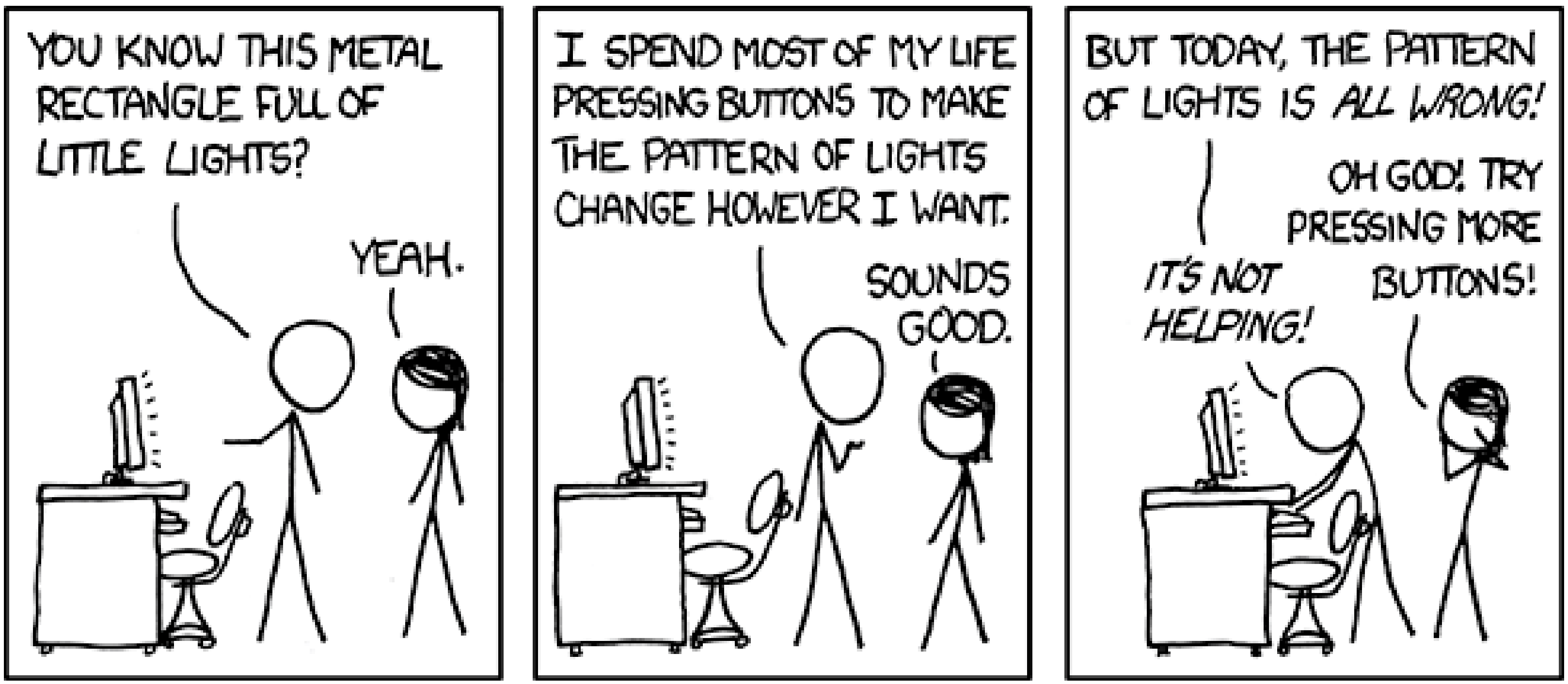
CS249r – 2019 Nuts and Bolts



What are the prerequisites for CS 249r?

1. CS 141 and/or basic computer architecture and digital design
2. CS 61/161 and/or a basic systems programming experience
3. CS 124 and/or a basic algorithms experience

We hope to have a diverse class and assume few students will have full exposure to the full breadth of topics we will cover. As such, we intend to provide some background on all of the topics. That said, students may find it helpful if they also have some background in some of the algorithms employed in autonomous systems from classes such as CS 181/182 or AM 121. Please contact the instructor or teaching fellow if you are interested in taking the course but are unsure about whether the background you have is suitable.

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Wed, Sep 11		Lecture	Intro to Robotics (Planning and Control)	
Mon, Sep 16		Lecture	Intro to Domain Specific Architectures	
Wed, Sep 18	Sample Presentations	Research Paper(s)	Example Research Paper Presentations	
Mon, Sep 23	Domain Specific Accelerators	Research Paper(s)	Domain Specific Accelerators	
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Mon, Sep 30	ML Motivation	Guest Lecture	Reinforcement Learning 101	Tentative
Wed, Oct 2		Guest Lecture	Deep Reinforcement Learning 101	Tentative
Mon, Oct 7		No Class	Columbus Day	
Wed, Oct 9	E2E Control	Research Paper(s)	E2E Control	
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Class on 9/11 will be video taped (but not posted anywhere) as I am doing a Bok Center teaching review. We will have a "no camera" section as well.

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We are also going to have a day of sample presentations to provide a guide for the types of presentations we hope you will give on your research papers throughout the semester and on your final projects

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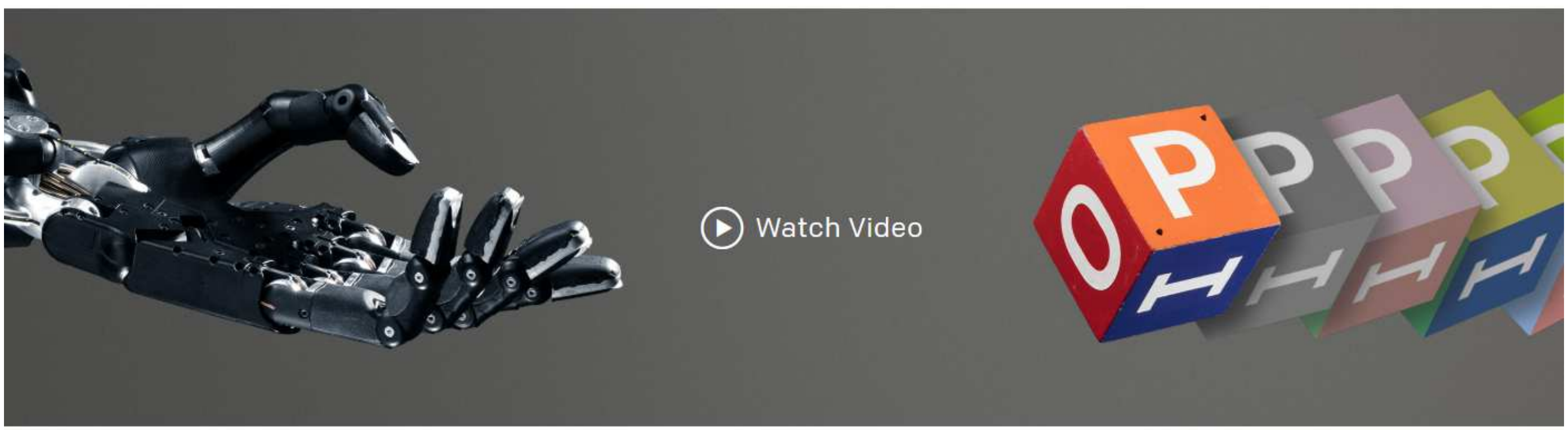
JULY 30, 2018 • 9 MINUTE READ

Learning Dexterity

We've trained a human-like robot hand to manipulate physical objects with unprecedented dexterity.

