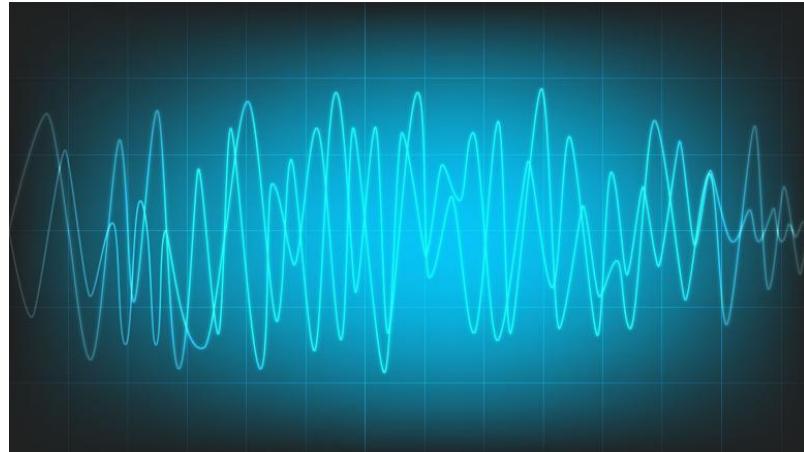


Welcome to ECE 3

## Introduction to Electrical and Computer Engineering

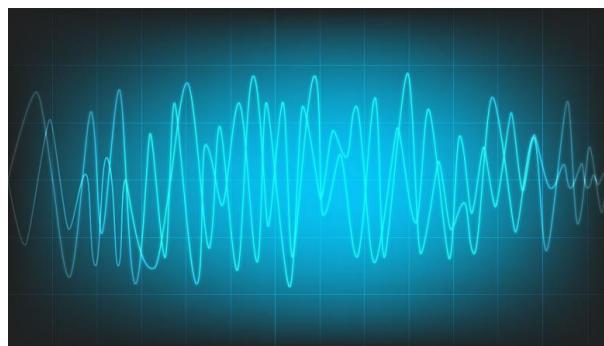
Nina Miolane - Assistant Professor

BioShape Lab @ UCSB ECE



## Outline: Welcome

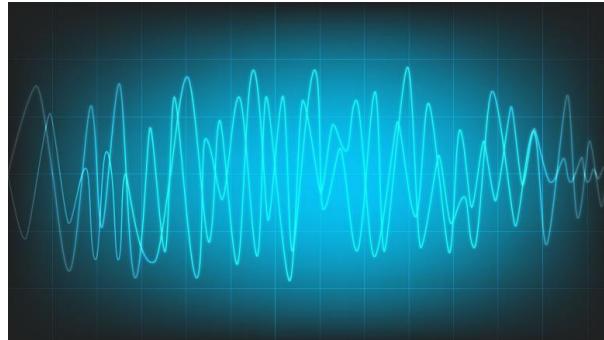
- Syllabus for ECE 3
- Real-World Applications Electrical and Computer Engineering
  - What is ECE?
  - ECE for Computational Medicine: Example of Diagnosis of Rheumatic Heart Diseases
  - ECE for Signal Processing: Example of Image Compression
- Outline of ECE 3



## Outline: Welcome

- Syllabus for ECE 3
- Real-World Applications Electrical and Computer Engineering

- What is ECE?
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## Instructor: Nina Miolane (me)

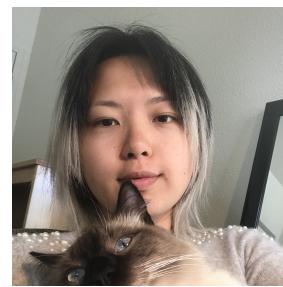


[Research](#): Exploring the geometries of life:

- how proteins, cells, organs adopt specific shapes to function,
- and how pathologies arise from abnormal shapes.

[Office Hours](#): Mondays 5 - 6 PM, ECE TA Offices in Trailer 699, Room 103.

