Simulating Military Decision-Making in Air Operations: A Novel Approach Using Unity Game Engine

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ABSTRACT

Military training traditionally relies on specialized simulation platforms. This research investigates the potential of using Unity, a commercially available game engine, to develop a serious game for enhancing military decision-making skills, specifically for air operations. This approach represents a new direction in military training, leveraging the accessibility and adaptability of game engines to create realistic and immersive simulations.

The proposed study involves developing a Unity-based simulation replicating the complexities of air combat scenarios. This serious game environment will allow military personnel to practice and refine their decision-making abilities in a controlled setting. By analysing player behaviour within the simulation, the research aims to identify key factors impacting decision-making.

The findings of this study can contribute to improved military training by offering a potentially cost-effective and adaptable platform for developing serious games tailored to specific operational needs. This research seeks to contribute to optimizing military decision-making processes, ultimately leading to better mission outcomes in real-world air operations.

KEYWORDS

Serious Games, Wargames, Training

1.0 INTRODUCTION

Serious games, unlike traditional games designed purely for entertainment, are developed with specific training or educational purposes in mind, providing users with immersive and engaging environments to practice critical skills. In the military realm, serious games are partially recognized as wargames with the potential of simulating complex and high-stakes scenarios, allowing personnel to develop decision-making skills in a risk-free, controlled environment. However, beyond the realm of traditional wargames, the application of serious games in military training deserves further exploration and development to fully realize its potential.

Traditional military training platforms often rely on specialized, high-cost simulation systems that demand substantial infrastructure and resources. These platforms, while effective, can be inflexible and challenging to update with new scenarios or capabilities. Furthermore, limited access to such resources restricts their use to specialized training centres, reducing their scalability and adaptability to evolving operational requirements.

This study explores the potential of using Unity, a commercially available and widely used game engine, to create a serious game for training military personnel in air operations. By leveraging Unity's flexibility and accessibility, the study aims to develop a training tool that replicates the complexities of air combat scenarios while being cost-effective and adaptable. The goal is to offer military personnel an interactive environment where they can refine their tactical and strategic decision-making skills and improve the quality of training.

2.0 RELATED WORK

Research into serious games and their applications in various fields, such as education, healthcare, and military training, has been expanding in recent years. A meta-analysis by Zhonggen highlights the effectiveness of serious games in education, where their ability to create engaging, risk-free learning environments has significantly contributed to improved knowledge retention and skill acquisition among learners. This study identifies key factors, such as game realism, interactivity, and structured feedback, which influence the effectiveness of serious games as educational tools. [1]

In the healthcare domain, the application of serious games is gaining momentum, as explored in a meta-review by Damaševičius et al. The review examined the use of serious games and gamification techniques in healthcare, focusing on mental and physical health interventions. It found that serious games effectively promoted positive behavior changes and improved patient engagement, particularly when combined with digital and mobile platforms. The integration of virtual reality and machine learning in healthcare-focused serious games has also shown promising results in adapting and personalizing interventions to suit individual patient needs. [2]

The studies on serious games for military training has been scarce in the literature. Karadeniz et al. explored the use of game-based simulation to test aerial defence strategies in their study *Drone Wars 3D: A Game-Based Simulation Platform for Testing Aerial Defence Strategies Against Drone Swarms*. Using the Unity game engine, this platform simulated drone swarm tactics and evaluated various defensive measures. The findings highlighted the potential of serious games to replicate complex scenarios and assess innovative tactical approaches. [3]

In medical education, Zohari et al. conducted a scientometric analysis comparing gamification, game-based learning (GBL), and serious games. Their analysis showed that serious games provided a structured and engaging learning experience that effectively improved cognitive abilities, decision-making, and problem-solving skills. The study emphasizes the importance of tailored serious games for specialized training, as their structured nature offers both challenges and rewards that contribute to learning effectiveness. [4]

These studies demonstrate the versatility of serious games across various fields, highlighting their ability to simulate realistic and high-stakes scenarios. The current research focuses on the potential of using a commercial game engine to develop a serious game tailored for military training in air operations, with the goal of enhancing decision-making skills and improving training outputs.

