

RI-Medium: Methods for Empirical Mechanism Design

The investigators will develop an empirical methodology to guide the design of mechanisms for multiagent interaction, and they will demonstrate the efficacy of their methodology in several significant application areas.

The design of computational systems that support group decisions, allocate resources to distributed tasks, or mediate social interactions is fundamentally different from the corresponding design problem serving individual or centralized users. When multiple parties, or *agents*, are involved, the designer's objectives are complicated by the fact that the interests of these parties are rarely, if ever, perfectly aligned. The field of mechanism design offers a theoretical framework that directly addresses the issue of incentives as it relates to the design of multiagent systems (MAS). However, this purely analytical approach carries with it inherent practical limitations.

The investigators propose a new approach, *empirical mechanism design* (EMD), whose premise is to extend the basic foundation of mechanism design with empirical methods. These extensions promise to dramatically expand the scope of mechanism design beyond the small-scale, stylized, or idealized domains to which it has been predominantly limited to date. The investigators will practically demonstrate the extended capabilities of their methodology through the development and analysis of novel mechanisms for significant application domains, primarily in the context of market design. As a bridge between two prevalent multiagent systems research paradigms—game-theoretic analysis and simulation experimentation—EMD promises to advance the broader MAS field.

Intellectual Merit EMD combines empirical methods from simulation, statistics, machine learning, search, and other computationally intensive approaches with strategic reasoning principles from game theory. Building on existing preliminary investigations, this project will develop new models and algorithms that expressly facilitate this combination. Expected algorithmic advances include the development of new sampling techniques that direct simulation efforts by accounting for strategic reasoning, new ways of inferring empirical games from these data samples, and new approximation algorithms for solving empirical games. Applied work in challenging, real-world domains will push the computational envelope of EMD, and is expected to yield practical results about market protocols, ranking algorithms, and two-sided matching mechanisms. Further, using EMD methods, designs optimized for a given environment can provide a starting point for the search for improved designs in a related setting.

Broader Impact While pursuing the technical advances necessary for the success of EMD, the investigators will devote a substantial fraction of our resources to concrete applications, both for the purpose of evaluating their methodology, and with the goal of directly impacting those domains. Their main theme of market design covers a broad scope with numerous applications to commerce, public policy, and distributed resource allocation. In public policy, for example, market-based approaches are likely to play a major role in, for example, instituting measures to cope with climate change, banking reform and regulation, and adoption of new energy sources. Each of these societal challenges will entail significant mechanism design efforts, and an empirical basis for evaluating candidate designs should complement the existing theoretical perspectives.

In the private sector, design decisions, while often the purview of commercial entities or consortia furthering their own interests, can also be influenced by stakeholder groups or government bodies such as regulatory agencies. Thus, scientific studies of commercially viable application domains can play an important role in achieving social objectives (e.g., stability of complex financial relationships).

Educational Value Both PIs have a persistent record of weaving their research interests into their courses. In the past, this strategy has resulted in heavy undergraduate involvement in their research.

Key Words mechanism design, empirical methods, agent-based modeling, markets, auctions