## Teaching Assistants



From left to right: Monsij, Orestis, Alejandro, Bella

Office hours in ECE TA Offices in Trailer 699, Room 103:

- M 4:00 – 5:00 PM (Monsij)
- Tu 4:45 – 5:45 PM (Orestis)
- W 2:00 – 3:00 PM (Alejandro)
- Th 11:00 – 12:00 PM (Bella)

## Classes and Labs

**Classes:** in CHEM 1171, MW 12:30 PM – 1:45 PM (slides posted on Slack)

**Labs:** in ESB 1003

- M 6:00 – 7:50 PM (Monsij)
  - Tu 6:00 – 7:50 PM (Orestis)
  - W 5:00 – 6:50 PM (Alejandro)
  - Th 6:00 – 7:50 PM (Bella)
- 
- You are required to attend all the lectures, labs and the exam.
  - Do not enroll in other courses whose schedule is conflicting with ECE 3.
  - If you cannot attend all lectures, labs and the exam, please drop this class.

## Covid-19 Guidelines

- Feeling ill or may have been exposed: stay home and contact staff in 24h.
- Complete daily symptom survey.
- Weekly testing for non-vaccinated.
- Masks indoors.

## Quick Survey

**Quick Survey to get to know you:**

- Are you a:
  - 1st year, 2nd year, 3rd year undergraduate student? Master student?
- How comfortable are you with pre-calculus:
  - Very comfortable, normally comfortable, terrorised?
- What is your programming experience:

- Comfortable in Python, Comfortable in another language, Beginner, No experience?

## Grading

- **Homeworks:** 55%
  - Posted on Thursdays by 11:59 PM PST, starting on the 2nd week.
  - Due next Thursday by 11:59 PM PST. No late homework.
- **Final exam:** 40%
  - Tuesday, Dec. 7th 12:00 PM - 3:00 PM in CHEM 1171.
  - No make-up exam.
- **Constructive Participation:** 5%
  - Asking and answering questions, in class, labs and on Slack.
- **Extra Credits:** up to +15% total
  - DataCamp (more on a later slide) + feedback on the class.

There is no midterm exam.

## Good practices: Homework and Exam

- **Notations:** Be consistent.
- **Reasoning:** Explain each step: which rule did you use and why are you allowed to use it? What are the assumptions?
- **Computations:** First do literal computations, then replace by numerical values.
- **Result presentation:** If there is a unit associated to the final result, add it: Dollars? Books? Coins?
- **Result checking:** Does my result make intuitive sense?
- **Plotting:** Label the axes, add the values to the axes, legend, etc.

These are taken into account while grading your assignments.

## Textbooks

The textbooks are considered supplementary to classes:

- [Introduction to Linear Algebra](#) (ILA), by Stephen Boyd and Lieven Vandenberghe.
- [Introduction to matrix computations](#) (IMC), by Margot Gerritsen

**Remarks:**

- Both are freely available online.
- We will not cover all topics in the books.
- We will cover a few topics not in the books.

## Python and Jupyter Notebooks

We will use:

- Python version 3.7 or higher as our programming language,
- Jupyter notebooks to run Python interactively in a web browser.

You should download Anaconda which will install everything you need to run Python 3.7+ and Jupyter notebooks:

- Anaconda: <https://www.anaconda.com/download>

The TAs will demo the setup process in the first lab session.

## Datacamp: Hands-on Python Exercises

Course in "Assignments": "Intermediate Python":

- Ex: Using "matplotlib" to create plots in Python

Deadline: Nov 2nd. Use [this link](#) to join with your @ucsb.edu address.

### Advantages:

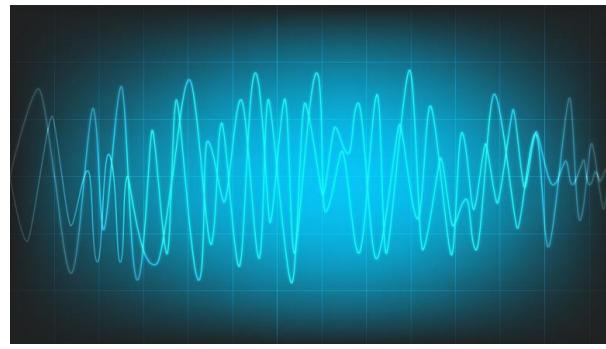
- Up to 10% extra credits
- Complete them within the first 2 weeks: will help you with homework!
- Python is used everywhere in ECE: learn the basics asap and save time.

## Read the Syllabus

- More details in the Syllabus.
- If, after (1) reading carefully the syllabus and the slides, and (2) having talked to your classmates, you still have doubts on how the course is structured and/or how the grading is performed, contact the course staff.

