Introduction to Signals, Information, and Computing

ECE 203

Fall 2016

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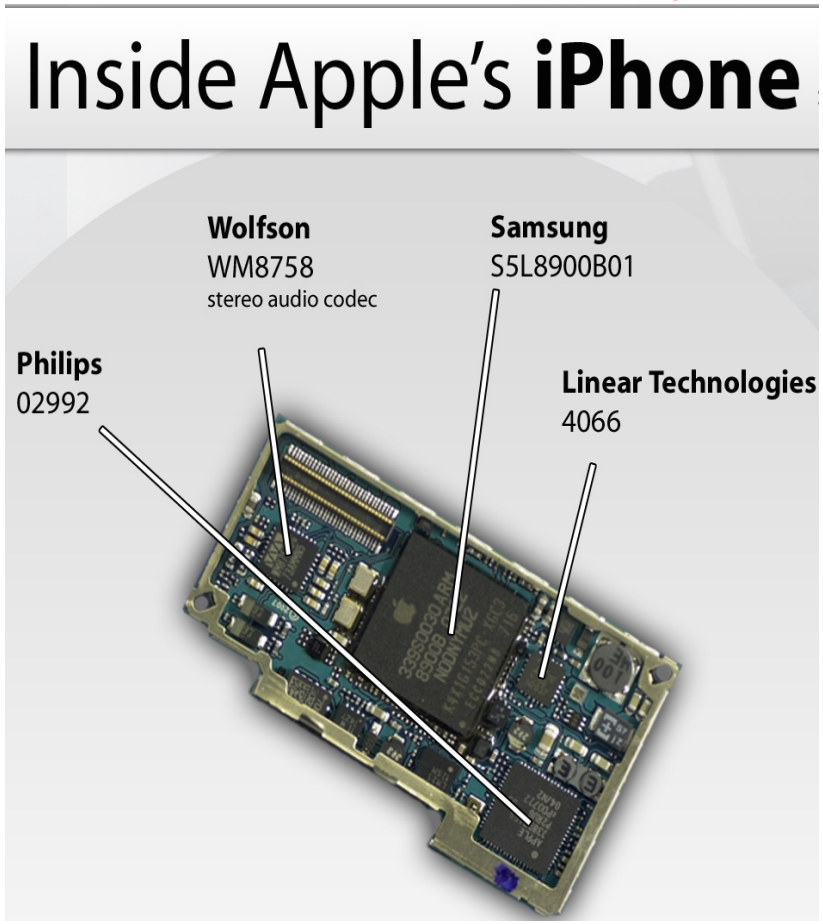
Signals, Information, and Computing

Every time you make a phone call, listen to digital music, use the internet, play a video game, ... , you are using signals, information, and computing.

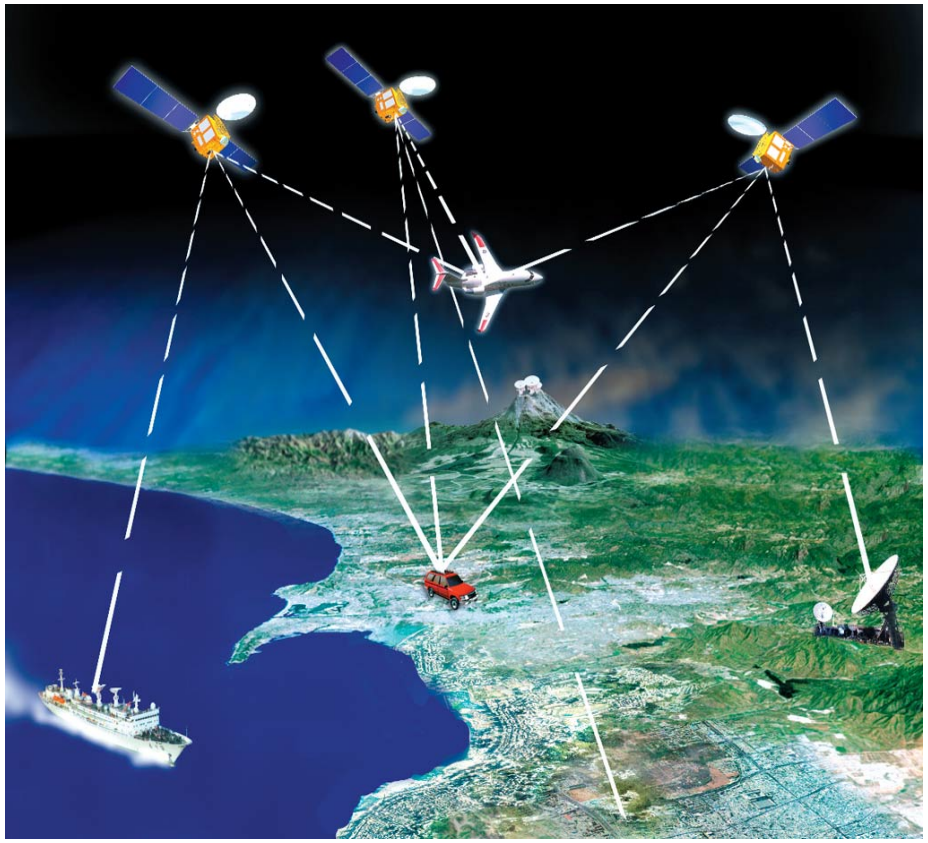
- Signals: measurable quantity that may vary with time or space
- Information: message or meaning conveyed by a signal. Ultimately information is represented with bits (0s and 1s)
- Computing: processing or analysis of signals and information. Computing is done with mathematical algorithms[1]

