Collective Decision Making in Multi-Agent Systems

Making collective decisions about allocating resources to agents or agents to teams in a fair, principled, and mutually beneficial manner is a central problem, whether the agents are humans, robots, or some other autonomous entities. Common features of multi-agent settings are that agents express preferences or utilities over allocation outcomes. Based on these preferences as well as other information such as priorities, endowments, and contributions, the allocation is made. For all multi-agent settings, designing formal models and efficient and principled algorithms to make collective decisions is a fundamental goal.

There are many important problems in microeconomics, where economists have largely ignored the computational issues that are necessary to build scalable systems. Artificial intelligence with its toolkit of optimization techniques, tradeoff analysis, and algorithm design is ideal to tackle such problems. In the other direction, concepts from microeconomics, especially social choice theory, mechanism design, fair division, and cooperative game theory, are suitable to reason about optimality, fairness, stability, and incentive properties in multi-agent systems.

A typical challenge is to incentivize agents to report their truthful preferences so that optimization can be done on the correct input. My work is at this very active interface between artificial intelligence and microeconomics. I try to design collective decision-making algorithms and protocols that not only satisfy compelling axiomatic properties but are also computationally efficient. This invariably requires understanding the tradeoffs between the properties.

A fundamental problem in coalition formation and discrete allocation is that of computing Pareto optimal outcomes. My research group came up with a versatile algorithm to solve this problem. A long-standing problem concerning envy-free allocation of divisible goods has been to design a protocol for more than three agents that requires bounded number of queries. A colleague and I solved this problem.

In contrast to work on deterministic voting and allocation rules, randomized mechanisms are relatively less explored. I've been investigating the use of randomization to devise protocols and voting rules that have desirable axiomatic properties. For example, a colleague and I proposed a new randomized voting rule that significantly generalizes a prominent assignment rule and provides an interesting connection between allocation of private and public goods.

As the digital world gives rise to new markets and complex cooperative settings, and multi-agent systems require principled protocols and mechanisms, the interplay between AI and economics will be crucial to come up with innovative solutions. As a researcher, it’s an exciting time to be working in this area.