Welcome to EECS16A!
Designing Information Devices and Systems I
Prof. Laura Waller
Spring 2021
All of these extract information from the real world and interact with it; we will be learning how to design and understand these devices & systems.
If you have a question for me, please type it into the Q&A.

If you have a question other students can answer, please use the chat.

If you would like to ask a question verbally, please use the raise hand feature.
Instructors

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Office Hours: right after lecture, but at
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About me

• Ph.D., EECS, Massachusetts Institute of Technology, 2010
• M. Eng., EECS, Massachusetts Institute of Technology, 2005
• B.S., EECS, Massachusetts Institute of Technology, 2004

• Lecturer in Physics, Postdoc in EE at Princeton 2010-2012

• Classes I teach:
  • EE118/218 Introduction to Optical Engineering
  • CS294 Computational Optical Imaging
  • EE84 Hands-on Optics
  • EE225A Statistical Digital Signal Processing
My hobbies...
My hobbies...
Other Staff

Head GSIs:
eecs16a@Berkeley.edu
Email with:
- Questions not for Piazza
- Conflicts, accommodations for exams etc.
- Emergencies
- Administrative questions

Amanda Jackson
Anika Ramchandran

Course manager
Great resource for 1-1 concerns
Krystle@eecs.Berkeley.edu

Krystle Simon
Teaching Assistants (TAs) Intro

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- Myaak Mckain
  - Content LAs

- Tyler Reinhardt
  - Content LAs

- Xiaocheng Zhang
  - Content LAs

- Bob Lintz
  - Content LAs

- Vansh Mehtani
  - Content LAs
We are here to help

• ~23 TAs, ~45 Academic Student Employee (ASE)
  • Lots of different research areas and interests represented (by design)

• So you want to be on 16A staff? Here’s the path:
  • Do great in 16A
  • Become an ASE
    • Grade homeworks, assist in labs, tutor and help out in OH, work on improving the notes …
  • Become a uGSI
  • Become head TA…
Course policies

• Syllabus is on the course website: https://eecs16a.org/
  • You are responsible for reading and following all course policies listed

• Piazza: http://piazza.com/
  • a resource for you to help each other out

• Gradescope

• Exam proctoring via zoom
Homeworks (HW)

• Due Fridays at 11:59pm
  • HW0 due Fri Jan 22
• HW Party: Thu 2-4 pm
• Office Hours (OH): at various times
• Self-grading:
  • due Mon at 11:59pm
  • resubmissions due Mon 11:59pm
  • resubmission self-grades due Mon 11:59pm

Note: Self-grading is not just about us being lazy!! (it is also to help you learn)
Homework Submission

• Homework submitted on Gradescope
  • enroll if you haven’t been automatically: code D5PEYX
• You must select pages
• You must submit printout of iPython code (see syllabus)
Study groups

• System to match you into study groups
• Fill out the information form in HW0
• Chance to meet new friends and study buddies
Course policies

• Attend lecture (required)
• Attend discussion (required, one on Mon, one on Wed. Automatic participation points, submit checkoff if watching recording.)
• Attend lab (required, at your scheduled time, checkoff during your lab)
• Attend office hours and homework party (optional)
You are here to learn!

- Learning can be hard and fun
- Collaborate and build community on Piazza/HW Party/Study Groups
- Encourage different perspectives – this is Berkeley!
- Cheating directly detracts from learning
  - Any cheating will be immediately sent to the Office of Student Conduct
  - Report bad behavior
- Everyone here is smart
  - Students have different backgrounds
  - Professors make mistakes – feedback helps
  - If you are struggling, ask for help!
How to succeed in 16A

• Get enough sleep
• Attend lecture and discussion
• Do not do the above two at same time
• Actively read notes
• Try HW on your own, early
• Discuss problems with study group and/or at HW Party
• Help others on Piazza
• Study with others as well as alone
• Seek and offer help
Slope is more important than intercept

- Student 1
- Student 2
- Student 3
Slope is more important than intercept

Skills (a.u.)

Day 1

End of semester

End of 2nd semester

Student 1

Student 2

Student 3
Any questions?
Did you know...

The same idea that allows touchscreens to detect touch,

Also allows an autonomous car drive in a straight line,

And allows search engines to rank webpages,

And trains deep learning neural networks.

Eigenvalues!
Did you know…

That the same idea that makes Shazam work

Also make the GPS on your phone work?

Cross-correlation!
Did you know...

