ME 586: **Biology-inspired robotics**

Lecture 1

Prof. Sawyer B. Fuller

Goals:

- Describe the need for "biology-inspired robotics"
- Describe how this course works

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overview from syllabus

- prerequisites
- meeting times
- office hours
- we will use canvas + course website:

http://faculty.washington.edu/minster/bio_inspired_robotics/

Course objectives

- Learn important biology-inspired advances in robotics
- Understand current limits of state-of-the-art
- Know how to find papers describing these advances online
- Efficiently read, explain, and note strengths and deficiencies in a research paper
- Describe and promote your ideas and discoveries
- Inspire you to explore biology-inspired robotics

how this course works

- Three parts to the course:

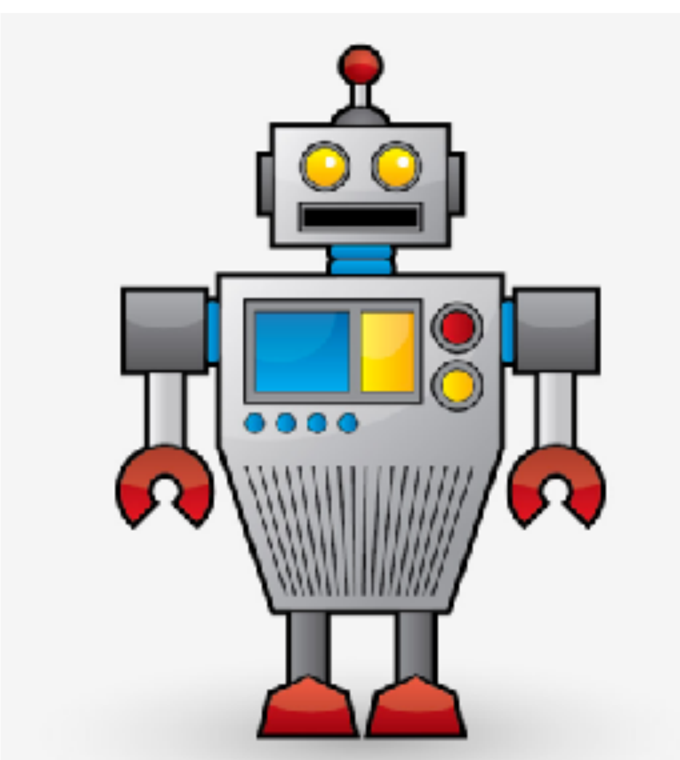
1. For each class session, there will be a presentation and discussion of two papers (20 papers total)
    - for the main paper, **a review is due online** the day before
    - skim the second paper
    - come prepared to discuss both papers
2. You will be responsible for **presenting a paper** during one of the class sessions
    - days with 2 student presenters: each student presents a paper and background
    - days with 3 student presenters: one student presents background, other two present 1 paper each
    - paper is assigned based on a lottery and your preferences
3. **Final project**
    - this year: you're the funding agency!

This year's final project

- You're the funding agency!
- each team submits a *research proposal* at the end of the quarter
  - format: 1-2 pages per student team member, NDSEG graduate fellowship format
  - includes preliminary work you did in this course
    - show a "proof-of-concept" initial work in some aspect of biology-inspired robotics (probably in simulation)
  - can be used to for your actual application
- There will be a peer vote for best proposals
  - criteria: quality of preliminary results, future promise
- top 3 proposals get funding — free coffee to start the research!

Robot (*noun*)

a machine capable of carrying out a complex series of actions *automatically*



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Related UW Classes
(many take a classical approach to robotics)

- Mechatronics:
  - ME581: Digital control systems (spring)
- Dynamics and control:
  - EE 543/544: Kinematics and dynamics of robot arms/manipulators
  - ME583: Nonlinear control
- Perception and planning:
  - EE 576: computer vision and robotics (spring)
  - CSE 571 Probabilistic Robotics: Perception, localization, mapping (fall)
  - ME599: Advanced Robotics: Perception and multi-robot control (fall. Ashis Banerjee)
- Also:
  - CSE 590: Robotics colloquium seminar (weekly speakers)
  - BI 427: Animal biomechanics (fall, Tom Daniel)

“biology-inspired robotics”

current state of the art

Honda's Asimo

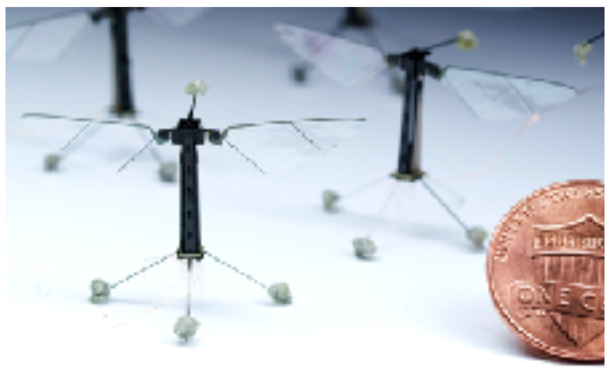
- very power hungry (20x human of same weight)
- only in controlled environments

current state of the art

Google's self-driving car

- power hungry - requires a bank of computers
- only in controlled environments

application areas where current robotics is still outperformed by nature



tiny robots
(minimal computation,
limited sensing)

complex environments and robots
(models are inadequate
and behavior must be learned)

agile robots
(limited time
to compute)

soft robots
(nonlinear
stress/strain curve
hard to model)