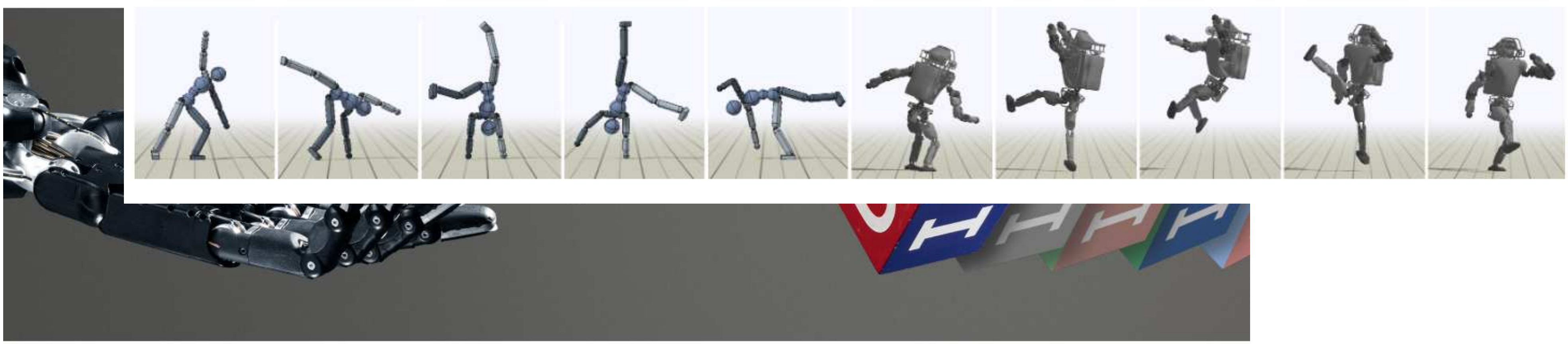


So how is CS249r actually going to run?

DeepMimic: Example-Guided Deep Reinforcement Learning of Physics-Based Character Skills

Transactions on Graphics (Proc. ACM SIGGRAPH 2018)

Xue Bin Peng(1) Pieter Abbeel(1) Sergey Levine(1) Michiel van de Panne(2)
(1)University of California, Berkeley (2)University of British Columbia



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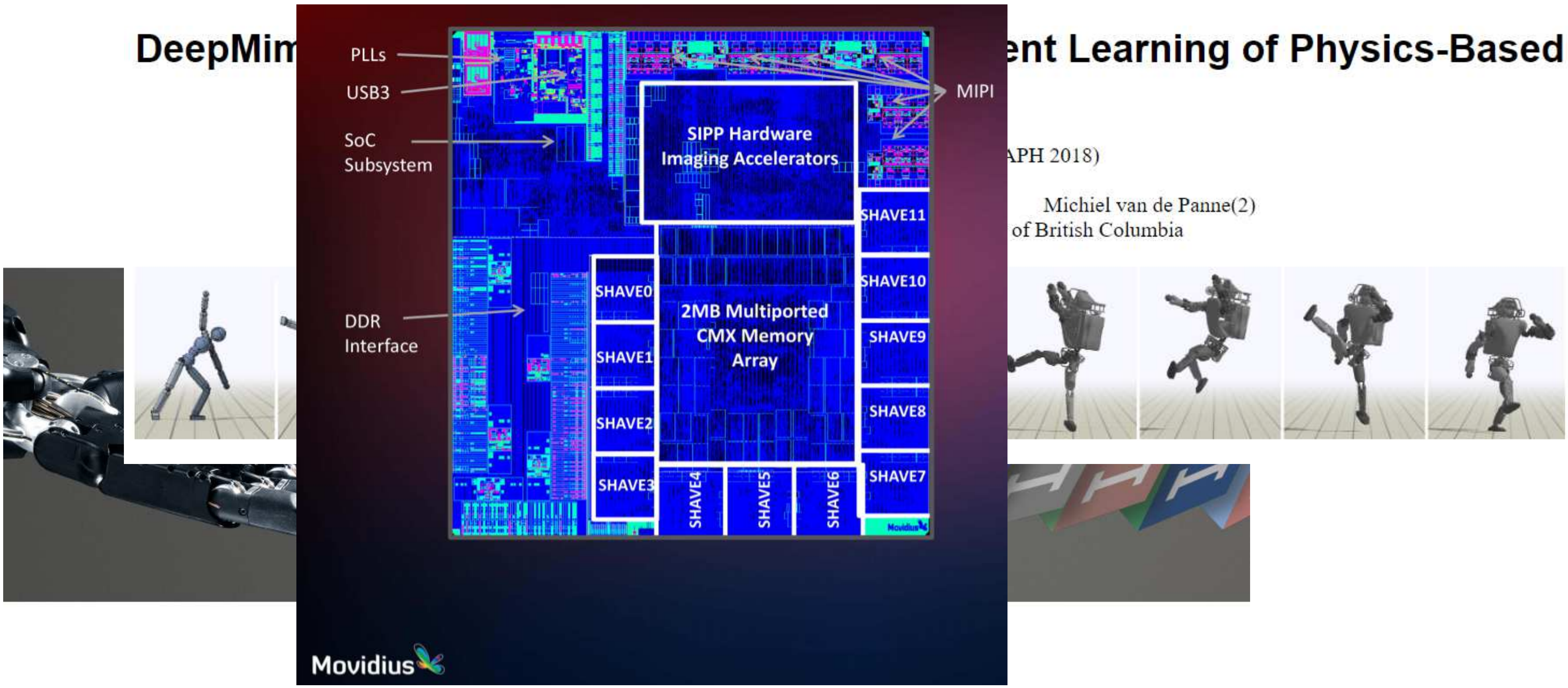

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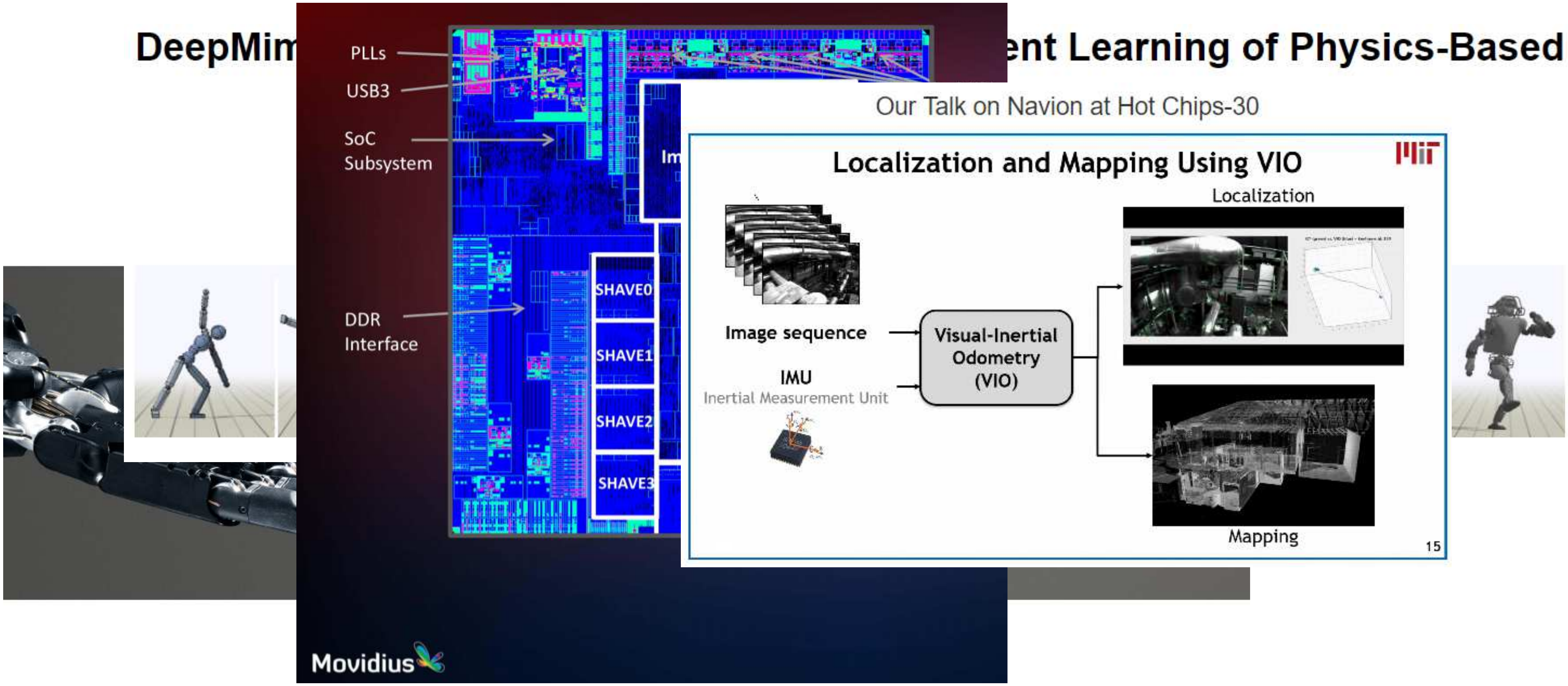