## Outline: Welcome

- [Syllabus for ECE 3](#)
- **[Real-World Applications Electrical and Computer Engineering](#)**
  - **What is ECE?**
    - ECE for Computational Medicine: Example of Diagnosis of Rheumatic Heart Diseases
    - ECE for Signal Processing: Example of Image Compression
- [Outline of ECE 3](#)

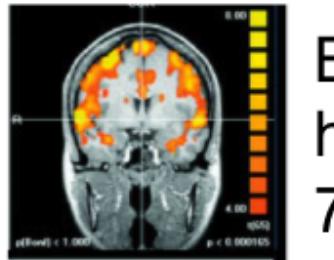


## What is ECE?

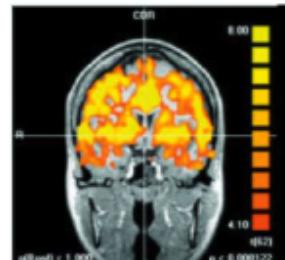
Electrical and Computer Engineering (ECE) focuses on design, development and production of:

- hardware, electronic devices: smartphone, laptop, GPS, LED lights
- software, i.e. computer programs

that can acquire, process, analyze and transmit information.



Breath holding,  
7s



Breath holding,  
14s

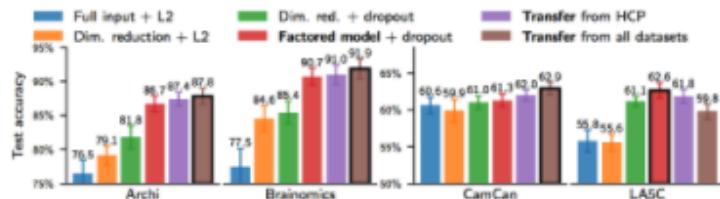


Figure 2: **Ablation results.** Each dimension reduction of the model has a relevant contribution. Dropout regularization is very effective when applied to the cognitive latent space. Learning this latent space allows to transfer knowledge between datasets.

## Why studying ECE?

Many good reasons to study ECE:

- ECE is at the core of modern society, and the unseen force behind today's intelligent systems.
- ECE is present all over us:
  - Precision health,
  - Clean energy,
  - Cybersecurity,
  - Autonomous vehicles,
  - Communications,
  - Quantum revolution,
  - and more...

## Electrical Engineers

- Develop wind, solar, and traditional energy systems to help provide everyone in the world with electricity
- Design controls and communications systems to help doctors perform surgery with smarter robots
- Enhance image processing and make better instruments to help diagnose and treat diseases
- Develop nanotechnologies to help scientists study microorganisms
- Design computer circuits to help speed up networks and processors that run your smartphone and other electronics
- Improve batteries that help run electric-powered cars

## Computer Engineers

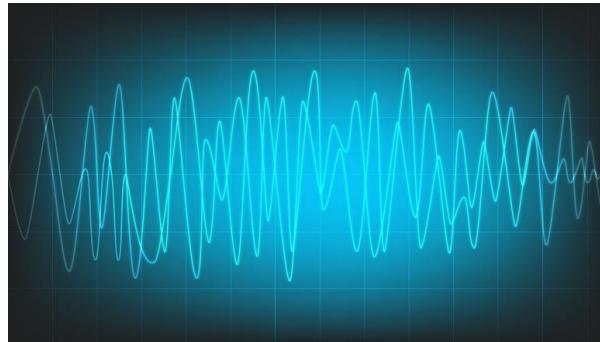
- Improve Internet security to help protect your information and make it safer to buy things online
- Design faster processors to help make HDTV and 3-D TV watching and video gaming experiences better
- Develop biomedical systems to help monitor patients in hospitals
- Implement sensor networks to help make robots more human-like
- Create the smart power grid to help manage energy distribution to households across the country
- Work with digital forensics to help police and the FBI track and catch cyber criminals

## Job Market for ECE

- One of the fastest growing career fields in the US
- Pays well: starting salaries at 70k\$ - 160\$, salaries up to 300k\$ after 3 years.
- Can be applied to different fields!
- Good knowledge foundation to start a company.

