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He received, the BS, MS, and PhD Degrees, all in Computer Science, from UCLA in 2002, 2003, an 2006 respectively. From 2006-2009 he was a Postdoctoral Scholar at EPFL in Switzerland. He has been with UC Riverside since 2009. His research interests include computer architecture, FPGAs and reconfigurable computing, and programmable microfluidics.

Title: "Design Software for Microfluidics: Integrating Fluid Modeling with Design Objectives"

Abstract:
Current design methodologies for microfluidic chips leave a lot to be desired, especially when compared to the highly customized software that has been available to semiconductor designers for decades. In particular, there is a disconnect between software used to design and physically lay out microfluidic chips, and fluid modeling software. Each modification to the design necessitates an update to the fluid model, but it is left to the ingenuity of the designers and modelers to make the necessary design modifications to eventually converge to a workable chip. Due to the ad-hoc nature of the design process, an unfavorably large number of design-fabricate-test cycles are required to produce a correctly operating prototype. There is an urgent need for software technologies that can reduce the costs associated with designing a new microfluidic chip, as well as time-to-market. This need can only be met by custom design software for microfluidic devices that integrates fluid modeling and is aware of the design objectives. This type of software can apply algorithms and other strategies from the domain of Computer Science to help microfluidic chip designers rapidly achieve design closure.

This talk will summarize two example projects where this approach has been successfully applied to the design of different types of microfluidic chips:

In the first case, we created functional microfluidic chips without actually designing them. We accomplished this by first generating a library of thousands of different random microfluidic chip designs, then simulating the behavior of each design using finite element analysis.
The simulation results were then saved to a database which a user can query to find chip designs suitable for a specific task. We used our library to select chip designs that generate any three desired concentrations of a solute. We also fabricated and tested 16 chips from the li- brary, confirmed that they function as predicted, and used these chips to perform a cell growth rate assay. In principle, any microfluidic chip that can be simulated could be designed automatically using our method.

In the second case, we observed that particle tracers in some existing commercial computational fluid dynamics software is not well-suited to accurate simulate the trajectories of particles such as cells, microbeads, or droplets. To address this issue, we introduce a microfluidics-optimized particle simulation algorithm (MOPSA) that simulates the trajectories of cells, droplets, and other circular/spherical particles in microfluidic chips, obtaining more realistic results that existing commercial particle tracers. When calculating

the velocity of a particle, MOPSA treats the particle as a two-dimensional rigid circular object instead of a single point and checks for unrealistic interactions between particles and channel walls and applies an empirical correcting function to eliminate these errors.
To validate the performance of MOPSA, we used it to simulate a variety of important features of microfluidic devices like channel intersections and deterministic lateral displacement (DLD) particle sorter chips.
MOPSA successfully predicted that different particle sizes will have different trajectories in six published DLD experiments published by three research groups; these DLD chips were used to sort a variety of different cells, particles, and droplets. While some of these particles are not actually rigid or spherical, MOPSA's approximation of these particles as rigid spheres nonetheless resulted in lifelike simulations of the behaviors of these particles (at least for the particle sizes and types shown here). In contrast, existing commercial software failed to replicate these experiments. Finally, to demonstrate that MOPSA can be extended to simulate other properties of particles, we added support for simulating particle density to MOPSA and then used MOPSA to simulate the operation of a microfluidic chip capable of sorting cells by their density. By enabling researchers to accurately simulate the behavior of some types of particles in microfluidic chips before fabricating the chips, MOPSA should accelerate the development of new microfluidic devices for important applications.