Dynamic Space Truss-Textile Membrane Assemblies

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Abstract

In the pursuit of thermally comfortable exterior urban space, static forms of architecture cannot accommodate changing environmental conditions. Creating dynamic structures that can transform in response to outdoor stimuli such as rain, sun, and wind is one potential solution to this problem[1]. However, this requires unorthodox structural considerations and new notions of material assemblies to ensure performance in multiple physical states. Furthermore, means of producing motion through energy-saving means have been underexplored, as current actuation mechanisms mainly operate within an electromechanical paradigm, relying on complicated, costly, and energy-intensive active mechanisms[2].

In this paper, we present the design and fabrication of a dynamic composite assembly consisting two key structural components: hygroscopically-actuated space trusses and a textile membrane. By designing cantilevering trusses with bio-composite chitosan films as critical tension members, a water-responsive structure with a large-scale shape change was conceived. To quicken the actuation time and stabilize the movement of the trusses, a pretensioned textile membrane spanning between the trusses was integrated. The reciprocity between the trusses and the membrane enables a performative mediation between structural rigidity and flexible motion. A digital simulation tool was created to predict the shape change of the assembly considering the hygro-mechanical properties of the chitosan films, the depth profile of the trusses, and the tensile properties of the membrane. As demonstrative examples, we include physical prototypes of rain-responsive canopy shelters with tailored shape changes (Figure 1).

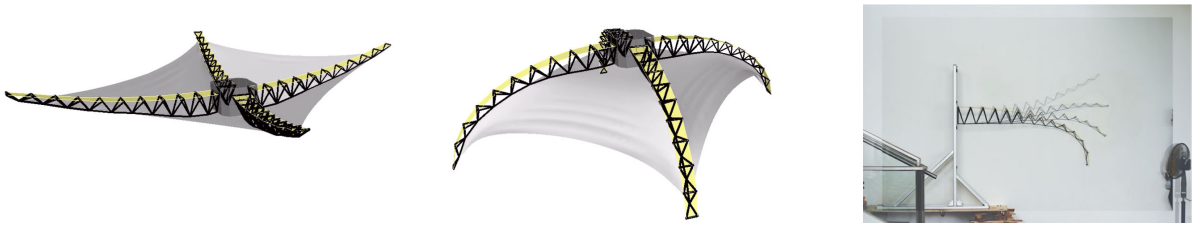

Figure 1. (Left) and (Middle) Dry and wet state of multi-truss assembly. (Right) 2 meter truss test

References

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