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Bayesian inference of the model parameters of a microfluidic acoustic flow

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Drop-on-demand inkjet printing is one of the most widespread applications of microfluidics. A typical inkjet printhead is composed of several microchannels and nozzles. Piezoelectric actuators placed at the microchannel walls are used to force ink droplets through the nozzle. After droplet injection, acoustic waves travel through the microchannels until they are damped by viscous dissipation. These reverberations must be cancelled before jetting the next droplet so that all droplets are uniform. Open-loop control of the actuator has been designed to damp these reverberations faster and increase the jetting frequency [1, 2]. However, the pressure waves generated can also deform the microchannel walls [3]. This deformation produces pressure waves in the adjacent microchannels. The amount of acoustic energy transmitted mainly depends on the structural properties of the shared boundaries. This phenomenon makes it challenging to control the reverberations effectively in the whole printhead. In this study, we formulate a Bayesian inverse problem to infer the mechanical properties of the compliant microchannel walls. The experiments are performed by selectively deforming one actuator while leaving the rest passive. The amplitude of the deformation is small enough to avoid droplet jetting. High-speed cameras capture the velocity of the meniscus attached to the nozzle outlets. We solve the data assimilation problem using a gradient-based optimization algorithm accelerated with the adjoint method for gradient computation. As a result, we obtain the wall properties that most likely fit the experimental data.

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