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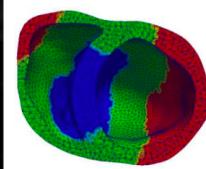
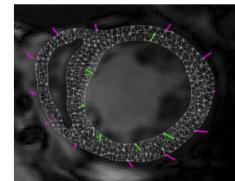
## ECE for Computational Medicine

### Computational Anatomy



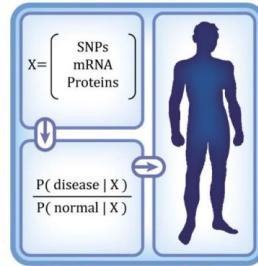
Organ shape analysis

### Computational Physiology



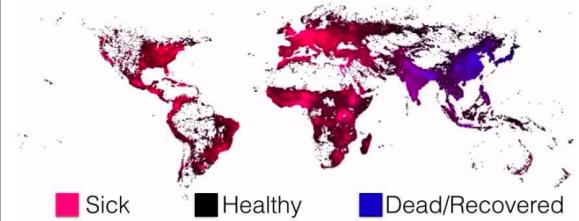
Electromechanical model of the heart

### Computational Molecular Medicine

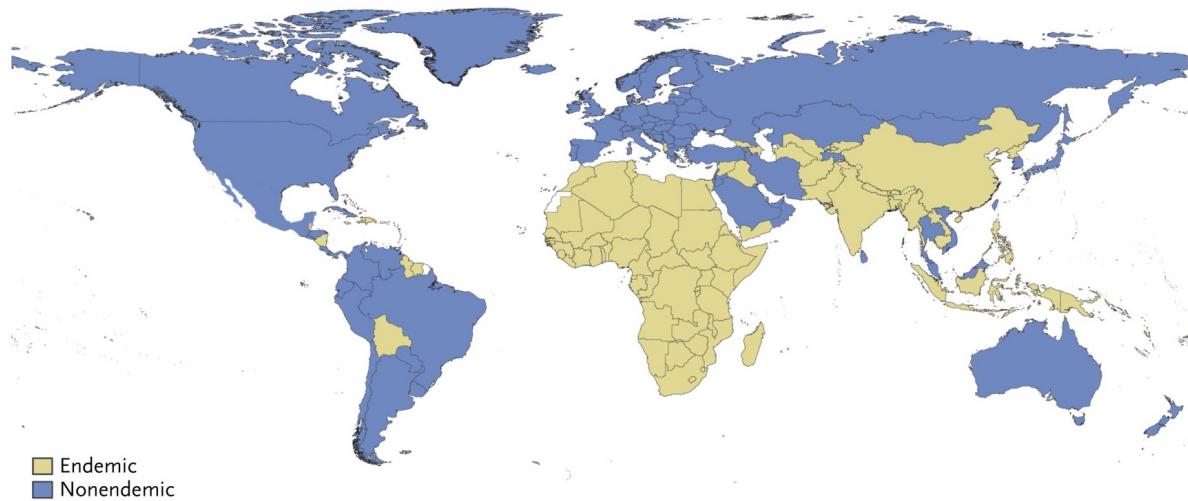


### Computational Healthcare

#### Planetary Scale Pandemic Model

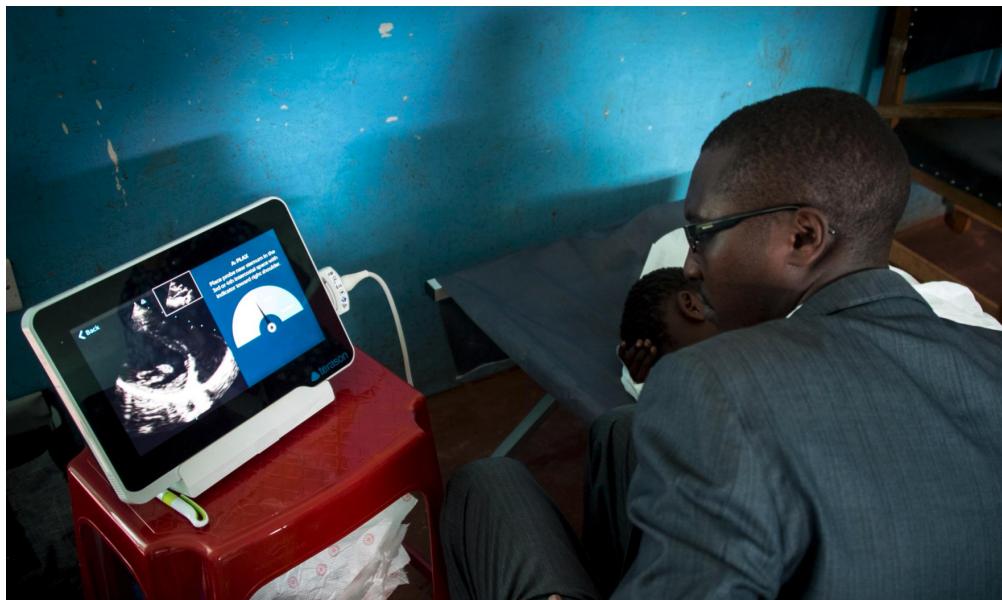


