Standardizing Design Performance Comparison in Microfluidic Manufacturing

Methods and means for microfluidic physical design tools

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1 INTRODUCTION

The automation of rote laboratory experiments and the transformation of ultrahigh throughput, controlled in-vitro testing environments have burgeoned in the space of microfluidic design automation, attracting researchers from biology, electronic design automation (EDA) and computer engineering alike over the last decade. Today a large section of the microfluidic devices represented in the literature are not published with sufficient information for automating the physical design process. With the advent of component level design tools like 3DuF1 [Lippai et al. 2018], the problem of microfluidic physical design automation is no longer just a computational problem to solved in a sandbox but also a necessity to proliferate the technology into research labs.

However, the lack of detailed design information accompanying published microfluidic designs has severely limited researchers’ ability to work with test cases that are representative of the latest class of devices that are being used in research labs. The work done by CIDAR2 at BU and CARES3 at UC Riverside has resulted in the development of methodologies and standards that allow researchers to gauge the efficacy of developed algorithms.

2 DEPENDENCE ON MANUFACTURING

Evolving manufacturing technologies and protocols and the emergence of low cost manufacturing tools [Lashkaripour et al. 2018; Walsh et al. 2017] have lowered the entry barrier for manufacturing microfluidic devices. Since microfluidic device architectures have to date been primarily dictated by the capabilities of the manufacturing technologies used, the emergence of low cost manufacturing techniques has the

\[\text{http://3DuF.org}\]
\[\text{http://cidarlab.org/}\]
\[\text{http://www1.cs.ucr.edu/faculty/philip/}\]

Figure 1: By generating and examining the designs of architectures that occupy various regions in the benchmark space, researchers can optimize/modify their physical design algorithms.

potential to upend the assumptions and constraints that are factored into the physical design algorithms.

3 BENCHMARK SPACES

Any abstract architecture of a microfluidic device has potentially infinite ways in which it can be realized as a design. Moreover any solution for a design of a microfluidic chip
could have numerous valid layouts based on the application space.

Hence to compare different devices and different algorithms we introduce Benchmark Spaces to understand the performance of algorithms on different devices compared against useful performance metrics. Each benchmark space is a 2D/3D visualization of the various microfluidic devices where each of the axes is a unique characteristic of the device. The graph in Figure 1 is an example of benchmark space characterizing the statistics of microfluidic components that constitute the device design. We believe that this visualization method allows the researchers to compare the quantitative and the qualitative results of their layout algorithms against different devices that occupy the same region in a benchmark space.

Since literature in the microfluidic physical design typically only characterize microfluidic devices by the number of components, connections. We believe that the work done towards formalizing and refining the parameters used in visualizing benchmark spaces will prove to be an invaluable resource to effectively monitor the efficacy of physical design algorithms against different classes of devices.

4 STANDARDS

While benchmark spaces can help address the problem of comparing vastly different microfluidic designs from different application spaces for the purposes of physical design, it is still necessary to create standards that not only ensures that the data can be shared efficiently between research groups that engage in algorithm research but also encourages device designers and manufacturers to adopt the standards. This is achieved by allowing the interchange format to include custom fields at the top level which can be used for application/algorithm-specific constraints. Figure 2 shows how the interchange format used for describing microfluidic device designs can capture the Specify, Design and Build work flow for microfluidic devices.

REFERENCES

