AM 207

ADVANCED SCIENTIFIC COMPUTING: MONTE CARLO METHODS FOR INFERENCE AND DATA ANALYSIS, AND STOCHASTIC OPTIMIZATION

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NW 235.1 or B164

All About Randomness

- Solve your problems using random numbers and uncertainty.

Outline

- Why care about this course
- What is the course about
- Who is helping you learn the material
- How will we learn it

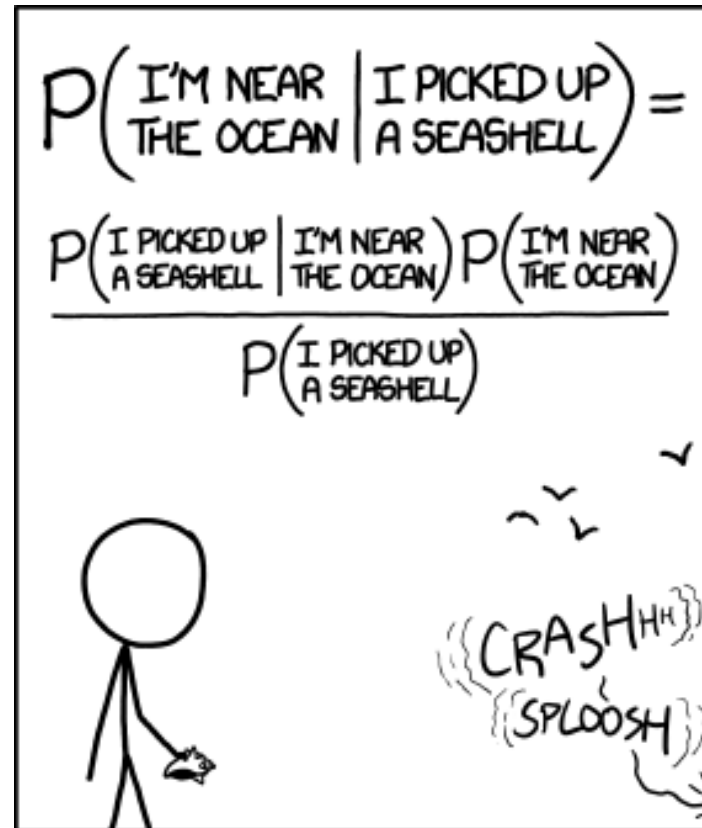START WITH WHY
Simon Sinek
www.startwithwhy.com
TED TALK

Why

- Sometimes defining your problem in a deterministic way is very hard / infeasible
- But computers nowadays are fast
- It is easier and faster to let the Computer run for a day than think for a week
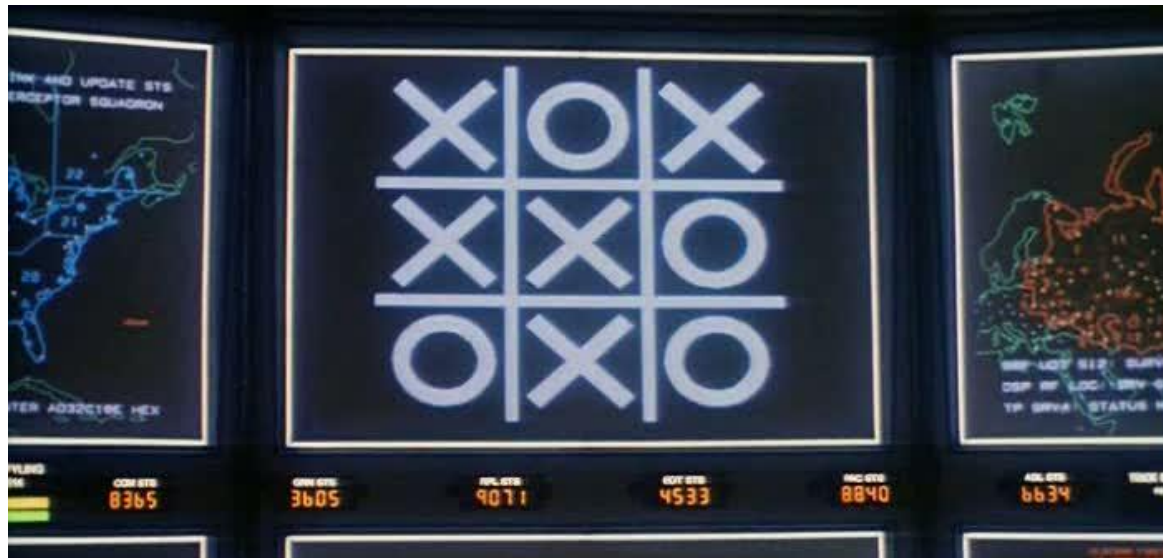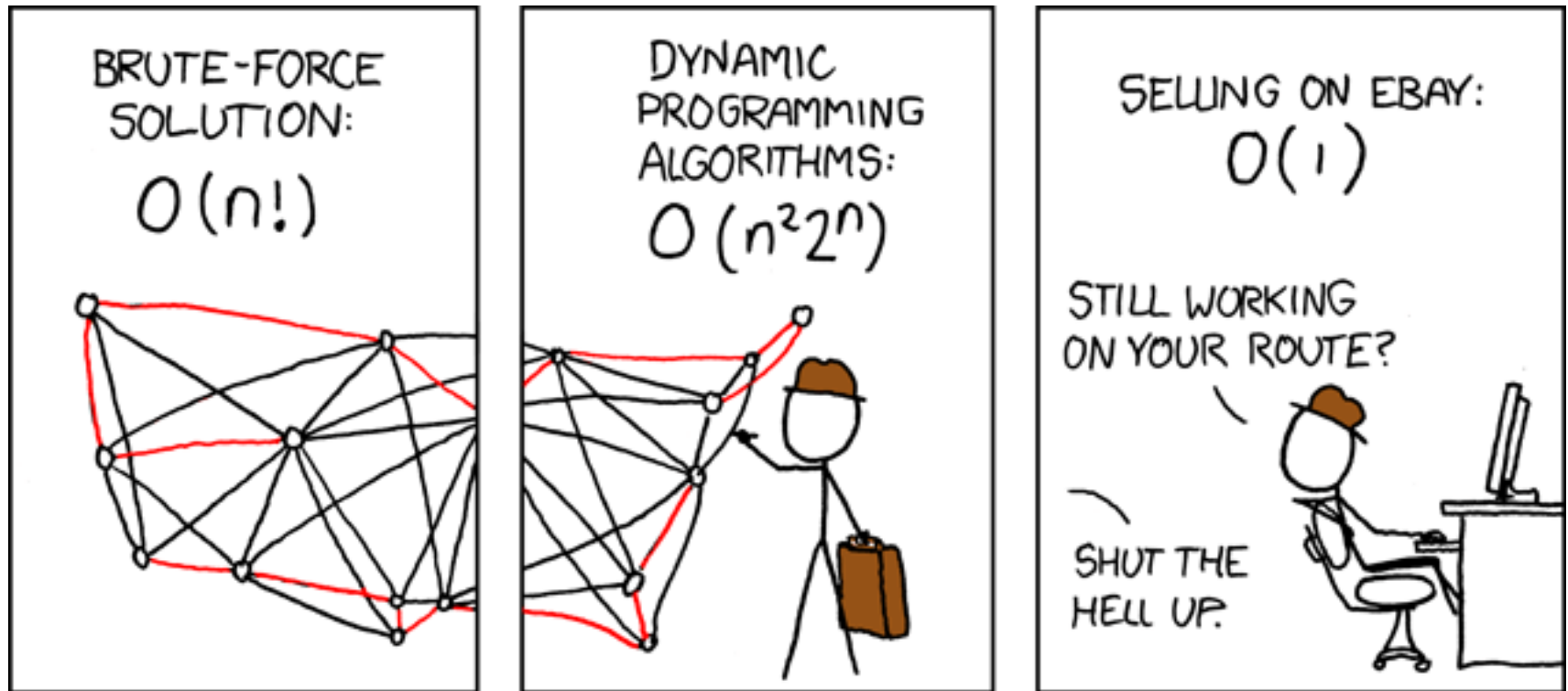
Why – Numerical Integration

