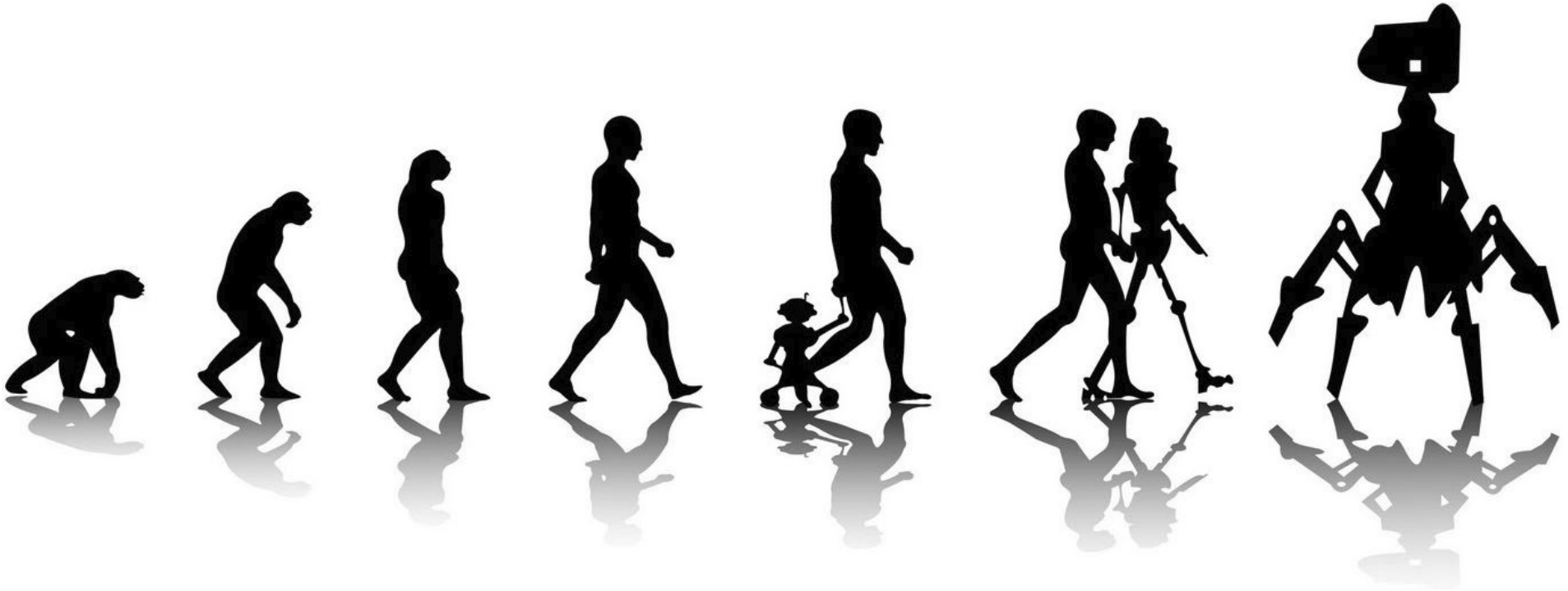


Modern Robotics: Evolutionary Robotics

COSC 4560 / COSC 5560

Professor Cheney

1/22/18

This course is based off of
popular courses designed by:

Josh Bongard at the University of Vermont,
Jeff Clune at the University of Wyoming,
Hod Lipson at Cornell University

and adapted with the help of
Joost Huizinga (our awesome TA!)

Many thanks to all of the above
for making this possible!

What's this all about?

