Abstract

Microfluidic chips, devices that transport fluids through channels on the micron scale, help make biological experiments more cost and time efficient. However, designing these chips can be challenging for a biologist entering the field. Specifically, a droplet generator, one of the most basic microfluidic components, requires many iterations of testing and validation to ensure it produces droplets at the correct rate and of the correct size. The goal of this research project was to make droplet generator design faster and simpler through the software we developed. The first program, Micro Droplet Rate/Region Occlusion Processing (u-DROP), was used to determine the droplet size and generation rate produced from various experiments in which we changed the chip’s orifice size, aspect ratio, width ratio, orifice length, and the water and oil input width, the capillary number, and the flow rate. The data gathered from these experiments was used by the second program, Design Automation based on Fluid Dynamics (DAFD) to suggest a droplet generator design that can produce droplets at the specified rate and size. DAFD employs two interpolation models, one to output generation rate and one to output droplet size, to make its predictions. DAFD was validated on a test data set of 2500 randomly generated points.

u-DROP

Input: Video & Meta Data
Frame Cropping & Edge Detection
Wave Smoothing
Average Pixel Values
Size Calculation at Local Maxes
Final Outputs
Generation Rate Droplet Diameters

DAFD

Desired Values
\( g (x) = (f (x) - f_0) / (f_1 - f_0) \)

Constraints
Show formula

Optimization parameters are optimal.

The simulated dataset is 2500 points created by running 8 inputs (randomly chosen to be within the range of our real data) through functions \( f_0 \) to get generation rate and \( g \) to get droplet size. \( f_0 \) and \( g \) are functions we created that are meant to be a simple (but inaccurate) representation of the real world function (which is mathematically difficult to determine) that maps our inputs to outputs.

The error for a given input \( i \) can be calculated as \( \frac{\| y - f (x) \|}{\| y - f (x) \|} \)

Additional Reading

- Wei-Yin Loh (2011). Classification and Regression Trees. WIREs Data Mining and Knowledge Discovery, Volume 1, 14-23.

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