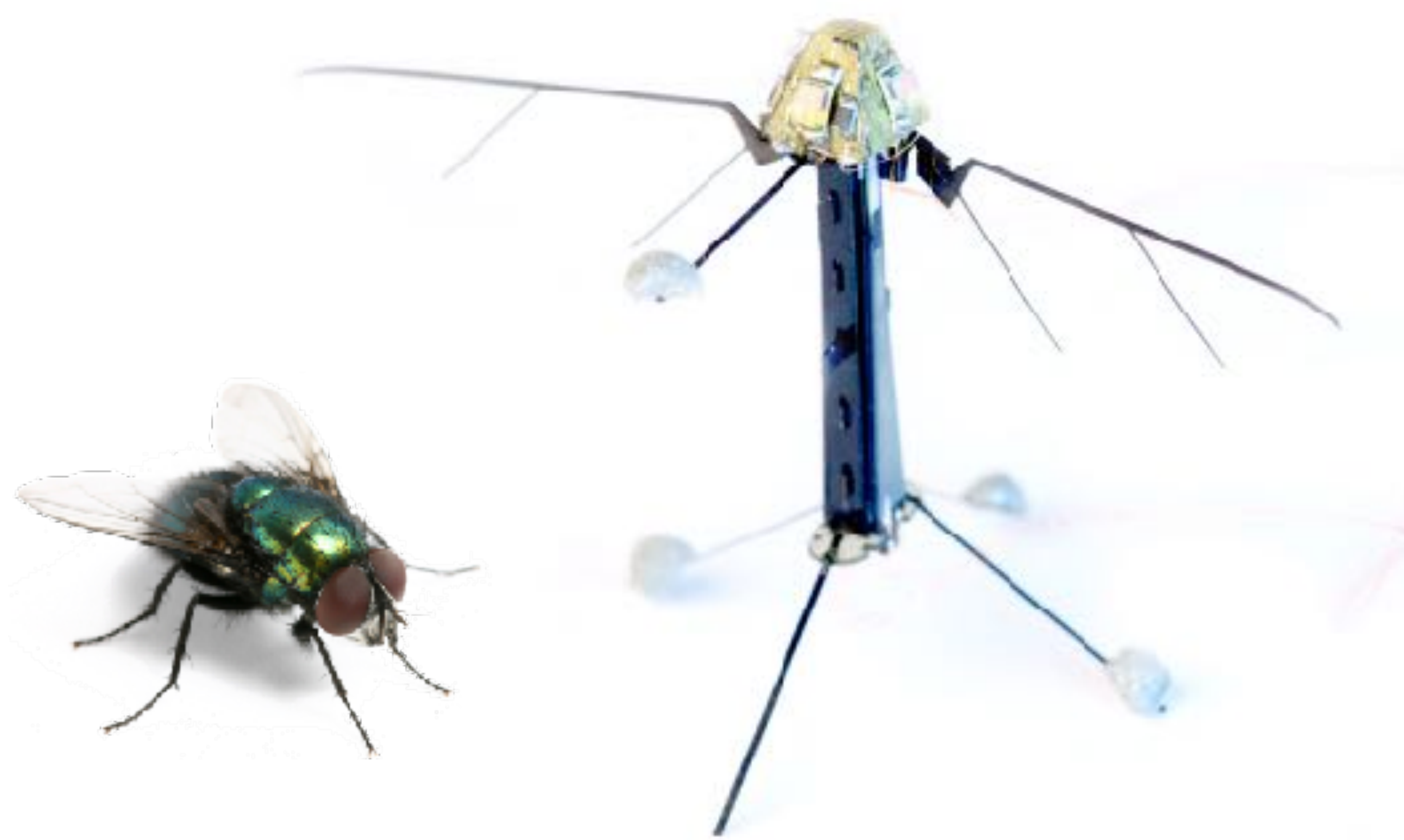
- rich behavioral repertoire


BBC

- aggressive, dynamic motions

- complex environments
- minimal energy expenditure on computation

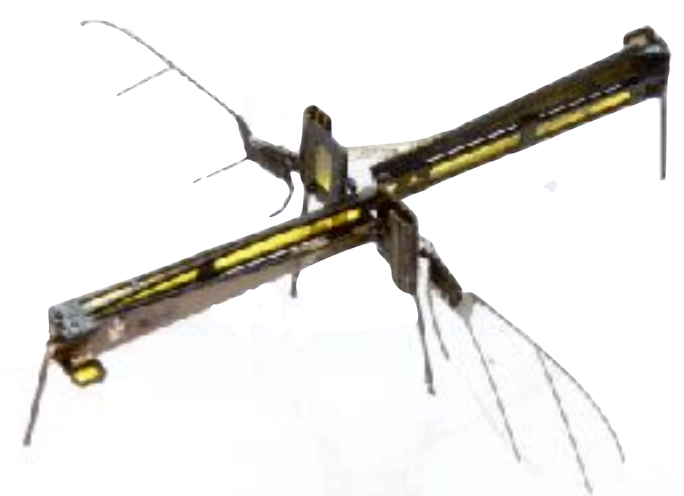
Aerial autonomy at insect scale



(images to scale)

