

LIS

Building a Computational Fly: Modeling *Drosophila melanogaster*

Semester Project: Midterm Presentation
Raphael Cherney



DROSOPHILA

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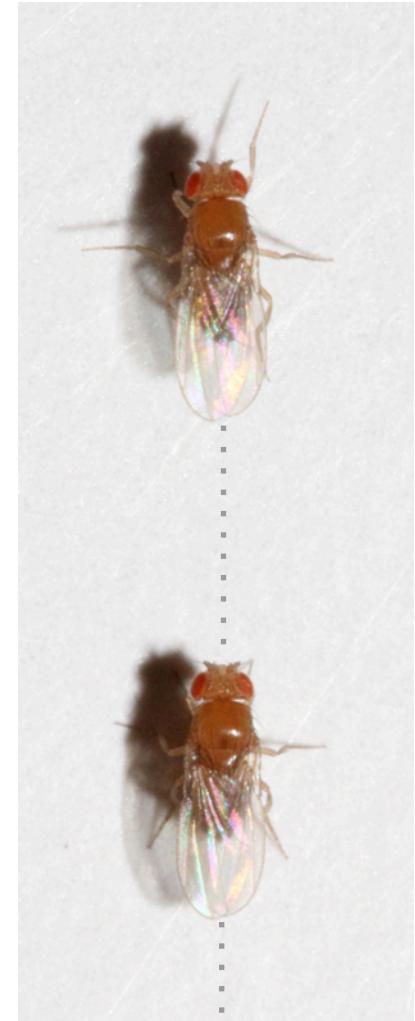
- Commonly known as “fruit flies”
- Model organism in biological research (extensively studied)
 - Small
 - Short generation time
 - Easy to care for
 - Large brood numbers



PROBLEM

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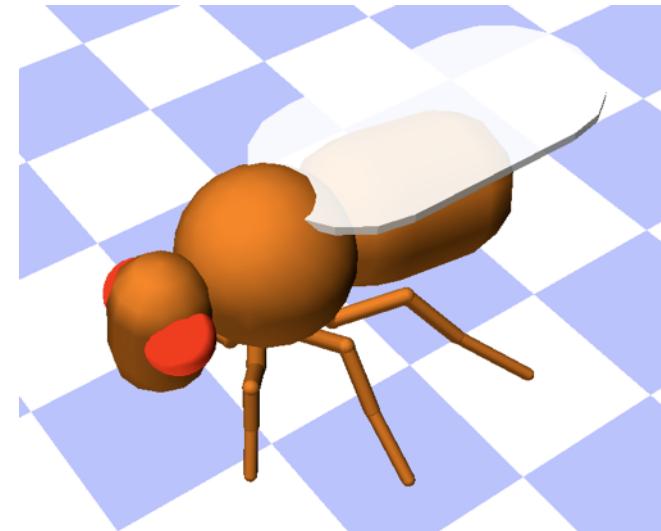
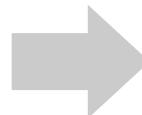
- *Drosophila* have been extensively studied, but only limited work has been done to understand their locomotion
- By understanding insect locomotion, we can harness insight from millions of years of insect evolution to build more robust, bio-inspired robots
- These same engineering experiments can also help answer biological questions



GOALS

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- Investigate *Drosophila* morphology and locomotion
- Build a biologically-accurate **3-dimentional model** of *Drosophila melanogaster*
- **Design controllers** to test biological and robotic locomotion questions



STATE OF THE ART

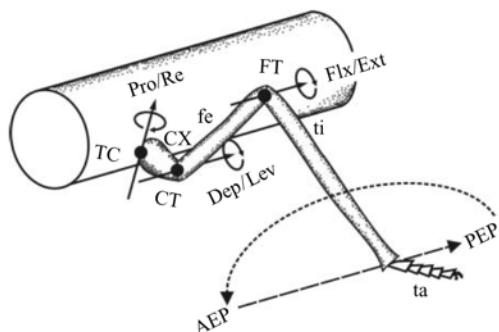
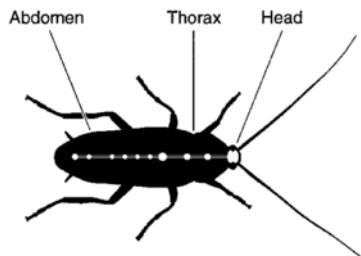
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Central Pattern
Generators (CPG)

