | Amy LaFleur | Dwight Lyons

18261

In remarks about the National Defense Strategy, the U.S. Secretary of Defense, Jim Mattis, observed that in a time of rapid technological change and an over-stretched military, "Success does not go to the country that develops a new technology first, but rather, to the one that better integrates it and more swiftly adapts its way of fighting" (2018, emphasis is ours). Services within the Department of Defense (DoD) and agencies across the national security community are transitioning from an antiquated learning model to a more agile one that better leverages innovation and emerging learning science and technology (S&T). Service members and the civilian workforce seek to integrate these new learning capabilities and expect to obtain more personalized and accelerated learning as a result.

Previous research (Raybourn et al., 2017) identified key recommendations for enhancing learning within the national security domain. These recommendations focus on enhancing instructional quality, competencies, credentials, data analytics, data interoperability, personalization, learning on demand, integrated human–machine systems, creating a technology-enabled continuum of learning, providing multiple paths for achievement, and implementing an enterprise approach to talent management. Although there appears to be much support regarding what to implement, it is unclear how to achieve these outcomes, integrate with legacy programs, and swiftly adapt innovative prototypes to obtain effective real-world results.

This paper describes current progress, challenges, and opportunities in integrating innovative learning science, instructional methods, and technologies in military environments using specific examples from the Marine Corps Training and Education Command (TECOM) and partner efforts. In collaboration with S&T partners, TECOM conducted limited military user assessments of emerging adaptive mobile learning technologies. To date, the results appear promising and support the premise that newer Marines, for both the officer and enlisted ranks, prefer these new technology-enabled personalized learning delivery methods compared to "Industrial Age" instructional delivery methods. Finally, this paper discusses current limitations, challenges, future directions, and recommendations for integrating and more swiftly adapting emerging S&T into military training and education programs.

Making Joint and Multinational Simulation Interoperability a Reality

Emilie A. Reitz | Kevin Seavey

18268

Consider the following hypothetical scenario: As tensions continue to rise in East Asia and with many of her fellow Marines already forward deployed, Captain Smith looks forward to a quiet Saturday as Staff Duty Officer catching up on email before her own unit's deployment. As she scrolls through her inbox, she notices "WARNING ORDER" in a subject line and double clicks. "FM II MEF... OPERATION RAPID FURY... EASTERN POLAND... JTAC/JFO SUPPORT." Captain Smith reads the order a second time while calling her Commander. After hanging up, she starts running through her mental checklist of things to do, "September is right around the corner! How do we shift gears from an exercise in Korea to a quick response, real world show of force in Eastern Europe with NATO partners? The WARNORD mentioned ground units from Poland and Germany, aircraft from the U.S., U.K., France and Italy. How in the world do I get my Marines ready for that?

Joint Staff J6 has been working to improve distributed simulator interoperability in the joint fires domain for the last five years as part of its Bold Quest series of coalition capability demonstration and assessment events. Despite decades of experience in distributed simulation, warfighters are still unable to rapidly and routinely connect simulators between different Services and nations. What price we are paying for our inability to connect these systems? What could we do better if warfighters were able to train together with their mission partners prior to the chaos of combat?

To better understand the scope of this problem, we conducted a survey of 60 current simulation subject matter experts. This paper provides the survey results and details recommendations to allow LVC systems to operate together in a joint and coalition context.

Mind the Gap: A Modeling and Simulation Gap Management Framework

Frank Mullen | Leigh G. Yu

18062

Modeling and simulation (M&S) capabilities continue to grow within the Department of Defense (DoD), including expansion into novel areas. This evolutionary process invariably exposes some capability shortfalls where the technologies, policies, and/or personnel resources are insufficient to meet all demands, creating "gaps" in the spaces ad-dressed by M&S capabilities. Several successful programs have established processes to understand these gaps and work towards their remediation. In recent years, there has not been an analogous DoD-level gap management frame-work, and nothing has existed to either provide an understanding of DoD-wide efforts in this area or to remediate emergent gaps. Instead, the DoD has relied on efforts and improvements made at the level of the M&S capability owner and user. This is a viable approach when the DoD use of the M&S capabilities is similar to original intent, but DoD-level adaptations often seek to extend M&S applications beyond those bounds. Additionally, a different class of gaps emerges when requirements at the DoD level dictate combining M&S capabilities in new ways to achieve a more complete representation of the full joint battlespace.

This paper describes a new Defense Modeling and Simulation Coordination Office (DMSCO) study for identification, prioritization, cataloguing, and remediation of M&S capability gaps with emphasis on those that impact M&S use at the DoD level. Current efforts to manage capability gaps that have proven valuable for other organizations are re-viewed to understand their keys to success. The most successful characteristics (including securing community buy-in) are enumerated and the process of adapting these for application in the DoD M&S context is explained. The paper continues with a description of a first-year prototype evaluation, conducted through a process of stakeholder review and comment, and culminates with an explanation of how the revised DMSCO framework could be applied in other areas.

Modelling & Simulation as a Service - Empowering Operational Users

Keith Ford, Ph.D.

18225

The need for modernisation of simulation capability by the United Kingdom Ministry of Defence (UK MOD) is being driven by a number of factors, including the need to: Provide a more agile and cost effective approach for rapidly delivering simulation capability to meet the increased and diverse use of simulation across MOD; Capitalise on the benefits of technological developments in the IT industry and align with UK MOD ICT (Information & Communication Technology) and NATO strategies e.g. 'cloud first'; Promote the re-use of simulation resources across the UK Defence Enterprise to reduce acquisition of simulation capability and reduce the through-life costs.

The UK MOD is researching the provision of Modelling and Simulation as a Service (MSaaS) as a potential Enterprise-level strategy to meet these needs and provide recommendations to de-risk the approach.

This paper provides an overview of the UK MOD's research's into implementing an MSaaS capability. It describes the elements of the MSaaS ecosystem and the stakeholders that interact with it. The paper highlights the challenges an Enterprise will face that wants to implement an MSaaS capability and describes issues that need to be resolved if the Enterprise wants to share its simulation resources with other organisations.

Use cases are described to demonstrate how MSaaS can support the needs and provide benefits to different operational users. These include training, mission rehearsal, concept development and experimentation (CD&E), crisis management and data farming. Recommendations are made for a phased approach for delivering an MSaaS capability and the paper identifies where further research is required.

Stretching to Achieve NFL-Caliber Agility for Software Development Programs

Scott Tufts | Ben Boyle | Ray Lyons

18122

Procurements with significant software development have a tradition of using the Waterfall process. The Waterfall method is well understood, and underlies the Navy's Systems Engineering Technical Review (SETR) process, which assumes that a system's components mature at the same rate. However, that is not always the best way to run a software development program. For the best outcome, the software development and review process should fit the program's needs.

A recent upgrade to an acoustic training system took a hard look at the traditional Waterfall method versus other best-practice software development processes. The combined efforts of the Government team and the developer to define and implement a novel software development process have yielded highly successful results in program cost savings and accomplishments. This novel method leverages key components of an Agile process with the spirit of the Rapid Capability Insertion mythology that has been embraced by the US Navy across many of its major development programs while meeting the contractual milestone requirements of the SETR process. The process utilizes sprint tasking focused on a disciplined "gate" process with early and continuing Government involvement to ensure that the design and development is achieving the desired result. The net result is a product that is representative of the US Navy's requirements while maximizing the funding and schedule performance of the program. This is significant to the acquisition community professionals who have been seeing disappointing results using traditional development approaches in complex software development programs.

This paper will address software development best practices; identify the characteristics of a program for which this novel method optimally works; the recommended metrics for monitoring progress and measuring success; and the specific seven actions that led to a successful outcome.

Team Orlando: Community of Progress

Jennifer J. Vogel-Walcutt, Ph.D.

18222

Team Orlando has become an international icon for the modeling, simulation, and training (MS&T) community. Countless examples of cooperation demonstrate the exceptional advantage of having co-located representatives from every military branch, academia, and industry. The benefit of this community exceeds the sum contributions of the individual players yet leadership has also recognized that a clear strategic message could drive increased collaboration and greater tangible measures of impact. While those of us intimately involved with Team Orlando can easily appreciate the impact of this synergy, making it transparent and understandable to others can be a challenging, but necessary, exercise.

From Operation Blended Warrior to the sharing of Army's new rapid award Training and Readiness Acceleration contracting vehicle, countless collaborative stories can be told just from this year alone. But across decades, the extended impact to the MS&T community has been immense. Accordingly, this paper provides data regarding time, fiscal, and human efficiencies accomplished through the establishment of these co-located key entities. Additionally, similar benefits to the state of Florida for hosting this community is included. Beyond the tangible returns on investment (ROI), insights are provided into intangible benefits such as the University of Central Florida's ability to justify the addition of their College of Medicine, the establishment of a M&S Certification for high school students to develop our next leaders, and to complete the lifecycle, the significant impact of retired Government and military personnel who participate substantially in this community.

Combined, this paper clarifies a process for how to measure ROI in expansive systems, defines guidelines for other communities that would like to replicate, and provides recommendations to the Team Orlando leadership for optimizing its future impact. We hope that the culmination of data, structure, and vision information will be used to inspire and provide fiscal efficiency and effectiveness justification for future programs.

The New Wave of Training Technology Standards

Robby Robson, Ph.D. | Avron Barr

18045

Technical standards often shape the economics of how new technologies are disseminated and applied. After Web based instruction and computer-based simulation emerged in the late 1990's, a wave of new standards that included the Sharable Content Object Reference Model (SCORM), Distributed Interactive Simulation (DIS) and High-Level Architecture (HLA) defined product categories and allowed the possibility of multi-vendor training solutions.

Without these first-generation learning technology standards, the costs and risks associated with acquiring and maintaining large-scale training systems might have dramatically slowed the technology's adoption.

These standards still heavily influence how training technologies are developed and deployed today, but we are in the midst of a new era characterized by ubiquitous computing and a wave of new learning technologies. From Amazon's Alexa to Kahn Academy to augmented reality, the way people learn is fundamentally changing. The old standards are no longer adequate, and a new set of standards is emerging – the last year alone saw the initiation of standards activities related to competencies and credentials; adaptive instructional systems; student data privacy and security; the Experience API (xAPI); and eBooks as platforms for learning. Standards efforts addressing

human performance metrics and augmented reality are already in full swing, and others that will define how virtual reality, cloud computing, AI, big data, blockchains, 5G, and other technologies affect training are on the horizon.

This paper provides practical insights into the new wave of standards and its implications for instructional designers, product developers, trainers, and acquisition commands. It explains what the standards are, what problems they solve, and how they fit together. Implications for training organizations, product developers, systems integrators, and acquisitions commands are outlined.

The strategic role of UCATT standards to NATO's enhanced Forward Presence Mission

Captain Sander Cruiming

18067

The undertaking of field training exercises (FTX) has always been the foundation of the militaries' preparations for war or for operations other than war (OOTW), like peace-keeping, peace-enforcing or disaster response operations. Even though these exercises are far more expensive than virtual training or on-the-map staff training, they serve an irreplaceable purpose in unit readiness training. Live training offers friction that virtual and constructive training (purposely) doesn't. Friction and logistical problems that a field commander will have to deal with during the deployment of his unit. Field training exercises also offer the training audience the necessary training of the mental component that is delivered by the terrain, weather and sleep deprivation. In 2002, a Team of Experts from NATO Army Armaments Group (NAAG) completed a feasibility study to investigate the need for a generic set of requirements for NATO/Partnership for Peace (PfP) countries in relation to live instrumented training. The conclusion was that several potential interoperability areas were identified and assessed to be worthy of further investigation. In accordance with NATO policy, an Urban Combat Advanced Training Technologies (UCATT) Product Development Group was then instated through SISO and continues to expand the requirements set and standards for Live training. This paper will highlight the added value of live simulation and live training in current-day and the "post-Afghanistan and Iraq" era. It will also illustrate the purpose and return-on-investment of M&S standards in a very pragmatic way, by means of present-day cases and examples. Finally, the modus operandi of the UCATT Working Group (and predecessors) will be highlighted, together with an outlook towards future interoperability efforts of the group and its vision on alliance interoperability in the live domain.

Toward Dimensional Analysis Conceptual Modeling for Reusable Modeling Primitive Specification

Ric Roca, Ph.D. | Dr. Eric Coatanéa

18142

Emergent technologies and threats prompt for more robust, nimble, adaptable, and stakeholder-friendly modeling and simulation (M&S) systems-engineering support of simulation-based training and experimentation in the US military. Arbitrary architectural paradigms, inconsistent interoperability protocols and database formats, and proprietary restrictions, among other reasons have given way to models and simulation systems incapable of being reused or used across multidisciplinary domains or communities of interest?severely hampering their return on investment. To be responsive and serve as a unifying and widely-accepted transdisciplinary discipline, the M&S community must provide coherent M&S know-how, leadership, and guidance grounded in tried-and-true science and engineering formalisms that garner multidisciplinary acceptance. We conducted a feasibility study to explore the specification of Reusable Modeling Primitives (RMPs) building on Dimensional Analysis (DA), Design Structure Matrix (DSM) for Complexity Management, and Bond/Causal Graph formal methods. The RMP paradigm underlies a Dimensional Analysis Conceptual Modeling (DACM) framework, conducive to objective specification of model elements and interdependencies. It conduces to methodical reverse engineering, restructure, and reengineering (RE3) processes to facilitate, respectively, harvesting codified simuland referents from legacy models, packaging referent information into configurable DA-based primitives amenable to objective fidelity specifications, and conceptual modeling for alternative intended uses leveraging RMPs. DACM facilitates the contextual decomposition of problem spaces mapped to corresponding solution spaces captured in "finger print" DSM matrixes that facilitate the enumeration of required codified simuland referent components?which facilitate validation of problem spaces and of corresponding fidelity requirement specifications underlying M&S solutions. DSM specification matrixes can help reveal not only problem space knowledge gaps but also which knowledge gaps may be resolved with simulation-based analytics and which require further empirical measures?enabling program managers to target their limited research resources. We present the progression and non-trivial realities of model reuse from a demonstration exemplar involving conversion of a rudimentary ship legacy model to a corresponding torpedo alternative model.