Example: iPhone

- Transmits and receives signals
- Signals carry and convey information
- Hardware uses algorithms to process information – computing

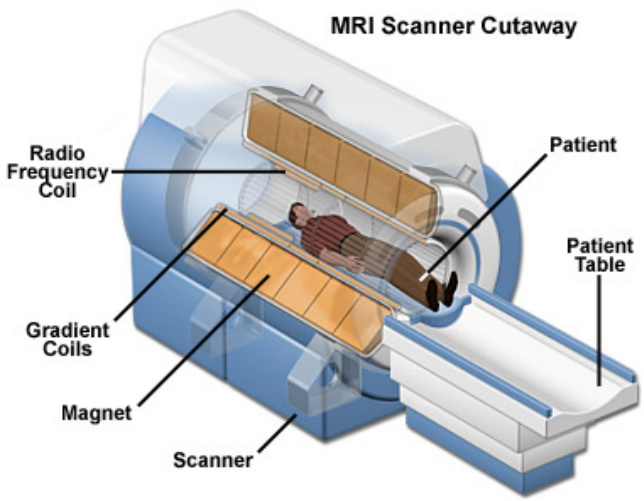


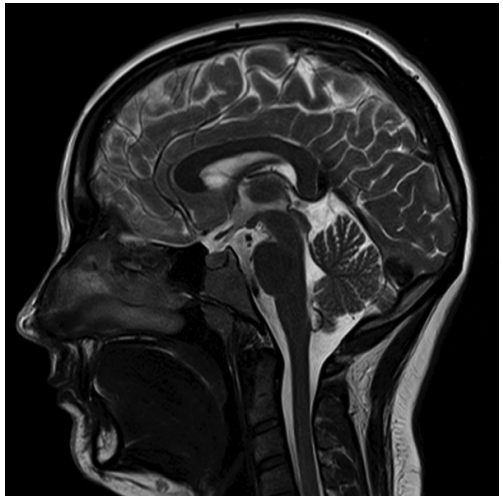
Example: Global Positioning System (GPS)



1. Satellite transmits a unique signal - sine wave near 1.5 GHz.
2. GPS receiver receives signal, extracts information: which satellite, location of sat, timing info.
3. GPS computes position using triangulation

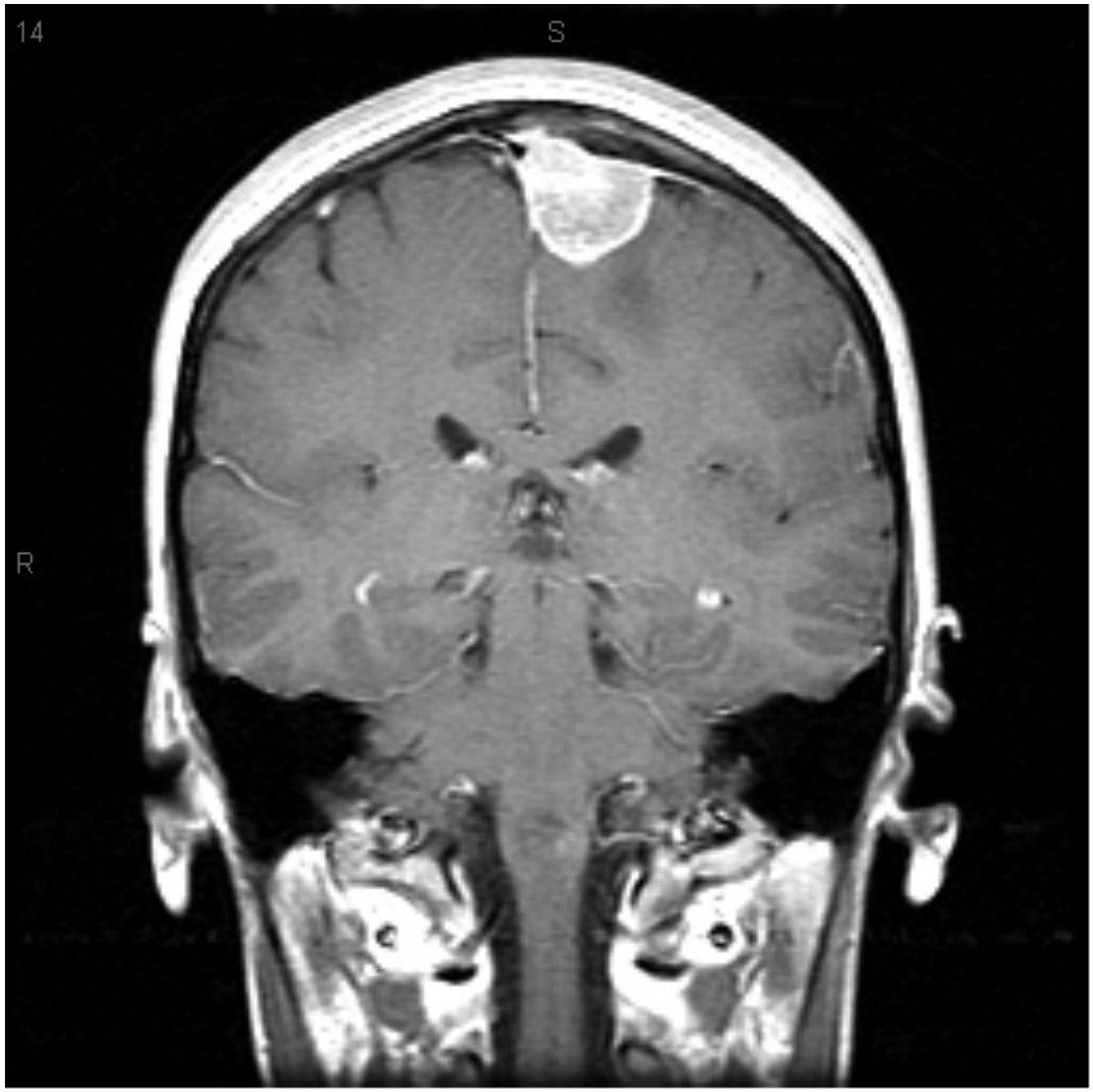
Example: Magnetic Resonance Imaging (MRI)