INSIGHT
Machine intelligence

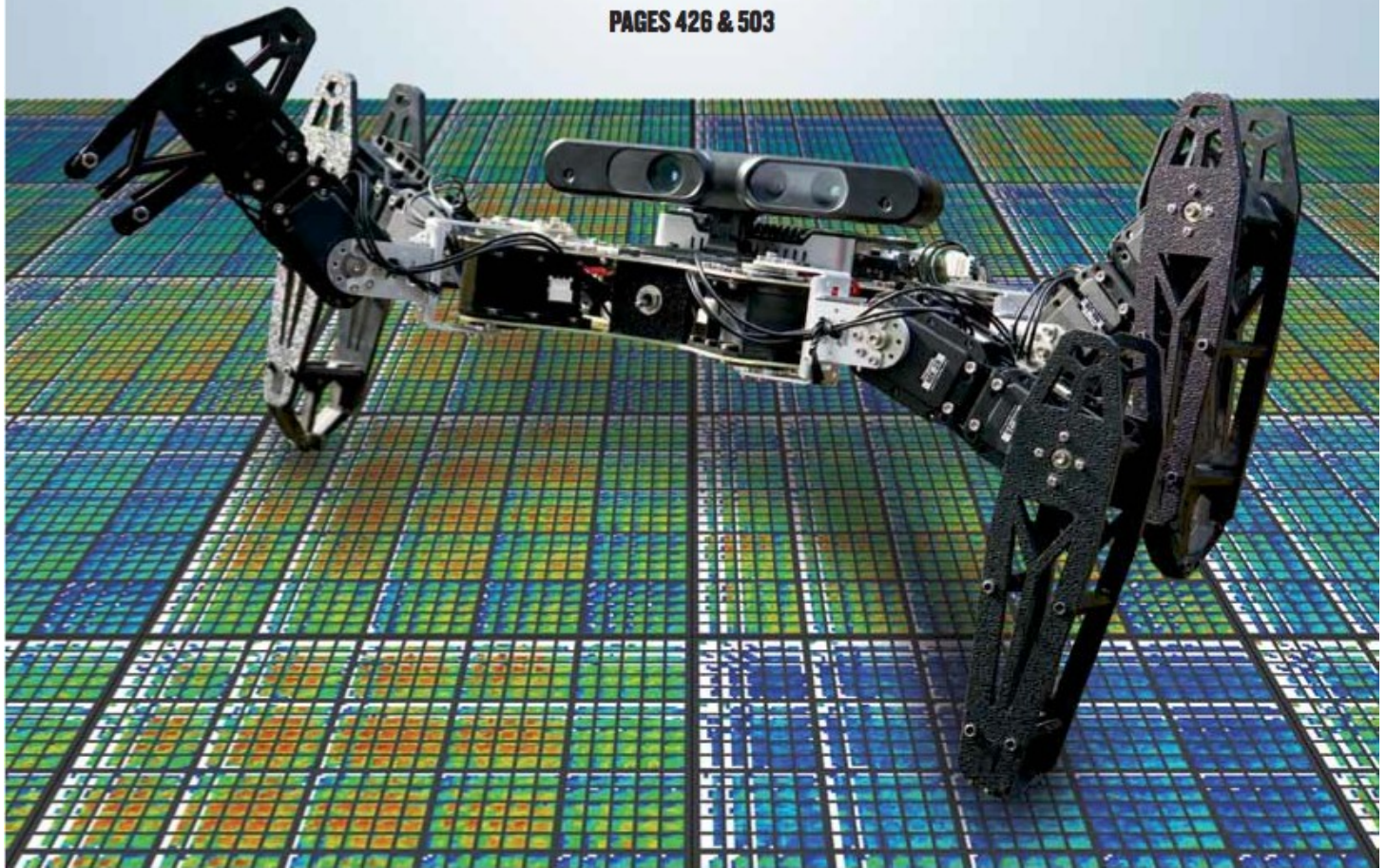
nature

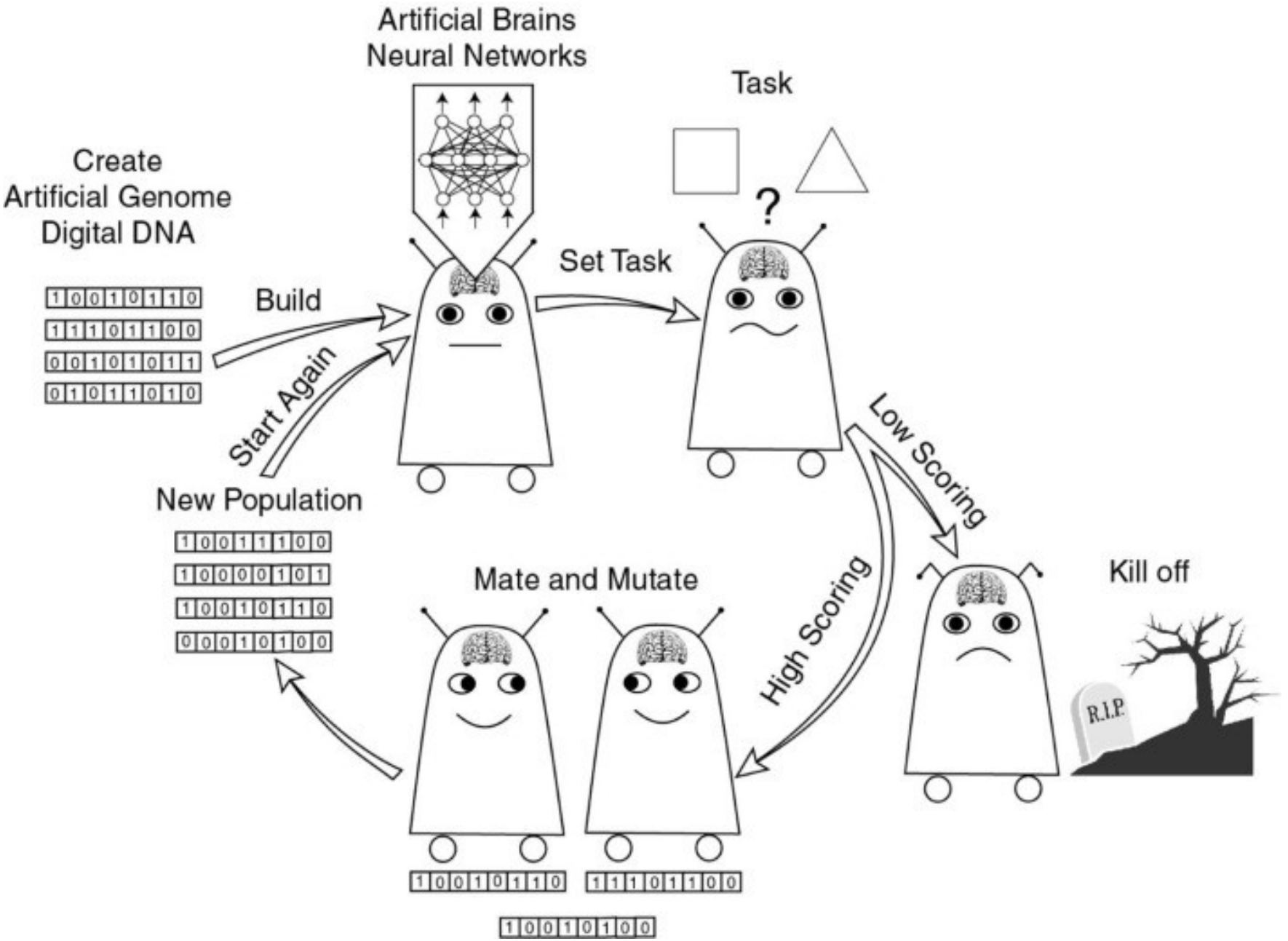
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