SIMULATION

A Methodology for Componentized Simulation Generation Using MBSE Definitions

Matthew Blair | Eric Sholes, Ph.D. | Gregory S. Reed, Ph.D.

18238

Model-based systems engineering (MBSE) is utilized in numerous enterprise applications to manage large, complex, long life-cycle systems such as ballistic missile defense systems. Additionally, models & simulations (M&S) are heavily employed to support assessment throughout a system's life cycle, with an emphasis on utilizing M&S to aid and reduce cost within development, integration, and test. A key recent objective has been to combine M&S with MBSE in order to 1) enhance development and evaluation of performance requirements alongside traditional methods of deriving functional and behavioral requirements 2) connect M&S and MBSE utilities to allow integrated comprehensive requirements development rather than parallel, disconnected paths for performance and functional requirements and 3) ensure M&S is implemented such that the M&S tools utilized to support requirements development are compatible with or extensible into the higher fidelity physics-based, engineering-level M&S tools utilized as system maturity develops.

This paper describes a new methodology for creating system behavioral simulations in tandem with existing MBSE processes being developed within the U. S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC). The data-driven approach utilizes system functional definitions, event sequences, and transition data from existing MBSE tools such as IBM Rhapsody to dynamically build a behavioral simulation from a library of component math, physics, and behavior models. This approach significantly reduces the integration effort required to create or update a simulation to reflect incremental changes to the system. The proposed methodology maintains traceability of simulation behaviors to their underlying requirements, allowing a simulation to evaluate requirements' impact on the system's behavior and assess sensitivity, suitability, and consistency of those requirements with respect to each other and the system's simulated performance. The resulting simulation can be executed independently of the original MBSE environment, enabling new use cases for systems engineering models, such as directly supporting integration into discrete event simulation frameworks and high-run-count Monte Carlo scenario execution. This capability provides systems engineers an opportunity to rapidly develop and iterate on requirements in cooperation with the modeling & simulation community.

A Modelling and Simulation approach to Cyber Domain

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18188

"In recent events, cyber attacks have been part of hybrid warfare. NATO and its Allies rely on strong and resilient cyber defences to fulfil the Alliance's core tasks of collective defence, crisis management and cooperative security. NATO needs to be prepared to defend its networks and operations against the growing sophistication of the cyber threats and attacks it faces." (NATO Cyber Defence, 2018)

The complexity of Cyberspace, its vast area of applications and the terminology adopted by both the Modelling and Simulation (M&S) and Cyber Community of Interest, make it difficult from both sides to achieve a comprehensive understanding on how M&S could support the Cyber Domain.

This paper proposes a holistic approach to better clarify the areas of application of state-of-the-art M&S technology in Cyberspace. Applying the NATO Concept Development & Experimentation methodology, the authors have developed a research phase, investigating possible solutions to implement a Modelling and Simulation as a Service environment to support and improve NATO's and Nations' efforts in the development of Cooperative Cyber Capabilities. In particular, this research focuses on the NATO Cyber Range Capability development and implementation, looking at improving and expanding its technical capabilities in a distributed cooperative environment through Cyber-based M&S services, namely the Cyber Synthetic Services (CyS2).

The result of this research activity is a Live-Virtual-Constructive simulation technology concept suitable to support studies and further research activities, focusing on use-cases related to the effects of Cyber threats against C2/C4ISTAR systems, Unmanned Autonomous Systems and Operational Technology like Supervisory Control and Data Acquisition systems. The CyS2 solution could potentially support any NATO or National organization dealing with the Cyberspace, and it could be considered a technical baseline for the implementation of a future NATO Cyber Synthetic Environment.

A Simulation Independent Framework for Composing Character Populations

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18187

As constructive simulations are increasingly used to represent training scenarios involving civilian populations, new tools are required for specifying and leveraging these populations. In this paper, we present a novel approach for defining culturally and geographically specific populations of non-player characters (NPCs), in a manner which is independent from any single simulation environment. Developed under contract with the United States Marine Corps (USMC), this system provides a web-based interface for defining populations of characters with a great deal of cultural and behavioral fidelity while localizing these populations to real-world geographical regions. They are then stored in a database for use by a simulation-independent scenario authoring tool, allowing for these populations to be specifically customized to support individual training events. This system represents a simulation independent framework for defining re-usable populations of characters that can be leveraged in a wide variety of training scenarios and environments. Effort expended in defining a population is not lost when migrating to a different simulation environment and its existence as an independent web-accessible server allows for participation by a distributed team of cultural analysts.

Additionally, we present a design for an architecture by which these populations can be instantiated across a DIS or HLA based training federation, their behavior models execute separately while leveraging the capabilities of all connected simulations. This allows the system to maximize the potential of all connected simulations, dynamically scaling behavior processing requirements based upon not only the specific needs of a training federation, but also a real-time assessment of the fidelity requirements imposed by current trainee actions. The system's design helps facilitate large scale populations of characters, dynamically shifting between high and low fidelity models as required by training, enabling high fidelity character interactions with trainees directly, while minimizing wasted processing for characters who are only observed from afar."

Advancing the State-of-the-Art in Airborne LVC Training

Lance R. Call | Rob Lechner

18249

There is a significant shortfall in required live aggressor support for 5th-generation airborne training. A live Virtual Constructive (LVC) environment could significantly reduce this shortfall by utilizing virtual and constructive forces to supplement live aggressors. However, creating a robust LVC environment capable of supporting advanced airborne tactical training has many challenges including information assurance, platform integration, spectrum availability/compatibility, latency, reliability, and high data throughput requirements. Advanced aircraft sensor simulations require accurate data, driving the need for reliable, low-latency networks. Data exchanged over these networks must be integrated into live avionics systems in real-time to maintain data fusion and prevent negative training while minimizing platform impact and cost. There is significant pressure to sell off the 1780–1850 MHz spectrum that is currently in use by military and training ranges. The DOD is being mandated to either move to other less efficient spectrum bands or cohabit with civilian cell phone systems. To address this mandate and further explore requirements for an on-aircraft LVC instantiation, the US Air Force Research Laboratory is conducting an Advanced Technology Demonstration called Secure LVC Advanced Training Environment (SLATE). SLATE is maturing a spread-spectrum waveform named 5th-Generation Advanced Training Waveform (5G-ATW) to test the feasibility of cohabiting with civilian systems that desire to use the 1780–1850 MHz band while providing low latency and high data rates. 5G-ATW will provide the airborne network between live aircraft and ground-based simulation systems to create the LVC environment. 5G-ATW is being integrated into a modified P5 Air Combat Maneuver Instrumentation (ACMI) system and flight tests are to begin in 2018 on an F-15E Strike Eagle modified to support a tactically relevant LVC environment. This paper will discuss technical approaches utilized on SLATE to address design challenges, present findings on the 5G-ATW waveform, and summarize LVC airborne training challenges for advanced platform tactical training.

Agile Terrain Development for Simulation-Based Training

Rick Osborne | Donald Washburn | Mark Faulk | Ronald G. Moore

18295

A large portion of the global population lives in areas of extraordinary geographic size and population density commonly referred to as megacities. Maintaining social stability and ensuring citizen safety in these megacities is a formidable challenge for both civilian and military forces. Disruptive technologies, such as mobile communication devices and social media, can result in near-instant social volatility. Expanded situational awareness, continuous real-time monitoring, and improved reaction and response methods are essential.

Several U.S. Department of Defense (DoD) organizations are working to define how military operations will address megacity-related challenges and what is required to train for these operations. It is unreasonable to define all the megacity geospatial requirements upfront for simulation-based training. Megacities include manmade and natural structures (surface, subsurface, and super-surface); utility networks; complex building interiors; patterns-of-life and emergency response data; sophisticated building usage information; and detailed transportation networks.

This paper presents an agile terrain development process to support simulation-based training. Agile frameworks support iterative product development. When enhancing a product iteratively, the product team does not start with a full specification of requirements. Instead, development begins

by specifying only the well-known requirements and implementing just part of the product, which can then be reviewed to identify further requirements. The team repeats this process, producing a new version of the product that builds upon prior versions. The agile terrain development process assumes there is a terrain data repository that consists of low-fidelity geospatial data for the world and higher-fidelity data for some areas. By leveraging this process, features can be iteratively added to the repository to meet training requirements, reduce cost, and reduce the time to deliver terrain databases to the warfighter. The paper also applies the process to two training examples to demonstrate its utility.

An Architectural Overview of the Augmented REality Sandtable (ARES)

Nathan L. Vey | Christopher Markuck | Yasmina Raby | Charles Amburn

18245

The Augmented REality Sandtable (ARES) is a research project from the U.S. Army's Natick Soldier Research, Development and Engineering Center (NSRDEC) that is investigating novel techniques for visualizing and interacting with complex battlespace information. The system is being used in collaborative research studies with Department of Defense, academic, and industry partners to provide a Common Operating Picture (COP) at the Point of Need. The ARES architecture was initially developed to support a variety of end user modalities (e.g. physical sand tables augmented with low-cost, commercial technologies; mobile devices; and personal computers). NSRDEC is now expanding the existing architecture to begin investigating user interactions using augmented reality and augmented virtuality (AR/AV) technologies, floor projection of augmented information, and distributed collaboration and telepresence across the various modalities. This AR/AV research also encompasses interaction methods using Commercial Off-The-Shelf tracked controllers (e.g. HTC Vive controller), voice recognition, gesture recognition, and game controllers. Intuitive interfaces across the modalities allow users to create, import, or choose maps and terrains from external data sources; place and move tactical graphics; and interact with models (e.g. line-of-sight, route planning, radio, or CBRN [Chemical, Biological, Radiation, and Nuclear]) in real-time. These approaches offer novel platforms for training and operational planning in Multi-Domain Battlefields. Studied benefits of using the initial ARES prototype already include increased user engagement, decreased cognitive workload, and high utility perceptions.

This paper details the modular, Service-Oriented Architecture of ARES. Topics covered include how it provides a COP while conducting expeditionary Mission Command; how it extends the scope of traditional mission planning tools by leveraging models and simulations; and how it allows for third-party application development and integration. It also outlines successful use-cases and provides lessons learned for other system developers.

Assessing Cyber Resilience of Military Systems Using LVC Models

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18323

Cyber Test Analysis and Simulation Environment (Cyber TASE) is a Centralized Test and Evaluation Investment Program (CTEIP) acquisition project designed to provide timely and accurate cyber evaluation assessments for military networks and systems. These include both C2 and Situation Awareness applications including systems such as the Global Command and Control System (GCCS). Cyber TASE has integrated and/or developed a set of innovative data collection, analysis, simulation, and visualization tools to provide a robust cyber assessment of capability. Cyber TASE leverages live, virtual, and constructive (LVC) elements to assess and visualize cyber resilience of DoD systems; in addition, such analysis can be extended to assess resilience of specific missions, especially in cases when some parts of the system under test (SUT) are compromised by cyber attacks. CyberTASE includes a simulation component called Cyber TASE Constructive Simulator (CCS). The CCS is designed to mimic large scale, operationally relevant cyber scenarios for the target systems to be assessed. The CCS can operate in both faster than real-time and near real-time (NRT) execution modes to simulate cyber attacks on the target system.

It also includes the capabilities to collect, report, and visualize relevant metrics from the simulated component. The CCS can be used to pre-run planned scenarios to predict outcomes and to perform "What - If" analysis over a larger parameter space encompassing network topologies, traffic profiles, cyber threats, and cyber defense architectures than would be possible using only live assets. In addition, the CCS directly supports LVC modeling and target systems via its support for real-time model execution, a set of interfaces to connect to live components, and virtual tap points to live data collectors. Thus, the CCS can be used to extend the target system to provide a scalable representation and to assess the cyber resilience of DoD systems in a wider system of systems context. Furthermore, the CCS can launch cyber attacks from the simulated network to expand the attack space for the target system, where cyber impact is limited to simulated devices within CCS. Finally, the CCS supports training use cases both for potential Cyber TASE users as well as for training red force role players.

This paper describes the CCS architecture and illustrates its use via a specific example of cyber testing of a mission vignette for a representative set of cyber attacks intended to disrupt the mission.

