micro-robots

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Micro Robots

This webpage QR code

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Actuated micro robots and millirobots can enable low-cost and high-precision motion for future high-precision micro-manipulation or positioning tasks.

PDF Version of the webpage (first pages)

Micro Robots and Ferrofluid

Developing microrobots with multiple deformabilities has become extremely challenging due to the lack of materials that are soft enough at the microscale level and the inability to be reconfigured after fabrication. In this study, it is aimed to prove that liquid microrobots composed of ferrofluid droplets are inherently deformable and they can be controlled, individually or in aggregate, with multiple programmable deformabilities. For example, the liquid-microrobot monomer (LRM) can pass through narrow channels via elongation and achieve scaling via splitting and coalescence. LRMs can also reassemble into various kinds of functional liquid-robot aggregates, such as microsticks, micropies, microtrains, microkayaks, and microrollingpins. Thus, they can respond to multi-terrain surfaces or perform various complex tasks. Moreover, the authors' physics-based theoretical model demonstrates dynamic self-assembly and group behavior of a multiple LRM system, which is conducive to investigating the mechanisms behind it. These ferrofluid droplet robots provide novel solutions for some potential applications, such as untethered micromanipulation and targeted cargo delivery.

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Exploiting ferrofluidic wetting for miniature soft machines

Abstract
Miniature magnetic soft machines could significantly impact minimally invasive robotics and biomedical applications. However, most soft machines are limited to solid magnetic materials, whereas further progress also relies on fluidic constructs obtained by reconfiguring liquid magnetic materials, such as ferrofluid. Here we show how harnessing the wettability of ferrofluids allows for controlled reconfigurability and the ability to create versatile soft machines. The ferrofluid droplet exhibits multimodal motions, and a single droplet can be controlled to split into multiple sub-droplets and then re-fuse back on demand. The soft droplet machine can negotiate changing terrains in unstructured environments. In addition, the ferrofluid droplets can be configured as a liquid capsule, enabling cargo delivery; a wireless omnidirectional liquid cilia matrix capable of pumping biofluids; and a wireless liquid skin, allowing multiple types of miniature soft machine construction. This work improves small magnetic soft machines' achievable complexity and boosts their future biomedical applications capabilities.

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Ferrofluid Levitated Micro Milli-Robots

Abstract:
In this article, we study the use of ferrofluids for levitating magnetic micro/milli-robots. With the addition of a ferrofluid, the robots improved their weight-carrying ability (xI2, >12 grams) and precision (x2 ~5 um) without any associated increase in actuation power of the robot relative to sliding versions without the ferrofluid. To better understand the longterm stability of a ferrofluid on the micro/milli-robot, we perform motion cycle testing on two different surfaces (graphite and Teflon), ultimately achieving a motion repeatability and pose angular stability of 5 um and 0.05 °, close to the limits of our measurement setup. The underdamped motion of the ferrofluid robot showed a natural resonance of ~58-60 Hz. Through careful control of the evaporation of the ferrofluid, we show long-term stability of a ferrofluid micro/milli-robot over the course of >11 hours. While the performance of the robot does change due to evaporation of the particular ferrofluid used, we also show that robots can easily be replenished with new ferrofluid after mechanically cleaning away the remaining ferrofluid. Overall, the application of ferrofluids toward magnetically actuated micro/milli-robots can enable low-cost and high-precision motion for future high-precision micro-manipulation or positioning tasks.

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RFID

Both ferro-fluid and microbots can be combined with RFID to perform inventory, ID, and other functions.

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