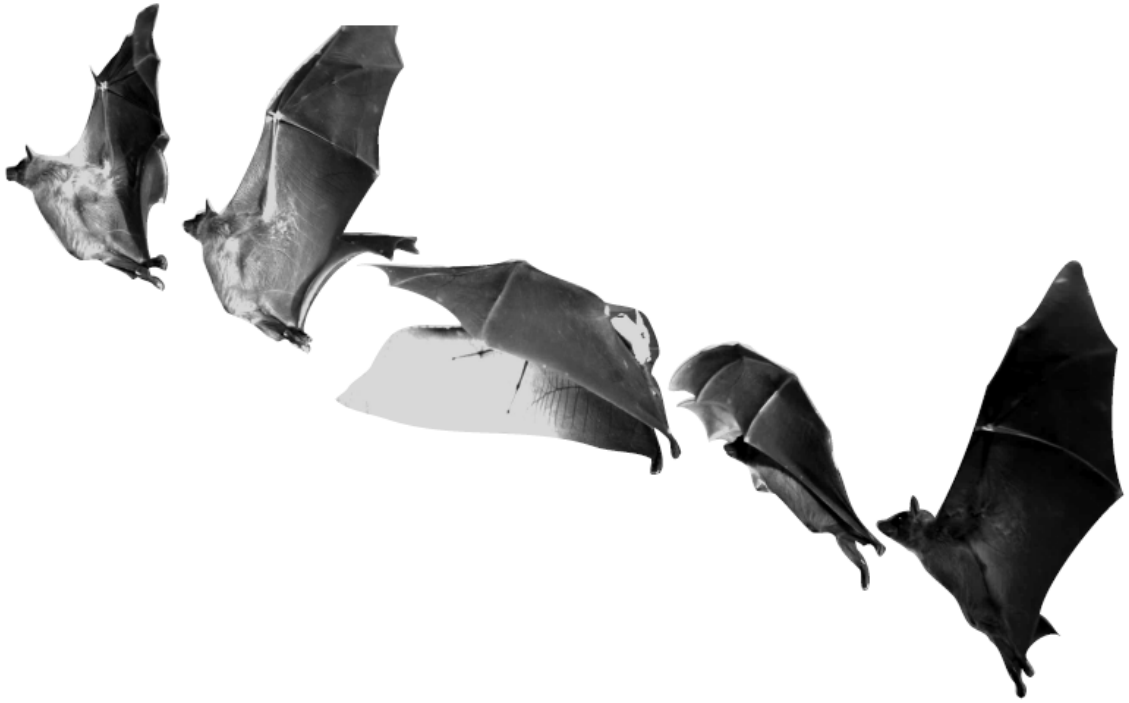


NRI:EAGER: Teaching Aerial Robots to Perch Like a Bat via AI-Guided Design and Control