Best Practices in Modeling and Simulation; Multi-Community Benchmarking

Steve Roemerman | John Volpi | Randal Allen

18125

Modeling, Simulation, and Analysis (MS&A) supports a wide range of economic, academic and governmental efforts. Many MS&A communities have agreed on methodology within their field. However, there is little interaction among communities. As a result, best practices in one MS&A community may be unfamiliar to others. This paper describes the Modeling Best Practices Benchmarking Project – an effort to identify modeling practices among professionals who might not otherwise gain insight outside their own communities. Practitioners from many disciplines volunteered to describe their practices and learn from others. The goals were to understand best practices across industries and disciplines and define best practices as a set of standards which apply broadly.

From the interview and survey topics, we developed a check list of 14 best practices for those doing MS&A. We also developed three other check lists of risk factors for some specific MS&A topics. Eventually we identified four best practitioners, all of whom impressively addressed the 14 best practices. Two agreed to be named in our work: The U.K. Metrology Office, and the U.S. Energy Information Agency.

The paper will present a sample of the results along with the best practices identified. An example of the results: most respondents did not know regulatory or statutory standards applicable to their work; most did not use processes important to high integrity MS&A. This is a contrast to exemplars.

Challenges and opportunities for the real-time simulation of ship/helicopter operations

Ian Cox | Dr. Gary Henry

18058

The challenges of accurately simulating naval helicopter launch and recovery operations have been actively researched over many years, both in industry and academia. However, the same problem remains – how accurate does the whole simulation package and its various components need to be, such that the simulation data can be reliably used to support the generation of Ship/Helicopter Operating Limits (SHOLs).

The UK the Ministry of Defence Chinook helicopter Delivery Team identified a need to utilize simulation for the first time as part of an integrated, safe and progressive approach to the development of SHOLs for the Chinook aircraft. If sufficient evidence can be generated on the validity of the simulation, then the opportunity exists to more widely utilize simulation data as a cost effective ally to data generated during flight trials at sea.

The Ship/Air Interface Framework (SAIF) simulation architecture was initially developed over 15 years ago, and has recently been updated to provide a more open and flexible flight simulator interface. This has allowed high fidelity models of ship motion and air wake effects to be integrated with an engineering flight simulator of the Chinook helicopter, providing the pilot with a more realistic simulation of the dynamic operating environment. Initial simulation trials of the Chinook operating from the new Tide Class tanker vessel were conducted in 2017, prior to sea trials to be conducted in 2018.

This paper will describe the driving factors for the increased use of simulation to support the Ship/Air Integration clearance process and the latest design evolution of the SAIF architecture. Several areas for fidelity improvements in different functional areas of the simulation are also highlighted, including visual fidelity and rotor wake interaction. An evidence based methodology for the verification and validation of the simulation is also required to enable greater acceptance of simulation-based data.

Controlling Synthetic Characters in Simulations: A Case for Cognitive Architectures and Sigma

Volkan Ustun | Paul S. Rosenbloom | Seyed Sajjadi | Jeremy Nuttall

18205

Simulations, along with other similar applications like virtual worlds and video games, require computational models of intelligence that generate realistic and credible behavior for the participating synthetic characters. Cognitive architectures, which are models of the fixed structure underlying intelligent behavior in both natural and artificial systems, provide a conceptually valid common basis, as evidenced by the current efforts towards a standard model of the mind, to generate human-like intelligent behavior for these synthetic characters. Developments in the field of artificial intelligence, mainly in probabilistic graphical models and neural networks, open up new opportunities for cognitive architectures to make the synthetic characters more autonomous and to enrich their behavior. Sigma (?) is a cognitive architecture and system that strives to combine what has been learned from four decades of independent work on symbolic cognitive architectures, probabilistic graphical models, and more recently neural models, under its graphical architecture hypothesis. Sigma leverages an extended form of factor graphs towards a uniform grand unification of not only traditional cognitive capabilities but also key non-cognitive aspects, creating unique opportunities for the construction of new kinds of cognitive models that possess a Theory-of-Mind and that are perceptual, autonomous, interactive, affective, and adaptive. In this paper, we will introduce Sigma along with its diverse capabilities and then use three distinct proof-of-concept Sigma models to highlight combinations of these capabilities: (1) Distributional reinforcement learning models in a simple OpenAI Gym problem; (2) A pair of adaptive and interactive agent models that demonstrate rule-based, probabilistic, and social reasoning in a physical security scenario instantiated within the SmartBody character animation platform; and (3) A knowledge-free exploration model in which an agent leverages only architectural appraisal variables, namely attention and curiosity, to locate an item while building up a map in a Unity environment.

Creating a 360-Degree RGB-D Sensor System for Augmented Reality Research

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18211

Augmented Reality systems require both localization of the user and mapping of the surrounding area in order to correctly display virtual objects in a manner that is believable to the user. A single sensor can accomplish this with a SLAM algorithm but faces issues if the user performs a significant and quick rotation of the head as features that were being tracked are lost. An omnidirectional camera (360-degree horizontal, near 180-degree vertical) can resolve this, but COTS solutions in this domain only provide RGB information. In this paper we demonstrate a prototype system that fuses the imagery of four RGB-D sensors to create a 360-degree horizontal sensor feed of both color and depth information. We detail the design of the sensor array and challenges faced when attempting to record or visualize the data in real time with each camera's frame synchronized to other information necessary for future experiments. We also discuss the fusion system used and how this can detect features as a user rotates the sensor array in motions similar to human head movements. In the end, our sensor array shows the potential for quick, COTS-based prototype units that may make use of two or more RGB-D sensors in order to provide accurate localization and mapping of the environment for augmented reality research.

Crisis Decision-Making with M&S Support in Complex Urban Environments

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18086

Natural disasters, complex emergencies, mass migration, armed conflicts, terrorism, cyber and hybrid threats can have a drastic impact on population and critical infrastructures in complex environments like large cities. To make decisions under stress when every course of action has its drawbacks, e.g. in crisis or disasters, is a very demanding task involving many challenges: uncertainties, shortage/overload of data, updated situational awareness, information exchange, knowledge management, civil-military and interagency coordination.

To address these issues the NATO M&S COE in collaboration with the NATO MSG-147 group has proposed the Interactive Model for Operations in Metropolitan Areas (IMOMA) developed while taking into consideration three different aspects: -An innovative approach by exploiting interoperable models, databases and simulations enabling iterative planning. -A technical framework that formalizes how to combine disaster physical models (e.g. toxic gas, earthquake, flooding, etc.) with urban geographic models and emergency procedures. -An urban Decision Support System providing the updated situational awareness to enable good decision-making in emergency and in operational and logistics planning.

With these considerations, the IMOMA model tested during the MSG-147 M&S-based interoperable architecture experimentation provides an environment and a city decision support tool for: estimating the preparedness level; evaluating mission concepts; analyzing damages, population impacts, and decisions; and simulating deployment and logistics by interacting with chosen tactical actions. Additionally, information provided by governmental agencies can be supplemented in near real-time by sensors' data, web-scraped data, and voluntary geographic information, citizens' damage reports, and tweets.

In conclusion, the IMOMA demonstrated a high level of interoperability among the proposed systems. In particular were tested the reuse of a geographic information system model of a large city, the latest innovative constructive simulators, and command and control systems interoperability using MSDL/ CBML standards.

Deploying Disruptive Technology in an Agile Intelligence Training Environment

Jason Rogers | Todd Neal

18079

As described in Army Warfighting Challenge #8, we must now find ways to support training of soldiers and leaders to accomplish a range of missions in complex environments against adaptive enemies that may actively avoid US strengths. In particular, military intelligence (MI) units must be able to execute collective tasks on organic equipment in austere environments. Many current live, virtual and constructive (LVC) training simulations are executed on robust, powerful and single-skill focused legacy solutions. Their very nature results in significant overhead to sustain or tailor, while not sufficiently engaging multiple military functions. In this paper, we describe novel methods to address these challenges through disruptive technology deployed in an agile intelligence training environment.

By constructing a simulation engine architecture with dynamic data generation based off real world demographics data, we've developed methods for the simple and fast injection of relevant raw data. Text generation and manipulation techniques are used to modify these inputs resulting in automatic production of unique, tool agnostic intelligence data with the fidelity and realism needed for pattern recognition and cross queuing targeting. Scenarios are generated with region specific threat and non-threat constructs, fully populated with correlated signals, communications, pattern of life activity and geospatial movements. Filter and distribution methods allow for scaling of generated "haystack" data around key trainer authored "needle" data, based on training audience skill level. The simulation is then deployed to an integrated full spectrum threat environment consisting of 1) a synthetic internet created by efficiently merging multiple resources of different fidelities into a single largescale network simulation and 2) a live broadcast environment designed around software defined radios, fixed frequency radios and unique lab cell tower equipment. Currently, these methods and technology are supporting SOCOM and INSCOM Units to provide a single, low cost mobile environment for multi-discipline training to address the challenges faced by our warfighters in an increasingly complex world.

Exploring Cloud-Based Terrain Generation Services

Lance Marrou | Glenn Carr | Keith Nielsen

18253

The U.S. Department of Defense (DoD) Chief Information Officer (CIO) has committed to the adoption of the data center/cloud/generating force computing environment (DC/C/GF-CE) under the DoD Risk Management Framework (RMF). The U.S. Army (Army) long-term objective of transitioning to scalable and reliable cloud-based information technology (IT) services cannot be realized unless the services are approved and secured under the RMF.

Organizations are becoming increasingly reliant on information system services provided by external organizations to conduct important missions and business functions. The Army's numerous instantiations of applications, services, and hardware hosting locations add complexity to applications interoperability, lead to untimely data sharing between communities, perpetuate inefficient functional processes, and require significant resource investments. These external providers are often cloud-based services in the form of infrastructure, platforms, and software. The Army Cloud-Enabled Network Concept of Operations describes an operational framework for using cloud-enabled technology. A change is needed in how applications, data, and services are hosted to meet future warfighter needs and exploit the evolving, data driven, interconnected eco-system, despite resource constraints. Although this problem is being addressed for the Army's mission command areas through the Common Operating Environment (COE) initiative, our effort builds on the work of DC/C/GF-CE for modeling and simulation (M&S) communities of interest.

In this paper we document the experiment of extending a military network (.mil) into the commercial cloud (.com) under RMF on an Army program of record. We briefly describe how we leveraged other concurrent and previous work to establish our use cases for cloud-based terrain generation services. We identify lessons learned in adopting a cloud CE for M&S training applications, and initial analysis conducted related to geospatial data processing in the cloud CE. We conclude with recommendations of future M&S usage of these capabilities.

Game-based Proving-grounds Simulation to Assess

Kevin F. Hulme, Ph.D. | Aaron Estes, Ph.D. | Matthias Schmid, Ph.D. | Emmanuel Gil Torres | Christopher Hendrick

18003

Driving & Learning Preferences"

Modeling & Simulation (M&S) is an effective mechanism for bridging the gap between experimentation and implementation; between basic theory, and real-world application. For example, in the field of engineering systems and dynamics, trainees can leverage M&S to experience vehicle control within a high-fidelity game-based environment to simulate the operation of a physical vehicle. Engineering insights gained through "active" learning with simulation are essential; as ground vehicle transportation continues towards fully self-driven vehicles, there remains numerous technological and human factors challenges yet to be overcome.

This paper discusses the experimental design of a game-based simulation environment implemented for a road vehicle dynamics (RVD) university-based engineering curriculum. The Simulation exercise is The (ISO 3888-2) Moose Test - an evasive vehicle maneuver, typically performed by on-road experts, to determine the thresholds of vehicle handling under aggressive driving conditions (e.g., swerving to dodge a moving obstacle). Our developmental basis is to provide a virtual-constructive Simulation environment for novice learners to: a) experience this maneuver under controlled conditions (e.g., two courses; three entry speeds; with or without electronic stability control), b) optimize performance (i.e., maintain vehicle control and remain path-centric), and c) obtain an improved understanding of vehicle stability that would not be feasible on an actual proving grounds.

Using both Simulator and self-report metrics, we will further observe if experimental performance correlates to tendencies relevant to driving and learning, which could inform the degree to which Simulation-based training is better suited towards certain categories of drivers. As critical Broader Impacts, this insight could advise how the operation of next-generation vehicles (i.e., mechanisms for operator intervention) can be tailored to individual differences (e.g., age, experience, aggressive tendencies) in specific driver types. Likewise, this M&S implementation has extensibility to military applications (e.g., pilots for aircraft) within transportation and human factors research.

In Search of Plausibility: Simulating a Future Contested Urban Environment

Justin Fidock, Ph.D. | Teresa Crea, Ph.D. | Trent Burnard | Scott Alexander | Shane Ploenges

18132

Urban warfare presents substantial challenges for our warfighters. Currently Australia and its allies are working together to explore the potential of promising technologies and associated concepts of use that could enhance the intelligence, surveillance and reconnaissance (ISR) capabilities of tactical forces in future contested urban environments (CUE). This paper highlights the learnings and innovations from a novel multinational technology trial, involving approximately 80 researchers from the 'Five Eyes' Nations and some 100 uniformed Australian Army and Airforce personnel, conducted in late 2017 using a combination of live and virtual simulation. One of the key challenges in exploring concepts of employment through simulation is ensuring that the concepts have enough 'plausibility' to reflect potential future use. The authors were cognizant that unless they worked with the diverse stakeholders to generate sufficient plausibility, the trial would run the risk of failing to adequately engage the participants or generate shared understanding. The methodological response to developing sufficient plausibility drew on a variety of disciplines and hinged on two key elements: firstly the need to identify and create urban contexts in live and virtual settings that presented a range of indicative urban stressors of relevance to exploring and exploiting ISR technologies; secondly, recognition of the potential of narrative methods to support deeper consideration of the proposed concepts of use, as well as strengthening the quasi-naturalistic research approach identified as most suited to the exploratory nature of the trial. The authors use key findings from the trial to illustrate the extent to which sufficient plausibility was achieved. They suggest that the methods used in the trial have implications for enhancing live and virtual simulation and supporting effective exploration of technologies in future CUE.

