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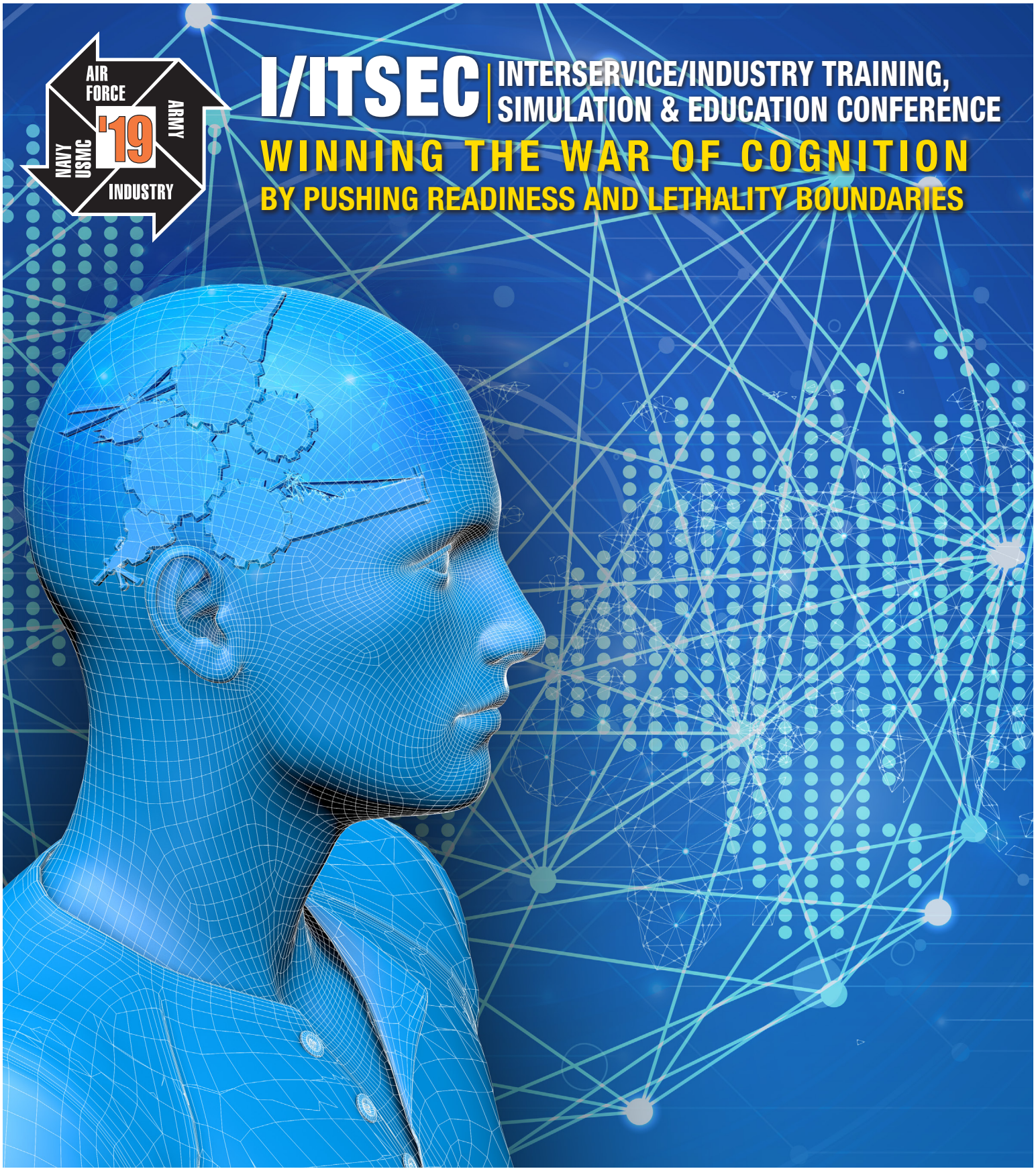

ABSTRACTS

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Reinforcement Learning for Automated Textual Reasoning

David Noever | Joseph Regian

19150

While many of the most popular machine learning algorithms (like convolutional and recurrent neural networks) date back decades, their practical realizations have spawned entirely new capabilities for the training community. Beyond just their breakthrough classification results for video, audio and imagery, the near-expert capability to understand natural language has surged with the late-2018 open-sourcing of Google's Deep Bidirectional Transformers for Language Understanding (BERT). As its name implies, BERT represents sentences and tokens bi-directionally, so context derives both left and right of each targeted meaning. The empirical results on 11 standard language tasks (such as next sentence prediction) surpass human experts. We investigate BERT's ability to answer questions in common language, to model topics and paraphrase large training documents. We test whether the underlying language model offers anything akin to a universal template, which practically means that its common architecture can pre-train on general domains and then quickly specialize to new, often-obscure technical domains like cybersecurity or non-English languages. This transfer learning feature offers a rich toolkit for future training and testing even in the absence of labeled data where supervised learning previously has seemed impossible. We finally apply our newly trained language model to the creation of scripted scenarios, or rule-bending approaches to derive novel variants of a previously known rehearsal narrative. One concrete scripted example focuses on training military officers to negotiate successfully with non-combatants. We score this machine learning approach to generate entire negotiation and bargaining strategies depending on current human terrain and the opponents' underlying motivation or interests.

The results highlight three of the big concepts underlying deep learning:
1) transfer learning with fewer examples;
2) creative or adversarial generation of training data, and
3) reinforcement learning or gaming with just rules and rewards in the complete absence of examples.

Adaptive Nonconvex Optimization for Artificial Intelligence, Machine Learning, and Quantum Computing

Randal Allen, Ph.D.

19109

This paper discusses a novel approach to nonconvex optimization which has broad-reaching applications, including those prevalent in artificial intelligence, neural networks, supervised (regression and classification) and unsupervised (clustering) machine learning, and quantum computing.

A system of methods which reaps the benefits of both grid search and random search, without their corresponding limitations, is uniquely combined with an exact method of multipliers to produce a novel approach to solving general nonconvex objective functions. At its core, independent random variables adapt themselves to produce a finer search for an extremum, according to user-defined precision specification. Because the system is gradient-free, the architecture allows for logic gates with implications for machine learning and quantum computing. Furthermore, Monte Carlo methods increase confidence in locating the global extremum facilitating verification and validation of trustable artificial intelligence.

Finally, as an example, the regression form of supervised learning (replacing neural nets with nonconvex optimization) is applied to determine the aerodynamic rolling moment coefficient based on only 20% of the data available compared with 100% of the data typically used by the method of system identification.

Human-Liked Auditory Capability for Intelligent Virtual Agents

Hung Tran

19125

Intelligent Virtual Agents (IVAs) are important components in simulated real-world environments. Usage of IVAs in training is mainly for task collaboration where virtual agents interact with each other or with human users. Last year's paper "Human-liked Auditory Detection Capability for Intelligent Virtual Agents" (I/ITSEC 2018) presented an auditory perceptual model that can be used to predict the capability to detect sound cues in noisy environments. Besides the capability to detect sound cues, the human hearing system has the ability to identify the direction from which the sound is coming, estimate the distance of the sound source and eventually assess the characteristics of the physical surrounding environment affecting sound propagation (Auditory Spatial Perception). Auditory localization represents the most critical element of the auditory spatial perception for human effectiveness and safety.

An IVA auditory perception model without a capability to localize sound sources is incomplete. To complement the previously completed auditory capability modeling of an IVA from last year's paper, a perceptual model will be added to simulate the capability of an IVA to localize sound sources. First, the paper will provide the foundation of this perceptual model, which is based on the Duplex theory of the human hearing system - Interaural Time Difference (ITD) and Interaural Level Difference (ILD). Then, it will explain how this model was integrated with the IVA model to simulate the sound localization capability. Finally, the paper will present the simulation results and assess the effectiveness of this auditory perceptual model when used with the simulation of an IVA. Preliminary analysis of simulation results indicated that Duplex Theory is suitable to simulate the capability to localize sound sources, especially when the Signal-to-Noise (S/N) ratio is favorable to the sound localization task, e.g. S/N is equal or greater than 12 dB SPL.

The Value of Cognitive Workload in Machine Learning Predictive Analytics

Amy Dideriksen | Joseph Williams | Thomas Schnell | Gianna Avdic-McIntire

19147

The Department of Defense plans to spend $1.7 billion over the next five years to stand up a new Joint Artificial Intelligence Center with goals to develop strategic plans, adopt and transition artificial intelligence, machine learning and emerging technologies into operational use (Longwell, 2018). Until roadmaps have matured, it is unclear how much of that budget will go towards training.

Several commercial industries have implemented solutions using data analytics to improve operations. Many in the military training industry are beginning to design architectures and plan research studies using learning analytics to predict performance, personalize and adapt training to optimize human performance. Large amounts of training data sets for effectively training the networks is one of the biggest challenges. Few researchers have assessed machine learning solutions that include physiological metrics to adapt learning. Collins Aerospace capitalizes on the unique data collection from previous, privately funded research conducted over the past two years. This research collected data on 30 pilots flying multiple flight maneuvers in a simulator and in a live aircraft with over 50 plus hours of live flight time. We collected metrics on task performance and cognitive workload.

Collins developed several deep neural networks to predict future states of student performance. We compared the results of our predicted performance using only task performance measures with the results of task performance measures in combination with cognitive workload metrics. The results show when cognitive workload is included in our deep neural networks, it increased the performance prediction to an extremely high level of accuracy.

Interpretable Network Architectures for Machine Learning

Randal Allen, Ph.D.

19149

With limited success, artificial neural networks bring several disadvantages. These shortcomings are related to architectural selection (e.g., number of neurons, number of layers) which are dependent on the number of inputs and outputs and the complexity of the input-output relationship. Also, training methods may require additional neurons and layers, increasing the size of the network, and may lead to underfitting or overfitting, rending the network useless beyond the data used for training and testing. The design process becomes an academic exercise in numerical investigation resulting in an untrusted "black box" where the designer has no influence over what is being learned. In the end, because of the depth of complexity, it's impossible to understand how conclusions were reached.

A system is needed with an architecture where the designer has control over what is being learned and thus provides inherent elucidation. This paper presents and discusses such a system architecture comprising a set of mathematical functions and logic gates lending transparency and explanation to applications based on artificial neural networks. A relatively simple example shows how the system architecture replaces the regression form of supervised learning to determine the aerodynamic rolling moment coefficient given aileron deflections, using 80% less data than required by traditional system identification methods. The paper concludes by discussing the implications this system architecture has on the other forms of machine and deep learning (classification and clustering), predictive and prescriptive analytics, and due to the inclusion of logic gates, quantum computation.

Persistent Machine Learning for Government Applications

Joshua Haley | Chad Dettmering | Ross Hoehn | Ryan Barrett | Ali Mizan | Alissa Tanaka | Brian Stensrud

19160

Machine Learning (ML) offers benefits such as adaptive systems that are more performant initially and continuously improve over time. However, we often encounter difficulties operationalizing commercial ML breakthroughs into the government sector due to a lack of available training data. While data collection is at the forefront of most commercial entities such as Google and Facebook who monetize the data, it is often neglected outside the commercial scope which lacks that incentive. However, it is often the data, not the model architecture, that defines many of the breakthroughs being commercialized. Google, for instance, freely shares many of its models and tools through publications and open source repositories, but not the training data used, preventing result replication. Collecting datasets is critical for effective ML given the dataset size needs by modern Deep Learning approaches. Even when datasets are available, too often ML algorithms are performed once and then never updated, not effectively using new data as it is collected. Too often a system is as performant initially as it will be after hundreds of hours of use.

This paper presents an architecture developed to support long-lifespan ML within the government space. This architecture provides three key components for an effective Machine Learning architecture. First and foremost, it supports continuous acquisition and curation of new training data. Secondly, LEARN provides computational resources to support Machine Learning exploration of data. Finally, it provides automatic continuous ML allowing models to update in response to new data observations. We describe several sample domains, such as speech recognition, that impact military training needs. Finally, we discuss and how this architecture addresses the ML needs that prevent operationalization of modern methods within the government space as well as outstanding challenges.

Prognostic Health Management Using Semi-Supervised Machine Learning

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19164

A report by McKinsey & Company indicates that by the year 2025 machine learning (ML) based predictive maintenance could save organizations $630 billion a year. The benefits associated with ML driven maintenance is not lost on the U.S. military. They are expected to spend billions to develop such systems. While ML does show incredible promise, applying it to military scale problems can be challenging. ML approaches popular in industries such as web services can be data hungry, requiring millions of well-balanced data points to be successful. The military and the defense industry, however, face many challenges and often do not have pristine data sets. As a result, ML algorithms must be carefully selected to effectively deal with a data set's limitations.

This work will describe the development of a ML model that identifies performance anomalies in an aircraft subsystem. Due to the highly engineered nature of this subsystem, anomalous performance was rare. In addition, due to the subsystem's complexity finding anomalies was challenging for a human. This made building a ML model difficult since there were few examples of anomalies and little was known about how anomalies presented themselves. To combat the limited data problem a semi-supervised ML algorithm based on Self-Organizing Maps (SOMs) was used to cluster known anomalies. Using the SOM clustering method, uncategorized examples that fell into clusters with high numbers of known anomalies were categorized as anomalous themselves. Testing results show the SOM based classifier can detect anomalous subsystem behavior with over 90% accuracy. The final paper will detail the machine learning model selection process, model development, and testing. Ultimately, this work will provide an example of how the U.S. military can apply powerful ML techniques for predictive maintenance using imperfect real-world data.

Building the World - Could AI Build Our Synthetic Environments?

Graham Long

19180

Constructing Synthetic Environments that satisfy the content, fidelity, functional and performance requirements and expectations of a widening range of applications, users and client systems, in a cost effective and timely manner, challenges todays Synthetic Environment (SE) production capabilities.

Rapidly expanding data availability, increasing processing and rendering performance, a heightened awareness and familiarity with digital, virtual environments in everyday life, sets an expectation and demand that Synthetic Environments will provide high quality, content rich, authentic representations of the real world.

Synthetic Environment production pipelines have evolved to incorporate a range of processes and activities that reflect the progressive convergence of traditional M&S with geospatial, gaming and other relevant domains. But despite employing efficiency enhancing techniques, such as procedural content generation, these production pipelines typically still require significant effort and time to accomplish the task.

This paper will explore how emerging AI, machine learning and deep learning could be applied to a typical SE production pipeline, based on the recently approved SISO Reuse and Interoperation of Environmental Data and Processes (RIEDP) standard.

Beyond M&S, AI is already being applied to the types of task and activity that crossover into SE production – geospatial data processing, construction of gaming assets and environments, computer vision, autonomous vehicles, behavioural modelling. The paper will identify potential AI techniques and technologies that may be applicable to each stage of the production process, consider the feasibility of applying AI across the entire pipeline, from design through to build of the complete SE, and the opportunities AI can offer to SE generation and SE users.

Mid-Air Haptics in Aviation

Alex Girdler | Orestis Georgiou

19184

Mid-air haptics - creating the sensation of touch where there is nothing but thin air.

Despite several industries adopting this exciting technology, it is yet to emerge in either simulated pilot training or real-life flight decks. Full-flight simulators are expensive to manufacture, maintain and operate. Not only that, each simulator is limited to one aircraft type, which is inefficient for the majority of airlines that have several in service.

With a growing trend in touch-screen instrumentation, cockpit displays require the pilot's attention to be drawn away from their view out of the window. The gesture recognition from mid-air haptics would add another dimension to this existing technology for pilots familiar with using legacy cockpits, complete with traditional instrumentation.

In simulation, Augmented and Virtual Reality technology has added a new aspect to immersive training environments. Combining this with a basic full-motion platform and the addition of tactile feedback via mid-air haptics would allow for an interchange of instrumentation layouts.

Certification criteria from regulatory authorities states that every single audio and visual element of a pilot's simulation experience must exactly represent a real-life experience. This to the extent that pilots can go from hundreds of hours of simulated training, to being responsible for hundreds of lives on their very first flight.

This study will evaluate whether (FAA Part 60, Level D) certification can be achieved without projectors, without a cockpit and without instrumentation. Likewise, with other simulation products, including lower-level Flight Training Devices and their (level 4/5/6) certification standards.

Finally, by exploring concepts within the Automotive sector, this paper presents how flight deck design could evolve by adopting this technology. If pilot testimony suggests that they can adapt to virtual objects, then can this replace physical controls?

A Cyberspace Electromagnetic Activities (CEMA) Framework for M&S

Clark Heidelbaugh | Nathan Vey | Chad Bates, Ph.D. | Jim Ruth | Mark Riecken | Tim Friest

19193

The computer and internet revolutions of the twentieth century have quickly yielded the amorphous concept of "cyber" in the twenty-first century across every enterprise involving computing devices and networks. The United States Army (USA) modeling and simulation (M&S) enterprise is no exception. The USA includes cyber in its concept of cyberspace electromagnetic activities (CEMA). Acknowledging both the challenges of this emerging domain and the opportunity to provide a systematic framework, the Army's Simulation and Training Technology Center (STTC), part of Combat Capabilities Development Command – Solider Center (CCDC – SC), is developing a CEMA M&S Framework (CMFW) in support of the Army Modeling and Simulation Office (AMSO). The CMFW consists of an ontology based on Army doctrine and informed by all six Army M&S communities of interest (COIs). In addition, the CMFW includes use cases and other engineering models that support stakeholder needs ranging from developing common models, supporting the development of consistent data exchange models (DEM), and informing program requirements. The methodology used to develop the ontology is a form of Domain Engineering that considers multiple exemplars from across all COIs. This paper discusses both the methodology and provides detail on data, results, and other important aspects of the CMFW including the Unified Modeling Language (UML) representation of the ontology. Although this work is sponsored by and performed for the USA, it considers the necessity of multi-domain operations (MDO) and the need to include the perspective of all Services and coalition partners. Lessons learned and challenges are also discussed. As this work continues to mature, the benefit to the Services includes increased commonality in CEMA M&S representation, improved interoperability, and greater efficiencies in training, analysis, test and evaluation (T&E) related to the CEMA domain.

Reinforcement Learning for Computer Generated Forces Using Open-Source Software

Johan Källström | Fredrik Heintz

19197

The creation of behavior models for computer generated forces (CGF) is a challenging and time-consuming task, which often requires expertise in programming of complex artificial intelligence algorithms. This makes it difficult for a subject matter expert with knowledge about the application domain and the training goals to build relevant scenarios, and keep the training system in pace with training needs. In recent years machine learning has shown promise as a method for building advanced decision making models for synthetic agents. Such agents have been able to beat human champions in complex games such as poker, Go and StarCraft. There is reason to believe that similar achievements are possible in the domain of military simulation. However, in order to efficiently apply these techniques, it is important to have access to the right tools. This paper presents how open-source software can be used to efficiently establish an infrastructure for deep reinforcement learning, a machine learning technique which allows synthetic agents to learn how to achieve their goals by interacting with their environment. We begin by giving an overview of available frameworks for deep reinforcement learning, as well as libraries with reference implementations of state-of-the art algorithms. We then present a case study describing how these resources were used to build a reinforcement learning environment for a CGF software intended to support training of fighter pilots. Finally, based on a number of exploratory experiments in the presented environment, we discuss opportunities and challenges related to the application of reinforcement learning techniques in the domain of air combat training systems, with the aim to efficiently construct high quality behavior models for computer generated forces.

Toward the Development of a Medical Simulation Training Architecture (MSTA)

Harald Scheirich | Jeffrey Beaubien | Rodney Metoyer | Gianluca De Novi, Ph.D. | Timothy Kelliher

19219

Unlike tactical simulators – which leverage open communication protocols such as High Level Architecture (HLA) or Distributed Interactive Simulation (DIS) to permit large-scale, networked training exercises – most medical simulators have been developed using closed or proprietary system architectures. While some open-source medical simulation platforms do exist – including the Open Surgical Simulator (OSS), the BioGears physiology engine, and the Advanced Modular Manikin (AMM) – these platforms are not general purpose. They were each only designed to provide reusable simulation components within very focused content areas.

The lack of "across-the-board" medical simulator interoperability presents numerous challenges for the medical simulation and training community. For example, it is not possible for a simulated patient's medical condition and physiological parameters to be transferred from one simulator (e.g., a realistic patient manikin) to another (e.g., a Virtual Reality surgical simulator) during a simulated "patient handoff" between Aeromedical Evacuation Crews and the Forward Surgical Team. Similarly, it is not possible to conduct tactical-medical training exercises where weapons automatically register realistic wounding on simulated casualties.

Recognizing these limitations, the Joint Project Manager for Medical Modeling and Simulation (JPMMS) has been leading the effort to develop a next-generation Medical System Training Architecture (MSTA) that will provide an open standard for next-generation medical training, and is currently developing middleware that will permit integration with HLA, DIS, xAPI, STE and related communications protocols. The MSTA effort is one part of a much larger DHA-sponsored effort that seeks to develop a robust Joint Medical System Enterprise (MSE) along the entire continuum of care from Role 1 (point of injury care provided by self and Combat Medics) to Role 4 (long-term treatment and rehabilitation that is provided at a CONUS facility). The purpose of this paper is to define the MSTA project's vision, goals, approach, current status, future plans, challenges,

The Foothold in the War of Cognition: The Operational Training Infrastructure Enterprise System Model

Christopher Reed

19226

The Air Force Lifecycle Management Center Simulators Program Office (AFLCMC/WNS) is creating an integrated and maintainable enterprise Model Based Systems Engineering (MBSE) system model for the current simulator enterprise baseline. This system model is essential to fulfilling the Operation Training Infrastructure 2035 Flight Plan and placing the Air Force simulator enterprise on the digital engineering path. The Operational Training Infrastructure (OTI) Enterprise System Model (ESM) contains data for each simulator to the subsystem level, including specifications, interfaces, data flows, and software versions. This system model will transform simulator acquisition into a digital engineering environment informing Request for Proposals (RFPs), Configuration Control Boards (CCBs), engineering design reviews, and verifying Engineering Change Proposals (ECPs). The system model will become a central hub for Government and industry to comprehensively control each Air Force simulator's baseline with requirements, testing, reporting, and simulator architecture all in one easy to navigate model. The OTI ESM will fundamentally change the communication between Government and Industry through the seamless delivery of simulator data through each system model, enhancing acquisition cognition. The OV-1 High Level Operational Concept Graphic below illustrates the scope of the OTI ESM.

Augmenting Cyber Assessment through Dynamic Malware Analysis

Ambrose Kam | Charles Johnson-Bey | Michael Nance | Wenke Lee | Kyuhung Park | Carter Yagemann

19249

Malware is one of the major threats in the cyber space today. It is estimated that over 400,000 new samples[1] are being introduced to the world every day. To defend against these evolving advanced persistent threats (APTs), there is a need for an automatic, scalable, and secure analysis capability. Lockheed Martin is leveraging Georgia Tech's technical expertise in malware behavior analysis capability, and applying the results to cyber operations analysis and risk assessment.

This paper will describe an approach on how Georgia Tech's dynamic malware analysis capability can help design a system with better cyber resiliency against existing and emerging advanced persistent threats (APT). In general, malware will remain dormant until it is triggered by specific computing or network conditions or events. Hence, malware analysis framework, like Georgia Tech's, needs to offer a flexible environment to evaluate a plethora of malware. Most current analysis frameworks cannot segregate the malware traffic in the test network environment; the analysts must decide to isolate, or to let the malware traffic pass through the security controls while letting the malware exhibit their behavior. Georgia Tech's solution leverages both static and dynamic code analysis techniques to examine the interactions between the malware and its command & control (C2) server so that malware can exhibit its intended behaviors in the native environment. With this capability, the Lockheed Martin cyber solution team can develop specific remedies more quickly against the threats given the detailed nature of the malware analysis. Additionally, with its simulation environment, the LM cyber team can also test and evaluate their "what-if" cyber defensive postures relative to zero-day threats that have not been launched in the real world. Ultimately, this will enhance the system survivability and resiliency.

Emerging Innovations for Next Generation Mission Planning and Debrief

Joshua Ziegler

19253

The pointy ends of our national defense spears involve some of the most sophisticated technologies in the world. Just behind these pointy ends, however, is a collection of planning and debriefing processes mired in decades-old technologies (e.g., chalkboards, whiteboards, laminated maps) that impede the operational ability to adapt, decide, and execute. This paper describes our research, development, and evaluation efforts for next generation mission planning and debrief. The objective is to simultaneously accelerate processes and improve outcomes. Our approach involves combinations of new technologies that allow human-machine teams to engage in these iterative processes together. The core of our in-house development is a web-based system we call Metis, after the ancient Greek goddess of wisdom, prudence, and deep thought. Metis provides a web interface for people, an API for agents, and a database backend to serve both in a real-time fashion. Using this service-oriented architecture we have begun to develop and integrate an array of agent technologies. These include an air tasking order parser, a reading agent that extracts constraints from mission planning guidance documents, a mission plan generation and validation agent, a planning product development agent, and an automated debrief focus point identification agent. Each of these and their integration is in the prototype stage of development, but already we have begun formative evaluations. These indicate dramatic improvements in workflow and resulting decreases in process completion time. Early comparisons of machine-generated content to human-generated content show that they are often (but certainly not always) comparable. The paper will describe all of these components and the latest evaluation results in detail.

Use of Natural Language Processing to Extract Technical Competency Frameworks from Maintenance Task Analyses

Wayne Gafford | Jeanne Kitchens | Fritz Ray

19255

Technical competencies focused on maintenance, operations, and troubleshooting tasks on engineered systems must be derived from trusted, authoritative data sources, such as system tasks analyses. Those trusted, authoritative data sources are constantly changing caused by engineering design changes. In this type of dynamic enterprise data environment, competencies must reliably link to systems, people, and their work. These data types linked together are prime sources for human and system performance analysis. In the Navy, technical competencies are not linked to authoritative data sources causing technical curriculum to become latent and disconnected from the supported system. The heavy impact on readiness is a costly effect that has resulted in untrained sailors and mismanaged content. To address this issue, the Navy and Credential Engine signed a Cooperative Research and Development Agreement (CRADA) to map the GEIA 0007 and the S3000L logistical support analysis specifications to the Credential Transparency Description Language (CTDL) specification to tie maintenance requirements to competency models. Through the use of natural language processing, the CRADA team developed software that converts the specifications and the inherent content into Linked Data formats, extracts key information from the specification, then molds that content into the syntax of terminal learning objectives (audience, behavior, condition, degree) structured in the CTDL. The resulting technical competency framework mirrors the product structure and the associated tasks in the logistics specification and is linked through unique system identifiers forming a "digital thread". The software then analyzes the competency framework in the CTDL and ouputs a corresponding course outline in S1000D, an international technical manual specification. The time saved on manual job duty task analysis allows for the same analysts to be part of an iterative cycle of reviews and approvals of competency frameworks from authoritative sources. The learning is binded to the work through data standards, which in turn allow a faster identification of curriculum impacted by engineering design changes. This paper describes the process.

