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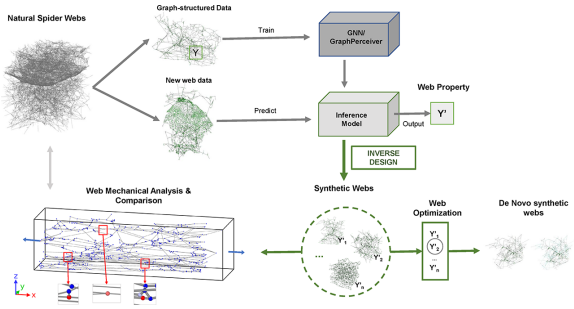
Researchers have developed and applied a computational method based on deep neural networks to model and create complex 3D spider webs.



Spider webs are appealing for fundamental studies due to their advanced structural performance. While simple 2D orb webs are reasonably well understood, many spiders weave highly complex 3D architecture webs, which currently lack a rigorous physics-based description.

Lu et al. developed a computational method combining advanced modeling techniques to relate spider web graph microstructures to effective mechanical properties, with a focus on strength and toughness. They used deep neural networks for web property prediction, which are trained on graph-structured web data and simulated mechanical properties.

“Challenges [to performing extensive spider web studies] exist due to high computational costs and limited quantified properties, which result from the higher complexity and detailed structural compositions of 3D spider web structures,” said author Markus Buehler. “Our algorithm has learned not only to predict properties of webs, but also to construct *de novo* synthetic web structures that look and behave like ‘real’ spider webs.”

The team compared three different models: two graph neural network models along with a natural language processing model that provides a general approach towards the description of complex physical structures within the framework of a building block model.

With the prediction model implemented, the researchers developed a multi-objective optimization prototype for synthetic, *de novo* web design to discover web structures that display specific mechanical properties as design objectives, which conversely verifies the prediction capability of the constructed regression model.

“The work presents a basis for rapid digital analysis of spider web structures, which could be implemented as validation tools for spider web studies, design tools of synthetic webs for design exploration and inspiration, and optimization tools for structural design,” said Buehler.

Source: “Rapid mechanical property prediction and *de novo* design of three-dimensional spider webs through graph and graphperceiver neural networks,” by Wei Lu, Zhenze Yang, and Markus J. Buehler, *Journal of Applied Physics* (2022). The article can be accessed at http://doi.org/10.1063/5.0097589.