$$\int \frac{\left[\cos^{-1}x\left\{\sqrt{(1-x^2)}\right\}\right]^{-1}}{\log_e\left\{1+\left(\dfrac{\sin\left(2x\sqrt{(1-x^2)}\right)}{\pi}\right)\right\}}\,dx$$

Why – Bayesian Inference

Why – Stochastic Optimization

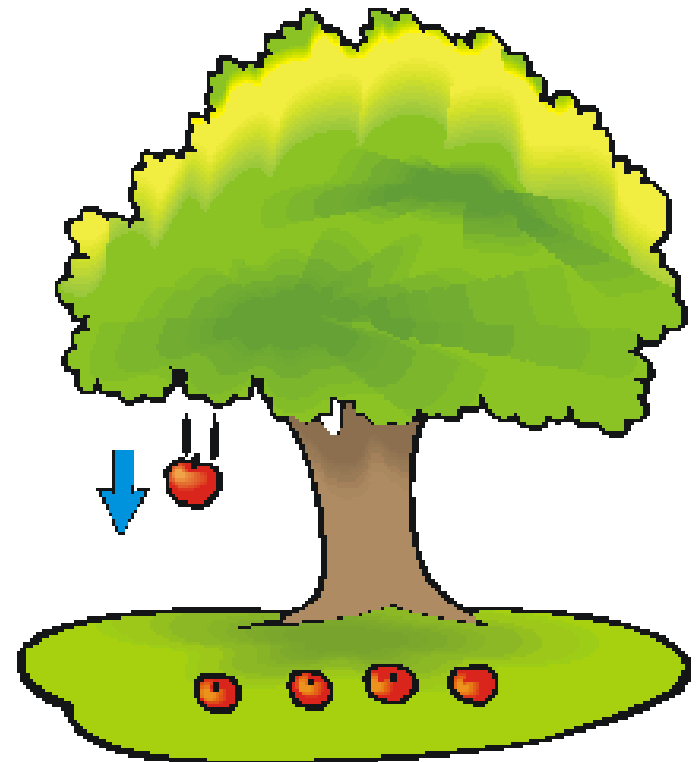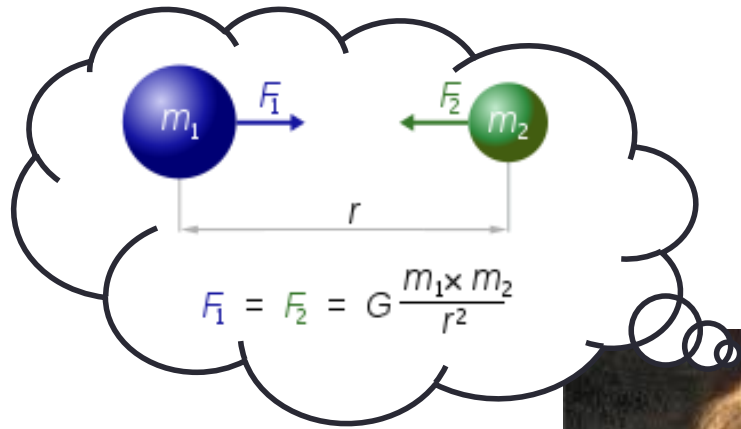https://i0.wp.com/imgs.xkcd.com/comics/travelling_salesman_problem.png