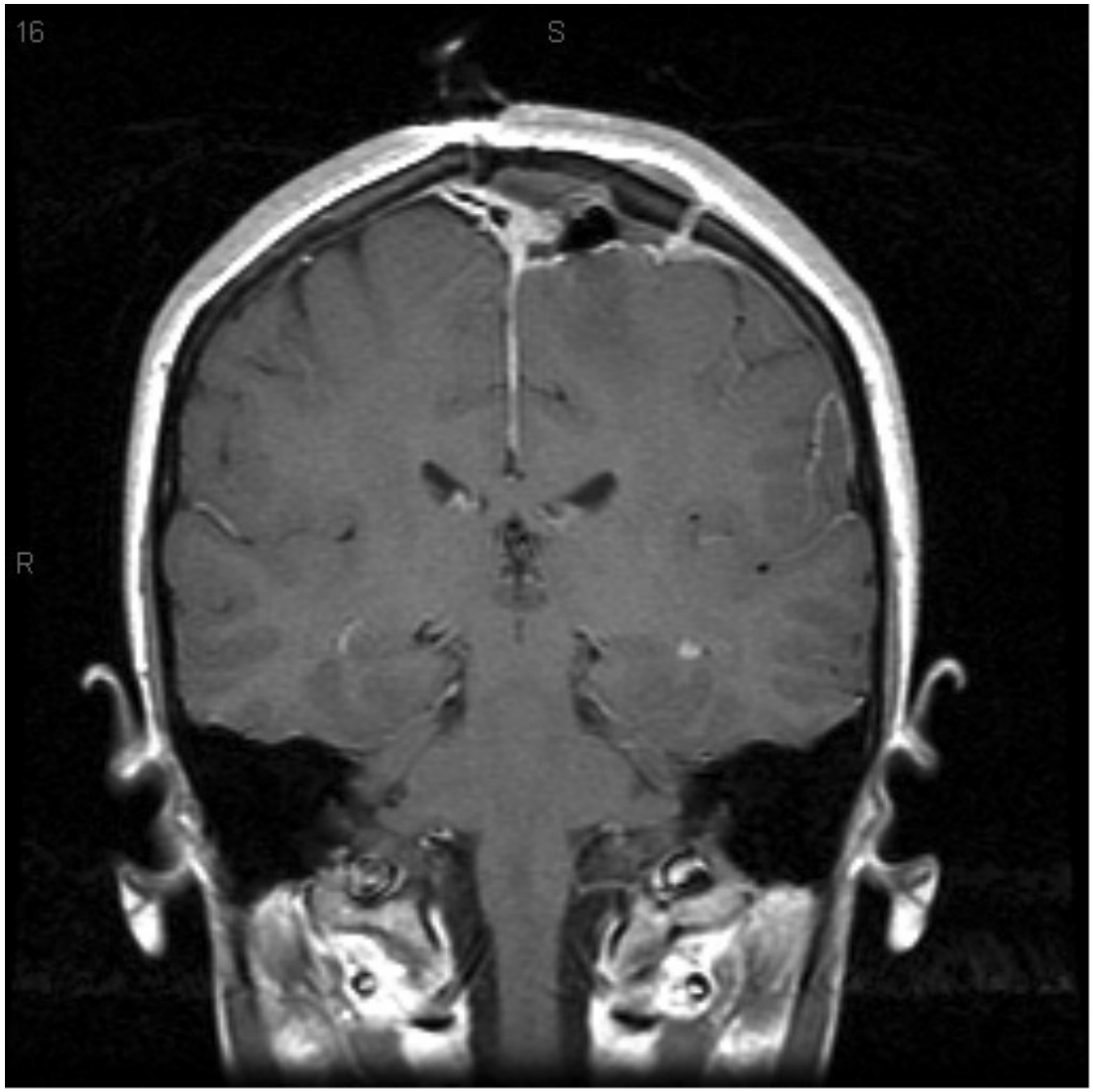


1. Hydrogen atoms align with magnetic field.
2. Radio frequency pulse perturbs alignment.
3. After pulse, H atoms re-align with field, generating a measurable EM wave (signal), proportional to density of H atoms.
4. Algorithms (computing) transform raw signal into useful information

MRI -- before



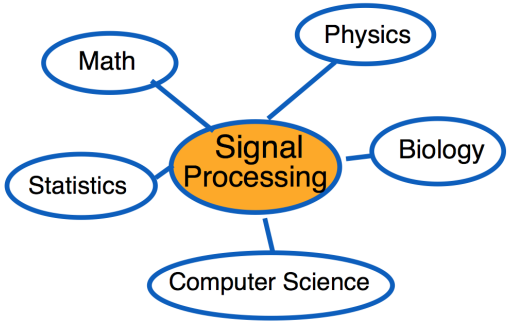
MRI -- after



Example: JPEG Compression

1. Light from each point in the scene as measured by a camera is the signal.
2. There is a lot of redundancy among the pixels; compression involves using computation to remove that redundancy.
3. We are then left with the scene's information content.