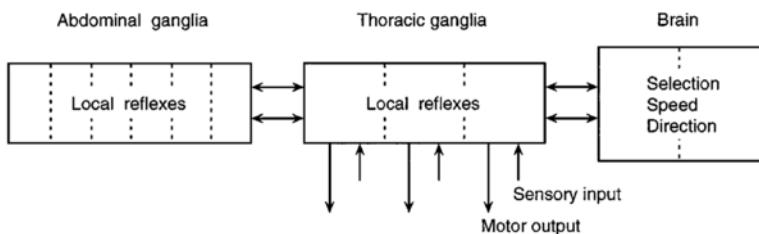
Distributed
Oscillators

Rule-based
Coordination

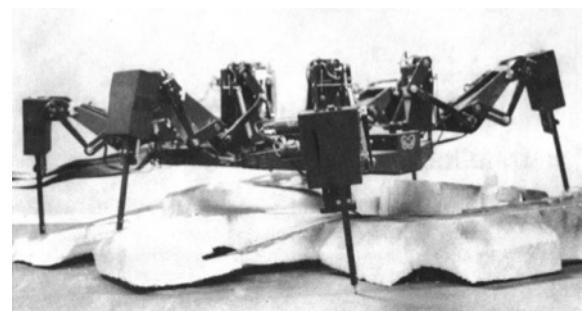
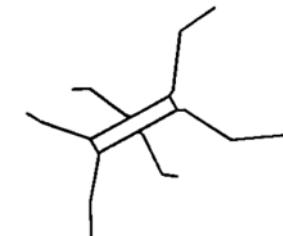
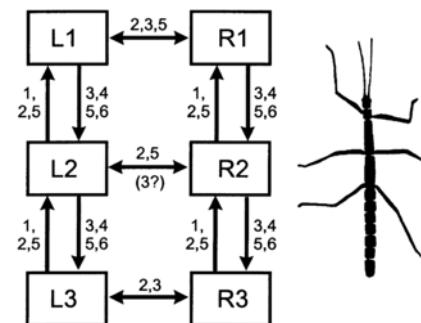
Series of
Reflexes