Autonomous Insect Robotics Laboratory

Est. 2015



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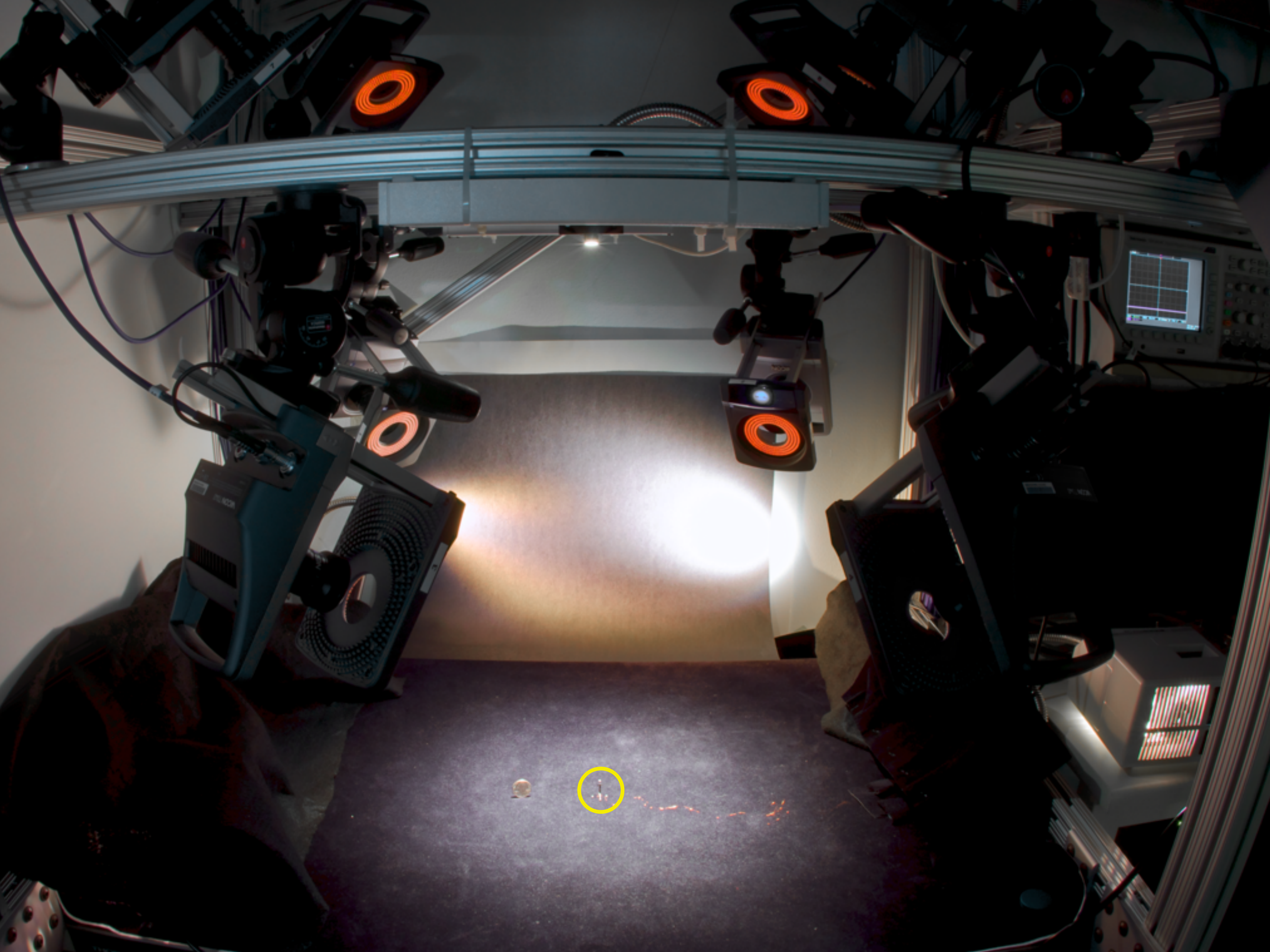
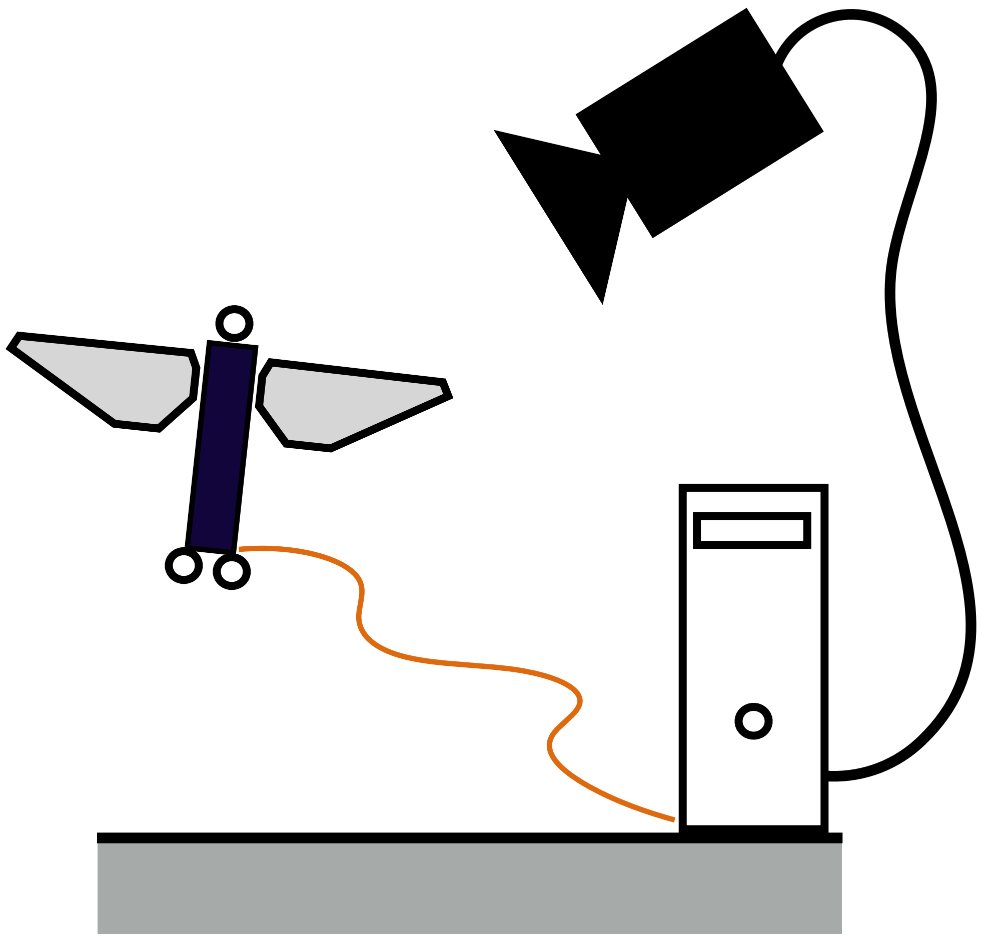
MECHANICAL ENGINEERING