3.0 METHODOLOGY

This study focuses on creating an interactive environment that showcases air combat scenarios and allows players to engage in tactical decision-making under realistic constraints. The following subsections describe the game design process, scenario details, Courses of Action (COAs), and the metrics used to evaluate player performance.

3.1 Game Design Approach

The design of the serious game followed a structured approach involving three main phases: planning, development, and testing. The Unity game engine was chosen for its adaptability, accessibility, and extensive support community, making it a viable option for developing serious games.

Planning Phase: The planning phase involved defining the objectives and the core mechanics of the game. A specific air combat scenario was designed to mimic the complexities of real-world operations, focusing on strategic decision-making, resource management, and minimizing collateral damage. The scenario required players to engage in air defense suppression, neutralize high-value targets, and make tactical decisions under evolving conditions.

Development Phase: During the development phase, Unity's built-in features and customization capabilities were utilized to create a game environment that includes:

- A mission briefing screen to present the operational context, mission objectives, and constraints.
- A map interface displaying key assets such as air units, and adversary defenses.
- A set of pre-defined Courses of Action (COAs) to represent different strategies and decisions available to players.
- A feedback mechanism to provide players with mission outcomes, performance metrics, and debriefing information.

Testing Phase: The game was subjected to iterative testing to refine its usability, balance, and effectiveness. Feedback from playtesting was collected to make adjustments to the game's mechanics, interface, and scenario complexity. Testing focused on ensuring the intuitive navigation of the interface, clarity of mission objectives, and the effectiveness of decision-making prompts.

3.2 Scenario Description

The generated generic game scenario simulates decision making process for an air operation targeting adversary installations and defenses. The political-military situation involves a mandate from the BLUE government to neutralize the RED country's nuclear capabilities while minimizing collateral damage and civilian casualties. The key mission tasks include:

- Neutralizing the X-Facility, a critical site for adversary nuclear activities.
- Disabling adversary SAM systems to ensure safe air operations.
- Maintaining strict adherence to Rules of Engagement (ROE) to avoid unnecessary damage.

3.3 Courses of Action

To simplify decision-making and streamline gameplay, the game presents players with six pre-defined Courses of Action (COAs). Each COA reflects a different strategic approach, balancing factors such as precision strikes, resource allocation, and risk management. Players select a COA based on the intelligence provided, mission constraints, and available resources. The COAs incorporate minimal chance factors to introduce an element of unpredictability.

The COAs are structured as follows:

1. minimize collateral damage.
2. Coordinated Saturation Attack: Launching simultaneous attacks to overwhelm adversary defenses while accepting increased risks.

3. Stealth Infiltration and Targeted Disruption: Employing stealth tactics to neutralize high-value targets without detection.
4. Decoy and Deception Maneuver: Using decoy tactics to mislead adversary air defenses and execute surprise attacks.
5. Full Suppression and Dominance Strategy: Engaging all known threats to establish complete air superiority.
6. Cautious Progression with Reconnaissance: Conducting thorough reconnaissance before engaging targets to reduce risks.

3.4 Metrics for Success

The effectiveness of each COA is evaluated based on several key performance indicators:

- Mission Success Rate: The extent to which the player achieved the mission's primary objectives.
- Collateral Damage: The level of unintended damage to civilian areas and infrastructure.
- Asset Preservation: The preservation of air assets, including aircraft, UAVs, and support systems.
- Operational Impact: The overall impact of the mission on adversary capabilities and strategic goals.

3.5 Outcome Feedback Mechanism

Upon completing the mission, players receive a detailed outcome report that includes:

- Performance Scores based on the success metrics.
- A summary of key decisions made during the mission and their outcomes.
- Recommendations for improvement to guide future training and decision-making.