Simulate Effects of Cyberspace Electromagnetic Activities (CEMA) in Mission Command Systems

Nathan Vey | James Geddes | Lawrence Elliott | Paul Tucker

19257

The United States Army (USA) is developing and experimenting with concepts and force structures to conduct multi-domain operations (MDOs). The successful integration of cyberspace electromagnetic activities (CEMA) is a key tenant of winning an MDO as they affect, and are affected by, all of the warfighting functions. To effectively train for these operations, the USA requires capabilities to simulate CEMA and their effects on mission command systems. Several enhancements to enable training for CEMA in MDOs were made to a current "cyber for others" prototype training tool, Cyber Operations Battlefield Web Service (COBWebS), that was developed by the Army's Simulation and Training Technology Center (STTC), part of the Combat Capabilities Development Command – Soldier Center (CCDC – SC). The enhancements were funded by the Army Modeling and Simulation Office (AMSO) to improve the fidelity of the electronic warfare (EW) attack models that can stimulate live mission command systems and to provide a means to generate CEMA effects on Fires-related mission command systems (e.g., Advanced Field Artillery Tactical Data System [AFATDS]). This paper discusses the technical approach, successes, and shortfalls of integrating COBWebS with the Naval Research Laboratory's Builder tool to provide advanced radio frequency propagation models to simulate EW effects and with existing Call for Fire and AFATDS cyber training tools that are being developed for the Army's One Semi-Automated Forces (OneSAF) program.

Towards a Rationalization and Valuation Methodology for Training & Simulation Capabilities

Manfred Roza | Jelke Van der Pal | Michel Van Einige

19292

For many reasons armed-forces around the world revert to a diverse mix of live, virtual and constructive simulation assets as their prime technology for training. As such an armed-force's simulation capability becomes the major cost-driver in military training programs. A way this is addressed by many is the increased deployment of COTS/MOTS immersive devices and natural user-interfaces such as virtual, augmented and mixed reality. Another envisioned way to deal with this increased simulation costs is the M&S as a Service paradigm. However, most armed forces still struggle to gain a better insight and grip on the life-cycle costs and benefits of their training & simulation capabilities. Returning questions are: what is the best value portfolio of simulation assets/services for our investments, and how to make the training & simulation capability highly sustainable, robust and agile. Currently, the Netherlands Airspace Centre NLR is developing the foundations for a rationalization and valuation methodology to support the Netherlands Air-Force and Swiss Armed-Forces in their needs to evolve and manage their future training & simulation capabilities in the most cost-effective manner. The methodology builds on an enterprise architecture approach to align the training & simulation capability with armed forces operational (readiness) and business (cost) goals. It uses a so-called corporate training needs analysis to gain insight in the present and future situation. A valuation framework is deployed that assesses the simulation assets/services and underlying simulation capability infrastructure, resources and organisation in three key areas: training value, technical quality and cost. The latter two are rooted in a simulation capability maturity and life-cycle cost estimate model respectively, though basic and rudimentary at present state. Datafication and digitization of training processes are chosen as the manner to mature these models and manage the future training & simulation capability. Initial lessons-learned from case-studies are presented in the

Visualizing Electromagnetic Spectrum Phenomena in Augmented Reality

Michael Longtin | Robert Hernandez | Richard Schaffer | Mark Wager

19298

The Tactical Decision Kit (TDK), developed by the Office of Naval Research (ONR), contains hardware and software components that allow users to rapidly create ultra-realistic geospecific terrain models and visualize them as holograms on the Microsoft HoloLens via an application called SandTable.

An early experiment in the development of the TDK involved the incorporation of a radio-frequency (RF) propagation model called Sandbar into the SandTable application. This enabled several electromagnetic (EM) phenomena such as probability of detection and received signal strength to be visualized on the SandTable's terrain models in the form of color-coded semi-transparent overlays. Early demonstrations of this capability have garnered a tremendous amount of interest from multiple groups within the military, as it provides a unique way to visualize RF phenomena which are normally invisible, allowing insight into a unit's RF footprint as well as its ability to intercommunicate.

During the development of the EM overlay capability within the SandTable, various challenges were encountered associated with running computationally intensive models on a non-tethered device with a relatively weak CPU. Novel techniques were developed in order to overcome these challenges, including shifting some of the computational burden from the CPU to the GPU, and offloading other computations to a powerful remote PC. This paper details the development of the spectrum operations capability within the SandTable application, and explores the techniques that were employed to overcome the aforementioned challenges.

Development and Demonstration of Augmented Reality Forward Surgical Care

Brandon Conover, Ph.D. | Jerry Heneghan | Tyler Harris | Geoffrey Miller

19301

This project was a demonstration of an augmented reality (AR) forward surgical care system. A sample of six persons, two each of Military physicians (non-surgeons), physician assistants, and special operations medics used a lightweight, rugged, wearable AR display (ODG R-7) with telestration software, bi-directional voice and video, and voice-controlled on-board magnification to receive remote guidance from surgeons across cell networks, army radios, and satcom. Two procedures (four-compartment fasciotomy; anterior exposure of femoral artery) were performed on synthetic-anatomy medical training manikins. The ODG R7's preserved user peripheral vision to enable tactical situational awareness while using the device.

This technology integration project demonstrated that surgical specialty care can be provided in far forward environments when timely access to in-person surgical care is impossible. The operational concept was to integrate COTS items into existing telecommunication systems within the U.S. Army to create a unique operative platform.

A Mastery Learning Model was developed and employed to train and assess skill performance of both the mentees (non-surgeons) and mentors (surgeons) during the exercise. As an integration project, the effort was not designed to reach statistical significance. Even so, the six students opened 23 of 24 fascial compartments successfully and achieved control of the proximal femoral artery on all of the six test models. The fasciotomy completion rates exceed the success rate that has been reported for attending surgeons in some studies.

This paper will discuss the development of the smart glasses system, the Army-approved training demonstration methodology and outcomes, lessons learned, and the roadmap for development of a fieldable system and best practices for future efforts based on our successful demonstration.

THE VIEWS EXPRESSED HEREIN ARE THOSE OF THE AUTHOR(S) AND DO NOT REFLECT THE OFFICIAL POLICY OR POSITION OFTHE US ARMY MEDICAL DEPARTMENT, DEPARTMENT OF THE ARMY, DEPARTMENT OF DEFENSE, OR THE U.S. GOVERNMENT.

A Roadmap to Achieve Cyber Modeling & Simulation Interoperability

Derek Bryan | Fuzzy Wells | Jim Ruth | Sara Meyer | Katherine Morse

19314

Cyberspace is a rapidly evolving and contested domain. As a result, government, industry, academia, and international organizations are continuously developing and deploying capabilities to meet the rigorous training and readiness requirements of its users. Ideally these organizations would have conceptual models, validated data, interoperability standards, and other authoritative references to design, build, and employ new capabilities. With this information, organizations could build federated systems-of-systems in an efficient and scalable manner. Without this information, organizations are forced to develop custom solutions that may be incompatible with other solutions and require re-work in the future. This paper will examine the requirements and current state of cyber M&S interoperability with a focus on cyber terrain, real-time cyber effects data exchange, cyber-aware cross domain solutions, kinetic and non-kinetic entity correlation, and battle damage assessment. Recommendations will be provided in the form of a candidate roadmap to achieve cyber M&S interoperability. The roadmap will be based on the authors' extensive experience developing kinetic and non-kinetic standards, tools, and systems in support of multi-domain operations training.

Utilizing Augmented Reality for Air Force Maintenance Training

Christina Padron | Charis Homer | Troy Westbrook | Josh Davidson

19329

Aircraft maintenance is critical to Air Force readiness. However, the 2014 drawdown, which saw a reduction in close to 20,000 airmen throughout the enterprise, combined with the retiring workforce have led to a shortage of maintainers and a skill and knowledge gap. The lack of an efficient method to store and transfer knowledge from expert maintainers and effectively train less experienced maintainers has resulted in increased personnel training costs as well as unplanned downtime, keeping the Air Force from pushing the boundaries of readiness. An example can be found in the 367th Training and Support Squadron (TRSS). Despite their current ability to develop a variety of training products, they have no mechanism to capture and provide hands-free training material on the actual equipment in use. Innovative solutions are needed to accelerate the development of junior maintainers to experts by leveraging the expertise of senior personnel. This paper details how the 367th TRSS integrated augmented reality (AR) into their training program to support knowledge capture from retiring experts and facilitate knowledge transfer to fellow maintainers. The paper will outline the targeted use case and associated metrics used to evaluate the impact of AR in enhancing aviation maintenance training. Generalized findings highlight where and how AR is best suited to support maintenance training, and outline the return on investment leading to an adoption plan for the 367th TRSS.

LVC-Enabled Range technology: Supporting Training For Next-Gen Weapons Systems

Ryan Littler | Angus McLean | Craig Smith

19332

The technology currently available on aviation test and training ranges is insufficient to support current and future operational needs. The capabilities of modern, 5th Generation weapon systems have outstripped the existing range capacities. The result is a gap in the range's ability to support proper employment, realistic operational testing & training, and ever-increasing operations security (OPSEC) requirements. To represent the growing scale and complexity of these threats, protect our employment methods, and adequately train the operational forces, a secure and flexible range construct is needed for highly capable advanced platforms with rapidly evolving tactics. This paper presents the results of recent efforts to understand and accommodate new, blended range training infrastructures that are able to present flexible and consistent Live-Virtual-Constructive (LVC) based environments in a secure fashion. Results from a recent set of experiments and demonstrations show practical implementation of networking, security, platform instrumentation, and simulation infrastructures that incorporate concepts first explored in the Office of Naval Research (ONR) LVC study: Virtual and Constructive Representations on Live Aircraft Displays (VCR-LAD). The live execution and practical implementations of these concepts is presented and explored, including virtual range extension, multi-level secure mission flexibility, and weapons flyout management to maximise the utility of live adversary aircraft. The detailed infrastructure supporting pre-mission, mission, and post-mission phases of blended LVC operations that incorporate live aircraft equipped with multilevel security and software defined radios is discussed. Presented are results from a recent set of experiments and demonstrations of live aircraft equipped with this instrumentation. We conclude with lessons learned and recommendations for interoperability among advanced range and range-less instances of instrumentation to support both testing and training.

Approaches for Deep Learning in Data Sparse Environments

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19333

Deep Learning (DL) techniques offer innovative solutions to automating DoD-relevant instruction. However, the improvement comes at the cost of large amounts of data. DL is not effective in data-sparse environments. Any application for DL without a dataset already available requires the laborious and expensive task of collecting data before outcomes can become useful. Within the DoD research community, operationally relevant datasets are difficult to acquire even when they have been collected, leading to difficulties applying DL techniques.

In spite of these challenges, we show that we can use domain knowledge and machine transfer learning to make initial progress while data is being collected. This paper presents a case study in transfer between random and published puzzles while using (DL) approaches to solve Sudoku. The Sudoku represent an instructional domain providing controlled evaluation of DL outputs. A published Sudoku puzzle uses the interplay of different patterns to engage a player, which represents a subset of all possible game boards. The patterns in published puzzles are analogous to the nuances within a domain that characterize operational data. Given the cost of operational data, we desire a DL approach that performs well with few published puzzles as training inputs.

We describe an approach that reduces the data requirement and increases the performance of DL when little data is available. The approach uses transfer from random training data to speed and enhance DL training on data with patterns reflecting operational characteristics. Using the Sudoku domain, we show that transfer from random generated puzzles makes DL efficient after relatively few published examples are added. Furthermore, DL performance increases over time as real data is added. The benefits are hypothesized to support delivering instruction in settings with new and emerging tactics.

Lean Scenes: Variable-Fidelity Models Reduce Machine-Learning Training Requirements

Blake Anderton, Ph.D.

19349

This paper describes an approach to avoid waste in machine learning.

Image-processing neural networks characterize objects from features learned in training data. In some applications, the amount of training data is constrained by expensive data collection or limited-number of physical images. In such contexts, it may be preferable to first train performance against simulated imagery, then fine-tune by training with physical images. This "transfer learning" procedure helps networks meet performance requirements with reduced demands for amount of physical data consumed.

Simulation-based transfer learning raises two key concerns. First, modeling highly-realistic scenery through high-fidelity simulations typically involves significant computational expense. This may constrain the amount of generated imagery available for training, leading to reduced performance. Second, modeling artefacts may result in the network learning to recognize and respond to artificial features having no real-world equivalent.

This paper examines several approaches which address these concerns within the application of an image-segmentation neural-network for calibrating camera pose. First, transfer learning is applied to a series of simulation results, beginning with a pool of many moderate-fidelity runs, then fine-tune training on fewer, higher-fidelity cases. Second, the influence of artificial features may be (A) mitigated through blending physical/synthetic imagery through object texturing or (B) monitored through saliency-map diagnostics which inform analysts of image regions most-responsible for network performance. Artefact robustness methods represents an active research area.

These approaches demonstrate that (A) simulation output need not be exclusively highest fidelity to be of utility to early-phase training, and (B) overall computational expense can reduce through training sequences which increase modeling realism while also reducing number of generated samples. In these ways, variable-fidelity simulations dynamically provide the modeled realism appropriate to a machine-learning algorithm's evolving capabilities.

Man-Machine Interoperation in Training for Large Force Exercise Air Missions

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19372

The United States Air Force strives to maximize human abilities in highly complex operational environments, and artificial intelligence (AI) affords opportunities to transform voluminous data into meaningful information to support human decision making. A Mission Analysis and Review System (MARS) was developed to explore how AI can automate current mission debrief processes and to visualize that information in a mission-specific context. The current effort explored the development of AI to assist Air Force commanders in evaluating the mission performance of a Large Force Exercise (LFE), which affords pilots the chance to hone their abilities to execute their individual role within a mission that may include dozens of aircraft. In an earlier but related effort, the research team developed machine intelligence to automatically label mission phases of a two-ship strike formation using entity state data of aircraft flown by human pilots in simulation. In the current effort, an LFE with 18 friendly aircraft was simulated using the Joint Semi-Automated Forces (JSAF) simulation engine. Models were created to score both individual aircraft behavior as well as overall mission objective success. Templates were used to determine if acceptable levels of key mission objectives are being estimated and evaluated. By enumerating the propositions included in the three temporal behaviors in the classification model, the behaviors the model deems necessary for evaluating the execution as acceptable were interpreted. Results showed that mission phases and their objectives could be correctly classified with an accuracy of .92 to .96 using a technique where mission objectives were encoded in a linear temporal logic (LTL) format. The findings suggest that AI can be used to make meaning of raw data for use by commanders to support LFE planning and debrief. The effort described is the first known application of machine intelligence to automatically score mission performance for

The Application of Augmented Reality for Immersive TC3 Training

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19379

Military medical personnel are the first responders of the battlefield, where they are tasked with maintaining tactical objectives and making critical decisions for care that may determine if a casualty lives. Having providers engage in realistic Tactical Combat Casualty Care (TC3) scenarios can optimize the leadership, teamwork, tactical, and medical skills required to succeed in the challenging situations they may encounter.

An issue that instructors face when attempting to create engaging TC3 training scenarios is effectively simulating battlefield injuries on the standardized patients imitating casualties. While medical moulage offers a static visual portrayal of a wound, instructors often have to provide supplemental content to the scenario using verbal prompts about the patient's injuries. The goal of this is to add realism and progress the scenario along, however it can often detract from the scenario and add to the workload of the instructor.

Augmented Reality (AR), especially the recent boom in wearable AR headsets, has the potential to revolutionize how TC3 training happens today. AR can provide a unique mix of immersive simulation within the real environment by overlaying dynamic virtual injuries on simulated patients. The AR field has seen billions of dollars invested for development and deployment of hardware and software, which has been leveraged into many fields (e.g., entertainment).

While AR offers many opportunities for training improvement within the TC3 training, several challenges for integrating these technologies still exist. TC3 scenarios present complex environments for AR tracking and projection due to the many dynamics of the scenario (e.g., sunlight, moving patients, tactile nature of procedures). This paper will describe the research and development of an AR-based TC3 training capability for combat medics. Specifically, this paper will explore the technical challenges encountered during development of the capability and provide identified solutions, both hardware and software, for addressing these limitations.

BEST PAPER

Enhancing Learning Outcomes Through Adaptive Remediation with GIFT

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19275

Adaptive instructional systems (AIS) will play a central role in the next generation of training systems for the military. A key feature of AISs is the capacity to automatically tailor instruction to fit the needs and skills of individual learners. Leveraging recent advances in artificial intelligence and machine learning, it is possible to tailor training and educational experiences based on the goals, learning needs, and preferences of individual learners and teams of learners. Tutorial planning, a critical component of adaptive training, controls how scaffolding and instructional interventions are structured and delivered to learners to create personalized learning experiences. Devising computational models that effectively scaffold learning experiences is a critical challenge for the field. For example, AISs need to determine when to scaffold, what type of scaffolding to deliver, and how scaffolding should be realized, all in real time. In this paper, we describe our work using the Generalized Intelligent Framework for Tutoring (GIFT), an open source framework for creating, deploying, and evaluating adaptive training systems, to create a web-based adaptive short course for teaching fundamental principles associated with counterinsurgency (COIN). The course presents students with a series of videos, integrated assessments, and remediation materials about doctrinal COIN concepts. The course's adaptive remediation features are based on the ICAP active learning framework to deliver constructive, active, and passive forms of remedial feedback to students. We report the results of a recent study in which 500 participants completed the adaptive training course along with pre- and post- training knowledge tests. The paper provides an analysis of learning gains and factors that moderated these gains and concludes with a discussion of future research as it pertains to the goals of the broader research program investigating applications of machine learning, and reinforcement learning in particular, to automatically generate policies for instructional remediation in AISs.

Track Mobile Learning with Secure Access Using xAPI and CAC

Paul Miller | Ilya Voloshin

19102

Delivering learning content to mobile devices has presented unique challenges not experienced in a traditional Learning Management System (LMS) environment. Identifying the student, securing student progress, presenting content offline, and reporting progress in a secure way are just some of the obstacles preventing mobile content delivery standardization.

Two technologies, when used in conjunction, can potentially solve these problems. They are Common Access Card (CAC) and Experience Application Programming Interface (xAPI). Naval Education and Training Command (NETC) conducted an experimental project intended to securely record mobile learning events to a Learning Record Store (LRS) via xAPI statements using the CAC provided to United States Defense personnel and DoD learners. This process presented three challenges, with the first being to integrate a compatible CAC reader with Microsoft Surface, iOS (iPad), and Android native applications. CACs securely identify a student and provide encryption tools to encrypt data on mobile devices so only the user with the encrypting CAC can decrypt/access the data.

The next challenge was to securely transfer verified data to the LRS. The xAPI standard provides a way to sign each statement with a cryptographic signature, allowing the LRS to independently verify the integrity of each statement at any time. We used the same cryptographic certificates from the student's CAC to securely sign each statement. The final challenge was to provide security while sending the statements to the LRS. The LRS implemented SSL client certificate authentication to allow access to send the statements. We again used the student's CAC certificate to gain access to the LRS endpoint to securely transmit the data.

This paper details lessons learned from each aspect of this project, from identifying the student to securely transmitting the data. We successfully brought the secure CAC infrastructure to xAPI solving the problem of secure mobile content tracking and delivery.

Implementation of a "True" Flipped Classroom Concept at the Norwegian Defense University College

Geir Isaksen

19116

As a result of an extensive educational reform in the Norwegian armed forces, digital learning is introduced across the military system. One of the measures implemented at the Norwegian Defense University College (NoDUC) is flipped classroom.

Flipped classroom, one of the most well-known buzz words in education for the last 5 years or so have reach learning institutions all over the world. But was does really mean to implement flipped classroom as part of your educational strategy? Is putting Power Point presentation's in the LMS together with digital copies of the syllabus enough to claim that flipped classroom is implemented? Is it really something totally new and is only suitable for certain subjects?

This paper gives an overview over what a flipped classroom concept really means, why it matters and how it is meant to be implemented as an educational strategy. Furthermore, both pros, cons, risks and common misunderstandings are discussed and compared to traditional learning methods, still existing in many schools and universities around the world.

Finally, lesson learned from the implementation of a flipped classroom strategy at the NoDUC is laid out and recommendations on how to use flipped classroom as an educational concept with success are presented.

Evaluation of sUAS Education and Training Tools

Brent Terwilliger | Andrew Shepherd | Scott Burgess | Kristy Kieman | Christian Janke

19136

The wide distribution and demographic composition of those seeking small unmanned aircraft system (sUAS) education, presents a need to fully understand the capabilities, limitations, and dependencies of effective training tools. Concepts, practices, and technologies associated with modeling and simulation, immersive gaming, augmented and mixed-reality, and remote operation have demonstrated efficacy to support engaged student learning and objective satisfaction. Identification and comparison of key attributes critical to an aviation educational framework, such as competency-based training, enables educational designers to identify those tools with the highest potential to support successful learning. A series of factors, such as system performance, regulatory compliance, environmental conditions, technological familiarity, and personal experience, require consideration in the selection, optimization, and application of such tools. Embry-Riddle Aeronautical University-Worldwide and Sinclair College National UAS Training and Certification Center have overseen the development, launch, and sustainment of respective sUAS education programs. Effectiveness of these programs is dependent on continuous evaluation of tools, specific to educational settings (e.g., online and in-person). A relevant example was the assessment of popular multirotor sUAS conducted by ERAU-W, which led to publication of the "Small Unmanned Aircraft System Consumer Guide" and selection of the Parrot BeBop 2 platform to support sUAS operations curricula. The intent of this work is to present critical considerations, including influencing factors and dependencies, associated with the selection and adoption of technological tools best supporting sUAS education. Background details; emerging approaches, models, and technologies; and examples of past tool evaluation, inclusive of assessment criteria and observations, will be discussed. Finally, a series of reflective remarks, including recommendations, relating to evaluation, adaptation, and incorporation of future tools supporting sUAS education will be presented. Examination of critical factors affecting successful tool adoption, among such a widely varied and distributed community, is envisioned to support improved development of future educational programming and tools.

Avoiding Pitfalls in Undergraduate Simulation Courses

Vikram Mittal

19168

Simulation development has historically been a specialized skill performed by engineers with graduate-level training and industry experience. However, advances in computing technology, coupled with the rise of model-based systems engineering, have dramatically increased the usage of simulations, such that most engineers now require a working knowledge of modeling and simulation (M&S). As such, an increasing number of undergraduate engineering programs are now requiring students to complete a simulation course. These courses are intended to reinforce foundational engineering knowledge while also teaching the students useful M&S tools that they will need in industry. Yet, a number of pitfalls are associated with teaching M&S to undergraduate students. The first major pitfall is focusing on the tool or software without properly teaching the underlying methodologies. This pitfall can result in students becoming fixated on the software, limiting their broader knowledge of M&S. The second pitfall involves the use of contrived, academic tutorials as course projects, which limits students from fully understanding the simulation design process. The third and fourth pitfalls are only superficially covering verification and validation and not building off material that was taught in other classes. Finally, the fifth pitfall is the over-reliance on group projects and tests over individual projects. These pitfalls were uncovered during academic years 2017 and 2018 in different undergraduate simulation courses at the United States Military Academy. The combat modeling course adapted its structure and content in academic year 2019 to avoid these pitfalls, with several lessons learned that are applicable to the broader simulation education community. Generally, students gained a broader understanding of M&S and submitted higher quality work. Additionally, the course-end feedback found an overall increase in M&S knowledge, with many students choosing to use M&S to support their honors theses and capstone projects, a trend not seen in past years.

Conducting Training and Simulation Research: A Primer for Practitioners

Philip Temby | Susannah Whitney

19179

Training is a fundamental input to defence capability and each year military units invest significant resources on training service personnel. To ensure this training is effective, it is important that the design, implementation and evaluation processes are based on best practices. Much has been written on the science of training including considerations for conducting training research in organisational settings. Despite this literature, our experience has highlighted the need for ongoing education of practitioners within the training and simulation community. The aim of this paper is to provide practical guidance for professionals involved in designing, implementing and evaluating training in military settings. While there are many excellent handbooks and articles available on training evaluation and simulation-based training, they are usually quite detailed or focused on specific aspects of training and simulation, and not well suited to professionals who may be relatively new to the area and seeking a quick introduction to key issues. To address this gap, this paper outlines key issues in the form of Frequently Asked Questions (FAQs) within each of the five stages of the commonly used ADDIE model of training. The contents of the paper are drawn from the published literature, as well as the authors' experiences of working in training and simulation research for over 15 years in military settings. We hope this 'primer' will become a practical resource for training designers, developers, instructors, device manufacturers, and researchers. The paper concludes with some suggestions for high-pay off research in the training and simulation community. This paper is important to the community because it provides an overview of key issues involved in conducting training and simulation research, and reinforces best practices associated with the design, implementation and evaluation of training systems; all of which is presented in a reader-friendly FAQ format.

An Evidence-Based Methodology for Evaluating the Community Impacts of a Science, Technology, Engineering, and Mathematics (STEM) Instructional Program

Jessica Cortez, Ph.D. | John Kegley | Wink Bennett

19220

One of the objectives of the Air Force Research Laboratory's Gaming Research Integration for Learning Lab® (GRILL®) is to leverage commercial modeling and simulation technology to support secondary student education and engagement in STEM disciplines. As with any community-focused intervention, traditional evaluation approaches are not always well-suited for assessing outcomes. As such, researchers identified methodological opportunities to explore student and community impacts in novel ways. This paper outlines the developed evaluation methods utilizing a constellation of student survey and self-report data, alumni academic and career experiences, and teacher/mentor feedback regarding such topics as models of student achievement, test-based accountability systems, and curricular interventions.

