2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

Real-time sorting of microtransponders for high-throughput DNA synthesis

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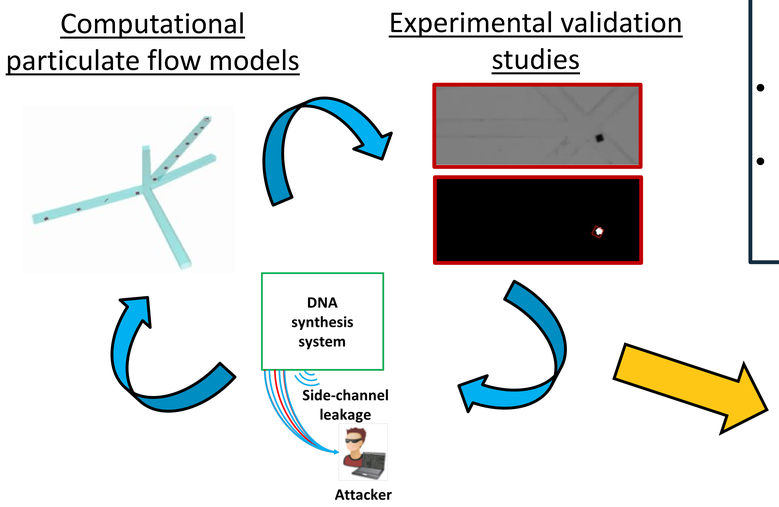
Challenges

- **Large-scale DNA synthesis** requires substantial improvements in **throughput**, **accuracy**, and **robustness**.
- Manipulation of solid-phase supports used for synthesis requires understanding of **particulate flow behavior** and methodology for **detecting**, **tracking**, and **sorting** particles in **real-time**

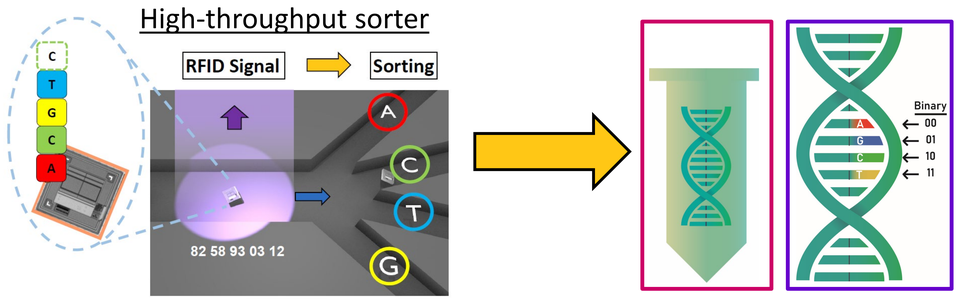


Solution

- Develop a platform for secure, high-throughput DNA synthesis involving sorting identifiable solid-phase supports (p-Chip, PharmaSeq, Inc.) to reaction reservoirs for parallel synthesis
- Utilize a cyber-physical co-design process employing computational simulations to evaluate geometrical design and operating parameters for a throughput-optimized sorter manifold, and experimental studies to validate the models
- Design an FPGA-accelerated implementation for real-time detection, tracking, and sorting of p-Chips

Key Contributions to Date

- Identified and utilized numerical frameworks to model the flow behavior of flat-plate, non-spherical particles in microchannels
- Developed a vision-based implementation for particle detection using pattern matching, and tracking using mean shift algorithms to control real-time sorting of p-Chips



Scientific Impact

- Project will lead to large-scale manufacturing of synthetic DNA which advances areas of research in synthetic biology and computer science
- Project will further the fundamental understanding of flat-plate particulate behavior in microchannel flows
- Project will inform the design and implementation of vision-based, real-time systems for actuations and control

Broader Impact

- Accurate, high-throughput synthesis of encrypted DNA will yield **therapeutic products** and aid in realizing DNA as a medium for **digital data storage**
- Project will train students in the co-design paradigm for fluidic cyber-physical systems, and engage the public in learning about particle sorting and the broader applications of DNA
- The project will **reduce the cost** of synthesized DNA oligonucleotides by **3-4 orders of magnitude**