Apples to Cards
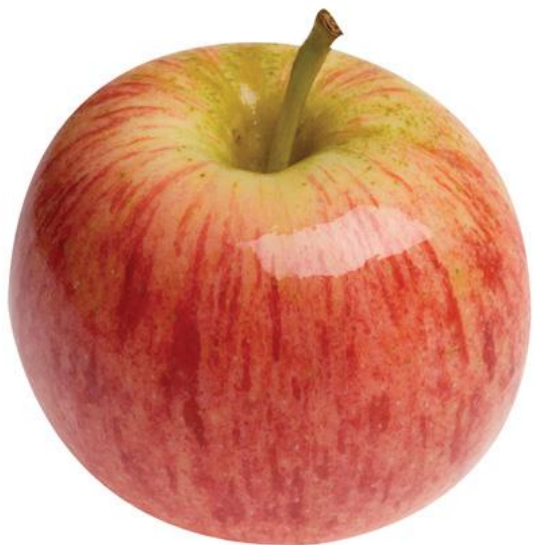
Deterministic Modeling
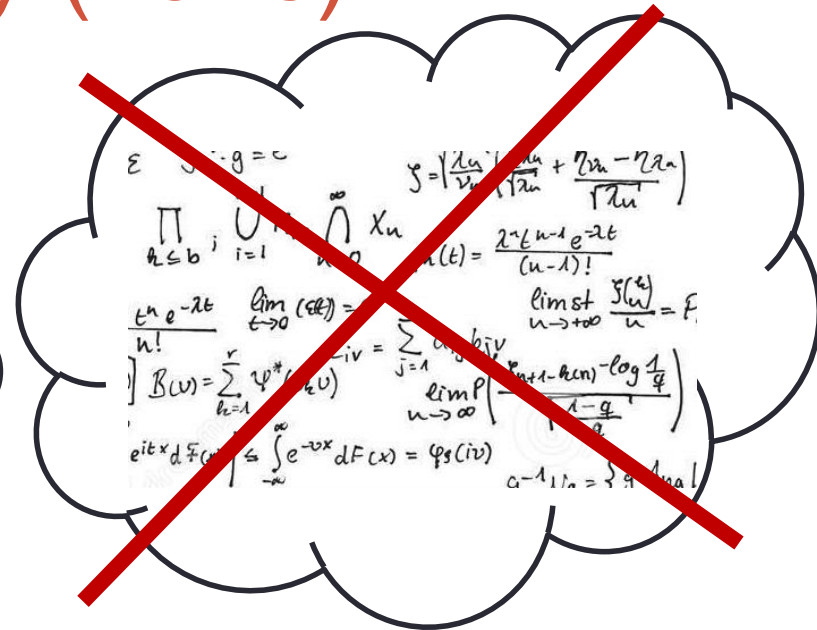
The Monte Carlo Way (1946)
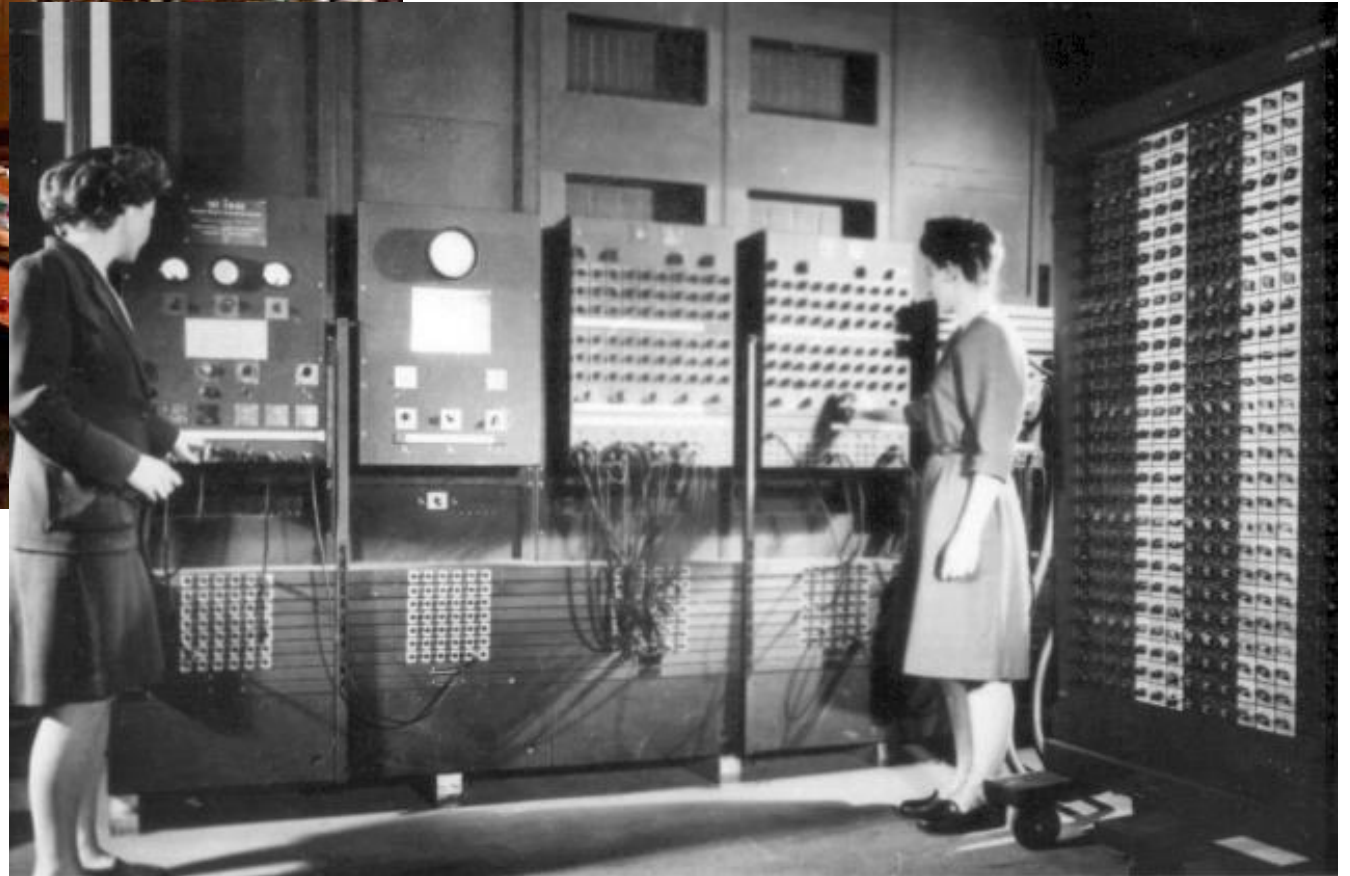
The Monte Carlo Way

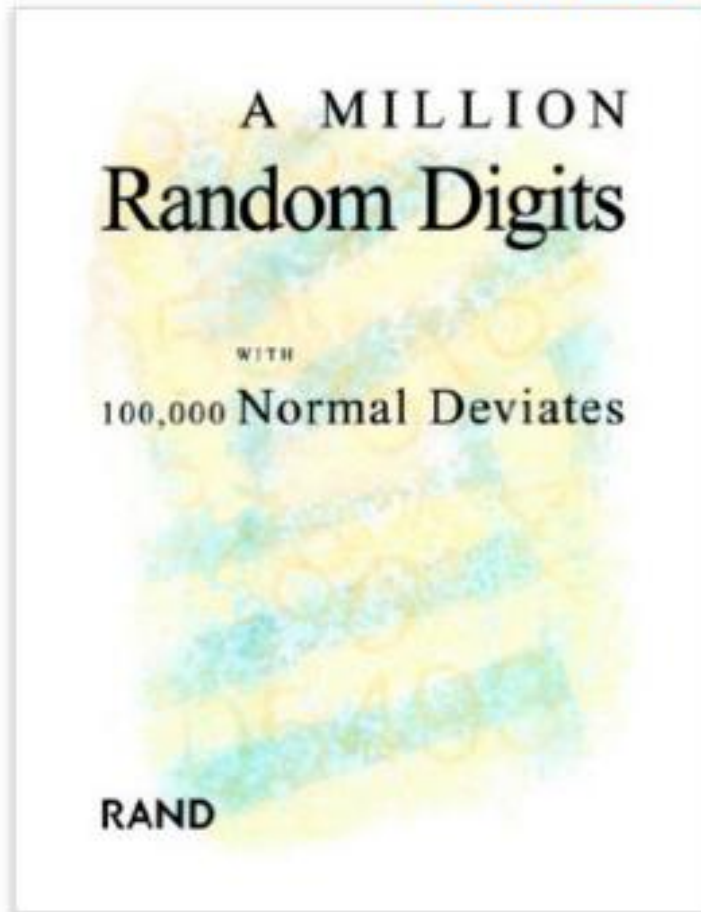

Just do it!

The Isaac Newton of Monte Carlo

- Stanislaw Ulam
- 13 April 1909 – 13 May 1984
- Polish-American mathematician

- Spend 1936-1939 in Harvard working on ergodic theory

- Worked later on Manhatten Project
- Teller-Ulam design is the basis for all thermonuclear weapons

Code Name Monte Carlo

Valuable Random Numbers

Valuable Random Numbers

Kindle Book   Print Book

Zoom – | Zoom +

A Million Random Digits with 100,000 Normal D... (Paperback)
by The RAND Corporation

★★★★☆ (632)
Paperback **$51.38**

Add to Cart

24 used & new from **$51.38**

Book sections «

Front Cover
Copyright
Table of Contents
First Pages
Back Cover
Surprise Me!