Signal processing is at the intersection of several converging fields.



- Physics and biology help us model the connection between what we a physical phenomenon (like sound waves from an instrument) and what we measure (symphony recording) or perceive
- Mathematics allows us to analyze our observations and make predictions about the future
- Computer science gives us tools for developing algorithms (grounded in physics and mathematics) for extracting information from our measurements
- Statistics helps us account for uncertainties in our data (for instance, a cell phone ringing during our symphony recording)

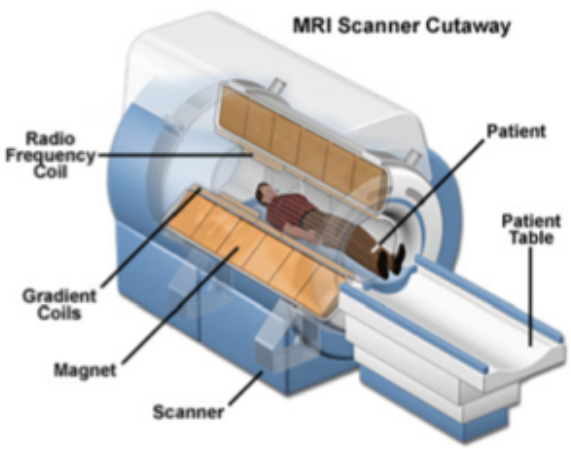
Signal Processing is Everywhere!