The findings presented herein foster the understanding of the degree to which STEM outreach activities, such as the GRILL®, are influencing the formal education community and generating desirable outcomes for participants. The objective is therefore to refine the measures of progress for STEM initiatives by evaluating multi-dimensional data sources for students, mentors, and educators participating in the GRILL® program. Constructs including the following are explored: the extent to which outreach activities increase educator awareness and confidence in implementation of STEM curricula, types of positive student outcomes (e.g., access to STEM materials and the pursuit of STEM related careers), and student-requested STEM learning experiences. These identify investment priorities and focus areas concerned with the underlying structure of learning opportunities. This paper highlights current identified impacts and describes our continued efforts to increase the precision for gathering more direct and quantifiable data. These lessons-learned and future directions provide guidance for evaluating STEM exposure and its impact on the community, regional workforce, and educational opportunities in other similar initiatives and programs.

Neuro-Designer: Informing the Development of Learning Solutions Through Application of Neurometrics

Adam Hall

19266

As the utility of neuro-studies in real life learning environments becomes clear, more out-of-lab approaches to this analysis are being developed. But, the essential components of the scientific process must be assiduously followed to advance these studies beyond data mining. Hypotheses framed around LMS (SCORM) course events with disciplined expectations and testable inferences are required from the start.

The Neuro-Designer software is intended to provide a workflow for producing experimental design alongside the develpment of report protocols and metric evaluation methods. The profound potential this process offers to the learning community can hardly be overstated; the variance of expectations to actual results (as they pertain to attentional and emotional states, when/whether memory is being encoded and/or retrieved, and the synchrony of brainwave data across multiple subjects given common stimuli) offers new and powerful insights into how effective and efficient a learning object is in delivering its intended results to an audience of learners.

The goal is to supply instructional designers with the tools to examine the efficacy of their courses in light of brain science, and gain insight into how course material and learning objects can be tailored to enhance a learner's response to attention, emotion and memory cues, as well as synchronous behavior among a class of students. The renowned neuro-scientist, Dr. Moran Cerf of Northwestern University, has provided essential guidance in the development and utilization of these neuro metrics and in utilization of these neuro metrics and in understanding the underlying psychological issues.

The elements and architecture of the Neuro-Designer will be discussed, as well as precursor studies that served to motivate the application.

LEGO Serious Play: A Powerful Sense-Making Tool in Military Contexts

Kevin Thom

19267

In recent years, the stress of multiple deployments takes a toll on Soldiers' relationships, mental and spiritual well-being and the Chaplain Corps. is there to support their mental and spiritual health. There is a belief that relationships will strengthen the whole Soldier, but the Chaplain-to-Soldier ratio is high. According to AR 600-100, U.S. Army Profession and Leadership Policy, investing in developing Mentors would enable Chaplains to identify issues early. Mentors would be trained to assist Soldiers as a liaison between the Chaplain and the Soldier at the unit level.

The U.S. Army contracted a counselor and consultant to design and deliver A 4-day workshop for the Chaplain Corps. Strong Bonds program backed by research for Chaplains and Religious Affairs Specialists. To emphasize the importance of mental and spiritual health in a relationship, LEGO Serious Play (LSP) methodologies were implemented as activities to communicate and discuss complex topics. LSP is an emerging communication, thinking, and problem-solving set of techniques based on the theory of constructivism (Piaget and Inhelder, 1958), constructionism (Papert and Harel, 1991), and play (Roos and Victor, 2004) where subjective views matter, and metaphors and storytelling are powerful sense-making tools.

This methodology was delivered at U.S. Army installations with high interest. Chaplain feedback of how tools and resources are being used suggests that implementing LSP in this context provides a low-cost, high impact means of instruction. LEGO Serious Play demonstrated reinforcement of concepts by building metaphorical models to discuss difficult topics such as trust, forgiveness, service, sacrifice, and more.

This paper describes the instructional design process behind implementing LSP into a military training context, its challenges, and opportunities for improvement. In particular, we will describe how the underlying principles behind LSP can inform best practices in instructional design for soft skills in military contexts.

Implementing Change for Greater Learning, Readiness, and Lethality

Kendy Vierling

19289

The United States Department of Defense (DoD) and the national security community can be certain that the future will continue to increase in complexity and pace, and that the availability of emerging science, technologies, and information will become more prevalent. Accordingly, organizational processes, practices, and concepts must continue to evolve. In the Summary of the 2018 National Defense Strategy, the United States Secretary of Defense stated that "Cultivating a lethal, agile force requires more than just new technologies and posture changes; it depends on the ability of our warfighters and the Department workforce to integrate new capabilities, adapt warfighting approaches, and change business practices to achieve mission success." Without sustained and focused efforts to cultivate agility and innovation, the military Services risk decreasing readiness and lethality.

To address these challenges, Services within the DoD are transitioning from an industrial age learning model to a more agile learning model that better leverages innovative methods, emerging learning science, and technology. Previous research (Raybourne et al., 2017; Vierling et al., 2018) identified recommended changes to enhance learning within the national security community, including enhancing instructional quality, competency-based learning, personalization, learning on demand, obtaining frequent end user feedback, exploring best practices to create integrated learning capabilities, and incentivizing innovation and performance. However, implementing a new learning model and the above recommendations within DoD has proven challenging.

This paper provides a flexible framework and specific examples from the Marine Corps Training and Education Command (TECOM) to explain how to implement changes to create a more student-focused, integrated, and agile learning environment. Training and education practitioners provided insights regarding obstacles and opportunities to enhance student learning. Finally, this paper discusses current limitations, challenges, future directions, and recommendations to enhance learning, readiness, and lethality.

Communication Skills Development for Non-Commissioned Officers (NCOs)

Kara Orvis | April Sanders | Jessica Shenberger-Trujillo | Kristy Kay | Krista Ratwani

19293

The Army NCO corps is an extremely diverse population of individuals from various ethnic, language, and socio-educational backgrounds. Being able to communicate effectively with Soldiers, officers, and civilians is an essential skill for all NCOs. However, recent research suggests that many NCOs have communication skills deficits (Ward, 2018). Before training solutions can be recommended, more research is needed to better understand the development of communication skills in NCOs and the most common challenges that they experience while learning these skills. The purpose of this research was fourfold: a) to map how interpersonal, written, and oral communication skills are developed both informally and formally over the course of a mid-grade NCO career (from E-5 through E-8); b) to identify skill gaps, c) to investigate communication challenges related to communication technology, generational differences, culture, English as a Second Language (ESL), and vertical and horizontal communication issues; and (d) make training recommendations. This research was conducted using semi-structured focus groups and questionnaires with 225 Soldiers, NCOs, and officers. Results indicate that the majority of communication skills are learned on the job, but that very little formal training is provided. The development of writing skills was identified as a particular challenge. Many NCOs reported that the development of writing skills varied greatly according to their senior leadership and Military Occupational Specialty (MOS). Further, results suggested communication challenges related to gender, but did not suggest significant differences related to culture, generational issues, or language. Results also indicate that while there is increasing use of texting as a primary method of communication, there is also emphasis on face-to-face communication when available. Finally, there is a need for on-the-job training solutions that are simple and fit into regular work activities. This paper will discuss these communication skills training challenges and suggest practical literature-based recommendations for resolving them.

A Once in a Generation Opportunity to Transform RAF Training

Audrey Caldeira-Hankey | Helen Dudfield | Lindsay Sargent

19294

UK Ministry of Defence (MOD) Defence Science Technology Laboratory (Dstl) worked in a collaborative partnership with industry and the UK Royal Air Force (RAF) to deliver evidence to underpin Programme PORTAL. The RAF is moving its provision of training for Airmen to a new site, which currently accommodates elements of its Officer training. Programme PORTAL provides a once in a generation opportunity to transform the way the RAF delivers elements of its Professional Military Education, in particular Phase 1 basic training to Airmen and Officer recruits. In thinking beyond technology and pedagogy, the research included an investigation of cultural impact on educational design to feed into a new campus. A number of innovative options were put forward on how to deliver future RAF training, including a cultural shift which could harness the potential of increased interactions between Airmen and Officers in the training environment. The research was able to capture feedback and provide a narrative from a range of stakeholders ranging from current cadets to 2* decision makers on options relating to formal interactions (such as, training serials and facilities), informal interactions (e.g. accommodation, messing and social) and interactions between learners and staff. This research delivered the requisite evidence to inform the development, approval and ratification of a range of ideas (such as integrating sports, welfare and staff facilities) and their associated benefits whilst maintaining a focus on the provision of world-leading training and mitigating potential risks through concepts such as safe-space to learn. This research supports the RAF 100 vision of an enabled and inclusive Force. Through encouraging creative thinking, which challenged cultural norms, we have provided decision makers with the ability to fully consider integrated training; equipping the next generation workforce to innovate, think differently and challenge the status quo.

Twenty-Five Emerging Trends in Learning and their Implications for Military Partners: An International Study

Sae Schatz

19299

The training and education domain is rapidly evolving. New capabilities, such as AI and data science, combined with a growing understanding of cognition, neuroscience, and educational theory are transforming the ways we learn. What are the implications for defense organizations, and what are military stakeholders' perceptions of them? These were the questions posed to our Technical Cooperation Program (TTCP) technical panel.

The TTCP is a multinational R&D cooperative for Five Eyes countries, i.e., Australia, Canada, New Zealand, United Kingdom, and the United States. This paper, written by the national delegates from each nation on the TTCP Future Defence Learning Technical Panel, describes work undertaken to analyze emerging learning approaches, compare international military perspectives on them, and identify opportunities for related multinational coordination.

Specifically, this paper will showcase findings from the group's learning trends study. We began by broadly evaluating emerging methods and technologies for education and training from industry, academia, and defense institutions. We identified 25 distinct trends, such as individualized personal learning, learning through social media, and ebooks as a learning platform. These trends were clustered into four categories: Learning Design, Learning Delivery, Enabling and Managing Learning, and Learning at Scale. After synthesizing the trends, we developed a survey to gauge our respective militaries' perceptions of them according to interest, level of current adoption, and estimated time for future adoption. From these results, we then evaluated our own organizations against these learning trends and comparatively across the nations. Finally, we identified ways to individually and collaboratively modernize our training and education enterprises, accordingly.

This paper presents the group's findings, including the background research, survey and subsequent results, and analysis. The paper also summarizes findings on how coalition military partners can achieve shared goals in innovating their learning approaches. (NOTE TO REVIEWERS: ALL DATA HAVE BEEN COLLECTED AND ANALYZED!)

Transforming the Operational Mindset: Self-Regulating Cognitive Performance Enhancement Strategies

Denise Stevens | Heather Seiser | Karen Tovar | Christa Bohannon | Dennis Lyons

19310

Lead Agents at The Transportation Security Administration (TSA) provide key support for the day-to-day operational security environment in major transportation infrastructures throughout the country. They are highly dedicated to the agency's Mission and work under tremendous pressure, having to make the right decisions at the right time to ensure maximum security for the traveling public. Frontline leadership personnel must uphold high standards of accountability and possess high levels of self-awareness, self-knowledge, and situational awareness to effectively manage work flows and personnel. Understanding themselves, the thinking process for building good leadership habits, and the skills for critical thinking are just a few of the many competencies needed to balance leadership principles and standard operating procedures in an operational security environment. For this reason, a new curriculum was designed to allow frontline leadership personnel to delve deeper into the cognitive elements of self-awareness, mindfulness, and the thinking processes that go beyond just a training event, but actually provides a self-directed competency roadmap for career progression.

This paper discusses the specific cognitive and metacognitive strategies that were used in the TSA Essentials curriculum to enhance lead officers' thinking processes with the goal of improving cognitive performance in an operational security environment as they attain higher levels of responsibility. Cognitive performance encompasses a change in the leadership mindset to better anticipate challenges and make the right decision to resolve critical situations quickly. The paper also discusses results and findings from evaluation procedures and how these results indicate improvements in cognitive performance outcomes.

Establishing Engaged Social Learning Communities: Formation and 'Sense Making'

Julian Stodd

19326

Formal learning takes place in classrooms, using organizationally owned assets and technologies. Social Learning takes place beyond classrooms -- facilitated by collaborative technologies, it involves learners creating assets, and collaboratively narrating their learning. Despite being outside classrooms, it can still be a guided, reflective, journey, taken over time, with application into the real world of the learner. Social Learning is a distributed, co-creative, and highly dynamic, learning design methodology, where extensive 'sense making' takes place within a community. The design of effective Scaffolded Social Learning maps out specific activities, techniques, and opportunities to be leveraged by the learner. Central is the notion of an effective 'Learning Community': not simply a space, but a high functioning entity, providing knowledge, context, challenge, and support to individual learners.

In this paper, we will consider 'Engaged Social Learning Communities' as holding a specific capability to support learning effectiveness. We consider mechanisms of community formation, explore what can be done to practically assist in this formation stage, and how 'formation' carries later implications for 'effectiveness'. To do this, we consider eight elements that contribute to the effectiveness:

1. Rituals of engagement: how members join a community.
2. Tribes and Trust: the granular social structure of a learning community.
3. Identity and ownership: how communities gain engagement through identity and self-determination.
4. Rules and Consequence: implicit vs explicit rules, and the ownership of consequence.
5. Totems and Tokens: artifacts of membership, and trading in the reputation economy.
6. Interconnectivity: between individuals, and diagonally through segregated social structures.
7. Segmentation of spaces: learning, rehearsal, and performance.
8. Currencies of Vulnerability, Gratitude, Reputation, and Reward.

Understanding each of these gives us a stronger foundation for design. We will share case studies and research exploring how these are used in practice in a range of international Organizations.

Increasing XR Technology's Return on Investment through Media Analysis

Martin Bogan | Scott Bybee | Jay Bahlis

19327

New developments in XR (virtual reality, augmented reality, and mixed reality) technologies promise to transform how we train. Research results in industries such as manufacturing and construction seem to support this promise and innovative ideas are generating a multitude of new projects. How do we ensure we are getting the best return on investment (ROI) when using XR before we commit significant resources? What do we need to account for in advance before we invest in XR training solutions? What are the limitations in developing sound competencies and proficiencies in learners using XR technology during training?

Whenever industry introduces disruptive technologies, there exists the challenge of adoption and integration. Questions raised concerning effectiveness and return on investment are warranted and healthy. We intend to empower the military training industry with proven tools and processes, which can guide the adoption and refine how we employ XR technology.

This paper will survey and compare existing research on the effectiveness of XR training solutions and compare competency and proficiency results against traditional training methods. It will provide a media analysis model comparing new and traditional training methods that recommends the best approach based on cost, schedule, and quality of training for learners in a military training environment. It identifies changes in both project management and acquisition that will increase the Return on Investment (ROI). Finally, it will make recommendations on how and when to employ new tech to maximize training effectiveness and increase customers' Return on Investment (ROI).

Cognitive Weaponry: Optimizing the Mind

JJ Walcutt

19380

As technology becomes increasingly interoperable and human-computer interaction enables us to work seamlessly with external memory, automated filtering, automated tasking, and other support tools, we have the opportunity to optimize the capabilities of the human mind and operate at a higher level of agility. Significant research has been conducted in the areas of resilience, mindfulness, cognitive load theory, decision making, and education for readiness. Further, technological interoperability is nearing reality and xAPI specifications are becoming standards, allowing real-time experiences to be tracked and analyzed. Thus, when we combine these theories from cognitive science with the technological tools, we create the opportunity to filter unnecessary information that could overload the mind in theater. We can measure real-time stress metrics through wearable devices allowing us to control what information is coming to an operator and in what manner it is presented. Augmented reality can allow us to use focus strategies like highlighting to help clarify for the warfighter what is important in the field but further, it can help connect seemingly unrelated data points in the field to help more quickly and more accurately identify threats.

Accordingly, this paper will investigate the enabling factors of technological interoperability and improved experience measurement as well as enabling tools such as wearables, augmented reality, learning science strategies, and emotional regulation strategies to create a future vision of seamless human-computer interaction. Benefits discussed include the concepts of mind armor (filtering out emotionally charged information to reduce PTSD onset), cognitive agility (enhanced cognitive maneuverability through automated filtering and augmented reality usage), intellectual recovery (react, recover, reload: improving recovery abilities through mindfulness training and bio-feedback from wearables), and mental endurance through stress inoculation (elongating the time to stress-induced chemical release through systematic desensitization techniques combined with bio-feedback from wearables during simulation exercises).

Air University Multi-Modal Research Course on VR/AR and Related Technologies

Tony Millican, Ph.D. | Dennis Armstrong, Ph.D. | Anthony Gould, Ph.D. | Lt Col Chris Willis

19388

Numerous emerging technologies have brought-about affordable capabilities that need to be more thoroughly explored for their practical application within the learning environment. The Air University (AU) chartered the Innovation in Learning Sciences Research Task Force to investigate the applicability of emerging consumer technology capabilities in the context of relevant learning theories and how the combination of capabilities and theories can inform the practice of educating, training, and developing national security professionals. The subject 6- graduate-hour class curriculum investigated virtual reality, augmented reality, haptic devices, 3D printing & related tech capabilities as well as myriad learning theories including experiential learning, social constructivist learning, situated cognition, anchored instruction, and connectivism. The class was designed as a joint endeavor that integrated efforts between three AU agencies, four AU master's degree programs, and multiple educational and non-profit partners including GMU's Serious Games Institute, and MGMWERX. During the first semester's twenty 3-hour synchronous sessions, 10 resident students engaged in-person, and 8 distance students interacted live via webinar. In concert with in-person and live webinar attendance, an hour or more of each class was experienced synchronously "inside VR" using multi-user VR co-presence platforms including Rumii, Engage, High Fidelity, and others. Beyond the "class sessions," students also conducted a research trip to the Lobaki VR Academy to experience hands-on engagement with dozens more developmental haptic devices and VR/AR applications. Through the second semester, based upon content learned about emerging tech capabilities and learning theories, each of the 18 students wrote a master's thesis on how DoD, interagency, and allies could apply VR/AR and related technologies to the learning process within the student's native area of national security expertise. Numerous lessons have been extracted from the lived experience of developing and executing this first-of-a-kind prototype class and a body of over 400 pages of graduate research was produced.

HPAE

BEST PAPER

Simulating Augmented Reality Spatial Accuracy Requirements for Target Acquisition Tasks

John Graybeal, Ph.D. | Rachel Nguyen | Todd Du Bosq

19343

Augmented reality (AR) technologies are one method of supporting military visual search tasks, such as target identification, recognition, and acquisition. However, whether or not a given AR technology actually improves human performance depends on many factors, including the quality of the display and the quality of the AR information provided to the Soldier. In this paper, we describe current research efforts by the U.S. Army CCDC C5ISR Night Vision and Electronic Sensors Directorate to use simulation to study one aspect of AR information quality: spatial accuracy. Specifically, we examine the level of AR spatial accuracy required to improve human performance as a function of the density of potential targets. Participants were placed in virtual scenarios and asked to locate and target a single virtual human holding a weapon amongst many unarmed virtual humans. Participants used realistic sensor controls to scan the virtual field of regard and to locate the target. Baseline performance was characterized by having participants locate targets without any AR assistance. In other control trials, participants were guided to the target with perfectly accurate AR symbology, located both on a situational awareness ring and in the operator's field of regard. In experimental trials, participants were guided by imperfect AR symbology distorted by fixed amounts of angular error. These experimental conditions of varying AR information were crossed with various densities of potential targets (i.e., virtual humans) in the field of regard, ranging from densely-populated to sparsely-populated search areas. Our results examine the effects of AR spatial accuracy on target acquisition time, comparing imperfect AR to perfect AR and unaided searching in scenes with different densities of potential targets. The ultimate goal of our research program is to support product development and virtual prototyping by simulating task-specific and sensor-specific AR accuracy requirements for sensors and head-up displays.

Psychomotor Skills Assessment via Human Experts, Simulators, and Artificial Intelligence

Roger Smith | Danielle Julian

19108

Surgical education programs present significant challenges for the creation of accurate and executable assessment methods and metrics for psychomotor skills. This assessment has historically been accomplished by (1) observation and scoring by a qualified expert, (2) examination and scoring of a finished product, or (3) simulator data collection and mathematic scoring of both performance and final product. Each of these offer unique advantages and limitations during real execution, as described in detail in the paper.

Surgical courses at the Nicholson Center combine all three of these assessment methods, while also investigating new technologies that offer improvements. Given the advancements that are being reported for artificial intelligence and deep learning we have studied the applicability of these techniques to the assessment of surgical skills. This paper describes the evaluation of techniques for processing video of surgical skills and for classifying the scores assigned to a performance. The techniques investigated include convolutional, recursive, and long short-term memory neural networks for the former and k-nearest neighbor, naive bayes, random forests, and support vector machines for the latter.

These techniques deliver impressive results in recognizing static objects in individual pictures and are beginning to address recognition of dynamic activities in video. For surgical skills performance, these techniques must (1) recognize stationary objects in the scene, (2) identify the dynamic activities that are demonstrated in the video, and (3) classify the quality of performance of the activity. The techniques are considered for processing both video of the live activity and simulator data streams. We found that automated assessment with deep learning presents several challenges for the humans who must specify the target answers and for the algorithms which must process the video and data. These hurdles are equally present for the assessment of psychomotor surgical, military, or industrial skills.

Real-Time Measurement of Team Cognitive Load During Simulation-Based Training

Jeffrey Beaubien | Sterling Wiggings | William DePriest

19129

The “Zone of Proximal Development” (ZPD; Vygotsky, 1978) represents the difference between a learner’s current and potential levels of mastery. While in the ZPD, learners experience facilitating levels of workload, motivation, and anxiety. During scenario-based training, instructors often attempt to keep learners in the ZPD by dynamically modifying the scenario’s difficulty. Doing so, however, requires real-time measures of individual and team Cognitive Load (CL), which have been heretofore unavailable.

Using wireless COTS neurophysiological monitors, we generated real-time measures of Average Cognitive Load (ACL; the arithmetic mean of each team member’s CL) and Cognitive Load Balance (CLB; the extent to which one or more team members was significantly over- or under-loaded vs. the rest of the team). We then integrated these measures with high-definition video and expert observer ratings to provide a holistic view of team workload and performance.

The validation study included 16 medical teams. Three members of each team – the surgeon, the scrub nurse, and the anesthesiologist – were outfitted with the CL monitors. Each team completed several clinical simulations of varying (low, medium, and high) difficulty. During each simulation, we measured the teams’ ACL and CLB in real time. During a typical 12-minute scenario, we collected nearly 600 streaming CL values per measure, per team. In addition, expert observers rated the teams’ performance, and counted the number of appropriate and inappropriate technical behaviors. At the end of each scenario, the team members self-reported their perceived levels of stress and workload.

Mean ACL and CLB scores (calculated per team, per scenario) differentiated the low-, medium-, and high-difficulty scenarios, respectively. In addition, as the teams’ workload increased: observer ratings of the teams’ performance decreased; the number of appropriate technical behaviors decreased; the number of inappropriate technical behaviors increased; and self-reported workload and stress increased. Implications and lessons learned are discussed.

Developing a Scaled Performance Evaluation Measurement System to Measure Performance

Garrett Loeffelman | Quinn Kennedy | Glenn Hodges, Ph.D.

19133

Background: Training capability developers lack consistent tools for analyzing the benefits of synthetic training environment integration – especially related to measuring the transfer-of-training for live, virtual, and constructive systems (Government Accountability Office Report 13-698). The purpose of this study is to define, develop, and test a scaled performance evaluation measurement system (SPEMS) that can be used across a wide variety of training tasks. We used the buddy rush task as a test case for the utility of SPEMS. Trainees are evaluated on a nine-step performance evaluation checklist (PECL) during the buddy rush task. Currently, trainees only receive a Go/No Go evaluation for each step. Method: We defined, developed, and tested SPEMS by Step 1. Convening focus groups to establish 5 level behaviorally anchored rating scales (BARS) to be implemented into SPEMS; Step 2. Convening subject matter expert (SME) focus groups to confirm SPEMS inter-rater reliability utilizing a virtual video analysis of the buddy rush task; Step 3. Empirically testing the accuracy and predicative capability of SPEMS in an operational environment. We will conduct an experiment by observing two groups of evaluators (control group and SPEMS group) who will be evaluating trainees’ performance of INF-MAN-3001, the buddy rush task, using either the current PECL or SPEMS evaluation systems. We expect to collect approximately 72 evaluations from each group. Additionally, we will determine if SPEMS predicts objective measures of performance in the buddy rush task. Preliminary results: Suitable inter-rater reliability was found for both the BARS (Step 1: 87% inter-rater agreement) and SPEMS (Step 2: Cronbach’s Alpha 0.93 to 0.98) The experiment will be conducted in March and data analysis will be completed by June. Conclusion: Validating the accuracy and reliability of SPEMS will provide training capability developers a method for determining the training transfer that results from employing alternative training solutions.

Simulations to Train Buried Explosives Detection: A Pilot Investigation

Crystal Maraj | Dean Reed | Jonathan Hurter | Latika Eifert

19134

The U.S. Army seeks to identify cost-effective methods to deliver training. Augmented Reality (AR) and Virtual Reality (VR) are proposed to offer low-cost, ubiquitous hands-on training for Improvised Explosive Device (IED) detection (i.e., Minehound device) training. Given the objective to assess new technologies, the primary goal of this initial study was to examine users’ reaction and performance using AR and VR trainers in a field experiment. Ten soldiers were randomly assigned to either the traditional training (i.e., control condition) or the experimental training (i.e., first VR, then AR). Objective data was logged as post-training IED detection accuracy and multiple choice pre- and post-test scores. Subjective surveys were used to guage participant reactions to the training. Initial results indicate marginal differences between the traditional and experimental groups for post-training IED detection accuracy, and a minor increase from pre-to post-test multiple choice scores. Results from a workload survey showed a pattern of increase scores across all subscales for the experimental group. Results from the open-ended questions provided evidence to substantiate the objective data. The results underscore a cost-benefit analysis, indicating the value of using AR and VR technologies for IED detection training. The use of AR and VR technologies show potential as a supplemental tool in the training continuum. The next steps for this research initiative will focus on expanding the sample size to accomodate three conditions (i.e., control, VR and AR conditions). Additionally, the initial results will need verification to confirm the current trends in workload.

Situational Awareness Measuring Method in Simulated Combat – A Case Study

Uriel Huri | Yisachar Shapira | Yoav Yulis

19153

Measuring situational awareness has been studied greatly in recent years, since situational awareness plays a critical role in decision-making processes, especially in the battlefield, where the commander's knowledge and understanding of the environment can be of vital importance to successfully accomplishing their missions. In the digital age, in which C4I Systems for improving situational awareness are developed, measuring this is even more necessary.