Ma, Chirarattananon, Fuller, and Wood, *Science* 2013

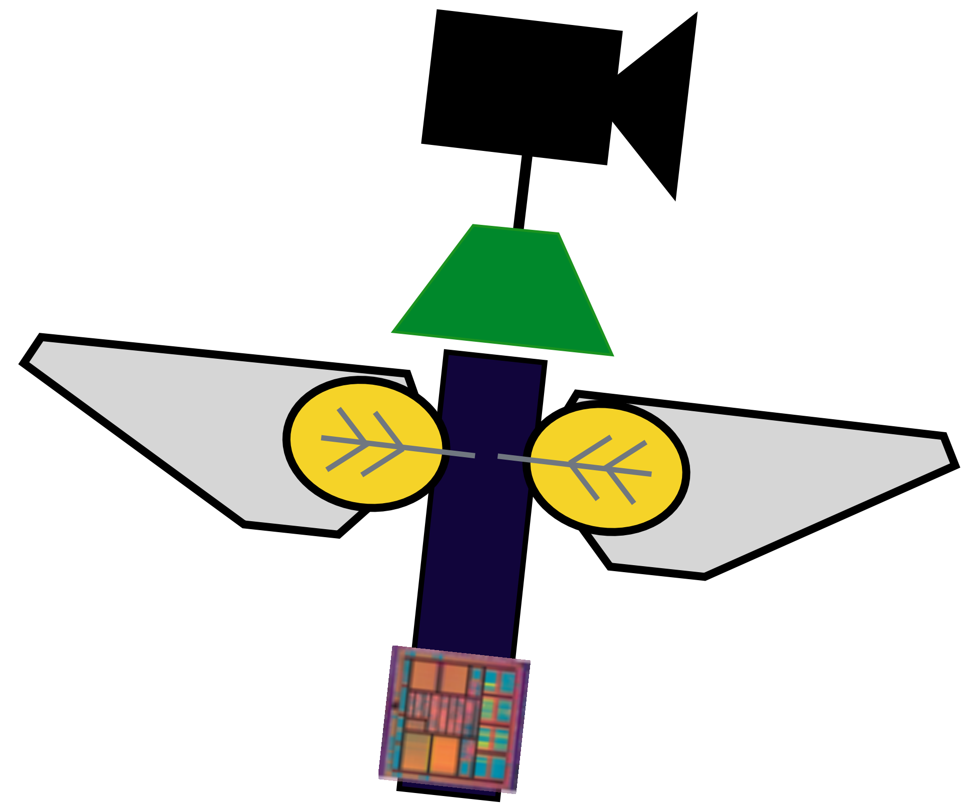


previous work



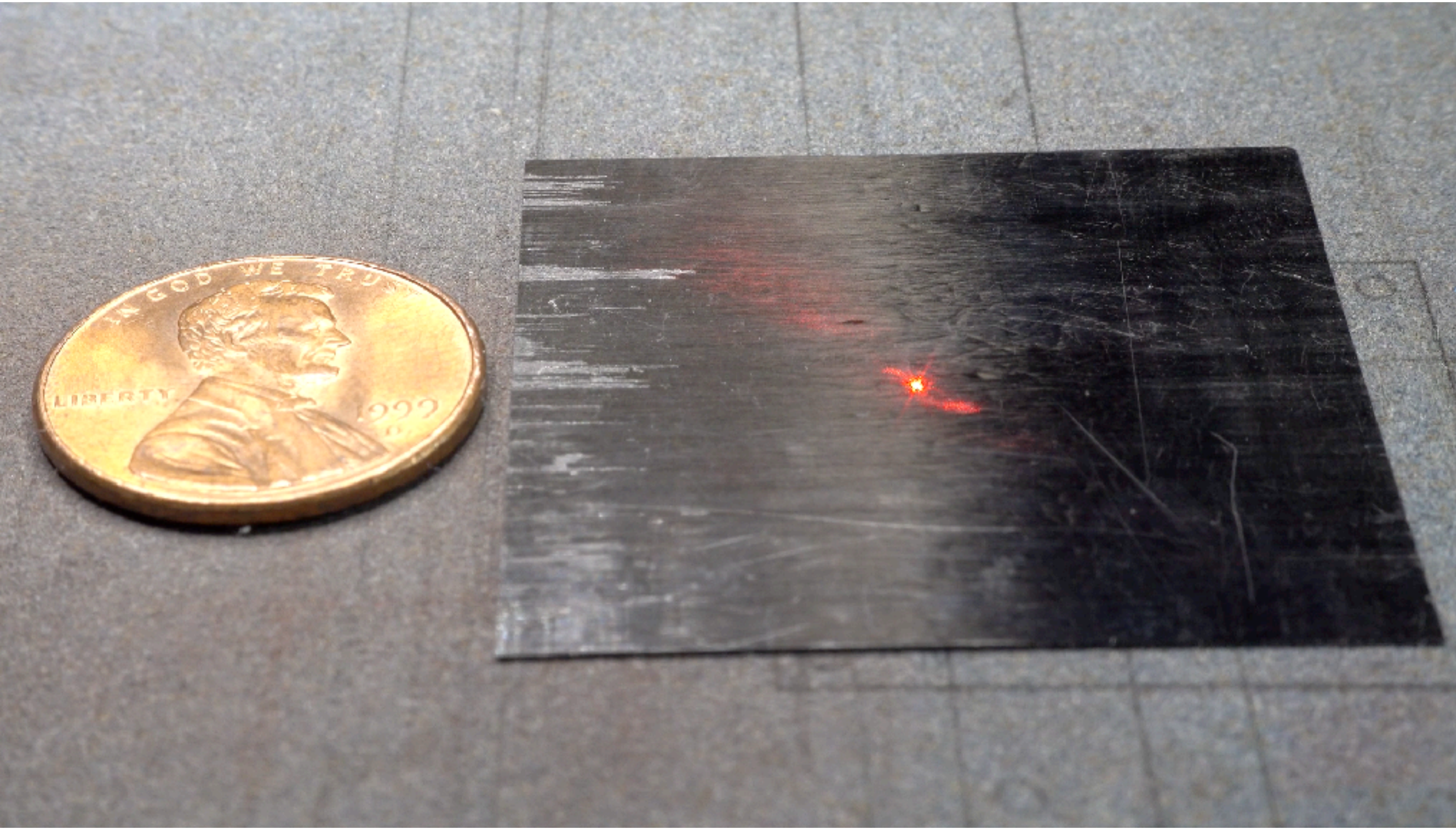
- external power
- external sensing
- external computation

