Proceedings of the 2015 Winter Simulation Conference
L. Yilmaz, W. K. V. Chan, I. Moon, T. M. K. Roeder, C. Macal, and M. D. Rossetti, eds.

MEASURING AND VISUALIZING COMBAT EFFECTIVENESS

Youngwoo Lee
Taesik Lee

Department of Industrial and Systems Engineering, KAIST
291 Daehak-ro
Daejeon, 34141, Republic of Korea

ABSTRACT

Combat effectiveness created by deployment of force is a key factor in leading successful combat operations. Measurements of combat effectiveness should consider the overall capabilities of the resources involved, and should capture spatial aspects to keep regional advantages for a combat operation. This study focuses on developing an analytical metric to measure combat effectiveness by adapting network representation of a combat environment, and visualizes it in a map format. Attack opportunity structures and their numerical values are computed for each unit area in a battlefield, which represents the force's possibility of creating attack opportunities in that location. In this study, we consider a defense operation where the force's initial deployment strategy plays a critical role in how the combat proceeds. Applying the proposed metric to a simulation of a defense scenario, we find that the spatial distribution of combat effectiveness is highly correlated with the combat results.

1. INTRODUCTION

Combat effectiveness is mainly created by firepower, but there are other capabilities connected to the effectiveness (Hayward 1968). For example, ISR(Intelligence, Surveillance and Reconnaissance) and communication are crucial to achieving combat effectiveness as they acquire the information required to execute tasks and missions. External factors including environmental factors also affect combat effectiveness as these factors can hamper the strategic progress of an operation. Likewise, spatial deployment of force should be taken into account in assessing combat effectiveness.

Spatial deployment of force is a key factor in leading successful combat operations. By strategically locating the main assets and units, the force can occupy vantage points that are advantageous to avoiding assaults by enemies; this is necessary to achieve successful strategies and tactics. In this study, we argue that specific deployment of force creates corresponding spatial distribution of local combat effectiveness, which ultimately determines the overall combat effectiveness.

Here, we consider a defensive operation where the force's initial deployment strategy (e.g., type of platforms and their locations) plays a critical role in how the combat situation proceeds. In a defensive operation, spatial distribution of combat effectiveness is as important as the overall magnitude of the force's combat effectiveness. In particular, operational principles in the doctrine state that the force must possess regional advantages in a battlefield, for example by covering the field as wide as possible, to effectively defend against enemy's unexpected penetrations in various routes. A metric to assess combat effectiveness should capture the spatial aspect to identify whether such general principles are satisfied or not.

We adopt a network representation to model a battlefield, which is useful to capture the vast complexity drawn from the rich context of a combat environment (Tolk 2012). Then we formulate an analytical metric in network structures that represent what we call attack opportunity by the force. Values of the metric are then visualized in a map format which can show spatial distribution of combat effectiveness at a glance.

2. METRIC FOR COMBAT EFFECTIVENESS

Lee and Lee proposed an attack opportunity model to measure combat effectiveness (Lee and Lee 2014). The number of attack opportunities created by a force is proportional to the force's power at enemy's casualties. Various factors in combat environment - e.g. force's intrinsic capabilities, their placement and task assignment, and capabilities of an enemy force - determines the number of attack opportunities the force creates. The study uses a network representation to describe attack opportunity structures, which in turn gives a metric for combat effectiveness.

In this study, we adopt the attack opportunity model, and apply it to measure spatial distribution of combat effectiveness for a force of a specific deployment. A map format can visualizes spatial distribution of combat effectiveness. A cell in the map format represents a unit area in a battlefield, and each cell is assigned a value indicating the amount of attack opportunities at the cell. This map format shows the spatial distribution of these values. Darker cells in the map represents an area of high attack opportunities (i.e. strong combat effectiveness), and brighter colors indicates a weak presence by the force. By visual examination, one can easily grasp the sense of the force's strength areas and vulnerable areas in the battlefield.

3. SIMULATION EXPERIMENTS FOR VALIDATING THE METRIC

To validate the proposed metric and demonstrate potential applications of the metric, we examine the metric in the context of a generic defense scenario. In the scenario, the red force infiltrates blue force's territory where the blue force is strategically deployed. The red force is divided into two units: a main-force unit and a tidal-force unit. The main-force unit penetrates through one path, and the tidal force unit remains at the other path to deconcentrate the blue force's power. To defend against the infiltration operation by the red force, the blue force splits into two units.

The proposed metric is applied to assess the effectiveness of an initial deployment of the blue force, given the red force's infiltration operations. Specifically, the metric is used to measure the combat effectiveness obtained from the initial deployment of the blue force unit. We examine the correlation between the simulation results and the metric results by testing several candidates for the initial deployments. Experimental results show that when the spatial distribution of the metric conforms to the operational principles in the doctrine, the blue force tends to successfully neutralize the main-force unit of the red force, leading to a successful defense mission.

4. CONCLUSION

The spatial distribution for combat effectiveness is an important element in an overall combat effectiveness. In this study, we demonstrate that the proposed metric and a map-based visualization can facilitate the decision making for deployment of force in a defensive operation scenario.

ACKNOWLEGMENT

This work was supported by Defense Acquisition Program Administration and Agency for Defense Development of Korea under contract UD140022PD.

REFERENCES

Hayward P. 1968. "The Measurement of Combat Effectiveness." *Operations Research*, 16(2): 314-323.

Tolk, A. 2012. *Engineering Principles of Combat Modeling and Distributed Simulation*, Hoboken, New Jersey: John Wiley & Sons. Inc.

Lee, Y. and Lee, T. 2014. "Network-based Metric for Measuring Combat Effectiveness." *Defence Science Journal*, 64(2): 115-122.