Overview

The outcome of the project is a decision-theoretic spatiotemporal inventory optimization system. This system will use supply chain cost-benefit information encoded in loss functions and full joint distribution demand forecasts produced by a spatiotemporal Bayesian economic simulation to compute optimal inventory placements that minimize risk and maximize profits.

Subtopic: Decision Support and Optimization (AA3)
Technical Expertise: Decision Theory, Bayesian Statistics, Economic Model, Inference and Optimization, Risk/Loss Functions, Markov Chain Monte Carlo
Application Areas: Supply Chains, Inventory Placement, Demand Forecasting, Enterprise Resource Planning, Logistics, Retail, E-commerce, Defense, Health

Intellectual Merit

This Small Business Innovation Research (SBIR) Phase I project creates new Bayesian machine learning methods and evaluates whether they can compute decision-theoretic models at the scale and complexity required to provide optimal inventory placement for modern supply chains.

The primary technical hurdles involve trading off structure for scalability and developing a coherent system of Bayesian methods based on highly parallelizable algorithms that support distributed computing. The goals of the proposed R&D are to create a system that produces full joint distribution demand forecasts and then uses these forecasts in conjunction with high-dimensional loss function information to minimize risk. The system will make demand forecasts by adding time series functionality and external information to a spatiotemporal economic model and minimize risk using sequentially adaptive Bayesian learning.

The normative economic approach underpinning the project is complementary to contemporary AI-based approaches. It handles uncertainty explicitly and produces transparent, human-interpretable, and verifiable results. If this approach can scale, it can apply to many industrial contexts, beginning a new paradigm of economic decision-making.

Broader Impacts

This project aims to make a theoretical approach to creating an inventory optimization system practical in industrial contexts for the first time. The result is neither traditional nor multi-echelon inventory optimization and could disrupt the markets for both technologies.

The commercial impact of this innovation comes from improved inventory placement. Putting appropriate inventory in the best locations to meet uncertain demand reduces transportation, stockouts, and overstocks. These reductions lower costs, spoilage, and obsolescence and increase sales, customer satisfaction, and profit margins. In addition, many applications have context-specific impacts worth billions of dollars. For example, better inventory placement can reduce the incidence, extent, and consequences of disease or catastrophic events or provide superior mission support and posture-appropriate military readiness.

Accordingly, improving the efficiency of America's supply chains will increase its economic competitiveness, reduce negative externalities and waste, improve health and welfare outcomes, and support the national defense. During times of crisis and uncertainty, supply chain efficiency and resilience can be primary determinants of American economic well-being and growth.