Urban Informatics: Harnessing data to understand socio-technical dynamics in the urban built environment

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We analyze data to understand interactions between **people**, **buildings** and **energy** systems in cities.

- **Intra-building dynamics**
- **Community dynamics** (inter-building)
- **Urban-scale dynamics**
Why *people*, *buildings* and *energy* in cities?

- 75% of world’s energy usage comes from cities
- 70% of city energy usage comes from buildings (Chicago, NYC)
- “Buildings don’t use energy, people do”

A sustainable, smart city must address challenges at the intersection of *people*, *building* and *energy* systems
Opportunity: emerging data streams

- **In-situ sensors**: +43 M smart meters now in the U.S.
- **Remote sensors**: Nearly 2 B+ people have smart phones
- **Organic data**: NYC generates 1 TB of data every day
Intra-building dynamics – socio-spatial dynamics of energy usage

Lacks co-optimization of occupants + building systems

Occupants
• Space
• Time
• Social

Data-driven optimization + design

Building systems
• Space
• Time
**Occupancy Energy Signal Processing on Graphs (OESPg) framework**

Community (inter-building) dynamics

What are community impacts of building energy usage?

How do we plan for distributed energy infrastructure amidst socio-technical complexities?

What are the socio-technical and energy burdens of slum redevelopment?
Data-driven infrastructure planning amidst socio-technical complexities

What customers “fit”?

City Block

What infrastructure “fits”?

Multi-objective optimization (e.g. min cost, emissions, risk)

Accounts for socio-technical complexities:

- Diversity
- Deployment
- Uncertainties
- Demand-side management
ReMatch results for 10k consumers in California

50% reduction in levelized cost of electricity (LCOE)

Data + simulation to assess lighting, comfort, energy efficiency and associated health outcomes of proposed slum rehabilitation in Dharavi, Mumbai, India
Towards a data-driven slum redevelopment toolkit

1. On-site surveys – physical dimensions, building features
2. In-situ sensors (temp, humidity) to calibrate simulation assumptions
3. Simulate morphologies (M1, M2, M3)

Vertical redevelopment (M2, M3) could worsen thermal comfort and increase energy burdens!

Urban dynamics

How do we target the most “inefficient” buildings across a city?

What are the socio-technical interdependencies of urban systems?
Performance benchmarking at the city-scale

How do you translate data into insights and effective building energy efficiency policies?!?
Benchmarking methods + results

STEP 1
Collect and clean data of building energy use and characteristics

STEP 2
Partition buildings into groups to reduce energy use variance

STEP 3
Define stochastic frontier to calculate building energy efficiency

STEP 4
Identify energy inefficient buildings for targeted policies and programs

- Do energy efficient retrofits improve educational outcomes?
- How do we drive policy for dual socio-technical benefits?

Palo-Alto “living lab”

Quantitatively and experimentally explore the coupled dynamics of urban systems through a “living lab”

Ontology to integrate urban data streams

Enable data-driven analysis across people, building and energy systems

Conclusions / Thoughts

• Need to bring people into the loop of building and energy systems design and management for smart, sustainable cities

• New data streams could enable a deeper understanding of interactions between people and their infrastructure

• Challenge: translate data → insights
  – Require lots of interdisciplinary research (engineers, computer scientists, social scientists) and civic-academic partnerships
Check out our lab site: uil.stanford.edu

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Questions?