Programming the next generation of living reconfigurable structures

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Abstract: Traditional methods of materials design for engineering applications consists of achieving optimal performance for specific conditions or moderate performance for a broader range of conditions. However, the integration of living materials can enhance their adaptability to external factors by adding a reconfiguration capability. This is achieved by implementing multiple elements connected by joints to create a system that can move and adapt in real-time. These systems can be visualized at the macroscopic level with adaptive facades, mesoscopic level with deployable origami-inspired structures and mechanical metamaterials, and microscopic level with microelectromechanical devices. In the field of robotics, achieving this adaptability often requires numerous actuators to facilitate a wide range of motion and capabilities. Nevertheless, this approach leads to exponentially increasing energy demands as the system size increases. This study proposes an alternative method that relies on a single linear actuator combined with semi-active joints with adjustable properties, such as friction-based joints that are activated with external non-mechanical stimuli, that will allow the change of shape of the entire system. Since this system only has a single active component, the shape control is restricted to the actuator's linear motion and the joints locking states, making motion planning a non-trivial problem. Therefore, this research introduces a motion planning algorithm based on Rapidly-exploring Random Trees and sub-slider-crank systems that explore the configuration space of the system through single degree-of-freedom motions. The proposed solutions are investigated toward the realization of living reconfigurable building facades for future adaptive architecture in smart cities.

Topical Keywords:

Material based actuators, environmental adaptivity, adaptive material systems, adaptive architecture, motion planning