MFDA Review

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1 Synthesis vs. Simulation

Current MFDA algorithms have been developed with the approach of 1) logic synthesis or 2) simulating microfluidic physics to develop a final chip design.

Synthesis is an approach inspired by current EDA logic synthesis, producing a microfluidic device layout through some method or methods of algorithmic optimization.[reference Wang (2)] [reference -]

- X. Huang et al., ”PathDriver: A Path-Driven Architectural Synthesis Flow for Continuous-Flow Microfluidic Biochips,” 2020

Simuation is a recent apporach to MFDA that deviates from traditional EDA approaches by simulating the physics of microfluidic components directly and solving the resulting differential equations. [reference]

- A. Voigt, et al. ”Method for the computer-aided design and simulation of hydrogel-based microfluidic chips,” 2021.

No current MFDA approach combines both synthesis and simulation to arrive at an optimized chip design.

A majority of papers use the approach of synthesis.

In the synthesis space, a small number of papers (5) and only two unique research groups focus on end-to-end synthesis, or synthesis that includes all layers, levels, and application of a devices. The most developed is Cloud Columba by the Schlictmann group (add references). Cloud Columba allows a researcher to easily define components and connections between them and generates 2 2D mask files for the flow and control layer respectively. Though easy to use for simple designs with few components, Cloud Columba becomes exponentially more time-consuming as components are added as connections between components are defined by users, not automatically generated.

Additionally, some synthesis papers have begun to target the outcome of a more reliable design. There are two main approaches to this: testing automation and fault tolerant design. In testing, (9 papers), the Schlictmann group and the Chakrabarty group have used algorithmic optimization to generate and determine results of tests of microfluidic chips executed experimentally. In fault-tolerant design, (3 papers), the Pop group includes tolerance to a set-list of faults as an optimization parameter alongside other optimization parameters such as chip area.

[table here]

2 Flow Layer vs. Control Layer

MFDA algorithms typically optimize either the flow layer or the control layer. The flow layer controls fluid and channel routing whereas the control layer operates

control pins or valves to control which channels the flow is routed to.

A majority of papers optimizes the control layer. discuss papers that talk about both

table: papers that target both flow and control layer

3 What is being optimized for?

Current MFDA algorithms are optimized for parameters of design complexity, manufacturing efficiency, chip behaviour, and algorithmic effectiveness, but each synthesis approach is often optimized to a very specific approach, application, or algorithm,and its performance is evaluated accordingly. This silohed approached to evaluating optimally makes it difficult to determine the optimal design automation approach. Additionally, not all of these parameters are relevant across every application, and optimizing for one parameter can sometimes preclude optimizing for another.

[can we use a table here?]

4 Some tables

Review papers: 5

Process	Num. Papers
Synthesis	26
Simulation	10
End-to-end	5
Testing	9
Fault-tolerant design	3
Flow layer	5
Control layer	9

Figure 1: Process organization

5 To Do

6 Notes

physical design default (vs. simulation)

control layer default (vs. flow layer or combined)

7 Questions

How many references/papers to include? - pick things that are the most relevant - important or unique contributions - telling a story, how does a reference support it? - some ”small” details - want to tell a unique or different story than other review papers - just talk about what each paper contributes, mention that they each track different metrics, maybe explain why one is better than another - balance of description vs. judgments - reserve judgments for ”when it’s useful”, mainly you’re saying ”here’s what’s out there” - papers that build on each other: maybe

Figure 2: This is a caption

first and last

What's a good citation method to use? - IEEE standards

what makes a table helpful? - what topics? - what comparison fields?

you have to figure out what the comparisons are, no comparisons, no table, don't always have to have something in every field - useful for finding papers - maybe whether or not it includes a design file

If you have a lot of possible papers for a table, how do you decide which ones to include?

8 Template Stuff

Figure 2 contains very important information.

I'm smart like Einstein. [1]

References

[1] Albert Einstein. “Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]”. In: *Annalen der Physik* 322.10 (1905), pp. 891–921. DOI: http://dx.doi.org/10.1002/andp.19053221004.