A fundamental algorithm in machine learning and artificial intelligence

Is used to make predictions in biology, brain-machine interfaces, social sciences, imaging algorithms and more?

Least-squares!
Example application: self-driving cars

- Sense
- Process Data
- Make a model
- Predict
- Actuate i.e take action

External environment

16a

16b
16A
Module 1: Introduction to systems
   How can we collect data? How do we build a model?
Module 2: Introduction to circuits and design
   How do we use a model to solve a problem?
Module 3: Introduction to Machine Learning
   How do we “learn” models from data and make predictions?

16B
Module 4: Advanced circuit design
Module 5: Introduction to robotics
Module 6: Introduction to unsupervised learning
16a Examples

**Imaging:**
- **Real World:**
- **Measurement:**
  - Systems of linear equations
  - Matrix analysis
- **Processing:**

**Touchscreens:**
- **Real World:**
- **Measurement circuits:**
- **Processing circuits:**

**Positioning:**
- **Real World:**
- **Measurement:**
- **Cross-correlation Optimization:**
How to approach something unfamiliar and systematically build understanding

Linear Algebra: conceptual tools to model
Circuits: How to go from model to design, grounded in physical world
Intro to foundational concepts in Machine Learning
How did we get from this...
To this...
Computational advances have been riding Moore’s Law

What is a transistor?

Gordon Moore
Intel Cofounder
B.S. Cal 1950!
Sense of Scale

- Mark: 1.66 m
- Fly: 7 mm
- Mite: 300 um
- Blood Cell: 7 um
- Virus: 100 nm
- Silicon Atom: 0.24 nm
Completing the puzzle …

Ada Lovelace wrote the first computer program.

Alan Turing figured out how to build a computer to execute programs.

Claude Shannon: Information theorist.
Module 1: Imaging
Seeing inside bodies: sans surgery...

All of these benefitted from the math/hardware design techniques you will learn in this class!
Tomography

‘tomo’ – slice
‘graphy’ – to write

Assume it is not desirable to slice open my brain. How does tomography ‘see’ inside?
Tomography

What is a projection? Sum of values along a line.

many projections
Example: Tomography

Can we solve for the pixel values from projections?

What do pixel values represent?

e.g. density, absorption, etc.

Yes, with tomography.

\[ x_1 \quad x_2 \]
\[ x_3 \quad x_4 \]
Example: Tomography

Input $X$ to measurement

What I want to know

Trust me that:

$b = ax$

Solve this:

$x = a^\dagger b$

Now I have 4 pixels

Take a projection:

$a = x_1, x_2, x_3, x_4 \rightarrow b = ax_1 + ax_2 + ax_3 + ax_4$

Can I solve for $x$?

No! Not with single measurement

1 equation, 4 unknowns

Now square grid 4 pixels (My Brain)

4 unknowns need 4 measurements

Now consider changing illumination

Not all $a$s are equal now.

Can I solve it?

Yes if I know what the $a$s are.

E.g. $b_1 = ax_1 + ax_2$

becomes

No. 4 unknowns + 4 equations does not mean you can solve it! They need to be ‘linearly independent’

i.e. each provides new information!

As, if I can derive one from the others, it's not new info!
All our measurements are *linear*

What does that mean? Each variable ($x$) is multiplied by a scalar ($a$) to contribute to the measurement.

This is called a *system of linear equations*.

*Linear Algebra* is what we need to solve it!
Imaging in general

Imaging System
(electronics, control, computing, algorithms, visualization…)

Energy source

Subject

Energy detection
What is the absolute smallest number of components you need to make an imaging system?

Example: flat illumination, one photosensor scans through pixels

OR scan the illumination, use only one big pixel
Can I create an image if I have just ONE pixel?
Single-pixel camera

Can I create an image if I have just ONE pixel?
Imaging Lab #1 Setup

Object to image

Projector

TI Launchpad

Breadboard

Solar cell
Imaging Lab #1

[Diagram showing the flow from Sensor to Analog Circuit, then to Analog to Digital, followed by Post Processing, with a solar cell circuit diagram and an IPython logo.]
Example: single-pixel camera

Pictures taken with ONE PIXEL!
Single-pixel camera

What if I can’t light up just one pixel at a time?
Can we recover the frog?
How many measurements do I need?
How should I choose illumination patterns?
What is linear algebra?

- The study of linear functions and linear equations, typically using vectors and matrices
- Linearity is not always applicable, but can be a good first-order approximation
- There exist good fast algorithms to solve these problems