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Conceptual 3D Modeling and Simulation for Wargaming

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CONCEPTUAL 3D MODELING AND SIMULATION FOR WARGAMING

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Abstract

Aelius Exploitation Technologies, LLC (AELIUS) is currently supporting efforts at the forefront of three-dimensional (3D) conceptual modeling and simulation for wargaming in order to advance and transform digital technology to the warfighter.

AELIUS has the demonstrated skill set, resources, and capabilities necessary to develop conceptual models for wargaming in an immersive (augmented reality/virtual reality [AR/VR]– capable), multiplayer simulation, 3D photo-realistic digital synthetic environment. AELIUS is currently contracted with the U.S. Air Force to support a large area test and training range to create an interactive, immersive 3D environment for their entire range area, and recently completed a Defense Advanced Research Projects Agency (DARPA) Phase II effort to create a digital twin of the moon and integrate 3D models of lander, rovers, and infrastructure for dynamic simulation.

AELIUS has managed and integrated wargaming technology into a 3D digital synthetic environment for use in Concept of Operations (CONOPs) development and planning, rehearsals and training, simulations and modeling, specifically in support of Special Operations Forces (SOF). AELIUS has also integrated artificial intelligence/machine learning (AI/ML) models into these synthetic environments, understands how to deal with the largest dataset problems in the environment, and knows how to address the biggest capability gaps in the diversity and robustness of the data available to use for training new algorithms. As such, AELIUS can expand on previous success in combining multimodality real-world data and synthetic data from theaterwide "digital twins" for the robust training of AI/ML models in wargaming applications.

Introduction

The rapid advancement of 3D modeling and simulation technologies, along with AI/ML, presents an opportunity to revolutionize wargaming for military training, strategic planning, and operational analysis. This paper outlines the development of a multi-dimensional/3D wargaming modeling and simulation system to enhance decision-making, improve tactical proficiency, and simulate complex battlefield scenarios with unprecedented realism and adaptability (Tribolet, 2024).





Figure 1. Sand Table in Synthetic Environment for Mission Planning



Figure 2. Synthetic Environment of Integrated Air Defense Systems for Mission Planning



Figure 3. Synthetic Environment of an Airfield



Objectives

- **Photo-Realistic Simulation:** Create a highly detailed 3D synthetic/digital environment that accurately replicates terrain, weather, and unit dynamics for immersive AR/VR wargaming.
- **Scalability:** Design a modular system capable of simulating small-scale tactical skirmishes to large-scale, theater-wide, multi-domain strategic operations.
- **AI/ML Integration:** Incorporate artificial intelligence and machine learning to model enemy behavior, adapt scenarios in real time, and provide post-simulation analysis.
- **Training and Analysis:** Enable military personnel to train in virtual environments and provide commanders with tools to test strategies and predict outcomes.
- **Cost Efficiency:** Reduce reliance on physical resources and live exercises by offering a reusable digital alternative that far exceeds current two-dimensional wargaming constructs.



Figure 4. Synthetic Environment of Taiwan



Figure 5. AELIUS Synthetic Environment of U.S. Navy deployed in the Indo-Pacific Theater



Scope

The proposed system-of-systems platform will include

- **3D Terrain Generation:** Procedural and manual tools to create realistic battlefields based on real-world geographic, bathometric, and architectural, data, or fictional landscapes.
- **Unit Modeling:** Detailed representations of infantry, vehicles, aircraft, and naval (surface and undersea) assets with accurate physics and capabilities.
- **Environmental Factors:** Dynamic weather, time of day, and seasonal effects that influence visibility, mobility, and equipment performance.
- Scenario Editor: A user-friendly interface for designing custom missions, objectives, and rules of engagement.
- **Multiplayer Functionality:** Support for collaborative and adversarial simulations across distributed networks.
- After-Action Review (AAR): Tools to record, replay, and analyze simulations for debriefing and learning.



Figure 6. Integration of AFSIM into UE5 Demonstration

Methodology

AELIUS's solution charts a path for 3D modeling and simulation wargaming, as well as how to integrate and train AI/ML models in contested environments. Even where data collection is possible, but wildly too expensive to gather, there is a wide range of data diversity, and even when the required assets are all owned by the U.S. government, arranging for every configuration option, in every lighting and weather scenario, is not feasible. Even for a simple data set around one vehicle, gathering the data could require weeks to months of work. With some assets and units costing tens of thousands of dollars an hour to operate, there may not be the budget to collect even a small percentage of the required data for accurate modeling, simulation, and training. For a hostile asset, this problem becomes exponentially worse.