Cruse et al., 2007



Delcomyn, 1999

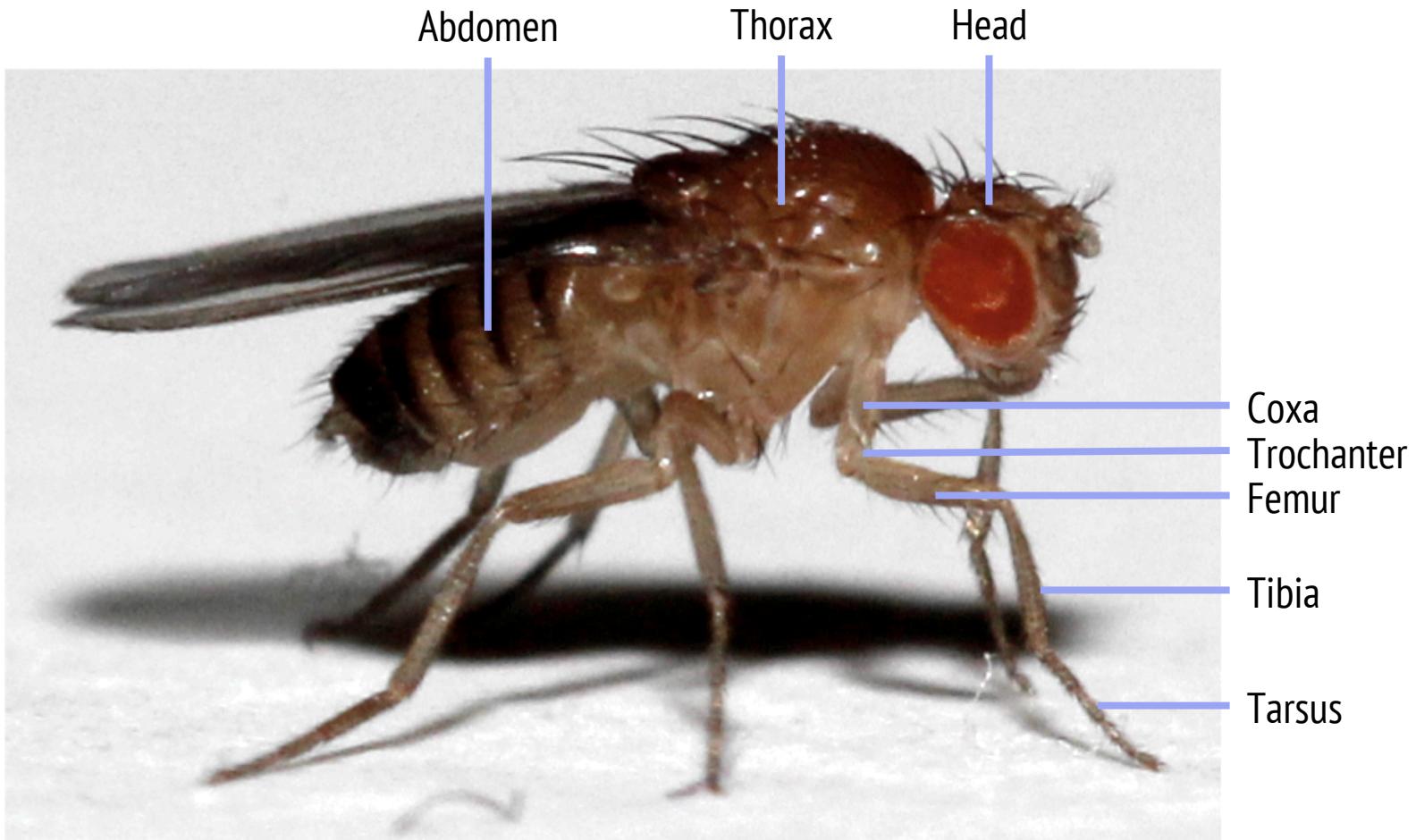


Espenschied et al., 1997

Schmitz et al., 2001

ANATOMY

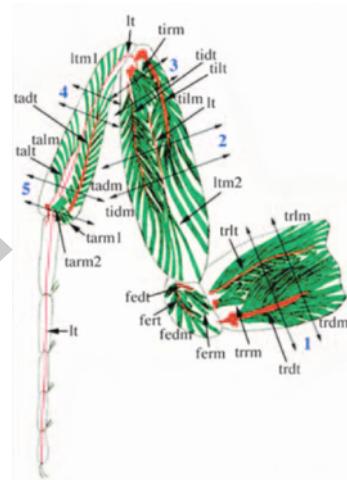
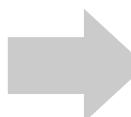
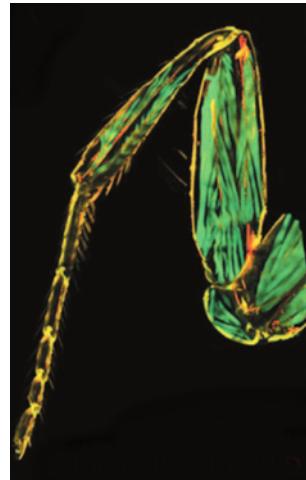
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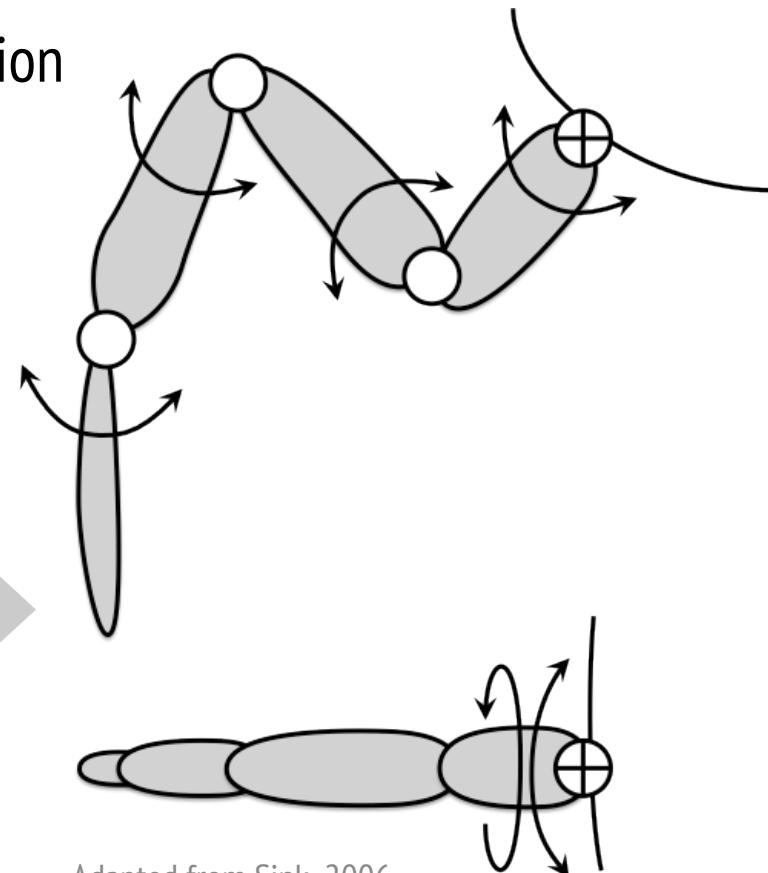
LEG MODEL

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- Model based on anatomy and observation
- Each leg has **6 degrees of freedom**
 - $6 \text{ DoF} \times 6 \text{ legs} = 36 \text{ total DoF}$