The Israel Defense Forces (IDF) Ground Forces Command Battle Laboratory (battle-lab) is a research oriented virtual environment, where active duty soldiers participate in a simulated combat on a large scale. This acts as an environment in which collecting data and control issues are easy to be dealt with. Over the last years, the battle-lab has developed a method for measuring situational awareness with a unique quantitative objective index.

Collecting the data was carried out on a digital map, in which during a warfare scenario participants marked situational factors while in action. The data addressed their perceived geo-location, friendly forces, and enemies. Every measurement was documented with exact time stamp and location, allowing it to be compared to what the "real situation" was in the simulation.

Analysis of the data was made by translating the differences between the participants' marks and the real situation to a quantitative value, by using deterministic algorithm and a machine learning algorithm based on expert assessments. This method brings a simple computer-based process to measure situational awareness and get it as an objective, quantitative rate.

This method of measuring and examining situational awareness will be presented in this paper, along with the results and the analysis of the process applied during an experiment conducted at the battle-lab in February of 2018.

Rethinking Effectiveness Evaluations: Measuring the Effectiveness of a Mobile Performance Support Application Using xAPI

Jennifer Murphy | Frank Hannigan | Tarah Daly | Chad Udell

19162

Evaluating the effectiveness of learning technology typically involves determining the extent to which a learner has gained and can apply knowledge, with an emphasis on long-term retention. Research designs in these studies typically involve comparing a group's performance before and after an instance of training, comparing a group who receives training to a group who does not, or comparing groups who have received different formats or levels of the same training. While these designs may be relevant for evaluating a single instance of training, they do not effectively address how people learn in the real world; learning is a process that occurs over time with repeated exposure to material across a variety of experiences and platforms. That learning can occur anytime and anyplace is the foundational premise behind the Experience API (xAPI), a specification designed to enable tracking and managing human performance data across training platforms and instances. One example of how these models fail involves evaluating the effectiveness of mobile learning. The benefits of mobile platforms are the ability to provide "just-in-time" training and performance support. The goal is not to support long-term retention of knowledge, but to provide just enough information at the point of need for the user to execute a task or solve a problem. This is a fundamentally different research question, and requires evaluations designed to determine the extent to which the user can apply information in real time. In this paper, we will discuss how xAPI data from a mobile learning application can be used to determine its effectiveness. To illustrate the methodology, we will present data from a recently conducted effectiveness evaluation of a mobile application designed to support Warfighters' financial literacy.

#CGHowTo – Performance Support for the Field

Timothy Quiram | Rachel Stutt

19203

#CGHowTo" – "Help Right Now" for Coast Guardsmen in the Field

Sharing expertise from the Coast Guard's Force Readiness Center's to the field is hampered by limited infrastructure, lack of focus on "point of performance" support, and confusing direction in multiple policies. This paper will discuss our effort to leverage a commercial unsecure video service (YouTube) to develop and distribute short "how to" videos to the fleet under the auspices of the Coast Guard's Innovation Program.

We started with a simple premise that we turned into an officially sanctioned 'Innovation Challenge." We asked, what if every time a School House got two questions from the fleet on the same topic, it triggered them to create a short "How To" video? The initiative was at first widely resisted from the generation that was most expected to embrace such a performance support opportunity.

Information the organization provides to performers is the number one influence on performance (see "Where the Performance Issues Are and Are Not" Performance Improvement Quarterly, 29 (1) PP. 35 – 49). This innovation challenge uncovered barriers to sharing information including communication, technological, cultural, societal, and policy. This paper will discuss the results of the initial innovation challenge with 35 entries, and the strategies to reach the entire Coast Guard through a second round. Finally, up-to-date quantitative and qualitative data will be included.

Wearable Stress Monitoring During Live Training

James Pharmer | Kelly Hale | Richard Plumlee | Zach Huber

19237

One of the most critical domains sailors must learn is shipboard firefighting. Firefighting exposes individuals to heat stress and fluid loss, which may be capable of causing sudden cardiac events (Holsworth, 2013) and to physical danger, physical overexertion, and mental stress, which can reduce performance (Gomes, 2013). It is critical to ensure sailors are trained to fight fires under realistic, stressful conditions to prepare them for shipboard firefighting. At the Surface Warfare Officer School (SWOS) Learning Site Firefighting School at Naval Station Mayport, the goal is to develop Warfighter readiness and effectiveness in firefighting onboard ship within a controlled, realistic environment. This includes incorporating physical and psychological stressors (e.g., physical ship layout challenges; multiple, active fires to control) into training. Quantifying the occurrence of stress experienced by trainees for this facility, and the majority of live training exercises is currently limited to subjective accounts during hotwashes. The integration of physiological stress levels tied directly to scenario events can potentially allow instructors to enrich the training through adaptation of physiological stressors to individual trainee response and performance. This paper will demonstrate an innovative approach to objectively evaluating stress within the SWOS Mayport Firefighting school training scenarios using wearable technology which monitors physiological and physical state of trainees. trainee stress state within scenario context can be monitored throughout a scenario in real-time via an instructor-based interface to alert instructors of potential stress issues before they become emergencies. The paper will discuss end user feedback based on the stress monitoring closed loop system and outline strengths and opportunities for improvement in enhancing awareness of scenario stress and training effectiveness. One of the most critical domains sailors must learn is shipboard firefighting. Firefighting exposes individuals to heat stress and fluid loss, which may be capable of causing sudden cardiac events (Holsworth, 2013) and to

Cognitive Expertise through Repetition Enhanced Simulation (CERES): Learning to Understand Topographic Maps

Paul Reber, Ph.D. | Kevin Schmidt | Marcia Grabowecky | Brooke Feinstein

19258

Understanding a topographic map is a non-trivial cognitive and perceptual process that is a critical part of Land Navigation training for many military personnel. The three-dimensional representation implied by the contour lines on a map must be mentally constructed and transformed in order to tie the map representation to the visual perception of the world. Understanding the relationship of map to environment is necessary for navigation and to make planning decisions appropriate to the environment. Developing this skill is a learning process typically done through a traditional combination of instruction and field exercise, with expertise developing from extensive field experience. The CERES project aims to accelerate the development of map reading expertise by a novel practice protocol using simulation-based training to provide many hundreds of practice events rapidly and inexpensively. With large numbers of repetitions, a process of implicit learning is engaged leading to development of fluid, automatic, and expert cognitive performance. The training approach is accomplished by using procedural generation of terrain environments from which topographic maps are generated. Over training, topographic maps are repeatedly paired with first person perspective views within the simulated environment, each shown briefly (30s total). Participants express understanding of the map by successfully indicating their facing orientation from the first-person. During training, feedback about the accuracy of their orientation judgment is provided and the task difficulty adjusted adaptively. With practice, participants gradually improve their ability to connect the visual features of their location with the structure implied by the contour lines on the maps and correctly read their position and facing on the map. Improved ability to understand the topographic maps is shown in better performance on a no-feedback post-training assessment (compared to pre-training) reflecting preliminary success at training rapid, intuitive map understanding with a high-repetition simulation-based training protocol.

Effects of Transparency Level and Controller Type on Performance using Augmented Reality and Synthetic Vision

Alex Priaps | Sarah Leibner | James Bliss

19272

Augmented reality application development faces the challenge of balancing key information visualization with users' cognitive constraints. VR Rehab Inc. is developing an application (FAR/SV) blending augmented reality (AR) with synthetic vision for use in complex, time-sensitive military operations. The FAR/SV approach provides several advantages over AR alone. This paper will describe R&D investigations into effective visualizations and interactions. The researchers investigated the effects of controller type and AR transparency level on performance. Participants completed a simulated reconnaissance task on a laptop by viewing feed from a simulated drone flying a preset path, using the sensor camera to search the area, and placing an icon to identify the location of simulated humans in the environment. They were also asked to recall AR building labels. These two tasks present a competition between the synthetic vision and the semi-transparent AR overlay. AR development efforts have failed to establish an optimal transparency level for overlaid graphics, while previous research has noted that foreground task performance diminishes at as little as 5% transparency This study compared transparency levels of 0%, 25%, 50%, and 75%. Little attention has been paid to controller type, with current AR applications varying from speech to eye tracking to touch-screens. Controller choice will vary depending on the platform used (e.g. iPad or HMD), and whether the user's hands are free. However, some controllers require less cognitive and physical effort than others. This study compared keyboard/mouse, speech recognition/keyboard, and Xbox One controllers. Participants' speed and accuracy in placing markers, and usability ratings of FAR/SV, were collected to compare these conditions. This research will fill a critical gap in guiding controller choice and AR graphic transparency level in AR applications. Future research will investigate the effects of varying synthetic vision and AR graphic transparency independently while streaming live sensor feed in the background.

Cognitive Skill Assessment in a Virtual Environment

Allison Hancock | Jennifer Phillips | Natalie Steinhauser | James Niehaus

19323

Adaptability is a critical skill necessary for current and future operating forces. In complex arenas where problems are shifting continually, adaptability is essential for achieving mission success . However, efforts to operationalize and assess the construct of adaptability have fallen short. Existing adaptability assessments do not meet the military's need for an objective, tactically realistic, and diagnostic capability. In addition, many are resource intensive to maintain and administer, and therefore are not sustainable. The Assessment Toolkit for Leader Adaptability Skills (ATLAS) addresses these challenges and extends the research and development in the area of complex skill assessment.

The ATLAS tool measures adaptability in tactical vignettes representing mission sets faced by maneuver small unit leaders. To eliminate the need for a resource-intensive human rater scoring process, five standard and objective measures of adaptability are captured from user actions and scored using automated algorithms. The measures of adaptability align with steps of a framework hypothesizing the flow of cognitive processes that must occur for a favorable adaptive outcome and are the basis for the diagnostic feedback provided to users.

To date, the measures and prototype vignettes have been instantiated in a Unity simulation environment for hypothesis testing. Pilot testing resulted in an expert performance model against which user responses are assessed. In addition, a detailed, diagnostic scoring approach has been developed. Future phases of research will validate the adaptability measures in a large-scale field test and examine the validity of the measures when a rapid content generation function is applied. This function will automatically modify the repository of vignettes for increased sustainability of the tool. The outcomes of this effort contribute to the research community by providing a framework, method, and automated measures for assessing individual developmental needs for adaptability in the context of engaging and realistic simulations.

Optimizing Haptics within AR/VR Training Given Human Sensory Capabilities

Kelly Hale | Chrstina Padron

19336

Haptics, including touch, pressure, temperature, proprioceptive and kinesthetic, and vibratory sensors, can provide critical cues for successful task completion in many military domains. To date, integration of haptic cues has been limited within augmented and virtual realities (AR andVR) due to technology limitations and challenges in appropriately activating this broad, sensitive perceptual system. With the establishment of the Army Futures Command in 2018 (Lacdan, 2018), the Army is positioned to push innovation at a fast pace to meet the needs of future operations. As the Army moves towards development of the Synthetic Training Environment (STE) under this Futures Command, critical research questions regarding how humans best perceive and comprehend information and interact with innovative training technologies in a team environment – localized or distributed – need to be considered. When and how to integrate haptics cues into synthetic training capabilities to optimize human learning and capabilities for operational success requires a guiding framework for haptic cue integration – covering technologies available, cues provided, and human perceptual capabilities and limitations across experience levels. Further, cross-modal impact of haptics plus other sensory cues need to be considered, as design advantages can be realized to produce psychological fidelity critical for optimal training (Straus, Lewis, Connor, et al., 2018).

This paper will present a haptics framework for synthetic training integration. This framework will be built based on sensory cue fidelity assessments for example ground and air systems use cases (e.g., tactical crew training for Close Combat Tactical Trainer [CCTT], aircrew for UH-60 Blackhawks), outlining which haptic sensations are critical for learning and training transfer. Further, human perceptual capabilities and limitations against available technology solutions will be considered to guide appropriate integration of haptics capabilities to maximize psychological fidelity for the human operator, resulting in optimal learning and training transfer.

BEST PAPER

Effects of Bottlenecks within Military Training Pipelines

Robert Floyd

19145

Military human resources (HR) systems must generate and sustain the human capability that underpins fighting power. Training pipelines, pathways comprising sequences of courses and activities undertaken by personnel to develop necessary skills, are essential components of military HR systems. However, Western military organisations including the UK Armed Forces have experienced persistent shortages of personnel in some skilled cadres leading to severe human capability challenges. Various initiatives have aimed to rectify skills shortages but these have usually taken little account of the dynamics of military training pipelines. Moreover, the literature includes few studies of military training pipelines and defence policy provides only very broad guidance on training pipeline management without precisely defining important terminology. Neither the presence nor the effects of bottlenecks in training pipelines are explicitly acknowledged in the literature or in current defence training policy.

Harrington et al. (2017) assert that supply chain management literature could be applied to training pipeline management to improve the flow of personnel through training systems. Accordingly, this paper synthesises Theory of Constraints, a mature systems-based management philosophy that has profoundly influenced modern supply chain management, with the human capability and military training pipeline literature. Drawing upon publicly available sources including government reports the paper examines how training pipelines contribute to the provision of human capability as important sub-systems within broader military HR systems and characterises the nature and effects of bottlenecks that occur within military training pipelines. From this, the paper develops principles to inform and guide the development of defence policy for training pipeline management and presents recommendations on identifying and managing bottlenecks to regulate the flow of personnel through training and improve the provision of human capability.

Using Design of Experiments to Improve Analyses, Simulations, and Cost

Steven Gordeon, Ph.D. | Karen Dillard

19104

The Department of Defense (DoD) is evaluating ways to accelerate acquisition and test and evaluation (T&E) programs in order to field more effective weapon and training systems sooner. Nations that were near-peers are fast becoming peers, with capabilities in some areas outpacing those of the United States. We can regain our advantages in several ways, including improving weapon system's effectiveness and improving combat training. For weapon systems, we can accelerate the model-test-model process and provide early system prototypes for warfighter use in simulation and gaming environments. For combat training, we can improve validation of key training models. An analysis and modeling method called Design of Experiments (DOE) has shown great promise to quickly model early prototype weapon systems, enable modeling for tradespace and requirements analyses, and pinpoint designs that are precisely on target. DOE is now, by policy, used wherever possible in DOD operational testing to assist in the evaluation of weapon systems and to improve the precision of these weapons. Researchers in DoD and in the Department of Homeland Security (DHS) are using DOE to augment Cyber Security teams evaluating system vulnerabilities in order to fully cover the threat landscape with fewer personnel. Also, for key models in virtual and constructive training and analysis simulations, DOE is used to conduct validation of the models compared to live testing results. This first known paper on DOE at I/ITSEC will discuss the methods used to develop DOE models and simulation of those models. A current example of model validation and the value of using DOE will be discussed. Several examples of DOE modeling will be presented, including an example of a Navy radar that was tested originally without DOE and then tested years later by the same Test Director using DOE with 10% of the resources – very high cost avoidance.

Executive Risk Assessments for the Age of Algorithms

Randal Allen, Ph.D. | Steven Roemerman | Eric Haney, Ph.D.

19110

Modeling, simulation, and analysis (MS&A) supports a wide range of economic, academic and governmental efforts. Different practitioner communities have agreed on local practices, but there is little interaction among communities. A related gap is the absence of executive level risk assessments for executive use. Executives often make multi-disciplinary decisions. Increasingly these are based on analytics. This paper presents an executive level risk assessment methodology. The method is based on a checklist founded on an international benchmarking effort.

The authors led a three-year benchmarking effort across various disciplines (including decision analysis, operations research, risk modeling, management science, conflict and combat simulation, and logistics and supply chain simulation). Practitioners volunteered to describe their practices and learn from others.

The authors also conducted research into specific risks, including legal risks which arise from increased reliance on analytics. Among the risks are some unique concerns related to Artificial Intelligence.

The work showed that risks arise from several sources, not just the absence of best practices. This led to development of a risk checklist which does not require in-depth knowledge of MS&A. This paper presents the checklist, as well as some of the deeper MS&A principles which support it. This is a dual framework, useful for both executives and practitioners.

Access Control in the Era of Big-Data Driven Models and Simulations

Anne Tall | Cliff Zou | Jun Wang

19115

In today's mobile-first, cloud-enabled world, where simulation-enabled training is designed for use anywhere and from multiple different types of devices, new paradigms are needed to control access to sensitive data. Large, distributed data sets sourced from a wide-variety of sensors require advanced approaches to authorizations and access control (AC). Motivated by large-scale, publicized data breaches and data privacy laws, data protection policies and fine-grained AC mechanisms are an imperative in data intensive simulation systems. Although the public may suffer security incident fatigue, there are significant impacts to corporations and government organizations in the form of settlement fees and senior executive dismissal. This paper presents an analysis of the challenges to controlling access to big data sets. Implementation guidelines are provided based upon new attribute-based access control (ABAC) standards. Best practices start with AC for the security of large data sets processed by models and simulations (M&S). Currently widely supported eXtensible Access Control Markup Language (XACML) is the predominant model for big data ABAC. The more recently developed Next Generation Access Control (NGAC) standards addresses additional areas in securing distributed, multi-owner big data sets. We present a comparison and evaluation of standards and technologies for different simulation data protection requirements. A concrete example is included to illustrate the differences. The example scenario is based upon synthetically generated very sensitive health care data combined with less sensitive fitness data and open social media data. This model data set is accessed by representative groups with a range of trust from highly-trusted roles to open public. The AC security challenges and approaches to mitigate risk are discussed.

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When Time Matters, Assessment Only and the Risk Management Framework

Douglas Wedel | Demica Robinson

19118

Time is often a program manager's most valuable resource. The Assessment Only process saves time and provides program managers with increased effectiveness and productivity through a common sense approach to Cybersecurity Risk Management. Properly assessing the security posture of simulator and training systems is critical to the organization's understanding of risks associated with their operational use. The Risk Management Framework (RMF) is a governance process that provides a standardized enterprise-wide decision structure for cybersecurity risk management that includes and integrates organizational mission areas. The RMF requires all Information Technology (IT) that meets the definition of a system, implement and document a corresponding set of security controls that can be technically assessed prior to authorization. While IT and Platform Information Technology (PIT) products and services categorized below the system level do not require full Assessment and Authorization (A&A) through the RMF, they must be "Assessed" for risk. These types of IT – as well as system modifications, upgrades, or configuration changes – must be securely configured, documented and reviewed by the responsible Information System Security Manager (ISSM). This review must be completed before integration, incorporation, connection to or use within an Information Systems or PIT systems authorization boundary. ISSMs assessing these types of IT need a standardized and structured process to follow that is acceptable to Authorization Officials that do not impose undue cost, schedule and functional impediments of the full A&A process. The ISSM is responsible for ensuring an appropriate risk assessment is completed prior to incorporation, connection or use within an authorization boundary. There are two categories to the Assess Only process; Assess and Incorporate and Assess and Inherit for use. This paper seeks to provide the reader with an understanding of the Assess Only process that can be used to increase effectiveness and productivity, cut costs, and save

A Proposal Standard for Distributed Aerial Refueling with Probe-and-Drogue System

Michael Tillett

19127

Advances in simulation technology and fidelity, specifically in the ability to network Weapon System Training (WST) devices together have made it possible to move more live aircraft training into virtual training. Benefits of transferring more aircraft training to the WSTs reduced cost, and improved safety. Furthermore, the use of WSTs in networking training provides a valuable tool for training aircrews during mission operations where it involves coordination between aircraft such as Aerial Refueling (AR) training.

The Mobility Air Force (MAF) Distributed Mission Operations (DMO) standard is the protocol used by the US Air Forces for Distributed Aerial Refueling training. It provides a set of specifications defining the technical requirements for Virtual Air Refueling (VAR). This standard enabled the capability of VAR over a distributed network using a flying boom refueling system. The US Navy, as well as most NATO countries, use the Probe-and-Drogue (P&G) refueling system as the primary method to perform Air Refueling. For this reason, the ability to train VAR with a P&G system in a distributed environment would be a valuable training capability. Currently, the MAF DMO standard does not provide the technical direction on how to perform distributed aerial refueling training using a P&D refueling system.

This paper proposes a complement data structures to the MAF DMO standard to enable the capability of Distributed Aerial Refueling with P&D systems. Using this proposed standard, a simulation of a distributed virtual air refueling was successfully performed with a C-130 synthetic aircraft as the aircraft tanker and a C-130J WST as the aircraft receiver. The paper will present the experiment results and discuss the crucial lessons learned from this effort. Finally, it will lay out the roadmap of how this proposed standard for VAR with a P&G refueling systems can be implemented in the existing MAF DMO standard.

Overview of USMC Modeling and Simulation Office Policy Lessons Learned

Eric Whittington | Brett Telford

19132

The United States (US) Department of Defense (DoD) has modeling and simulation (M&S) offices to manage M&S policies and coordinate complicated enterprise technologies across subordinate organizations such as live, virtual, and constructive (LVC). The US Marine Corps M&S Office (MCMSO) operates under a Marine Corps Order that established the office but does not provide guidance and direction for effectively managing or coordinating diverse M&S communities across the Marine Corps. Since there are no unifying policies, individual commands and program managers develop unique and often competing policies which create both confusion at the senior leadership level and technical interoperability challenges at the engineering level. This paper will provide an overview of the current USMC governance and discuss the issues that have arisen from the lack of unifying policies, such as conflating LVC for training uses and M&S capabilities for analytic uses during formal requirements documents production, and individual program managers selecting technical standards that may not be compatible with an interoperability requirement of a future system of systems. This paper will then discuss the analysis that was performed to determine the policy required to effectively manage M&S across the Marine Corps. The analysis consisted of reviewing relevant DoD policies, interviews across the Marine Corps M&S communities, and conducting initial action officer review. This paper will describe the five lines of effort that are necessary to implement M&S enterprise management within the USMC, covering a wide range of topics including policy implementation, workforce management, and research coordination. Finally, this paper will provide an overview of the new draft USMC M&S policy. The merits of the draft policy have been well received by the USMC and DoD M&S communities, and several existing DoD level M&S challenges are beginning to reference the ideas within the Marine Corps draft policy as potential DoD solutions.

Live-Virtual-Constructive Training Environment Analysis of Alternatives Lessons Learned

Eric Whittington | Byron Harder, Ph.D. | William Brobst

19135

The Marine Corps Systems Command (MCSC) and Training and Education Command (TECOM) recognized the need to develop a detailed analytic methodology to justify fiscal decisions for procuring and fielding live-virtual-constructive training environment (LVC-TE) capabilities. The analytic challenge was a unique endeavor for a complex system of systems with no prior analog identified, and external guidance demanded more concrete analysis and return on investment metrics. The Marine Corps LVC-TE Analysis of Alternatives (AoA) began with a training and readiness (T&R) based requirements analysis and the definition of a measures of effectiveness hierarchy. This paper will summarize lessons learned from the LVC-TE AoA and the associated methodologies that were developed. The AoA's analytic methodology traced capability requirements to the T&R training basis, and the metrics hierarchy captured current training requirements, future training requirements, institutionalization of enterprise capabilities, and compliance with external requirements. The analysis covered all four elements of the Marine Air-Ground Task Force for both home station training and service level training, linking mission essential tasks with T&R events across collective training audiences. The analysis used workshops, interviews, and briefings for primary stakeholders to gather data. Distinctive, strategic technical alternatives were determined, refined, and assessed against the measures of effectiveness and cost to complete the analytical framework. The technical alternatives spanned a wide range including connecting current Marine Corps systems, using existing LVC solutions across the DoD, and developing a new fully customized solution. Lessons learned from this comprehensive effort have applicability to broader requirements and acquisition audiences requiring analysis of similar training capabilities, and should be applicable to ensuring adaptability of training systems to meet evolving technology capabilities. The draft AoA final results have been briefed and accepted by the milestone decision authority and TECOM, and MCSC is pursuing procurement actions consistent with the AoA analytic methodology and metrics hierarchy.

The Flying Car - Emergent Modeling & Simulation (M&S) Policies and Standards concerns

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19140

Emergent modes of Transportation are becoming increasingly paramount to our everyday lives. Simultaneously however, our surface transportation infrastructure is suffering from overuse (e.g., traffic congestion, roadway disrepair), which necessitates novel mechanisms for "motorized mobility". Current pathways to overcoming these limitations include the gradual transition towards connected and autonomous motor vehicles for human transport, as well as "drone" technologies that are steadily revolutionizing airborne egress and transport logistics for surveillance, package deliveries, and agriculture. Longer-term, Transportation scientists are already investigating the technology – and regulations – associated with "passenger drones" - a convergent form of ground/air vehicle transportation - specifically, the once-seemingly futuristic notion of The Flying Car.

In this paper, we conduct an extensive review of current literature to explore emergent Flying Car technological capabilities (e.g., Cognitive systems, AI, Machine learning) – each requiring appropriate regulations and governance - to become fully sustainable. For specific benefit to the PSMA subcommittee, a targeted focus is placed on the rapidly emerging Policies and Standards issues – each with relevance to wide-ranging M&S disciplines - that will inform future Test, Evaluation, Validation, and Deployment of Flying Cars. Namely, this paper will explore issues pertinent to Safety, Environment, Navigation, Infrastructure, Logistics/Sustainability, Cybersecurity, and Human Factors (e.g., technology acceptance). By addressing these Policies in advance, we can forecast and enable Readiness for the anticipated impacts upon the foundational aspects of I/ITSEC: Training, Simulation, and Education.

The primary findings of this paper are driven by qualitative and anecdotal reporting that is representative of the present state-of-the-art. However, this paper will conclude with a preliminary quantitative analysis exploring Human Factors data associated with projected acceptance of Flying Car technology. This data will help to inform next-generation Policies and Standards associated with the gradual advancement of Flying Cars, and the resulting impacts on related M&S domains of interest.

A New Approach to Building Agile Simulations

Charles Sanders

19157

Technology and threat change is outpacing Defense Acquisition and M&S development processes. The current M&S architectures do not support agility. DoD struggles with interoperability between simulations and reuse of models and data. Models and data generated in new capability design and development are often not available for testing, analysis or training systems development. M&S Community stovepipes inhibit data and model sharing and reuse, partially because M&S is funded and managed separately by each community. There is no easy fix, as DoD lacks a coherent process or infrastructure to rapidly develop and deliver new M&S capabilities based on emerging technologies and threats. This paper will explore existing modeling frameworks that enable integration below the federate level and could provide an infrastructure for agile simulation to facilitate perpetual prototyping and rapid development.