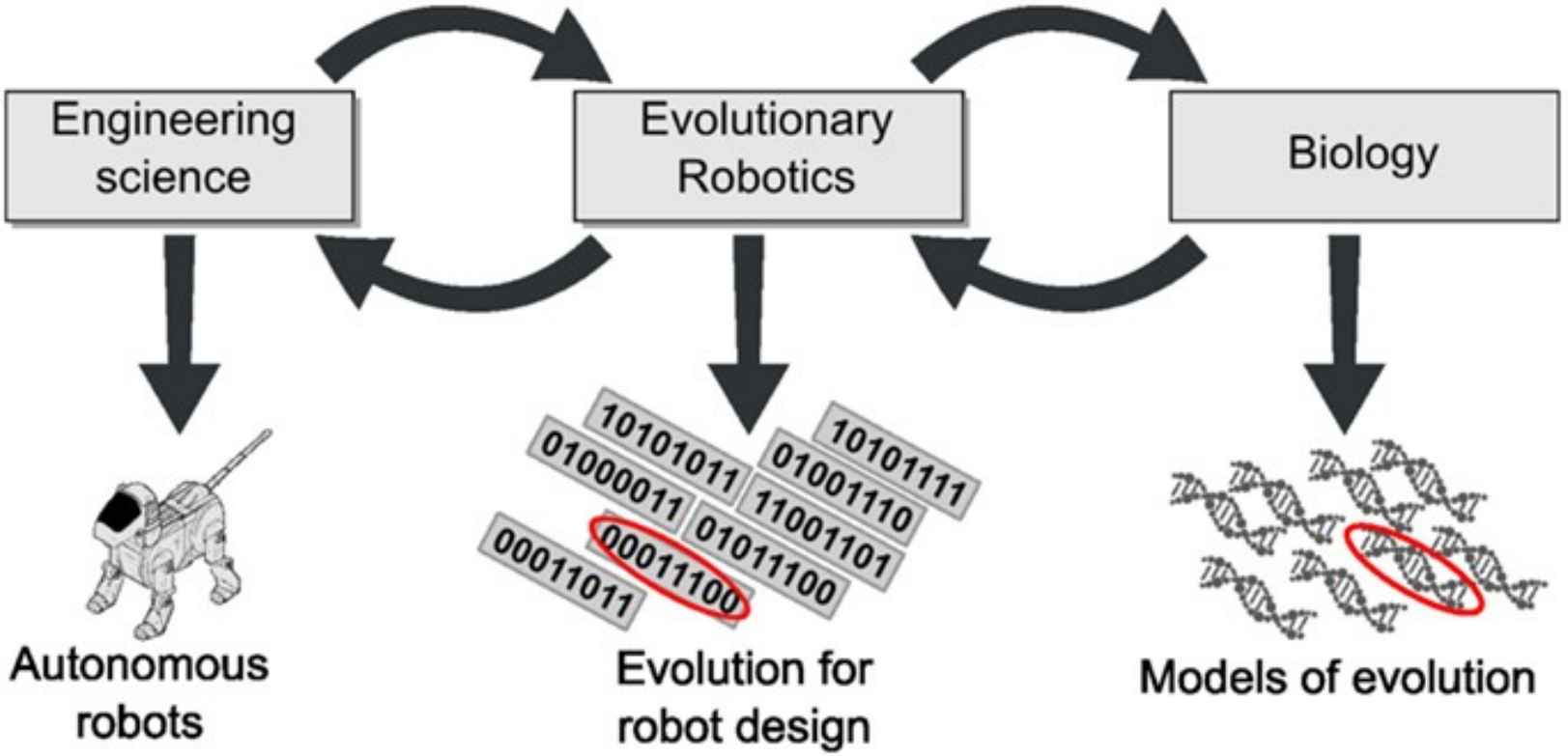
Back on its feet

Using an intelligent trial-and-error learning algorithm this robot adapts to injury in minutes

PAGES 426 & 503




Artificial Brains
Neural Networks
Task
Create
Artificial Genome
Digital DNA
Set Task
Build
Start Again
Low Scoring
New Population
Mate and Mutate
High Scoring
Kill off
R.I.P.


Engineering science
Evolutionary Robotics
Biology
10101011
01000011
11001101
01011100
00011011
00011100
10101111
01001110
Autonomous robots
Evolution for robot design
Models of evolution

Evolved Virtual Creatures

Karl Sims

Course Contents

Week 1: Intro and Motivation

- Big Picture... Why?

Week 2-3: Methods and Optimization

- Evolutionary Computation
- Neural Networks for Robotic Control

Week 4-6: Embodied Agents

- Embodied Cognition and Body-Plan Optimization
- Pattern Formation and Genetic Encodings

Week 7: Advanced Optimization

- Exploration vs. Exploitation

Week 8-12: State of the Art in Evolutionary Robotics

- Evolution and Development
- Multi-Agent Systems
- Active Learning

--- ***PROJECT PROPOSAL PITCHES –-***

Week 13-14: Reinforcement Learning for Robotics

- Deep Reinforcement Learning

Week 15-16: Open Problems

- Real World Uses and Pitfalls

--- PROJECT VIDEO PRESENTATIONS –-

Course Website:

ncheney.com/teaching/robotics

Homework Assignments

Hands-on Implementation of concepts we learn in class

Learn by doing![1]

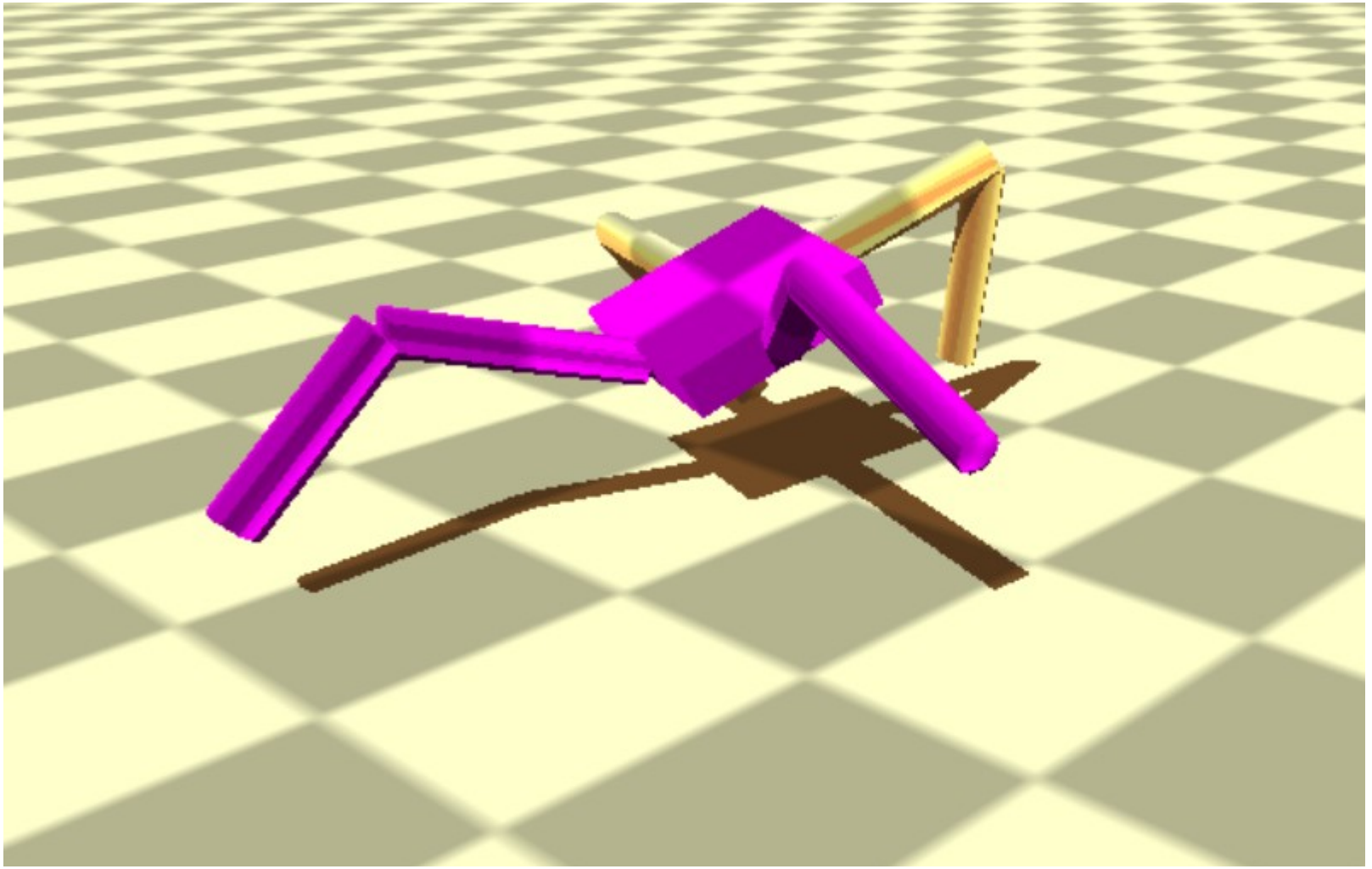
Programming in C++ and (visualizations in) Python (due every week)