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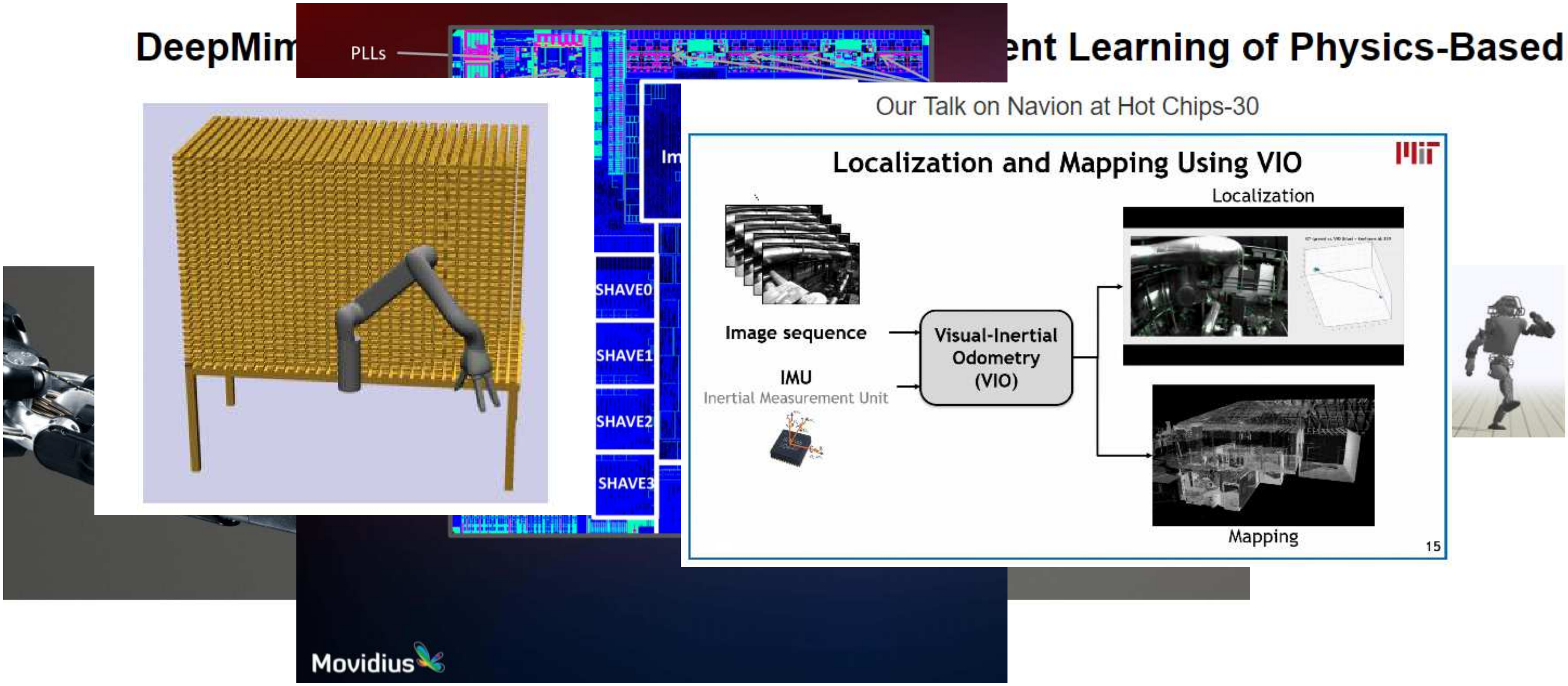

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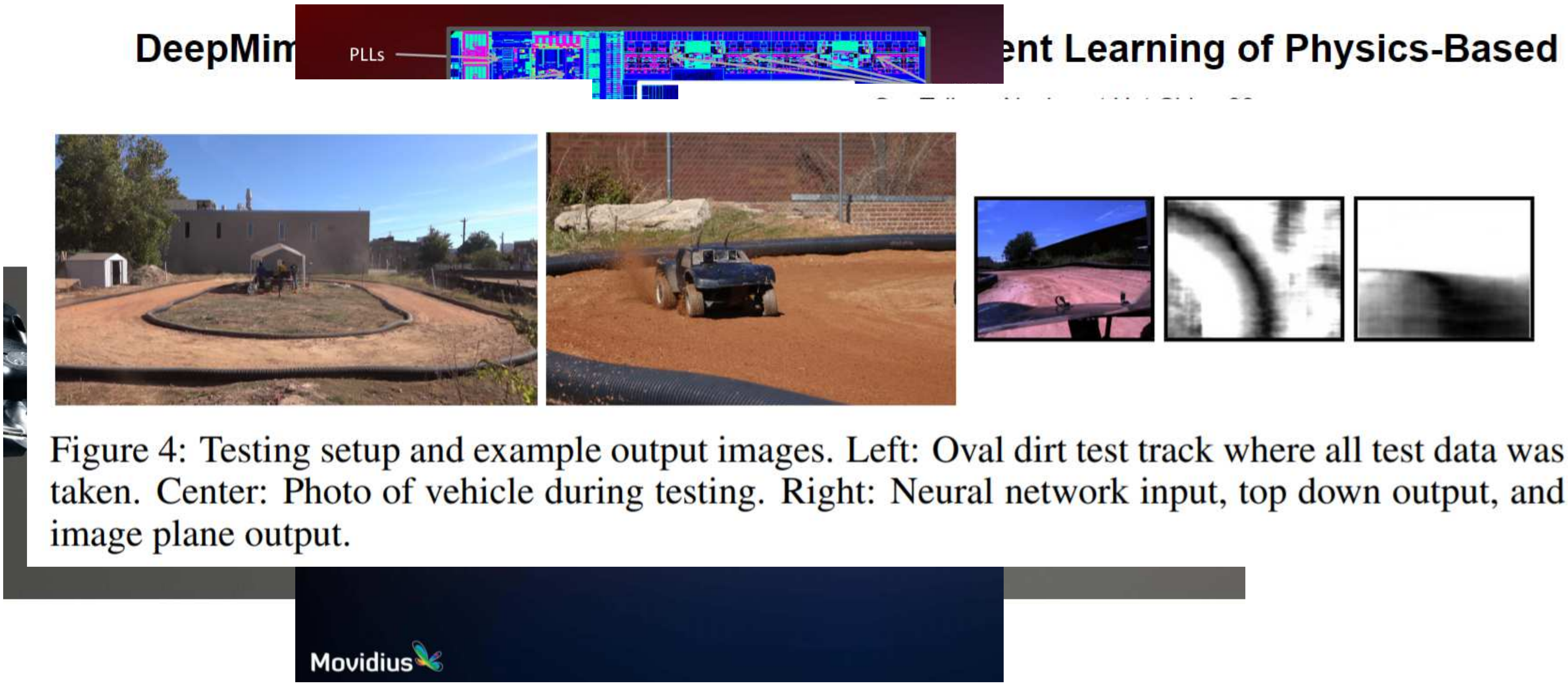