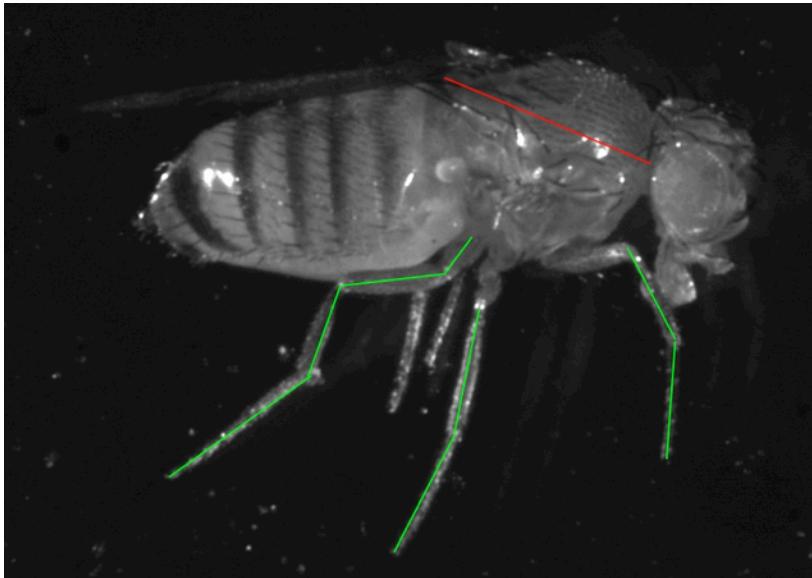
Soler et al., 2004



Adapted from Sink, 2006

IMAGE ANALYSIS

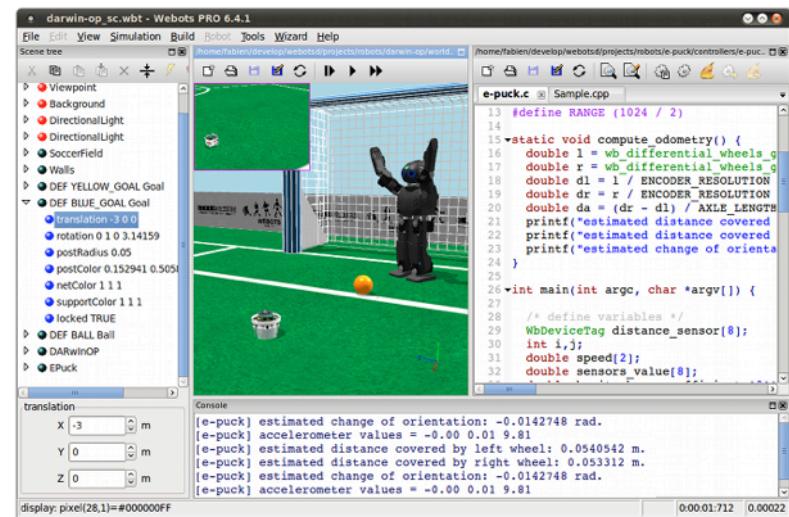
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WEBOTS



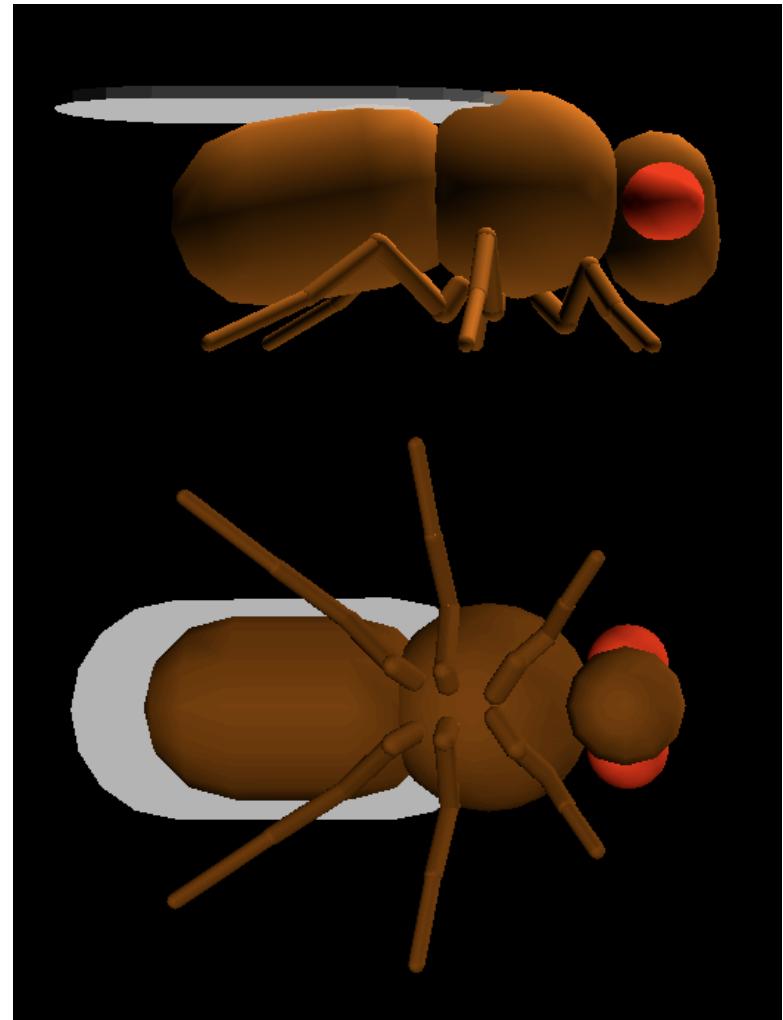
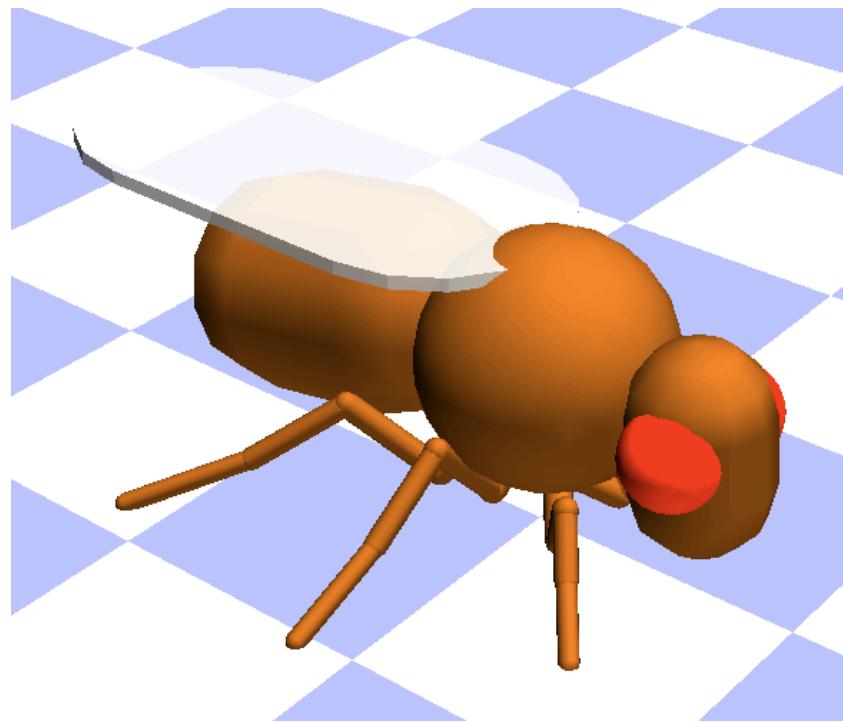
- We are using the Webots™ environment to build and test our model
 - Open Dynamics Engine (ODE) for physics simulation
 - 3D visualization
 - Sensor and actuator libraries to ease implementation
 - Choice of programming languages (C, C++, Java, Python, MATLAB)
 - EPFL knowledge base (BIOROB)
 - Availability through EPFL license
 - Expandable
 - Existing documentation
 - Easier conversion into hardware