4.0 GAME MECHANICS

4.1 Decision-Making Elements

The core of the game is built around decision-making, requiring players to choose between six pre-defined Courses of Action (COAs). Each COA represents a distinct strategic approach to accomplishing mission objectives, ranging from high-precision strikes to more aggressive, coordinated attacks. Players must evaluate the mission constraints, available resources, and risks before selecting a COA.

4.2 Chance Factors and Real-World Uncertainty

While the game provides structured COAs, each course also incorporates minimal chance factors to simulate real-world uncertainties, such as the effectiveness of stealth approaches or the detection of adversary assets. These chance factors are implemented through virtual dice rolls or probability-based calculations.

5.0 CONCLUSION AND FUTURE PLANS

This study explored the use of a commercial game engine as a platform for developing a serious game aimed at enhancing military decision-making skills in air operations. By leveraging the flexibility and accessibility of a commercial game engine, the project successfully created a cost-effective and adaptable environment. The game's design, centred around structured Courses of Action (COAs) and dynamic decision-making elements, allowed players to engage in tactical planning while navigating uncertainties.

This study demonstrates the potential of serious games to improve military training outcomes. The interactive and immersive nature of the game environment enabled players to refine their strategic thinking and assess risks. Additionally, the feedback mechanisms embedded in the game provided valuable insights into player behaviour and performance, helping to identify areas for improvement.

The lessons learned from the development process underscore the effectiveness of commercial game engines as a platform for serious game development, as well as the importance of balancing realism and simplicity to maintain an engaging user experience. Moving forward, future development plans include expanding the game's scenario complexity, enhancing AI dynamics, and extending its applications to broader military domains.

In conclusion, the use of serious games represents a promising direction for military training, offering a scalable and versatile solution that addresses the limitations of traditional training platforms. By continuing to refine and expand this approach, the project aims to contribute to more effective and adaptive training solutions, ultimately leading to better mission outcomes in real-world operations.

5.1 Lessons Learned from Development

The development of this serious game provided valuable insights into the use of commercial game engines as a platform for creating military training simulations. Several key lessons emerged from the project:

Effectiveness of a commercial game engine as a Development Platform: Unity's adaptability and extensive asset library proved instrumental in creating a realistic and interactive simulation environment. The flexibility of the game engine allowed for rapid prototyping and iterative development, enabling adjustments based on player feedback.

Importance of Playtesting and Feedback: Playtesting sessions revealed critical insights into the user experience, scenario complexity, and decision-making processes. Direct feedback from players highlighted the need for clearer mission objectives, and balanced tactical options.

Balancing Realism and Simplicity: Achieving a balance between realism and simplicity was a central challenge. While realism is essential for an immersive training experience, simplicity ensures that the game remains accessible and engaging. The project focused on simplifying complex military concepts into clear, manageable scenarios.

5.2 Future Plans

Based on the lessons learned during the project, several future development plans have been identified to further enhance the game's capabilities and expand its applications:

Expanding Scenario Complexity: One of the primary goals for future development is to introduce more complex mission scenarios that involve multi-phase operations, branching decision paths, and dynamic responses from opposing forces. This would increase the depth of tactical planning and challenge players to adapt to evolving situations.

Enhanced AI and Threat Dynamics: Future iterations of the game will focus on developing more sophisticated AI behaviour for adversary assets, including SAM systems and adversary aircraft. Enhanced AI will provide a more realistic and challenging simulation, simulating adversarial tactics and responses with greater accuracy.

Broader Training Applications: While the current game focuses on air operations, there is potential to extend the framework to cover other domains. This expansion would provide a more comprehensive training experience for military personnel, allowing them to practice decision-making in a variety of operational contexts.

Integration with Learning Management Systems (LMS): To improve long-term training effectiveness, there are plans to explore integrating the game with existing Learning Management Systems (LMS). This would enable detailed tracking of player progress and performance, allowing for personalized feedback and continuous skill development.

6.0 REFERENCES

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