Connecting the Smart-City Paradigm with a Sustainable Urban Infrastructure Systems Framework to Advance Equity in Communities (P.I.: S. Shekhar, A. Ramaswami, R. Feiock, J. Marshall, V. Merwade)

Vision for the Project

The overarching vision of our project is to link the smart city paradigm on sensor technologies and data sciences with an interdisciplinary integrated Social-Ecological-Infrastructure & Urban Systems (SEUIS) framework to advance WHE outcomes in cities, with equity-focused planning for infrastructure transitions.

Conduct interdisciplinary community-engaged research with:
- 4 Communities: Minneapolis, St Paul, Tallahassee, Hennepin County
- Schools, teachers and students will be engaged in citizen science component helping reach many diverse neighborhoods within cities

Research Questions

Our project addresses two inter-connected overarching research questions:

RQ1: How can we better understand spatial equity (including inequality and fairness) in the context of 7 basic infrastructure provisions (i.e. food, water, health, etc.) in cities? (Note: Equity, E, is explored as the spatial distribution of the WHE outcomes and their correlates with SEUIS parameters)

RQ2: Given the opportunity of transformative smart infrastructures on-horizon (e.g. smart electricity grid, autonomous vehicles) and their interactions with built areas, buildings, solar PV deployment, urban farming and green infrastructure to manage climate risks, can smart infrastructure planning initiatives, initiated today, encompassing all 7 physical infrastructure sectors, advance all four WHE outcomes? In particular, how does an equity first approach differ from conventional approaches that focus on “average” outcomes?

Research Objective

To address the key gaps in science, data and knowledge, we propose 3 broad research themes that are closely aligned with Education

Preliminary Results (Continued)

Citizen Science for Near-Real Time Urban Flood Simulations

Near-real time modeling (50 SP model area: 340 m²)

- Hyper-resolution physically-based distributed flood modeling
- Model simulated from June 9th – July 15th 2016
- Existing state ➔ Uncalibrated parameters + river bathymetry absent + no stormwater infrastructure
- Current step ➔ Bathymetry incorporation + model calibration and validation

Bathymetry incorporation using W-RCM

Next Steps:
- Finalize W-RCM outputs and embed bathymetry as an active variable
- Calibration and validation of model after bathymetry incorporation
- Embedded storm-water network at multiple resolutions over a 2D overland structure (data obtained from City of Minneapolis)
- Near-real time simulation using forcing from regional forecast center

Mapping Trees for Green Infrastructure Equity

Theme 2: Advance spatial data analysis
Task 2A: Algorithms for spatial patterns

Recent accomplishments: individual tree detection for Ash Borer problem
- A TRIMBER (true reference by minimizing ground-and-band errors)
- Optimization to find tree locations and sizes
- Deep learning to construct features to distinguish trees and non-trees
- A CORE (Core Object Reconstruction) to accelerate the detection process


Work in progress: Tree species classification, including arbor text
Idea: Use tree shadows from high-resolution lead-off imagery

Next steps: Algorithms for tree shadow enhancement and clipping
- Deep learning for tree species prediction

Mapping Trees for Green Infrastructure Equity

Work in Progress: Assess urban garden food production capacity

Collaborators
- Anu Ramaswami, Peter Nixon, Lin Zeng, UMN
- Joshua Newell, Dimitra Gounaridis, School for Env. and Sustainability (SEAS), University of Michigan

Initial Approach
- Digitize urban garden from Google Earth imagery
- Walk neighborhoods for ground-truthing
- Worked well in Detroit
- Did not work well in Minneapolis due to occlusion
- Tree canopy, shadows, etc.

Current Approach
- Use high resolution spring aerial imagery
- Top-down and tree-based
- Using ground truth from initial approach.

Details: Transforming Smart Cities with Spatial Computing, Yiqun Ke, Jayent Gupta, Yan Li, Shekhar, IEEE International Smart Cities Conference (SSCI) 2018.

Acknowledgment:
- Data Source: PI, Hennepin County, Ramsey County

Household level Tallahassee database

Comparing Consumption Hot Spots

First Spot Analysis of WHEE Energy Use

Next Spot Analysis of WHEE Water Use

Data Set: Energy Consumption (2011-2016)
- 30 mins interval energy consumption of electricity and gas, monthly consumption of water for about 120,000 customers

Community Engagement

Citizen Science with Schools For Neighborhood Infrastructure & Wellbeing Assessments

Innovation: First attempt to measure both cognitive WBI, emotional WBI and life purpose, in diverse neighborhoods along with satisfaction with urban infrastructure at the neighborhood level. (Task lead: PI Ramaswami, UMN)

Innovation: Engaging Middle-High Schoolers in neighborhood exploration, data gathering, online reporting/mapping and discussion on equity. (Project Lead: Brown, UMN).

City Partners:
- St. Paul
- Minneapolis
- St. Paul
- Carls Mayfield, Hennepin County
- Michael C. Fyfie, St. Paul
- City Council, St. Paul

Schools Partners:
- Charlotte Elementary
- Minneapolis Public Schools
- Dublin Elementary
- Minneapolis Public Schools
- South Park Elementary
- Minneapolis Public Schools
- New Rebecca Elementary
- Minneapolis Public Schools

2016-2018:
- SRN global survey
- Measure 2 different aspects of wellbeing (cognitive and Emotional)
- Very long but useful strategies - being published
- Streamlined survey and analysis technique developed in SACC
- Project run by: My Neighborhood, My Life
- Work with City of Minneapolis Public Works on ways for long term tracking of inequality in wellbeing and relationship to infrastructure
- Two rounds of 2017 surveys run through Minneapolis Department of Community Engagement

October 2016:
- On line survey developed
- Neighborhood associations
- Facebook surveys w. PI Ramaswami, Sparks and Reza

February 2019:
- Contact all 87 Neighbors Associations
- Dissemination through Newsletters and Facebook accounts
- Dissemination in MSP Schools
- Working with schools to reach underserved populations
- Survey in 5 pilot classes: current
- IBR Status: IBR Exempt
- 287 surveys currently completed

Theme 2: Multi Infrastructure Modeling

- Developing a framework to model urban energy transitions to electric heating and electric vehicles
- Explore transition patterns w.r.t urban form, typology, and circular economy
- Collaboration with Kate Kockelman in the SRN on SAV/SAEVs
- Next steps: Connect to Venkatesh’s group to add on water infrastructures.

K-12 Citizen Science

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