CAREER: Modeling Services as Interactions: A New Direction in Design and Control of Services

Overview

To borrow an aspiration I once heard nicely posed by Sonia Sotomayor, to belong to a community is to *be involved in bettering it*. As an operations researcher, my approach to bettering is through modeling. Within my area of services and stochastic models, this means that my long-term research goal is both to employ models and analysis in solving critical service problems and to develop new models that advance our capabilities to represent the world around us.

Towards this aim, the research objectives of this CAREER proposal are to establish and analyze *stochastic models of service at the level of interactions*, rather than at the level of systems. Conventionally, operations research (OR) views the duration of service simply as some (typically independent and identically distributed) random variable. However, both in prior works and in new sources in this proposal, service interaction data shows that this perspective is too coarse: it overlooks the fact that (i) each service interaction is composed by a unique collection of multiple *contributions* and (ii) these contributions come from two distinct and interacting *sides*, the customer and the agent.

At its core, the proposed interaction framework views service not as a mere random variable, but rather as a finite point process of contributions. Then, the conventional duration random variable can arise in two different ways: either at the moment of the final contribution (if the service closes *naturally*) or at a stopping time on the filtration of the point process (if the service must be closed *systematically*). By moving from the prevailing macro-level perspective to the micro, the proposed interaction models will identify novel managerial decisions for the control and design of services. Additionally, the expanded dimensions of the model will introduce the degrees of freedom needed to model and analyze the new frontier of services that are assisted or driven by AI.

As an OR educator, bettering my community means *making modeling more inclusive* and, by consequence, more impactful. Hence, my long-term education goal is to expand the OR tent and involve new, possibly underrepresented or underserved, groups in modeling; some of my career's most rewarding moments have come from efforts to do so.

Accordingly, the twin education objectives of this CAREER proposal are to (i) develop instructor-facing resources to introduce *AI-supported modeling curricula* in undergraduate business programs nationwide and (ii) design simulation-based *undergraduate research projects* built on meaningful yet accessible scholarly tasks. Leveraging the experiences I have had at my institution, this proposal is based on the belief that undergraduate business education constitutes an unrealized opportunity to advance the literacy, advocacy, and adoption of modeling.

Intellectual Merit

The proposed service interaction framework is grounded in the self-exciting Hawkes point process and the history-driven clusters which form within it. The two key stochastic model quantities for the service context, the natural closure time and the systematic closure time, answer a pair of fundamental questions: how long will, or should, an endogenously driven activity last? For the natural duration, this quantity has been studied essentially ever since the Hawkes process was introduced half a century ago, but it has developed a notorious reputation for analysis – even the mean has been out of reach. Fortunately, preliminary work by the PI has uncovered techniques that can deliver the natural duration's distribution via probabilistic combinatorics; the proposed agenda builds from this methodological cornerstone. On the other hand, the systematically stopped duration appears to be novel relative to the prior literature, and the value of both its concept and its potential solution likely transcends the focal services context.

Broader Impacts

The impact of this research lies in the fact that the interaction framework is a model *for services*. By capturing micro-level details that were previously overlooked, this proposal will address novel and societally important service problems, offering to recover wasted time and improve customer outcomes without additional resources. Furthermore, this research will help us understand how services actually differ from seemingly similar areas with which it has shared models. Moreover, these models, problems, and solutions will be grounded in real-world data from an industry collaborator, creating a bridge back to practice. In its education objective, this proposal claims that undergraduate business education may also offer an opportunity to broaden participation in modeling. As evidenced both nationally and locally at the PI's institution, these students comprise an extensive and representative population of future team members and leaders. Thus, their understanding, involvement, and support of modeling can better the overall quantitative literacy of the workforce and public, advancing the scientific and industrial competitiveness of the nation.