Telecommun-
ications

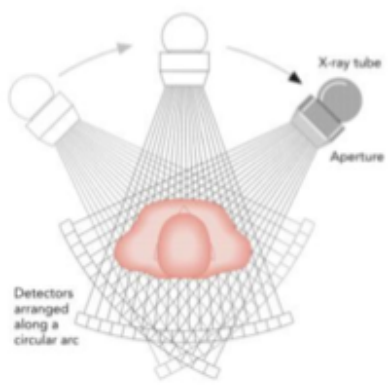
Optics

Digital
music

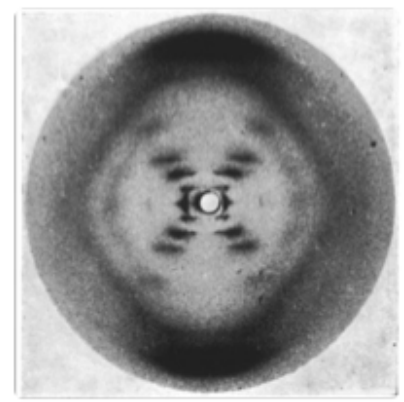
Radio astronomy



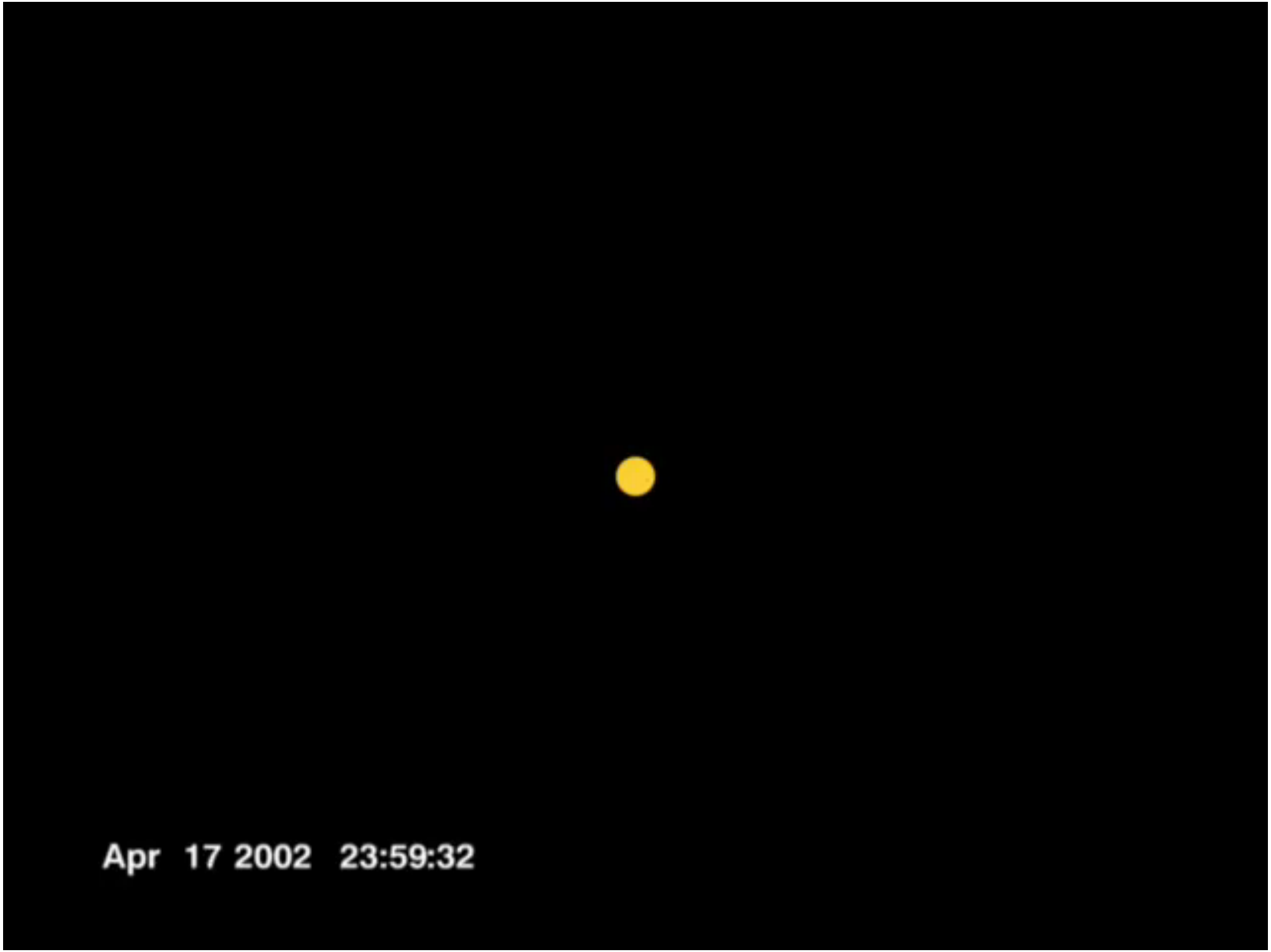
Nuclear Magnetic Resonance



Tomography



x-ray crystallography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Signal Processing is Everywhere!

We will talk a lot about music and auditory signals in this class because it helps us build intuition and understanding of many fundamental concepts. However, modern signal processing extends far beyond consumer electronics:

- detecting IEDs and landmines before injuries occur
- heart rate monitoring
- helping deaf people hear with cochlear implants
- helping soldiers see in the dark
- tracking wildfires and other environmental changes
- seeing into the farthest reaches of the universe
- monitoring credit histories for identity theft
- analyzing neural spike trains

Auditory signal example

- The note "A" is a sinusoidal signal
- the frequency of the wave is 440 Hz (cycles/second)
- This should be the mathematical formula:

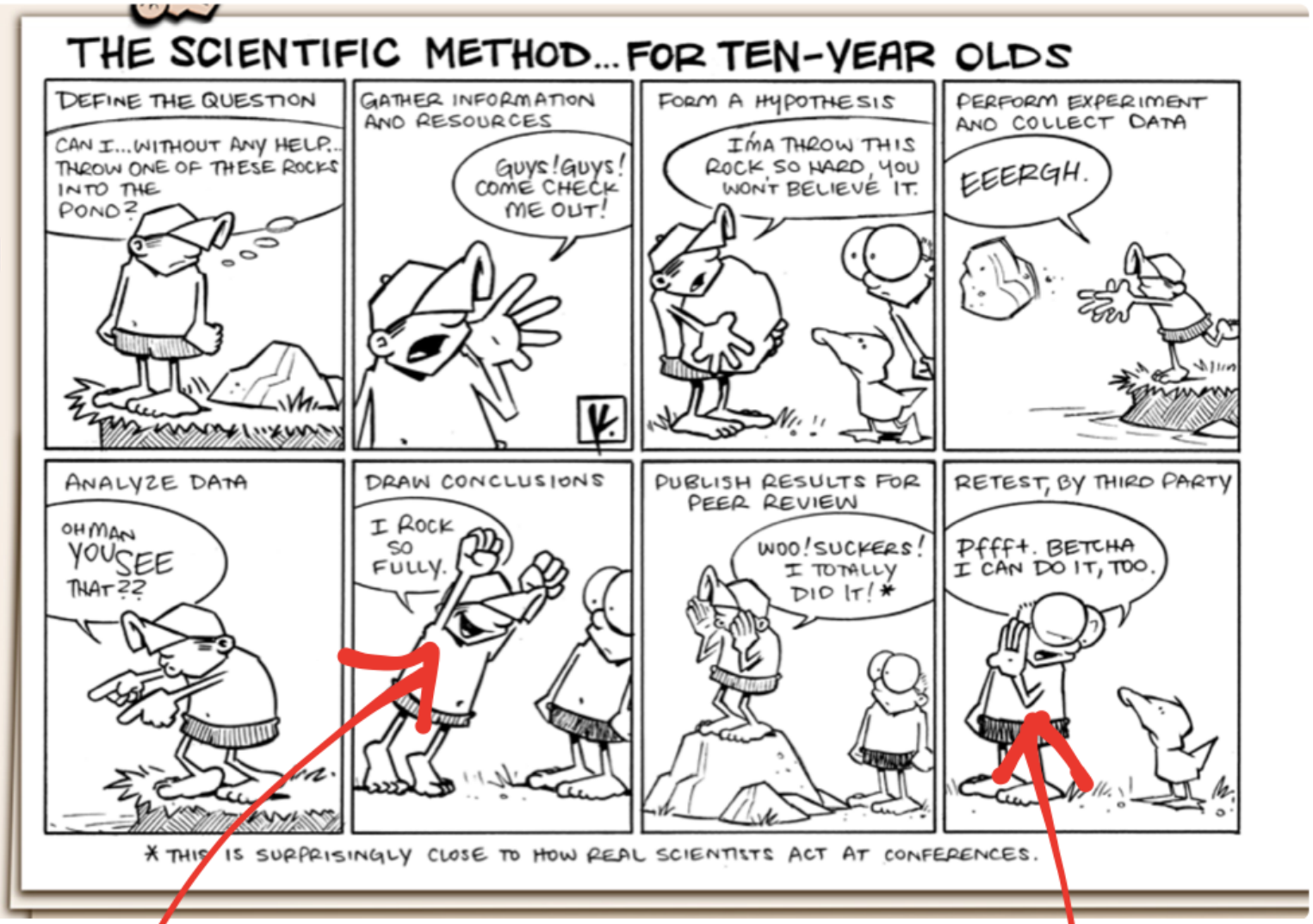
$$f(t) = \underbrace{A}_{\text{amplitude}} \cos(2\pi \underbrace{440}_{\text{frequency}} t + \underbrace{\phi}_{\text{phase}})$$