Sarah Ostadabbas **Alireza Ramezani**

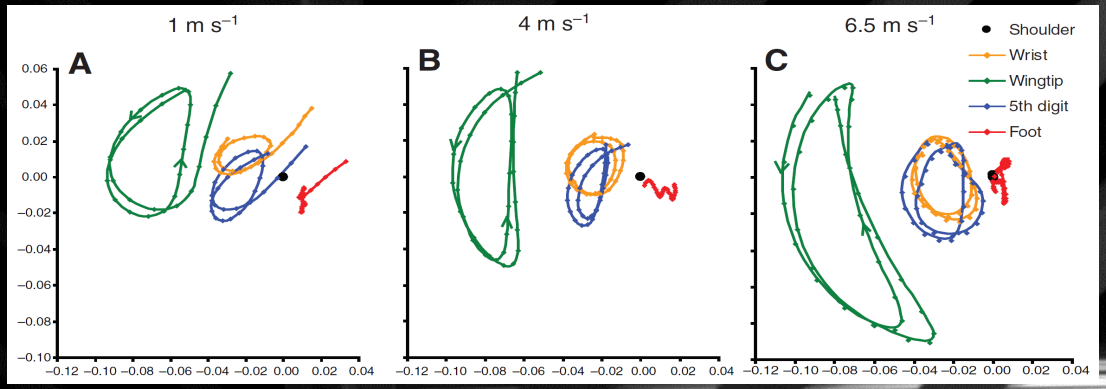
Electrical and Computer Engineering

Northeastern University

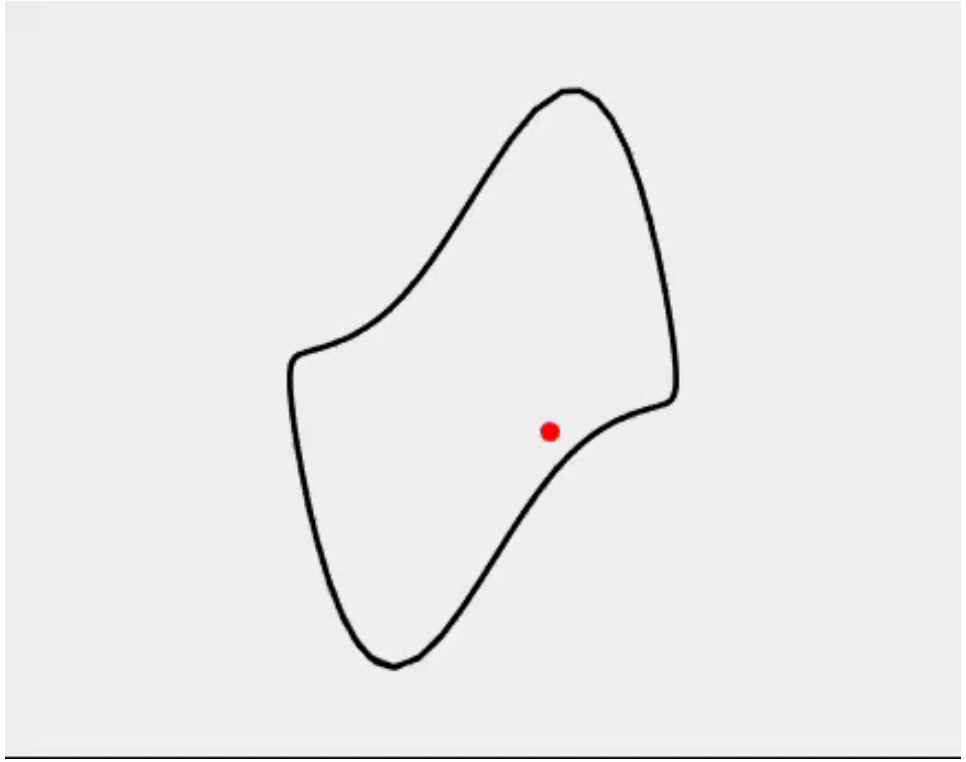
Northeastern University

A bat being hit by air jet,

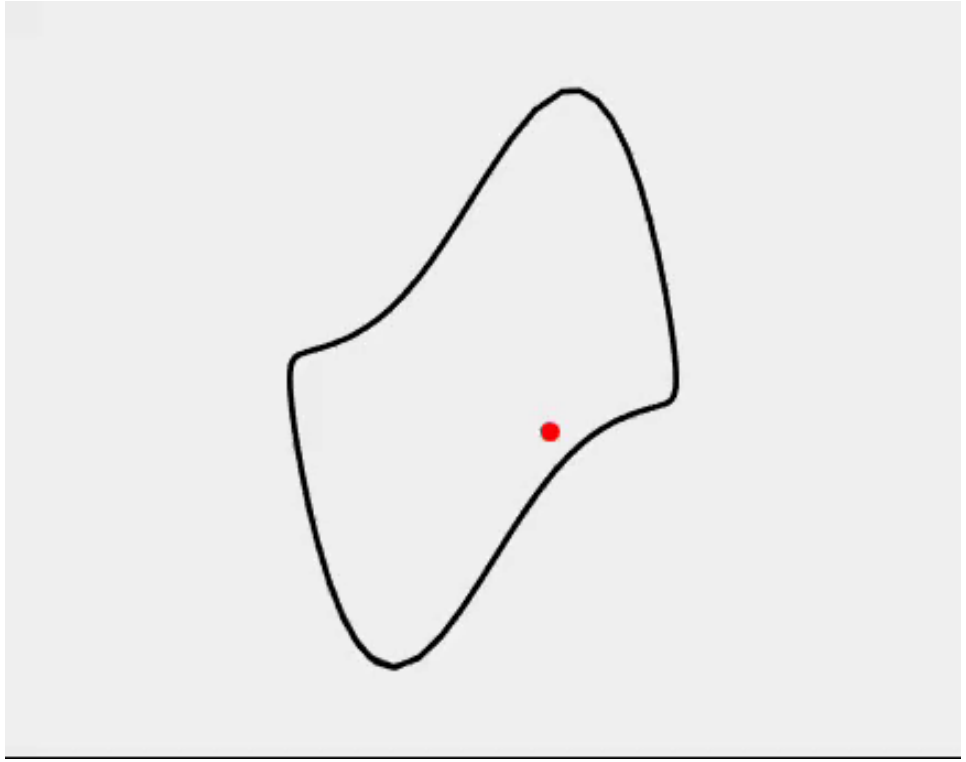
credit: David Boerma, Brown University



Wolf et al., J. of Exp. Bio, 2010.



