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Abstract

Manipulation of Microrobots Using Chladni Plates and Multimode Membrane Resonators †

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Abstract: (1) The advent of micro/nanorobotics promises to transform the physical, chemical, and biological domains by harnessing opportunities otherwise limited by size. Most notable is the biomedical field, in which the ability to manipulate micro/nanoparticles has numerous applications in biophysics, drug delivery, tissue engineering, and microsurgery. (2) Acoustics, the physics of vibrational waves through matter, offers a precise, accurate, and minimally invasive technique to manipulate microrobots or microparticles (stand-ins for microrobots). One example is through the use of flexural vibrations induced in resonant structures such as Chladni plates. (3) In this research, we developed a platform for precise two-dimensional microparticle manipulation via acoustic forces arising from Chladni figures and resonating microscale membranes. The project included two distinct phases: (i) macroscale manipulation with a Chladni plate in air; and (ii) microscale manipulation using microscale membranes in liquid. In the first phase (macroscale in air), we reproduced previous studies in order to gain a better understanding of the underlying physics and to develop control algorithms based on statistical modeling techniques. In the second phase (microscale in liquid), we developed and tested a new setup using custom microfabricated structures. The macroscale statistical modeling techniques were integrated with microscale autonomous control systems. It is shown that control methods developed on the macroscale can be implemented and used on the microscale with good precision and accuracy.

Keywords: chladni plates; multimode membrane resonators; acoustics; microparticle manipulation; microrobots

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