Reduced-Order Dynamical Models for Microrobots Driven By Laser Light

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Abstract

The objective of this research is to develop a general modeling framework for the description of laser light powered microrobots. The microrobots considered in this study are fabricated using Micro Electro Mechanical Systems (MEMS) technology. They consist of a "body", a set of actuated "legs", and other payload components. Microrobots are propelled (actuated) using laser light. Some of the actuation schemes considered in this study are based on the photo–thermo–mechanical process: upon laser light absorption, thermal expansion of the material is induced, which in turn initiates the motion of the structure (chevron or pseudo rigid beam structure). Control of the microbots' velocity can be realized through variation of the laser beam parameters: wavelength, intensity, duty cycle, repetition rate, size of the beam, and its position relative to the robot's structure. Finite Element Analysis (FEA) simulation and reduced-order modeling methodologies have been applied to develop a photo–thermo–mechanical model of the microrobots. The FEA model (based on ANSYS simulation software) is compared with a lumped model implementation in MATLAB, as well as with experimental results. Models follow the steps of the photo–thermo–mechanical process: laser light absorption in the robot's surface, heat generation, transfer, thermal expansion, dynamic motion generation, and stick-slip motion. Reduced order models based on the thermodynamic equations are constructed by analogy to the electric RC circuit – represented by thermal resistance, and thermal capacitance respectively. Those thermal components can be used to obtain temperature maps of the microrobot, and then can be utilized in a mechanical dynamic model (robot's components motion, and stick-slip propulsion). Proposed reduced-order models for microrobots can be implemented in the development of other systems of different classes, e.g., controllers. On the other hand, the presented reduced-order models, with a description of its development, can help illustrate and navigate the tradeoffs between modeling precision and computational complexity.

Biography of Presenter

Zhong Yang was born in TianJin, China, in 1989. He received his B.S. degree in Electronic Science and Technology from TianJin University, China, in 2012, and his M.S. degree of Electrical and Computer Engineering from University of Arizona, Arizona, in 2016. Currently, he continues his studies toward the Ph.D. degree in Electrical Engineering at the University of Louisville.