Search Inside This Book

[   ] GO

Sample searches in this book:
digit table
normal deviates
random digits

00047	11664 49883	52079 84827	59381 71539	09973 33440	88461 23356
00048	48324 77928	31249 64710	02295 36870	32307 57546	15020 09994
00049	69074 94138	87637 91976	35584 04401	10518 21615	01848 76938

2   TABLE OF RANDOM DIGITS

00050	09188 20097	32825 39527	04220 86304	83389 87374	64278 58044
00051	90045 85497	51981 50654	94938 81997	91870 76150	68476 64659
00052	73189 50207	47677 26269	62290 64464	27124 67018	41361 82760
00053	75768 76490	20971 87749	90429 12272	95375 05871	93823 43178
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00055	08358 69910	78542 42785	13661 58873	04618 97553	31223 08420
00056	28306 03264	81333 10591	40510 07893	32604 60475	94119 01840
00057	53840 86233	81594 13628	51215 90290	28466 68795	77762 20791
00058	91757 53741	61613 62269	50263 90212	55781 76514	83483 47055
00059	89415 92694	00397 58391	12607 17646	48949 72306	94541 37408
00060	77513 03820	86864 29901	68414 82774	51908 13980	72893 55507
00061	19502 37174	69979 20288	55210 29773	74287 75251	65344 67415
00062	21818 59313	93278 81757	05686 73156	07082 85046	31853 38452
00063	51474 66499	68107 23621	94049 91345	42836 09191	08007 45449
00064	99559 68331	62535 24170	69777 12830	74819 78142	43860 72834
00065	33713 48007	93584 72869	51926 64721	58303 29822	93174 93972
00066	85274 86893	11303 22970	28834 34137	73515 90400	71148 43643
00067	84133 89640	44035 52166	73852 70091	61222 60561	62327 18423
00068	56732 16234	17395 96131	10123 91622	85496 57560	81604 18880
00069	65138 56806	87648 85261	34313 65861	45875 21069	85644 47277
00070	38001 02176	81719 11711	71602 92937	74219 64049	65584 49698
00071	37402 96397	01304 77586	56271 10086	47324 62605	40030 37438
00072	97125 40348	87083 31417	21815 39250	75237 62047	15501 29578
00073	21826 41134	47143 34072	64638 85902	49139 06441	03856 54552
00074	73135 42742	95719 09035	85794 74296	08789 88156	64691 19202
00075	07638 77929	03061 18072	96207 44156	23821 99538	04713 66994
00076	60528 83441	07954 19814	59175 20695	05533 52139	61212 06455
00077	83596 35655	06958 92983	05128 09719	77433 53783	92301 50498
00078	10850 62746	99599 10507	13499 06319	53075 71839	06410 19362
00079	39820 98952	43622 63147	64421 80814	43800 09351	31024 73167
00080	59580 06478	75569 78800	88835 54486	23768 06156	04111 08408
00081	38508 07341	23793 48763	90822 97022	17719 04207	95954 49953
00082	30692 70668	94688 16127	56196 80091	82067 63400	05462 69200
00083	65443 95659	18288 27437	49632 24041	08337 65676	96299 90836
00084	27267 50264	13192 72294	07477 44606	17985 48911	97341 30358

Valuable Random Numbers

Most Helpful Customer Reviews

1,687 of 1,726 people found the following review helpful

⭐⭐⭐⭐☆ **almost perfect**

By a curious reader on October 26, 2006

Format: Paperback

Such a terrific reference work! But with so many terrific random digits, it's a shame they didn't sort them, to make it easier to find the one you're looking for.

40 Comments | Was this review helpful to you? [Yes] [No] Report abuse

734 of 750 people found the following review helpful

⭐⭐⭐☆☆ **Wait for the audiobook version**

By R. Rosini on October 19, 2006

Format: Paperback

While the printed version is good, I would have expected the publisher to have an audiobook version as well. A perfect companion for one's Ipod.

4 Comments | Was this review helpful to you? [Yes] [No] Report abuse

Monte Carlo Applications

- Model evolution of galaxies
- Weather forecasting
- Predict energy output of a wind farm
- Wireless network panning
- Computational biology (Bayesian inference in phylogeny)
- Computer graphics: 3D rendering by random ray tracing
- Game AIs (Monte Carlo tree search)