[1] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410-8415.

Over 8 weeks of assignments, you'll build a toolkit for conducting evolutionary robotics experiments!

As each assignment adds a new piece to your system, they are cumulative and build on your previous code

This means you'll still have to make up any you don't turn in on time (so turn them all in on time!)



Posted ahead of time – start early!

Really… start early!

Piazza is a great place to ask clarifying/high-level questions
(not to ask for solutions…)

Joost will be available to help answer questions
(both on Piazza, and during office hours)

Course Project

You'll use the experimental platform you've made
(or some other Evolutionary Robotics platform…)
to conduct a brand new experiment
(e.g. new algorithm, environment, task, etc.)

The goal is to create publication quality work
(class projects have gone on to be published before,
and that should be your goal too!)

This project will start with a proposal (written)
and a pitch (presentation) that demonstrates
your knowledge of the field of Evolutionary Robotics
(based on readings and lectures),
and makes a case for why your project
is new and interesting

The final project will be a YouTube video that you share
with your classmates (and with the world!)
showing off and explaining what you accomplished

Projects are meant to be done individually or in small groups
(Groups of two or three are held to a standard of
two or three times the work and results –
which is not easy to do! Be warned!)

If pursuing a group project, you'll also have to demonstrate
that each member did their share of work
for both the proposal and the video
(i.e. the same as an individual project)

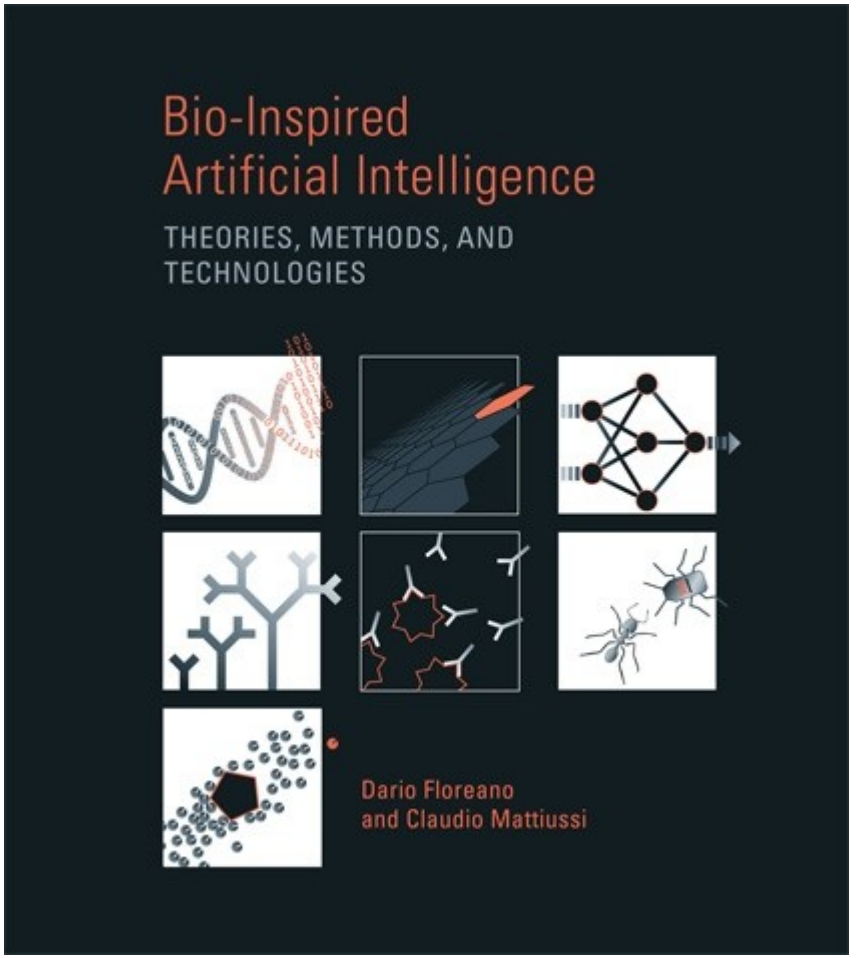
Textbook

Required:

Bio-Inspired Artificial Intelligence

Theories, Methods, and Technologies

By Dario Floreano and Claudio Mattiussi

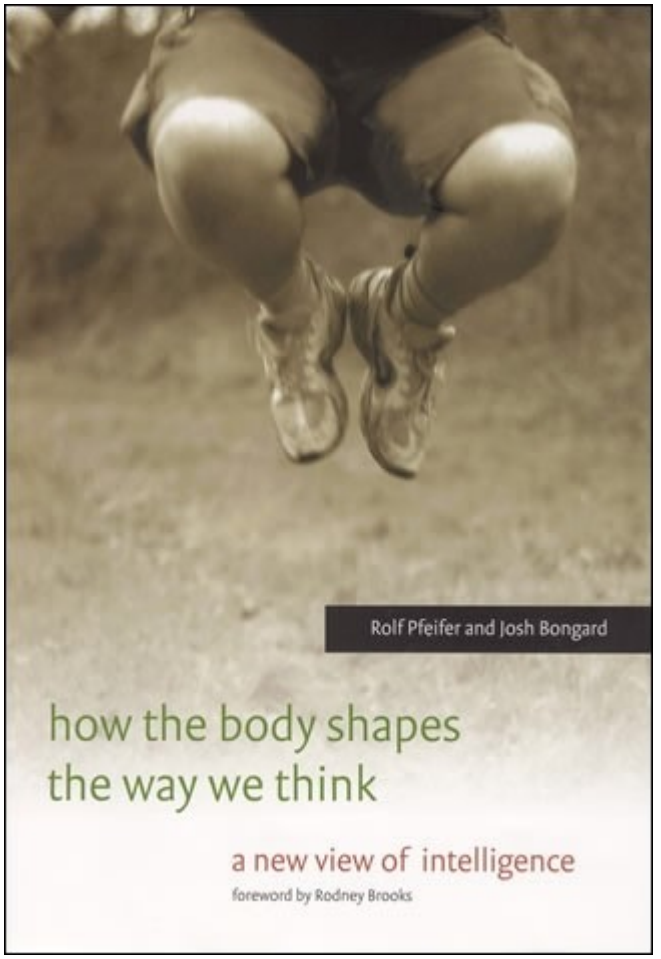


Optional:

