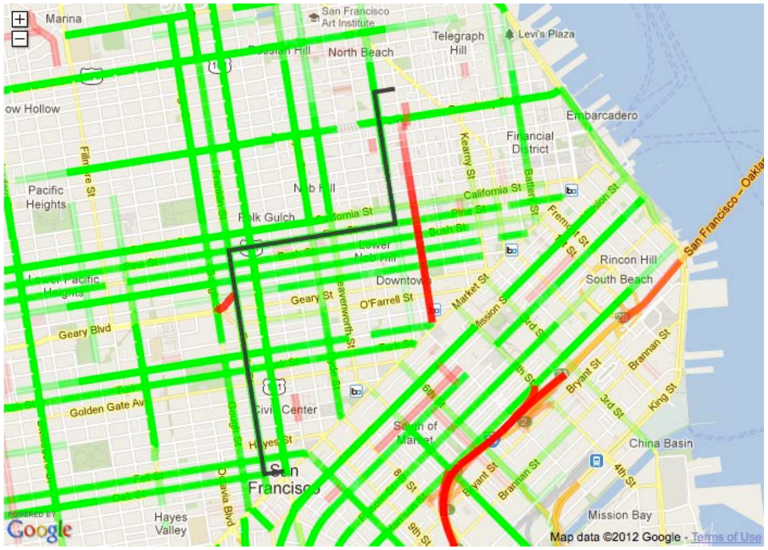
Cogill Research Group



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"Methods for decision making, performance analysis, and estimation in the presence of uncertainty."

Widespread availability of data and computing power is opening up new possibilities for performing large-scale, automated, data-driven decision-making. As an example, the location data generated by mobile devices can be used to improve the quality of route suggestions produced by automotive navigation systems. However, the real value of this data is unlocked by applying algorithms that can learn meaningful models from this data, then using these models as the basis for decision-making. Our group develops and applies optimization and control algorithms, stochastic models, and machine learning algorithms. These topics are tightly coupled; our work often exploits the relationships among these topics.

Optimization and Control

The topic of computational optimization deals with models and algorithms for finding the most desirable option out of many possibilities. Furthermore, optimization can be performed in settings where decisions must be made sequentially over time, possibly with uncertainty about future events. We have collaborated with numerous groups on optimization-related projects, including Xerox, MIT Lincoln Laboratory, and the Rolls-Royce Corporation. Our work with Xerox and Lincoln Laboratory has dealt with problems involving optimal allocation of resources within networks, with the goal of the attaining efficient operation in the presence of dynamic changes to the network. Our work with Rolls-Royce involves process monitoring, where decisions regarding replacement and reconditioning of tools must be made in real-time, where tool condition is uncertain and can only be estimated from indirect measurements.

Stochastic Control

The starting point for applying optimization methods lies in the development of models that capture system behavior, together with quantifiable metrics for system performance. Our work spans several topics related to the modeling of stochastic systems, learning system models from data, and performance analysis of system models. For example, in our past work with MIT Lincoln Laboratory, we have developed stochastic models of the performance of strategies for encoding data in communication networks, ultimately leading to precise criteria under which these strategies outperform existing scheduling strategies. Another area where we have more recently been leveraging our expertise and stochastic modeling and performance analysis is in the development and application of machine learning algorithms. Given data collected from a system to be modeled, machine learning algorithms attempt to automatically infer model parameters from the given data. For example, in our work with the Rolls-Royce Corporation, we use real-time cutting force measurements taken from machining processes to infer stochastic models that characterize the progression of wear on tools. As another example, we have developed a novel algorithm for learning models to be used by automotive navigation systems. This algorithm learns models from data collected from the trips taken by actual drivers.

RECENT RESEARCH DEVELOPMENTS

- Our work on the RouteMine algorithm, for which we have an international patent pending, uses historical data from actual drivers to build optimization models that can be used in specialized route guidance systems.
- In our NSF sponsored work on analysis and control of reversible process, we are uncovering properties of reversible processes that we are using to speed the convergence to and improve the quality of the solutions produced by stochastic sampling schemes.

RECENT GRANTS

- NSF – Optimal Reversible Policies for Markov Decision Processes
- MIT Lincoln Laboratory – Distributed Algorithms for Dynamic Networks

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