Ensuring Psychometric Validity Within an Automated Performance Measurement Standard

Mitchell Tindall, Ph.D. | Beth Atkinson

19170

Previous research and development work by the Navy has focused on developing an industry standard for system generated performance measurement that facilitates the mining of individual operator and aircrew performance data from simulators as an effort to continue the advancement of training systems. However, a standard alone does not provide the guidance necessary for implementation that will ensure this measurement medium adheres to psychometric principles. A major focus of science is ensuring reliability and validity when measuring psychological constructs. That is, when we measure a psychological construct (e.g., intelligence) is there consistency (i.e., reliability) within and between measures (e.g., observers, computer systems) and, are we measuring what we intend to measure (i.e., validity). While this latter distinction may seem obvious, people often make the mistake of measuring something that is unintended (i.e. construct contamination) or not fully measuring what they intend to measure (i.e., construct deficiency), and then use that information to inform feedback and decisions. The consequences of these measurement mistakes may be critical. As we work toward a standard that guides engineers in the development of system generated measures of performance, this standard must also incorporate important psychometric concepts and analytical techniques such as reliability, validity, local data norming, regression weighting, and structural equation modeling to name a few. One of the more robust findings in psychology is that ratings made by humans inherently contain some degree error. This error reduces the usefulness and legitimacy of findings. While system generated measures of performance will be void of these common human errors, they will still need to adhere to psychometric principles to ensure their utility in applied and academic settings. This paper will provide a review of the science of human performance measurement and provide specific recommendations for policies and approaches that support the automated performance standard.

Raising the Standard – Industry and Government Working Together for Simulation Coherence

Simon Skinner | Grant Bailey

19187

The UK Ministry of Defence (MoD), along with many other defence organisations around the world including NATO, increasingly promotes the use of a variety of standards within simulator based systems. This initiative is part of an UK pan-defence enterprise approach to reduce total lifecycle costs, and increasing reuse and interoperability called Defence Modelling and Simulation Coherence (DMaSC).

This paper describes the practical application of simulation standards through the development lifecycle of a typical fielded simulator based training system – the AJAX armoured fighting vehicle driver training simulators – the first practical example within the UK of a new approach to mandating standards within training system acquisition requirements.

While familiar interoperability standards such as DIS and HLA have been successfully integrated many times; the authors (from industry and government) describe the integration and use of newer and less well-known standards such as the Common Image Generator Interface v4 (CIGI) and various terrain repository formats, along with the technical and commercial issues around government custodianship of geospatial data and the derived terrain and model datasets.

The authors share insights on successes, areas for improvement, and necessary compromises from the work carried out in developing a highly complex simulator based training device within the typical environment of a lengthy development lifecycle and a multi-level supply chain.

The lessons learned will help industry developers and government procurement agencies to work more closely together in this important area and achieve the objectives of reduced cost and better reuse and interoperation.

Privacy Concerns with Big Data Analytics: US DoD/Army Landscape

Mariusz Balaban

19210

Big data analytics is a relatively new field but matured enough to provide innovatory solutions to automate mining and extracting data from the next generation Mission Command (MC) and Live, Virtual and Constructive (LVC) simulation systems. It provides powerful technologies and methods to quickly analyze huge amounts of data but also introduces potential harms to individuals whose personal data is collected, stored, analyzed, used for decision-making, and disclosed. Desire to keep big datasets indefinitely, reuse it for different projects, combine it with additional data, and automate decisions based on data presents privacy and security challenges. Moreover, big data may increase system opacity because of many streams of data created by multiple stakeholders, complicated algorithms processing the data, multiple storage locations, and multiple data consumers with different data aggregation needs. This increased complexity can lead to data leaking, breaches, spillages, and re-identification of individuals. On the other hand, it is critical to take full advantage of big data by processing special data categories on individuals and a variety of data types. Without using combined personal attributes, quasi-identifiers, and sensitive attributes combined with insensitive attributes data utility decreases or may even render analysis useless. This paper discusses the importance and benefits of using big data especially focusing on the US Department of the Army (DA). It presents privacy laws, policies, and regulations relevant to the DoD/DA and investigates their incompatibilities with big data principles. Moreover, it identifies privacy-preserving components relevant to big data, allowing for a balanced approach that benefits the DoD/DA while preserving the privacy of individuals.

Model Based Systems Engineering for Acquiring Vehicle Training Simulations

Richard Cope | Devarshi Desai | Cattien Nguyen | Naomi Acosta

19221

The constraints of a document-based engineering approach limit designers to chronicling the development of systems with written descriptions and illustrations that fail to keep pace as the design progresses. A transformational shift from the documentation-based approach is Model-Based Systems Engineering (MBSE), an emerging disciplined innovation for blueprinting architectures of complex systems. With MBSE, the system model is independent of the views a modeler creates for acquisition stakeholders and when the model changes, the modeling tool automatically updates established views to reflect the changes. Further, the effectiveness of MBSE is exhibited when there is a common architecture for establishing the reuse of components across many similar systems. For these reasons, vehicle training simulations seemingly are an ideal target application for MBSE. Several disciplines are involved with the development of common vehicle training simulation components – engineering, physics, image generation, computational systems, instructional design, test, and graphical modeling languages such as Systems Modeling Language (SysML) so participants can communicate in a standardized manner. The paper is a focused exploration of MBSE capabilities for acquiring training simulations. To illustrate a possible approach for modeling vehicle training simulations, a basic architecture with sample stakeholder views is presented complete with use case diagrams for conveying stakeholder expectations, activity diagrams for specifying uses cases, and structure diagrams for depicting system decomposition. Implications are reviewed for using an MBSE approach to manage requirements vice the document-based approach.

Measuring the Impacts of Transitioned Solutions

Darren Wilson | Jesse Flint

19234

Department of Homeland Security (DHS) Science and Technology Directorate (S&T) delivers solutions with innovative tools, technologies, and knowledge products for the Homeland Security Enterprise and first responder communities to support ongoing operations and dynamically respond to emerging threats. DHS S&T faces similar challenges to DoD transitions, where (1) technology advances occur faster than acquisition requirements development and (2) widely available commercial technology allows increased adversary access to technology. These challenges combine to make it difficult to maintain a technological advantage. It cannot be assumed that even well designed R&D solutions will successfully transition to full operational use and positively impact operational metrics. Rather, this must be explicitly planned, funded and incrementally measured. Ending S&T involvement in programs at transition can result in solutions that are not fully operationally integrated by the end users and/or are potentially shelved by component leadership without operations and maintenance budget planning or reach back to developers during this critical post transition operational implementation phase. S&T has recently gone through an organizational revitalization that has prioritized and shifted the view of the life of a program to include a Post Transition phase and is currently piloting Post Transition Performance (PTP) assessments as a systematic approach to not only support operational integration of delivered solutions, but also the planning and execution of assessment for operational impact. A critical part of the performance assessment process/method includes defining appropriate metrics and sampling at various stages of the R&D program, including project inception (to establish a baseline), mid-program (to assess operational changes that could confound measurement), at transition (to ensure the solution functions as described/intended), and after operational implementation (to assess if the solution did improve operational efficiency and/or effectiveness in the intended operating environment). The presentation will focus on demonstrating the need for PTP assessments and establishing standard processes.

Requirements Engineering Innovations for Agile-Based Programs

Cynthia Harrison | Paul Butler | Barbara Pemberton | Bill Fetech | David Hobby | Amy Lim

19247

In 2001, with the penning of the Agile Manifesto in Snowbird Utah, agile development practices were coined and have evolved in response to Department of Defense and industry frustration with long software development lead times and inflexibility of technical and management decisions made early in the development lifecycle. With the increasing popularity and adoption of agile practices, organizations have focused primarily on transforming their approach to software development, less so on their practices in systems requirements engineering. There has been significant focus, and consequently progress and improvement, in the application of agile software development practices. However, agile, continuous management of requirements remains a challenge because requirements are dynamic, changing over the course of a project and because of the considerable coordination effort required. To operate effectively and efficiently, project teams must holistically adopt agile practices throughout their organization and integrate them into all aspects of their systems engineering and project management practices. This paper identifies and explores four significant challenge areas that are impacting innovation and adoption of agile solutions for requirements engineering. These challenge areas include culture, requirements management, requirements definition, and tools as enablers. As part of this exploration, each challenge area will be analyzed by an integrated team of military experts (U.S. Army, U.S. Air Force) and agile systems engineering professionals from The MITRE Corporation. These explorations will utilize case studies to understand why and how agile requirements innovation lags that of agile software development. Based on data obtained from the case studies, the authors will provide the following requirements engineering innovations for agile-based programs: (1) how to change cultural bias to improve organizational adoption of agile-based requirements engineering; (2) agile techniques for managing requirements; (3) contextual best practices for developing just-in-time requirements; and (4) integrated tools that simplify time-intensive tasks associated with traditional requirements development.

Air Force Methodology for Overarching Joint Training Policy for Joint Interoperability

Lillian Campbell-Wynn, Ph.D.

19262

The Air Force Operational Training Infrastructure (OTI) 2035 Flight Plan established the Air Force vision for future training and how best to achieve readiness. Annex L of the Flight Plan – entitled "Strengthen Joint/Interagency Interoperability", has an objective to maximize the ability to conduct frequent, relevant and realistic Joint training through the interoperability of the operational training infrastructure. The Chief of Staff of the Air Force indicates a relevant and realistic operational training environment is a critical step to achieving readiness and also supports his priorities of strengthening Joint teams. Modeling and Simulation (Live, Virtual and Constructive) capabilities are integral components of the OTI and critical enablers to the readiness of our warfighters.

To fully meet the objective of frequent, relevant and realistic joint training multiple challenges must be addressed. There are ongoing efforts to offer technical solutions to specific joint interoperability problems such as standards, common authoritative data, cybersecurity, and modifications to our various simulations and simulators. These technical efforts need to continue, but DoD must overcome challenges pertaining to policy and instructions that drive joint training requirements. Concentration on Air Force policy and instructions is occurring. Based on preliminary reviews of existing Air Force policy and instruction, more tightly coupled, overarching policy directives are required for frequent joint training. Additionally, initial findings indicate in some cases when joint training occurs, it is not seamlessly managed or recorded within the Air Force

We hypothesize that the policy issue spans the Services as it pertains to joint training. Without closely coupled joint training policy across the entire DOD, frequent, relevant joint training is at risk. The proper mix of directives and Joint Mission Task Lists will guide joint training and increase readiness. This paper will identify gaps between DoD and service joint training guidance and provide solutions for closing the seams.

Air Force Agile Development Methodology for addressing Future Air Operations Capabilities

Lillian Campbell-Wynn, Ph.D.

19268

A single cohesive collection of capabilities is required to present air power operations within the USAF and joint community. The Air, Space and Cyber Constructive Environment (ASCCE) represents air, space, cyber and intelligence, surveillance and reconnaissance (ISR) capabilities during joint battle staff training and experimentation. The Air Force Modeling and Simulation Toolkit (AFMSTT) primarily portrays detailed air operations and is a key component of the ASCCE. The Air Force must modernize or replace AFMSTT to address the multiple training challenges of the future, including the emergence of 5th generation capabilities, Multi Domain Command and Control (MDC2) employment in joint environments, reduction of the exercise footprint or Human in the Loop (HITL) and the integration of Live, Virtual and Constructive simulation into blended training environments. ASCCE is the USAF-endorsed air component of multiple joint service training environments such as Joint Live Virtual and Constructive Confederation (JLVC), Joint Land Component Constructive Training Capability (JLCCTC) and the Battle Lab Collaborative Simulation Environment (BLCSE). Integration into these environments requires continuous sustainment, testing and coordination activities that must be considered in the modernization approach. There are emerging approaches to this continuous cycle of modernization, sustainment and coordination such as Kessel Run that requires further examination. Kessel Run is already an agile approach to development and is specifically addressing efforts such as the modernization of Air Operation Center components. There are preliminary successes and lessons learned from this approach. This paper will provide a proposed methodology to take advantage of agile development activities and address the migration of the legacy AFMSTT capability into a modular, open system architecture that reduces sustainment and HITL through artificial intelligence and can meet future synthetic training requirements based on warfighter execution of employment strategies. Meeting the training requirements of our warfighters addresses readiness for real world operations.

Application of the M&S Community of Interest Discovery Metadata Specification to Standards Profiles for Acquisition and Air Force Training

James Coolahan, Ph.D. | William Oates, Peggy Gravitz | Kenneth Konwin

19270

Technical standards are important enablers for compatibility and interoperability. Because many standards exist, when starting to develop a product, or to use multiple products together, one needs to discover applicable standards efficiently. Standards "profiles" have emerge to reduce the number of standards that a specific effort should consider.

From 2007-2012, the U.S. DoD M&S Community of Interest developed a Discovery Metadata Specification, the MSC-DMS. It defines sets of metadata, called "metacards," to describe M&S data or services, a key one of which is the Resource Metacard. Because a standard is a resource, the MSC-DMS is a good starting point for a standards profile.

Recently, two standards profile efforts have applied the MSC-DMS. Both use the Resource Metacard as a starting point to define pertinent metadata. The Acquisition M&S Standards Profile has been developed by the Simulation Interoperability Standards Organization (SISO) to aid discovery of M&S standards useful for systems acquisition and engineering efforts. It provides a living reference document to remain current with standards revisions, and to add new applicable standards. The Air Force Agency for Modeling and Simulation has led the development of a standards profile for the Air Force's Operational Training Initiative (OTI). It provides extensive metadata on standards useful to OTI participants. To help keep these profiles current in a usable text format, a Microsoft Excel-based tool has been created that allows multiple selected metadata fields to be printed as a text document.

After providing an overview of MSC-DMS version 1.5, this paper will explain how different subsets of, and allowable extensions to, metadata defined in the MSC-DMS have been applied to the SISO Acquisition M&S Standards Profile and the OTI Standards Profile. A description of the Excel-based tool, which may also be useful in the creation of other standards profiles, will also be provided.

With Uncertainty Comes Opportunity: Solving the DoD's Flash Problem

Trey Hayden | Yihua Liu

19305

The Department of Defense (DoD) estimates it currently hosts approximately 70,000 hours of Adobe Flash-based course content. This presents a considerable challenge, as Flash player functionality will be discontinued by all major browsers, and Adobe will end support for Flash in 2020. The Advanced Distributed Learning (ADL) Initiative is working with the DoD's Chief Management Office (CMO), the Services, and DoD Component agencies through the Flash Deprecation Analysis of Alternatives (AoA) Working Group to understand the scope of the migration effort and potential solutions that create best value across the DoD enterprise.

Given the complexity and variety of content created using Flash and ActionScript, no silver bullet exists for converting this content into a modern standard like HTML5. These organizations and their vendors tackle the problem with non-uniform methodologies tailored to their unique situations. Given the scale of the problem, a fragmented response results in duplication of efforts and increased costs to the government. Through the working group, participants are sharing technical approaches, best practices, tools, and acquisition strategies for migrating courses away from Flash. The CMO is working to align the different efforts through recommended technical practices, policy guidance, and a coordinated acquisition strategy across DoD.

The scale of this effort presents an opportunity to modernize the technical underpinnings of these courses through enhanced metadata and increase performance tracking. This aligns with other initiatives from the CMO IT & Business System Reform, including the DoD common course catalog and the migration of learning technologies to USALearning. The working group has coordinated numerous data calls, technical discussions, and collaborative interchange. This paper will summarize the technical guidance and policy discussions that took place in the working group. It will clearly articulate the approach for identifying, prioritizing, and migrating Flash content and will provide links to tools, scripts, and calculators shared

Cybersecurity Strategies for Accrediting Experience API

Miguel Hernandez | Michael Neeley | Andy Johnson

19308

Large-scale social networks, interactive content, and ubiquitous mobile access have emerged as driving technologies in education and training. At the same time, data analytics presents new opportunities for assessing the effectiveness of training content and instructional strategies for different learners, understanding organizational trends across large volumes of education data, and utilizing this data to continually improve the way we train and educate. The Department of Defense (DoD) Instruction 1322.26 recommends the Experience API (xAPI) as the primary method for capturing learner performance across the DoD enterprise. xAPI statements are a form of JavaScript Object Notation (JSON), a common data format used across industry and Government. In practice, xAPI Statements collect and store information about individuals and system performance within a Learning Record Store (LRS).

xAPI captures data about all these formal learning experiences, but can also capture informal learning that occurs in work environments . Capturing data from the field provides great insight into learners. xAPI presents an extremely complex cybersecurity challenge that includes multi-level security and the management of Personally Identifiable Information (PII). The Advanced Distributed Learning (ADL) Initiative has been analyzing the xAPI through the lens of accrediting to run on the Global Information Grid (GiG).

This paper will report on the results of this work by providing specific implementation guidance that is required for xAPI to conform to cybersecurity requirements. It will also provide an overview of current accreditation initiatives and an overview of related tools and technologies required to manage xAPI solutions. This paper will provide readers with a background on the relevant cybersecurity topics, explore use cases, and create awareness of the technology and its existing challenges within the DoD.

Tailoring Acquisition to Deliver at the Speed of Commercial Industry

Graham Gleener | James Jozlowski | Carolyn Sprague | Simone Acha | Micheline Lopez Estrada | Julio Villalba

19315

The Department of Defense (DoD) has received legislation and guidance from Congress in recent years to improve the speed and efficiency of the acquisition process. A significant challenge for DoD Project Managers (PMs) has been the administrative and documentation burden associated with a new program. Often times the documentation requirements are duplicative and exhaustive with little value added. The PM has to balance the compliance with regulatory directives with producing a quality system for the end user all the while ensuring adherence to statutory laws. In 2017 the Department of the Army, Office of the Assistant Secretary of the Army, Acquisition, Logistics, and Technology (ASA(ALT)) produced guidance on implementing acquisition streamlining and cultural change. The Product Manager Cyber Resiliency and Training (PdM CRT) has fully embraced the streamlining guidance as they progress towards Milestone B with the Persistent Cyber Training Environment (PCTE). One of the key tools for PMs to enable streamlining is the Simplified Acquisition Management Plan (SAMP).

PCTE is currently leveraging the SAMP to achieve Milestone B. A challenge the PCTE team experienced as work began on the SAMP was the lack of guidance, support, and approved examples. This paper will share the best practices, challenges, and solutions the PCTE team discovered as they went through the SAMP process to better enable the greater community to leverage our experience. Additionally, we will capture the transition and migration from a Traditional Milestone B process to SAMP, and compare and contrast the two approaches. We will describe the transition impacts for internal and external stakeholders and how we generated community wide buy in while addressing each of the stakeholders unique concerns, impacts, and questions. To conclude, we'll provide recommendations to help the training and simulation community navigate through the acquisition documentation streamlining and tailoring process.

Government - Industry Collaboration: Essential to Training Evolution and Relevancy

Michael Rambo

19347

The traditional model of training system creation in the defense arena, especially the aviation space, relies on near-linear progression along a need-solicit-propose-develop-evaluate-select-field-fix continuum. This limits industry to reactionary behavior, precluding government consideration of advanced technical and or philosophical approaches, which in the absence of established funded programs, may be more immature than they would have been under a more cooperative developmental environment. Further, this technical requirements dominated approach lends more to hardware solutions than to innovative holistic solutions, such as comprehensive training programs that exploit co-evolution of technology and training concepts for revolutionary advances in training capabilities. Cooperative research and development agreements (CRADAs), and new approaches to experimentation have gained more prominence in recent years, and the intent is promising; however, industry investments rely heavily on hope that a program will eventually materialize, sharing risk with the government. It is a posture which, when programs do not materialize, suggests the status quo is perhaps more comfortable – and appropriately less costly. This paper will suggest methodologies by which industry partners can establish relationships with each other and the government to arrive at solutions in tandem with the realization of need - not fielding a brand-new legacy solution. It will outline effective historical programs where such relationships were successful, examine the lessons learned from recent experimentation activities, and evaluate possible outcomes of theoretical scenarios using a suggested cooperative approach. Finally, the paper will provide recommendations and specific examples of how such an approach will enable dramatic increases in solution acquisition and fielding efficiency, implementation of solutions at the speed of operational relevancy, and establishment of relationships critical to getting to the future faster.

A Tale of Two T's: Enabling Testing Through Reuse of Training Services

Thomas Kehr | Robert Cox | Scott Nix

19356

U.S. Army Training and Testing activities can look conflicting when viewed by the uninitiated observer, but deeper analysis reveals that these requirements often converge towards commonality among the two communities. As a result, the Training and Operational Testing communities historically maintain separate hardware and software capabilities to meet their needs, which can lead to unnecessary redundancies and costs. To overcome this challenge, the U.S. Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) and the U.S. Army Operational Test Command (USAOTC) have mapped commonality and differences across their Training and Testing requirements.

Based on this analysis, the U.S. Army material developers for Live Training and Operational Testing are collaboratively developing products utilizing a Product Line Management and Engineering approach. This collaboration allows developers within both environments to synchronize development efforts for the reuse of services, software, and hardware to enable the Operational Test environment. This reuse has resulted in significant cost avoidances for development and maintenance activities across products having significant overlap in requirements. In addition, the superset of requirements enhances both test and training capabilities, offering more realistic environments for both domains by collectively providing systems that address capabilities such as human factors and battlefield effects. Through the application of the Live Training Transformation (LT2) Product Line approach, the Integrated Live, Virtual, Constructive Test Environment (ILTE) program was able to deliver a hardened Version 1 capability to the USAOTC based on reuse of mature training services.

This paper provides a thorough analysis of the common requirements that enabled reuse of existing training solutions and standards, as well as where we found requirements that could be met by adapting training solutions to meet similar testing requirements. This analysis is presented through the lens of the Version 1 ILTE development and delivery activities to show real-world application of our approach.

Medical Simulation for the Future of the Joint Training Community

M. Beth Pettitt | David Thompson

19385

Over the past 20 years, the U.S military has significantly increased it use of medical simulations for training. In 1996, the Army began structured research and development (R&D) to bridge the training gap between the traditional warfighter and the medical warfighter. From that effort, significant progress has been made that has shaped the medical simulation and training industry. The last 20 plus years saw the development and refinement of full body manikins and task trainers specifically designed for the military. It also saw the emergence of virtual environments and virtual patients. Additionally, surgical simulations advanced as visually immersive and more natural hand held devices reached technology maturation.

Many of the developments were pursued by the R&D community because they met a current critical training gap identified by the training community. As the Department of Defense moves into the next decade a more strategic approach is desired and needed. Resources are limited, and there is a desire to work across the Joint medical and Warfighter communities. Challenges still exist, including interoperability across simulations platforms, scaling simulation and training fidelity to the needed complexity as well as for the different levels of medical care providers, tailoring training content to the learner, objective performance measures, and natural and meaningful interactions with simulated patients.

This paper will present a brief history of successes, lessons learned and future challenges. It will focus on several projects, as representative case studies, that have gone from a concept, through research and development, testing, and transition to fielded capabilities. It will also include a path forward as the medical simulation and training community moves to a more unified approach across the services.

SIMULATION

BEST PAPER

Fully Automated Photogrammetric Data Segmentation and Object Information Extraction Approach for Creating Simulation Terrain

Meida Chen | Andrew Feng | Kyle McCullough | Pratusha Bhuvana-Prasad | Ryan McAlinden | Lucio Soibelman

19245

Our previous works have demonstrated that visually realistic 3D meshes can be automatically reconstructed with low-cost, off-the-shelf unmanned aerial systems (UAS) equipped with capable cameras, and efficient photogrammetric software techniques (McAlinden et al. 2015; Spicer et al. 2016). However, such generated 3D meshes do not contain semantic information/features of objects (i.e., man-made objects, vegetation, ground, object materials, etc.) and cannot allow sophisticated user-level and system-level interaction. Thus, being able to segment and extract object information from the generated meshes are essential tasks in creating realistic virtual environments for training and simulations. The objective of this research is to design and develop a fully automated photogrammetric data segmentation and object information extraction framework. The designed framework utilizes concepts from the areas of computer vision and deep learning. Photogrammetric data are first segmented into different categories (i.e., man-made objects, vegetation, and ground) using deep learning algorithms. Following that, object information such as individual tree locations and related features and ground materials are extracted with unsupervised and supervised machine learning techniques. In order to validate the proposed framework, the segmented data and extracted features were used to create virtual environments in the authors' previously designed simulation tool – the Aerial Terrain Line-of-sight Analysis System (ATLAS). The results showed that 3D mesh trees can be replaced with geo-typical 3D tree models using the extracted individual tree locations and that the extracted tree features (i.e., color, width, height) are valuable for selecting the appropriate tree species and enhance the visual quality. Furthermore, results showed that the identified ground material information can be taken into the consideration for path finding. The shortest path can be computed not only considering the physical distance but also the off-road vehicle performance on different ground surfaces. An overview of the designed data segmentation workflow is available online (USCICT, 2018).

Lessons Learned in the Experimental Use of Simulated Malodors to Support Live Training

William Pike, Ph.D. | Michael Proctor | Deborah Burgess

19107

randomly assigned in a between-groups experimental design with control. Each cadet performed a medical evacuation order task under assigned experimental conditions. Findings with respect to soldier performance, stress, escape behavior, and the physiology of olfactory adaptation are reported below. In addition, the research contributes to the use of the Atmospheric Quality Scale and the Electrodermal Activity Data via wrist-worn Q-Sensors in field experimentation. Outcomes and lessons learned provide future olfactory researchers considerations for design and testing of alternative training methodologies.

Demonstrating the Effects of Human Behavior in Simulation Using the RAND Will to Fight Model

Glenn Hodges, Ph.D. | Alfred Connable, Ph.D. | Aaron Frank, Ph.D. | Henry Hargrove

19111

Since at least 1997, work has been ongoing to address the human behavior representation (HBR) gap in military simulations (Hutson, 1997; Cornwell et al., 2003; Silverman et al., 2006). In 2018, the Army formally recognized the HBR gap, initializing an effort to reduce it. Prior to that, the RAND Corporation was commissioned by the US Army to develop a method to analyze and account for the will to fight of partner nations in support of operations. Two RAND reports (2018a, 2018b) describe the development of a model and method of analyzing the construct of will within a military context. The Will to Fight model has evolved from a report to a software instantiation using a game environment as well as a constructive simulation. This paper and presentation will describe the development of the Will to Fight model and the instantiation of the game as well as our progress on the development of a referent software implementation of the model to be experimented on by the Army with the goal of incorporation into the OneSAF program of record. As of January 2019, the modeling and initial coding preparations are underway. Implementation and initial testing in the IWARS simulation and OneSAF will be conducted throughout 2019. Assessment of the process will be iterative with observation and participation of AMSO, PEO-STRI, and other U.S. Army stakeholders including the Soldier Lethality, Synthetic Training Environment, and Army Position, Navigation & Timing, Cross-Functional Teams of Army Futures Command. The current one-year effort will conclude in January 2020 with a working Will to Fight agent- and unit-level model suitable for full testing and iterative improvement and modification in official U.S. Army simulations. RAND will transfer control of the Will to Fight model to the U.S. Army in 2020 according to the OneSAF user agreement.

