Statement of Research Interests

Recent technological advances in computing, in general, and in sensor networks, in particular, have reduced the costs of performing pervasive instrumentation of the physical world. However, massive deployment of these monitoring devices, alone, will not help in improving the systems being monitored. Moreover, further optimizing the cost of these solutions requires a comprehensive approach to the problem. Considerable domain knowledge is needed when designing and implementing the instrumentation systems, as well as when analyzing the vasts amounts of data that they generate. In an increasingly data-driven world, future infrastructure systems will need to be able to interact with their environment and with each other; and to achieve this vision an interdisciplinary approach is necessary. My research interests, like this problem, are broad and cross-disciplinary. I am interested in instrumenting our civil infrastructure (e.g., buildings, highways, etc.) to increase its resilience, adaptiveness and self-monitoring capabilities. In particular, I am interested in utilizing and/or implementing cost-effective sensor systems that maximize the value of easy-to-obtain data sources to help us better understand the behavior of infrastructure systems, learn from the patterns and better plan for the future.

As an example of this vision, for my Ph.D. thesis, I have been working on building energy management, focusing on the application of signal processing and machine learning techniques to data collected from a variety of sensing systems in a building to infer the operational schedule and power consumption of individual appliances and provide detailed energy feedback to the building's occupants. Inspired by a real-world problem, namely the delayed and aggregate feedback provided by monthly electricity bills, we designed and implemented a prototype Non-Intrusive Load Monitoring (NILM) system for a residential building, that carefully analyzes the overall voltage and current feeding the home, as measured at a single location, and is able to correctly detect the effects of the individual operation of most appliances and track their consumption. I believe that simple, inexpensive and low-maintenance systems like this are the key to future infrastructure monitoring.

Through the NILM project, which is now funded by an NSF grant as a result of a proposal adapted from my thesis work, I was able to explore and learn from the whole life-cycle of the data: from designing and implementing data acquisition systems, to analyzing, storing and managing the data. However, despite being an end-to-end opportunity, it also revealed many additional challenges that are common to virtually all IT-enhanced infrastructure. For example, because of the need to acquire data from separate sensing systems, we came across the problems of data fusion and interoperability: how to easily combine and share data from sensors (RFIDs, cameras, power meters, etc.) and historical records (e.g., databases). Towards this end, I have been involved in the design and development of *Sensor Andrew*: a collection of hardware and software elements that together form a virtual instrument for large-scale sensing and actuation, intended to simplify the task of finding, using and sharing transducers at Internet-scale.

I would like to extend my current work on building electricity monitoring to leverage a wider range data-sources present in a building and at the same time account for other energy sources, while still minimizing the intrusiveness. These new data sources could be additional sensor streams, but also historical and contextual information such as past electricity bills and building characteristics. I would also like to investigate the possible benefits of NILM in Automated Demand Response scenarios, and other grid-level optimizations. Additional avenues of research include the integration of sensor data with building and energy models used for the design, construction and operation of facilities. The vast amount of data that is already being generated by current sensor deployments throughout the world will only continue to increase at an exponential rate. With this trend, the problem will slowly shift from being about where and what to sense, to being more about how to easily access and effectively utilize all this information. My goal is to contribute *smart* and cost-effective solutions to these problems through seamlessly integrated monitoring systems that make use of indirect measurements to infer the conditions of our built-environment.