In silico investigation and machine learning for bioinspired composite design

Shu-Wei Chang[1,2,*], Zheng-Shun Su[1], and Bo-Xue Chen[1]
[1] Department of Civil Engineering, National Taiwan University, Taipei 106319, Taiwan,
[2]Department of Biomedical Engineering, National Taiwan University, Taipei 106319, Taiwan

Abstract

Natural materials have attracted considerable attention due to their intricate and versatile architectures, which often combine lightweight characteristics with high mechanical strength. Biological tissues, in particular, exemplify multi-layered, multifunctional, and lightweight structural designs. For instance, birds have evolved extremely lightweight skeletons to enable flight, characterized by hollow bones reinforced with intersecting struts and truss-like frameworks. Along the longitudinal axis of avian bones, increased cross-sectional and polar moments of inertia enhance resistance to bending and torsion. In this talk, I will present our recent research on the in silico investigation of bioinspired composite materials. Drawing inspiration from the microstructure of bone, we extract two-dimensional structural patterns from CT scan data and analyze their geometric characteristics. We have developed an innovative approach to convert CT images into particle-based models for mechanical characterization. By integrating machine learning techniques, our work seeks to uncover the general relationship between complex geometric patterns and mechanical performance. Our results demonstrate strong predictive capability for mechanical behavior and enable rapid identification of mechanical properties across a range of geometries. This facilitates the exploration of novel material design spaces for advanced engineering applications.

*E-mail: changsw@ntu.edu.tw