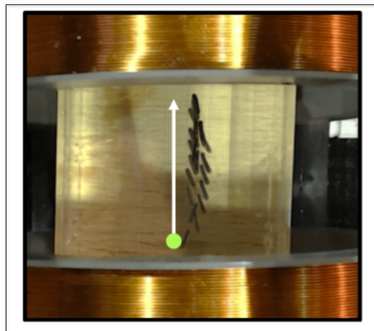
CPS: Small: Geometric Self Propelled Articulated Micro-Scale Devices
Award #: 1739308, Award Date: September 1, 2017

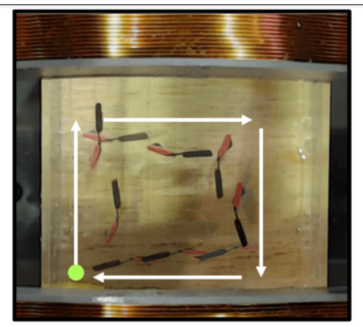
Matt Travers[1] and Rebecca Taylor[2]
1: http://biorobotics.ri.cmu.edu/index.php 2: http://www.andrew.cmu.edu/user/bex/stories/welcome/

Objective:

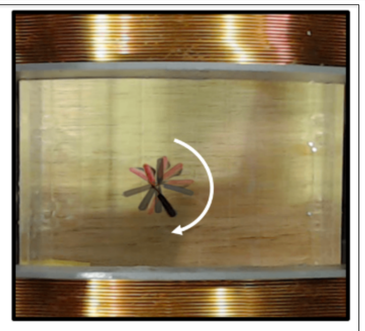
Demonstrate geometry-based trajectory generation methods for self-propelled millimeter-scale devices. Prototype optimized micron-scale devices. Integrate robotics and microfabrication systems to fundamentally change cyber-physical system design and control.



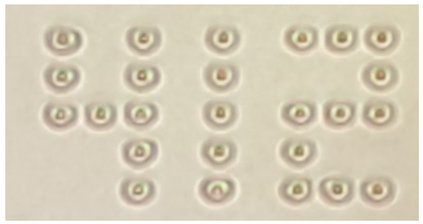
(a) Translation in the two-link swimmer



(b) Rectangular Trajectory Following



(c) Turning in place



100% pocketing with microspheres (Phosphorex, avg. dia. 1.8µm), sonication at 30V for 2 min.

Challenge:

Integrate motion planning and mechanical design for microscale devices

Scientific Impact:

Develop cyber-physical system design process that informs the construction of mechanical prototypes via geometric modeling and optimalmotion planning

Broader Impact – Society:

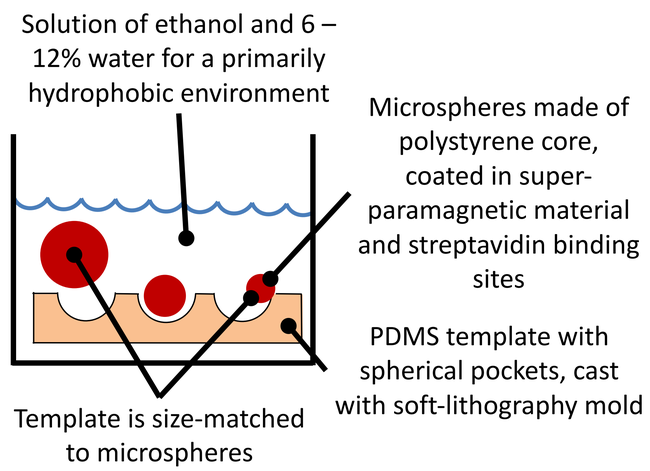
Establishes the foundation for novel medical device deployment. Enables non-invasive surgery, biosensing, targeted drug delivery

Broader Impact – Outreach:

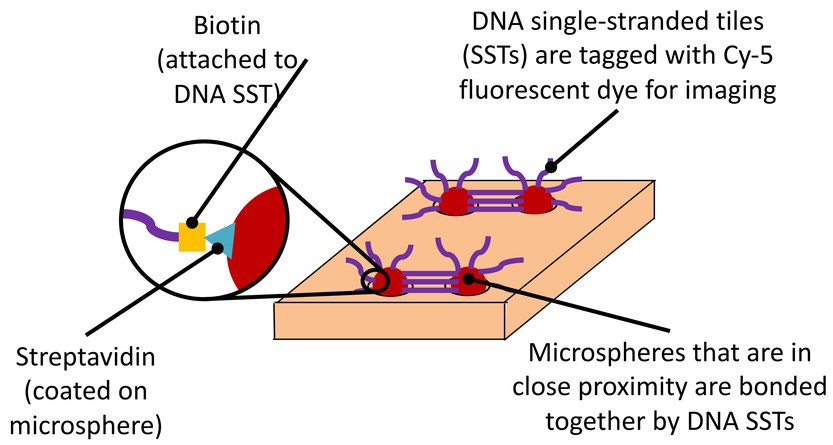
- Saturday class on DNA origami taught through CMU Gelfand Outreach Center to 30+ middle school students bi-annually
- Diverse team of graduate and undergraduates are mentored on this project

Y2 Outcomes:

- Created novel motion primitives for millimeter-scale two-link, springless swimmer in low Reynolds number regimes and investigated stability. Demonstrated control paradigms for different motions including translation, turn-in-place and trajectory tracking [1]
- Established a robust pocketing technique for templating micron-scale paramagnetic beads by tuning sonication energy, environment hydrophobicity and size matching parameters. Completed early experiments in connecting beads with DNA SSTs and transferring to biotinylated surface



Use sonication and hydrophobic environment to pocket microspheres in a patterned template.



Drop DNA single-stranded tiles (SSTs) on template and incubate to allow biotin-streptavidin bonding to occur. Image via fluorescence microscopy.

[1] Grover, J., Vedova, D., Jain, N., Vedova, P., Travers, M., & Choset, H. (2018). Trajectory Generation for Millimeter Scale Ferromagnetic Swimmers: Theory and Experiments. Retrieved from http://arxiv.org/abs/1810.11191

Mechanical Engineering | Carnegie Mellon University | The Robotics Institute

Award ID#: 1739308