Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Derek Hamel
Nathan Johnson
Gary Morris
Mikhail Chester
Anna Scaglione

Contact

Shen Yan
shen.yan@skysonginnovations.com

Real-Time Simulation of Interdependent Infrastructure Responses to Environmental, Cyber, and Kinetic Disruptions

Background

Modern infrastructure combines numerous interdependent systems including power, water, and cyber. These systems are often designed in isolation but necessarily interact in practice. Such interactions make it challenging to identify and quantify vulnerabilities using engineering practices specific to individual disciplines. This challenge is exacerbated as complexities increase across highly variable spatial and temporal scales, making it more difficult to prevent, predict, and track hazards. Therefore, practical modeling of infrastructure relationships would enable city and military planners to better analyze failure propagation, develop contingency plans, and invest resources to improve resiliency comprehensively.

Invention Description

Researchers at Arizona State University have developed a real-time simulation and training platform to observe the effects of stressors—be they environmental, cyber, or kinetic—on complex infrastructure networks. With a highly visual interface, this software tracks system states and features using (1) an Editor mode to build infrastructure using drag-and-drop placement of assets and connections, (2) a Controller mode to simulate adverse effects on infrastructure systems, and (3) an Operator mode to train real-time infrastructure operators to manage threats in real-time. Simulated stressors can be customized to affect individual components (e.g., cyber attack of an electrical relay), all components in an area (e.g., flooding from water pipe failure), or all components in the simulation (e.g., extreme outdoor heat). The associated adverse effects propagate within an individual infrastructures (e.g., cascading failure of the electric grid) and between infrastructure systems (e.g., water supply outage to a power plant reduces cooling water and the power plant must cease operation).

Potential Applications

- Utility providers, city planners, regulators, and military operators
  - Training for crisis management
  - Identification of social and economic impacts of system stressors

- Resiliency analysis for power, water, and cybersecurity threats

Benefits and Advantages

- Provides quantitative perspectives on how performance issues propagate across interconnected infrastructures
- Customizable stressors can be input in abstract or targeted manners, appearing as geographical areas on a map or defined for specific components
- Vulnerabilities across infrastructures are displayed with both technical and financial metrics to guide resource allocation decisions