Sensor and Actuator Placement in Tensegrity Structures through Cellular Morphogenesis

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ABSTRACT

Tensegrity structures are self-stressed frameworks composed of elements in compression and elements in tension (bars and cables, respectively). Their stability is attributed to the existence of one or multiple set of forces (self-stress states) that induce self-equilibrium in the structure without any external loads or supports [1]. Tensegrity structures are thus statically indeterminate. Moreover, they are also often kinematically indeterminate: there exists a nodal motion (infinitesimal mechanism), except for the rigid-body motions, that can occur without changes in the element lengths. Since no deformation of the element lengths is required, infinitesimal mechanisms have been identified as ideal motion-control paths [2]. Consequently, tensegrity structures are materially and mechanically efficient systems that can combine structural elements with actuators and sensors. They thus have been proposed for active applications in science, engineering and architecture. However, existing form-finding and design methods typically do not address or provide any insight regarding sensor and actuator placement in tensegrity structures. In this paper, self-stress and infinitesimal mechanisms are investigated through cellular morphogenesis [3-4], a generative design process for tensegrity structures based on elementary units (cells), to identify appropriate sensor and actuator placement strategies. It is shown that the minimal number of sensors to characterize a tensegrity structure is the number of cells composing the structure, while optimal sensor and actuator placement can be linked through self-stress and infinitesimal mechanisms to the cellular composition of the structure.

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