How the Body Shapes the Way We Think

A New View of Intelligence

By Rolf Pfeifer and Josh Bongard



Papers:

Both foundational and state-of-the-art
(pdfs will be provided on course website)

Reading will be posted on course website:

ncheney.com/teaching/robotics

Schedule will be updated regularly
check back often!

Read **before** class!!!

Some of the material will be covered in class
(read it anyways!)

Some will not be covered during the lectures,
but still important and helpful for assignments and projects

Read **before** class!!!

The reading will be focused heavily on important and state-of-the-art topics in the field

Knowing both the topics in the scientific literature and how to deconstruction and interpret scientific papers are an enormous part of being an AI researcher/scientist/engineer

Read **before** class!!!

But actually…. do it!

Graduate students will be required to hand in
paper reactions (not summaries!) at the end of each week
describing their thoughts on the readings

Undergraduates with aspirations for research-related careers
(e.g. graduate school, AI engineer/scientist)
are encouraged to also hand in weekly paper reactions
for extra credit!

Lecture Slides

Link to pdfs will be posted on the course website

ncheney.com/teaching/robotics

within a day or two after class
(let me know if I'm being slow…)

Grading

40-50% – Homework Assignments, learn by doing!

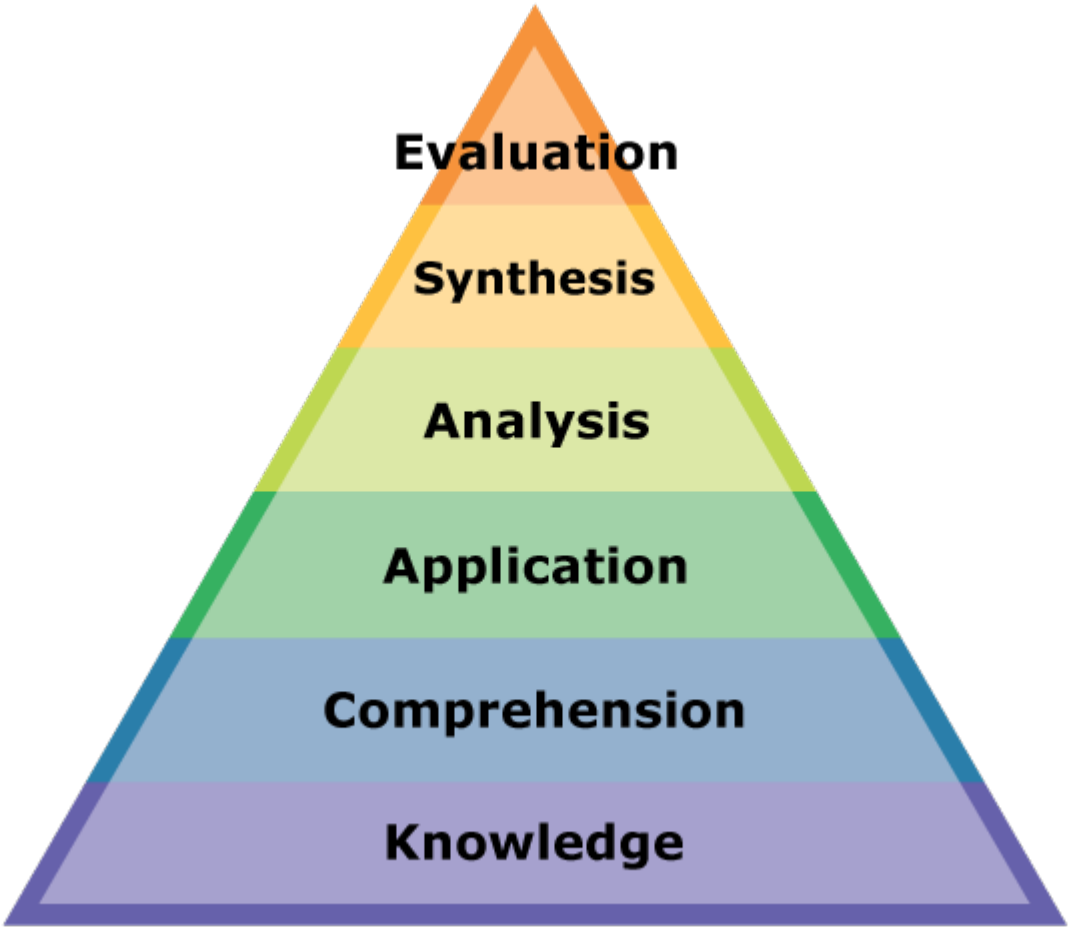
0-10% – Paper Reactions, from readings

15% – Project Proposals (including background from readings)

30% – Course Project (final), hands on research project

5% – Participation (involvement in class discussions, Piazza, ...)

Bloom's Taxonomy



Participation

Part of being an AI researcher is being involved
in an active community of discussion

Class should be a discussion with lots of feedback
(you and I get rare feedback on learning from exams/grades)

The Piazza online forum is a great way to earn participation credit outside of class times

Earn credit for both asking and answering questions to/from your classmates

http://www.piazza.com/uwyo/spring2018/cosc4560cosc5560

This is also a huge part of being an AI researcher!
(e.g. Stack Exchange)

Attendance is also a part of participation grades

Expectation is that you will attend all lectures
(I'll try to make it that you really want to also!)

