Lecture 1: Welcome to Mathematics / Science of Information

DANIEL WELLER
TUESDAY, JANUARY 15, 2019
Agenda

Welcome!

About this course

What about the iPhone / Android?

So, what is information anyway?

What’s next?

Today’s lab: getting started with MATLAB

Image credit: Randall Munroe/xkcd.com
Welcome!

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Haris Jeelani (TA)
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Are you a first-year student? Be sure you’re registered for APMA 2501

Are you a 2nd-year (or later) student? Register for ECE 2066 (including a lab section)

On the waitlist? Be sure to attend the lectures, and do the homework, in case a spot opens up

Check out the Collab site: 19Sp Math of Information (visit https://collab.its.virginia.edu/)
  ◦ Review the syllabus
  ◦ Check out the Resources tab for lecture slides (including this one)
  ◦ Check out the Assignments tab for Homework #1 (due next Tuesday)
A new take on “How the iPhone Works”

Course description (from the syllabus):

This course surveys the mathematical topics that are needed to understand the fundamental principles that govern the storage, processing, and transmission of information on any device. We will study both the mathematical foundations and the engineering solutions enabled by these foundations. We will frequently use digital technologies such as the iPhone as examples to demonstrate them. For instance, how does the iPhone, which has mostly digital components, interact with an analog world? How does it store different types of data (music, video, apps) reliably, when the storage device itself (flash memory) is unreliable? What makes it possible to stream music over noisy wireless channels that sound so good (well, most of the time)?

Topics include: mathematical representation of information; spectral analysis and the sampling theorem; probability, uncertainty, and information; linear/abstract algebra and error correction; number theory and encryption; Boolean algebra and computation
Part 1: Numbers and signals

Topics include:
- Countable and uncountable sets of numbers
- Digital and analog signals
- Number representations
- Quantization
- Analog-to-digital conversion
Part 2: Frequency representation

Topics include:
- Frequency and spectrum
- Complex numbers
- The Fourier transform
- Filtering signals and images
- Multiplying signals
- Sampling and reconstructing signals
- Time and frequency
Part 3: Probability theory

Topics include:

- Probability, likelihood, uncertainty, and information
- Counting
- Probability distributions
- Expected value
- Independence and conditional distributions
- Repeated (e.g., Bernoulli) trials
- Entropy, mutual information, and capacity
- Compression and coding
- Communication and information
- Orthogonal representations
Part 4: Linear algebra

Topics include:
- Vectors and matrices
- Matrix operations
- Matrix equations
- Eigenvalues and eigenvectors
-Finite fields
- Error detection and error correction
- Parity checking and Hamming codes
- Multiple-access communication and orthogonal coding
- Amplitude, frequency, and phase modulation
Part 5: Number theory

Topics include:

- Number systems and binary arithmetic
- Number theory and encryption
- Divisibility, prime numbers, congruences
- Public key cryptography and Chinese remainder theorem
- Boolean algebra and computation
What about the iPhone / Android?

The mathematical concepts have many applications in how smartphones work:

- Camera: sampling, quantization, compression, ...
- Phone calls: spectrum, sampling and reconstruction, communication and coding, error correction, ...
- Processor: Boolean algebra, logic gates, computation, ...
- Privacy and security: encryption, number theory, ...
What is information, anyway?

Information describes the state of the world around us

We will study information in multiple ways:
- As numbers representing signals, audio, images, or video
- Through probability
- As related to noise and errors
- In encryption
- Via processing using a computer
What’s next?

We’ll talk about sets, different types of numbers, and how they relate to the concepts of analog and digital signals.
Learning more about information

Due to the broad, yet particular, nature of this class, we will not be following a specific textbook. However, there are many textbooks on specific topics that we will introduce in this class; a partial list of them can be found in the syllabus. If you are looking for a more thorough treatment on those topics, feel free to give these textbooks a try. Many of them are available online or through the UVA library. And, if you find another textbook not on the list that your classmates may find valuable, please share with me.
Office hours

Meet with Daniel Weller on Tuesdays (3 – 4 PM) or Thursdays (11 AM – noon) in Rice 309
- We’ll be going beyond what’s covered in the lectures
- Learn about how the mathematics of information is used in engineering and medicine
- Discuss topics covered in class
- Email Prof. Weller to schedule an individual meeting

Meet with Haris Jeelani on Mondays (9:30 – 10:30 AM) in Rice 314

Meet with TA’s during Tuesday afternoon labs (2 – 2:50 PM and 5 – 5:50 PM) in MAE 213
- All students are welcome! (ECE 2066 mandatory)