CMs in insect-style flight



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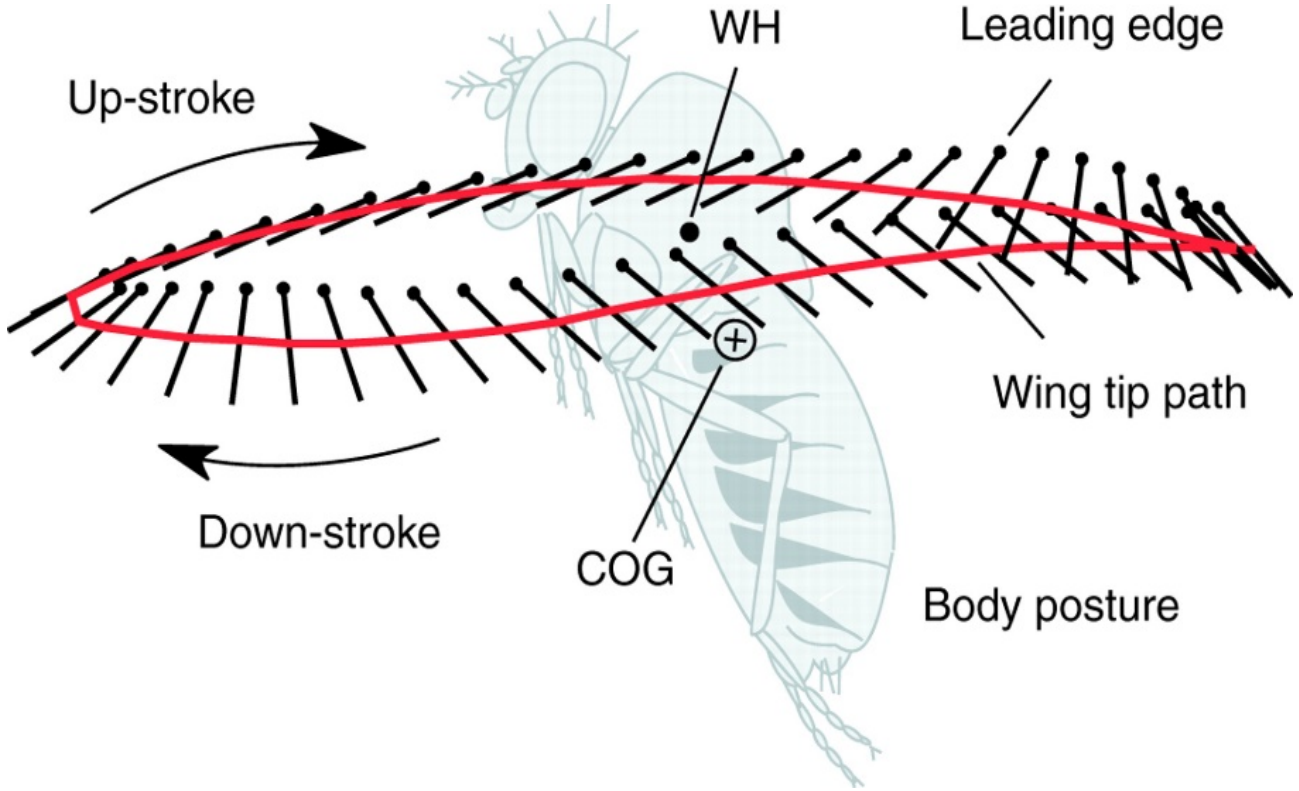
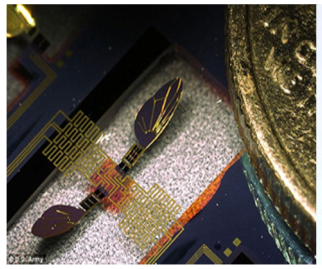
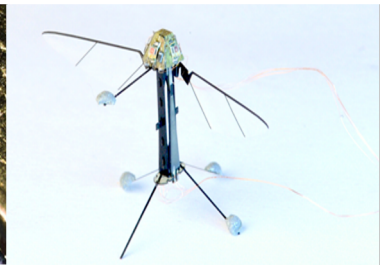


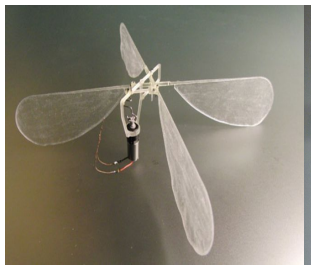


Army Research Lab Insect Robot

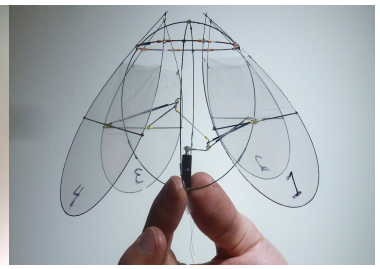


Harvard RoboFly

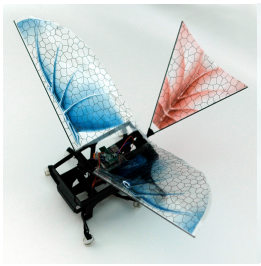
NanoHummingbird



Cornell Robot

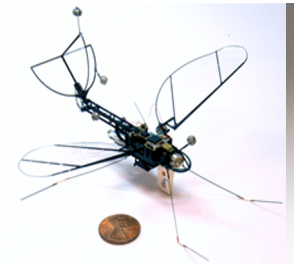


Jellyfish Flyer



UC Berkeley Dash

UCB Bolt



Harvard Moth Robot

CIA Inceptothopter

FESTO Dragonfly

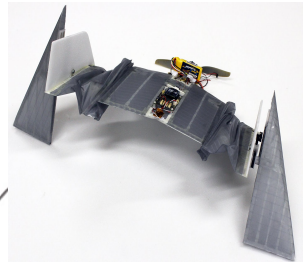
FESTO Bird

MIT Phoenix

RoboSwift

UF's Morphing Design

EPFL's Morphing Design



EPFL DALER

NRI/Collaborative Research: Improving the Safety and Agility of Robotic Flight with Bat-Inspired Flexible-Winged Robots (PI S. Hutchinson, 2014)

Long-term Objective:

- *Expand airborne, vertebrates locomotion theory and practice*
- *Tight integration of aerial robots in human-occupied spaces*
- *Diversify the field of robotics-inspired biology*

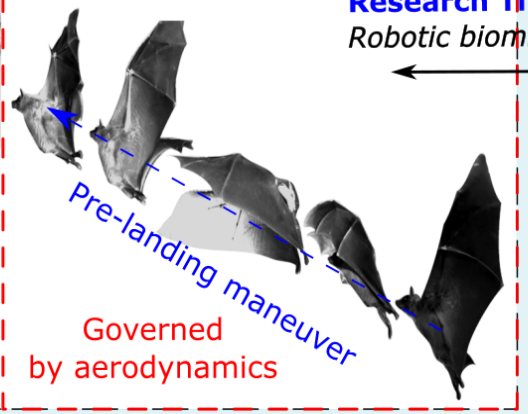
Expeditionary Cyber and Unmanned Aerial Systems Research Facility