Acquisition Research Program department of Defense Management Naval Postgraduate School Given the limitations of current modeling and simulations, which rely primarily on preestablished scenarios and require extensive human interaction and decision-making, the incorporation of AI/ML offers the capability to simulate numerous scenarios and outcomes. Advances in AI and significant increases in computing power offer opportunities to mitigate the above cost, time, and other identified constraints (Jung, 2024).

With AI-embedded and generative simulation versus traditional simulation, there is the ability to simulate thousands of tactical and strategic battle events in a short period. Through these iterations of play, Jung (2024) proposed AI could "generate vignettes autonomously, produce numerous courses of action for given scenarios, and offer decision-makers multiple options. It also can evaluate or generate optimal actions for opposing forces and devise countermeasures to defeat them."



Figure 7. Simulated Beach Assault Force on Various Islands

- A. Research and Requirements Gathering (Phase 1)
 - a. Collaborate with military experts to identify key wargaming needs.
 - b. Benchmark existing simulation platforms to establish technical standards.



- B. Development of Core System (Phase 2)
 - a. Use a game engine (e.g., Unreal Engine) for 3D rendering and physics simulation.
 - b. Integrate AI frameworks (e.g., reinforcement learning models) for adaptive opponent behavior.
 - c. Build initial terrain and unit libraries based on open-source data and licensed assets.
- C. Testing and Iteration (Phase 3)
 - a. Conduct alpha testing with a small group of military users to refine usability and realism.
 - b. To validate system flexibility, simulate a variety of scenarios (e.g., urban combat, distributed maritime operations, and desert operations).
- D. Deployment and Training (Phase 4)
 - a. Deploy the system to military bases or cloud-based servers for accessibility.
 - b. Provide training workshops for operators and scenario designers.

Technical Requirements

- **Hardware:** High-performance GPUs for rendering and AI processing, and VR compatibility for immersive training.
- **Software:** Game engine (Unreal Engine) with robust physics and networking capabilities, AI libraries, and secure data management tools.
- **Data Sources:** Satellite mapping imagery, military equipment specifications, and historical battle records for authenticity.

Technical Summary

Wargaming in a 3D Synthetic Environment Using Unreal Engine

AELIUS's solution develops a wargaming construct within a 3D physics-based gaming environment (Epic Games, Unreal Engine 5 [UE5]) with digital twin models of assets (including equipment, buildings/facilities, aircraft, ships/submarines, vehicles, etc.) and "avatar" personnel, allowing for VR user interface. The digital synthetic environment creates, simulates, and models a photo-realistic presentation of the actual projected combat locations with environmental/weather effects, time of day, and other plug-in features, as required.

AELIUS can continue to enhance and enable USN's wargaming models through visualization enhancement and integration of gaming software (e.g., UE5), as well as AI/ML tools. AELIUS provides the USN a unique blend of technical/scientific and SOF subject matter experts (SMEs) who are practiced in accomplishing operational missions in demanding and austere environments with an in-depth understanding of mission requirements and constraints.





Figure 8. Aelius's Extensive Library Repository of U.S. and Foreign Assets

AELIUS has a resident staff of commercial engineers, scientists/technologists, communications experts, and former SOF operators who can immediately begin supporting 3D wargaming tasks and requirements, as well as a strong bench of additional SMEs and commercial like-minded business partners to meet and exceed Department of Defense (DoD) client-specific data analysis and visualization needs.

Recent Example of AELIUS's Capability of 3D Visualization, Simulation, and Modeling

AELIUS recently created one of the largest landscape data sets for DARPA, comprising over 14.6 million square miles of a photo-real, fully immersive 3D mapping model of the moon's surface. The model integrated NASA's existing maps to simulate future landing sites and lunar surface unmanned operations, with a physics engine replicating the one-sixth scale gravity and incorporating true orbital distances and dynamics for the sun, the moon, and the earth.



Figure 9. AELIUS Synthetic Simulation of Lunar Ice Mine Operations





Figures 10–11. AELIUS Synthetic Environment of the Digital Synthetic Moon Landing Site

Benefits to the DoD

- Enhanced Preparedness: Train personnel in diverse, repeatable scenarios without logistical constraints.
- Strategic Insight: Test hypotheses and refine tactics in a risk-free environment.
- **Cost Savings:** Minimize expenses associated with live exercises, such as fuel, ammunition, and equipment wear.
- Adaptability: Quickly update simulations to reflect emerging threats or new technologies.

Conclusion

AELIUS's proposed 3D wargaming modeling and simulation platform offers a transformative tool for military training and strategic analysis. By leveraging cutting-edge technology, this system-of-systems will empower decision-makers and warfighters to prepare for modern conflicts with greater precision and confidence.

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