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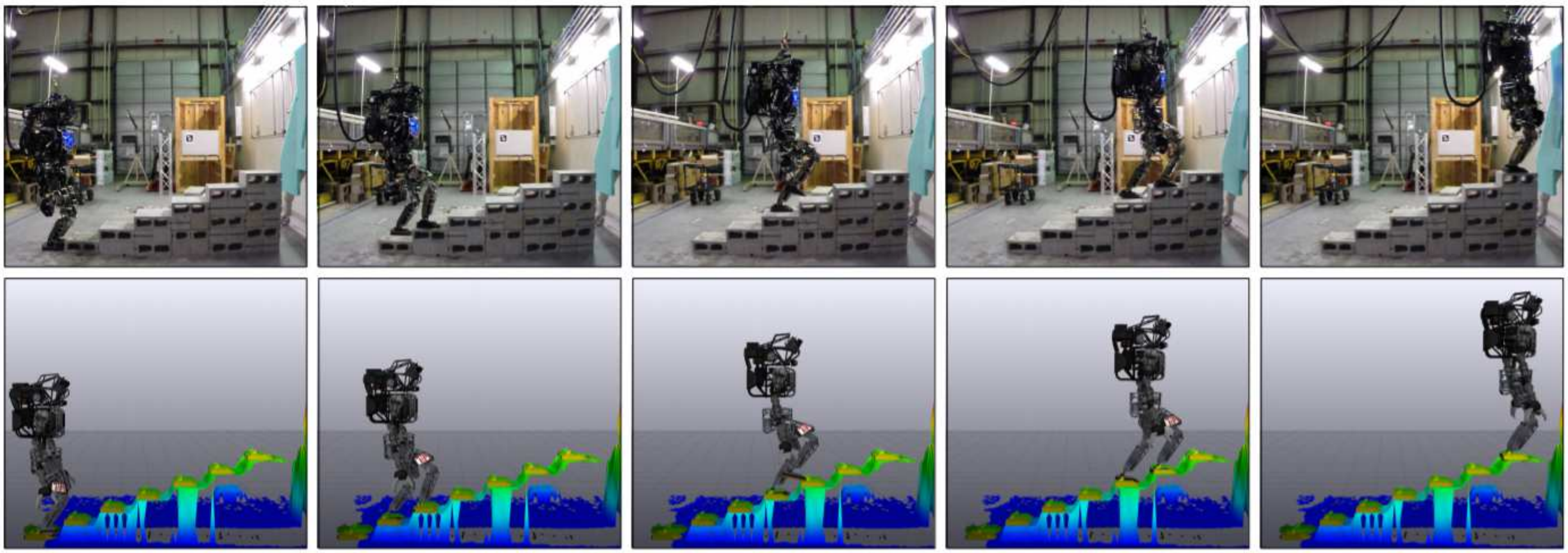

Fig. 12 Atlas walking continuously up six cinder block steps using LIDAR-based state estimation in a closed loop with the walking controller. Top: images of the robot climbing the stack of cinder blocks in our laboratory. Bottom: the state estimate rendering in our user interface.

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Mon, Oct 28	Perception / Mapping	Research Paper(s)	Perception / Mapping	Project Proposals Due
Wed, Oct 30		Research Paper(s)	Perception / Mapping	
Mon, Nov 4		Research Paper(s)	Perception / Mapping	
Wed, Nov 6		Research Paper(s)	Perception / Mapping	
Mon, Nov 11	Planning / Control	Research Paper(s)	Planning / Control	
Wed, Nov 13		Research Paper(s)	Planning / Control	
Mon, Nov 18		Research Paper(s)	Planning / Control	
Wed, Nov 20		Research Paper(s)	Planning / Control	
Mon, Nov 25	Final Project	No Class	Thanksgiving	
Wed, Nov 27		No Class	Thanksgiving	
Mon, Dec 2		Final Class	Wrap Up / Project Check-Ins / Office Hours in Class	
Wed, Dec 4		No Class	Reading period	
Mon, Dec 9		Project Presentations	Project presentations	Project Reports Due

Finally we wrap up the semester with a lot of time to work on and then present final projects.

Note the mid semester project proposal due date!

How do you get an A in CS 249r?

1. Paper Reviews – 20%
2. Paper Presentation – 20%
3. Class Participation – 10%
4. Final Project – 50%

Paper Reviews – 20%

Goals:

1. To develop the skill of reading papers and quickly taking away the big picture ideas.

Assignments:

1. Submit a short "review" on each research paper read during the course (and submit the review 36 hours BEFORE the class in which it is presented)

Paper Reviews – 20%

We will use HOTCRP (the standard submission system from Computer Architecture Conferences)

Goals:

1. To develop the skill of reading papers and quickly taking away the big picture ideas.

Assignments:

1. Submit a short "review" on each research paper read during the course (and submit the review 36 hours BEFORE the class in which it is presented)

Paper Reviews – 20%

Goals:

1. To develop the skill of reading papers and quickly taking away the big picture ideas.
2. **Crowdsource a best practice guide on writing papers**

Assignments:

1. Submit a short "review" on each research paper read during the course (and submit the review 36 hours BEFORE the class in which it is presented)

Paper Presentation(s) – 20%

Goals:

1. To develop the skill of understanding a paper in detail
2. Practice presenting a (conference) paper to audience and teaching a concept to a class

Assignments:

1. Give at least one 18 minute presentation on a research paper followed by 10 minutes of Q&A (and meet with the course staff a week prior to your presentation)

Paper Presentation(s) – 20%

Goals:

1. To develop the skill of understanding a paper in detail
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1. Give at least one 18 minute presentation on a research paper followed by 10 minutes of Q&A (and meet with the course staff a week prior to your presentation)

- **~5 minutes of setup** (What is the problem? Why is it important? What are the key challenges?)
- **~5 minutes of contribution** (What did the author(s) do? Why was it novel?)
- **~8 minutes of context** (What work did it build on /how does it compare?)

Class Participation – 10%

Goals:

1. Practice absorbing a (conference) paper presentation
2. To give feedback to presenters

Assignments:

1. Be an active participant in class
2. Submit anonymous feedback on each presentation

Final Project – 50%

Goals:

1. Practice being a graduate student:
   a) Coming up with a research idea
   b) Workshopping the idea with others / advisors
   c) Collaboratively conducting the research
   d) Writing up a (conference) paper in Latex
   e) Giving a presentation on the paper

Assignments:

1. Work in teams of 2-3 students to submit a project proposal midway through the semester and a final project report at the end of the semester as well as presenting that research to the class

Final Project – 50%

We would love to find a way to incorporate your research into your final project

Goals:

1. Practice being a graduate student:
   a) Coming up with a research idea
   b) Workshopping the idea with others / advisors
   c) Collaboratively conducting the research
   d) Writing up a (conference) paper in Latex
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Assignments:

1. Work in teams of 2-3 students to submit a project proposal midway through the semester and a final project report at the end of the semester as well as presenting that research to the class

Any questions?