Brown University Animal Flight and Aeromechanics Study Facility

Northeastern Center for High-rate Nanomanufacturing

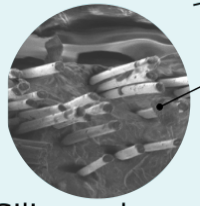
Research Thrust-I: *Reduced-order description of landing bat*

Research Hypothesis: *Landing bat manipulates inertial dynamics*

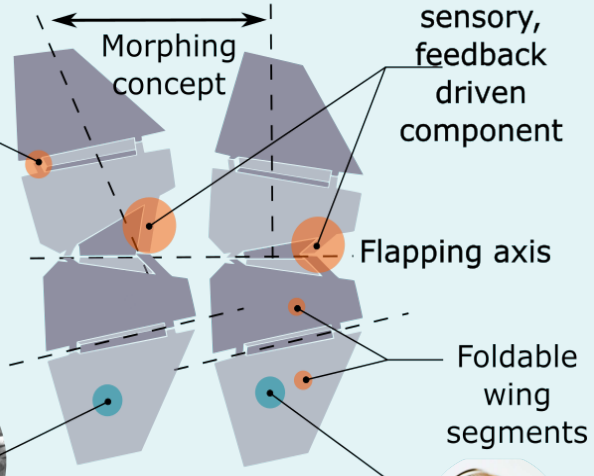


Research Thrust-III: *Robotic biomimicry of perching*

Research Thrust-II: *Robot design*



Silicone-based anisotropic membrane



Soft electronics, direct force sensing

Long-term Objective:

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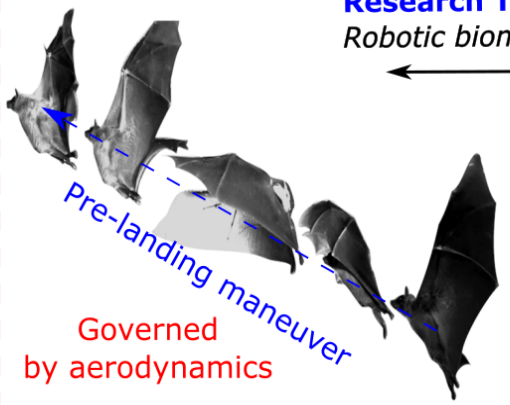

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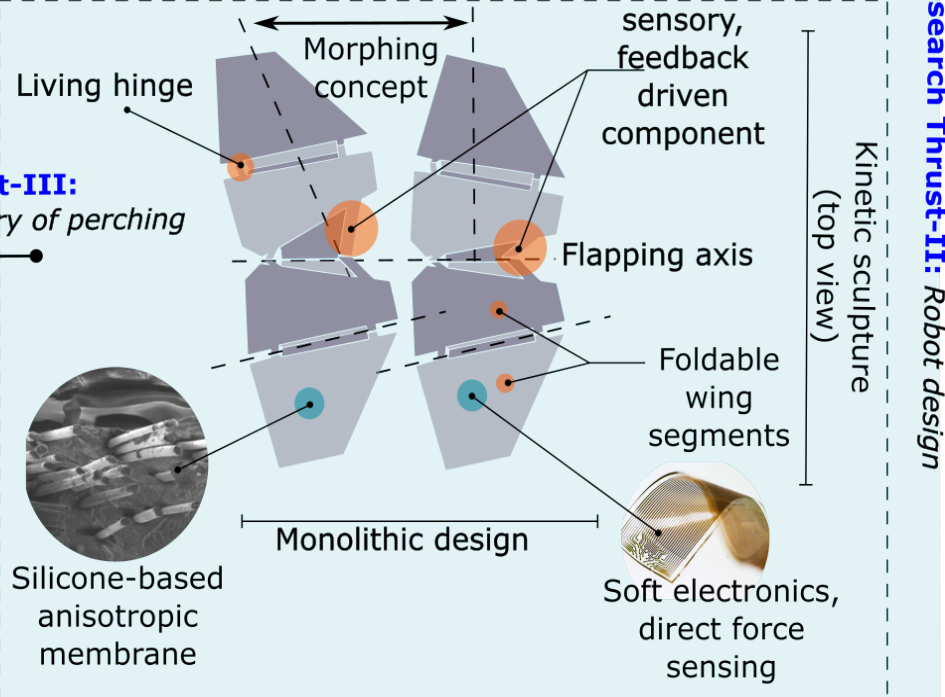
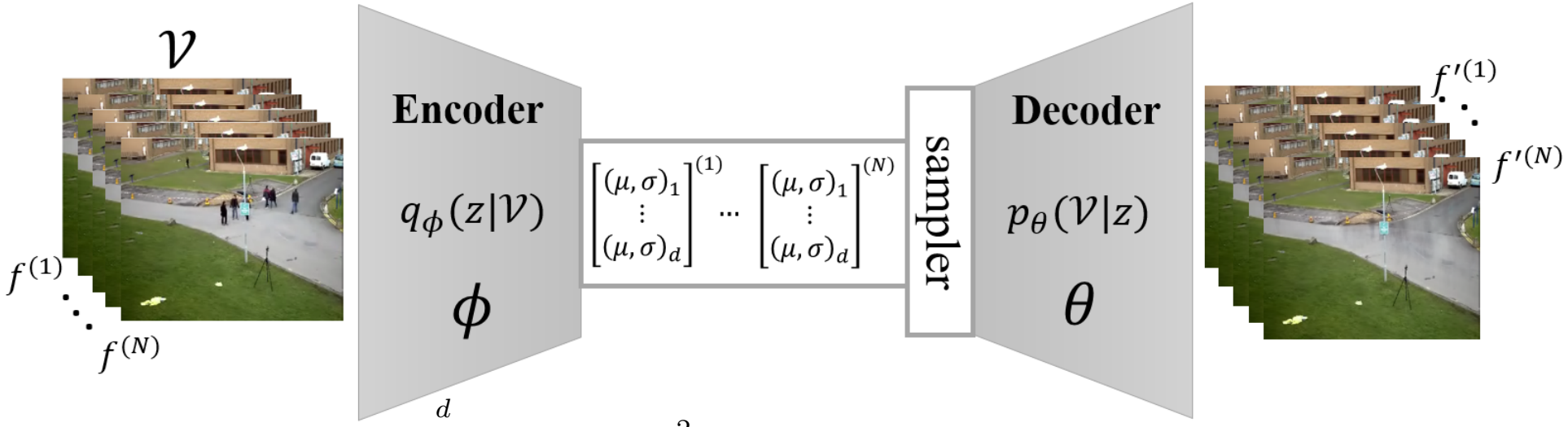