For exam/project presentations,
only University Excused Absences are excepted
(you can get these from the Dean of Students)

Additional accommodations (including taking exams at the Disability Support Services office) are available for any students with physical/learning/psychological disabilities

Please first contact the DSS office (again with the Dean of Students) And they will work with me to arrange the necessary accommodations

Laptops and smartphones are not allowed in class
(this is also part of your participation grade)

Leads to worse overall learning outcomes[1]
(distracting for you, distracting for others around/behind you, distracting for me

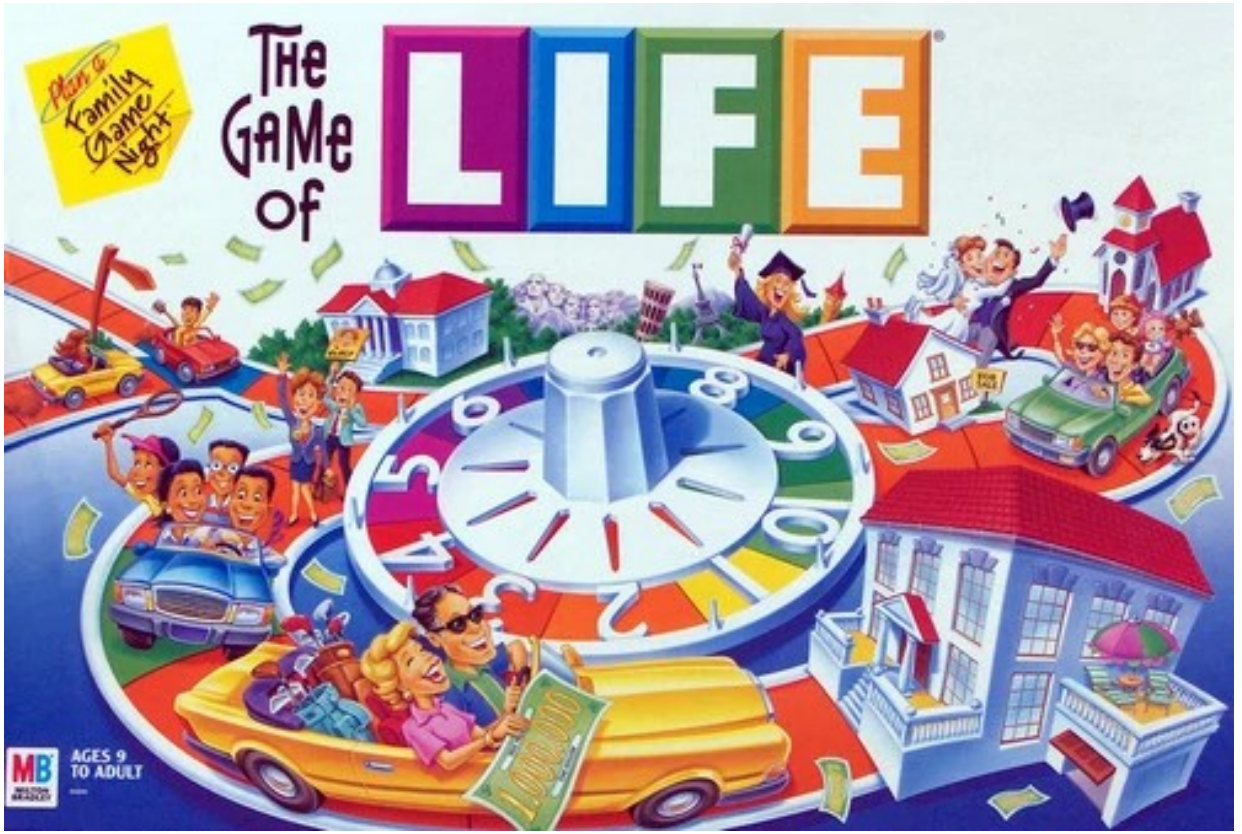
Please bring a pen and paper for in-class exercises
You do not need to bring your textbook

[1] Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. Computers & Education, 62, 24-31.

Participation Extra Credit:

(+1) come to office hours so I can get to know!

(I can only help you to achieve your goals if I know them)



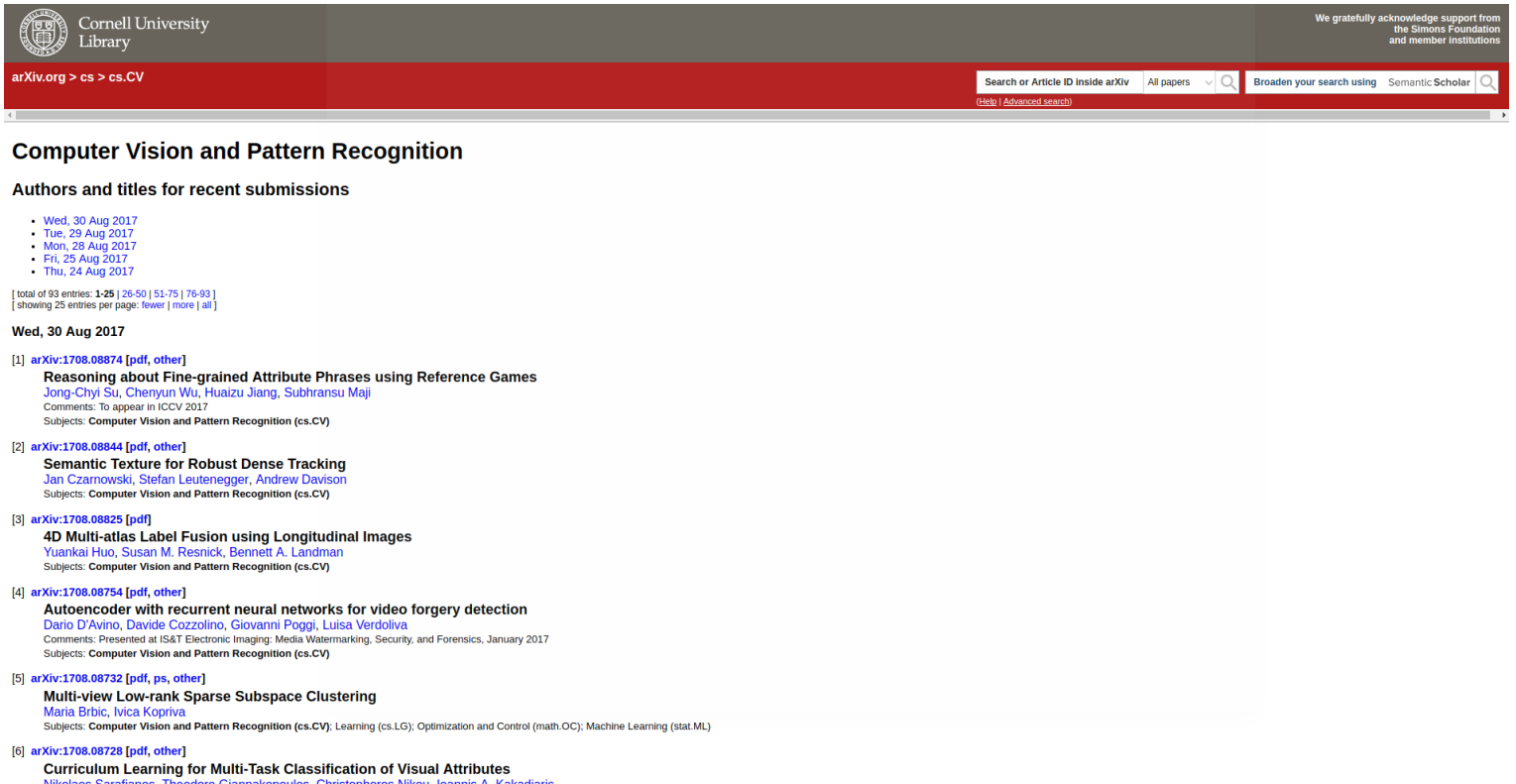
Participation Extra Credit:

