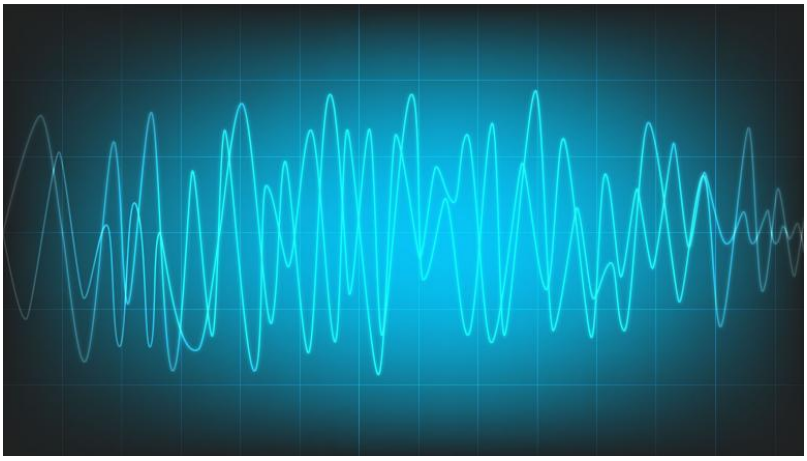
Welcome to ECE 3

Introduction to Electrical and Computer Engineering

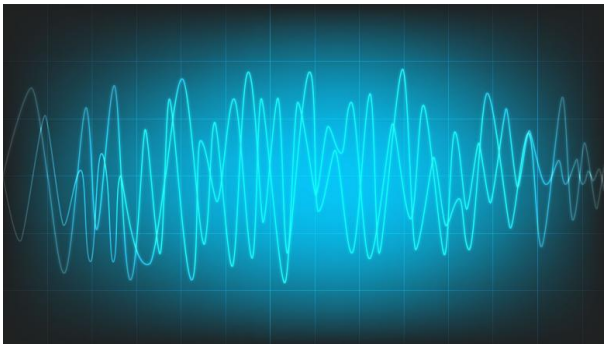
Nina Miolane - Assistant Professor

BioShape Lab @ UCSB ECE



Outline: Welcome

- Syllabus for ECE 3
- Real-World Applications of 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



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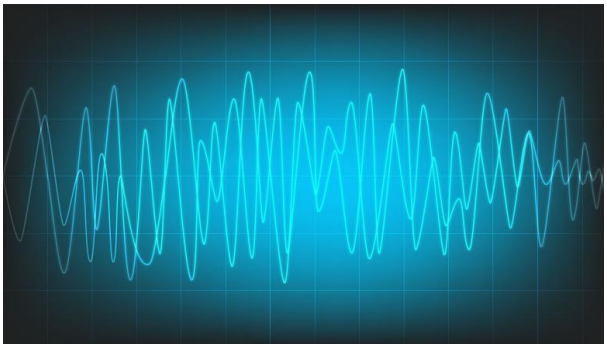

Instructor: Nina Miolane (me)

Research: Exploring the geometries of life:

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

Office Hours: Wednesdays 2 - 3 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 11:00 - 12:00 PM (Alejandro)
- Th 11:00 - 12:00 PM (Bella)

Preferred communication channel: Slack.

Classes and Labs

Classes: in CHEM 1171, MW 12:30 PM - 1:45 PM (slides posted on GitHub)

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.
- **Exception:** Covid-like symptoms or medical condition.

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, 2nd, 3rd, 4th 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 GitHub/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 on GitHub.
- 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 via Slack.

Any question?