Jamming Techniques and their Usage in Distributed Electronic Warfare Simulation

Charles Brooks | David Haber | Patrick Merlet

18252

The Institute of Electrical and Electronics Engineers 1278.1 Distributed Interactive Simulation (DIS) Standard's Electromagnetic Emission Protocol Data Unit contains a Jamming Technique field and the associated jamming techniques are enumerated in SISO-REF-010. There are currently 134 hierarchical jamming techniques listed with no information provided other than their name and location in the hierarchy. This is not enough information to ensure common understanding among Electronic Warfare (EW) subject matter experts and simulation developers to support interoperability, fair fight, and good training. This paper describes an ongoing effort to provide definitions for these techniques, address issues with the hierarchy, and provide additional jamming interaction data that will support higher fidelity simulation.

This effort has two phases. The first phase is to provide concise and unambiguous definitions for all valid jamming techniques. To document jamming technique definitions in an open environment, we cite unclassified and exportable academic and research sources. The jamming technique definitions allow jammer and radar modelers to have a common understanding of the techniques which facilitates fair fight distributed EW between manned simulations, constructive forces, and live assets participating in a training scenario. The jamming technique definitions are proposed for a new annex of the DIS Standard.

The second phase will redesign the hierarchy to properly support interoperability between systems with different levels of fidelity. One of the main reasons for the proposed redesign is that the current hierarchy contains a problematic mixture of jamming system architectures and techniques. This phase will also propose additional attributes that will allow jammer and radar simulations to more efficiently represent more detailed EW interactions. The additional attributes help define the quality of the jamming waveform and will allow higher fidelity simulation of the effects on the victim radar.

All proposed changes will be vetted with the simulation community.

Knowledge is Power - Representing Complexity in the Information Age

Rob McConachie

18300

Thales UK undertook self-funded research and development (SFR&D) to explore the nature of the changing operational environment, and options for supporting training systems.

This paper seeks to describe the information problem space; first from an operational and doctrine viewpoint to determine how the operating environment is described and understood, and which principles are advocated for the conduct of operations within it. It describes the need to train military decision makers to obtain and maintain understanding of an evolving information environment; to identify relevant audiences whose behaviours, perceptions, and attitudes are to be affected, and to make informed decisions in the employment of capability for effect.

Secondly, the problem space is described from a training and force-readiness perspective; suggesting how training could be improved by integrating models that provide a dynamic context to simulated operations. It considers how forces can develop and maintain this operational superiority, and why these complex synthetic training environments are an important discriminator for modern armed forces' training in the Information Age.

Finally, the paper introduces initial concept development and experimentation activities to explore candidate methods for the future rapid modelling of dynamic contexts from raw data. It is proposed that the application of these techniques could be used to deliver tooling or services to enable training for the full spectrum of military effect; by credibly representing all aspects of global operating environments.

Machine Learning-based Avionics Simulator for Cyber Security Intrusion Detection

Wenlong Zheng | Geoffrey Greenwalt

18094

A cyber attack on an airplane is more feasible than physically taking control of the airplane. The attack can intrude into the airplane via the communication bus to create a frightening situation. Such an attack can circulate malicious commands or simulate malfunctions to impact the avionics such as flight controls, navigation or offensive system operations. MIL-STD-1553 is a commonly used multiplex data bus system in military and aerospace avionics. Recent studies have assessed the physical impact of successful cyber attacks on an aircraft using the 1553 communication bus. This paper presents a modern avionics modeling and simulation framework using an object-oriented, scalable simulation software architecture and proposes a novel approach to detect airborne cyber-attacks using a machine learning algorithm. The major components of the simulation framework consist of an operating system application interface, simulation model units, a data communication network, and a simulation scheduler. The simulation framework facilitates modularity, scalability, portability, reusability and robustness for the commercial or military avionic platforms. This research also conducts a security analysis of the MIL-STD-1553 communication bus, evaluates possible cyber-attack methods, and simulates the 1553 data transmission topology. Moreover, we propose a Hidden Markov Models (HMM) machine learning-based algorithm to detect sequence anomalies in the 1553 communication bus. Being an HMM statistical model, the 1553 communication bus system is modeled as a Markov process with hidden parameters. The hidden parameters are deduced from the observable parameters and the states of the HMM are modeled from unobservable conditions. The HMM algorithm has a training phase and a detection phase: the

training phase identifies the Markov model states and computes the anomaly threshold, while the detection phase determines the message anomalies. We use the avionics simulation framework to simulate 1553 communication topology settings under different cyber attack scenarios. The experiment results are evaluated and discussed.

Maintaining Deep Content Libraries While Meeting Rising Quality Standards

Brian Vacek

18024

We live in an era of data proliferation, where content is born quickly, but ages quicker. The standards enforced by regulatory bodies and customer expectations are continuously on the rise, increasing the rate at which simulation content becomes qualitatively stale. A year, a month, or less goes by and once-fresh satellite imagery turns into a history lesson; ex-state-of-the-art 3D models are reassessed as blocky embarrassments; formerly "photorealistic" textures appear to our modern eyes as impressionist blurs; databases defined in yesterday's format de jour aren't even compatible with the latest hardware or IG. The constant churn means that, for many organizations, they are losing value to data obsolescence faster than they can add value through data acquisition.

This paper delves into the issue of maintaining deep content libraries while meeting rising quality standards. We break down the problem space into a set of overlapping topics: • Scalability – Generating static data faster, leveraging dynamic data • Compatibility – Standards, converters, and outpacing the format treadmill • Timeliness – Capturing real-world changes. We survey classical and novel solutions to these problems, make predictions based on current trends, and propose best practices.

Operation Blended Warrior 2017 - Behind the Curtain!

Cathy Matthews | Kent Gritton | Dave Kotick | CDR Gilbert Gay, USN | Farid Mamaghani | Gary Fraas

18129

The Wizard of Oz quote, "Pay no attention to that man behind the curtain!" is applicable in many ways to the Modeling, Simulation and Training (MS&T) community. This paper takes you behind the Operation Blended Warrior (OBW) curtain. OBW, conducted as an I/ITSEC special event for three consecutive years, has allowed an opportunity like no other for industry, government and academia to collaborate and showcase their Live, Virtual, and Constructive (LVC) systems, tools, and capabilities. Integrating a disparate group of systems, requiring use of common data, defining a common infrastructure, and providing rules of operation are just a portion of the significant efforts undertaken by OBW and its participants. Yet, gaining real insights into what makes the event a success is difficult by merely watching the event from the conference floor. We, as an MS&T community, are far from turnkey integration of diverse LVC systems. The LVC community must do more than hope for a "plug and play" state where all systems magically connect, fully interact, and consistently represent the military mission environment. In fact, many do assume this is a relatively easy task, and for good reason; often the presentation of the final product is made to look easy. Flag level interest in LVC solutions for military applications continue, but the challenges in conducting successful LVC events are still not fully understood. Better understanding would allow leaders to better focus their resources. OBW 2017 was the most recent opportunity to bring all interested parties to such an open and varied networking event. This paper highlights specific topics to include technical challenges, innovative workarounds, and unintended benefits of bringing a slice of the MS&T community together for the common goal of OBW success. Valued insights gained from OBW are documented as a baseline for further growth.

Operation Blended Warrior 2017 Terrain Database Interoperability Lessons Learned

Michael Woodman, Ph.D. | Thomas Kehr | Farid Mamaghani | Ron Sprinkle

18254

This paper explores the lessons learned from using a high-resolution terrain database, and the establishment of an on-line repository for its distribution, in order to support Operation Blended Warrior (OBW) 2017. OBW has been a multi-year, annual Live, Virtual, & Constructive (LVC) special event, conducted during the Inter-service/Industry Training, Simulation, and Education Conference, focused on exploring the challenges in using LVC simulations for training. To support OBW 2017, baseline terrain databases, runtime formats, and 3D models were shared with OBW participants via a common online repository. This proved to be extremely valuable, as previous OBW exercises required participants to access multiple disparate and often ad hoc repositories to locate terrain source data and database products. Despite using a single terrain distribution source, there were still clear difficulties in terrain interoperability: multiple systems used by various organizations – both government and industry – resulted in variations in appearance and quality of the terrain and models displayed; some hardware was insufficient for processing or displaying the high-density database; and anomalies such as floating buildings, broken roads, avatars walking in air, vehicles driving through trees, and avatars on ship remaining stationary while the ship was moving up and down (ankle deep in steel!). We explore the causes of the problems – whether hardware-related system problems, terrain development glitches, interoperability standards or compatibility issues, or software configuration settings. These problem areas are evaluated from a technical perspective and also from the perspectives of several OBW participants. Finally, we explore the impact on "fair fight" interoperability vice purely visual anomalies and highlight how to avoid them.

Performance assessment of the communication infrastructure for the LVC Simulation

Sangjin Lee | Dohyung Kim

18130

Each of the Korean Army, Navy, and Air Force has plans to build its own Live-Virtual- Constructive (LVC) simulation. To build a LVC simulation environment, it is necessary to link distributed resources and models. However, interoperation with distributed resources and models has many complexity issues, such as designing the communication infrastructure for distributed environment, linking between heterogeneous architectures (e.g. HLA, DIS, DDS etc.), interpreting differences in resolution of models, and overcoming the differences in time advance techniques between models. This paper reports on a method to check whether the communication infrastructure has the capabilities for the distributed LVC simulation environment. We extend the performance assessment method of a gateway in the LVC Architecture Roadmap Implementation (LVCARI) to apply to the Korean force's operational characteristics and distributed simulation environment. The method proposed consists of three parts: defining performance indices, considering test scenario, and configuring test environment. First, the test scenario generates the test cases in which communication infrastructure is operated. The scenario has some properties, e.g. number of entities, number of interactions, number of transactions in a unit interval, pattern of message generation, and complexity of translation between architectures. Second, performance indices represent how much the communication infrastructure supports the LVC simulation environment. The speed of message transfer has to be high in a small size and high-resolution model such as an engagement-level simulation with entity models. However, the speed could be low in a large-scale simulation such as the combined forces simulation with aggregate models. Third, test environment that evaluates the communication infrastructure. As the LVC environment is distributed and has communication devices, the way of collecting statistics and configuration have to consider these aspects. This performance assessment method can be applied to check if the communication infrastructure satisfies the requirements of an LVC simulation environment.

Rendering Effects of Wind on Vegetation for Flight Simulators

Abhishek Verma | Tyler Ricks

18102

The effects of wind on vegetation provide important visual cues for training in a flight simulator. For example, the influence of wind on trees is used to determine the intensity and direction of the wind. Rendering such wind effects on vegetation is a complex problem for typical flight simulators because they contain large-scale vegetation areas with disparate vegetation types. Simply creating large numbers of vegetation entities of the same vegetation type does not accurately represent real-world environments. Therefore, the effects of wind must be simulated using techniques that will accurately produce varied effects for different vegetation entities.

This paper describes a GPU-based method to apply the effects of wind on different types of vegetation. The vegetation types discussed in this paper are categorized based on species, height, shape, and geometry. Depending on the category, this method makes use of vertex or pixel manipulation to morph the entities in order to simulate dynamic wind effects. The application of this methodology is further elaborated by adapting it for the vegetation areas rendered using techniques described in the paper "Rendering Large Areas of Dense Trees for Flight Simulators," presented at I/ITSEC 2016 by Verma, Thorpe, and Ricks. The next section of the paper describes techniques to generate vegetative entities. The last section of this paper goes through visual and system performance results to show the effectiveness of this methodology.

Saving Eyesight Using Simulation

Teresita Sotomayor, Ph.D. | Margaret P. Bailey | Ian T. Dykens | Steve Dorton

18074

Over the past 13 years of conflict, eye injuries have occurred at a rate of 5-10% for combat injuries attributed to improvised explosive devices (Owens, Kragh, Wenke, Macaitis, Wade, & Holcomb, 2008). Many of these injuries result in a compartment syndrome of the orbit, easily decompressed through the use of a simple procedure called a Lateral Canthotomy and Cantholysis (LCC). Curricula at the U.S. Army Center for Pre-Hospital Medicine (CPHM) Tactical Combat Medical Care (TCMC) incorporates LCC training presented in lectures and taught through limited use of live tissue. This eyesight-saving skill must be practiced and rehearsed by military providers to increase competency, presenting the need for a low cost, reusable, haptic training device for developing and refining the required psychomotor skills. This paper describes the iterative design and development process of an LCC prototype training system. The paper emphasizes the process used to define qualitative medical requirements and technical objectives, and their translation into quantitative design and production metrics. Additionally, the incorporation of modern additive manufacturing technologies (i.e., three-dimensional (3D) printing) is discussed, highlighting the benefits this emerging technology could provide during development and production. 3D printing enables more rapid design iterations through low cost on-site prototyping, and enables local small quantity production of single use medical training devices. The ability to produce units at low cost will make the system feasible for training by enabling the training audience to practice multiple times as needed to develop the required psychomotor skills for the LCC procedure, thus improving trainee confidence. Applying this process to reduce the time and cost for designing, developing, and fielding haptic medical simulators in general is discussed. The paper concludes with results from user evaluations, discussion of technical challenges and lessons learned, and the path forward.