current research

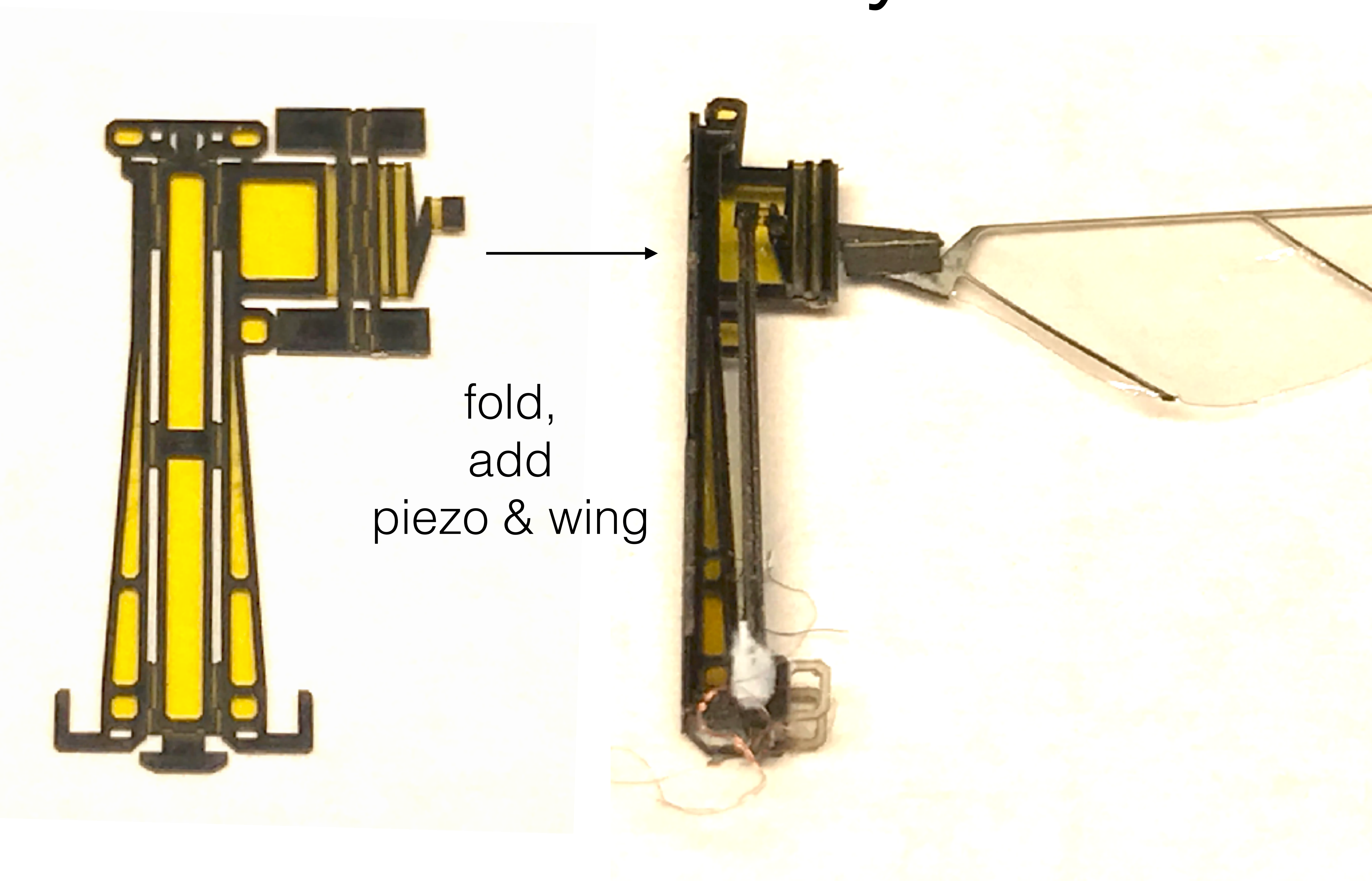


- improved capabilities
- onboard sensing
- onboard computing
- onboard power

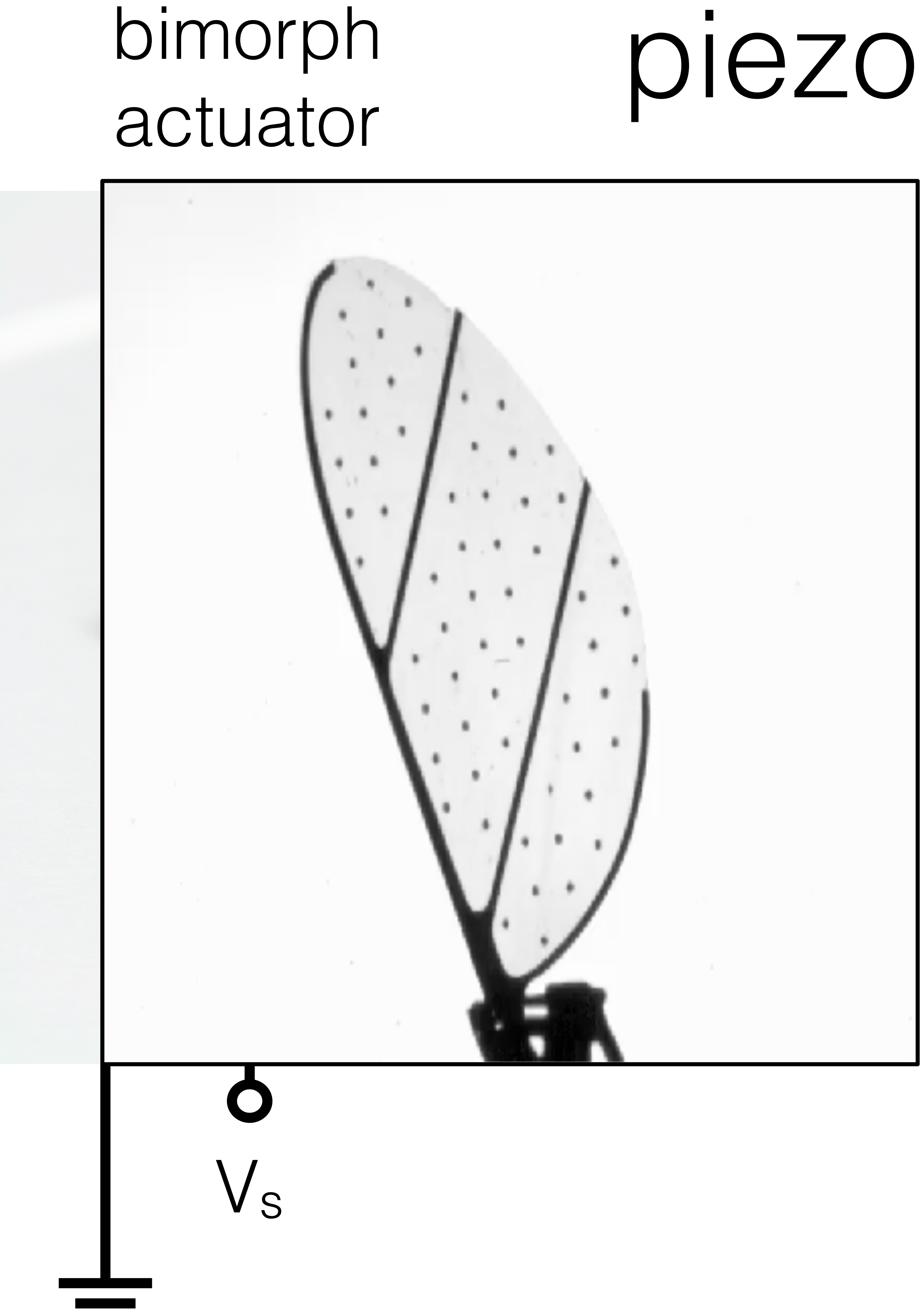
355 nm laser micromachining

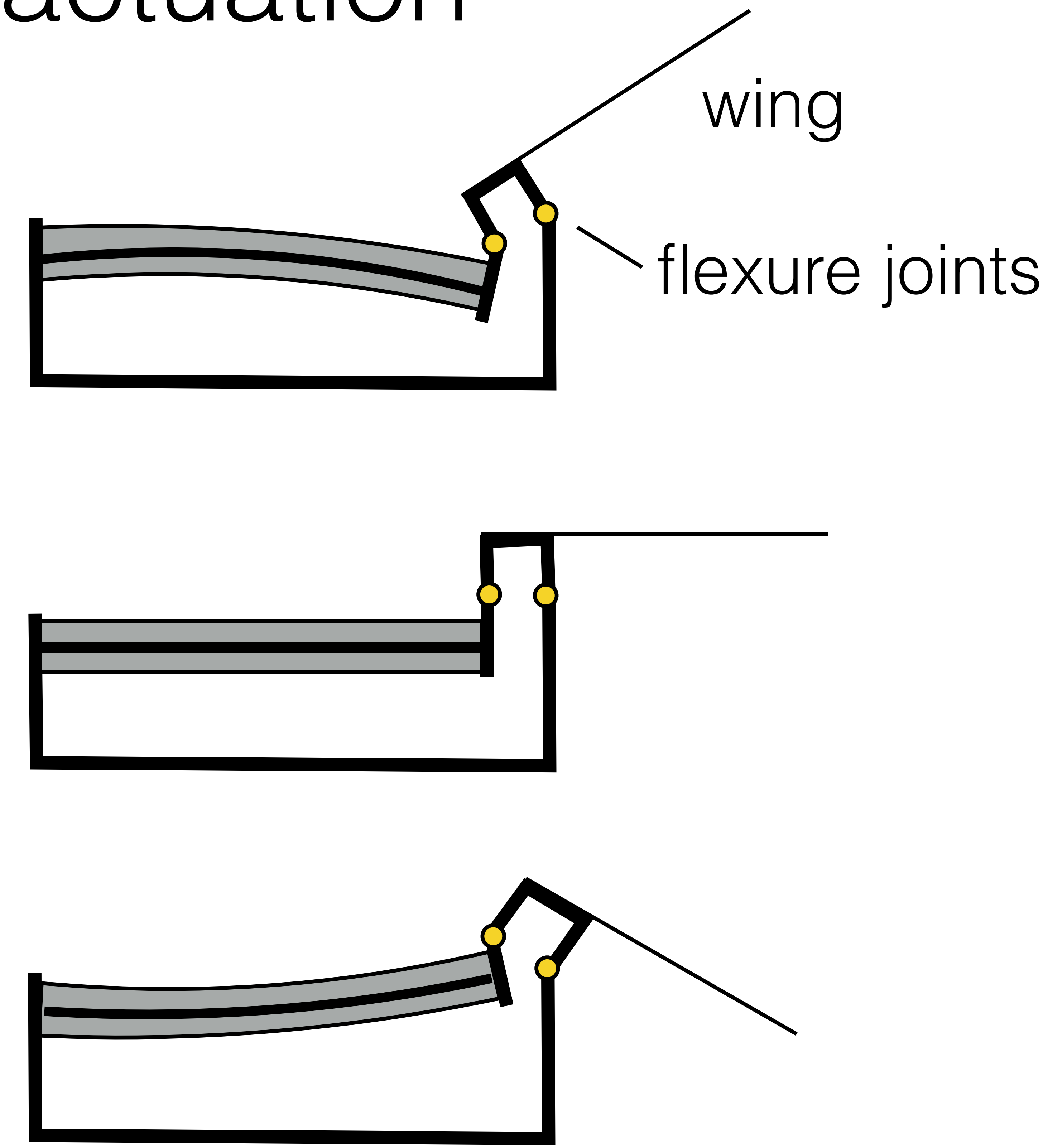


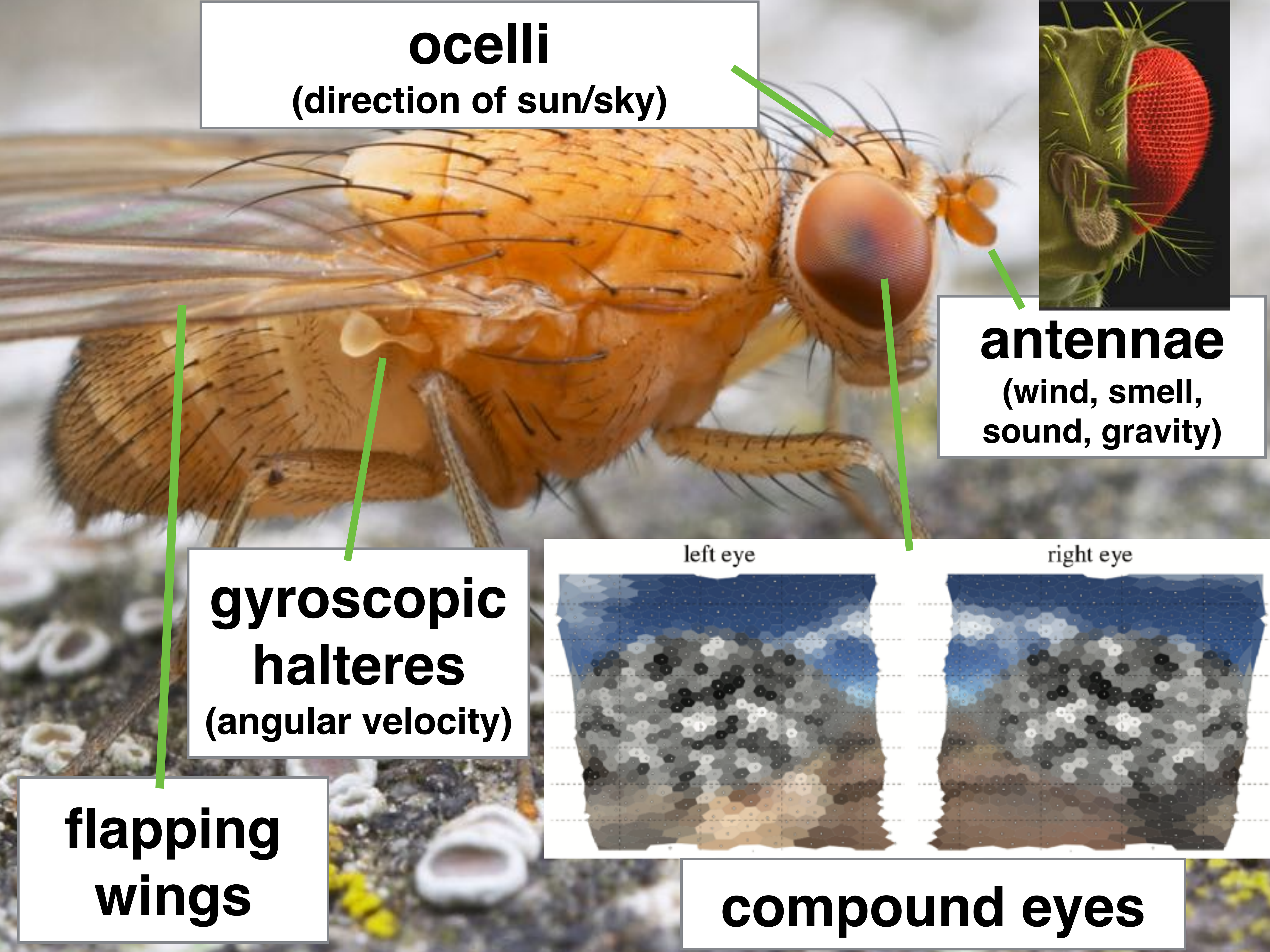