## Example of Rheumatic Heart Disease



- Heart valves damaged by rheumatic fever (complication of strep throat)
- Rare in developed countries, 1% of children in developing countries
- **Treatment:** Easy to treat with antibiotics
- **Problem:** Hard to diagnose without proper medical infrastructure
- Source: <https://www.hopkinsmedicine.org/health/>

## A solution from ECE

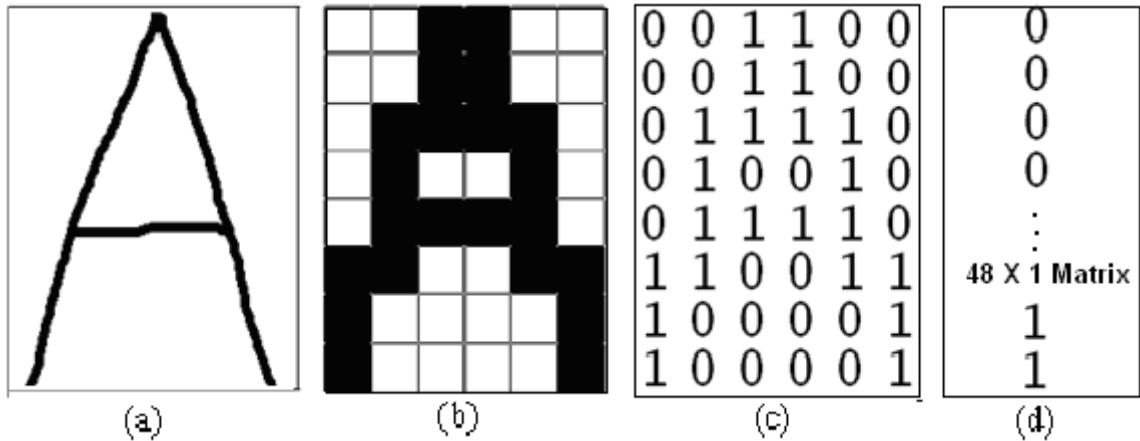


Teacher in Kenya acquiring echocardiographies of his students (Caption Health)

- Hardware: Portable echocardiography system
- Software: Automatic diagnosis algorithm