Simulation Architecture for Network Centric Sensors and Electronic Warfare Engagements

Reeshen Reddy | Brian Burmeister | Solly Manamela | Ushik Mewalal | Umur Kathree

18156

Network Centric Operations describe the modern form of military action in the information age. Networked Sensors allow for information superiority acting as a force multiplier, greater lethality and increased survivability. The modern network centric battlefield requires advanced modelling and simulation (M&S) to predict performance of sensors and the effect of their performance on platform protection and weapon lethality in many-on-many scenarios.

This paper presents a novel M&S architecture for engagement scenarios in modern network centric operations involving sensors such as radar, communication and electronic receivers; effectors such as missiles, jammers and chaff; and systems that combine inputs and outputs of sensors and effectors such as combat management suites (CMS), threat evaluation weapon assignment (TEWA), aircraft mission computers (AMC) and command and control (C2) systems.

The key differentiators between system centric, platform centric and network centric scenarios are described. Emergent properties of networked platforms and systems are analyzed to arrive at the emergent functions of sensor management, threat evaluation and effector assignment. General requirements for each of these functions are expanded upon by inferring from typical examples in the air, naval and ground domains and the conceptual modelling approach for each are described.

The architecture presents a shift from traditional time line or scripted based simulation and requires a certain degree of autonomy where the simulated platforms and systems decide on an action depending on the scenario and pre-defined rules of operation. This fundamentally requires systems triggering actions or commands of other systems via the functions of sensor management, threat evaluation and effector assignment. The increased autonomy of the simulated platforms lends to modelling engagements with cognitive systems using artificial intelligence and machine learning.

This novel M&S architecture allows for a closer representation of Network Centric Operations for Sensors and Electronic Warfare Engagement Simulation (SEWES) and enables advanced tactics and doctrine development.

The OBW Emerald City Inset Experience

Ronald Moore | Thomas Kehr | Sean Sedlak | Ryan Boyd

18139

The Operation Blended Warrior (OBW) integration demonstration at the Interservice/Industry Training, Simulation and Education Conference 2017 (I/ITSEC'17) provided the U.S. Army an opportunity to evaluate the shareability of the SE Core Master Database by providing OBW participants with source data and correlated terrain datasets. SE Core and OBW'17 leadership selected a 200x300km area of the Pacific Northwest (PacNW) that met the land, sea and air requirements. SE Core prepared the PacNW dataset to meet the "DISTRIBUTION C" classification requested. During the first OBW planning meeting, the ground scenario group expressed the desire for a small inset representing a Dense Urban Terrain (DUT) area with unlimited distribution. A small 10x10 kilometer area of Seattle Washington, labeled the Emerald City Inset (ECI), was selected, and SE Core prepared this dataset to meet the "DISTRIBUTION A" request of the OBW leadership. After providing the initial production of a source dataset to all interested OBW participates, SE Core produced several run-time terrain formats to enable more participates to become part of the OBW ground scenario. SE Core provided both the PacNW and ECI source data to eighteen Government, Industry, and Academic organizations, while simultaneously generating multiple other formats including OpenFlight®1, OneSAF, Virtual Battlespace 3 (VBS®23), and Virtual Reality Scene Generator (VRSG™3) used during the OBW'17 demonstration events. Once the availability of an open-distribution SE Core DUT proliferated,

many other Modeling and Simulation industry members outside of OBW'17 requested a copy for experimentation and demonstration at the I/ITSEC'17 conference. This paper describes the production processes and license coordination required to deliver the Distribution-C PacNW and Distribution-A ECI source dataset, along with the associated runtime databases. Additionally, this paper provides important lessons learned from the coordination across the various OBW'17 and general industry consumers and provides insightful feedback on what would have made the SE Core data more easily consumed by their respective products and processes.

Toward Megacity Simulation: A Proposed Pattern-of-Life Definition Standard

Adam Easton, D.Phil. | DRomesh Ranawana, D.Phil.

18262

Pattern-of-life (POL) is used to make simulation scenarios more realistic. POL should include the information necessary to add crowds of people, traffic, public transport, and when relevant, even animals to a simulation scenario. The POL has to specify how each of these entities will behave within the scenario. The challenge for simulation planners is the amount of effort required to manually add a scenario and geography specific pattern-of-life to a simulation. Such scenarios are often not portable and have to be largely reworked for a different scenario or geography. These challenges are particularly prevalent when simulating large 'megacities' containing thousands or even tens of thousands of entities.

We present a proposed Pattern-of-Life Definition Language (PLDL) as a potential industry standard to provide standardized, portable and re-usable POL definitions. The PLDL schema allows a simulation planner to design POLs which are independent of simulation scenarios, platforms and geographical locations. The PLDL can be used to define POLs at different levels of abstraction. Levels of abstractions can be chosen to suit the simulation requirement. A PLDL POL definition can be modified to use demographic information.

Our proposed PLDL is terrain independent, allowing a POL to be defined and later mapped to a specific terrain through a series of building tags. Such tags can be manually added to a terrain or automatically generated through existing technologies such as OpenStreetMap or ShapeFiles.

With further refinement, the PLDL can become an industry accepted standard with the potential to facilitate a new wave of pattern of life capability within simulations.

BEST PAPER

Understanding Cloud-Based Visual System Architectures

Jeanette Ling

18042

The Government's "Cloud First" policy of 2011 set an accelerated course of government technology migration to cloud resources. The benefits of cloud services and infrastructure are appealing for use in simulation and training for many reasons, including the ability to provide point-of-need (PoN) simulation, freedom from hardware maintenance and upgrades, reduction of capital expenditure and hardware footprint, and practically limitless resources that allow ease of scalability. Evaluation of the fitness of visual system services for migration to the cloud as per the cloud-first guidance of readiness and value is highly dependent on the intended use case and architecture of a cloud-based simulator.

While attractive in concept, serious limitations in training quality and effectiveness can exist depending on the implementation strategy of a cloud-based visual system. This paper explores the technical challenges and functional ramifications of distributing visual system components across the cloud compared to on-premises resources. Topics include latency, performance, distributed visual system architectures, latency tolerance of basic visual system components, and edge device computing.

A wide spectrum of use cases exists within the simulation and training realm, and cloud-based visual systems must provide a flexible and adaptable hybrid cloud architecture to achieve required goals across very diverse training needs and physical infrastructure.

Using Modeling and Simulation to Design the Future Squad

Neil Pinto | Chris May | Andy Gross

18241

As emerging and disruptive technologies for both Blue Forces (BLUFOR) and near peer Opposing Forces (OPFOR) change the respective tactics, techniques and procedures (TTPs) for Army operations, we must understand the impact across the multi-domain (land, air, maritime, space, and cyberspace) battlespace. Modeling & Simulation (M&S) provided analysis can inform technology investment decisions now, so that the Future Infantry Squad can improve the fundamentals of shooting, moving, communicating, protecting and sustaining. In the past, disparate efforts across organizations have caused duplication of efforts instead of a combined/interoperable solution. Current and future M&S-supported analysis and data need to be more readily accessible to inform Program Executive Offices (PEOs) to drive Science and Technology (S&T) investments with the best return on investment. To address this issue, the Soldier Lethality (SL) Cross Functional Team (CFT) has established an M&S Working Group (WG) to look at the following questions. 1) What are the Soldier Lethality CFT M&S requirements based on S&T roadmaps? 2) What past and current M&S and analytical efforts have been used to support similar efforts and can be leveraged to support future efforts. 3) How can modeling and simulation be used effectively to show component level, system level, and squad aggregate advantages? 4) What gaps exist when predictively simulating real world technology and the human element? 5) What improvements are needed to make the technical aspects of M&S easier to use? Finally, this paper will present the findings and path forward from the 2018 Soldier Lethality CFT Workshop where the Future Infantry Squad M&S WG investigated considerations to reduce design time, improve quality of delivery, and more easily integrate complex systems.

Using the Advanced Modular Manikin Architecture to Extend the Scope of Medical Task Trainers

Daniel S. Silverglate | Edward M. Sims, Ph.D. | Teresita Sotomayor, Ph.D.

18184

Whole-body medical manikin systems can be prohibitively expensive for training specific medical procedures and may compromise the fidelity of important cues. As a result, many Tactical Combat Casualty Care and Prolonged Field Care procedures are taught using part-task trainers that simulate the visual, aural, and haptic cues required for only one or very few tasks. Using these part-task trainers reduces cost, but requires learners to practice skills in isolation, without the patient cues relied on when performing clinical reasoning and critical decision-making in a real situation. Also, learners do not have the opportunity to observe patient outcomes or refine treatment based on patient response.

The Defense Health Agency has funded the Advanced Modular Manikin (AMM) Architecture to develop an open-standard modular manikin platform. Although AMM was primarily envisioned as a standard for interoperability of physical manikin segments, the AMM data standards can also be used to integrate a combination of virtual and physical modules, enabling new forms of blended reality training. To promote flexibility and modularity of the AMM specifications, the team selected the open standard Data Distribution Services (DDS) specification and developed a common AMM Data Model that represents clinical data in vendor-neutral formats.

To demonstrate the feasibility and effectiveness of this multi-modal AMM approach to medical simulation, several modules were adapted to be conformant with the AMM standards. This application of AMM includes integration of a part-task trainer for Humeral Head Intraosseous Infusion (HHIO), a physiology module and AMM core software on an embedded computer, a virtual patient system, and instructor, learner and technician user interfaces on tablets. In this paper, we will provide a description of the integrated platform, the open standards implemented, and the interactions and interventions that could be shared. Integration challenges and lessons learned will also be addressed.

Validation of a Wind Profiler Using Modeling and Simulation

Amanda Cinnamon | Sarah Lampke

18103

The Precision Airdrop (PAD) Program of the Air Force Research Laboratory (AFRL) has funded the development and testing of the Airborne WindTracer® for Precision AirDrop (AWPAD), a wind profiling light detection and ranging (LIDAR) system that can be used onboard during airdrop operations. A demonstration of the AWPAD's suitability for PAD was performed at Yuma Proving Grounds (YPG) in Yuma, AZ in June 2017. To fully assess the system's fitness for mission, validation of the WindTracer® data was required.

Validation of remote wind sensors is a unique challenge because they perform in uncontrolled environments where it is impossible to know the exact wind at any given location. Traditionally, wind sensor validation is achieved by comparing data from a new wind sensor to that of a previously validated source. One of the biggest challenges in remote wind sensor validation is the impossible task of finding a previously validated system that assesses the same volume of air at the same time. Wind profiling radar and lidar systems have their own parameters, such as beam width, bin size, and scan pattern, that determine the geometry and timing of the wind field measurements. Sampling rates and altitude coverage also varies, making direct comparisons challenging. Additionally, each system has its own filtering algorithms and integration times which can result in significantly different results that are not due to inaccuracies. In essence, each system has its own truth.

To validate the AWPAD system, AFRL used a novel approach that minimized some of the challenges mentioned herein. While traditional validation efforts focus on direct comparison of data values, AFRL used an airdrop trajectory simulation that determined the payload point of impact (PI) for each independent wind profile. Distance between PIs then corresponded to wind profile similarities and were used to assess the validity of the AWPAD data.

TRAINING

A Multi-Role Reconfigurable Trainer for Naval Combat Information Operators

Bruno Emond, Ph.D. | Irina Kondratova, Ph.D. | Guillaume Durand, Ph.D. | Julio Valdés, Ph.D.

18223

The paper describes our efforts to identify a key set of requirements for a Naval Combat Information Operators training simulation based on a Multi-Role Reconfigurable Trainer framework. The project was executed for the Royal Canadian Navy by the National Research Council Canada with the collaboration of Defence Research and Development Canada. The main training issue to be addressed is to augment team training readiness in the transition from individual training to team training. The training domain use case was the acquisition of tactical voice procedures by novice Anti-Submarine Plotting Operators (ASPO), a skill domain particularly suited for a learning-by-doing approach using training simulations. The project explored training technologies that use synthetic teammates to improve the readiness of novice individuals to participate in live team training. The approach we used to achieve this objective included a literature review of key technology areas of interests, training application prototyping, and generation of simulated data of learners' performance. Each of these aspects of the approach is discussed in the corresponding section. The focus of the literature review was on technologies incorporating synthetic teammates using automatic speech recognition and speech synthesis to capture trainees' utterances and simulate teammates communication. The section on the training application prototype presents a use case for the verbal tactical procedure which provided the basis to develop the software's interactive workflows, and, in particular, the construction of a Multi-Role Reconfigurable Trainer prototype. The section on simulated data provides examples of three learning analytics methods applied to a simulated dataset for a group of trainees learning the tactical verbal procedure associated with an initial contact report. Finally, a conclusion reviews the main project results, and identifies possible areas for future research work.

