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Bio-Design Automation: Nobody Said It Would Be Easy

We choose to go to the moon in this decade and do the other things, not because they are easy — but because they are hard!

John F. Kennedy, Rice University, September 12, 1962

"Biology is complex." "Biology is not well understood enough to engineer." "Biology is not ready for design software." Sound familiar? As an electrical engineer entering synthetic biology in 2007 I have heard all of these and more (some are less polite). It is often pointed out that biological systems lack many of the characteristics that have allowed mankind to engineer electronic systems. While it is undeniably true that biological systems and electronic systems have differences that must be respected, I strongly reject the idea that somehow designing electronic systems is "easy" or that electronic systems consisting of millions of analog and digital components are "simple". Additionally, I would also not state that we fully "understand" electronics particularly at the nanoscale or even, at times, at the system level (consider real time computing or embedded large scale systems). I would contend that the work in electronic design automation (EDA; the field that designs computer software for electronic design) represents some of the most important and groundbreaking research of the 20th century. The result of this work is an automated design flow that allows human readable designs to be translated seamlessly into an engineered semiconductor. Processes such as hardware design languages, logic synthesis, physical design, and solid state manufacturing represent a design workflow involving a diverse set of technical expertise and a rigorous adherence to design standards. Moreover, these phenomena are captured in commercialized software — this has not only fueled the growth of Silicon Valley but also made it possible for undergraduates to design electronic systems as early as in their freshman year.

It is with this history that electrical engineers and computer scientists enter synthetic biology. I believe that we have roughly two choices: first, we wait until biology is fully understood to create design tools, or second, we start today with what we know and create flexible, adaptive software that paves the way to a more fully understood future while providing tangible, experimentally verifiable results today. If synthetic biology is to be an engineering discipline, then I cannot imagine any of its practitioners not agreeing with the latter approach. Also, I cannot imagine an experimental synthetic biologist that could not think of at least a dozen computational tools that would make his or her life easier. Everything from data management tools to DNA assembly planning algorithms are practical ways that computational approaches can have immediate impact in real working laboratories. It is our responsibility as a community to clearly identify these opportunities and help make the connection between researchers so we see these tools come to fruition. We need to continue to work together instead of finding reasons why X will not work or why Y is too hard. In fact, I would issue a challenge to the synthetic biology community that if your research does not produce results incorporated in engineered, computational artifacts you are not doing synthetic biology.

This issue highlights a number of computational approaches that begin to pave the path for the creation of computational software tools that respond directly to the need of synthetic biologists. These include entire computational workflows, tools for simulating Multicellular systems, and algorithms for assigning physical DNA parts to functional descriptions.

In conclusion, can you envision a world where computation does not play a role? Will synthetic biology be a computation-less domain? As you read these articles on a computer/ipad/cellphone, you think 'no'. So, we are in agreement! Perfect! Therefore, let us work together to further the fantastic history of interdisciplinary collaboration in synthetic biology. Let us find solutions not excuses, create standards not propriety, take risks, and not remain conservative. Until next time, see you in the lab (on my computer).

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