UCLA Samueli
Civil & Environmental Engineering

Seminar Series

"Structures as Sensors: Using Structures to Indirectly Monitor Humans and Surroundings"

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1:00 – 1:50 PM

Zoom Link:
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ABSTRACT

Smart structures are designed to sense, understand, and respond to various situations involving the structure itself, the humans within, and the surrounding environment. However, traditional direct monitoring approaches using dedicated sensors often result in dense and heterogeneous sensing systems that are difficult to install and maintain in large-scale structures. This talk introduces the "structures as sensors" approach that utilizes the structure itself as a sensing medium to indirectly infer multiple types of hidden information relating to the structure (e.g. the users and the surrounding). This is by realizing that the conditions of the structure itself, the environment around, and the activities of users within all have a direct impact on the physical responses of the structure. For example, human walking induces building floor vibrations, uneven road surfaces and bridge settlement change vehicle motions, etc. By using only the structural responses for extracting multiple types of information, and because of wave propagation characteristics, the structures as sensors approach significantly reduces the number and type of sensors needed to install and maintain. Challenges lie, however, in creating robust inference models for analyzing convoluted noisy structural response data (e.g., a mixture of building responses due to human activities, outside traffic, seismic events) while meeting sparse deployment and low-cost maintenance goals. To this end, we developed physics-guided data analytics approaches that combine statistical signal processing and machine learning with physical principles. Specifically, I will present two projects as examples of this approach; 1) Vehicles as Sensors: indirect infrastructure health monitoring through vehicle responses; and 2) Buildings as Sensors: occupant tracking and characterization through footstep-induced building vibrations. In these projects, new learning methods are developed incorporating structural dynamics, wave propagation, and human gait models. These methods are evaluated with real-world experiments, including our 5-year railway and eldercare center deployments.

BIOGRAPHY

Hae Young Noh is an Associate Professor in the Department of Civil and Environmental Engineering at Stanford University. Her research focuses on indirect sensing and physics-guided data analytics to enable low-cost and non-intrusive monitoring of cyber-physical-human systems. She is particularly interested in developing smart structures and systems to be self-, user-, and surrounding-aware to provide safe and resilient environments and improve user's quality of life, while reducing maintenance and operational costs. The result of her work has been deployed in a number of real-world applications from trains, to the Amish community, to eldercare centers, to pig farms. She received her Ph.D. and M.S. degrees in Civil and Environmental Engineering and the second M.S. degree in Electrical Engineering at Stanford University. She earned her B.S. degree in Mechanical and Aerospace Engineering at Cornell University. She received a number of awards, including the Google Faculty Research Awards in 2013 and 2016, the Dean's Early Career Fellowship in 2018, and the National Science Foundation CAREER award in 2017.