Structural Engineering Seminar Series

CEE 595 S

Adaptive deployable lightweight structures inspired from biology

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Abstract:

Lightweight and modular structures are ideal candidates for robotic adaptive control. Improvements and novel work in form-finding and statistical diagnostic tools have enabled practical applications of adaptation such as controlling the shape of civil engineering, aerospace, and architectural structures.

Although deployable structures, such as tensegrity structures and origami structure, are already fairly common, deployable active structures that change shape either autonomously or remotely to accommodate challenging environments are rare. A tensegrity structure is a pin-jointed composition of bars and cables held together in a state of self-stress. Since tensegrity structures are geometrically non-linear, they are ideal candidates for studying deployable structures (http://youtu.be/FeXxjerleZE). An origami structure possesses intrinsic kinematic-mechanic relationships that allows for easy deformation control and reconfiguration. However, deciding how to actuate and geometrically orient tensegrity and origami structures is a non-trivial task. Additionally, given a large number of possible actuator locations to address various load cases requires a computationally effective selection algorithm.

Using this large-scale deployable tensegrity structure, biologically-inspired computational methods have been developed for damage identification, adaptation, and learning. To show future potential of these computational methods, they are adapted for mechanics of other deployable structures, such as origami, and applied to large-scale structural elements for deployment and small shape-changes. A statistical diagnostic tool is improved to determine optimal actuator layout for adaptive movement of an origami panel. The diagnostic method compares measurements with generated simulation cases. Candidate locations of linear actuators installed between nodes (corner points) of a Miura origami pattern, and are used to control local and global shape-changes. Dynamic relaxation, a static-domain form-finding method, is implemented for form-finding throughout the actuator optimization process.

This interdisciplinary work addresses a challenge with practical applications in structural engineering b including mechanical and electrical engineering practices. This contributes to the practical solution for deployable and adaptive structures. Impact of this work on the engineering field is two-fold: building of the structure to show feasibility and generalizing active control systems for implementation for industry construction projects.

Bio:

Ann Sychterz obtained her PhD in 2018 from the Swiss Federal Institute of Technology Lausanne (EPFL) addressing the novel use of control algorithms, statistical diagnostic tools, and real-time feedback on a full-scale tensegrity structure to enable smooth deployability, damage detection, adaptation, and learning. During her masters of applied science obtained in 2014 at the University of Waterloo (UW), she built full-scale aluminum pedestrian bridges for vibration characterization and control. She completed her bachelor of applied science in civil engineering at the University of Waterloo in 2012. Before coming to the University of Illinois, she completed a postdoctoral position at the University of Michigan through the successful Swiss National Science Foundation Early.Postdoc Mobility grant that she authored on the actuator optimization of adaptive origami structures. Her research work is focused on designing, building, testing, and simulating of structures that are adaptive, lightweight, large-scale, resilient, and sustainable.

Dr. Sychterz has had industry experience in design firms such as civil and mechanical engineering at Walterfedy in Kitchener, Canada and structural engineering at MMM Group in Toronto, Canada. These large-scale interdisciplinary projects -- such as Conestoga College and St. Joseph's Healthcare in Hamilton -- were focused on sustainable design and LEED certification. During her undergraduate degree, she was a captain of the UW student team for the Great Northern Concrete Toboggan Race and also served as a mentor for the concrete canoe and ASCE steel bridge student teams.

Monday, February 3rd, 2020   4:00 – 5:00 p.m.

1310 Yeh Student Center