A Simulation Based Application for Naval Navigation Training

Jason Ralph, Ph.D. | Lauren Ogren | Sushil Louis, Ph.D. | Richard Kulesh

18109

Recent high profile collisions involving naval vessels point to potential deficiencies in current training processes. The current work evaluates a training tool, the Target Angle Simulator (TAS) which aims to improve junior officer bridge skill sets. TAS provides the ability for students to practice skills in a simulated environment, providing hands on experience which could improve knowledge retention when compared to traditional, classroom-style instruction. The current work reports the results of two experiments demonstrating the value added of the new training tools. Experienced (Advanced Division Officer Course) and inexperienced (non-military) populations used the new target angle simulator to learn how to estimate angle-on-bow calls and identify vessel types in both day and nighttime

conditions. A pre-test/post-test protocol resulted in significant improvement for the inexperienced population when they were allowed to practice with the target angle simulator. Improvement was not significant for the experienced group but feedback was extremely positive. The results suggest that the TAS is an effective tool which may be most effective for incoming Basic Division Officer Course students, who have some sailing experience but little prior experience making angle-on-bow calls.

A Systematic Approach for Human Patient Simulation Assessment

Jennifer Winner | Col Douglas Hodge, USAF (Ret.) | David Malek | Caitlan Rizzardo | Victoria Krumholtz

18090

Eastridge et al. (2012) reviewed US Service Member deaths between 2001 and 2011 and found that nearly a quarter of these deaths were potentially survivable, and the majority of those were largely attributable to missed and incorrectly performed interventions for hemorrhage injuries and airway obstruction. The focus of this paper is to describe an approach to improve the empirical assessment and therefore design of Human Patient Simulation (HPS) for training lifesaving airway and hemorrhage interventions. Every action taken by a combat medic has a corresponding outcome for the patient and is in response to the medic's continual assessment of that patient. There are identifiable cues (visual, auditory, or tactile) for successful and unsuccessful airway and hemorrhage interventions, and medics must be capable of detecting them. As more training is performed using HPS devices, the ability to support both procedural practice and patient assessment skills at the right level of fidelity become increasingly important.

Systematic methods are necessary for identifying and addressing deficiencies in HPS and their corresponding impact on training effectiveness. Four considerations relevant to the desired specificity of data are included in the proposed systematic approach to HPS assessment: mapping fidelity assessment to training objectives, representing patient assessment cues, representing variations in injuries and pathologies, and converging measures of trainee performance. While this approach emphasizes a systematic approach to HPS assessment for the training audience of interest (combat medics), the aim is that these considerations will be broadly applicable for medical training.

Achieving Air and Surface Dominance through a Joint Secure Interoperable LVC Solution

CDR Thomas J. Weaver, USN | Richard A. Brisbin

18214

Achieving and sustaining world-wide Air and Surface Dominance in highly contested environments is a requirement for our Joint Air Forces. Currently, there are no universal Live-Virtual-Constructive (LVC) standards to integrate 4th and 5th generation fighter and command and control (C2) capabilities across the Combat Air Force (CAF) and Carrier Air Wings (CVWs) with surface warfare operators using the Aegis combat system. An LVC solution with joint technical and interoperability standards will enable cost-effect, advanced training opportunities to attain and sustain pilot and surface warfare proficiency across 5th generation, advanced counter-air capabilities of the Navy, Marine Corps and Air Force. The Secure LVC Advanced Training Environment Advanced Technology Demonstration (SLATE ATD) is the most-critical step in the attainment of these joint standards. This paper provides an overview of SLATE and its objective to establish joint LVC standards across the Department of Defense (DoD). Additionally, an overview of the Adaptive Air and Surface Warfare Readiness Initiative (A2WRI) is provided to address phase II follow-on technology maturation and transition initiatives referred to as Joint Secure Interoperable LVC Solution (JSILS). JSILS will establish Internal Mount and modeling standards for 5th generation aircraft and Aegis integration. The successful transition of SLATE and JSILS core LVC technologies to 4th Generation and 5th Generation tactical and C2 platforms, surface combatants, and test and training ranges will enable the development of Joint LVC technical and interoperability standards and the attainment of Navy and Air Force enterprise-wide LVC interoperability.

Assessing the Validity of Driver Response: Simulator vs. Real Vehicle

Rick D. Giovengo, Ph.D. | George Buck

18052

Objective: The Federal Law Enforcement Training Centers (FLETC) initiated research to determine if a blended approach of instruction was effective for teaching the driving technique "determining and following an ideal line of travel (LOT)." The LOT is defined as the most efficient path to steer a vehicle when traveling through a turn. It is commonly taught in emergency vehicle operations training. Currently, this concept is taught using a lecture block and a hands-on driving on an outdoor driving range. The problem is students do not get as much driving time due to the limited amount of cars, instructors, and driving ranges available. Research Questions: Can participants who receive training in a blended learning environment perform better on the driving range practical examination? Can participants who receive training with a blended and traditional learning environment transfer that knowledge when presented with a new environment? Can participants who receive training in a blended learning environment (both simulated and live driving) gain a better understanding of the principles of LOT on a cognitive test? Methods: Participants were given a one-hour lecture on the concepts of an ideal LOT. The group was divided into two. The control group went to the driving range to practice LOT techniques. The experimental group was taken to the driving simulators to practice LOT techniques. After practice, the experimental group was then taken to the driving range and allowed to practice with the other group. At the end of practice both groups were giving a driving assessment on the familiar range and a novel range. Then both groups were given a written exam. Results: The differences in driving performance and passing rate between groups were minimal, although a statistical significance was found between groups on the familiar range. Lack of training transfer was found in both groups when taken to the novel range. The blended / simulator group scored higher on the written exam. Conclusion: Use of simulators in a blended approach produced similar results compared to traditional instruction for LOT.

Bridging the Joint Close Air Support Training Gap

Emilie A. Reitz | Kevin Seavey | Marsha Mullins

18012

As enemy armored units threaten to overrun coalition forward lines, the Finnish Defence Forces Company Commander tries to contact the supporting Joint Air Ground Integration Center (JAGIC) to request fires. Enemy jamming has degraded voice radio communications. The supporting Joint Terminal Attack Controller (JTAC) requests immediate close air support (CAS) by sending a digital joint tactical air strike request to the JAGIC. The JAGIC, manned by U.S., Swedish and Finnish personnel, determines CAS is the best joint fires solution. The JAGIC digitally assigns two on-station Danish Air Force F-16C fighters to provide the required CAS while an airborne Royal Air Force MQ-9 shifts its orbit to provide follow-on CAS support. As the F-16s approach the target, the section leader informs the JTAC they are "digital capable" and the JTAC transmits his digital SITREP.

Digital systems in aircraft and Digitally-Aided Close Air Support (DACAS) ground kits provide significant benefits that improve CAS planning and execution. DACAS allows the use of digital messages to expedite communications, rapidly build shared situational awareness, reduce human error and shorten the kill-chain. DACAS is an increasingly important operational capability. However, with rare exceptions, current joint fires simulators do not support DACAS, leaving a gap between how joint fires personnel operate in the real world and how they maintain readiness.

How do we close this gap so warfighters can build and maintain the proficiency required to conduct effective joint and coalition DACAS missions? What role can simulation play in maintaining DACAS readiness? How do we make sure our traditional training strategies and methods are still relevant in an increasingly complex, digital world?

Building on our previous work (Reitz and Seavey, 2014), this paper discusses the challenges faced in developing DACAS capabilities in simulation to close this training gap across the Live, Virtual and Constructive (LVC) continuum.

Building Automated Assessments of Interpersonal Leadership Skills

Randy Brou, PhD | Gary Stallings | Sean Normand | Blake Ledford | Ian Stearns

18010

Producing effective leaders is a concern for training departments across the military, industry, and academia. The specific skill requirements for leaders across these domains varies, but effectively interacting with people is a requirement in any leadership role. Despite the broad utility of interpersonal leadership skills, methods available to systematically assess those skills are limited. Some organizations rely on self-report measures or situational judgment tests of leadership skills. Others may use performance measures gathered during observations of live assessments. The former set of methods is disadvantaged by social desirability bias and ability to identify criteria distorting participant responses. The latter set of methods is costly in time and human resources, and may suffer from observer subjectivity. The current research investigated another option for assessing interpersonal leadership skills: reactive, computer-based scenarios using unprompted, natural language responses as inputs. This method helps to mitigate the problems of self-report measures and may be widely used at a fraction of the costs associated with live assessments, but it faces two challenges. First, the assessment tool must be able to interpret natural language responses accurately. Second, virtual agent behaviors must be flexible enough to believably react to unguided inputs. In an experiment, US Army Officer Candidates interacted with virtual agents representing leaders, peers, and subordinates in three scenarios composed of 4 to 7 related vignettes. Free-text responses provided during real-time conversations with the agents influenced the outcomes of each scenario. Interactions with the agents were analyzed to determine if the assessment method could accurately detect differences in interpersonal leadership skills among Officer Candidates. Results of this research provided initial evidence that such differences can be detected using the experimental method. Further, results provided insights into the amount of training data needed for language libraries to accurately interpret unprompted inputs and for developing sufficiently flexible agents.

Comparison of Augmented and Virtual Reality Training for Spatial Anatomy

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18144

On a spectrum from fully real to fully virtual environments, augmented reality (AR) systems allow a user to visualize three-dimensional objects. AR combines elements of real and virtual environments allowing the user to maintain a sense of presence in the real environment while manipulating virtual objects. Virtual reality (VR) immerses the user into a virtual environment, typically through the use of a head-mounted display (HMD). As consumer access to AR/VR has increased over the past few years, so have the potential applications for these systems to enhance training and education. Anatomy is one such field that requires a thorough understanding of difficult, spatial relationships, and serves as the knowledge foundation for medical practitioners. Some work has been done with newer AR or VR systems for anatomical training, but a comparison between the two systems for (i) anatomical knowledge acquisition, and (ii) the workload incurred by the learner is lacking. The present work provides a comparison between AR (i.e., zSpace) and VR (i.e., HTC Vive) for the learning of macroscopic brain anatomy. A suite of objective (pre/post-learning tests), subjective (surveys), and physiological (EEG) measures were used to provide a comprehensive evaluation of AR and VR systems for anatomical training. Results suggest a high degree of similarity between AR and VR, yet hint at some differences in the associated cognitive processes. These results inform selection of the most beneficial training platform for anatomical knowledge acquisition in first-time learners and provide insight into alternative implementations for these emerging technologies.

Cyber Training Experimentation through Operation Blended Warrior

Steven R. Moore | Mathew Chaney | Larry Flint

18309

The obstacles to incorporating cyber training into Live, Virtual, and Constructive (LVC) events are both technical and cultural. Culturally, traditional operators understand that training to cope in a Cyber-Degraded Environment is critical but resist implementation of technical solutions they view as risky. The technical community has developed concepts and systems that require a greater demand signal from operators to gain resourcing, acceptance, and momentum. Operation Blended Warrior, (OBW), an I/ITSEC special event, provided a venue for demonstrating current and potential technical solutions in a compelling manner; appealing to both the technician and traditional operator. With recent advances in the sophistication of cyber ranges and simulation networks, cyber injects can be generated to meet specific training objectives while holding operational and training networks safe. The cultural challenges of "mainstreaming" Cyber-Degraded Training can be overcome technically and without derailing an entire training event or sacrificing "primary training objectives." By allowing prototype and non-accredited commercial systems to participate in an isolated environment, OBW overcame the significant technical hurdles of accrediting systems prior to installation on an operational network. Working with proven OBW LVC participants, the OBW Cyber Working Group developed cyber injects relevant to both cyber warriors (cyber for cyber) and non-cyber warriors (cyber for all). The team employed the Cyber Operational Architecture Training System (COATS) framework to integrate a cyber range with the active LVC event. Tools such as Network Effects Emulation System (NE2S), Navy Training Baseline (NTB), Behavior Based Network Management (BBNM), and various vendor systems facilitate the OBW cyber injects. This paper describes cyber training injects, simulation architecture, system capabilities, and the lessons learned from the demonstrations and employment of cyber injects during OBW.

Define "Expert": Characterizing Proficiency for Physiological Measures of Cognitive Workload

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18059

Training providers continue to be challenged in accurately measuring the effectiveness of performance-based training solutions. Studies have shown interest in measuring cognitive state to improve human performance (Schmorrow & Kruse, 2002), yet the training industry still lacks a non-invasive, near real-time deployable method to objectively measure the trainee's cognitive state. Our collaborative research team has developed and documented a valid methodology for quantitatively assessing training effectiveness, using physiological measures of cognitive state coupled with task-specific performance metrics. To successfully employ this method and design personalized training, we must develop standard definitions of proficiency levels in terms of the physiological signature of cognitive workload.

During an initial study performed in 2017, we measured the total cognitive load, spare cognitive capacity and task-specific performance metrics (i.e., flight technical performance) of novice pilots performing standardized hand-flown tasks in a simulator and in live flight. We extended this evaluation in 2018 to include competent and expert pilots. The purpose of this follow-on study was two-fold: to further validate the approach for measuring training effectiveness, and to characterize the effect of pilot education and experience on cognitive workload, spare cognitive capacity, and task-specific performance. Through this research, we have defined an initial set of standards for the interplay between cognitive workload and performance associated with various learner proficiency levels.