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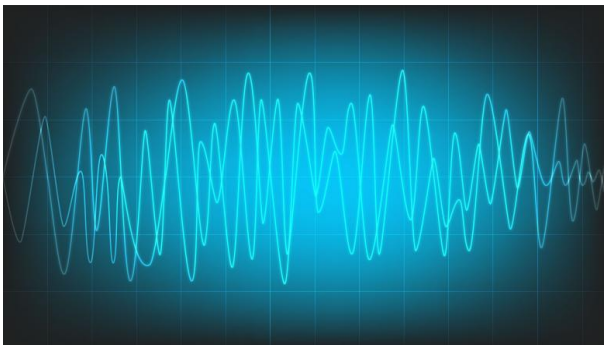
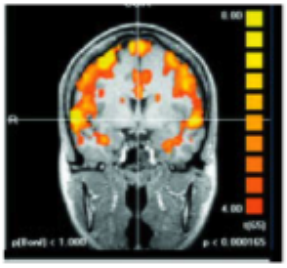


What is ECE?

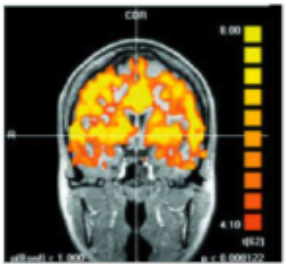
Electrical and Computer Engineering (ECE) focuses on design, development and production of:

- **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

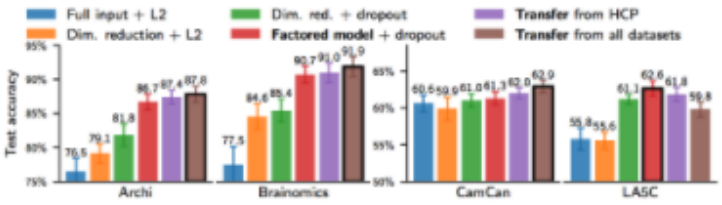


Figure 2: **Ablation results.** Each dimension reduction of the model has a relevant contribution. Dropout regularization is very effective when applied to the cognitive latent space. Learning this latent space allows to transfer knowledge between datasets.