MODEL

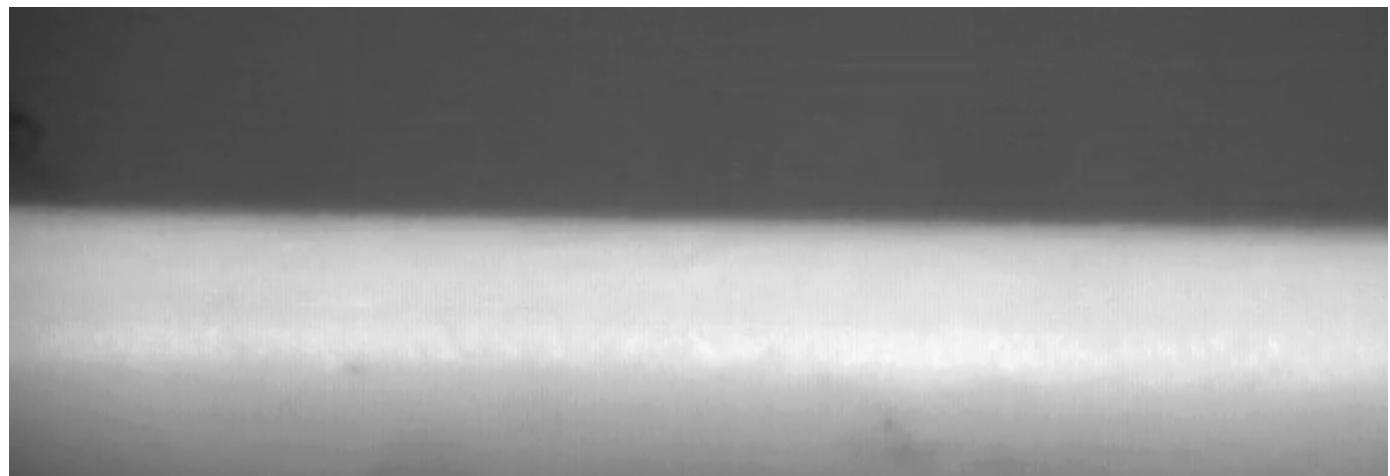
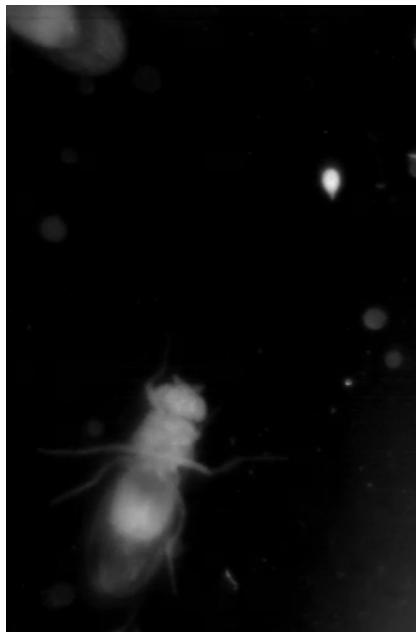
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- Same morphology as *Drosophila*
- Biologically plausible fly



