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DEFORMATION OF A MAGNETIC FLUID DROPLET WITH AN IMMERSED MAGNETIZABLE BODY UNDER UNIFORM MAGNETIC FIELDS

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The potential of magnetic fluid (MF) droplets to be used as miniature reconfigurable soft robots and actuators for a range of biomedical, microfluidic, and lab-on-a-chip applications has been widely explored, e. g. [1-2]. Such robots, capable of controlled movement, can also engulf/transport or push/manipulate particles. Since position and shape control of MF droplets by the magnetic field gradient, direction, and magnitude has been well studied, we focus on combined shape control of a droplet and position control of an immersed body by uniform fields.

The effect of a uniform applied magnetic field on the deformation of a MF droplet with an immersed magnetizable ball is investigated numerically and compared with experimental data. A droplet is placed on a horizontal plane, and a ball takes its equilibrium position in the droplet at a certain levitation height above the plane under a uniform tilted field (see Figure 1). Spherical shape of the body is chosen for ease of calculating due to a known expression for the magnetic field near the surface of the ball being magnetized in a uniform applied field, but bodies of other shapes are also considered in the experiment. In the noninductive approximation, an analytic expression is obtained for the force exerted by MF on the body. We develop a 3D model to predict the deformation of the droplet under uniform fields of different directions and magnitudes. The levitation of a ball in a droplet is demonstrated experimentally and theoretically. It is shown that the ball levitation height increases with an increase in MF volume, magnitude and tilt angle of the applied field. It is found that there are minimum and maximum volumes of MF, and a minimum field magnitude required for body levitation. Given these results, we conclude that the droplet shape and the ball position could be controlled by tuning the tilt angle and magnitude of the field.

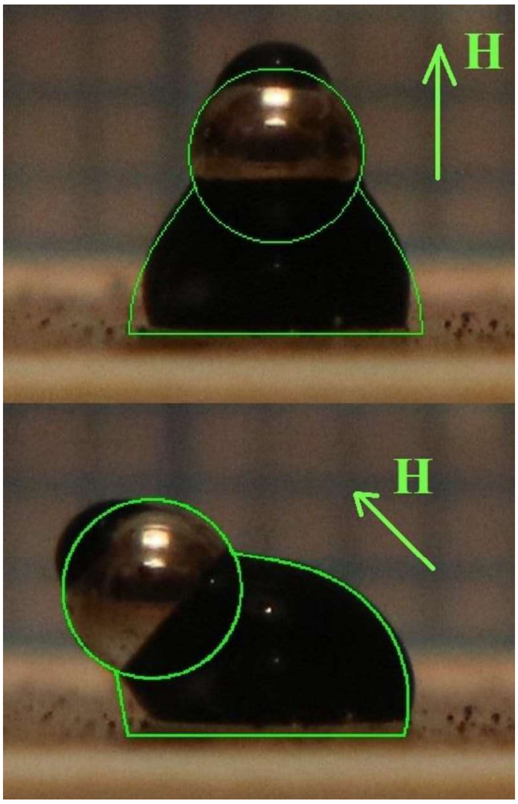

Figure 1. Experimental and calculated profiles of the MF droplet with an immersed magnetizable ball under the uniform field of different directions.

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[1] R. Ahmed et al., *Soft Robotics*, **8** (2021) 687-698.
[2] L. Yang et al., *IEEE/ASME Transactions on Mechatronics*, **3** (2023) 1-11.