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,
  - Autonomous vehicles,
  - Cybersecurity,
  - 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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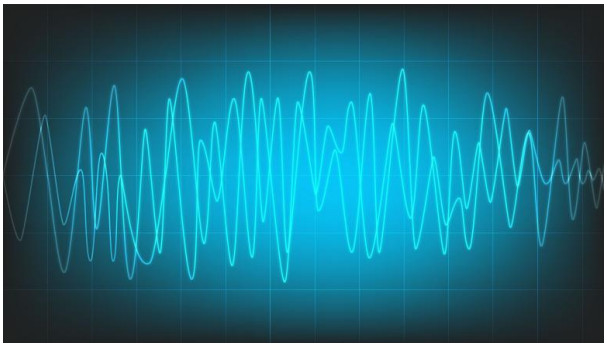
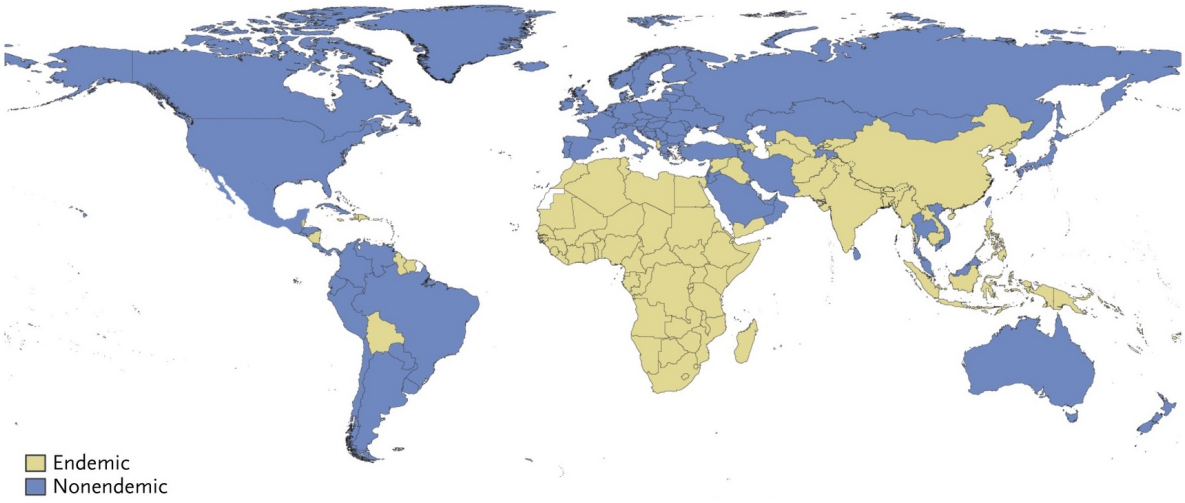
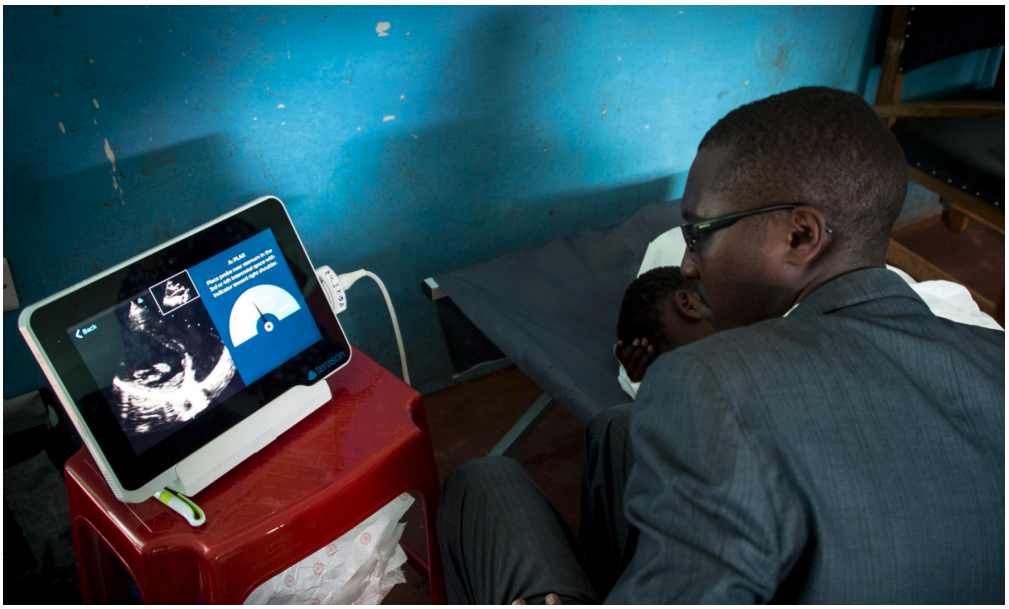