Stochastic Optimization - Deep Learning
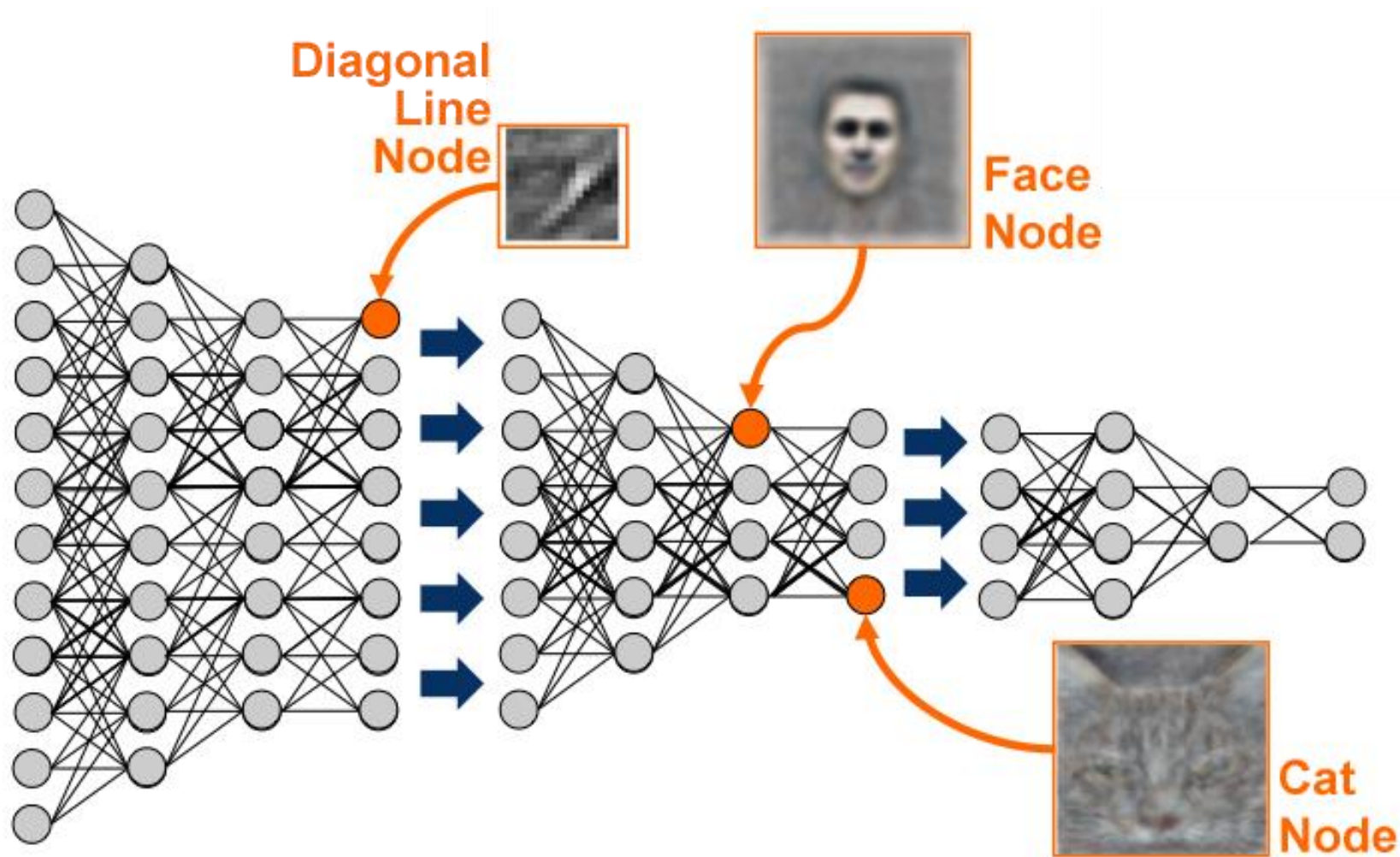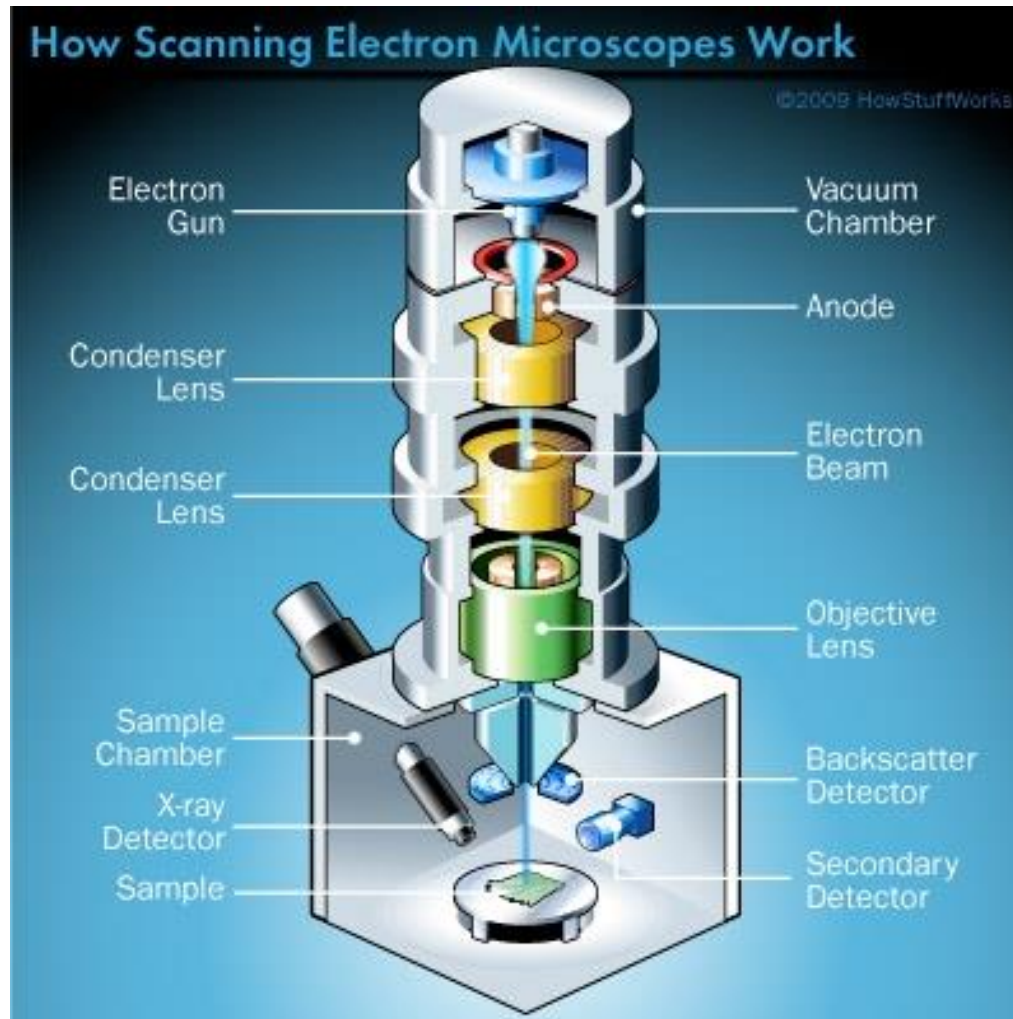
What - Course Schedule

Five Modules:

- Monte Carlo integration and variance reduction

- Bayesian inference

- Stochastic optimization

- Time series

- Advanced methods

Course Schedule

- http://am207.github.io/2016/pages/schedule.html

Scanning Electron Microscope

Electron Beam – Sample Interaction
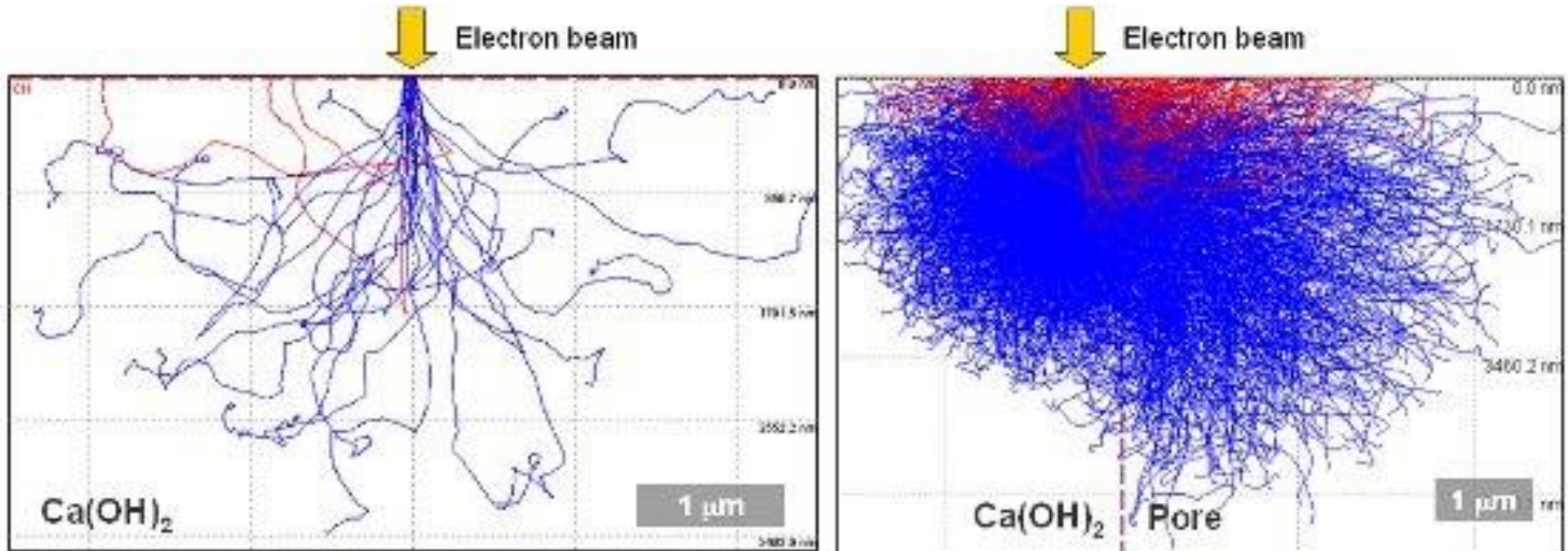
Monte-Carlo simulation of electron-sample interaction in a solid phase and across a pore boundary. Each electron is followed until it is either backscattered (red) or loses all of its energy (blue)

