Intelligent Infrastructure & the Digital Transformation:
Improving Lives Through Automation

Now pervasive in intelligent infrastructure, internet of things technologies allow intelligently augmented humans to make decisions rapidly as they engage with the systems that facilitate public services and support movement of goods, economics exchanges, and safety. The world is simply more connected. Basic services are now more than ever a two-way street: users can consume and produce. We can pull up our smart phone and command a car in seconds, we can purchase and sell goods through a digital platform and have them delivered in under a day, and we can manage our participation in smart grid demand response programs. Within this context, our phone coordinates and engages in markets on our behalf, translating our minimal inputs into complex decisions in real-time in the marketplace. In the midst of this digital transformation, we are seeing platform-based market mechanisms emerge in which interactions occur on multiple time-scales, are constrained by cyber and physical system dynamics, and are exposed to exogenous uncertainties, information asymmetries, and behavioral aspects of human decision-making.

Fundamental challenges persist in part due to the meshing of the cyber and physical worlds in which digital platforms that support market-based services are entangled with physically constrained socio-technical systems in which humans are integral. One such fundamental challenge lies at the interface of economics and machine learning: there is a great need to price services and provide incentives in learning-based multi-sided markets that operate in the cloud but are constrained by physical real-world resources. This is particularly true in intelligent infrastructure, an liaison for the digital transformation. For instance, congestion on urban arterials is a challenge for city officials and commuters alike, made worse by slow-cruising vehicles hunting for curbside parking. Growth of urban areas is causing great strain on the transportation systems that support them. While efficient movement of goods and people is a major concern for cities, so is business district vitality and neighborhood livability. Cities and researchers are keen to architect and create support systems for data-driven, dynamic policies that balance these diverse needs. Currently, cities are leveraging data streams to create automated decision processes such as performance-based pricing of parking spots and tolls on roadways as well as real-time traffic light management. Beyond the technical challenges which include legacy equipment, resource constraints, and the need for real-time solutions, unintended consequences such as disparities in equity across different socio-economic groups or increased congestion in surrounding neighborhoods, both a potential outcome of myopically designed pricing schemes, are sure to arise.

In an effort to address to such challenges, private solutions such as innovative platform-based markets that build on public infrastructure are emerging. Intelligent transportation systems are representative owing to the emergence of such services in all dimensions including diverse vehicle sharing models, smart parking systems, improved public transit options, and even analytics engines to support policy design and day-to-day system management. The arrival of competing markets that consume, often publicly owned, physical resources exposes a perverse incentive structure that leads to exacerbation of the so-called tragedy of the commons, in which public goods and resources are over consumed by self-interested parties and access to private services is largely granted those with the economic means.

Despite these challenges, there is an upside: there are numerous opportunities to improve lives by leveraging new data streams to develop predictive analytics in support of automation. Compelling new research at the interface of economics, computer science and engineering is leading to solutions that not only enable more efficient markets, but also are aware of fairness and equity issues that arise when humans are active participants in the day-to-day operations of intelligent infrastructure systems. It is an exciting time as communities are becoming smarter and more connected and the social fabric is becoming more universal.

This talk aims to articulate a vision for smart and connected communities that highlights recent advances in practical algorithm design as well as opportunities and challenges faced in intelligent infrastructure. The audience will be exposed to novel solutions from a variety of perspectives ranging from economics to computer science to engineering. Each of these domains is crucial for progress. Recent research on the design of certifiable algorithms for robust inference and influence as well as the design of market mechanisms for negotiating the exchange of data and goods will be spotlighted. To facilitate the discussion and make ideas concrete, the focus will be on some key applications in intelligent transportation, an envoy for emerging, innovative markets and technology-based solutions. The talk will conclude with an exposé on opportunities to address some of the more prescient challenges and exciting directions for future research in the next five to ten years.