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Robotic Materials

Advances in miniaturization of electronics, polymers and manufacturing have enabled a new class of of composite materials that tightly integrate sensing, actuation, computation and communication. Such a material, potentially consisting of thousands of identical computing elements, provides the potential to off-load high-bandwidth sensing, processing, and control into the material, which can then react autonomously to its environment. I dub these novel composites “robotic materials”. The challenges in creating robotic materials lie at the intersection of computer science, controls, and materials engineering and – from a CS perspective – require advances in distributed algorithms for signal processing, control and routing of information. I will illustrate these challenges and recent advances by my group using four systems that emphasize high-bandwidth sensing, distributed information processing, distributed feedback control, and self-assembly of robotics materials: (1) a soft robotic skin that can locate and classify textures by locally sampling, processing and classifying 3kHz vibration signals and route relevant information to a central processing unit using multi-hop networking. (2) A modular building block for creating intelligent walls and facade systems that can recognize complex gestures spanning multiple building blocks. (3) A variable stiffness composites that can assume arbitrary shapes using simple actuation and local feedback control. And (4) a swarm of ping-pong ball miniature robots “Droplets” that form a “Liquid that thinks” and allow us to study a variety of distributed algorithms including self-assembly and pattern formation. Robotic materials also provide novel means for artistic expression, allowing to create life-like systems that exhibit emergent behavior and chaotic dynamics in response to external stimuli including people. The talk is concluded with a brief discussion on the challenges that robotic materials pose in interdisciplinary education.