http://www3.imperial.ac.uk/portal/page/portallive/concretedurability/researchprojects/porestructureanalysis

Monte Carlo Integration – Ray tracing

https://en.wikipedia.org/wiki/Ray_tracing_(graphics)

Ray Tracing

Image

Camera

Light Source

View Ray

Shadow Ray

Scene Object
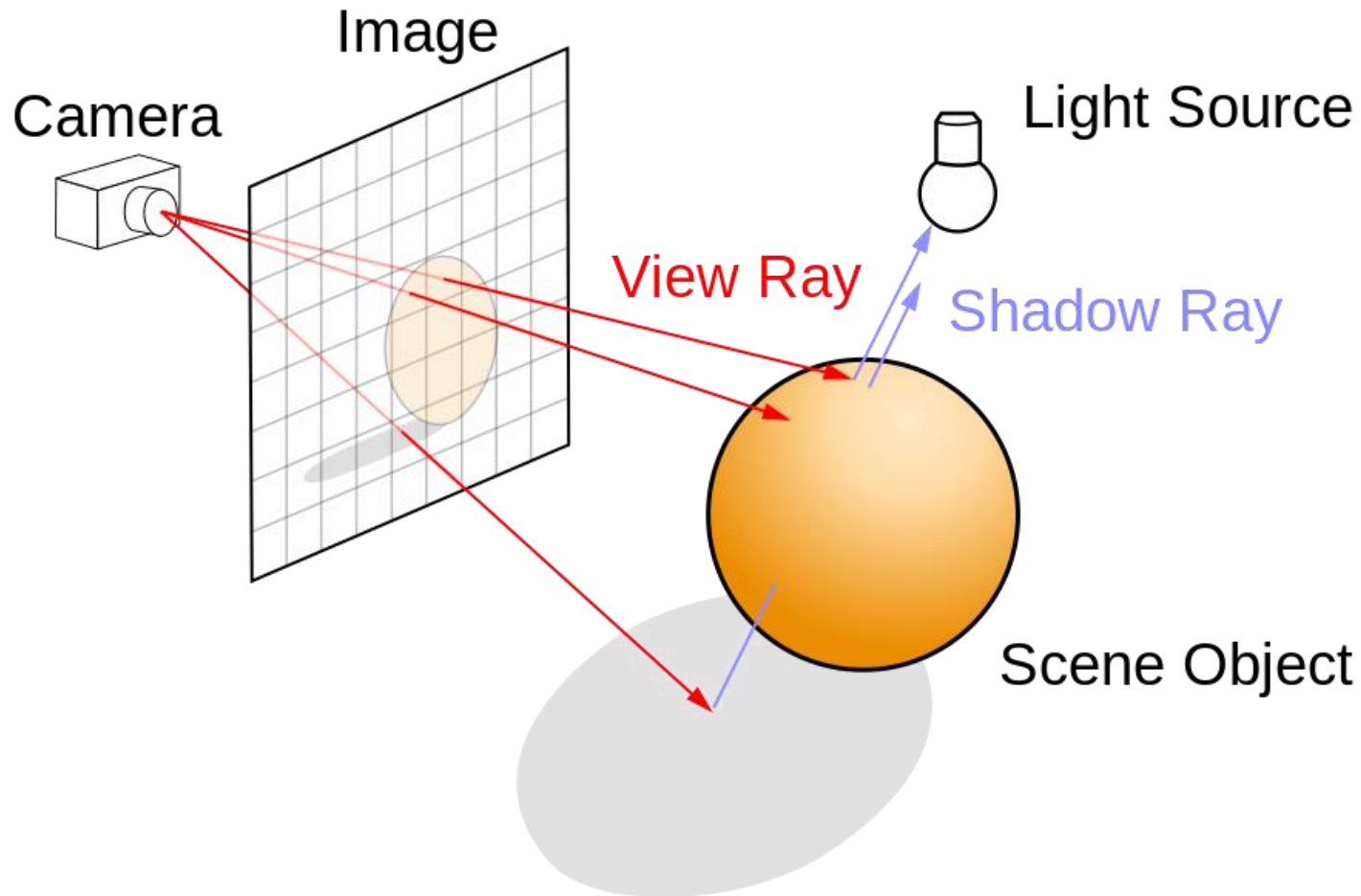
Importance Sampling

ray_tracing_importance_sampling.mp4

https://www.youtube.com/watch?v=mYMkAnm-PWw

Bayesian Inference

USS *Scorpion* (SSN-589)

https://en.wikipedia.org/wiki/USS_Scorpion_(SSN-589)

Bayesian Inference

Bayesian_search.mp4

https://www.youtube.com/watch?v=U9-G-noZrwc

Stochastic Optimization

Traveling_salesman.mp4

https://www.youtube.com/watch?v=SC5CX8drAtU

Gaussian Process Inpainting

GP_inpainting.mp4

https://www.youtube.com/watch?v=8vIZnWKV8zw

Who

- Verena Kaynig-Fittkau
- Pavlos Protopapas

- Wei Dai
- Rafael Martinez Galarza
- Giri Gopalan
- Alexander Isakov
- Richard Kim
- Steve Klosterman
- Xide Xia