Enhancing Situational Awareness Anywhere in the World with Geospatially Accurate Scene Simulation using Automated 'Real World' Content Generation

Brian Miles | Thomas Creel | Arthur Kenton | Mark Abrams | Kathy Wilder

19112

(Approved for Public Release #19-359)

Gaming environments have achieved a remarkable level of realism in their simulation of urban environments that make a user feel as if they are a participant within a real-world environment. However, the creators of these gaming environments make liberal use of their artistic licenses, bringing to light that these environments are not real world, just incredible simulations. Training simulators for the military strive to achieve the same artistic environment using real-world content but are caught between realistic training environments and real world data, which is more complex to capture and render in a geodetically correct environment. NGA's Foundation GEOINT 3D (FG3D) will produce and curate the most current geospatially accurate topographic and 3D feature content (areas, buildings, roads, etc.) to support US military preparation, training, and operational requirements. FG3D will leverage petabytes of imagery, radar, and lidar data to enable geodetically correct simulation of the real world in 3D, achieving the ambition of photorealistic immersive virtual worlds using real world content. FG3D tools transform dense point clouds into efficient, accurate 3D surfaces with correlated vector data, enabling realistic models to be created from real-world, geospatially accurate data. FG3D is built upon the Geospatial Repository and Information Dissemination (GRiD) open architecture and thereby fully operationally seasoned and scalable. Various metrics exist in 2D and 3D but are insufficient. FG3D is developing novel metrics to quantify and qualify the accuracy and completeness of the 3D vector representation of a simulation. In contrast to existing metrics, FG3D seeks to describe the visual acuity of the scene content through extension of the Polygons-and-Line-Segments (PoLiS) metric to provide superior shape analytics. This novel metric will have built-in tuning capabilities thereby enabling the analyst to customize the measured outcomes to meet their specific thresholds of the 3D surfaces created from FG3D.

Controlling Computer-Generated Lifeforms using Fuzzy State Machine

Hung Tran | Nguyen Tran

19126

Simulated real-world environments represent a powerful tool for learning and training. Intelligent Virtual Agents (IVAs) can participate with people in such environments to facilitate training tasks that would normally require additional human participants. An IVA is a computer-generated lifeform that is not only visually similar to a human but also exhibits human-like behavior. An IVA can be seen as a simulated system situated in a virtual environment and capable of autonomous actions to meet its design objectives. Typical usage of IVAs in Naval Mission Training is Search and Rescue (SAR), Helicopter In-Flight Refueling (HIFR), or Vertical Replenishment (VertREP). In these applications, each IVA is assigned with a specific role to accomplish pre-defined tasks.

A suitable Modeling & Simulation approach to simulate the behavior of an IVA is a Finite State Machine (FSM). However, using an FSM to model human behavior has a couple of drawbacks:

An FSM can become very complex, especially when the IVA is required to perform its role autonomously and respond to the surrounding environment in a timely fashion.

A simpler FSM to model the IVA's behavior can appear predictable and repetitive.

This paper proposes a simulation approach to reduce the predictability of the behavior of an IVA while enhancing their autonomy during the training by using Artificial Intelligence (AI) which can be achieved through the use of a Fuzzy State Machine (FuSM). First, the fuzzy logic technique and its basic rules are introduced. Then, the paper will explain the development process and how this technique can be applied to efficiently control IVAs behavior. The effectiveness of the FuSM modeling approach is assessed through the implementation of a typical Naval Mission Training application. Preliminary simulation results indicate that it is possible to easily control the behavior of computer-generated lifeforms using the FuSM modeling technique.

Simulation and Sensitivity Analysis of Mobile Proximity Stopping Distance in Unity

Jennica Bellanca | William Helfrich | Brendan Macdonald | Timothy Orr | Jacob Carr

19152

Proximity detection systems (PDSs) on underground mobile haulage equipment are intended to protect mineworkers from striking, crushing and pinning by slowing and stopping the vehicle before a collision occurs. However, highly variable and changeable environmental and vehicle conditions can drastically alter PDSs performance, and the magnitude of these effects is not clear. Furthermore, overly conservative setups can interfere with other work, making it difficult to appropriately configure these systems. NIOSH researchers leveraged their existing VRMine simulation and proximity detection system expertise to examine these problems. This paper presents the results of a deterministic simulation exploring the sensitivity of vehicle stopping distance to a variety of environmental, vehicle, and PDS configuration variables. The simulation was uniquely created using the Unity game engine and PhysX physics engine to simulate the time based relationships between friction / slip, vehicle performance, and PDS behavior in order to leverage the visualization component for improved communication of the results. Using this simulation, over ten thousand trials were run on a range of variables such as slope, friction, vehicle type, load level, braking behavior, and PDS configuration. Values for the physical parameters were derived from a large number of sources including manufacturer specifications for vehicle parameters, field observations of existing PDSs, and field measurements. The model was validated with results from lab tests of a loaded and unloaded scoop on pavement as well as some unloaded field measurements in underground mines. The results of this simulation will be used to develop guidelines on the configuration of PDSs based on mine environment and vehicle parameters. The visualization afforded by Unity will also be used in real-time VR applications to communicate the results and compare different configurations.

Simulation-Based Autonomous Systems Testing – From Automotive to Defence

Timothy Coley | Dave Fulker | Robert McConachie

19166

The introduction of autonomous systems into safety-critical domains poses many challenges – from system safety assurance to public acceptance of the use of such systems. Recent autonomous vehicle incidents have underlined the need to establish clear regulations for the introduction of such systems into public environments, while the challenge of conducting adequate testing in the real world makes simulation-based testing an attractive proposition – reducing time, cost and risk associated with development and evaluation.

This paper will seek to elaborate on an XPI-led feasibility study examining the use of simulation for the certification of autonomous vehicles (CAVinSE), co-funded by the UK Centre for Connected and Autonomous Vehicles, and draw parallels with accrediting autonomous systems for defence applications. This will include consideration of the emerging standards, regulations and methodologies in the automotive sector with regard to autonomous systems. Moreover, it will highlight the importance of establishing a trusted environment for autonomous systems testing activity – with a root of trust that can be relied upon by certifying bodies, system developers and the general public. Potential approaches for accrediting simulation tools associated with such autonomous systems testing will also be addressed.

The paper will consider how the different operating environment and capability of defence systems, as well as different regulatory frameworks, could nonetheless benefit from the outputs of CAVinSE and similar endeavours in the automotive domain. As well as XPI's work on CAVinSE, a use case for simulation-based autonomous systems testing in the maritime domain will be covered.

In concluding, some of the key technical challenges that remain in this domain will be identified – with a particular focus upon sensor models, representation of the physical environment and adequately representing human behaviours in simulation.

Aimpoint Solutions on Complex Area Targets

Matthew McLaughlin

19172

In artillery fires, the use of multiple aimpoints can spread damage over a large area when a unitary target location is inaccurate or when a collection of enemy targets span an area. Little research exists for computing an optimized pattern of aimpoints to maximize lethality. Current methods includes only basic geometric shapes and software solutions that are often hard-coded and scaled for these simple target areas. Since processing is not a major issue in modern computing, dynamic solutions are obtainable for irregular geometries and clustering of enemy detections. This research is a mathematical optimization solution that demonstrates how to tailor aimpoint configurations to complex area targets. Several factors are weighed when generating these aimpoint configurations including the target-weight density function, weapon accuracy, type of damage, and radius of effects. The goal of this research is to reach greater effectiveness against complex area targets with fewer rounds—saving the military the extensive logistic transportation requirements and ammunition costs.

Wargaming Evolved: Methodology and Best Practices for Simulation-Supported Wargaming

Per-Idar Evensen | Svein Erlend Martinussen | Marius Halsør | Dan Helge Bentsen

19182

When developing and assessing future force structures, wargaming is a key activity for better understanding the strengths and weaknesses of the force structures. Today simulation systems let us create synthetic environments that to a high degree replicate the physical properties of the real world for these wargames. Furthermore, advances in artificial intelligence (AI) and behavior modeling has given us more realistic computer-generated forces (CGF) that can execute battle drills and lower level tactics with a fairly high degree of realism. However, at the higher levels of the chain of command, AI has not yet replaced human leadership, and planning and conducting simulated operations require participation of officers.

For more than a decade, the Norwegian Defence Research Establishment (FFI) has supported the Norwegian Army with conducting wargames for capability planning, with varying degree of simulation support. Throughout this period, the wargames have evolved from what can be described as computer-assisted wargames towards more realistic simulation-supported wargames. Moreover, to get a closer understanding of the deterrent effect of the force structures, which may not be observable when monitoring the actual gameplay, our emphasis has also shifted towards replicating the planning process more properly, and especially on monitoring the planning process of the opposing force. For example, it has been important to find out to what extent specific structure elements discourage the opposing force from taking certain actions.

In this paper, we describe our evolved methodology for simulation-supported wargaming, which includes a preparation phase, a gaming and execution phase including a planning process, and an analysis phase. Furthermore, we discuss what type of data and results we are able to extract from the wargaming sessions, and present a set of best practices for how to conduct successful simulation-supported wargames.

Assessing and Measuring Interoperability Between Multi-national Live Training Systems

James Benslay, Jr. | Rhea Pritchett | W. Bogler | Greg Carrier

19186

The U.S. military increasingly uses virtual environment training simulators which are demonstrating to be an effective complement, but not a replacement for Soldiers training in "live" physical environments using real vehicles and weapons. To ensure Soldiers' safety when training with real weapons, the Army has used an advanced version of "laser tag", which is currently referred to as the Instrumentable Multiple Integrated Laser Engagement System (I-MILES). Several U.S. coalition partners have adopted MILES-like systems from various companies to conduct live training of their own forces. Unfortunately, these MILES-like systems are not always interoperable which limits our ability to train with allies. When allied countries cannot effectively train together, it becomes a significant limiting factor for planning real-world joint operations. To help address these interoperability issues, PM TRADE tasked MITRE to conduct the Multi-national Live Training Interoperability Study (MLTIS). As part of this effort, we are partnering with the NATO Modeling and Simulations Group (NMSG) Urban Combat Advanced Training Technologies (UCATT) team to develop a common picture of training systems interoperability. A significant early outcome of this partnership is a methodology for consistently and objectively assessing the level of interoperability achieved at an exercise event using multiple MILES-like systems. This approach, referred to as the Interoperability Readiness Assessment Methodology (IRAM), leverages the previously established Levels of Conceptual Interoperability Model (LCIM) and applies that model to the live training systems domain. This paper will provide an overview of the IRAM and demonstrate how it provides a defined and objective approach to identify interoperability issues in live training systems. The U.S. with our MLTIS coalition partners is currently developing the IRAM as an essential foundational element in promoting live training between multi-national allied forces.

Designing Virtual Reality Tools: Making Simulated Interventions Feel and Act Like their Real Counterparts

Meghan Smith | John Desnoyers-Stewart | Gregory Kratzig

19190

While global leaders in Virtual Reality (VR) simulation maintain a strong presence in use-of-force scenarios, their VR systems are consumer-oriented. This leads to compromises that lack crucial qualities such as appropriate pistol weights and missing magazine clips, which military personnel train to recognize and control through muscle memory. Using consumer-focused equipment for training could contribute to hazards and reaction errors in the field.

Training officers in scenario-based decision making simulations is integral to preparing cadets for service; however, it is challenging to simulate the significance of real-life scenarios. The University of Regina and Royal Canadian Mounted Police (RCMP) have partnered to resolve this by building effective tools to train the paramilitary. VR promises more life-like visuals and complex situations, which require the trainee to use their body as they would in the target scenario. Yet, the use of VR risks gamifying the situation and trivializing the consequences of the trainee's choices. Making a simulated decision bear the weight of the real-world is a multifaceted problem, but one crucial aspect is ensuring simulated interventions feel and act like their real counterparts.

We present two prototype VR weapons based on the service pistol and the CEW of the RCMP. Using the SteamVR hardware development kit, with 3D printed and original manufacturer parts, we have produced synchronized virtual weapons. By reproducing the feel of these tools and matching them with their visual representation in VR we are taking initial steps towards decision-making simulation that begins to adequately represent the real-world object it simulates. Guidelines arising from the development process can help further the development of physically reproduced forms of interaction for VR training. The project advances research-creation practices, adds critically designed tools to a use-of-force training industry, and forms a unique network for co-creating innovative research focused on improving the safety of Canadians.

Reusability and Efficiency in Behaviour Modelling for Computer Generated Forces

Joost van Oijen | Armon Toubman | Gerald Poppinga

19211

In military Modelling and Simulation (M&S), there is an increasing need for Computer Generated Forces (CGFs) with advanced autonomous behaviours for use in training, Concept Development & Experimentation (CD&E) and decision support. However, the development of behaviour models is often resource-intensive and reuse across applications, simulation systems or scenarios is difficult. This is clearly illustrated by the plethora of platform-specific (proprietary) modelling tools on the market and is considered a burden throughout interviews conducted with staff operating various simulators of the Dutch military.

Our paper regards the CGF behaviour modelling process from the perspective of different stakeholders such as subject-matter experts (SMEs), designers, developers and operators/instructors, with a twofold purpose. We both sketch a holistic overview of current challenges and opportunities for reusability, and we propose three synergetic directions for improving reusability.

The first focuses on technology-independent behaviour descriptions which facilitates SME knowledge elicitation and allows for (semi)-automated conversion to executable models.

The second concerns the use of machine learning techniques to generate (parts) of a behaviour model by making use of military reference material such as doctrine documents or rules of engagement.

Finally we propose a general-purpose executable behaviour construct, modelled specifically for reusability. As a reusable construct, it can represent any level of behaviour (tactics, procedures and/or actions) and is agnostic to specific implementation techniques. Being self-contained makes it suitable for repository storage and cloud execution, in line with NATO efforts on M&S resource management and M&S as a Service.

The above techniques are evaluated jointly in a use case for air-to-air combat behaviour. We demonstrate the reusability of tactical behaviours across two simulation systems, for CD&E purposes and fighter pilot training. The behaviours employ both hand-crafted and machine learning techniques and are (partly) generated from (reusable) behaviour descriptions created by former F-16 pilots acting as SMEs.

Supporting Military Planning with Simulation

Rikke Amide Seehuus | Jo Hannay | Ørjan Rise | Roar Wold | Philip Matlary

19212

An important aspect when planning a military operation is the ability to see various possibilities and assess consequences of a plan. To this end, wargaming can be used for assessing possible courses of action (COA) of own and enemy forces. Traditionally, this is done by drawing tactical graphics and moving pieces representing military units on a large map. We propose that computer-assisted wargaming holds a potential to help commanders visualize and evaluate different possibilities, beyond what is supported by the traditional method.

We have developed a minimal prototype of a system for supporting operations planning "Simulation-Supported Wargaming for Analysis of Plans" (SWAP). The system consists of a simulation system that runs in the cloud and a simple, intuitive web-based user interface that does not require a lot of training. The user interface has basic functionality for terrain analysis, such as route planning and identification of favorable vantage points around a target area, and the user can give units basic tasks and create phase lines to coordinate the units. Once a COA is specified, the user can choose to execute the COA, upon which the underlying simulation system simulates the planned tasks and shows possible consequences such as engagements, time expenditure and resource consumption.

In February, we conducted a study with 52 cadets from the final year at the Norwegian War Academy as subjects. The purpose was to test the basic functionality of SWAP in comparison to the traditional way of wargaming for COA analysis. The cadets were divided into groups and asked to make COA Decision Briefs for two different battalion operations, one using SWAP and one using the traditional method.

In this paper, we describe SWAP and discuss the potential and requirements of such a system for operations planning based on the results of the study.

Jamming Techniques 2.0

Charles Brooks | David Haber | Patrick Merlet

19224

This paper completes the initial effort described in 2018 Paper No. 18252 "Jamming Techniques and their Usage in Distributed Electronic Warfare Simulation." The end results are proposed changes to SISO-REF-010, Reference for Enumerations for Simulation Interoperability, and to IEEE Std 1278.1, Standard for Distributed Interactive Simulation—Application Protocols, to correct problems with the Jamming Technique enumerations/hierarchy and to improve distributed electronic warfare simulation.

SISO-REF-010 Change Request (CR) #TBD provides definitions for valid jamming techniques, deprecates the entire existing Jamming Technique enumerations/hierarchy and replaces them with a new and improved list/hierarchy. This approach enables a smooth transition plan and uninterrupted interoperability with legacy systems. CR#TBD reassigns all valid Jamming Techniques within the new hierarchy. For Jamming Techniques that are not considered valid, CR#TBD includes the rationale for their deprecation. This information provides an opportunity for and encourages simulation community review and feedback to further improve the Jamming Techniques.

IEEE Std 1278.1 Problem Change Request 253, Jamming Technique Descriptions, proposes modifications for the Electromagnetic Emission (EE) Protocol Data Unit (PDU) to include new fields in the beam data for jammers that will support: a) multiple jamming techniques, b) the jammer architecture (e.g., Transponder, Direct Digital Synthesis), and c) jammer quality attributes (e.g., Persistent, Coordinated, Bounce). The new standard content explains their usage for both jammer (producer) and radar (consumer) simulation modelers. This new EE PDU information along with the new and improved Jamming Technique enumerations/hierarchy provides a more accurate, advanced, flexible and higher fidelity representation of simulated radar jamming interactions while improving the support for multiple levels of fidelity

and thus increased interoperability. The additional protocol information also provides a jamming modeling simplification that results in more uniform and efficient processing of distributed electronic warfare simulation interactions.

Towards A Common Reference Architecture for Mission Training Through Distributed Simulation

Tom van den Berg | Wim Huiskamp

19225

NATO and nations have a common need for combined and joint collective tactical training to ensure mission readiness. There are however significant challenges: while current and future operations are multinational in nature, missions and systems are becoming more complex and need detailed preparation and rapid adaptation to changing circumstances. At the same time, opportunities for (live) training and mission preparation are reduced due to fewer available resources and limited time span between political decision making and deployment.

Simulation has become an essential tool to meet the training demands of our military forces. Improvements in technical capabilities and reduced costs enable more effective use of simulation. Mission Training through Distributed Simulation (MTDS) is therefore crucial to NATO's and nation's readiness.

Nations are moving toward greater use of simulation for mission training and adopting national MTDS capabilities. Over time several NATO Modelling & Simulation Group (NMSG) initiatives provided valuable inputs into the development of a NATO MTDS vision and concept of operations (MSG-106/NETN, MSG-128/MTDS). So far these have not led to a persistent MTDS capability, due to the lack of a common technical framework and complexity of preparing an MTDS event.

Building on previous results, ongoing NMSG activities (MSG-165/MTDS-II, MSG-169/LVC-T) aim to address this by amongst others developing a common MTDS Technical Reference Architecture (TRA) for Joint and Combined Operations. The TRA provides MTDS requirements in the form of building blocks, interoperability standards and patterns for realizing and performing collective mission training and exercises supported by distributed simulation, independent of application domain (land, air, maritime).

This paper provides background, objectives and principles of the MTDS TRA, an interim status update of the work, and planned way ahead. The work is performed in a collaborative effort by several NATO nations, partner nations and organisations under the auspices of the NMSG.

Adapting Existing Simulation Architectures to Enhance Tailored Instruction

Robert Sottilare | Ross Hoehn | Alyssa Tanaka

19239

This paper examines the theory, design, application and recommended standards associated with adaptive instructional systems (AISs) as drivers for tailoring military training in existing simulation environments. Adaptive instruction has been found to be significantly more effective than classroom or other non-adaptive methods. Most military simulations today are classified as minimally adaptive in that they modify content based solely on learner/team performance, and generally do this in a prescriptive way. AISs are artificially-intelligent, computer-based systems that guide learning experiences by tailoring instruction and recommendations based on the goals, needs, and preferences of each learner/team in the context of domain learning objectives. AISs come in several forms including intelligent tutoring systems (ITSs), intelligent mentors (e.g., recommender systems), and intelligent media. Adaptive instruction is desired as a military training tool to improve training efficiency (e.g., accelerate learning) by intelligently focusing tutoring resources where they are needed most - on gaps in learner knowledge and skill. Both US Army Synthetic Training Environment and My Navy Learning programs have design goals to enable adaptive instruction. Adaptive instruction has been a topic of research for decades and AIS architectures such as the Generalized Intelligent Framework for Tutoring (GIFT) have been used to demonstrate the efficacy of tailoring simulation-based military training (e.g., Virtual BattleSpace – VBS) to optimize learning outcomes. However, the principles needed to automatically tailor training within existing simulation architectures have not been fully described nor generalized. No interoperability standards yet exist. This paper ties together instructional theory and design principles needed to seamlessly integrate AISs with military training simulations with the goal of enabling AISs to automatically tailor instruction in real-time. To realize a fully enabled AIS for military simulations, we have identified components, models, functions, gateways, and data requirements to support both syntactic and semantic interoperability. Recommend practices, standards and use cases will also be discussed.

Cyber Model-Based Engineering (MBE)

Ambrose Kam | Matthew Curreri | Carl Hein | Michael Stebnisky

19254

As systems continue to evolve due to complex mission needs, the inherent vulnerabilities are growing exponentially. This drives the need to identify and detect system vulnerabilities early on. Modeling & simulation have become a staple in the systems engineering process; and model-based engineering (MBE) has become a focal point within system architecture. Hence, it is critical to consider combining the two related activities in the context of cyber-security beginning from the design phase and carry on through the lifecycle of the program. For many Department of Defense (DoD) programs, System Modeling Language (SysML) is used to generate system architecture artifacts. We believe cyber aspects need to be considered early in the systems engineering process so security features are "baked in" starting from the requirements definition, rather than "bolted on" later in the deployment phase due to cost constraints at the beginning of the program. Our Lockheed Martin team has demonstrated that successful use of cyber MBE efforts can be a cost avoidance opportunity. Our approach ties traditional MBE methodology to cyber operations analysis. Through automation and machine learning, optimum cyber solutions are identified and integrated to the rest of the system appropriately to ensure all performance requirements are met. Ultimately, this will enhance the overall cyber system resiliency.

Enhancing Wargaming Fidelity with Network Digital Twins

Jeff Hoyle | Rajive Bagrodia, Ph.D. | Ha Duong | Jeff Weaver

19269

Human decision-making fundamentally relies upon communications and networks to contain, extract, and disseminate time-sensitive, mission-relevant information to win decisively against opposing forces, particularly when engaged in asymmetrical combat. Future conflicts will involve attempts to disrupt information technology systems that are critical for communication and for assured operation of highly sophisticated weapons systems. This creates an urgent need for wargames to incorporate real-world cyber, communications and networking effects to support the development of effective operating concepts, capabilities, and plans. The complexity of a multi-domain, combined cyber and kinetic battlefield requires incorporation of high fidelity, physics based network digital twins into future wargaming environments to adequately account for potential impacts resulting from degraded network operations and/or cyber vulnerabilities on overall mission outcomes, improving the knowledge and insights gained from wargame execution. In order to do so effectively, the digital twin must have sufficient fidelity to accurately reflect the network dynamics due to the interplay between the communication protocol and topology, application traffic, the physical environment, and cyber attacks.

This paper will present a case study on the use of an innovative prototype to incorporate a high fidelity network digital twin into a wargaming environment. This prototype establishes an interface between the Naval Air Warfare Center Aircraft Division Next Generation Threat System operational mission models and Scalable Network Technologies EXata high fidelity cyber, communications and networking modeling and simulation software to incorporate connectivity and cyber vulnerability effects in support of pre-wargame benchmarking, outcome adjudication, and post-wargame analysis. The Department of Navy Modeling and Simulation Architecture Management Integration Environment is leveraged to provide a reliable and standards-compliant interface between NGTS and EXata. The resulting prototype capability enhances wargaming by incorporating cyber, communications and networking simulation to better assess overall mission outcomes.

Reconfiguring Synthetic Environments as Inputs to Unity 3D

Abhisgek Verma | Triston Thorpe

19277

Game developers have been leaders in utilizing the latest hardware technologies, including highly parallel computing using GPUs, physics processing units, and deep learning cores. Game engines provide features using these hardware technologies, and allow simple use and access for developing content. Synthetic environments represent data synthesized from satellite imagery, modeled content, and procedural data. This paper explores techniques to prepare legacy commercial and military simulation synthetic environments to be readied for use in a game engine. In this preparation we will be discussing multiple game engine features that can augment existing synthetic environments.

This paper uses Unity 3D game engine for discussing six key features. The first key feature is the visual effect graph, which uses GPU instancing to render a large number of particle effects, such as an explosion. The next key feature is entity instancing which allows the GPU to render a large number of features, such as trees. Unity's physics capabilities provide easy access for tagged features to interact appropriately in physics-based scenarios. Physics-based shading with the custom shader pipeline is a feature that provides added realism to a scene. Unity offers an intuitive UI engine, allowing users to easily construct scenarios. Finally, Unity provides the ability to deploy to multiple platforms, including Windows, Android, and iOS.

This paper explores ways to make changes to data pipelines in synthetic environments to allow the system to utilize said features provided by Unity 3D. The changes include reconfiguration of data streams to GPUs, coordinate system conversions, restructuring of asset pipelines, data tagging to fit Unity 3D's formats and shader alterations to produce post-processed effects.

Toolset 3D Position Tracking for a Visio-Haptic Mixed Reality System

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19279

Mixed reality simulation combines real and virtual objects in the same simulation environment. Applications that also include some form of haptic interaction are categorized as visio-haptic mixed reality (VHMR). With the advancement of augmented reality technologies, there has been a growing interest on VHMR. Positive contribution of haptic interaction especially in training simulators is brought to attention in recent literature.

A haptic interface is designed to generate force feedback in a mixed reality environment. This haptic interface allows users to use their real-life tools. Real-life tools are attached to end-effector of the haptic system when haptic interaction is needed according to virtual object shape. Therefore 3D position of the tool in space should be determined precisely.