Quick survey of all of you

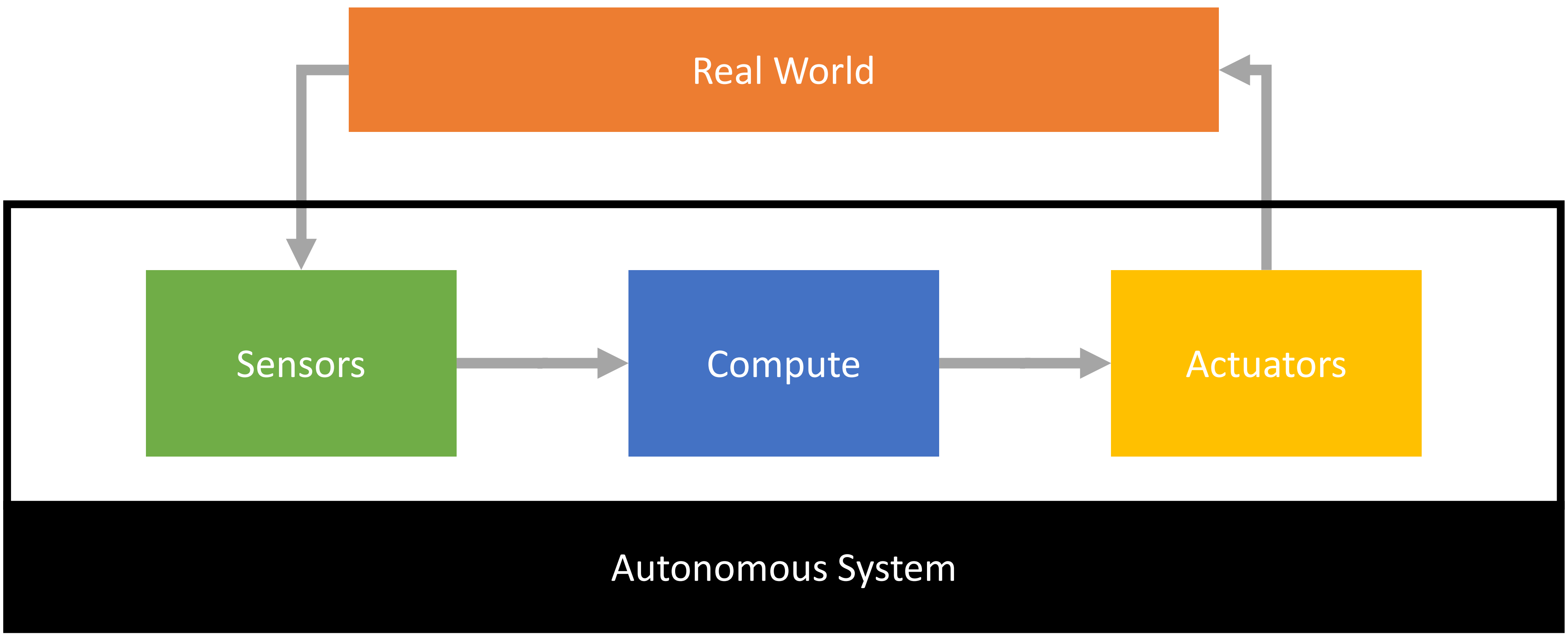
Undergrads vs Grads

Definitely vs Maybe Enrolling

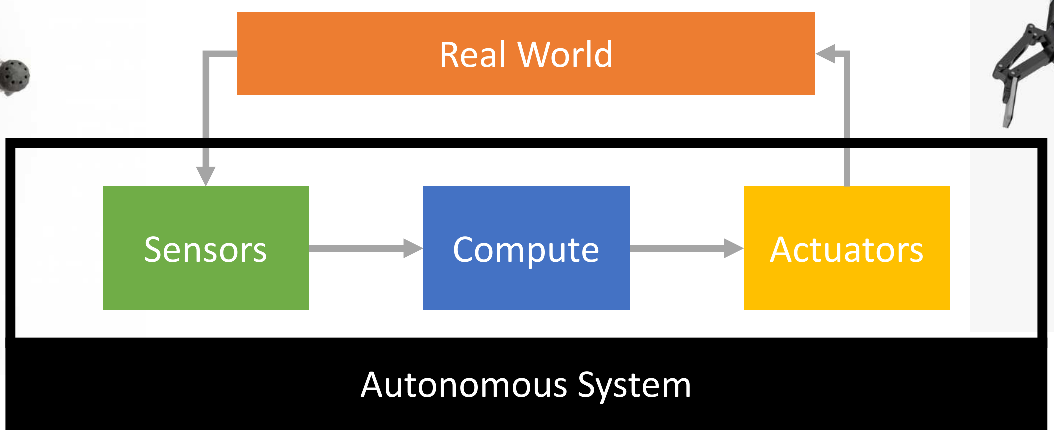
Architecture vs. Robotics / Autonomous Systems vs. Neither

Ok so lets dive into a little material for next week!

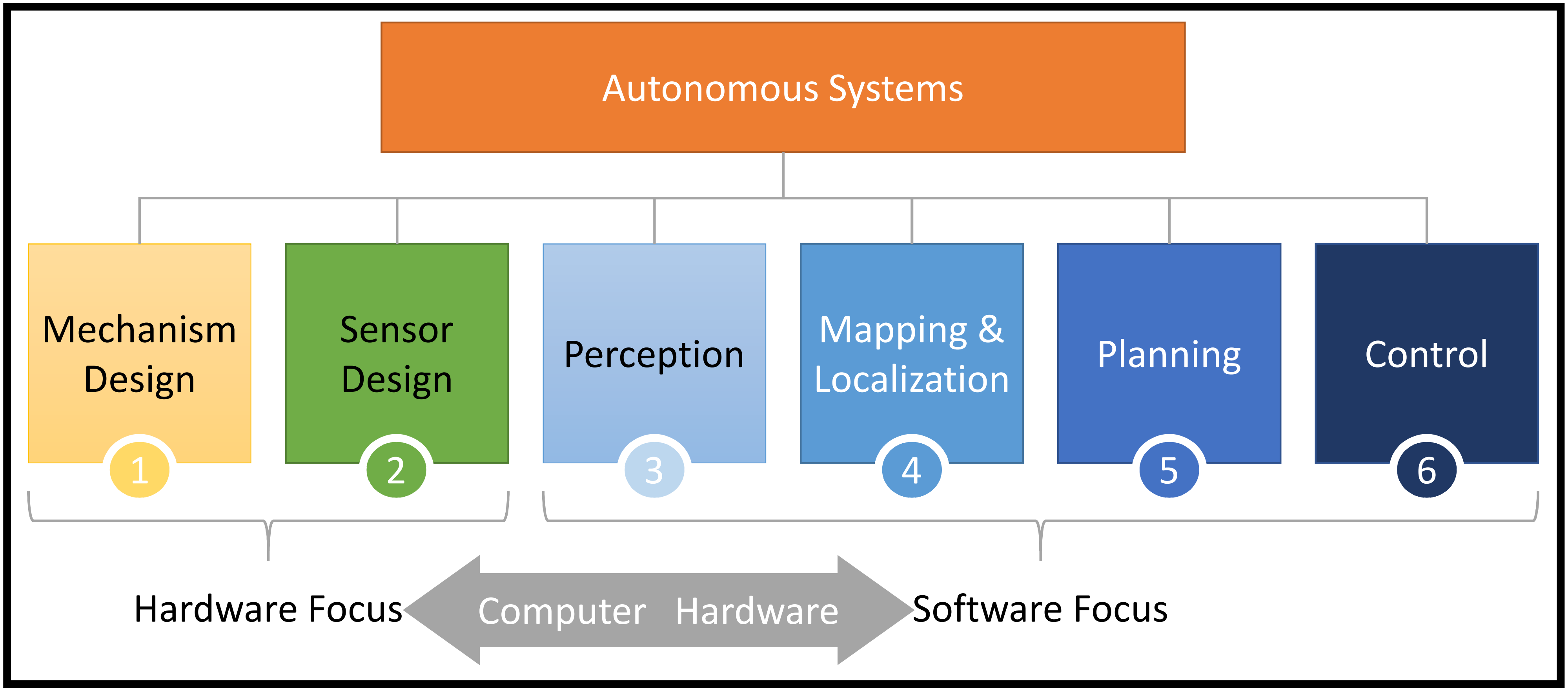
What do we mean by an Autonomous System?



What do we mean by an Autonomous System?



