An efficient deterministic algorithm for designing novel large-scale non-periodic 3D textile architectures

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Abstract

For critical aerospace applications, novel 3D non-periodic textile composite preforms are a promising method for fabricating near-net shape structures with fiber tows aligned along principal loading paths. However, the nondeterministic polynomial-time complete (NP-complete) nature of the problem of identifying optimal tow locations makes design of the textile architecture a forbidding challenge. As a result, preforms are currently designed largely by trial and error. In this work, we propose a new method which addresses different design requirements and constraints through the introduction of uniquely defined background vectors such that the NP-complete challenge in design can be avoided. Tunable designs with tailored targets are achieved by adjusting the weights of the background vectors. Moreover, the design method utilizes a manufacturing-based parameterization that can be easily integrated with an orthogonal weaving loom. The method is highly computationally efficient, making it suitable for large-scale non-periodic textile structures. Case studies will be presented to demonstrate the capabilities of the proposed method.

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