HIGH SPEED VIDEO

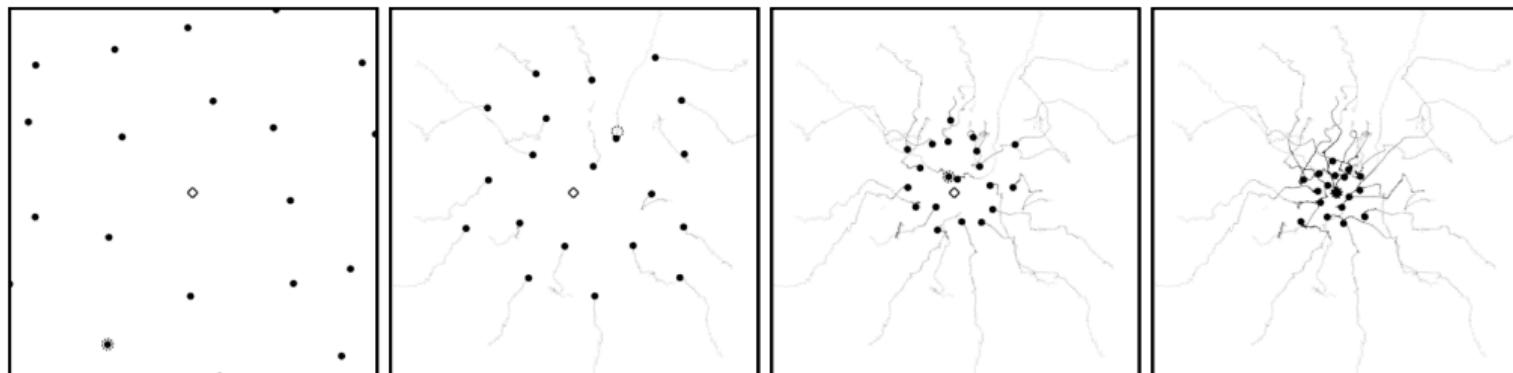
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NEXT STEPS

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- Hand-tuned (sine-based) controller
 - Try to learn basic relationships between limbs for different motions
- PSO or GA optimization
 - Tests different fitness functions (maximizing speed, minimizing effort, etc.)
 - Evolve behaviors
- Test different insect locomotion theories



Kim et al., 2009

THANKS

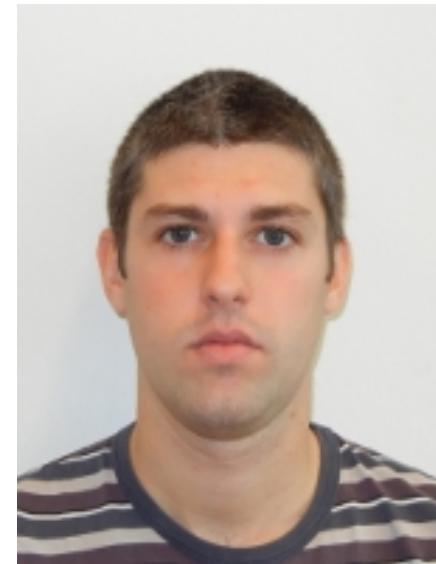
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ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