Verena Kaynig-Fittkau

Lecturer and research scientist at IACS

NW B164 or 235.1

vkaynig@seas.harvard.edu

Pavlos Protopapas
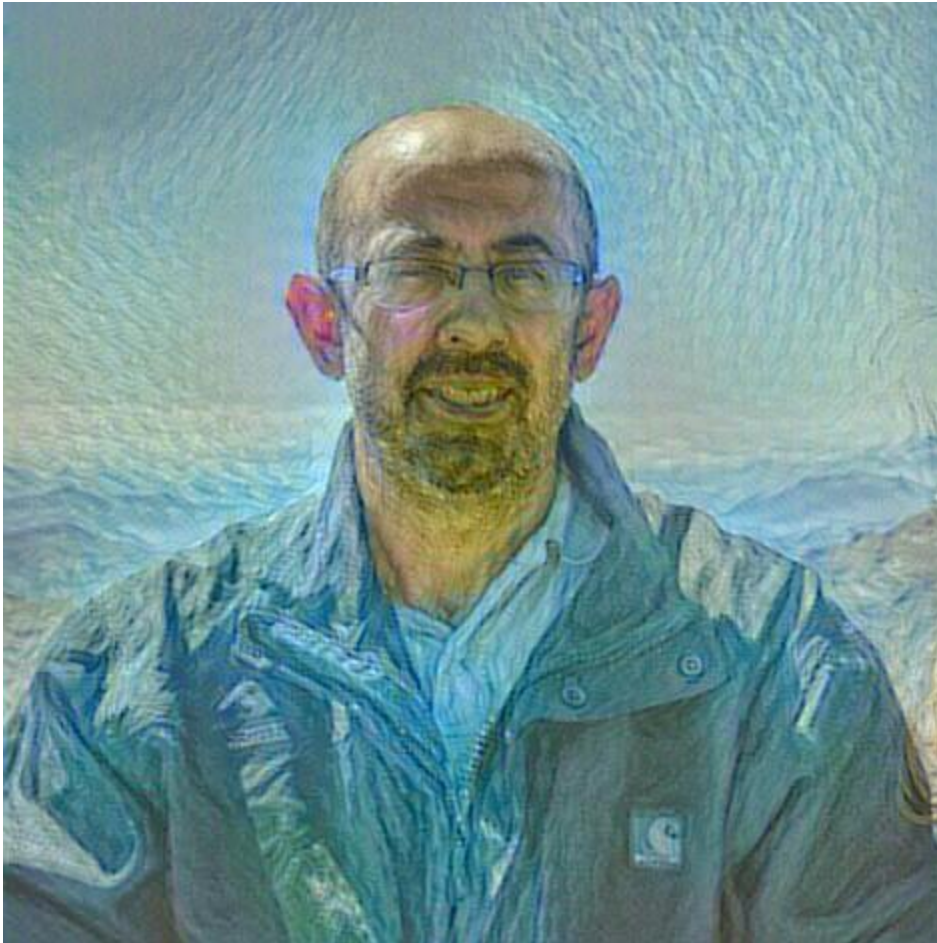
Scientific Program Director
and Lecturer at IACS

NW B155

pavlos@seas.harvard.edu

Rafael Martinez Galarza

Postdoctoral fellow at the Harvard-Smithsonian Center for Astrophysics.

Research interest: infrared studies of galactic and extra-galactic star-forming regions, stochastic optimization.

He likes to sail on the Charles and is also interested in artificial intelligence. He is a volunteer for the Future of Life Institute.

Wei Dai

G2 master student in Computational Science and Engineering

Master Thesis on High Frequency Market Beta Using HMM Model

I Love Mexican food.

Giri Gopalan

Giri is a researcher interested in applications of Monte Carlo to science and engineering with a background in applied and computational mathematics and statistics.

Alexander Isakov

Alexander Isakov is a 5th year PhD student in the Department of Physics. His work focuses mainly on behavior on networks, including synchronization or cooperation on networks. He has reached frequently for some of the tools in the toolbox AM207 provides (especially the optimization component), and hopes you enjoy the course!

Richard Kim

- - I am a Harvard Extension School graduate student pursuing the master's degree in Information Technology with concentration in Mathematics & Computations.
- - Prior to coming back to school, I worked as an investment banking analyst and equity research analyst for approximately 6 years. I am also a Chartered Financial Analyst (CFA).
- - I went to work in Tokyo, Japan for 3 years after graduating from UCLA with BA in Economics.

Steve Klosterman

Steve is a 5th year PhD student in Organismic and Evolutionary Biology. His research focuses on the interaction between plant life cycle events and climate change.

Xide Xia
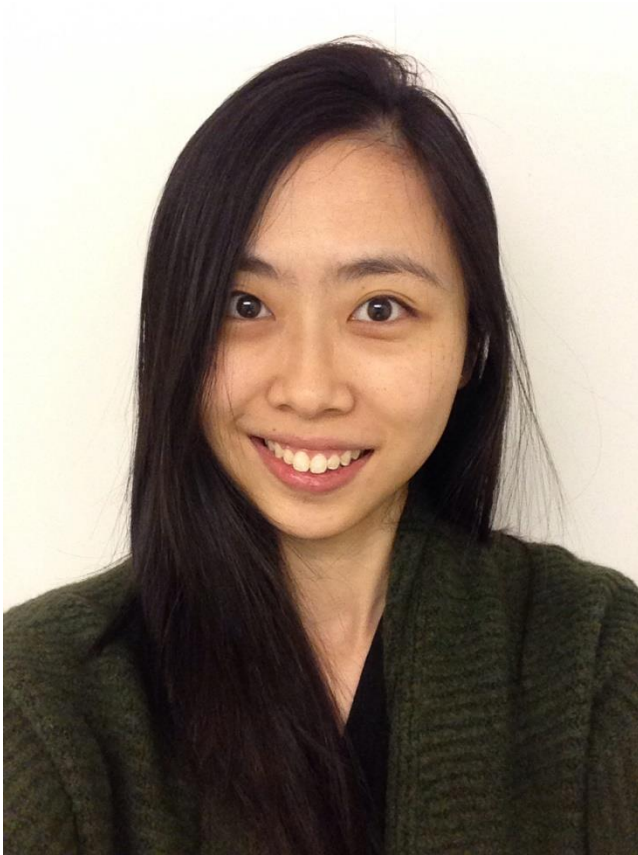
Hi! My name is Xide Xia. I am a second-year ME student in the Computational Science and Engineering program at Harvard. My academic interests broadly include machine learning, artificial intelligence, and data science. AM207 is a great course and you will love it. Looking forward to working with you all!