Autonomous Systems / Robotics is a BIG space



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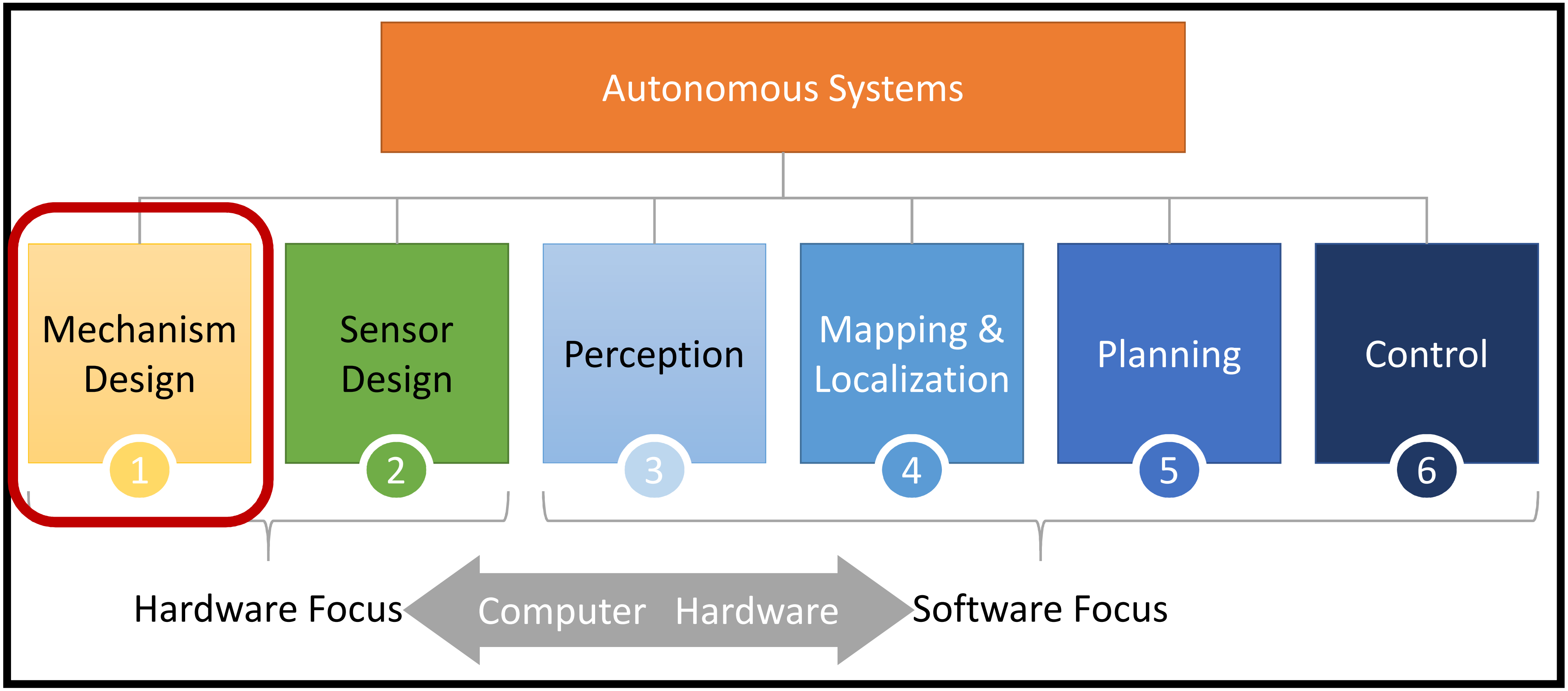
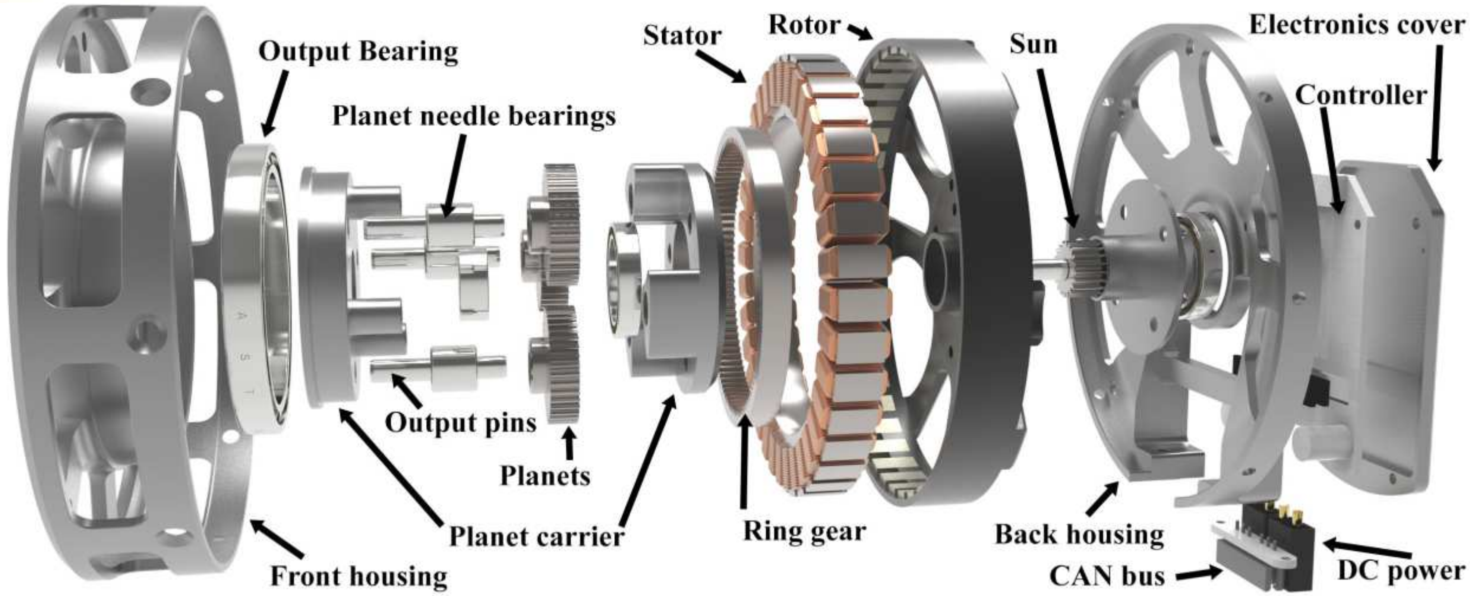


1 Mechanism designers create new robots and actuators

Fig. 4: The modular actuator used in the Mini Cheetah. Motor, planetary gear set, and control electronics are all built-in.

Fig. 5: Exploded view of the actuator.



Katz, Di Carlo and Kim ICRA 2019

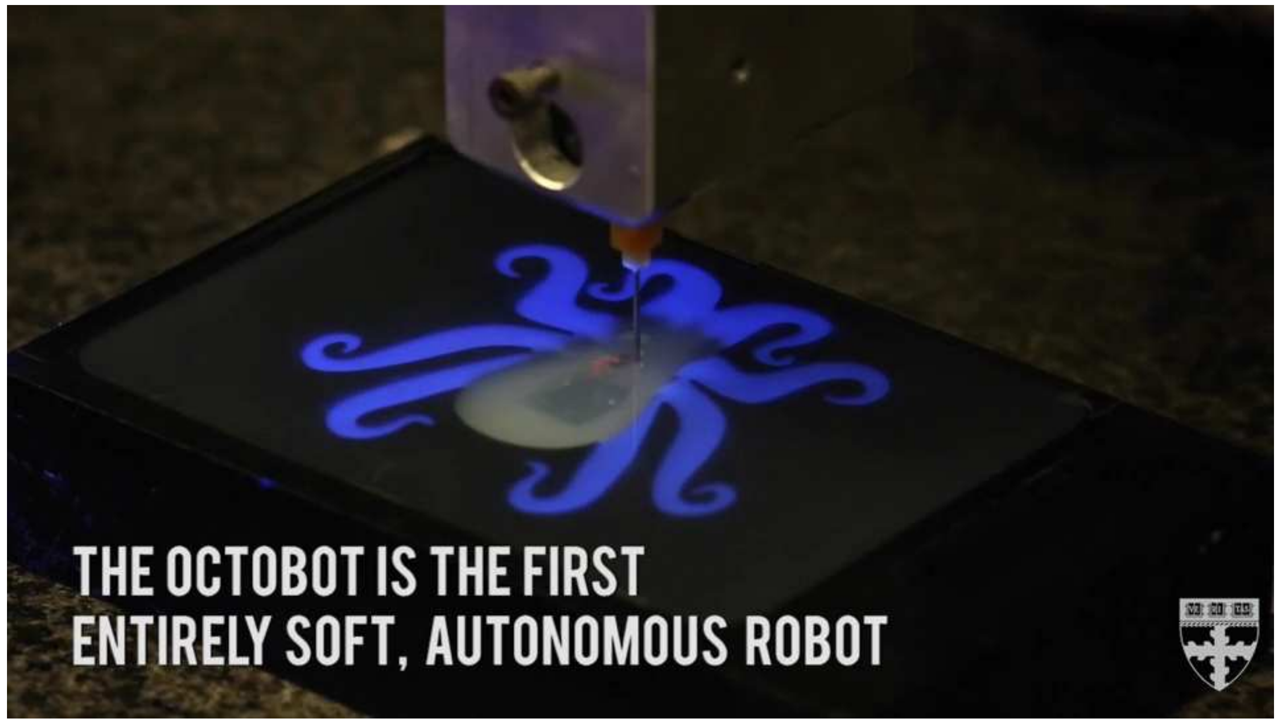
1 Mechanism designers create new robots and actuators

