Chapter 48
A Fuzzy–Based Approach to Support Decision Making in Complex Military Environments

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ABSTRACT

Data for military intelligence operations are increasing at astronomical rates. As a result, significant cognitive and temporal resources are required to determine which information is relevant to a particular situation. Soft computing techniques, such as fuzzy logic, have recently been applied toward decision support systems to support military intelligence analysts in selecting relevant and reliable data within the military decision making process. This article examines the development of one such system and its evaluation using a constructive simulation and human performance model to provided critical understanding of how this conceptual information system might interact with personnel, organizational, and system architectures. In addition, similarities between military intelligence analysts and cyber intelligence analysts are detailed along with a plan for transitioning the current fuzzy-based system to the cyber security domain.

INTRODUCTION

Since the end of the Cold War, decision making in the military has evolved to keep pace with an increasingly dispersed, loosely-coupled enemy. The 2001 Quadrennial Defense Review called for the command and control structure of the US military to change from its highly-centralized form to a more decentralized, agile structure to conform to the newer threats (Flournoy, 2001). Towards this end, US

Army Field Manuals 5-0 ("Army Planning and Orders Production") and 6-0 ("Commander and Staff Organization and Operations") have replaced the previous Field Manual 101-5 ("Staff Organization and Operations") (US Army, 2011; US Army, 2005, US Army, 1997). This change, as postulated in (Nunn, 2010), suggests moving from alternative-based decisions to a value-focused methodology, allowing for the application of Multi-Criteria Decision Making (MCDM) processes such as that proposed in (Goztepe & Kahraman, 2015).

Decision making has been defined and described in a myriad of ways, but basically it is a cognitive process by which some choice is made from a list of reasonable, potential options. The goal, of course, is to pick the "best" option from the available alternatives. The typical complicating factor in decision making is uncertainty; that is, many aspects of the alternatives as well as the exact outcome of each prospective option may be unknown, unclear, or unpredictable.

Decision making in a military environment is especially rife with uncertainty. Military staff procedures have evolved since the late nineteenth century in an attempt to define a common process by which decisions are reached. While doctrine has been successful in providing a framework for guiding the decision making process, it has done little to address the uncertainty inherent in evaluating and selecting from potential courses of action. Complicating the situation is today's nearly unlimited access to vast quantities of information that may or may not need to be applied to a specific decision making situation. Thus, while it would seem that more information is better, the fact is that having too much data can increase cognitive load and may result in overlooking other information that is more pertinent to the specific current circumstances. The challenge for the military intelligence analysis process is to enhance military decision making by providing timely, relevant, reliable information to commanders.

The material in this article is organized with three goals in mind with respect to facilitating a comprehensive treatment of the subject domain material. The first goal is to provide necessary background information to ensure the reader is familiar with the concepts and previous work on which the new efforts in this paper are built. Note that much of the material, especially that of earlier work in developing the fuzzy Value of Information (VoI) system, is heavily cited from prior publications. The second goal is to then present new work done with respect to using human performance model simulations to exercise the fuzzy VoI system and observe its effects on decision quality and situational understanding. The final goal is to discuss the similar situations faced by military intelligence analysts and cyber intelligence analysts, and the insightful new plan for demonstrating that the fuzzy VoI system can be transitioned to the cyber security domain.

This article is organized as follows: First, the military decision making process and situational understanding are described followed by a section discussing information valuation. The next section presents the recent fuzzy-based system developed for calculating Value of Information (VoI) as a potential tool for military intelligence analysts along with anecdotal results determined via feedback from subject matter experts. The subsequent section details simulation results obtained through the use of human performance models. This is followed by a section that discusses the commonality of the military intelligence analyst and cyber intelligence analyst and a plan for demonstrating the applicability of the VoI fuzzy architecture in the cyber security domain. Finally, conclusions are presented and future work is considered.

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