# Distributed Simulation of Multi-Agency Coordination in Maritime Emergencies

**The Seventeenth International Conference on Advances in System Modeling and Simulation**
**SIMUL 2025**

**Presenter: Xu Jing**
**National Defense of Technology University**

Lisbon, Portugal, September 28, 2025 to October 02, 2025

# Xu Jing

jenniferxu98@163.com

## Professional Experience

- Student of College of System Engineering, National University of Defense Technology

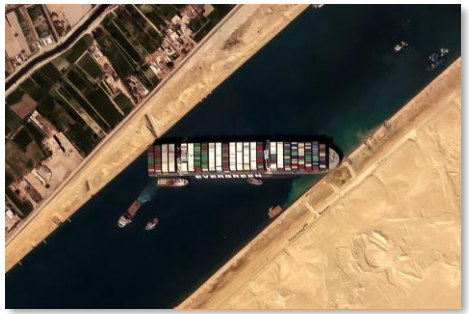
## Publications & Activities

- 4 SCI-indexed journal articles
- 4 EI-indexed conference papers
- 9 patents/software copyrights

# Research Background and Problem Statement

- The Suez Canal blockage incident exposed the flaws of traditional emergency response systems.
- The limitations of centralized command systems in multi-jurisdictional and multi-stakeholder environments.
- The urgent need for distributed collaboration

- To develop a distributed optimization framework adapted to maritime emergency response



# Model Formulation

**Formalization of the Multi-Agency Resource Coordination Optimization Problem**

**Mathematical Model:**

- **Objective Function: Minimize the total cost (response time, resource consumption)**
- **Constraints: Resource coupling, task completion guarantee**

$$\min \Sigma_{i=1}^{n} f_i\left(\mathbf{x}_i\right) + g\left(\Sigma_{i=1}^{n} \mathbf{A}_i \mathbf{x}_i\right)$$

# Model Construction

### A. Distributed Auction Mechanism

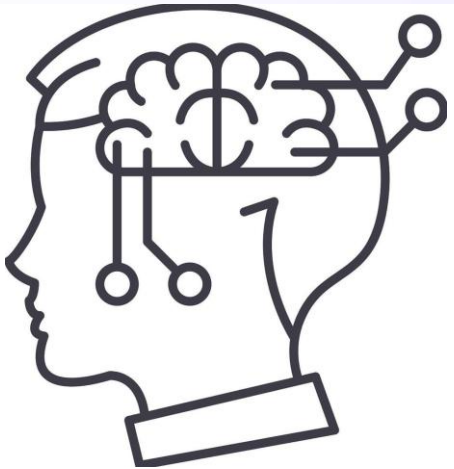
An iterative bidding protocol based on spatiotemporal constraints enables efficient resource allocation through marginal utility and adaptive price updates.

### B. Dual-Decomposition for Collaborative Task Assignment

In tasks that involve collaboration among multiple agencies, such as area searching and pollution containment, we apply dual decomposition to the distribution of optimization while coupling constraints are retained

### C. Federated Q-Learning

Integrating distributed reinforcement learning with a federated architecture to achieve secure knowledge sharing and optimal pre-positioning strategy learning.



# Research Significance

## Multi-Agent Autonomy

Each agency independently makes resource allocation decisions without the need for global information sharing, adapting to operational autonomy under sovereign independence.

## Cross-Domain Collaboration

Distributed consensus mechanisms enable cross-border and multi-agency task coordination, ensuring consistency in multi-party collaboration.

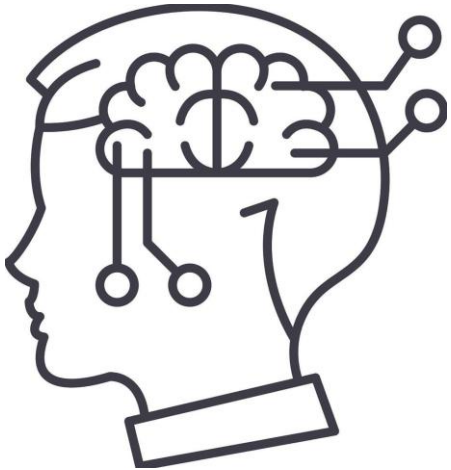
## System Robustness

The decentralized architecture avoids single points of failure, maintaining local response capabilities even under communication constraints or disruptions.

# Future Work

**Multi-Scenario Validation:**
Validate the effectiveness and scalability of the framework in real emergency scenarios.

**Dynamic Environment Adaptation:**
Continuously optimize algorithms to adapt to emerging challenges such as extreme weather conditions and autonomous vessels, enhancing system robustness.



# THANKS

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