(+1) volunteer at the Laramie Robotics Club with us!

(teach middle schoolers about programming and robotics)

Participation Extra Credit:

(+1) be curious and share you findings with the class!
(make a slide or two from something you saw
in class or in the news and did extra research on)



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arXiv.org > cs > cs.CV

Search or Article ID inside arXiv | All papers | Broaden your search using Semantic Scholar

(Help | Advanced search)

Computer Vision and Pattern Recognition

Authors and titles for recent submissions

- Wed, 30 Aug 2017
- Tue, 29 Aug 2017
- Mon, 28 Aug 2017
- Fri, 25 Aug 2017
- Thu, 24 Aug 2017

[total of 93 entries: **1-25** | 26-50 | 51-75 | 76-93]
[showing 25 entries per page: fewer | more | all]

Wed, 30 Aug 2017

[1] arXiv:1708.08874 [pdf, other]
Reasoning about Fine-grained Attribute Phrases using Reference Games
Jong-Chyi Su, Chenyun Wu, Huaizu Jiang, Subhransu Maji
Comments: To appear in ICCV 2017
Subjects: **Computer Vision and Pattern Recognition (cs.CV)**

[2] arXiv:1708.08844 [pdf, other]
Semantic Texture for Robust Dense Tracking
Jan Czarnowski, Stefan Leutenegger, Andrew Davison
Subjects: **Computer Vision and Pattern Recognition (cs.CV)**

[3] arXiv:1708.08825 [pdf]
4D Multi-atlas Label Fusion using Longitudinal Images
Yuankai Huo, Susan M. Resnick, Bennett A. Landman
Subjects: **Computer Vision and Pattern Recognition (cs.CV)**

[4] arXiv:1708.08754 [pdf, other]
Autoencoder with recurrent neural networks for video forgery detection
Dario D'Avino, Davide Cozzolino, Giovanni Poggi, Luisa Verdoliva
Comments: Presented at IS&T Electronic Imaging: Media Watermarking, Security, and Forensics, January 2017
Subjects: **Computer Vision and Pattern Recognition (cs.CV)**

[5] arXiv:1708.08732 [pdf, ps, other]
Multi-view Low-rank Sparse Subspace Clustering
Maria Brbic, Ivica Kopriva
Subjects: **Computer Vision and Pattern Recognition (cs.CV)**; Learning (cs.LG); Optimization and Control (math.OC); Machine Learning (stat.ML)

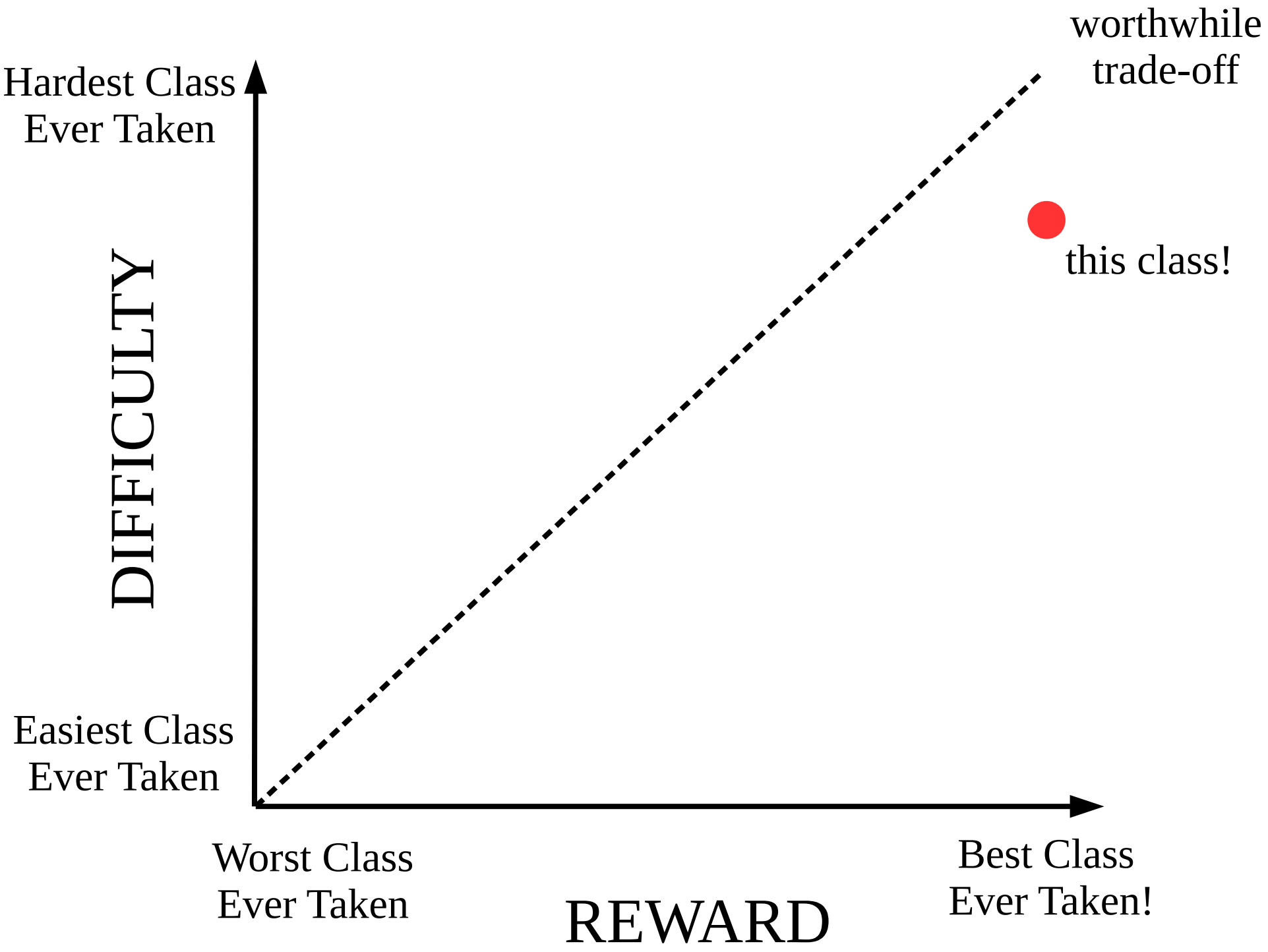
[6] arXiv:1708.08728 [pdf, other]
Curriculum Learning for Multi-Task Classification of Visual Attributes