assembly



piezo actuation



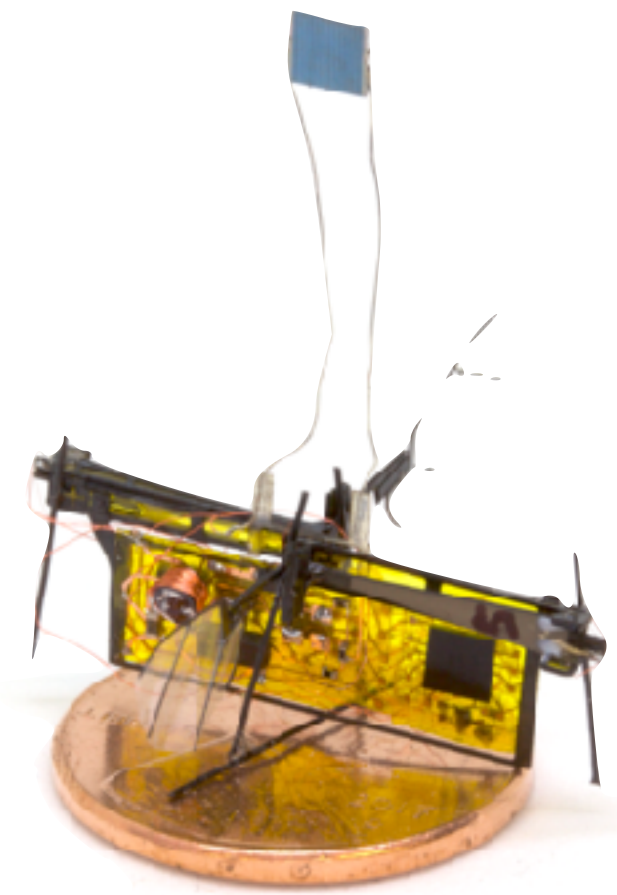



ocelli
(direction of sun/sky)
antennae
(wind, smell,
sound, gravity)
gyroscopic
halteres
(angular velocity)
flapping
wings
left eye
right eye
compound eyes

current research

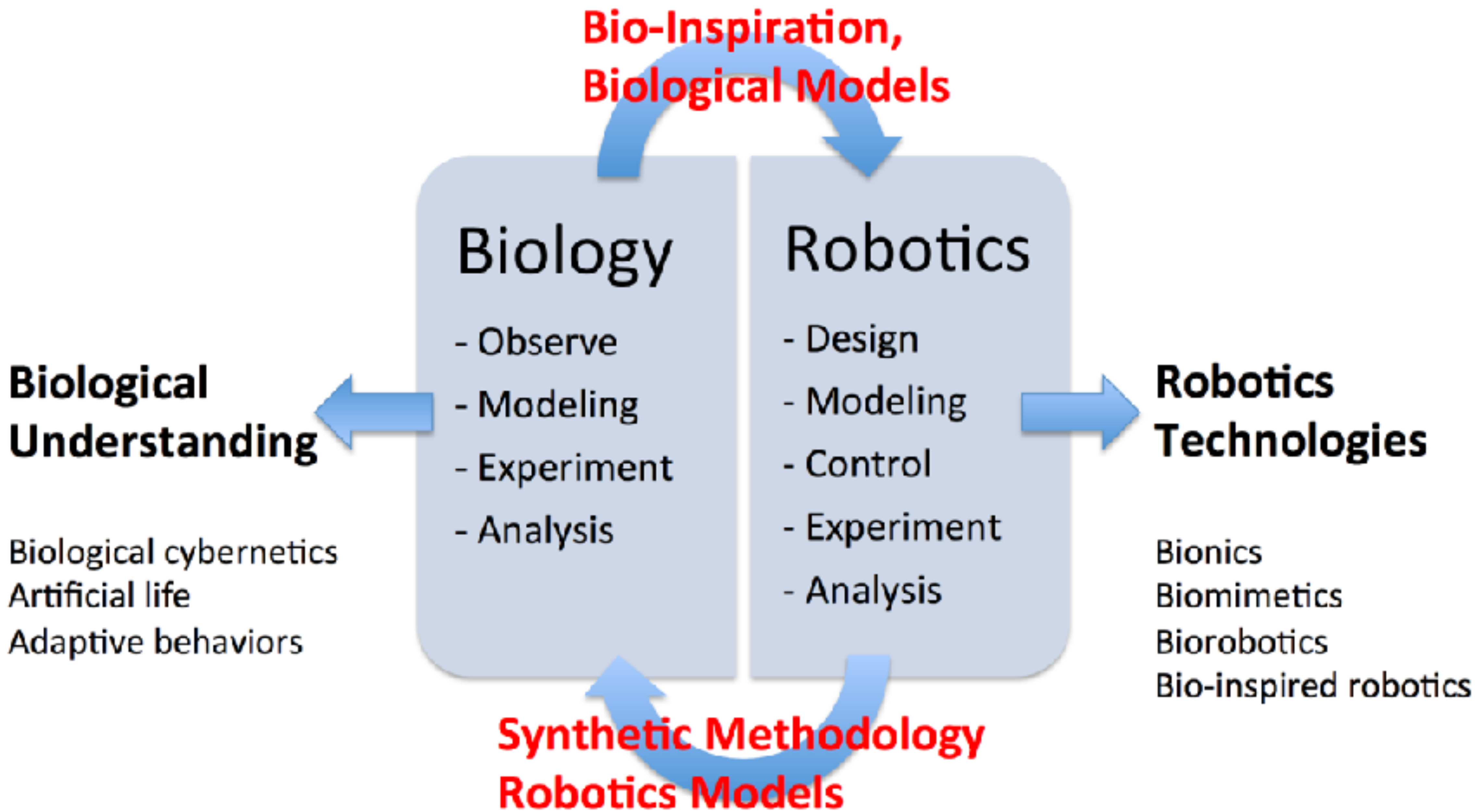
vision (tiny camera)

odor (using moth antenna)



onboard power

biology-inspired robotics



this course takes the view that biology beats robotics for two reasons:

1. better at adapting through evolution and learning

2. mechanical intelligence

mechanical intelligence

this fish is dead!

