Information Design in Spatial Resource Competition

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Abstract. We consider information design in spatial resource competition, motivated by ridesharing platforms sharing information with drivers about rider demand. Each of N co-located agents (drivers) decides whether to move to another location with an uncertain and possibly higher resource level (rider demand), where the utility for moving increases in the resource level and decreases in the number of other agents that move. A principal who can observe the resource level wishes to share this information in a way that ensures a welfare-maximizing number of agents move. Analyzing the principal's information design problem using the Bayesian persuasion framework, we study both private signaling mechanisms, where the principal sends personalized signals to each agent, and public signaling mechanisms, where the principal sends the same information to all agents. We show:

(1) For private signaling, computing the optimal mechanism using the standard approach leads to a linear program with 2^N variables, rendering the computation challenging. We instead describe a computationally efficient two-step approach to finding the optimal private signaling mechanism. First, we perform a change of variables to solve a linear program with $O(N^2)$ variables that provides the marginal probabilities of recommending each agent move. Second, we describe an efficient sampling procedure over sets of agents consistent with these optimal marginal probabilities; the optimal private mechanism then asks the sampled set of agents to move and the rest to stay.
(2) For public signaling, we first show the welfare-maximizing equilibrium given any common belief has a threshold structure. Using this, we show that the optimal public mechanism with respect to the sender-preferred equilibrium can be computed in polynomial time.
(3) We support our analytical results with numerical computations that show the optimal private and public signaling mechanisms achieve substantially higher social welfare when compared with no-information and full-information benchmarks.

Keywords: Bayesian persuasion · Spatial resource competition

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