MIT 2.74

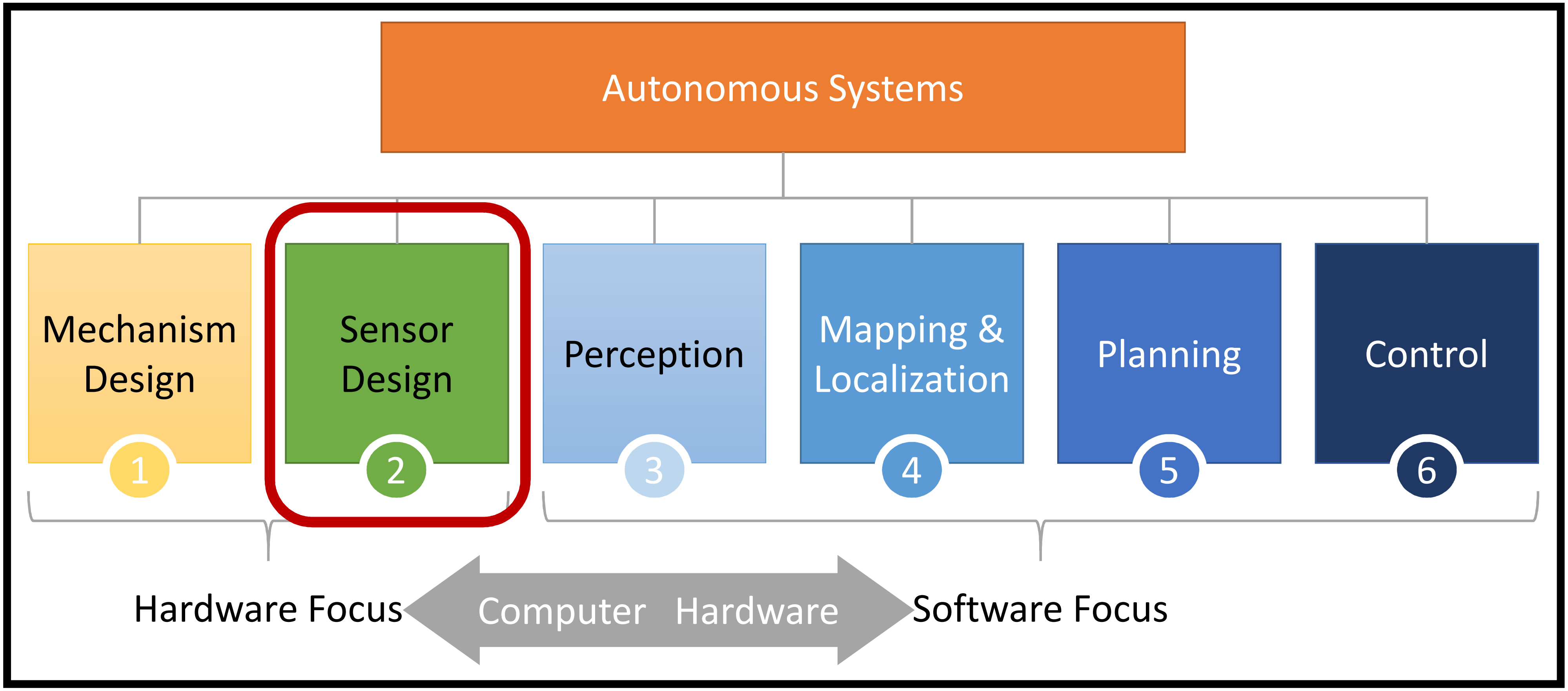
1 Mechanism designers create new robots and actuators

1 Mechanism designers create new robots and actuators

WYSS INSTITUTE



Autonomous Systems / Robotics is a BIG space



Sensor designers try to find new ways to collect data about the world around the autonomous system

2

MEMs IMUs / Gyroscopes

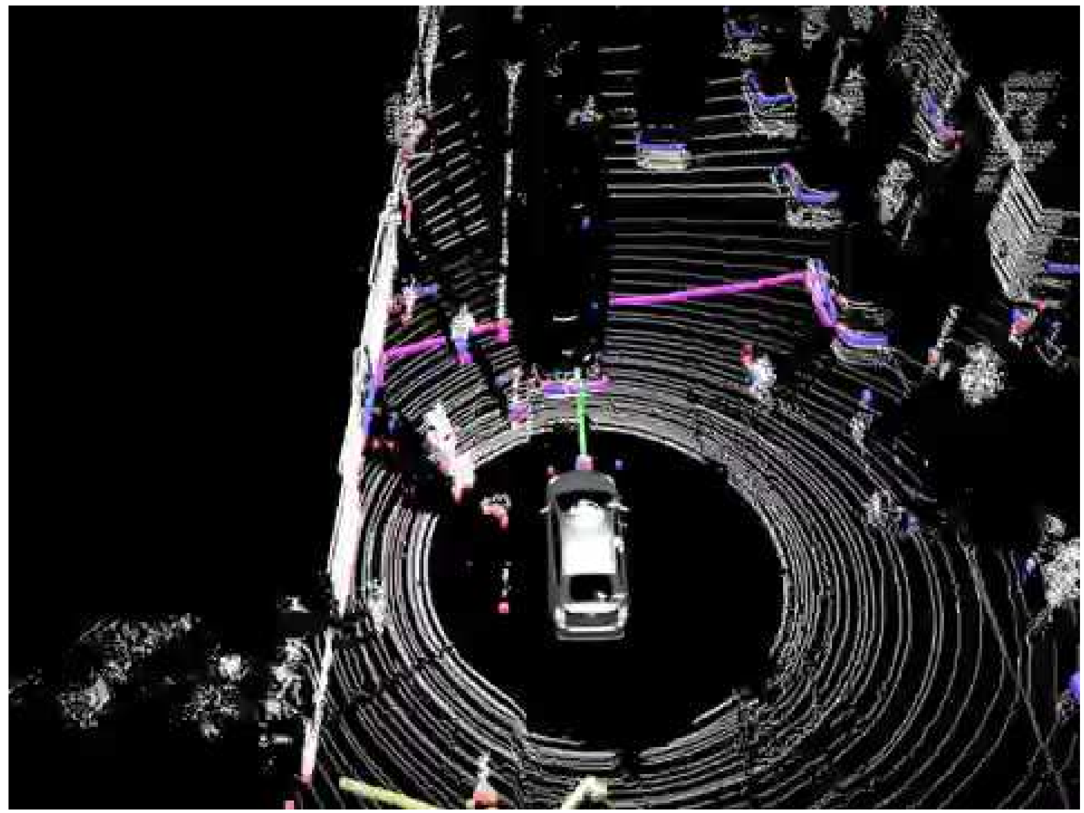
Motor Encoders

2

Sensor designers try to find new ways to collect data about the world around the autonomous system

Structured Light (e.g., LIDAR)

(and other Structured Waves e.g., Sonar, RADAR, etc.)



2 Sensor designers try to find new ways to collect data about the world around the autonomous system

Unstructured Light (aka Cameras)

2

Sensor designers try to find new ways to collect data about the world around the autonomous system

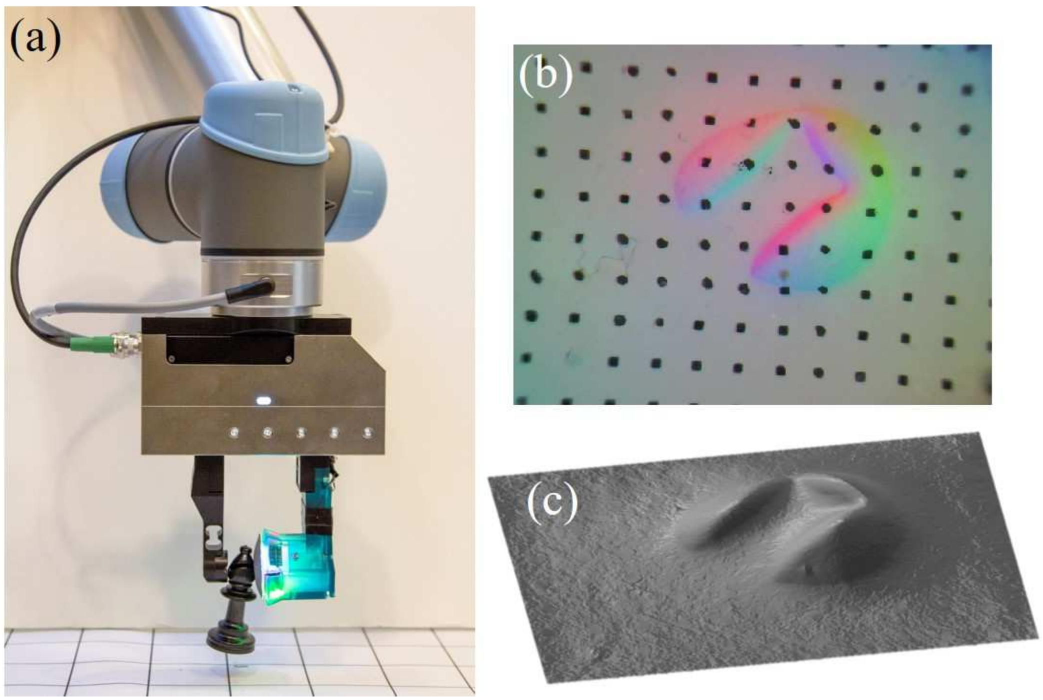
Unstructured Light (aka Cameras)

