Digital Microfluidics Using Marangoni Flows

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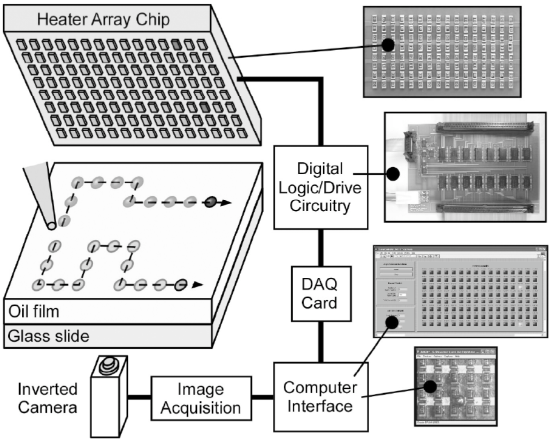
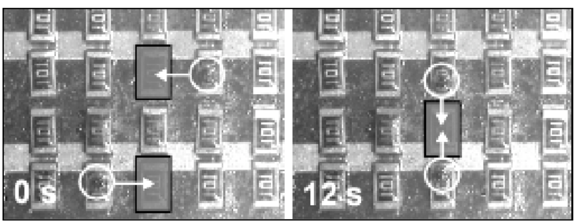


Schematic of the programmable system for noncontact droplet actuation based on Marangoni flows. The system includes a 128-pixel array of resistive heaters suspended above the oil layer, control circuitry, and a graphical user interface.



Manipulation and merging of 500nL droplets via sequential activation of heater pixels.

In digital microfluidic systems, microdroplets submerged in oil serve as isolated reagent containers. Compared to the traditional channel-based microfluidic systems, droplets offer low-reagent consumption and an elegant approach for handling thousands of isolated samples simultaneously. Existing techniques for droplet manipulation require physical contact between the droplet and a solid surface, which leads to device contamination and sample loss. This project explores the use of Marangoni flows to manipulate droplets without contact. Flows are generated by an array of heaters suspended above the oil surface. Multiple droplets can be transported and merged through the sequential activation of heaters. A variety of other flows, engineered through the geometric design of the heat source, can emulate common microfluidic components such as filters, traps, and pumps. Supporting simulation models show that the Marangoni effect scales favorably to smaller dimensions, providing >1mm/s flow velocities with <5° change in surface temperature. This project is being supported by the National Science Foundation, the National Institute of Health, the University of Michigan, and by a Whitaker Foundation Fellowship (AB).