Title:

Bayesian Networks for Robust and Interpretable Multi-System Integration

Bayesian Networks as Robust and Interpretable Multi-System Integrators

Bayesian Networks for Robust and Interpretable Multi-System Fusion

Abstract:

The concept of Multi-Domain Operations and its evolution into JADC2 are hailed as critical paradigms initiating the development of new technologies to ensure military operational effectiveness in the 21st century battlespace. Underpinning the development of these next generation systems will be advanced artificial intelligence systems to aid in muti-system fusion and decision making. While LLMs and other 2nd wave artificial intelligence systems have recently received the bulk of attention and research funding, 1st wave artificial intelligence techniques are typically overlooked yet remain as valuable tools offering much better explainability and reasoning capabilities than deep neural network-based approaches. Largely unmentioned is the fact that legacy sensors and systems will continue to be in use for the duration of their operational lifetime alongside next generation sensors and effectors. Because of this, the success of JADC2 in many ways will hinge on the ability to seamlessly integrate operation of both legacy and new systems on the battlespace.

In this paper we examine the air defense regime as a subset of MDO and the use of Bayesian Networks acting as a systems integrator across independent sensing systems. While Bayesian Networks and other variants have been used up and down the stack in the realm of target tracking and classification systems, the use of Bayesian Networks to fuse together at a high level any number of sensing systems that ultimately perform the same task (by different means) has yet to be explored. In this work we explore the use of Bayesian networks to act as a systems integrator and expose our proposed network framework to a variety of synthetic scenarios that may be encountered on the battlespace. Through this, we find that Bayesian networks are favorable tools to perform last-mile reasoning over any number of non-explainable black-box type approaches, producing more reliable, trustable, and interpretable results than any sensing system operating independently.

* Furthermore, the generalized approach is suitable for application to other sub-regimes of JADC2 and is no way limited to air defense.