Northeastern University



$$q_\phi(z|f) = \prod_{k=1}^{d} \mathcal{N}(z_k|\mu_k^f, {\sigma_k^f}^2)$$

$$p_\theta(\mathcal{V}, z) = p_\theta(\mathcal{V}|z)p(z)$$

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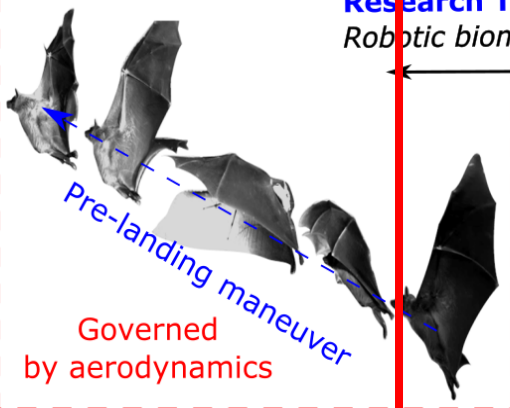

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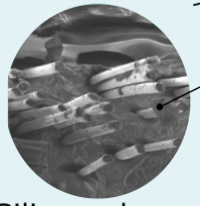

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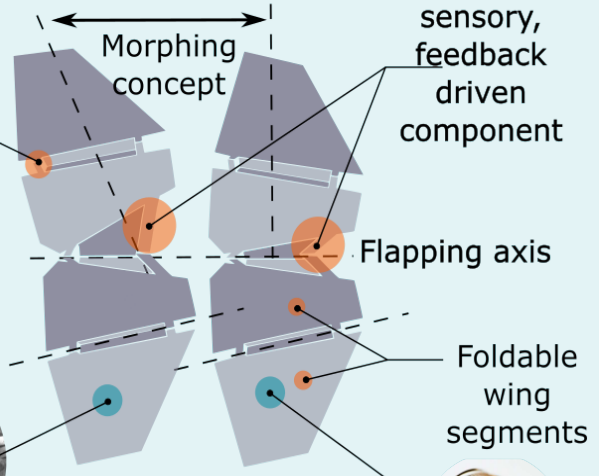


