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AI RE Mission Planning CE: From Integration and Fusion to Adaptive SA at the Tactical Edge

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ARTIFICIAL INTELLIGENCE RUNNING ESTIMATE MISSION PLANNING COMMAND ELEMENT:

FROM INTEGRATION/FUSION TO ADAPTIVE SITUATIONAL AWARENESS AT THE TACTICAL EDGE

Period of Performance: 10/15/2018–10/14/2019

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NPS NRP Executive Summary

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Report Date: 10/14/19 Project Number: NPS-19-N333-A and NPS-19-M103-A

Naval Postgraduate School, Graduate School of Information Sciences

EXECUTIVE SUMMARY

Project Summary

The ability to integrate environmental conditions into combat operations is critical to Navy and United States Marine Corp (USMC) battlefield success. Therefore, dynamically extracting and projecting operationally relevant events from data significantly enhances the commander's ability to make informed decisions, as compared to decisions based purely on a theoretical understanding of the events. The framework of our study included requirements for the proposed data architecture to potentially provide environmental data to commanders and troops, one that could garner high-fidelity results for computer-assisted mission planning and tracking of Running Estimate (RE) metrics. These capabilities include execution of high-level, scalable viewpoint of a commander's intent, appropriate for tactical edge mission execution or at the operational or strategic level.

The research was conducted using a literature review, interviews and discussions with subject matter experts (SMEs), followed by market research focused on commercial startups that are state-of-the-art leaders in data processing. SMEs were selected from the areas of Information/Knowledge Management for Mission Planning, Future Concepts of Operations for MEF and Subordinate Commands. Additional collaboration with the Navy Digital Warfare Office and the Center for Naval Analysis led the team towards a "thinking chess" approach to tactical maneuver courses-of-action (COA) analysis: a software product created by Stilman Advanced Strategies, based on the Linguistic Geometry (LG) mathematical foundation.

From the research, a knowledge representation (KR) leveraging modern technologies emerged, based on additional considerations of performance and scalability, and the need to support access by decision makers at all levels of warfare. Ultimately, this research study revealed a layered ontology for describing the battlespace in a way that provides real-time decision support, and enables COA development and assessment by human warfighters, and ultimately, by artificial intelligence (AI).

Keywords: *ontology, taxonomy, battlespace, decision, situations, events, entities, courses-of-action, COA, mission planning, execution, decision, tactical, strategic, Observe-Orient-Decide-Act, OODA, situational awareness, SA, artificial intelligence, AI*

Background

Our research is based on the highly-adopted Observe-Orient-Decide-Act (OODA) Loop developed by Air Force Col John Boyd, combined with the study sponsor's operational background, centered on event-driven decision making. In February 2017, Dr. John Launchbury made an announcement for AI stepping into the 3rd Wave of AI, which Dr. Launchbury coined as "Contextual Adaptivity." This announcement coincided with our team's understanding that state-of-the-art decision making requires an in-context adaptive operational picture. As such, our proposed research hypothesis was formulated as the following: "*For decisions to be on-time and informed, SA must be capable of managing adaptive context of the*

operational world model by absorbing operational and environmental events. Integrating SA which embraces "Contextual Adaptivity" will empower the "Orientation" phase of the OODA loop. Modern COA would have to utilize event-based representation of the battlespace by using reasoning over knowledge, particularly in terms of maneuvering and shooting in the battlespace to reach adaptive contextual understanding of the SA and SA-driven COA."

Findings and Conclusions

We considered a commonly used model in data science literature: a pyramid built from the bottom up, transforming from data to information and knowledge, and finally, to understanding. This study attempts to bridge the gaps from the information domain to the knowledge domains and understanding, where cognitive processing is paramount. Early in the study, SME inputs resulted in the observation that events in space and time represent an intersection point between the information/knowledge space and the cognitive space. This observation was critical, as commanders and other decision makers depend strongly on connecting information and knowledge layers to produce the level of cognitive understanding required for decision making. This observation was further augmented by the work of Dr. Mica Endsley, former Air Force Chief Scientist, who developed a SA model for dynamic decision making.

Building on the work of Dr. Endsley, we used the Stilman LG COA engine to extend her SA model for OODA loop application to the MEF Information Group for adaptive decision-making in the battlespace. This engine replaces computationally unscalable search—essentially an endless scattershot of possibilities—for a model that successfully constructs COAs for maneuver and fires, using discrete mathematical calculations which build operationally-relevant trajectories, which are then stored as future-projection events in the Linguistic Geometry (LG) Zones. The purpose of LG Zones is to support short-term plan sub-strategies to enable advancing the progression of sub-strategies from the starting moves to the final moves. Mission planners may choose from several COA options with different risk tolerance, available within the context of each of the LG Zones.

In essence, the concept of LG Zones connects strategy to tactics by computing and combining sub-strategies within and across LG Zones, in order to meet the overall strategy expressed via the commander intent.

Considering the sponsor's great interest in the concept of the RE, it was a pleasant discovery that LG tracks the RE in parallel with the assembly of selected COA options. The topic sponsors found the COA-Running Estimate Analytical Engine to be a powerful AI technology solution for many applications, including those combat operations requiring maneuvering and shooting functions. Other contemplated areas include: supply chain management, manpower, mission and rescue. The proposed data strategy then integrates well with the sponsor's command requirements, and validates our initial hypothesis.

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Recommendations for Further Research

The Stilman LG COA engine is an example of a closed-architecture application, given its unpublished LG Zones-oriented Knowledge Base (KB). Our research recommends that the Navy and USMC invest into an open-architecture KB using Causal Bayesian Network Inferencing algorithms, with a focus on temporally adaptive "situation events" of the battlespace based on the integration between closed-architecture LG Zones-oriented KB and open-architecture Knowledge and Causal-oriented KB. This would enable bi-directional integration of the overall knowledge of dynamically evolving battlespace situations, due to full understanding of adaptive battlespace context due to contextually rich COA.

Acronyms

Artificial Intelligence	AI
Courses-of-Action	COA
Knowledge Base	KB
Knowledge Representation	KR
Linguistic Geometry	LG
Marine Expeditionary Force	MEF
Observe-Orient-Decide-Act	OODA
Running Estimate	RE
Situation Awareness	SA
Subject Matter Expert	SME
United States Marine Corps	USMC