There is a lot to cover!

This class will be a lot of work – it's going to be hard!

Lots of reading, lots of coding

But it will be totally worth it, and you will learn a lot!


worthwhile
trade-off
Hardest Class
Ever Taken
DIFFICULTY
this class!
Easiest Class
Ever Taken
Worst Class
Ever Taken
REWARD
Best Class
Ever Taken!

Feedback

Please let me know how you feel about the class
(e.g. too fast/slow, not enough/too much time
on a given concept, good/bad application examples)

Tell me: after/before/during class
mid-term survey
office hours
email (including anonymous email)

I will strongly consider your feedback
(good chance I will implement it in some way)

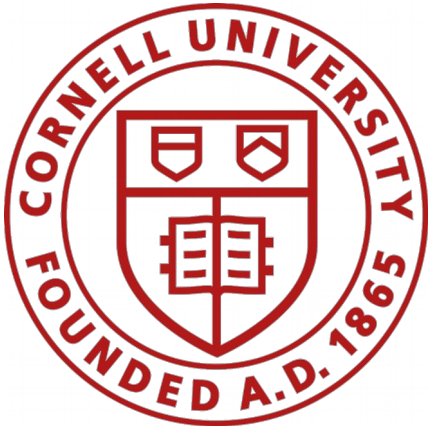
Office hours:
(lectures, readings, project brainstorming, life stuff)
By appointment – ncheney@uwyo.edu

TA office hours:
(coding help and assignments)
TBD – to be posted on course website

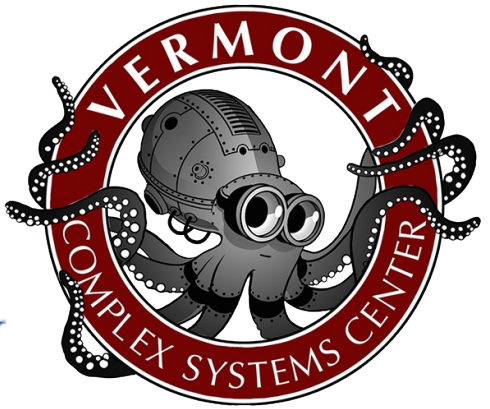
Meet and Greet


Burlington, VT
BEN & JERRY'S
Cookie Dough
ICE CREAM
Vanilla Ice Cream with Chunks of Chocolate Chip Cookie Dough
NEWPORT
ST. ALBANS
MT. MANSFIELD 4393 FT.
BURLINGTON
STOWE
CHRISTMAS TREES
ST.JOHNSBURY
WATERBURY
MONTPELIER
GREEN MT. NATIONAL FOREST
BARRE
SUGARBUSH VALLEY SKI AREA
MIDDLEBURY
WOODSTOCK
RUTLAND
KILLINGTON SKI RESORT
MANCHESTER
MT. SNOW SKI RESORT
BRATTLEBORO
BENNINGTON
State of Vermont
PURE
MAPLE
SYRUP
REGISTERED
1 pint 2 fl. oz 533 ml


The University
of Vermont


CORNELL UNIVERSITY
FOUNDED A.D. 1865


COLUMBIA
UNIVERSITY

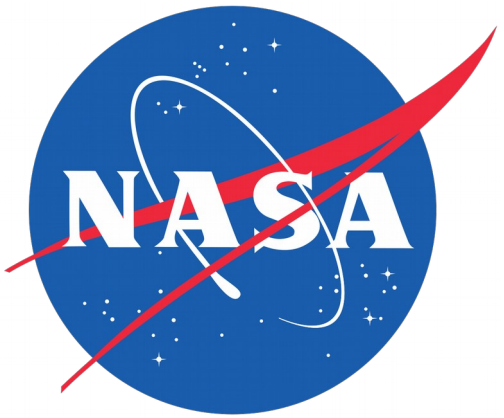

VERMONT
COMPLEX SYSTEMS CENTER


UNIVERSITY
OF WYOMING


UBER
AI Labs

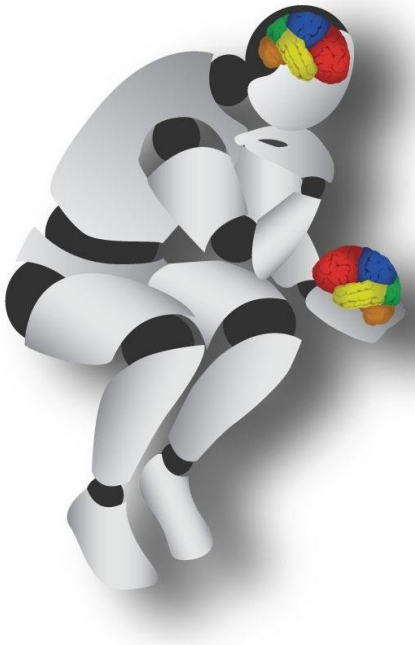

DARPA


SANTA FE
INSTITUTE


NASA


SCIENCE TO SHAPE THE FUTURE OF THE ARMY
ARMY RESEARCH OFFICE
1951


NSF



EVOLVING ARTIFICIAL INTELLIGENCE LABORATORY

UNIVERSITY OF WYOMING

Build robots
that rival animals

CREATIVE MACHINES LAB
COLUMBIA UNIVERSITY

Build robots that
create and are creative

USLacrosse®

High School All-Americans

And you… ?

What's your name?

Where are you from?

Why are you here?
(What's your background/major?
What are you hoping to learn?)

One fun fact about yourself