This paper summarizes the key results of the follow-on study and describes the standards of cognitive workload developed as a result of the two-year research effort. It also illustrates how cognitive workload trends can assist in developing personalized, performance-based learning for trainees with varying degrees

of proficiency. It concludes with a discussion of how this methodology can be applied to improve training outcomes and future studies that would further extend its value in the simulation and training industry.

Effective Deployment of LVC-TE on Wide Area Networks

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18092

The Marine Corps' Live, Virtual and Constructive Training Environment (LVC-TE) connects training systems at geographically separate bases to enable collective and battle staff training. The long-haul circuits that provide the connections are not dedicated to training exercises but are shared and simultaneously carry other network traffic for the Marine Corps. Excess latency and jitter injected into training exercises from these circuits can invalidate results and bias the results of the exercise for one side.

A major existing deterrent to the planning of large scale exercises is the inability to accurately estimate the load that will be placed by a local, regional, or country-wide training exercise on the underlying communication networks. This significantly prolongs the planning and approval processes.

In this paper, we present a new simulation-based framework to predict the impact of connecting training systems across different types of long-haul network circuits, validate key performance parameters, and streamline the planning of distributed training exercises. The framework profiles different training simulations/simulators and correlates captured traffic to scenario events. Traffic models can be scaled to represent higher numbers of entities, simulators, and time-varying, overlapping scenario events. Authoritative Marine Corps descriptions of the network on which the training exercise is run, in the form of Visio or similar formats, are converted into an executable, dynamic network simulation model. The traffic models are overlaid on the simulated network to predict how traffic generated during a training exercise, competing with non-training traffic, will be delivered, using metrics such as throughput, latency, packet loss and jitter. The framework enables reconfigurable, on-demand tradeoff analysis to derive optimal solutions.

Utilizing this framework, the authors present findings for the network performance impact of running a Virtual Battlespace 3 (VBS3) training exercise on the 29 Palms network.

First Steps in 5th Generation Aircraft - IAF's Innovative Technical Training

LTC Ran Shneor

18127

The Israeli Air Force (IAF) recently entered the era of fifth generation aircraft. Israel was the first country outside the United States to receive, operate, and maintain the F-35A Lightning II aircraft. F-35 are maintained by young technicians (ages 18-20) during their compulsory military service after a short maintenance course. Many of them lack aerial experience or have no technical background at all. Teaching inexperienced personnel about complex systems, like the F-35, in a constantly changing environment is a significant training challenge for the IAF. To overcome this challenge, the IAF employed innovative approaches to technical training. The focus of this innovative approach was on adjustments to the system (i.e. the organization) to efficiently and effectively meet individual training needs. This paper presents unclassified and non-commercial information of the different activities in technical training, followed by a detailed description of the innovative actions taken in preparation for the F-35 reception in the IAF. It is based on the Technological Pedagogical And Content Knowledge (TPACK) model. An important insight based on the IAF's experience implies innovative technical training is achieved by contradiction andinteraction between opposite forces and perceptions. The effectiveness measurements of the IAF's performance show remarkable results. Guidelines are deduced based on the IAF's experience. These guidelines are relevant for organizations facing a leap in technology or major changes in operations and training environments.

Initial Evaluations of Adaptive Training Technology for Language and Culture

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18145

The Department of Defense has 40,000 positions requiring foreign language skills, yet 70% are filled by people who lack the necessary language proficiency. Too many language learners fail to reach the desired level of proficiency, or lose proficiency if they do not have continuing opportunities to practice. We propose that adaptive training technology can address this problem and help learners quickly develop and maintain language proficiency. To do this, adaptive training should (a) provide learners opportunities to practice using the language in realistic situations, (b) identify gaps in the learners' language competencies in the context of language use, , and (c) recommend personalized exercises to overcome these gaps. Such an approach offers significant advances over conventional methods that emphasize passive language skills (reading, listening) and basic knowledge of vocabulary and grammar without realistic practice in using the language.

We have implemented this approach in ALLEARN (Adaptive Language LEARNing), an open architecture for language learning and retention. ALLEARN provides a simulation-based training environment for practicing language use and assessing language competencies, and recommends personalized learning trajectories that focus on overcoming each learner's individual competency gaps. It is designed to be used in a blended learning curriculum, supplementing classroom instruction.

To obtain formative feedback and identify best practices for designing adaptive training, focus groups were conducted with Modern Standard Arabic (MSA) students and instructors at the US Army JFK Special Warfare Center and School. Two classes of MSA students were assigned to either the adaptive version of ALLEARN or a non-adaptive version which followed a fixed curriculum sequence. The study investigated a variety of outcomes between these conditions, such as improved performance on oral and written examinations, time-on-task, and training usage behaviors in the context of blended learning. The findings offer implications for best practices of competency-based adaptive training and language learning technology.

Integrating Advanced Distributed Learning into Multinational Exercises

Maj Niclas Ljung | Maj Tohmas Ax | Aaron Presnall, Ph.D. | Sae Schatz, Ph.D.

18152

Armed forces around the world face similar challenges regarding exercises and live training. The context is increasingly multinational, and operations and supporting systems are more complex, all requiring more extensive training. To thrive in these volatile, complex and evolving security environments, military personnel also require an expanding range of competencies and at higher levels of proficiency, and the quick acquisition of new knowledge and skills to confront novel multi-domain challenges. In resource constrained systems, this outcome must be achieved without significantly increasing training and education time or costs. Operational integration of Advanced Distributed Learning (ADL) into multinational exercises is one step toward this goal.

As computer-aided exercises increase in number and scope and educational systems go online, the ability to produce ADL training and education becomes a critical capability. ADL has been a supportive learning concept in the Viking series of computer-aided exercises since 2003. The ADL-concept for Viking 2018 expanded the scope and scale of learning resources to include assets of both pre-training and operational value, and highlighted analytics on a common dashboard with data from both the Learning Management System and the Command and Control system. Thus, it was possible to compare pre-training data to data from the execution phase of the exercise, including data from the designated evaluation team and exit interviews with participants.

Based on previous lessons identified and data from Viking 18, this paper shows that ADL, blended into a computeraided exercise, produces more effective and efficient outcomes. To bolster the effort of integrating ADL into future exercises, the paper also describes an outline for a multiyear design-based strategic plan to achieve operational integration of ADL across a suite of joint and national exercises to support and enable readiness.

Lessons Learned from leveraging Simulation as a Service in Viking18

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18329

Complexity is ever increasing in current military operations, due typically to the fact that missions are more often performed in a comprehensive environment with many different actors, including military and civil. In order to prepare for these missions, advanced training, in which the military and civil trainees are immersed in such complex environments, is required. (Distributed) simulation has been recognized by NATO as a solution to support training of these missions and the concept of “Mission Training through Distributed Simulation” (MTDS) is currently developed by several nations under the umbrella of the NATO Modelling and Simulation Group. The Netherlands MoD has also identified the need for MTDS capabilities and initiated an MTDS research programme in 2017.

Development of MTDS solutions is a technical and organisational challenge that can be addressed by defining a so-called Reference Architecture. The Reference Architecture and its specific generic elements descriptions (Architecture Building Blocks or ABBs) offer both a blueprint and a flexible approach for rapid implementation of exercise environments. The VIKING-18 CAX exercise was selected as a use-case to identify ABBs and evaluate service based implementations of these ABBs.

This paper presents the MTDS ABBs that have been derived from the VIKING-18 requirements as well as the lessons learned from their use. The specific ABB implementations provided for VIKING-18 consisted of simulation services for realistic computer generated maritime vessel traffic, including transmission of ‘Automatic Identification System (AIS)’ messages, and services for the simulation and control of land units. These simulation services leveraged the results of the NATO task group MSG-136 M&S as a Service (MSaaS). The work was performed in a collaborative effort by TNO Defence Research (NLD), Pitch Technologies (SWE), and the Swedish Armed Forces (SWAF) Joint Training Centre.

Maximizing Return on Training Investment in Mixed Reality Systems

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18075

Many simulated team training systems developed across the Department of Defense, e.g., the Army’s Close Combat Tactical Trainer (CCTT), focus on high fidelity systems that require high initial expense and maintenance costs, require trainees to travel to a specific training site, and cannot be easily updated or reconfigured to reflect changes to the operational equipment/environment. The Army’s future Synthetic Training Environment may leverage advances in virtual and augmented reality technology to provide mixed reality training that balances physical components and virtual assets, which would decrease the cost of networked training environments and increase reconfigurability and mobility. However, indiscriminate use of virtual technologies could remove sensory cues critical to task performance, thereby decreasing training value. Further, without an understanding of tasks and users, inappropriate virtual or augmented reality headsets could result in negative training and user sickness. A human-centric sensory task analysis can be effectively used to identify and optimize system fidelity- virtualizing what can be, while maintaining physical components required for training value. The purpose of this article is to introduce a human factors approach that capitalizes on sensory task analysis to maximize training effectiveness while minimizing cost, leading to maximal return on training investment. The goal is to provide practitioners with guidance for the effective use of innovative mixed reality technologies in training systems. In this study, using a sensory task analysis, design guidelines were derived for a mixed reality tactical trainer for the M1 Abrams, identifying constituent cues that needed to remain veridical and those that could be virtualized. These guidelines specified (a) when VR/AR would best be implemented within a complex training simulator based on training objectives, tasks, and environment, (b), VR/AR headset parameters to consider for optimized training value, and (c) software design elements unique to VR/AR, such as how to design to minimize user sickness.

BEST PAPER

Pilot Training Next: Breaking Institutional Paradigms Using Student-Centered Multimodal Learning

Jennifer Lewis | Joyner Livingston

18239

The United States Air Force (USAF) Air Education and Training Command (AETC) is responsible for training and educating Airmen across the Air Force enterprise. AETC seeks to revolutionize the pilot training experience, from student selection through content delivery and course completion, by leveraging insights from recent academic studies and experiments, with an orienting objective of reducing the USAF Undergraduate Pilot Training (UPT) course from 12 to six months. Known as Pilot Training Next (PTN), this initiative will serve as a testbed for evaluation of technologies, such as Virtual Reality (VR), Artificial Intelligence (AI), physiological data collection and cognitive mapping, on commercially available hardware while simultaneously conducting pilot training for an initial class of 20 students under accelerated training timelines. PTN will also provide data-backed insights into return on investment, training effectiveness, and desired characteristics for use in recruiting future candidate pools. Based in Austin, Texas, PTN seeks to immerse itself in an entrepreneurial, innovation-centric environment that will challenge current thinking on how pilots are trained. AETC will apply PTN’s lessons learned to many other pressure points across the AETC areas of responsibility, by continuing to maintain a close connection to industry

partnerships. This paper discusses the execution of the first PTN course from inception to insights, with a specific focus on exploring the use of commodity Commercial Off the Shelf (COTS) technology to build affordable, portable simulation systems. This paper describes in detail the technical solution in place for training and data collection, including the VR-based flight simulation, AI-enabled virtual flight instructors, biometric sensors, and learning management system. Finally, this paper provides PTN's initial insights into training modernization and a path forward for the use of emerging technologies in training.

Simulator-Based Driver Training: Moving up a Gear

Timothy Coley | Steve Dethick

18085

Introducing simulator-based training to civil markets poses various challenges – from public acceptance of the validity of simulator-based training to simulator adaptation syndrome (SAS).

This paper describes a methodology for establishing an approved commercial facility designed to offer simulatorbased driver training. This methodology is based upon observation and evaluation of XPI's experience of setting up and running a Driver Simulation Centre (DSC) offering simulator-based training to commercial drivers. The methodology will inform readers about the challenges associated with provision of such training services, and provide particular focus on the approval of the training centre by the UK Royal Society for the Prevention of Accidents (RoSPA).

While relevant to all audiences, the paper specifically examines aspects relevant to delivery of training within commercial domains, such as engagement of new user communities with limited exposure to simulation and certification by relevant authorities. Common aspects relevant to driver training delivery applicable to all domains, such as device- and system-level user engagement, measurement of training effectiveness and use of consumer technology are also addressed.

Socio-technical simulation for denied environments training: A contested airspace example

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18226

Today's warfighters are being trained for information-rich, networked, automated battlespaces. But what happens when information access is disrupted? How can training prepare personnel to win in contested environments with austere access to sensors, navigation and communications? A renewed focus across DoD on near-peer adversaries is highlighting the need to answer these questions by incorporating Anti-Access/ Area Denial (A2AD) effects (e.g., datalink jamming, GPS spoofing) into training. Despite continuing improvements in simulations, modeling how people and technology (a "sociotechnical system") coordinate under nominal and denied conditions requires new approaches. Simulations must, for instance, model the disruptive effects of communications degradations on mission effectiveness. We are exploring an area of relevance across the training community, simulating sociotechnical processes to train today's forces for denied environments. AFRL, Eduworks Corporation, and the Florida Institute for Human and Machine Cognition are exploring pilot training for contested environments, focusing initially on A2AD effects in denied airspace. We use a Government-owned framework called Brahms to model agents, objects, geography, cultural features and information systems. For interoperability with existing training environments, we employ an AFRL tool for connecting models to simulations using Distributed Interactive Simulation, m2DIS, enabling Brahms models to serve as constructive agent controllers. The testbed includes visual, drag-and-drop scenario generation and automated visualization that extracts patterns and trends from multiple scenario runs under different initial assumptions. We discuss how the Brahms Contested Airspace Simulation Testbed (Brahms-CAST) will enable simulations to incorporate A2AD effects and support experimentation and analysis of contested environments.