ECE: Example of Rheumatic Heart Disease



- 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

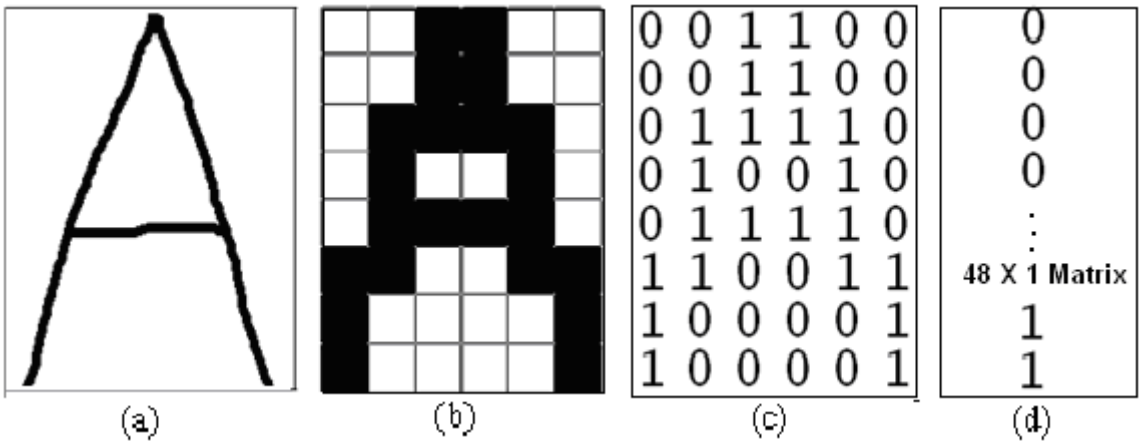


Teacher in Kenya acquiring echocardiographies of his students (Caption Health)

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

Make quality medical imaging universally accessible

A closer look: Image in the Computer

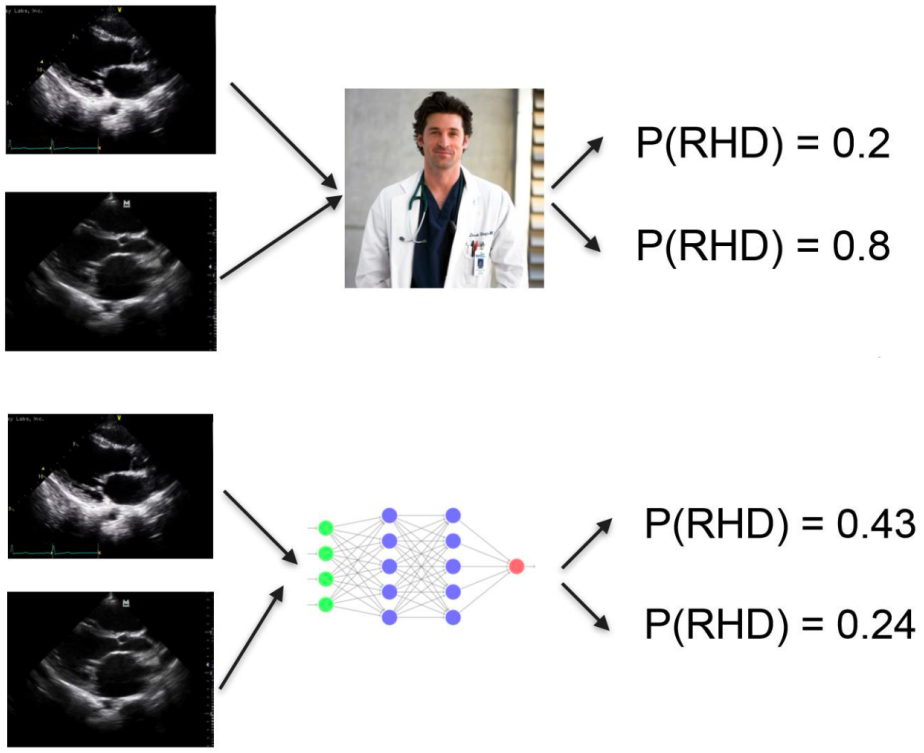


(a) Grayscale image of character 'A' (b) Binary representation of character 'A'; (c) Binary matrix representation and (d) Reshaped sample of character 'A'.

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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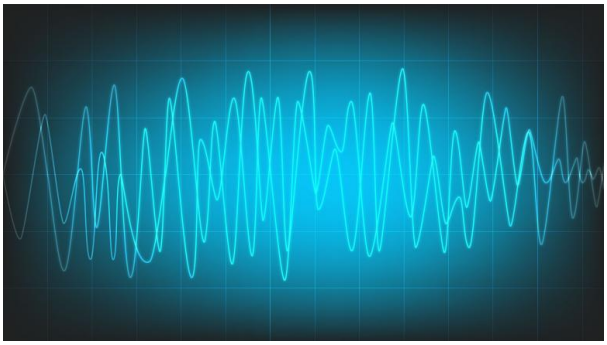
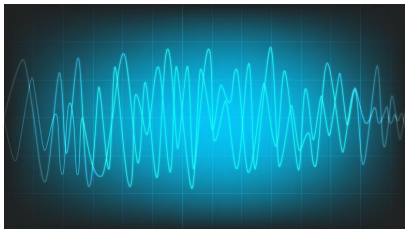