How

- Lecture
- Lab
- Homework

- Office hours
- Piazza
- Final project
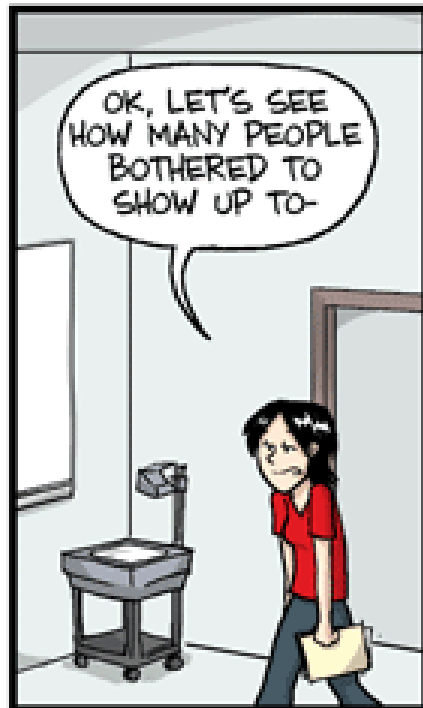
Lab

- Fridays 2-4 pm
- Cruft 309

- Homework comes out on Thursdays
- This is your large office hour before the weekend!
- Meant to give you a good start

Homework

- 5 assignments
- Out: Thursday evening
- Due: Two weeks later on Thursday
- Late days:
  - May use up to 2 per assignment
  - Not more than 6 total
  - Otherwise we deduct points

- Canvas:
  - Folders are timed
  - Might close few minutes early
  - **It is your responsibility to be on time!**

Homework

- 55% of your grade
- Work you submit must be your own! Discuss in groups, program / write on your own
- Please see also guidelines on the webpage

- Ipython notebooks
- **Treat them as reports, not only as code!**

- **HW0 comes out today**, not graded, but do submit!
- We want to make sure everything works for you

Python
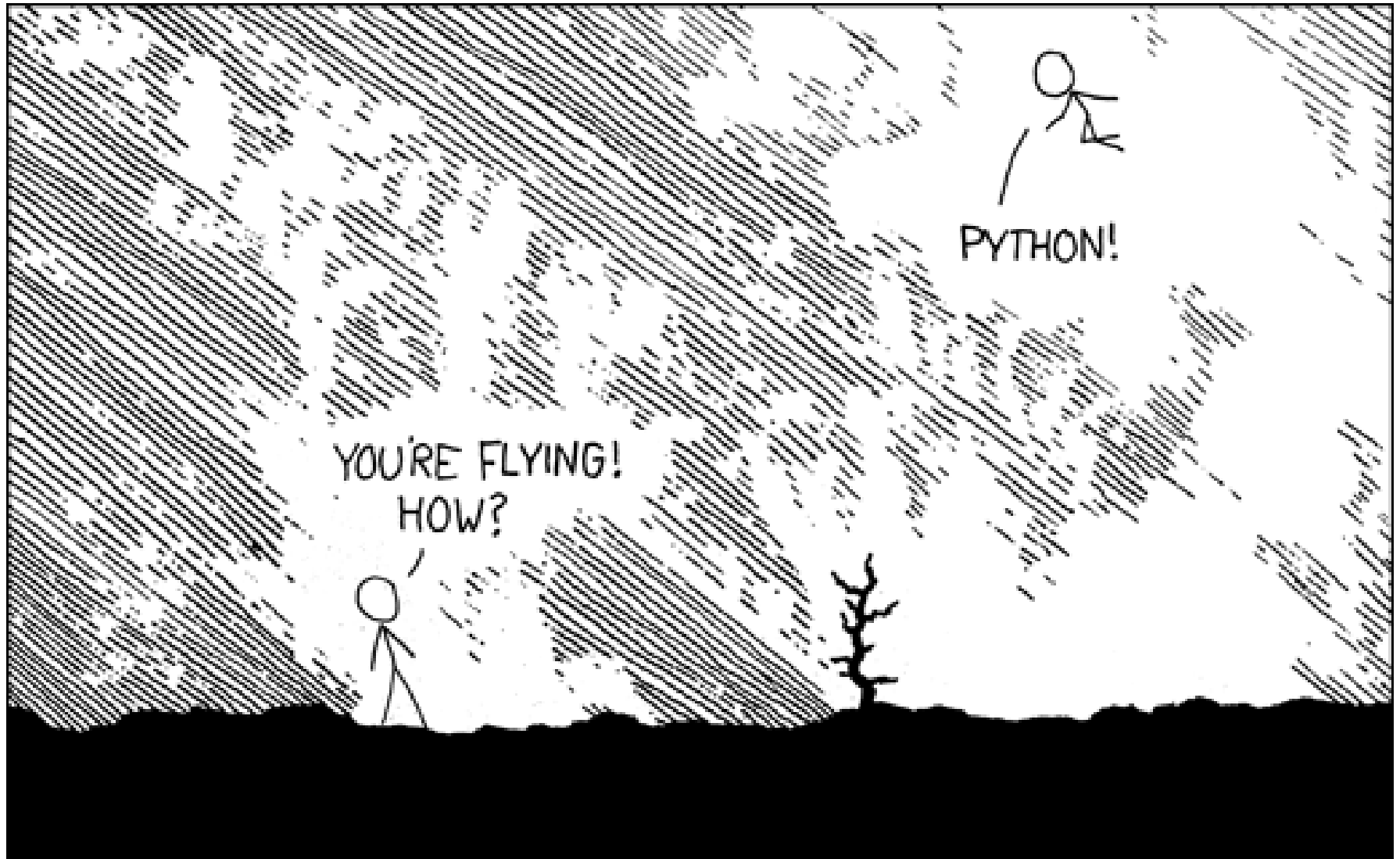
Python Resources

- Google is your best friend
- Really.. try googling: length of a list in python

- Stackoverflow

- Enthought training in python with academic license:
- https://training.enthought.com/courses

Grading

5 = Exceptional / above and beyond

4 = Solid / no mistakes (or really minor)

3 = Good / some mistakes

2 = Fair / some major conceptual errors

1 = Poor / did not finish?

0 = Did not participate / did not hand in

Grading is holistic, not subtract half a point here, half a point here, its about the learning process.

Piazza

- This is a very valuable resource, ask, and save time, answer and show off!
- Let's apply Stackoverflow rules

- Counts as participation
- Participation is 5% of your final grade

Final Project

- Your chance to show off what you learned
- 3-4 person teams!

- Hand-ins:
  - written paper (<= 6 pages)
  - screencast
  - poster

- 40% of your grade

Is This Course For Me?

- Fond of math and statistics
- Basic statistical knowledge
- There is going to be magic and beauty!

- Basic background in programming
- Python knowledge helps

- Willing to learn new software and tools
- Read online documentation
- This can be time consuming

Be constructive

Be proactive

Be patient

HW0

- Out this afternoon

- Not graded, but you should submit!

- General Python setup
- Make sure all works!
- Some first exercises

Github

- All materials are in the github repository

- https://github.com/AM207/2016

- Just pull to get lecture notes, extra material, and homework assignments

- If you don't feel comfortable with git you can also download them from the webpage.

Github

Office Hours

Xide	Mon 10am-11am
Steve	Mon 3pm - 4pm
Giri	Monday 7-8pm
Rafael	Tuesday 2pm-3pm
Richard	Thur 4pm-5pm
Wei	Friday 11am-noon
Alex	Friday 6pm-7pm

Also Lab starts this Friday!

Next Steps

- Register for Piazza
- Follow setup instructions in HW0
- Run HW0 notebook on your machine
- Solve what you would like to solve
- Submit HW0

Questions?