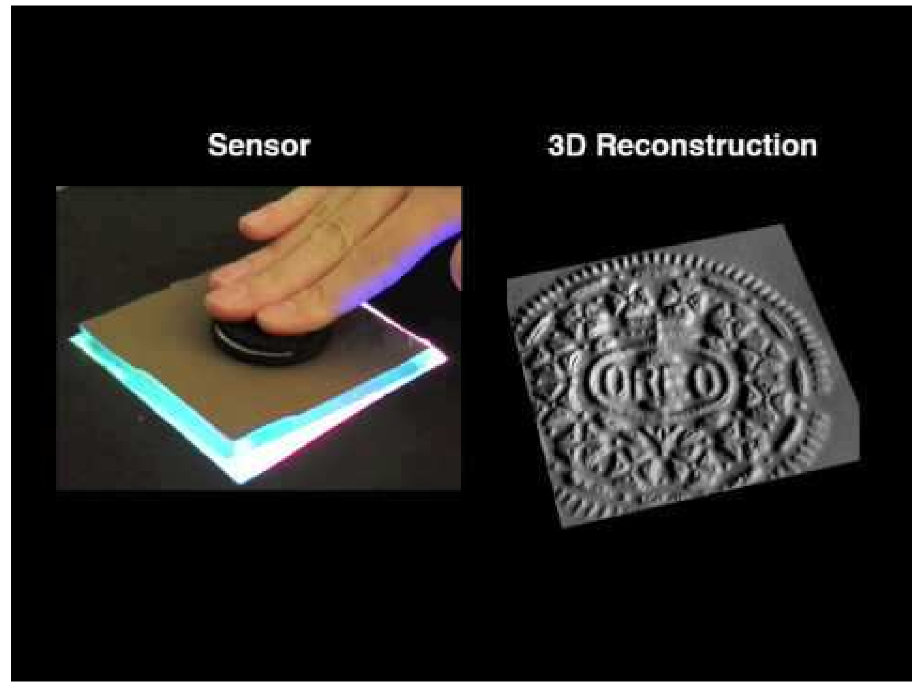
Computer Vision (we'll talk about this later)

Usable Data

2

Sensor designers try to find new ways to collect data about the world around the autonomous system





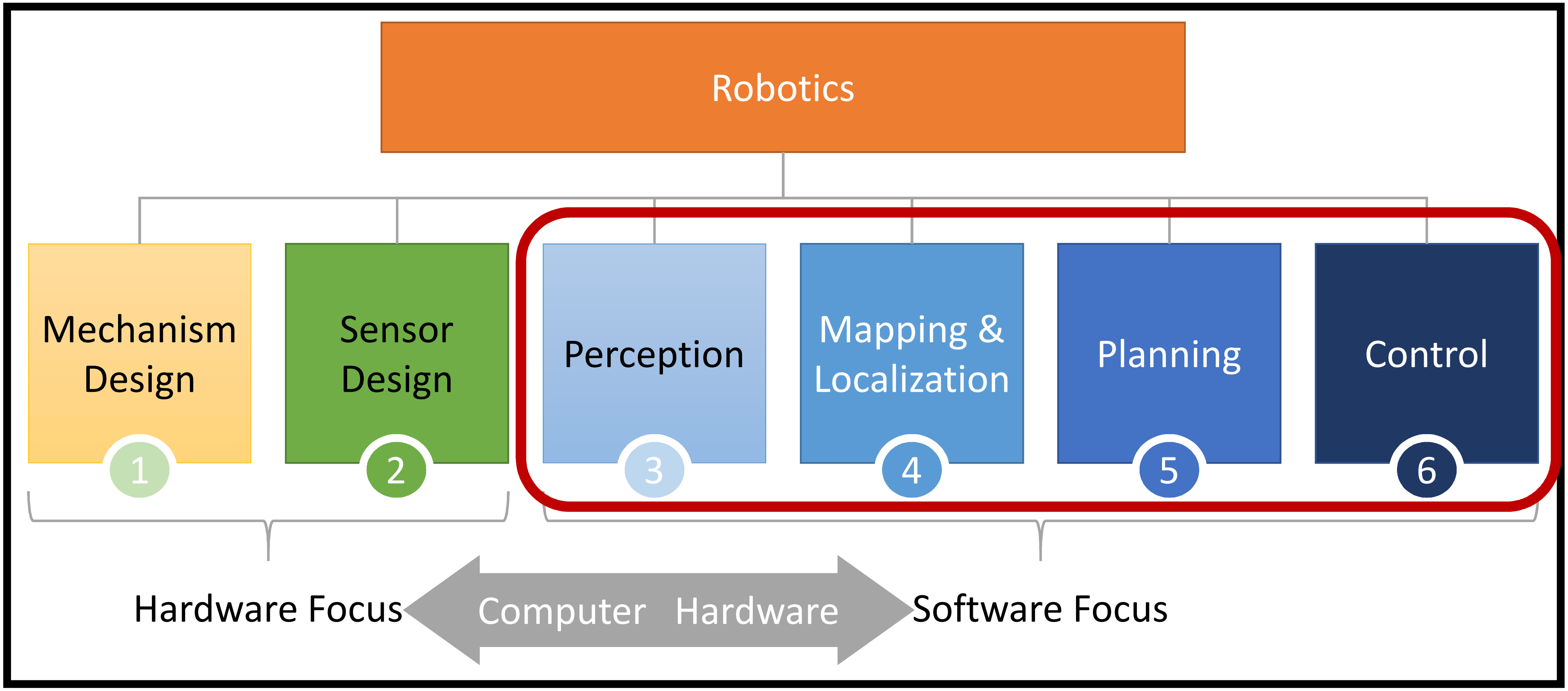
http://www.gelsight.com/

Key Takeaways:

1. Different kinds of systems will have different power, weight, and performance budgets for computer hardware and requirements for control algorithms
2. Understanding the sensors on your system will help you understand at what rate you can get information and the bandwidth of the information you will need to process
3. Different kinds of sensors will require different amounts of onboard compute to process the information

Our topic for next week – Compute!

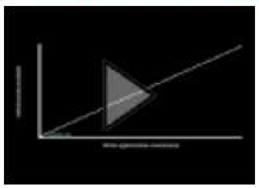
Autonomous Systems / Robotics is a BIG space



Your homework for next week 1/2

Pre-Reads for Intro to Robotics (Perception and Mapping)

[Chris Urmson: How a driverless car sees the road]



[Meet Spot, the robot dog that can run, hop and open doors | Marc Raibert]

Your homework for next week 2/2

Pre-Reads for Intro to Robotics (Planning and Control)

Computer Architeecture to Close the Loop in Real-time Optimization: https://ieeexplore.ieee.org/document/7402937

The Architectural Implications of Autonomous Driving: Constraints and Acceleration: https://web.eecs.umich.edu/~shihclin/papers/AutonomousCar-ASPLOS18.pdf

A Summary of Team MIT's Approach to the Virtual Robotics Challenge: https://agile.seas.harvard.edu/files/agile/files/vrc_entry.pdf

And finally some fun robot videos