- Let's see in matlab.

Course Objectives

At the end of this course, you will be able to

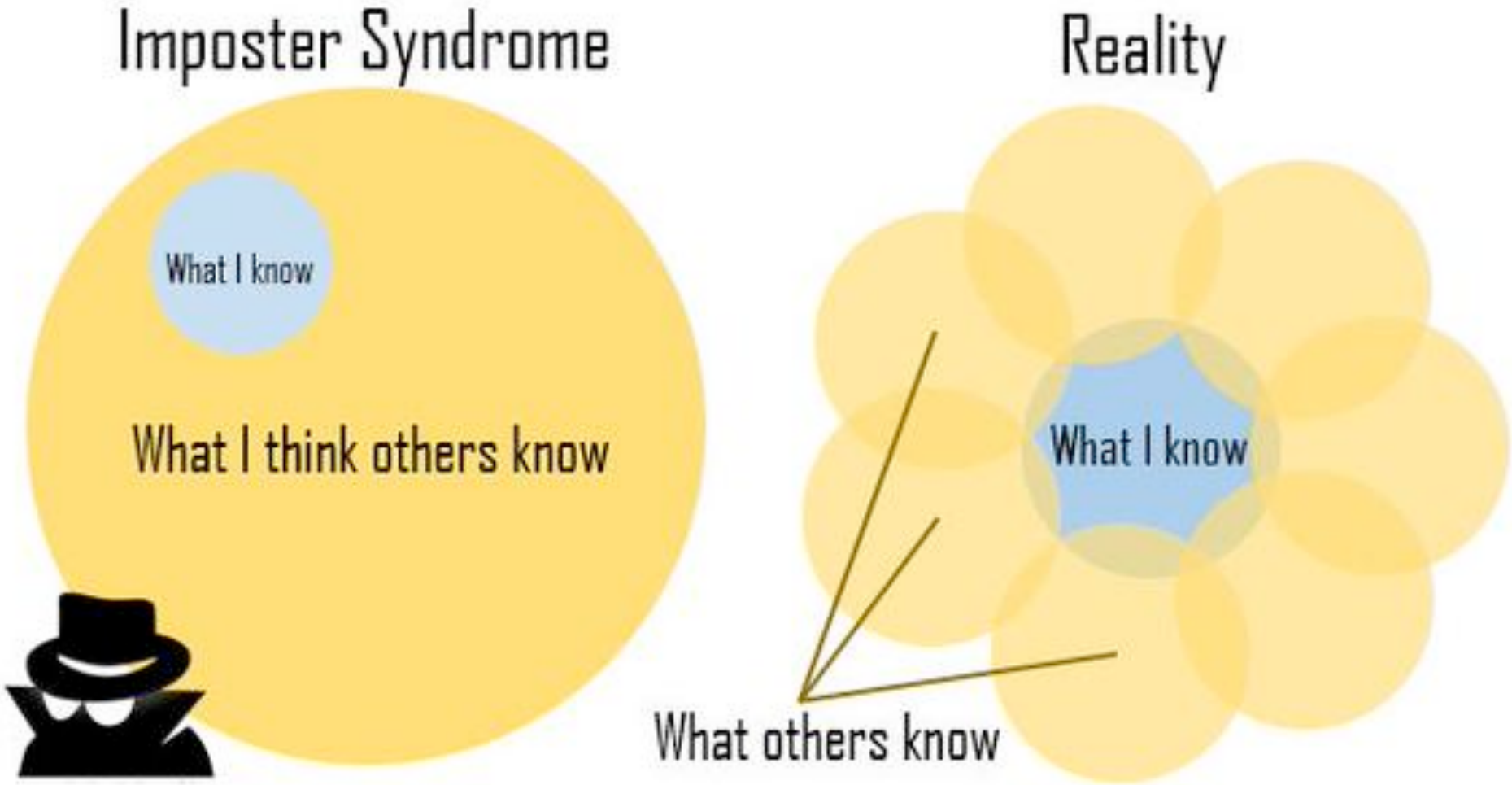
- represent various types of signals
- understand mathematical descriptions and models of systems and signal processing algorithms
- express these algorithms as computer implementations (MATLAB)
- analyze various systems and understand how they transform signals of interest to us
- synthesize systems with desired properties
- use signal processing in basic application areas
  - communications
  - music analysis
  - imaging

