Microfabrication of Biological Machines for Sensing and Locomotion

Ritu Raman, Mechanical Science and Engineering

Co-Advisers: Rashid Bashir, Bioengineering & Electrical and Computer Engineering

Taher Saif, Mechanical Science and Engineering

Key Research Aims and Goals

- To develop cell-based soft robotic devices, or "bio-bots" that utilize the dynamic nature of living components to perform myriad sensing and actuation tasks.
- To develop the design rules and principles that govern building integrated cellular systems capable of complex behaviors.

Research Highlights and Results

- Recent studies in our lab have demonstrated bio-bots fabricated via stereolithographic 3D printing that use the autonomous and synchronous contraction of engineered cardiac muscle as an actuator for locomotion.[1]
- We have extended this work by micro-fabricating bio-bots powered by the contraction of 3D strips of engineered skeletal muscle that can be paced and controlled via external electrical signals. [2]
- Currently, we are developing engineered cardiac and skeletal muscle based bio-bots that are genetically engineered to express a light-activated cation channel (Channelrhodopsin-2) and contract in response to pulsed blue light (490 nm). This "optogenetic" control of bio-bots is expected to enable targeted and noninvasive muscle actuation in real time with high spatiotemporal resolution.

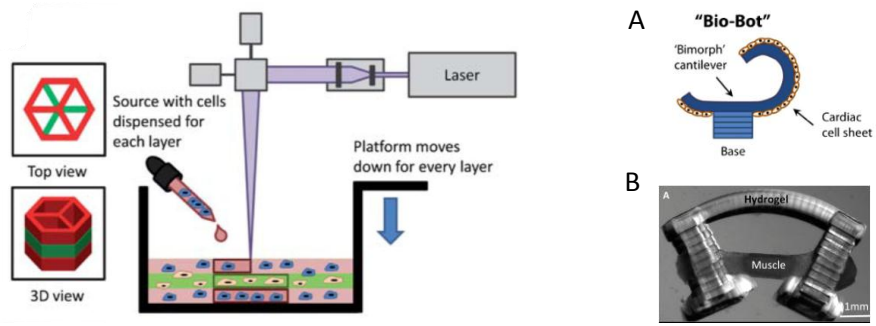

Figure 1: SLA system for fabricating: A) 2D Cardiac Cell Sheet based bio-bots; B) 3D Skeletal Muscle Strip based bio-bots . [1,2,3]

Future Research Plans

- To integrate multiple cell types into the bio-bots, including neuronal circuits that can interface with the engineered muscle via functional neuromuscular junctions.
- To develop bio-bots that are robust and can function in non-ideal environments by engineering soft microfabricated exoskeletons that provide them with an appropriate biochemical and physical environment.
- To apply the bio-bot technology to applications in drug delivery, non-invasive surgery, and biocompatible microelectronics.

[1] V.Chan, et al. *Scientific Reports* (2012).
[2] C. Cvetkovic, R. Raman, et al. (In Review)
[3] V.Chan, et al. *Lab on a Chip* (2010).