- system is stable without active feedback

Liao, 2004

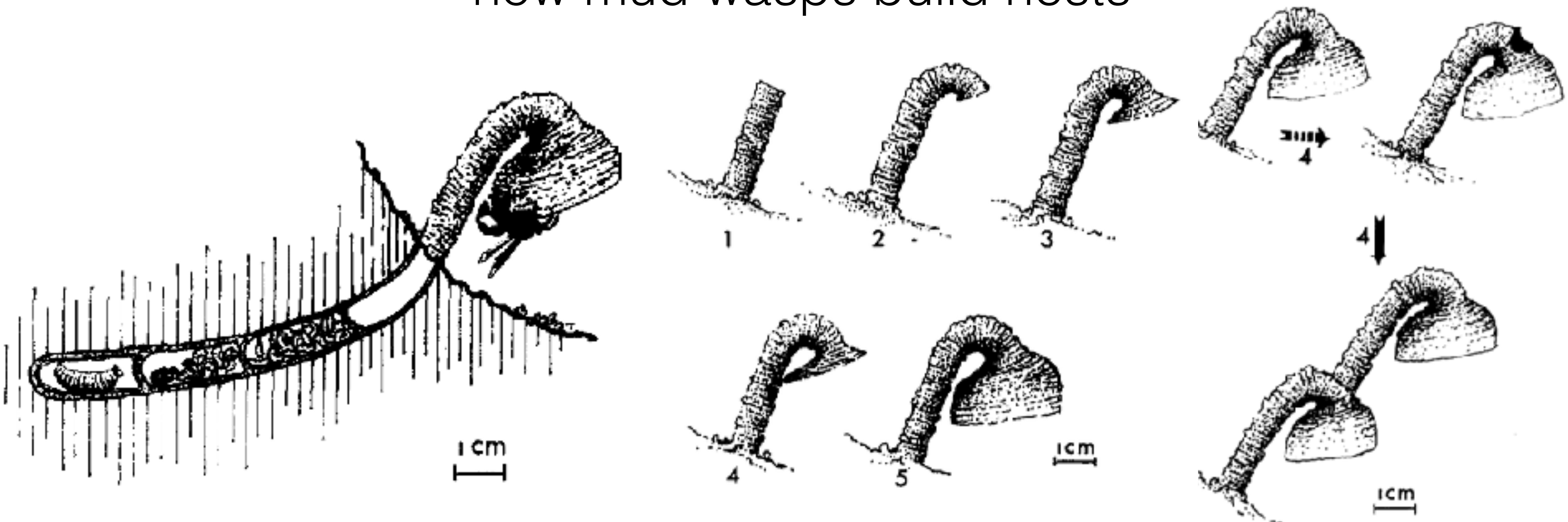
robot mechanical intelligence

walks with no feedback and very little power

collins 2001

example of adaptation: reflexive/model-free control

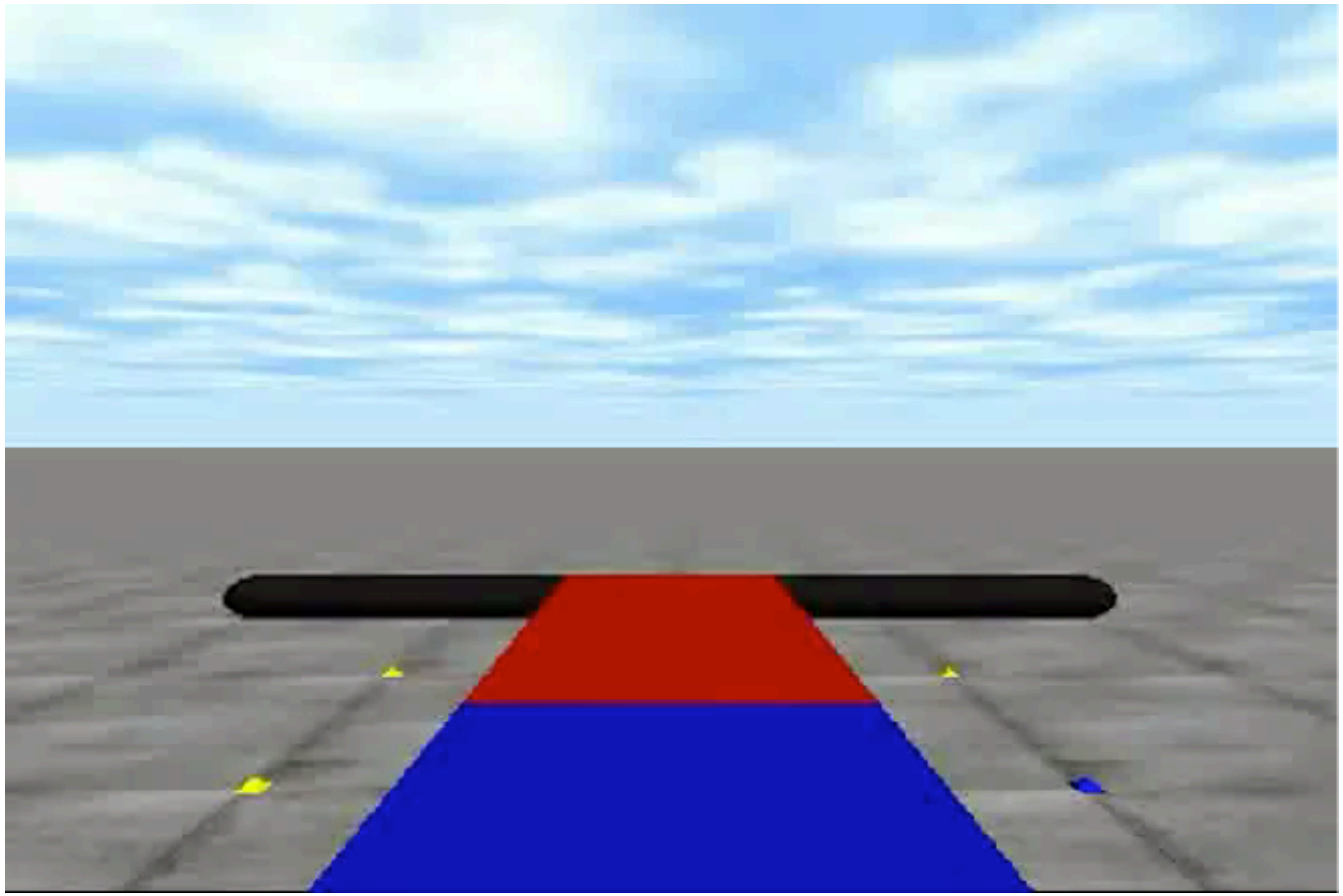
how mud wasps build nests



- minimal internal representation
- cascaded behaviors

Smith, 1978

example of model-free control



a gait learned by a neural network

bongard 2011

Wednesday

- due by Thursday 9pm: Review of paper 0
  - because of the short time available, only write the short synopsis of the paper, you can leave out the other three parts of the review.

next week

- paper 1 review due Tuesday 9p
- paper 2 review due Thursday 9p