Soft electronics, direct force sensing

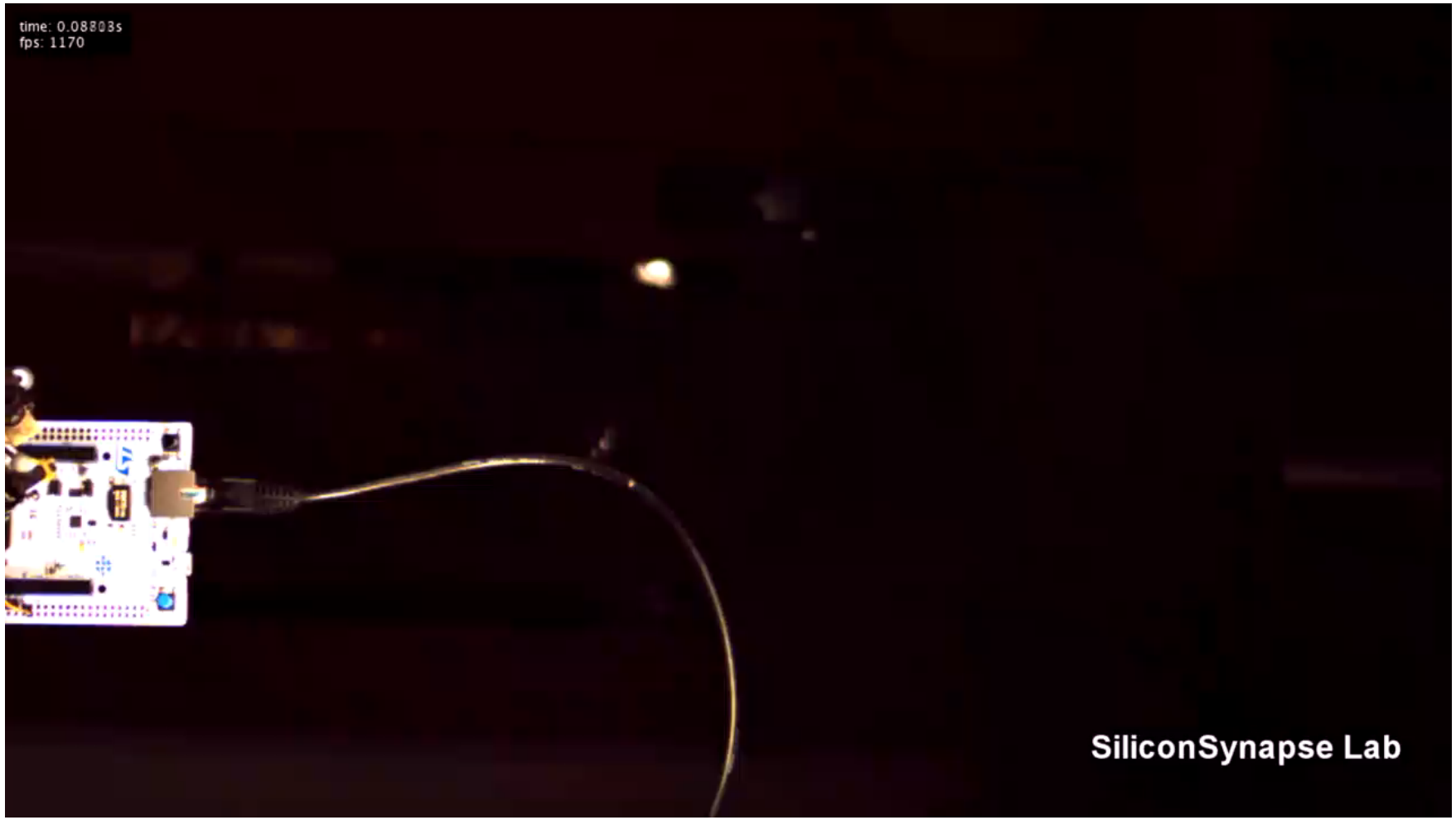
Northeastern University

Slow motion (playback speed: $\frac{1}{40}$x)