Pavan Ramdy'a



Andrea Maesani

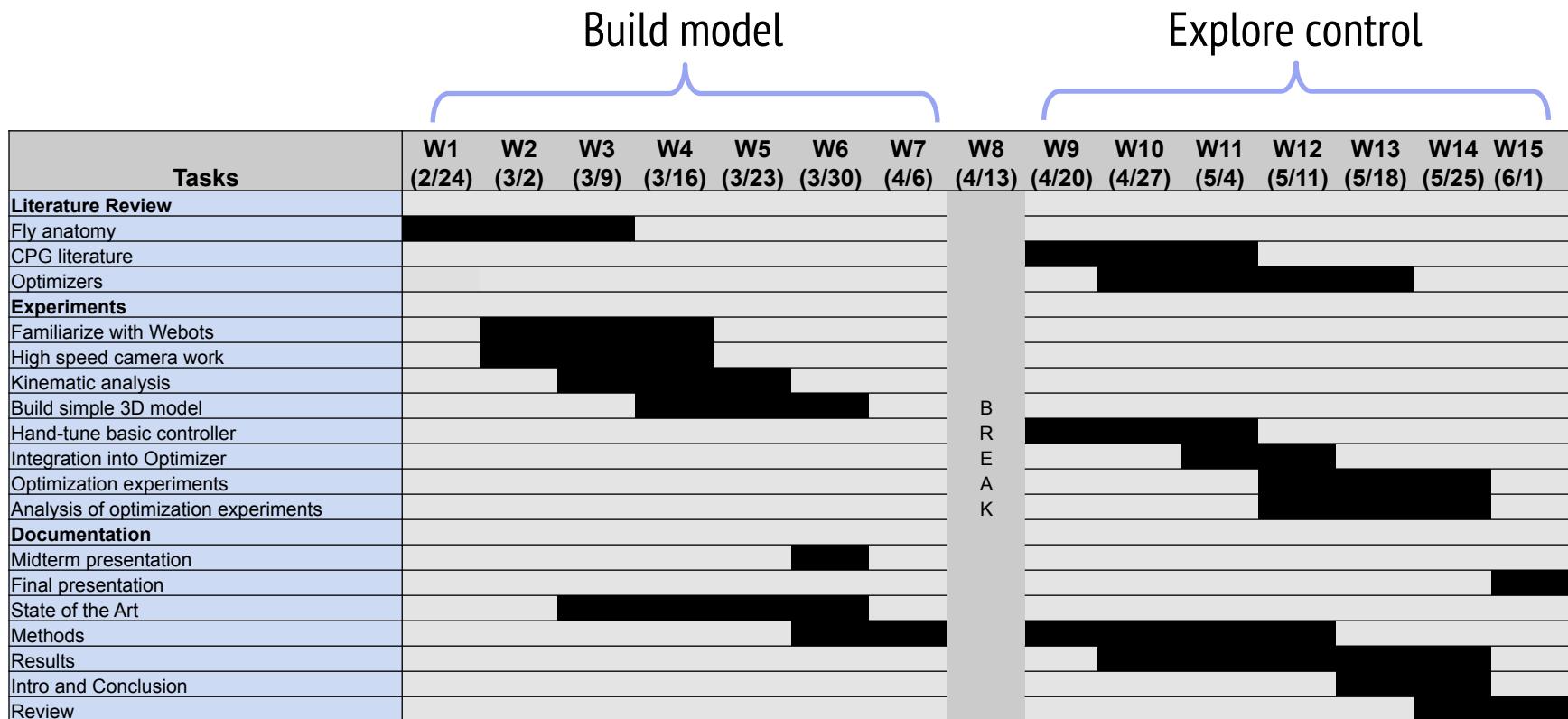
Questions

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PLAN

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References

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- Soler, Cédric, et al. *Coordinated development of muscles and tendons of the Drosophila leg*. Development, 2004.
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