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Synthetic Infrastructure Model for Vulnerability, Failure, & Future Transition

Urban infrastructures are complex and vulnerable to cascading failures (e.g., a hurricane causing large-scale power outages). Understanding urban infrastructures, their relationships, and propensity for cascading failures is essential to preparing for future extreme events. Often seemingly innocuous failures trigger a catastrophic hazard as the initial failure's magnitude increases over time as downstream assets go offline. Without precise information as to the nature of the cascade, tracking the root cause of such a failure is difficult. Fine-scale information and failure patterns are vital to prevent a similar future catastrophe. As such, knowledge of how each urban infrastructure is used and operates at a fine-scale is necessary to analyze the root cause of a catastrophic event. However, there is often limited to no fine-scale information on infrastructures due to weak historical records, security concerns, or limited willingness to share data.

Synthetic infrastructures are a promising solution to the lack of publicly available data on urban infrastructures. Synthetic infrastructures allow us to better understand the dynamics of urban infrastructures and resilience strategies. Moreover, synthetic infrastructures are well positioned to support the modeling and understanding of interconnections among urban infrastructures. Although synthetic infrastructure algorithms provide useful information, their modeling capability has so far been limited to a single infrastructure (e.g., to power systems). To better understand the criticality, adaptability, and vulnerability of networked systems, we also need to know the interdependencies and interconnections among them. Thus, what is needed is a model that assesses coupled infrastructure networks, their vulnerabilities, and opportunities for improving resilience of those networks.

Researchers at Arizona State University (ASU) have developed a synthetic infrastructure model designed to estimate the location and characteristics of urban water and power distribution networks, estimate how those networks are interconnected and connected to buildings and transportation systems, and asses how failures propagate within and across the systems. The model synthesizes and estimates the interdependencies of water, power, buildings, and roads for a city into a single platform.

Related publication: A synthetic water distribution network model for urban resilience

Potential Applications:

- Infrastructure planning and management

- Urban planning and management

Benefits and Advantages:

- ASU model performs all of the following:
  - synthesizes fine-scale critical infrastructure data
  - analyzes interdependency of water systems, power systems, buildings, and transportation systems
  - assesses the propensity for cascading effects across water systems, power systems, buildings, and transportation systems
- ASU model output can feed into state-of-the-art water and power simulation tools (e.g., EPANET, OpenDSS, etc.)