ECE for Signal Processing



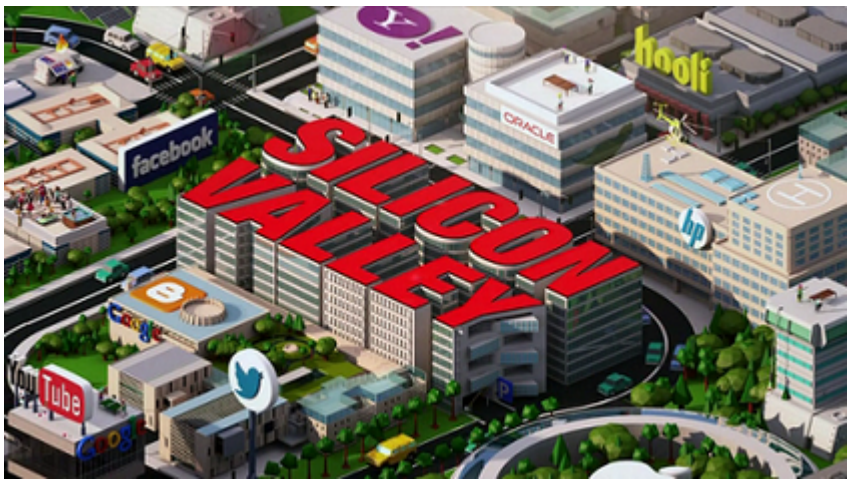
Signal processing is an ECE subfield that focuses on:

- 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 -> decrease expenses in storage & transfer.

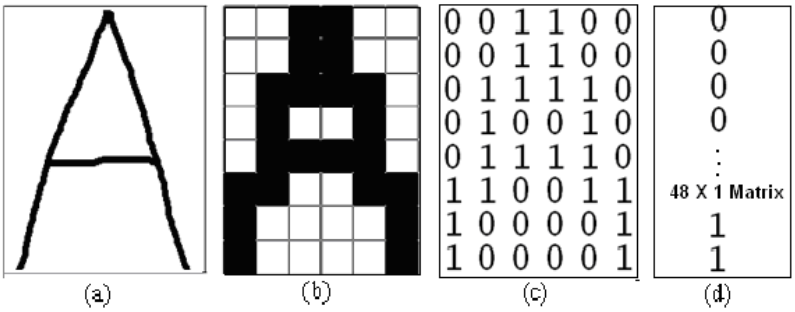
A Solution from ECE

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



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We find the "best decomposition": $A \simeq \alpha_1 u_1 . v_1^T + \alpha_2 u_2 . v2^T$ where:

- α_1, α_2 are just numbers called "scalars"
- u_1, v_1, u_2, v_2 are "vectors", T means "transpose"

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

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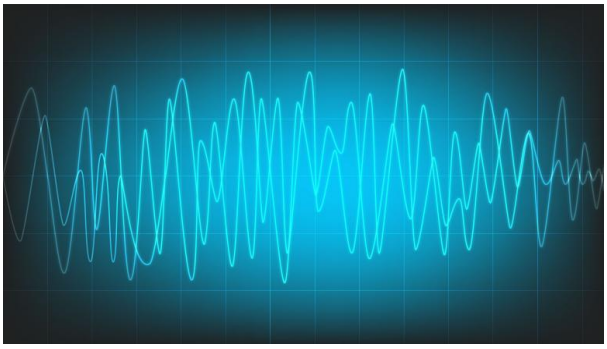

Outline of ECE 3

- 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?