Egyptian bat roosting maneuver,

A. Ramezani, MEMS-based instrumentation

S. Swartz & K. Breuer (Brown University)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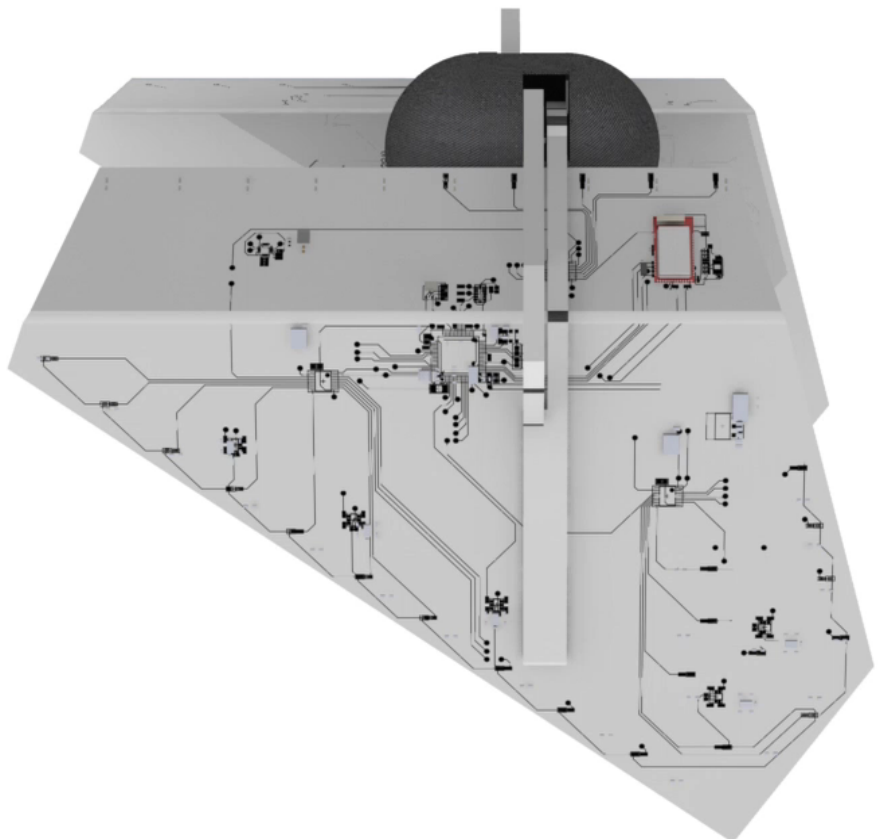
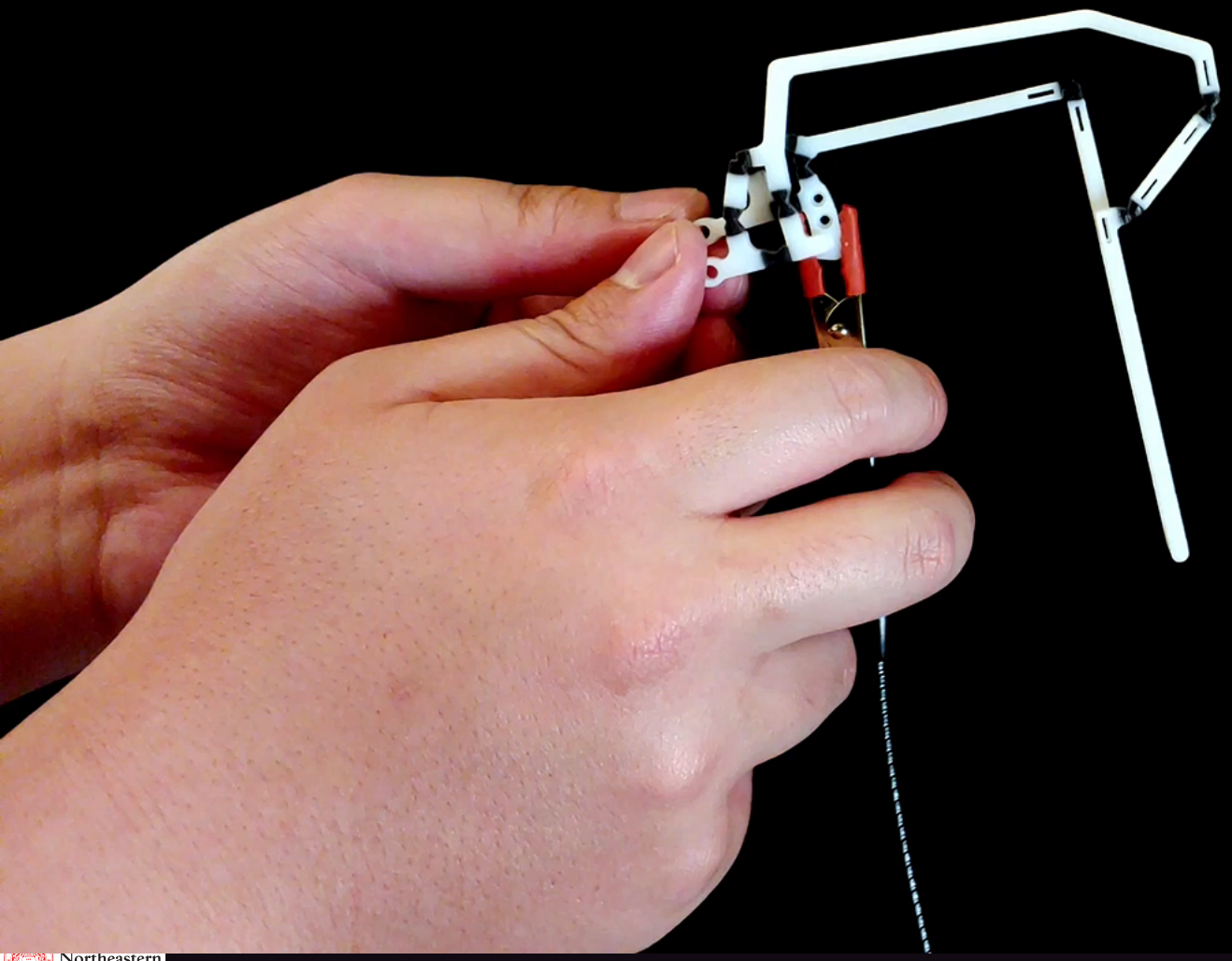
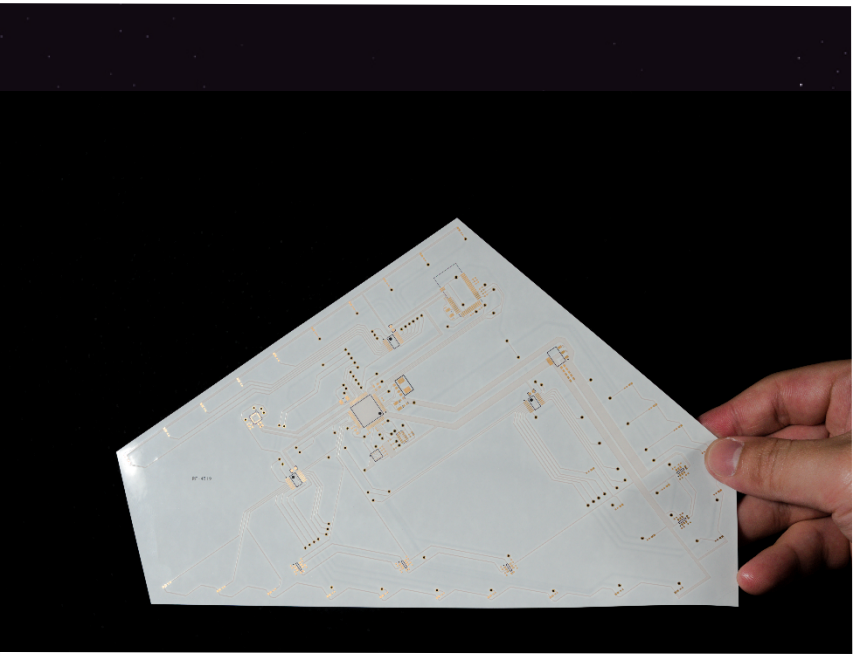
fps: 1170
SiliconSynapse Lab