Team Training for Enemy Identification Using an Intelligent Tutoring System

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18291

Team training has been identified as critical to the operations of the Department of Defense (DoD) due to the complex and frequent interactions required in military teams. Effective training is necessary to develop complete understandings of the task and to build cooperative teams. Intelligent Team Tutoring Systems (ITTSs) have the potential to reduce training costs, improve learning, and increase feedback consistency in comparison to traditional human tutors. Currently, ITTSs are underdeveloped due to the state of the technology and the complex nature of intelligent agents, which require a variety of considerations and many hours to create. In this paper, the authors explore the impact of automated tutor feedback and team composition on performance for participants tasked with identifying and tracking enemy combatants.

Thirty-seven three-person teams, each composed of two spotters and one sniper, were tutored on their surveillance task performance over four trials. The scenario was constructed using Virtual Battle Space 2.0 (VBS2) and a version of the Generalized Intelligent Framework for Tutoring (GIFT), which assessed learners and delivered real-time feedback. In 18 teams, members received private, individualized feedback, while in 19 teams, members received individualized public feedback (i.e., their teammates could observe). Additionally, all teams experienced a change in team composition as the sniper and one of the surveillance spotters traded roles for the fourth trial. Each team's performance in the task was assessed. Evidence of training effectiveness is observed in participants' subjective performance and task workload. While feedback privacy was not found to influence the subjective performance, an effect was found for objective performance. These results about the effectiveness of feedback in team settings will influence the future study and development of ITTSs for the military by adding to the literature on how automated feedback should be designed within team training settings.

Toward Recommendation across Learning Systems

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18330

In modern learning environments such as Ready Relevant Learning, often multiple learning systems work together (e.g. computer-based training, intelligent tutors, and training simulations). Effective recommendation has been well studied within each of these learning systems. However, when several systems are available that train in different ways, a new challenge emerges to understand the data that systems share, in light of their varied instructional designs and understanding of science of learning. Emerging data specifications and machine learning promise to help recommend which learning systems best fit individual learners' needs and desired learning outcome.

An exemplar recommendation component was created to drive training progression in several different learning systems. Recommendations were produced by combining and deconflicting learner information from multiple systems. Experiments with historical data and simulated students showed that the recommendation component could prioritize available learning systems and content adaptively. The recommender successfully inferred needed science of learning information, such as relating learning activities to skills and estimating the varying difficulty of skills.

The initial research reported here focuses on objective learner performance metrics. Our results show that the recommender accurately matched ground truth in estimating learner mastery and skill difficulty. The recommender also incorporated simulated input from human instructors, which reduced its error rate to near zero. Finally, a simple exemplar algorithm deconflicted learner mastery estimates from different learning systems and used them to give learners qualitatively different recommendations.

The feasibility demonstration reported here enables a 2018 human-participants study applying the same components to additional factors. Subjective learner states (boredom, confusion) and science of learning facts about training (well-defined vs. ill-defined, introductory vs. worked example, static vs. interactive) can drive the same recommendation tools (shared data specifications and machine learning). Our simulation studies suggest that recommendation across learning systems will make real training more effective than the sum of its parts.

Towards Zero Fratricide – Simulation Enabled Live Field Firing

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18265

Live field firing represents the apex of operational preparedness training for land forces, yet carries persistently high risks of dangerous occurrences and fratricide. To date simulation has developed various individual tools to aide in the preparation, planning, conduct, optimization and analysis of live field firing, yet the collective application of these to systemically enhance training outcomes and reduce risk has not materialized. This paper proposes employing multiple simulation technologies to support essential military live field firing within acceptable risk thresholds, whilst reducing the ongoing instances of fratricide modern armies continue to experience.

Currently live field firing planning is largely paper based. Manual creation of Range Danger Areas onto clear overlays are positioned on paper maps of the training area. A supervisor then manually reviews these range templates, applying several hundred pages of doctrine from memory to verify safety. Complexity and risk both increase exponentially for more intricate range practices incorporating multiple phases, combined arms effects, simultaneous manoeuvre, night activities, lasers and joint assets. For such practices, several thousand pages of complex safety doctrine must be applied, with sequencing or policy errors resulting in increased risk to personnel during live conduct. Simulation is conspicuously absent from this process, despite its potential to deliver relevant tools in planning and conduct phases to reduce risk and enhance capability.

This paper proposes integrating various simulation technologies to persistently reduce risk in military live fire training. In the planning phase this includes geospecific replication of military live fire ranges, automated construction / visualization tools for range design, creation and sequencing, and automated rule checking of doctrine safety and compliance. During the conduct phase this enables the replication of terrain / range templates with real-time geolocated troops, platforms and targets to anticipate emergent risks – the core reasons fratricide occurs – then prompt commanders to mitigate these risks before they eventuate.

Training with Virtual Reality: Lessons Learned

Amanda Palla | Linda Brent, Ed.D. | Eric Sikorski, Ph.D.

18040

Vertex Solutions, under contract with the Combating Terrorism Technical Support Office (CTTSO), recently delivered an immersive AC-130 virtual reality part task trainer (vrPTT) for use by the Air Force Special Operations Command (AFSOC). The vrPTT provides checklist instruction and practice to AC-130U copilots through the use of an immersive 3D virtual reality (VR) cockpit combined with an intelligent tutor to guide students through 16 copilot checklists and track performance. Key to its delivery, the research team facilitated a verification, validation, and accreditation (VV&A) to confirm that the system met the training requirements for inclusion in the AFSOC 19th SOS Syllabus of Instruction for the AC-130U Mission Qualification Course. Additionally, we conducted a formative evaluation to measure training effectiveness and to inform final refinements to the system. The evaluation participants were AC-130U instructor subject matter experts, current squadron copilots, and current copilot students. The evaluation data included observation of participants using the system, written usability and confidence self-assessment surveys, and individual performance data collected by the intelligent tutor. The results of the evaluation can inform the design and development of future VR training systems. Participants found the system easy to use and 100% believed that the vrPTT would positively supplement existing training to increase confidence and proficiency prior to entering the full motion simulator. Data also indicate the importance of scaffolding within the VR environment to assist with task completion. While the evaluation confirmed many benefits of VR training, it also identified a number of limitations, with most centered on the relative lack of VR hardware/software maturity. Given that technology matures quickly and the identified limitations did not surround the design or implementation of a VR system, we are confident that VR training systems can be a viable time- and cost-saving training option for the military.

Using Simulation to Assess Performance in Emergency Lifeboat Launches

Randy Billard | Jennifer Smith

18179

Launching a lifeboat in an emergency requires safety-critical proficiency which can only be achieved and maintained with hands-on practice. Simulators have been specifically created for offshore oil and gas personnel to practice lifeboat launching and maneuvering using representative equipment and virtual environments. As an alternative to live boat training, lifeboat simulators allow for practice in plausible, high-risk events in a safe, realistic environment. An automated simulator is an alternative offering the benefit of on-demand practice while expanding training capabilities. Providing training for these types of scenarios presents challenges for evaluating trainee performance in conditions traditionally not used in training because performance metrics may not exist. The study uses simulation to assess performance in lifeboat training from two perspectives: a live instructor and automated simulator. An experiment was performed to evaluate performance of lifeboat operators

in an emergency scenario which included adverse weather and hazards. A simulator was used to provide a safe and controlled means to assess trainee performance. A rubric was created to define scoring for launching and maneuvering tasks in weather, including moderate sea sates. The rubric identified quantitative measures which could be used by the simulator and live instructor to assess performance. The study compared performance measurements taken by a live instructor and simulator with automated tracking as each assessed participants in a simulated emergency exercise. The results show the simulator provided an advantage of being able to consistently track performance on tasks where multiple performance criteria were measured simultaneously. The study also identified limitations in the simulator which were not present in instructor led evaluations, including subjective measures made through visual observation. The paper discusses how simulation can be used to automate scoring and reduce instructor workload, and how simulators can be used to measure trainee preparedness for an emergency event with waves and hazards.

Validating Distributed Mission Simulation in a Tactical Integrated Training Environment

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18202

According to the Commandant's Planning Guidance for 2015, FRAGO 01-2016, his intent is, "…for Marines to encounter their initial ethical and tactical dilemmas in a simulated battlefield vice actual combat." Suitability of simulation systems and their capability to deliver on this demand depends on accurate identification of capability gaps and affordances. Identification of these capability gaps and affordances have traditionally focused on simulators in standalone configurations. However, the shift toward Live, Virtual, Constructive (LVC) training conducted within Distributed Mission Training Environments and System-of-System (SoS) configurations demands new, standardized procedures to assess suitability and effectiveness.

This paper is the second of three assessments of a multi-phased effort led by TECOM in collaboration with Program Manager Training Systems, Marine Operational Test and Evaluation Squadron One, and Marine Aviation Weapons and Tactics Squadron One. Extending results from the first effort, and to support validation of a strategy for SoS accreditation, this paper presents results of an assessment of SoS capability within the framework of TALONEX 2-18. During TALONEX 2-18, the focus was on Marine Pilots and Joint Terminal Attack Controllers (JTACS) using Virtual Battlespace 3 simulation software training in conjunction with a Battalion Staff via high-fidelity flight simulators (UH-1Y and AH-1Z), as well as AV-8B weapons system trainers.

Outcomes of this SoS evaluation include a standardized evaluation methodology to support VV&A of SoS configurations, lessons learned for future integrated training, and identification of improvements for current training systems. Resource sponsors, developers, operational and support commanders, designers, users, and other stakeholders will benefit from these results as they develop and employ other LVC assets and evaluate capabilities of other SoS evolutions. Recommendations for optimizing training value by improving training design with performance metrics for elements such as communication and coordination, to objectively assess collective performance-oriented standards of tactical and technical competencies, are also provided.

Virtual Supplementation of Tactical Decision Making Training

Randy Brou | Jennifer Tucker | Ray Morath | Joanne Barnieu | Jonathan Bryson | John Grantz | Jessie Hyland

18113

A fundamental aspect of training U.S. Army infantry Platoon Leaders (PLs) includes providing junior officers with opportunities to make leadership decisions during realistic scenarios and giving them constructive feedback about the timeliness and effectiveness of their actions. Traditionally, this has been accomplished during live exercises in the Infantry Basic Officer Leader Course (IBOLC). However, live exercises take extensive time and resources to conduct. Given resource constraints and the typical student throughput IBOLC must maintain, any given student may only have one or two opportunities to practice in the role of PL during a live exercise. The current research attempts to increase the number of opportunities for PL decision making practice by examining the effectiveness of virtual tactical decision making exercises (VTDEs) as supplements to live exercises during IBOLC.

Six VTDEs were piloted with IBOLC graduates. Each VTDE provided a brief overview of a scenario in which participants played the role of a PL. Each overview detailed an initial plan of action being conducted by the PL's unit. Following the overview, participants were provided ongoing updates to the unfolding situation via audio and textual ""injects." The participants were asked to monitor the situation and when/if necessary to press an ""override"" button, indicating they would significantly deviate from the current plan. After overriding, participants would be asked to provide their rationale for overriding as well as to indicate what changes they would make to the plan. Infantry subject matter experts identified a window of time within each VTDE (typically consisting of 3 to 4 consecutive injects) wherein participants should ideally override the plan. After responding to each of the VTDEs, participants were provided with feedback on the timeliness and effectiveness of their actions. Results indicated participants benefitted from the use of the VTDEs and the method holds promise for supplementing live exercises.

When Expertise Fails: Designing for High Uncertainty Decision Making in Virtual Worlds

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High risk, high volatility task environments require extensive hands-on training, detailed protocols and the experience of expert decision makers who can anticipate, adapt and respond effectively to complex situations. But what happens when even expert-level decision making reaches its limits? How do people behave when protocols and best practices fail to account for unanticipated sources of risk? How can we develop better learning paradigms to address training needs in environments where the best course of action is unknown? Operators in these environments know that experience is key: exposure to repeated, high risk events helps them develop sophisticated response strategies. But what happens when novel challenges render expert decision models obsolete? Immersive simulations and wargames can create ideal learning environments to address this issue, by rapidly accelerating exposure to a variety of rare, nonroutine, or hazardous events. However, two primary issues constrain their ability to deliver effectively: First, many of these programs are focused on replicating events that can assure proficiency among operators. Using the Dreyfus five stage model of expertise, we argue that immersive simulation is most effective when it pushes decision makers beyond proficiency assurance and is able to destabilize their mental models, challenging them toward innovative approaches to chaotic situations. Second, training needs in industry, military and government organizations are often highly constrained by time, money, capacity, schedule, and staffing requirements. Immersive, multi-player Virtual Worlds allow us to relieve some of this training burden by providing a platform to sandbox novel techniques for expert decision making in extraordinary conditions. However, many limitations and challenges still remain. Drawing from our own implementation efforts, we will discuss some of the successes, failures, constraints and opportunities virtual environments offer as a platform to drive learning outcomes and challenge expert level decision makers.

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