This study focusses on 3D position tracking of slender real-life tools (i.e. scalpel, screwdriver) in a novel VHMR environment, in which the free end of the tool is automatically engaged/disengaged by a haptic interface according to the haptic rendering requirements of the simulation. A depth-camera based method is developed, markered and markerless tracking approaches are compared in terms of speed and precision.

Using LVC Technology for the Military Planning Process

Perry McDowell | Ryan Lee

19290

The Department of Defense has used live, virtual and constructive (LVC) technology primarily in the training and testing communities. We feel that LVC technology has significant capabilities in the operational realm as well and built two proof of concept applications to demonstrate how military organizations can use such technology operationally in the planning processes.

Chapter V of Joint Publication 5-0: Joint Planning lists the seven steps of the planning process as:

- Planning initiation
- Mission analysis
- Course of Action (COA) Development
- COA analysis and wargaming
- COA comparison
- COA approval
- Plan or order development

Each service has its own publication which lists the steps its staffs should follow in planning, but, except for combining steps 1) and 2) above into one, they generally follow these closely. We used LVC technology to improve steps 3-6: developing, analyzing/wargaming, comparison and approval of COAs.

The two applications, one for planning ground operations and another for planning air missions, display the plan in a Unity-based environment which allows the planners to easily see the location of blue forces, reported position of red forces, mission objectives as well as terrain. It provides information, such as line of sight determinations, that are not readily apparent from maps. It also allows planners to alter the locations and paths of units to develop COAs.

After finalizing, each COA is then sent to a constructive simulation, where it can be run multiple times. We used COMBAT XXI for the ground simulation and Next Generation Threat System for the air mission. The results from these simulation runs are returned to the virtual environment, where the staff can analyze the wargame results to compare COAs. It also provides an easier to understand result for the commander to approve.

New Techniques for High-Fidelity Modeling and Simulation in 5G Mobile Network Environments

Steven Kropac

19322

LGS Innovations and SCALABLE Network Technologies will introduce innovative new techniques for Modeling and Simulation (M&S) of 5G mobile networks to enable effective proficiency training, cyber situational awareness, network analysis and mission rehearsal exercise support for cyber physical activities. This is important to the community because commercial mobile network environments are evolving and proliferating globally. M&S live, virtual, constructive (LVC) techniques must advance to accurately represent and be interoperable with 5G mmWave and cmWave Access Points (AP), smart buildings and homes, mobile-to-mobile, telematics, and sensor networks. LiveRAN (LGS) is federated with the EXata (SCALABLE) network simulator, which provides high-fidelity models of wired and wireless communication networks that include cellular, enterprise, and battlefield networks. EXata also provides detailed propagation models of signal transmission through rural and urban terrain and also provides a comprehensive library of cyber attack and defense models. The federated LiveRAN+EXata solution provides an interoperable simulation for network elements and physical elements such as trees, houses, cellular towers, people and weapons systems. This architecture is being extended to provide deep operational understanding of new 5G elements and their impact on cyber situational awareness, particularly in contested environments. For 4G LTE networks, the LiveRAN+EXata® solution enables understanding network chokepoints and analyzes how a network is affected in scenarios in which certain elements are perturbated or degraded through kinetic or non-kinetic effects. A 5G Non-Standalone Architecture utilizes much of the same authentication techniques for 4G but allows 5G enabled handsets to connect simultaneously to 5G base stations (gNodeBs) for higher bandwidth and lower latency. We describe how cyber effects alter network performance in simulated or live 4G vs 5G environments. Our integrated high fidelity 5G mobile network M&S platform will provide important capabilities as cyberspace operations become more integrated into the tactical mission space.

Exploring Game Industry Technological Solutions to Simulate Large-Scale Autonomous Entities within a Virtual Battlespace

Kyle McCullough | Raymond New | Noah Nam | Ryan McAlinden

19328

In support of Simulation and Training Environment (STE) goals of a virtual battlespace, we explored experimental technologies in the commercial game industry to determine the feasibility of running one million autonomous entities while maintaining performant simulation and fidelity. In conventional software architectural methods, the number of entities represented do not exceed hundreds (or at most a few thousand) due to the expense of simulating relatively complex behaviors for each entity. Even when using group behaviors to provide the illusion of large quantities of simulated characters, these simulations fail to provide behavioral fidelity at a higher level. To tackle this problem, the Unity game engine was chosen to simulate this virtual battlespace, and specifically to explore the Unity-specific Entity Component System (ECS), Job System and Burst Compiler experimental technologies. Unlike traditional methods of AI representation, the ECS uses a data-driven approach (not object-oriented one) to represent large numbers of identically-structured data. While it is an unfamiliar departure from usual game object representation, its format enforces low-level contiguous storage of the data in memory, dramatically decreasing in-cache misses and preventing loss of data representation compared to random location storage. This results in far quicker iteration and access through large numbers of data blocks in memory. Also, the Unity Job System allowed for better distribution of the computational workload among multi-core processors, while the Burst Compiler improved the performance of the overall system by translating the .NET C# code into highly optimized native code. The work has shown promising results with its current implementation allowing up to 150,000 autonomous, simple-behavior entities to be simulated while running at relatively performant standards (20-30 fps on average). Further optimizations can still increase the number of entities, but eventually, we will consider using a distributed systems solution to simulate a million entities in this virtual battlespace.

Tactical Decision Kits for Infantry Training

Christopher Young | Richard Schaffer | Brian Stensrud | Marcus Mainz | Michael Longtin

19341

The natural environment for infantry training is in the field where unit leaders learn the decisions made on a map may be different from those operating in the battlefield environment. When a unit is in garrison, the commander has a difficult challenge effectively promoting those same decision-making skills throughout the ranks. To better utilize his Marines' time between field exercises, one battalion commander envisioned a solution that would foster tactics training across all echelons. The resulting Tactical Decision Kit (TDK) married the work being done by the Office of Naval Research to address small-unit decision-maker training and extant fielded simulators to replicate the real-world experience and form that connection between 2D tactical planning and 3D execution, resulting in better decision-makers.

The TDK supports a full spectrum of training, including tactical decision games, sand table exercises, competitive simulated engagements and field exercises across all phases of the mission from planning to execution to after-action review. Technologies employed include web-enabled collaborative technologies, HoloLens mixed-reality, low-cost drones and photogrammetric terrain models, streaming media, distributed simulation, adaptive training and after-action review capture and playback. The experimental battalion, 2nd battalion 6th Marines (2/6), experienced increased performance in tactical thinking and communications using competitive simulated engagements, shorter planning cycles and increased efficacy of after-action reviews in field exercises with ready access to data and visualization tools. This lead to the decision by the Assistant Commandant of the Marine Corps to field the TDKs as an experimental platform to all infantry units with the latitude for battalion commanders to develop a tactical training path for their Marines.

This paper will discuss the operational concepts, the technologies and training approaches employed to address them and analysis collected both during the initial trials and after fielding the kits across the Marine Corps.

Utilizing Commodity Virtual Reality Devices for Multi-User Training Simulations

Jack Miller | Austin Hanus | Eliot Winer, Ph.D.

19361

In 2019, the US Military requested $8.8 billion for the training and education of soldiers for operations and maintenance to fund programs such as recruit training, specialized skills training, and flight training. One method to decrease the cost and improve the efficiency of training is to utilize commodity virtual reality (VR) technology. Studies have shown that this technology can be used in a variety of fields to improve training and learning outcomes with cost and performance benefits. Although previous VR environments have been developed to train personnel, these environments are geared towards a single user, include limited input capabilities, and require expensive hardware preventing them from large scale use. Developing VR environments for multiple users with real-world, passive haptic interactions on low-cost commodity devices will broaden the applications of VR training environments for the military.

To investigate this, a framework was developed to explore the capabilities of the HTC Vive in a multi-user training simulation. In various scenarios, trainees may interact with a plethora of virtual objects. While the Vive provides tracked wands for user input, the physical motions needed to grasp and move the controllers rarely represent the actual motions required to interact with a virtual object. To address this, passive haptics were implemented to provide sensory cues. Furthermore, to support a multi-user experience, the physical and virtual environments were synchronized to allow both users access to the same passive haptic cues. This was accomplished by establishing a common frame of reference through a shared tracking system. To evaluate this framework, informal pilot tests were performed on a simulated maintenance operation. Participants reported high levels of immersion through intuitive interactions with their partners. By combining low-cost commodity devices, this framework provides the benefits seen in expensive VR environments to the US Military at a fraction of the cost.

Radio Network Automation for Operational Testing: An Practical Resource for Radio Networks Planning

Carlos Leon-Barth | Patricia Wright | Thomas Mitro | Robert Cox | Scott Nix | Robert Carpenter

19366

This paper summarizes the research conducted by General Dynamics in cooperation with the United States Army Program Executive Office for Simulation, Training and Instrumentation (PEOSTRI) in the development of a Radio Network Planning application that leverages Scalable Network Technologies (SNT) Radio Frequency (RF) modelling combined with the visualization power of NASA Web World Wind open source virtual globe API. The resultant product delivered to the U.S. Army at Ft. Hood Operational Test Command (OTC) site permits Test Officers with no previous RF training to identify the optimal network coverage automatically for different selected test range locations. The simulation considers terrain features using Digital Terrain Elevation Data (DTED), tower location, uplink and downlink transmission, environmental and ground effects, using pre-configured radio models for Cubic Army Mobile Instrumented Training System (AMITS) and Saab Interim Range System (IRS). The final product supports the Home Station Instrumentation Networks and Test Center networks while promoting an interactive user interface experience with graphical network coverage heat-map overlays displayed via open source products utilized throughout the Integrated Live-Virtual-Constructive Test Environment (ILTE) product line. The methods, models and research results summarized in this paper shall be of interest to the radio networks simulation software design and development community with interest in a practical approach to Radio Network Planning.

Geospecific 3D Terrain Data Optimization Solutions for Game and Simulation Engines

Lathin Liles | Jorge Ortiz | Chris Caruthers

19368

As the upper threshold of geospecific 3D terrain fidelity increases, so too does the difficulty in utilizing such dense data in Live, Virtual, and Constructive simulations. Right now, units have the ability to rapidly generate high fidelity terrains at the point of need through drone and photogrammetric solutions, but utilization of such data in game and simulation engines is inhibited by enormous polygon counts and texture sizes. These impressively large and detailed datasets pose critical performance problems. This paper reflects on a joint effort between USC's Institute of Creative Technologies (ICT) and GameSim to determine best practices to optimize the performance of high quality geospecific 3D terrains through processes executed at runtime within game engine applications. The application of focus is built on top of the Unity game engine, but these findings may be extrapolated to other game and simulation engines. First, several industry standard mesh texture formats are presented with analysis of the bottlenecks created when mesh textures are converted by the Unity game engine. A texture preprocessing solution is suggested, which reduces the texture load time of high fidelity 3D terrains. Similarly, the conventions of industry standard 3D mesh file types are explored and contrasted with Unity native 3D format conventions. Optimized custom 3D file type solutions are detailed as an alternative to avoid unnecessary computation during conversion from source 3D file type to Unity's native format. Furthermore, runtime mesh decimation is reviewed as a solution to simplify overly polygonized areas of terrain meshes while maintaining the quality and accuracy of meshes and textures. Finally, the paper recommends a formal set of best practices to optimize geospecific 3D terrain data at runtime. Such guidelines are necessary to efficiently utilize geospecific 3D terrains of the highest fidelity within game and simulation engines

TRAINING

BEST PAPER

Advise When Ready for Game Plan: Adaptive Training for JTACs

Matthew Marraffino, Ph.D. | Cheryl Johnson | Daphne Whitmer | Natalie Steinhauser | Aadam Clement

19105

The U.S. Marine Corps (USMC) faces a future of increasingly complicated and volatile environments, in which Marines must be prepared to make difficult decisions in high stress and high stakes situations. As a result, the USMC Vision and Strategy 2025 highlights the need for training that focuses on the individual and leverages the latest advances in technology to prepare Marines for complex operational environments. Adaptive training (AT), which is training that is tailored to an individual's strengths and weaknesses, is well-suited to meet this need and has led to more efficient and effective learning gains than traditional non-adaptive approaches in certain domains. However, little research has examined the effectiveness of AT in complex military decision-making tasks. To these ends, this paper will discuss the development of a testbed called Adaptive Training for Terminal Air Controllers (ATTAC) and the results of a training effectiveness evaluation.

ATTAC tackles game plan development, which is a critical decision-making task performed by the Joint Terminal Attack Controller (JTAC) that sets the stage for executing close air support (CAS) missions. Developing a game plan includes selecting and employing the best ordnance to meet mission requirements and is a challenging topic for many JTAC trainees to master. Informed by science of learning principles, ATTAC works by presenting a trainee with a series of CAS scenarios, and based on the trainee's responses, the system provides tailored feedback and adjusts the difficulty of subsequent scenarios. In this way, the trainee receives a unique training experience optimized to his/her ability level.

We are conducting a training effectiveness evaluation of ATTAC and have collected data from 34 USMC personnel to date. The final paper will include results from the completed experiment, but initial results suggest that AT leads to more positive learning outcomes compared to non-adaptive and traditional training methods.

Enhancing Training of Supervisory Control Skills for Automated Systems

Natalie Drzymala | Thomas Graves | Tim Buehner | LTC Steven Aude, USA (Ret)

19120

Contemporary warfighters operate in fast-paced and complex domains that, without assistance from automated technologies, would overwhelm their information-processing and decision-making capabilities. These warfighters must exercise supervisory control, learning to monitor, initiate, change, and stop processes in automated systems. Several challenges to supervisory control are identified in scientific literature, but there is little information concerning how supervisory control is exercised for air battle management in air defense systems. One system requiring supervisory control is the Army's Phased-Array Tracking Radar to Intercept on Target (Patriot) missile defense system. Our research collected data about Patriot crewmembers' performance of supervisory control to inform the compilation of a supervisory control skillset and identification of training interventions to enhance its training. Twenty-nine (N = 29) Patriot crewmembers, trainers, and evaluators were interviewed about the general supervisory control issues and challenges presented in the literature, their prioritization of those for supervisory control performance in air battle management, and the skills and training required to perform supervisory control effectively. Problems with understanding how the system works, comprehending and integrating critical information to maintain situational awareness, understanding one's role within the tactical situation, and attentional tunneling were identified as potentially being most detrimental to mission performance. We identified crew resource management, decision-making, interpretation, situational awareness, system operation, and vigilance as key complex skills for effective supervisory control in this environment. We proposed seven training interventions to enhance development of those key skills and the training of supervisory control. While the U.S. Army's Patriot system was the focus of this research, supervisory control training is applicable to other Department of Defense applications, particularly those that require exercise of supervisory control over individual networked systems (such as integrated air and missile defense) or multiple grouped systems (such as multiple unmanned vehicles) by single operators or teams.

Game-Based Learning to Enhance Post-secondary Engineering Training Effectiveness

Kevin Hulme, Ph.D. | Aaron Estes | Mark Schiferle | Rachel Su Ann Lim

19139

In recent times, Game-based Learning (GBL) and "Gamification" serve as emergent mechanisms for modern-day Training. In accordance with Dale's Cone of Learning, knowledge retention and trainee engagement have been shown to be more effective within a Training environment that purposefully exploits active and experiential opportunities for skillset acquisition. The application of GBL within a high-fidelity Simulation, presented in a Live, Virtual, Constructive (LVC)-context, serves as an innovative mechanism for STEM/ Engineering and Post-secondary Training.

Accordingly, this paper summarizes the design, development, and deployment of GBL Training experiments intended for a Mechanical Engineering college curriculum. Specifically, we have designed two experiments for undergraduate seniors and graduate students who are studying ground-based vehicle dynamics: 1) a Triangular Race Track that institutes and compares "Ghost" vs. "Gauge" GBL-Trainer elements to optimize real-time vehicle performance, and 2) a Skid Pad closed-course proving grounds that visualizes weight-distribution adjustment to optimize vehicle stability towards a (desirable) neutral steer condition. To assess the ultimate effectiveness of our Training solutions, quantitative data (e.g., speed, X/Y position) was collected by the Simulator, and likewise, our class cohort (N=70) offered supplementary self-report data (e.g., Concept Mapping and Learning Styles) relevant to the GBL experience. As a component of our holistic multi-measure evaluation, these data are analyzed to report lessons-learned along with any meaningful correlates.

To conclude this paper, we will also discuss planned future extensions of our GBL-based Training solution into other Engineering courses. Namely, our framework can be employed in a Junior-level Dynamics course to demonstrate a second-order spring-mass-damper representation of a vehicle suspension system, and similarly, within the context of another engineering discipline (e.g., senior-level Aerospace Engineering), short-period flight modes can be actively demonstrated for an Aircraft Dynamics experiment. Likewise, framework extensibility to a portable augmented/mixed reality deployment for other engineering systems (e.g., military/Marine, K-12 and STEM/location-based entertainment) is forecasted.

Simple to Complex – Evolution of Workforce Training in a Rapidly Changing Environment

Mike Thorpe

19155

The challenge; a brand new federal program called the Affordable Care Act (ACA) or also known as Obama Care. Our charge was to find, hire, and train 4,500 new employees for four (4) brand new processing centers in four (4) different states in about 3 months' time. To add to the challenge the systems, processes, and laws were all new, or non-existent and changing rapidly. The fluid component of this program hasn't stopped and we continue to look for ways to deliver effective training that has an immediate need but a short shelf life. The objective of this paper is to detail how we created a rapid Training development and delivery model that continues to evolve as the Federal ACA program matures. The training solution includes an innovative workforce development component where we have elevated the skills and abilities of an SCA mandated workforce and created expertise in healthcare policy and processing. The paper will demonstrate how we are utilizing real-time performance and quality data to target performance improvement training. And how we are utilizing a complex learning architecture to provide hands on, micro learning, and on-demand learning content. We threw away the book and created an extensive training program that involved basic job and workforce skills, social rules (e.g. emotional intelligence, customer service), as well as skills for tasks that were rapidly becoming more and more complex. This paper will tell the story of our journey and the challenges that were met along the way. Looking back, the Training component of this program has changed significantly from when we started in 2013, and continues to evolve as we face new challenges in workforce development and policy change. The information within this paper will provide a complex case study on how to rapidly design and deploy training resources and content.

Impact of Malodors on Tourniquet Application: A Longitudual Study

Christine Allen | Claudia Hernandez | Sasha Willis | Brian Goldiez | Grace Teo | Laura Reinerman-Jones | Mark Mazzeo | William Pike, Ph.D.

19169

In military and first responder training, malodor (i.e., unpleasant odor) exposure is common. First responders are required to perform life-saving interventions during highly stressful events.

The purpose of this longitudinal study was to research tourniquet application reaction times with malodor exposure. Participants were randomly assigned to one of three groups, in two parts. The two parts were separated by approximately forty days. Part 1 had seventy-one participants, while Part 2 had fifty-eight participants. Group 1 was exposed to malodor in both parts, Group 2 was not exposed in Part 1, but was exposed to malodor in Part 2, and Group 3 was not exposed in either part. All participants received tourniquet training via videos, flash cards, and application to an arm. The culminating event was a timed tourniquet application to a leg.

The results revealed that malodors did not negatively impact performance. Groups 1 and 2 (exposed to malodors during Part 2) reported a slight increase in perceived odor but did not suggest a negative impact. These two groups also applied the tourniquet faster, maintaining the same accuracy with possible odor adaptation. Group 1 (receiving odors during both parts) increased performance (faster tourniquet) over the other groups. Group 2 (exposed to odors during Part 2) significantly outperformed their reaction time during Part 1 (no exposure). It is important to note Group 3 (not exposed to malodors in either part) did not perform as well as the groups that were exposed to malodors. The results from this study suggest that the addition of a malodor, in the proper context, may improve performance without having a negative impact on subjective measures.

Revolutionizing Formal School Learning with Adaptive Training

Amanda Bond | Jennifer Phillips | Natalie Steinhauser | Brian Stensrud

19215

Marine Corps formal schools are challenged to prepare Marines for increasingly complex and varied roles without a commensurate increase in instructor time or course duration. One promising technology-supported approach to maximizing learning and gaining efficiency is adaptive training, whose premise is to customize instruction to individual needs by measuring and then targeting individual deficiencies with tailored remediation (e.g., Landsberg, Mercado, Van Buskirk, Lineberry, and Steinhauser, 2012). The authors hypothesize that adaptive training tools can modernize formal school learning for the Marines in multiple ways. First, they enable self-paced learning of basic concepts so instructor-led time can be devoted to advanced topics and application. Second, they improve the remediation process by offering individualized support for knowledge gaps and misconceptions rather than a one-size-fits-all approach. Finally, they increase instructor visibility on student performance.

The efficacy of the adaptive training paradigm was tested with entry-level Marines using the Adaptive Perceptual And Cognitive Training System (APACTS). Land navigation training was selected as the domain for this testing, and content was generated for ten classroom-based learning objectives. An experiment was conducted in which Marines were randomly assigned to the adaptive training or control group. Both groups received a 23-item pre-test, intervention, then a 23-item post-test. The adaptive training group intervention consisted of targeted remediation on the learning objectives not mastered on the pre-test, while individuals in the control group received standard land navigation slides used by a preeminent Marine Corps school. Results indicate the adaptive training group experienced learning gain from pre- to post-test of 42.5% in contrast to the control group learning gain of 16.5%. This constitutes an effect size (Cohen's d) of 0.69 over the control condition. These results lend support to incorporation of adaptive training into Marine Corps formal schools for increasing the effectiveness and efficiency of training.

The Development and Implementation of Speech Understanding for Medical Handoff Training

Alyssa Tanaka | Brian Stensrud | Gregory Welch, Ph.D. | Lee Sciarini

19235

The success of a healthcare team relies on the concerted effort of multiple members of an interdisciplinary team and the failure of the team directly translates to patient outcomes. A medical team can consist of several individuals or potentially dozens of members spanning the spectrum of care. Similarly, military medical teams exist at specific echelons of care and may not work in the same hospital, country, or continent. These complex environments require an emphasis on effective communication and a shared understanding of common goals for team success. The criticality of effective communication can be seen in patient handoffs, during which the responsibility of care and a cognitive off-load of patient information is transferred from one provider to another. During these exchanges, a lapse in information transfer can be detrimental to the patient. These critical moments in patient care are even more complex within the context of combat casualty care, where casualty information is transferred in austere environments and providers may be managing multiple casualties with multiple injuries, over long periods of time.

The successful performance of handoffs in these complex situations require reflectively complex training environments; However, there is currently no standard training or certification for combat casualty handoffs. This paper will describe the design and development of a capability aimed to train and assess medical teams on performing combat casualty handoffs. The core of the system is a speech understanding capability that automatically recognizes, captures, and assesses the verbal components of a handoff. The recognized speech populates two user interfaces in real-time: a digital patient chart to facilitate the scenarios and an instructor dashboard to support trainee assessment and performance review. This paper will describe the development and use of this system as a training tool within the medical field, including domain specific design considerations, limitations, and lessons learned.

Improving Assessments using Intelligent Agents with Transient Emotional States

Angie Dowdell | Rania Hodhod | Suleyman Pölat | Randy Brou | Julia Grove

19251

The assessment of interpersonal leadership skills has historically been impeded by the lack of assessment techniques free of response bias and/or resource prohibitions. Advances in psychology and computer science (e.g., Reactive, Open-Response Assessments; RORAs) have provided novel alternatives to traditional assessment methods (Brou, Stallings, Normand, Stearns, & Ledford, 2018). RORAs assess interpersonal skills via scenarios in which users interact with virtual agents; however, these agents currently lack sophisticated emotional response capabilities. The present research begins to address this shortcoming by developing virtual agents with the capacity to parse emotional inputs and generate appropriate emotional responses. Such techniques applied in other domains using intelligent agents have been shown to increase the effectiveness of information delivery and retrieval (Janarthanam, 2017). Four intelligent agents were developed using the DialogFlow Platform. Agents' affective states and user inputs were classified using Russell's Circumplex Model of Affect (Russell, 1980). One-hundred and twenty-five participants provided conversational inputs intended to modify the agents' affective states in particular ways during interactions. Affective models correctly classified 78% of user inputs, leading to the appropriate shifts in agent affective states. Next, deep learning techniques (e.g., sequence to sequence) were used to generate novel agent utterances based on agent affective states. Novel agent utterances were evaluated using the BLEU metric (Papineni, Roukos, Ward, & Zhu, 2002). Utterances achieved a BLEU rating of 0.2, indicating performance consistent with similar natural language generation systems in the literature (Gkatzia & Mahamood, 2015). These results demonstrate the potential for improving effective dialog between a human user and an intelligent agent during interpersonal skill assessment.

Training Teamwork Skills in an Intelligent Tutoring System

Robert McCormack | Tara Kilcullen | Alexander Case | Dan Howard | Alexander Wade | Tara Brown, Ph.D. | Anne Sinatra

19276

The importance of acquiring and maintaining teamwork skills for high team performance is well documented in both academic literature (e.g., Sottilare, et. al. 2017; Wilson, et. al., 2007) and military doctrine (e.g., ADRP 6-0, 2012). However, effective training of teamwork skills (as opposed to task skills) has remained a challenge. To maximize training effects, while reducing costs, and increasing reusability, there has been a push in the military toward using intelligent tutoring system (ITS) frameworks, such as the Generalized Intelligent Framework for Tutoring (GIFT; Sottilare et. al., 2012; Sottilare et al., 2017). The majority of ITSs are designed to train individual skills rather than teamwork skills, since there are both theoretical and technological challenges associated with developing ITSs for teams (Sinatra, 2017; Sinatra, 2018). While there have been implementations that extended ITSs to team-level training (e.g., Bonner, et.al., 2017 extended GIFT to 2-3 person teams), challenges in scaling to larger teams (e.g. 9 person teams), providing realistic training environments and scenarios, and measuring teamwork skill acquisition in both real-time and after the fact remain. This paper describes the design and implementation of an extensible system for training teamwork skills within a realistic simulation environment. This includes development of doctrinally-relevant military scenarios within Virtual Battle Space 3.0 (VBS3), strategies for measuring teamwork process and state constructs (in particular, coordination and cohesion), and training feedback strategies for delivering both individual and team feedback.