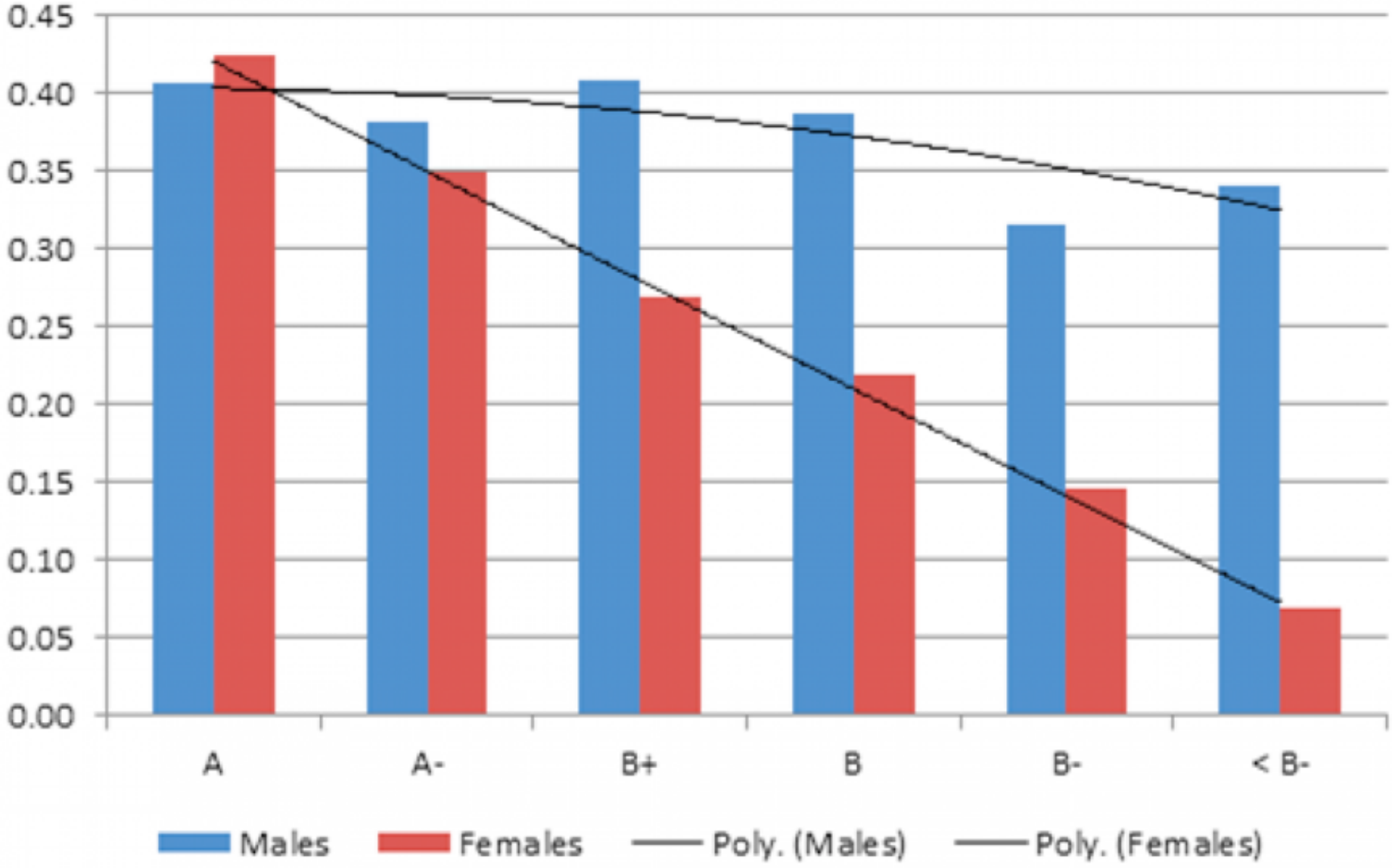


http://www.sheldoncomics.com/archive/100806.html

Prof. Willett

you in 3 months

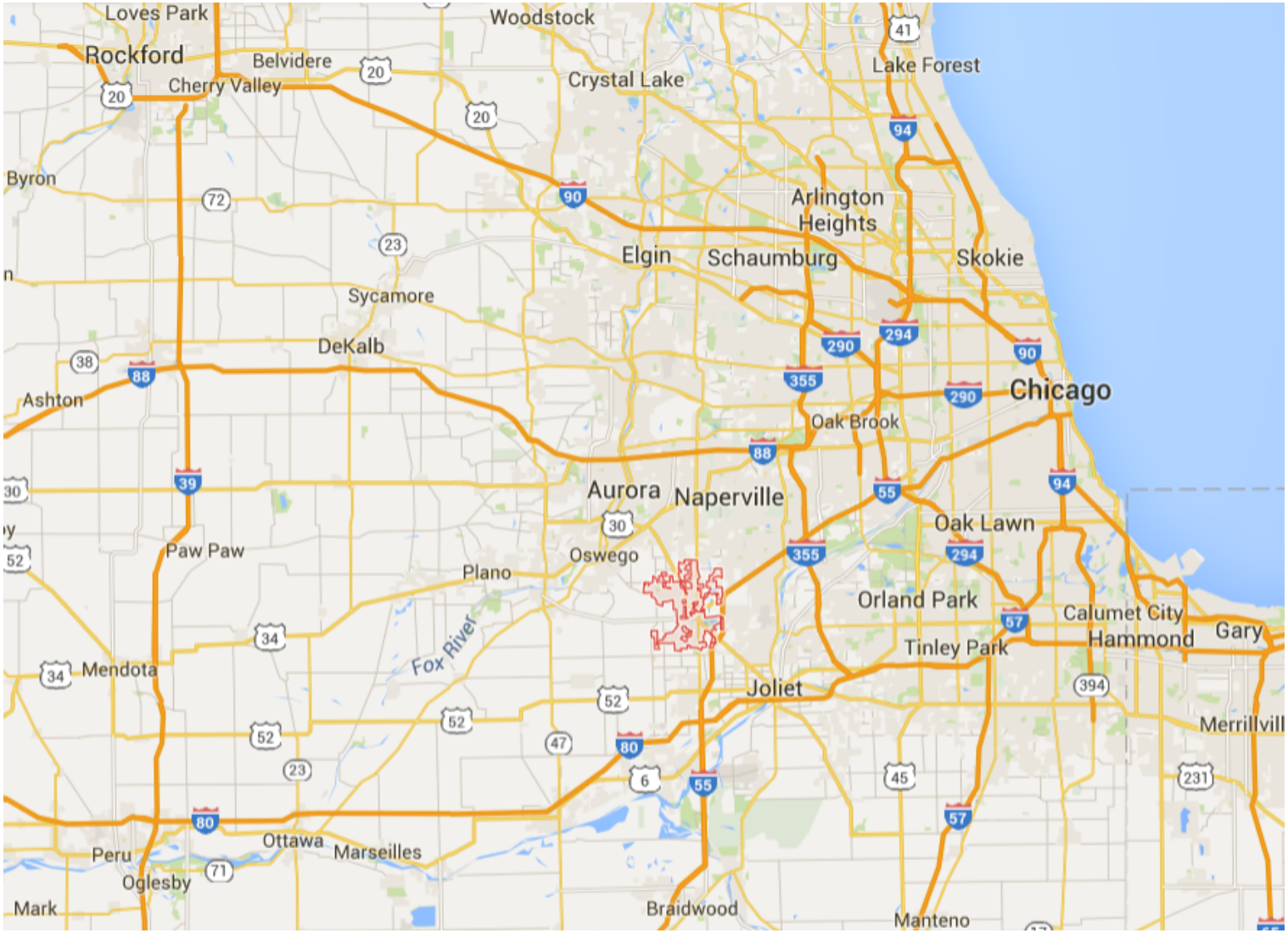

Imposter Syndrome
What I know
What I think others know
Reality
What I know
What others know



This chart shows the percentage of male and female students who received a given grade in introductory economics course who then later majored in economics. Data refer to an anonymous research institution, from a study by Harvard Professor Claudia Goldin.


KING

