Computational Environment Design

A dissertation presented
by

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Abstract

The Internet has evolved into a platform on which large numbers of individuals take action and join in collaborations via crowdsourcing, social media, and electronic commerce. When designing social and economic systems on the Internet, a key challenge is understanding how to promote particular desired behaviors and outcomes. I call this problem *computational environment design*.

Notable abilities afforded by the Internet, such as the ability to recruit large numbers of individuals to join problem-solving efforts via crowdsourcing and social media, and the ability to engage in a data-driven iterative design process, are creating new opportunities and inspiring new methods for computational environment design. This dissertation focuses on these abilities and proposes an approach for arriving at effective designs by *reasoning and learning about characteristics of participants and how these characteristics interact with a system's design to influence behavior*.

The dissertation consists of two major components. The first component focuses on designing *crowdsourcing* and *human computation* systems that leverage a crowd to solve complex problems that require effective coordination among participants or the recruitment of individuals with relevant expertise. I show how reasoning about crowd abilities and limitations can lead to designs that make crowdsourcing *complex tasks*

feasible, effective, and efficient. The solutions introduce new design patterns and methods for human computation and crowdsourcing; notable contributions include a *crowdware* design for tackling human computation tasks with global constraints, and incentive mechanisms for *task routing* that harness people's expertise and social expertise by engaging them in both problem solving and routing.

The second component focuses on understanding how to design effective environments automatically. I introduce a general *active, indirect elicitation* framework for *automated environment design* that learns relevant characteristics of participants based on observations of their behavior and optimizes designs based on learned models. Theoretical contributions include developing an active, indirect elicitation algorithm for a sequential decision-making setting that is guaranteed to discover effective designs after few interactions. Practical contributions include applications of the active, indirect elicitation framework to crowdsourcing. Specifically, I demonstrate how to automatically design tasks and synthesize workflows when optimizing for desired objectives given resource constraints.

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- Haoqi