Make quality medical imaging universally accessible

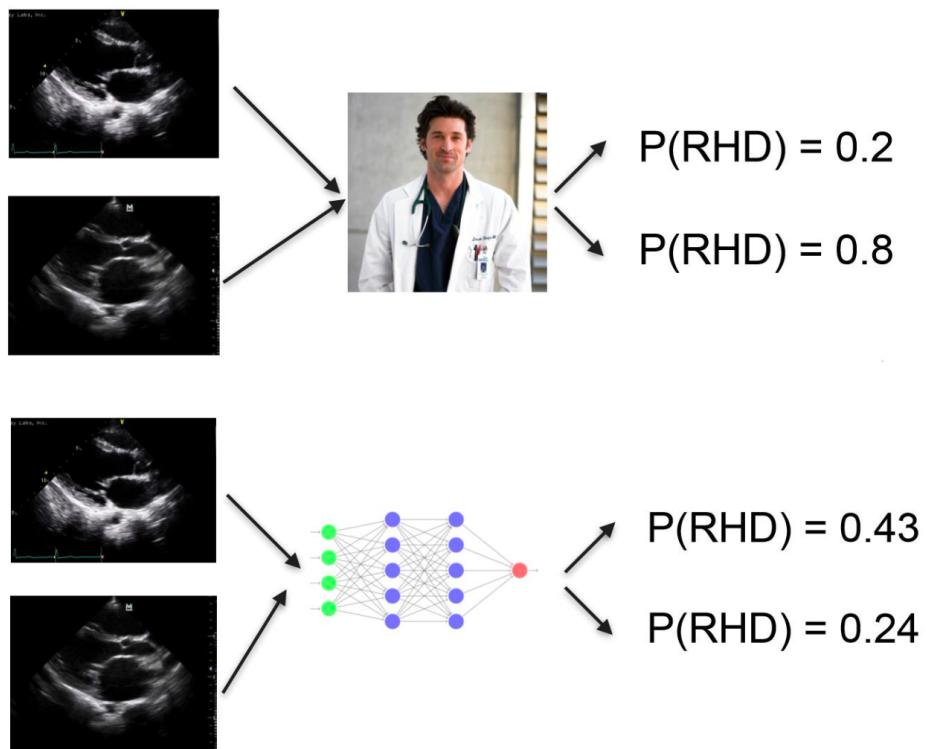
## A closer look: Image in the Computer



An image can be represented as a matrix or a vector.

We will learn how to perform computations on vectors and matrices, and thus on images.

## A closer look: Computing with Images



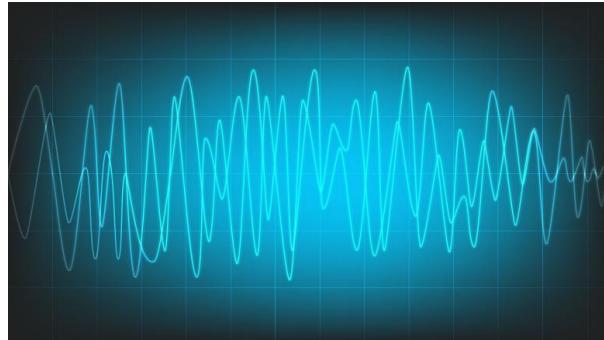
In this neural network (NN):

- Input = an image = vector/matrix
- Each layer = "transformed image" = vector/matrix
- In the NN, we perform operations on vectors and matrices

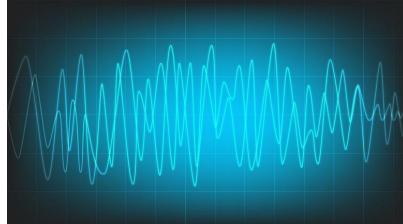
We will learn how to compute this and use it in ECE applications.

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## ECE for Signal Processing



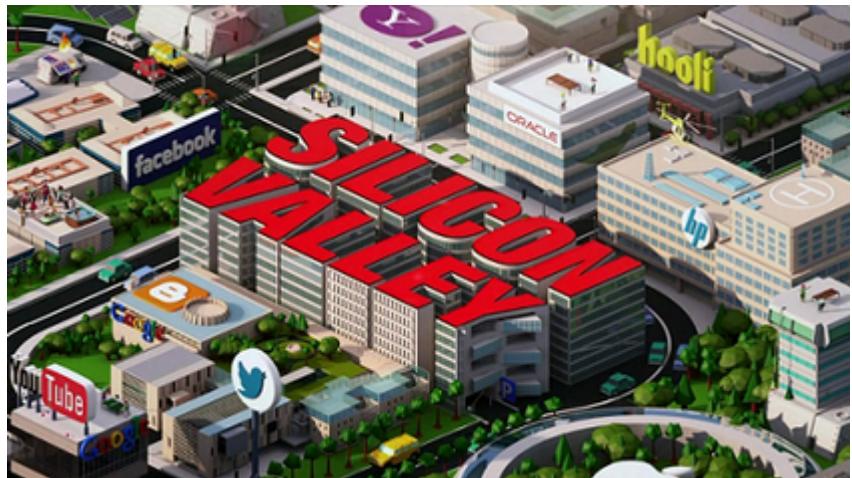
Signal processing is an ECE subfield that focuses on:

- analyzing, modifying, and synthesizing signals --- such as:
  - sound, images, and scientific measurements.

Signal processing can be used to:

- improve transmission, storage efficiency and subjective quality
- and to emphasize or detect components of interest in a measured signal

## Example of Image Compression



Silicon Valley TV Show

Silicon Valley (TV show) synopsis:

