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NAVAL COMBAT WARGAME SIMULATION FOR SUSCEPTIBILITY ANALYSIS

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ABSTRACT

An engagement between naval ships is defined as a multi-agent system with multiple ships interacting. Because of the limitations of conducting and analyzing engagement, it is common to use modeling and simulation or wargame simulations. Most of the existing wargame simulation studies focus on simulation frameworks rather than real-world applications and tend to focus on the evaluation of single entities that comprise a wargame. Thus, this study improves the reality of the simulation by modeling objects that constitute a complex engagement situation based on the simulation framework. In addition, developed analytical tools to automate and accelerate Monte Carlo simulations of engagement-level wargames that require large numbers of human and time resources. The developed simulations enable the application of various engagement scenarios to evaluate strategies and tactics. Furthermore, experiments are possible while altering the design parameters of the naval ship, which allows for the evaluation of the ship's performance in combat.

1 INTRODUCTION

A wargame is a modeling of a military collision as a strategy game or simulation. The purpose of wargame is to analyze real-world military training, missions, and the application of military tactics. In this study, the naval engagement situation, which is the subject of a wargame, has a complex characteristic that involves the interaction of limited resources such as naval ships and armament systems. Therefore, if conventional mathematical modeling methods are applied, excessive assumptions are added and it is difficult to fully reflect the complexity of reality. The modeling and simulation (M&S) method is a commonly used method for modeling military operations to overcome these limitations. The main reasons for applying M&S to modeling military operations are listed next. 1. Facilitates scientific decision-making. 2. Efficient in terms of time and resources. 3. Significantly reduces risk when compared to live-fire test. In this study, a hybrid simulation method combining a kinematic model and a discrete event system is applied to an engagement-level wargame of a naval ship. The developed wargame simulation is utilized to conduct experiments by naval ship design parameters and scenario parameters. The selected parameter is the radar cross section (RCS) of the naval ship. For the scenario parameter, the experimental results according to the number of enemy naval ships are analyzed. For the purpose of comparing the designs and scenarios, the key performance indicators (KPIs) are defined as the naval ship's average engagement hit rate and average threat response rate.

2 SIMULATION FRAMEWORK

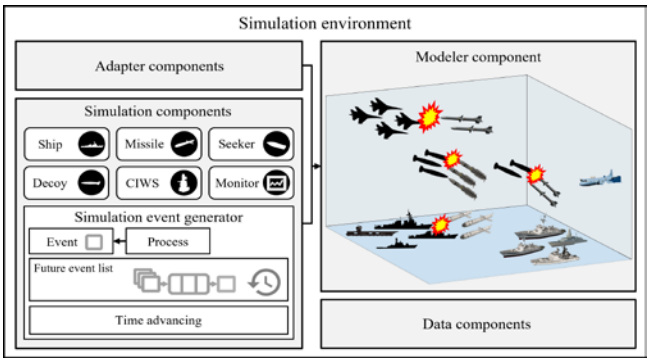

Figure 1: Simulation framework.

Nam, Oh et al. (2022) utilized discrete event simulation(DES) to evaluate the production system layout of a shipyard and defined a simulation framework for the development of a DES program. Figure **1** is the proposed simulation framework by customizing the simulation framework suggested by Nam, Oh et al. (2022) for this study. The simulation framework consists of adapter component, simulation component, modeler component, and data component. The adapter component is a step to input, store, and preprocess the characteristics of the essential elements that constitute a naval engagement. The simulation component is a set of classes required for modeling the naval engagement environment and consists of naval ship, missile, missile seeker, decoy, close-in weapon system (CIWS) and a monitor class that records events that occur in the simulation. In addition, each class has a built-in event generator that fires the required events. The modeler component combines the simulation component according to the information input from the adapter component and performs the interaction between the classes according to the time-forward logic. The data component contains data information generated by the modeler component and outputs event logs and simulation KPIs.

3 EXPERIMENT

The experiments are performed with the developed simulation and demonstrate the KPIs along with the design parameters (Table 1). The KPIs are quantitative metrics, with two outputs: average engagement hit rate and average threat response rate. The average hit rate is an indicator of how many times a friendly naval ship is hit by a threat from an enemy naval ship. The average threat response rate is an indicator of the percentage of total threats from the enemy that are responded to by friendly naval ships. Experiment 1 is an experiment with controlled RCS parameters. It shows that Design #2, with a 50% reduction in RCS pattern compared to the original Design #1 with 100% RCS pattern, reduces the hit rate by about 3%. For Design #3, which reduces the RCS pattern by 70%, there is no further reduction in hit rate. Experiment 2 shows the effect of changing the hit rate and threat response rate of a friendly naval ship to account for multiple threats from a naval ship's fire network in a one-to-many engagement situation. The number of enemy naval ships increases which increases the number of multiple threats from the fire network. As a result, the experiment shows that the hit rate of friendly naval ship increases and the threat response rate decreases.

Table 1: Experiment results.

		Experiment1			Experiment2		
Control indicator		Average RCS value			Number of enemy naval ships		
Case		Design#1	Design#2	Design#3	Scenario#1	Scenario#2	Scenario#3
Parameter control		100%	50%	30%	1 vs. 2(Foe)	1 vs. 3(Foe)	1 vs. 4(Foe)
KPI	Hit rate	0.67	0.65	0.65	0.67	0.78	0.85
	Response rate	·	·	·	0.48	0.35	0.27

REFERENCES

Nam, S.H., S.H. Oh, H.C. Yoon, Y.I. Cho, K.Y. Cho, D.-H. Kwak and J. H. Woo. 2022. "Development of DES Application for Factory Material Flow Simulation With Simpy." In *Proceedings of the 2022 Winter Simulation Conference*, edited by B. Feng, G. Pedrielli, Y. Peng, S. Shashaani, E. Song, C.G. Corlu, L.H. Lee, E.P. Chew, T. Roeder, and P. Lendermann. 1545-1556. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.