Learning Next: Self-Improving Competency-based Training Rooted in Analytics

Jennifer Lewis | Kathryn Thompson | Tobie Smith

19302

During the past two years, the US Air Force (USAF) Air Education Training Command (AETC) graduated 26 pilot candidates from an experimental Undergraduate Pilot Training (UPT) program called Pilot Training Next (PTN). AETC envisioned PTN as an aviation-centric use case for a greater "Learning Next" initiative, oriented on changing how institutions instill requisite knowledge and skills effectively using the latest commodity technologies. Working in collaboration with the Aviation and Missile Center under the US Army Combat Capability Development Command (CCDC), Army Futures Command, AETC trained two separate cohorts of PTN students using similar paradigm-changing methodologies but with different execution. The focus during the first cohort was to make training tools more accessible using creatively-applied commodity Commercial Off the Shelf (COTS) systems and sensors. The focus during the second cohort was to holistically revamp the learning environment to enable self-improving competency-based learning rooted in solid data analytics. Competency-based learning is a game-changing shift for AETC that will help create aviators who are skilled pilots as well as self-directed learners and critical thinkers who can adapt to complex and changing adversarial tactics. This paper discusses the execution of the second PTN course with a focus on how AETC and CCDC created PTN's learning framework and how it can evolve based on data collected from the learning environment. This paper provides specific examples of how collected data transform into insights for the curriculum, using both traditional analytics workflows and industry-standard learning technology specifications. It also describes the technical solutions in place for the Learning Management System (LMS), Learning Record Store (LRS) and automated visualization workflows as well as the types of simulated flight, biometric and proficiency data the program collected. Finally, this paper discusses lessons learned regarding data collection, correlation and availability that are critical to the success of any data-backed curriculum development.

Driving Digitally-Aided Close Air Support Capabilities in Simulation: Lessons Learned

Emilie Reitz | Kevin Seavey

19320

Digitally-Aided Close Air Support (DACAS) is an increasingly important operational capability for many nations and Services. DACAS now allows the use of digital messages to expedite communications, rapidly build shared situational awareness, reduce human error and shorten the kill-chain. Digital systems in aircraft and DACAS ground kits provide other, previously unexpected and significant benefits that improve CAS planning and execution. For example, a Joint Terminal Attack Controller (JTAC) can now transmit digital target coordinates directly into an aircraft's weapons system before the aircraft even checks on station. However, with rare exceptions, current joint fires simulators do not support pilots or JTACs with DACAS training that exercises basic or complicated uses of this vital capability. This training often occurs during scarce national and international training and experimentation events.

As the scarcity of live training opportunities increases, so does the challenge of how do we provide warfighters the most realistic environment to create and maintain their proficiency in joint and coalition DACAS missions. Building on last year's efforts (Reitz, Seavey and Mullins, 2018), this paper discusses the challenges faced in developing a standard methodology for DACAS capabilities in simulation to close this training gap. It also provides lessons learned from the first field test of simulated DACAS systems that allowed a Joint Terminal Attack Controller (JTAC) in a virtual trainer in France to digitally control a live aircraft operating at a range in Finland during the Joint Staff's BOLD QUEST 19.1 coalition capability demonstration and assessment event in Finland.

Adaptive Network Planning for Infrastructure Networks for Test and Training Events

Rajive Bagrodia, Ph.D. | Jeff Weaver | Wei Liu | Defend Xu | Gil Torres | Kent Pickett | Jason Richardson | David McClung

19337

A central requirement in test and training events is that the Test Engagement Network (TEN) provide sufficient coverage and bandwidth to ensure:

Personnel and platforms participating in the event can be monitored

All traffic needed to monitor the participants, both live and constructive, is delivered to the Exercise Control (ExCon) in a timely manner for accurate computation of Real Time Casualty Assessment (RTCA)

The energy requirements of the various transmitters and other mobile equipment deployed as part of the TSN do not exceed their battery capacity during the course of the OT. Tower locations have a direct impact on the power required for satisfactory network service quality.

For a successful test or training event, the access points or towers of the TEN must be located such that they can meet the preceding requirements. On most ranges, towers are an expensive asset to deploy and monitor during the test, and as such they must be managed optimally - using more towers than needed will drive up the cost of the event and having insufficient coverage may raise concerns on the validity of the data collected during the test.

The primary goals of the Integrated Planning of Tactical, Test Support, and Tactical Engagement Network (IPT3N) project, is to provide an automated capability for planning and optimization of range network laydowns to meet specified coverage, bandwidth, and power consumption requirements.

This paper will describe the use case driving the development of continuous planning of the range networks and the algorithms used to improve coverage and bandwidth. We will discuss test planning challenges and how they can be overcome by support technologies like IPT3N. We will use data from a TEN deployment using TAPETs towers from a previous Network Integrated Evaluation (NIE) at the White Sands Missile Range (WSMR).

Game On: Storytelling Narrative Applied to Simulator-Based Training

Margaret Merkle | Tara Browne

19363

The current MQ-9 Initial Qualification Training (IQT) curriculum uses a mix of classroom, simulator, and live-fly training instruction. The current curriculum has experienced challenges with meeting aircrew readiness requirements. Specifically, resource constraints and outside factors such as weather affect the ability to execute live-fly training. These negative impacts are driving the effort to increase simulator-based training events. In order to meet the increasing demand for MQ-9 flight certified aircrews, MQ-9 training is executing an experimental redesign to expand use of Live, Virtual, and Constructive (LVC) capabilities within the MQ-9 high-fidelity aircrew training simulator.

The LVC lessons include additional roles in simulator-based training scenarios that approximate the multimodal environment of live-fly exercises. These scenarios loosely mimic the multi-role and multimodal engagement style of many popular video games. These games use narrative devices to engage users in situations that require critical thinking and problem solving to progress toward goals within complex multimodal environments.

The goal-based scenario (GBS) framework describes a learning environment that exploits the learn-by-doing method demonstrated in these games. Game Based Learning (GBL) explores the concept that games are effective in teaching skills not just because of engagement, but because the skills are applied within the narrative context of the game. Both the GBS framework and GBL depend on a narrative thread or storyline, and that narrative ties to the learning objectives of training.

This paper considers the tools and methods used in the simulator-heavy training and applies academic and industry findings to investigate how storytelling and narrative techniques in GBS and GBL can be combined with the LVC capabilities within a high-fidelity aircrew training simulator to improve training outcomes and aircrew readiness.

BEST TUTORIAL

An Introduction to Cognitive Systems for Modeling & Simulation

Randolph Jones, Ph.D | Dylan Schmorrow

1914

There are increasing requirements for automated reasoning abilities across the broad spectrum of modeling and simulation, as well as in battlefield information and control systems. Additionally, the cognitive capabilities that have been developed and tested in simulation are migrating to real-world systems. Cognitive systems represent a maturing computational approach to intelligence that can provide robust, scalable, and adaptive decision making. This tutorial provides an introduction to cognitive systems, concentrating on production system computation and high-level design of human-like reasoning systems. We draw examples and comparisons from existing cognitive systems, focusing on the tradeoffs between cognitive and non-cognitive modeling approaches. The tutorial content does not require any specialized knowledge, but some experience with software engineering or behavior modeling can be helpful. Attendees will learn to recognize problems that suggest cognitively based solutions, and they will be better able to assess risks, costs, and benefits of different approaches. This tutorial is targeted toward developers who might be interested in cognitive approaches to software engineering, as well as customers who have problems that may be amenable to a cognitive approach.

BEST TUTORIAL

Artificial Intelligence: Past, Present, Capabilities and Limitations

Robert Richbourg, Ph.D. | Robert Lutz

1919

Many in the political, 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 now reach impressive performance levels. These success stories beg answers to questions about the limits of performance and potential.This tutorial describes artificial intelligence in its historical context of boom and bust cycles. The AI discipline has a 60-year record of remarkable achievements fueling heightened expectations that were followed by disillusionment (“AI Winters”) when the technologies failed to satisfy popular expectations or generalize to wider application. The tutorial develops parallels between the current deep neural network requirements for success and those of previous intelligent technologies that were once inspiring but are now less widely used. The tutorial also identifies application areas where deep neural network technologies have been applied, highlighting both successes and limitations to develop, frame and temper expectations. Finally, the tutorial will examine the state-of-the-art in terms of methods and tools for testing AI-enabled autonomous unmanned systems. The tutorial is open to any who would benefit from developing an appreciation of the larger context surrounding current AI achievement. It provides an overview of the field. It is not intended to teach use of available deep learning utilities or to provide detailed information about constructing deep neural networks.

BEST TUTORIAL

Superforecasting: Proven Practices for Leveraging Human Ingenuity

S. (Sue) Numrich, Ph.D.

1921

Those of us who work for the military in some capacity are well aware of the emphasis placed on lessons learned. 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? Are there other practices available to help us throughout the process of creating and using modeling and simulation for training (and other purposes as well)? 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 tutorial 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.

A Comprehensive Introduction to Medical Simulation

Roger Smith | Danielle Julian

1910

Simulation tools and techniques have been a part of acquiring medical knowledge and skills for over 4,000 years, with more scientific approaches emerging hand-in-hand with the European Renaissance. These devices were initially used as a means to convey homeopathic experience and the knowledge gained through cadaveric dissection. More recently, the devices have been computerized and restructured according to modern learning theories.This tutorial is a comprehensive overview of medical simulation to include “what’s new”, history, proposed system taxonomies, devices and techniques for representing external and internal anatomy and physiology for medical interventions, the role of team training, and criteria for current simulation accreditation programs. The tutorial concludes with a predictive view into the future of the devices and practices as outlined by forward thinkers in the field. This includes an understanding of the financial, cultural, and scientific forces which both aid and restrain the application of simulation in medicine.The story includes manikins, part-task trainers, surgical simulators, standardized patients, physical prostheses, team training events, and certifications. These categories are drawn from taxonomies initiated by the American College of Surgeons and the Society for Simulation in Healthcare. The tutorial concludes with a predictive view into the future of the devices and practices as outlined by forward thinkers in the field.

Distributed LVC Event Integration and Execution Process

Michael O'Connor | Kenneth LeSueur

1911

Integration and execution of large distributed Live, Virtual, Constructive (LVC) events consume substantial time and resources. While the underlying distributed LVC technologies are mature, the processes for integrating events are not. The IEEE Std 1730-2010 Distributed Simulation Engineering and Execution Process (DSEEP) standard presents a process model for the development of an event. However, the user still has to instantiate the process and develop artifact templates.Based on the experience of the integration and execution of many distributed LVC events, an instantiation of two of the seven DSEEP steps has been developed. This tutorial provides a detailed set of processes, templates, and guidance on how to perform step 5 Integration and Test Simulation Environment and step 6 Execute Simulation steps. The tutorial also describes how the products produced in the first 4 steps are used the subsequent steps. The process covers the integration of simulations and tactical systems to meet the objectives of the LVC event.This tutorial is beneficial for anyone involved in the integration and execution of large distributed events. The tutorial is particularly beneficial for engineers tasked with planning and executing distributed events. The tutorial does not require knowledge of the DSEEP standard.

Introduction to HLA

Bjorn Moller | Robert Lutz

1916

The High-Level Architecture (HLA) is the leading international standard for simulation interoperability. It originated in the defense communities but is increasingly used in other domains. This tutorial gives an introduction to the HLA standard. It describes the requirements for interoperability, flexibility, composability and reuse and how HLA meets them. It also describes the new features of the most recent version: HLA Evolved (IEEE-1516-2010) and the upcoming HLA version (HLA 4). Finally, it provides some recent experiences of the use of HLA in NATO M&S groups as well as an overview of recent evolution of Federation Object Models for military platform simulation. This tutorial is intended for all audiences; however, some familiarity with basic principles of distributed computing is recommended.

Cybersecurity in LVC Training Environments

Joseph Beel | Kurt Kollmnasberger | Josh Turner

1917

Cyber adversaries have a vast array or tools and a keen sense of when to use each one for maximum effect. You may not be able to stop all attacks but, you can minimize risk and impact of threats by constraining adversaries' operational space. Given LVC's inherently connected nature and the increasing dependence on commercial technologies, cybersecurity is critical to training and simulation. The objective is to reduce any adversary's ability to operate in your environment.Network flow data provides a wealth of behavioral information that is useful in understanding normal operations and detecting abnormalities. Detailed flow information can enable pervasive visibility and effective cybersecurity from the endpoint, through the network, to the data center and to the cloud. An effective cybersecurity architecture will provide early warning to help you get inside the attacker's timeline and then it will help you block attacks to prevent damage, compromise, loss of information or even operational and safety risks. It's also importantly to close the vulnerability and ensure that your system learns from the attack and strengthens defenses after an attack.The ability to collect flow data and contextual information about users, applications and devices enables the network to serve as a powerful security resource. Coupled with accurate and timely threat intelligence, new technology and techniques allow today's network infrastructure to leverage embedded security capabilities to enable the entire network and even the data center to serve as an invaluable security resource that can sense abnormalities and threats and automatically enforce security policies in response. Integration and communication between network control and security are absolutely essential.

Design of Experiments: Applications for the Simulation Profession

Steven Gordon

1918

The Department of Defense (DoD) is currently evaluating ways to accelerate acquisition and test and evaluation (T&E) in order to field more effective weapon systems sooner. DoD is also seeking ways to improve models of selected weapons systems in simulations for test and for training. Design of Experiments (DOE) can assist DoD in accelerating the development of combat systems, increasing precision, and improving the validity of simulations. DOE is used to calculate relatively accurate models of a system quickly, identify the most significant inputs (factors), and characterize how the system performs in the region modeled. DOE is used to improve the quality of consumer products or defense systems, find optimal solutions, and calculate settings to hit targets consistently. DOE is also used to accelerate the vulnerability scans and reduce the number of cybersecurity experts required to fully analyze a system's cyber threat landscape. DOE is a rapid modeling method that provides new types of information to simulation developers. This tutorial will discuss the upfront analysis steps for the DOE process, key benefits of using DOE, and typical use cases. These use cases include development of functional representations of systems in order to characterize how the systems perform within the region modeled. The tutorial will illustrate how DOE models can be used to define a relationship between inputs and outputs for the purpose of analysis, early prototyping, tradespace studies, simulation, evaluation, and optimization. For one radar system, DOE was shown to produce more information than any previous testing methods, while using only 10% of the previously-required test resources. This was truly a unique example of faster, better, and cheaper. Use cases such as Model-Based Systems Engineering, test and evaluation, cybersecurity, and validation of models will be discussed. There are no requirements for mathematical or statistical knowledge for attendees of this tutorial.

M&S Case Study Analysis: Design for Additive Manufacturing & 3D Printing

Kevin Hulme | Sourabh Saptarshi

1920

Additive modes of product manufacturing, more commonly referred to as 3D Printing (3DP), are substantially altering the manner in which we approach subsystem component and design prototype conceptualization and generation. Lighter, stronger, and far more complex (i.e., both in terms of shape, and material) components can be achieved by leveraging these advanced technologies, and in a manner that is typically more process- and cost-efficient than traditional (subtractive) methods of manufacture. However, as these technologies continue to rapidly mature, the iterative pipeline between Conceptual Modeling, 3D digital Design, preliminary Rapid Prototyping, and end-product Manufacturing is continually evolving to improve process efficiency and overall rates of success. In this Tutorial, we feature four extensive 3DP Case Studies, each within separate domains of interest pertinent to Modeling & Simulation (M&S) (i.e., Military, Health Care, Aerospace, Entertainment) that emphasize the "Design for Additive Manufacturing (DFAM)" process pipeline. The Case Studies will be preceded by core introductory material for those new to Additive Manufacturing (AM) practice, including a targeted discussion of Fundamental printer, material, structural, and critically – COST considerations all interrelated to 3DP. Likewise, the associated impacts of emerging AM and 3DP technologies upon Training, Simulation, and Education – the three critical "pillars" of I/ITSEC – will be justified and emphasized throughout this emergent technology Tutorial.

A Functional Approach to Distributed Network Architectures for LVC

William Louisell | Grimt Habtemariam | Chuck Otts

1922

Recent innovations within the networking industry are converging to greatly enhance the distributed simulation environment and set the foundation for achieving the full LVC objective state. Future distributed network architectures leverage hardware innovations that include converged compute, storage, and transport management functions and device virtualization that allows a single device to perform multiple roles i.e. routing, switching, and security appliances. Innovation in network and security operations include advances in software defined networking, development of agile identity and access management, and the incorporation of real-time network and security policy compliance and application performance visibility functions. Further, the use of National Security Agency approved Commercial Solutions for Classified voice and data transport simplify implementation of multi-level security operations inherent in distributed simulation and LVC. Emerging network architectures and evolving operating practices create operational effects at a lower capital and operating cost. Resource utilization can be dynamically adjusted to suit the function at hand. During a simulation sequence, load surges can be distributed via to ensure quality of service required to achieve the realism demanded as hundreds, thousands, or tens of thousands of entities interact within physics-based models.Automation and real-time security policy implementation support live, virtual, and constructive entity pairings in large-scale sessions. Automation is key to access and security policy compliance assurance that is a prerequisite for dynamically paired entity interactions taking place simultaneously on multiple levels including flight or ground path interaction, multi-spectrum signature representation, multi-spectrum detection representation, and multi-spectrum weapons and countermeasure interaction characteristics.The future LVC network environment will effectively resemble a highly distributed high-performance computing center. Multiple networks will join together on a session basis to support high intensity, many-to-many interactions on multiple, segregated classification planes. In this environment, assuring the moment-by-moment integrity of the architecture and computational operations through multi-epoch scenarios is a must. Both are possible with visibility functions that continuously run checks and balances verifying the integrity of the simulation.

Introduction to DoD Modeling and Simulation (M&S)

John Daly | James Coolahan

1923

This tutorial will describe the fundamental technologies, terms and concepts associated with Modeling and Simulation (M&S) and describe M&S development and application in the Department of Defense (DoD). The tutorial will cover various aspects of M&S including key M&S terms and concepts that describe M&S technology, development, and application. It will include: (a) M&S terminology and concepts used in the DoD; (b) M&S technology, architectures and interoperability protocols; (c) the processes for developing valid representations of DoD warfighting capabilities, threat capabilities, cyber, natural environment, complex systems, and human/organizational behavior. The attendee will become familiar with how M&S is used in the DoD for operational purposes - especially training and other areas of direct warfighter support; and the DoD M&S role in enabling key functions of the Department. This tutorial will identify key policies and procedures for DoD M&S, and present the critical role of Verification, Validation and Accreditation (VV&A) in ensuring that models and simulations meet the needs of their users. The tutorial will present the role of M&S Standards in the Defense Standardization Program, its role within the M&S framework, and its relationship with the Joint Information Enterprise (JIE) and cloud-based DoD IT. The tutorial will describe the characteristics and associated challenges of M&S applications within DoD functional areas with examples of: Training, Analysis, Acquisition, Test and Evaluation, Experimentation, Planning, and Intelligence. The tutorial will also identify accessible DoD M&S information resources and explain the role of the DMSCO as the focal point of DoD M&S information, practice, technology, and functional use.

TENA/JMETC: Live-Virtual-Constructive Integration for Test and Training

Edward Powell

1928

The Test and Training Enabling Architecture (TENA) and the Joint Mission Environment Test Capability (JMETC) program provide an advanced set of interoperability software, interfaces, and connectivity for use in joint distributed testing and training. This tutorial will provide information about the how TENA works and why it is important to the test and training communities, with some comparison to other interoperability architectures. TENA provides testers and trainers software such as the TENA Middleware—a high-performance, real-time, low-latency communication infrastructure that is used by training range instrumentation software and tools during execution of a range training event. The standard TENA Object Models provide data definitions for common range entities and thus enables semantic interoperability among training range applications. The TENA tools, utilities, adapters and gateways assist in creating and managing an integration of range resources. The current version of the TENA Middleware, Release 6.0.5, is being used by the range community for testing, training, evaluation, and feedback and is be used in major exercises in the present. JMETC is a persistent test and evaluation capability throughout the US DoD, connecting many test ranges together, including a bridge to the JTEN training network; a set of TENA-compliant software middleware, interfaces, tools, and databases; and a process for creating large distributed test events. The combination of TENA and JMETC gives testers and trainers unprecedented power to craft a joint distributed mission environment that forges the future for innovative testing and training.

Live, Virtual and Constructive (LVC) Simulation Interoperability 101

Kurt Lessmann | Damon Curry

1931

The tutorial is intended for decision makers who have recently come in contact with distributed simulation and need a top-level understanding of Live, Virtual and Constructive (LVC) interoperability and the supporting standards, technology and processes. The purpose of this tutorial is to provide managers the necessary insight needed to support intelligent decision making. The tutorial will discuss the various domains of the technology and how it can potentially relate to their LVC needs. The tutorial provides a relevant use case as the mechanism to explain the concepts and the solutions required to achieve success. The tutorial will not be an in-depth technology review of LVC interoperability yet will provide sufficient management-level insight into interoperability solutions and standards like Distributed Interactive Simulation (DIS), High Level Architecture (HLA), and the Test and Training Enabling Architecture (TENA) product line.

Location, Location, Location: Big data, Artificial Intelligence, and Analytics in the Cloud

Joe Rohner | Kaye Darone | Justin Neroda

1936

Following last year's tutorial on Machines Crave Big Data that outlined Big Data, Machine Learning, and Artificial Intelligence, we continue the journey with a tutorial on developing and hosting analytics in the cloud. Cloud technology is rapidly changing the way the organizations design and operationalize their artificial intelligence projects and the DoD has begun small scale adoption with a massive enterprise cloud environment in the next year. These movements and changes will help revolutionize training, simulation, and education. In this tutorial, we will cover: options on hosting your analytic environments to include on-premise, public cloud, and private cloud; discuss advantages to adopting and operationalizing a cloud environment for your analytic needs; provide an overview of cloud architectures to support the whole life-cycle of analytics from the storage of data to abstraction layer for your analyst workforce; discuss open-source and cloud vendor analytics tool that can be deployed to help meet artificial needs around computer vision, natural language processing, and machine learning; provide real-life examples from the U.S. Army's Training and Doctrine Command (TRADOC) G-2 experiences with implementing cloud-based analytic solutions; and last but not least, we will provide an industry overview on future trends for the use of cloud technologies to enhance training, simulation and education.

Distributed Interactive Simulation (DIS) 101

Donald Brutzman | Christian Fitzpatrick

1937

The Distributed Interactive Simulation (DIS) protocol is a well-established IEEE standard for packet-level exchange of state information between entities in military simulations. DIS facilitates simulation interoperability through a consistent over-the-wire format for information, widely agreed upon constant enumeration values, and community-consensus semantics.Anyone can obtain the IEEE-1278 standard and implement their own compliant, interoperable, DIS application. A large variety of tools and codebases simplify this effort, and enable multi-architecture integration of simulations using the DIS stand baseline. DIS focus begins with real-time, physics-based, entity-scale simulations, providing state update and interaction mechanisms which can scale to large virtual environments.This tutorial is a "DIS 101" introduction for software implementers and an introduction to the DIS philosophy for simulation systems integrators. Examples are provided using the open-source Open-DIS library for DIS v7 support, available in multiple programming languages. Ongoing work is included in WebRTC browser streaming, unit testing of DIS streams, and Web-based implementations using 2D maps and X3D Graphics.

Risk Management Framework: Cyber Security Compliance for Modeling, Simulation, and Training Systems

Donald Lawson | Charles Cohen

1939

Cybersecurity, it is everywhere we look in today's world and when it comes to government systems it can seem like an extremely broad topic which evokes the fear of insurmountable regulations that ultimately provide little benefit. This tutorial aims to break the stigma surrounding Cybersecurity compliance as nothing more than a burdening nuisance and leave the audience with an understanding of the ultimate goals of the Risk Management Framework (RMF) and how it was designed to relieve excessive regulation and costs. The primary goal of Cybersecurity RMF compliance is to ensure the confidentiality, integrity and availability of government run systems, software, and data are upheld, enabling those systems to remain operational and available to support military missions. Such missions include simulation and training environments which are becoming increasingly more important to protect as the concept of force readiness becomes a priority for the world's militaries.This tutorial will focus on understanding the requirements for the Cybersecurity Risk Management Framework (RMF) and how it applies to modeling, simulation, and training systems. We will detail the need for Cybersecurity compliance, the key concepts, and why it is critical for military, government, and even civilian applications. The tutorial will then dive deeply into the regulations behind RMF and the certifications required for compliance. This will include where to find additional information and how to achieve those certifications, from both a government and contractor perspective.The tutorial will then explain the general process of approaching RMF compliance and how the Cybersecurity implementation plans are created and revised in the requirements gathering phase. Using these RMF requirements and concepts, the tutorial will then take it a step further and analyze the documentation deliverables associated with RMF, their purposes, and finally the government processes necessary to submit a system for an Authority-to-Operate decision. Attendees will gain a strong foundational understanding of the Cybersecurity Risk Management Framework and how to apply it in their own programs.

Addressing the Challenges of Rigorous Simulation Validation

Simone Youngblood | Mikel Petty

1941

The process of validation is essential to the credible and reliable use of any simulation. Although Department of Defense policy and guidance increasingly emphasizes the importance of rigorous validation founded in the application of strong statistical analysis, implementation of rigorous validation continues to face multiple challenges. This tutorial will address several of those challenges:* How to identify, collect, and combine validation referent data (what the simulation results will be compared to)* How to identify the simulation measures and metrics to use as the basis of comparison (the aspects of the results that will be compared to the referent)* Methods to apply when performing the results/referent comparison* How to quantify risk and residual uncertainty associated with the application of the simulation. The tutorial will enhance the learning experience by incorporating lessons learned derived from the many applications with which the authors have been involved.

Simulation Conceptual Modeling Theory and Use Cases

Jack Borah

1943

Simulation Conceptual Modeling (19XX)Simulation conceptual modeling is a critical step in simulation development frequently overlooked in the rush to demonstrate program progress. A simulation conceptual model is an abstraction from either the existing or a notional physical world that serves as a frame of reference for further simulation development by documenting simulation-independent views of important entities and their key actions and interactions. A simulation conceptual model describes what the simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the stakeholder's requirements. It bridges between these requirements, and simulation design.This tutorial will present the theory and application of simulation conceptual modeling as documented during the research done by the NATO MSG 058. In addition, Use Cases that have been drawn from previous conference presentations will be presented to illustrate how conceptual modeling has been performed. Additional work is necessary to mature the state-of-the-art of simulation conceptual modeling before a recommended practices guide could be standardized. This tutorial has been created to continue the maturation of the simulation conceptual modeling best practices.

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