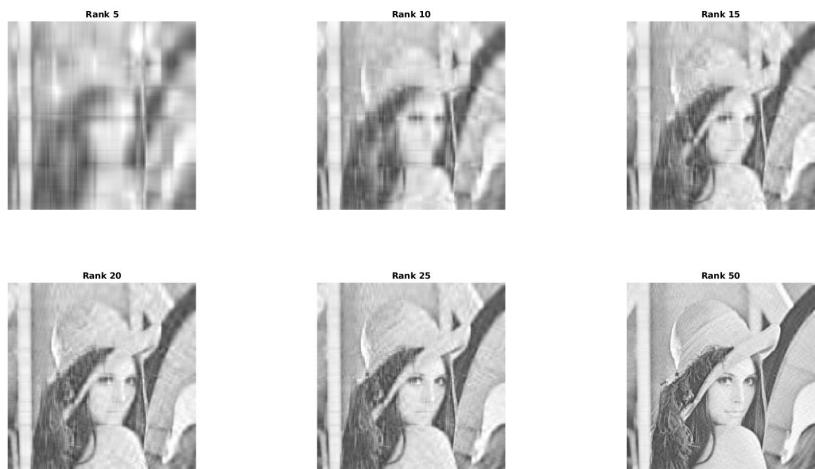
- an engineer creates an app called "Pied Piper" with a revolutionary data compression algorithm (reduce size in bytes of a file, such as an image).

### Why is data compression so important?

- Compressed files take less space in memory
  - decreases in expenses for storage
  - takes less time for transfer
  - consumes less network bandwidth (amount of information that can be sent/received from a device over a particular time)

Compression helps with costs and productivity.

## A Solution from ECE



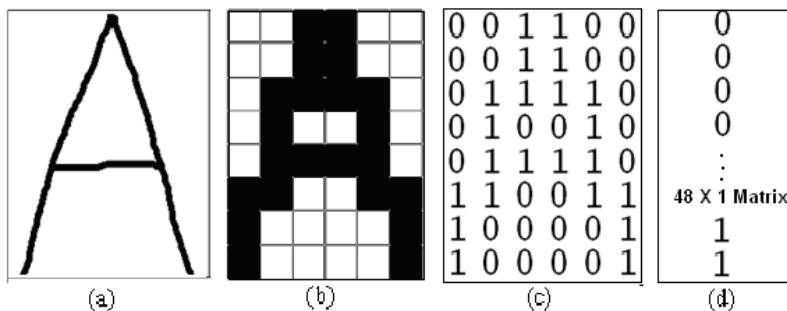
Several Levels of compression for "Lena"

- Most used image in computer vision literature: used to develop .jpeg
- Originally comes from the cover of a playboy magazine (1972)

- New documentary "Losing Lena": end the use of her image.

Source: <https://pursuit.unimelb.edu.au/articles/it-s-time-to-retire-lena-from-computer-science>

## A Closer Look: Image in the Computer



(a) Grayscale image of character 'A' (b) Binary representation of character 'A'; (c) Binary matrix representation and (d) Reshaped sample of character 'A'.

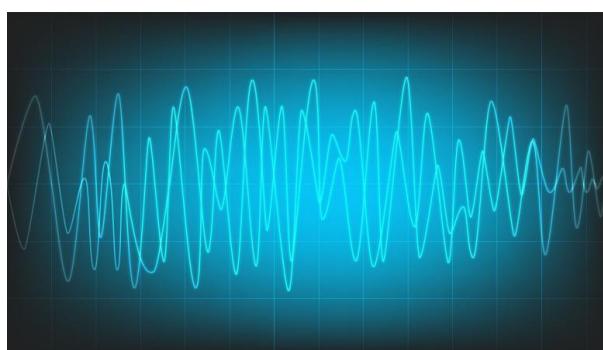
We find the "best decomposition":  $A \simeq \alpha_1 u_1 \cdot v_1^T + \alpha_2 u_2 \cdot v_2^T$  where:

- $\alpha_1, \alpha_2$  are just numbers called "scalars"
- $u_1, v_1, u_2, v_2$  are "vectors",  $T$  means "transpose" If image  $A$  is of size  $n \times n$ , then image  $A$  is now stored with  $2 + 4 * n$  elements.

We will learn how to compute this, and use it for applications.

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## Outline of ECE 3

- Unit 1: Vectors, Book ILA Ch. 1-5
- Unit 2: Matrices, Book ILA Ch. 6-11 + Book IMC Ch. 2
- Unit 3: Least Squares, Book ILA Ch. 12-14 + Book IMC Ch. 8
- Unit 4: Eigen-decomposition, Book IMC Ch. 10, 12, 19

**Remarks:**

- The course is organized according to the concepts.
- We will see ECE applications of these concepts in each unit.

## Questions?

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