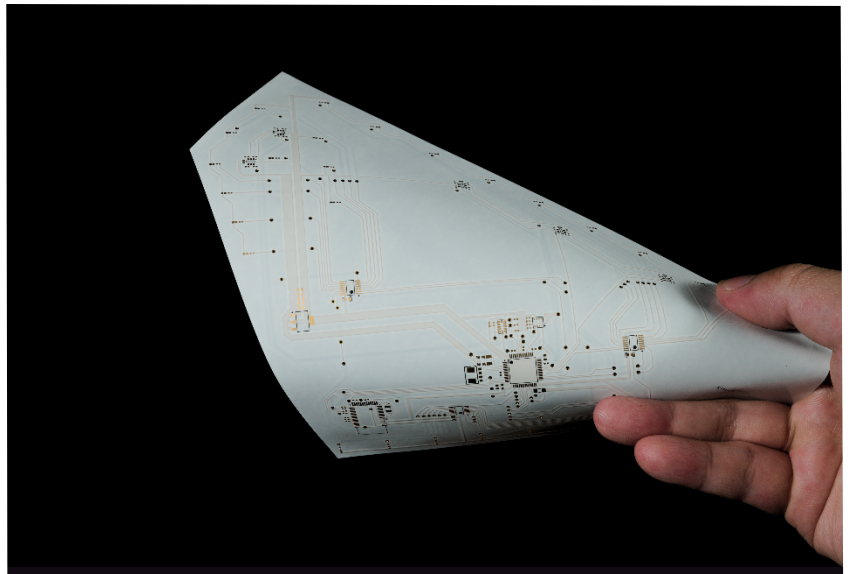


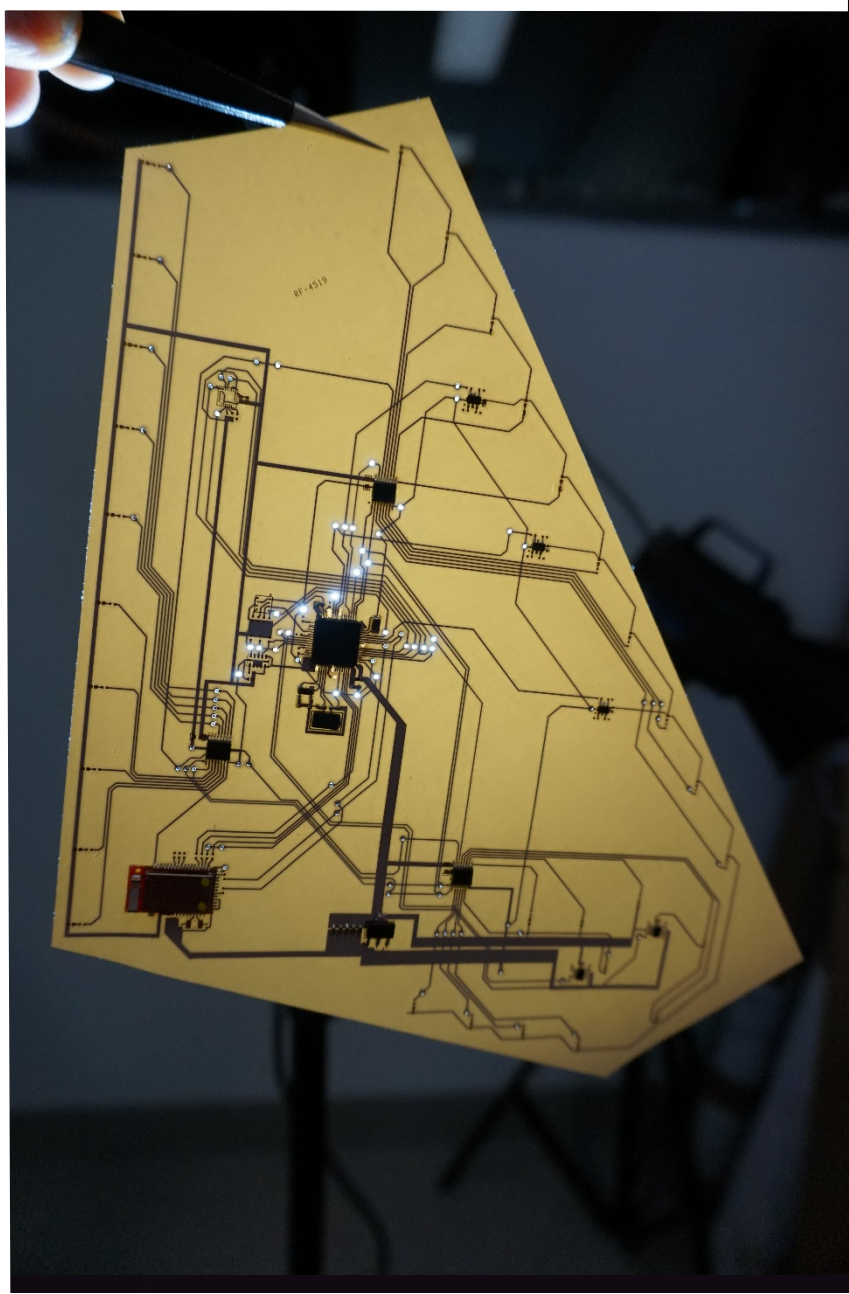
NU’s SiliconSynapse Lab.



“Responsibility of feedback subsume under mechanical intelligence in armwing design”







NU's SiliconSynapse Lab.