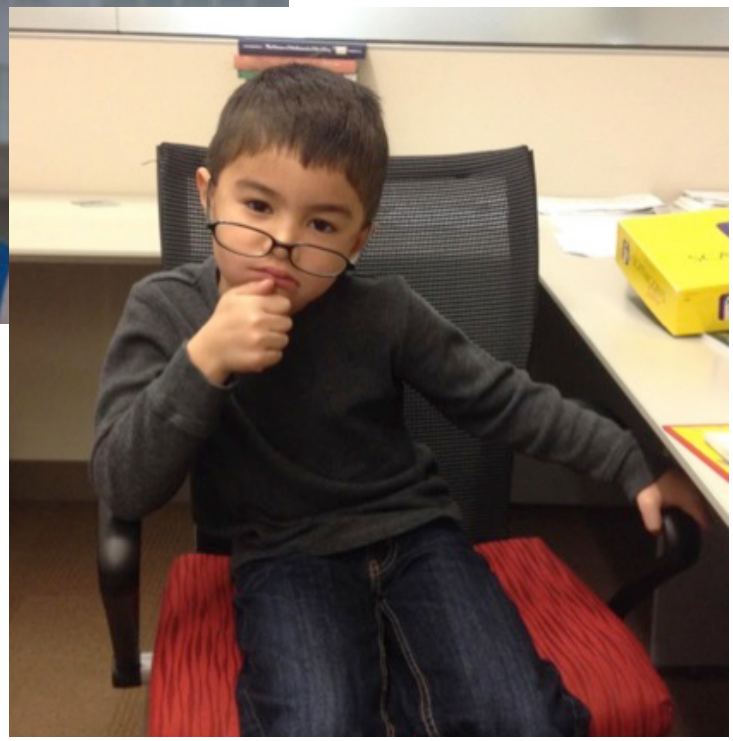
Plainfield, IL



Plainfield 25 years ago

Signal processing for disaster relief

About me



- Faculty are regular people with demanding jobs who generally love their work
- They are musicians, artists, athletes, political activists, religious, atheists
- Talk to them. Ask for advice and direction. Get to know them.

Don’t be afraid to speak up

The next time you’re afraid to share your ideas, remember that someone once said in a meeting “Let’s make a film with a tornado full of sharks.”