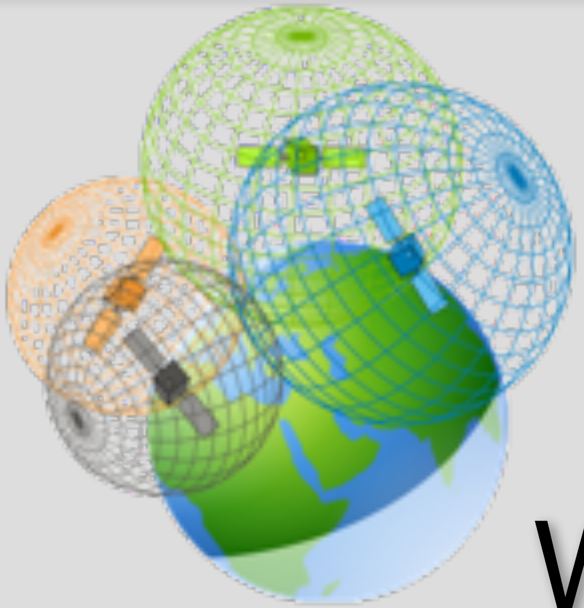


Welcome to EECS 16A!

Designing Information Devices and Systems I

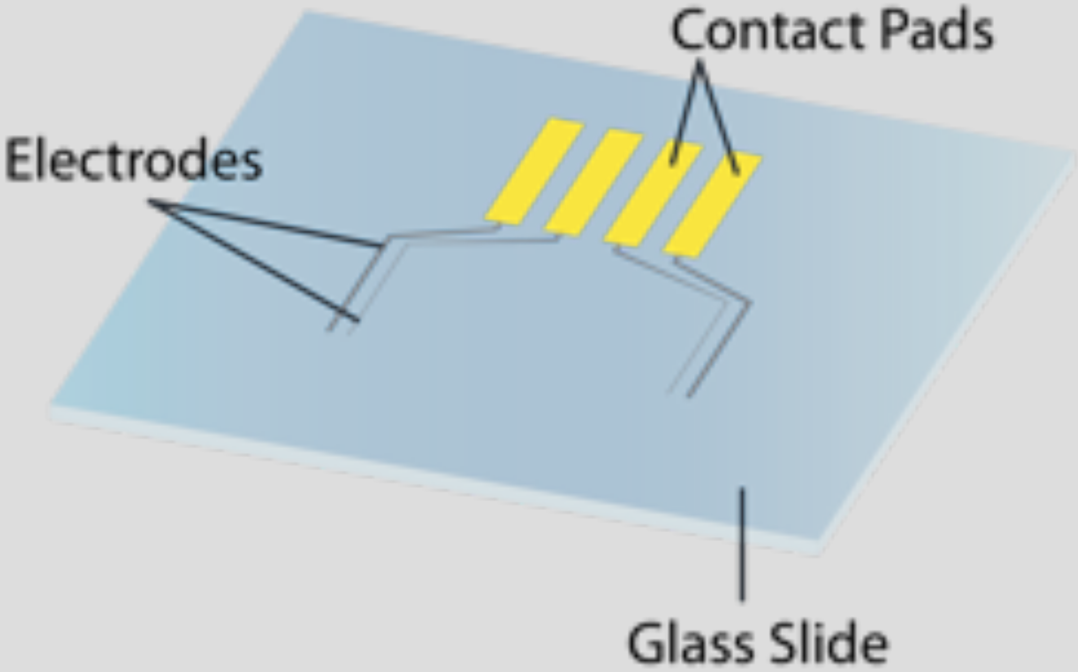
Ana Arias and Miki Lustig

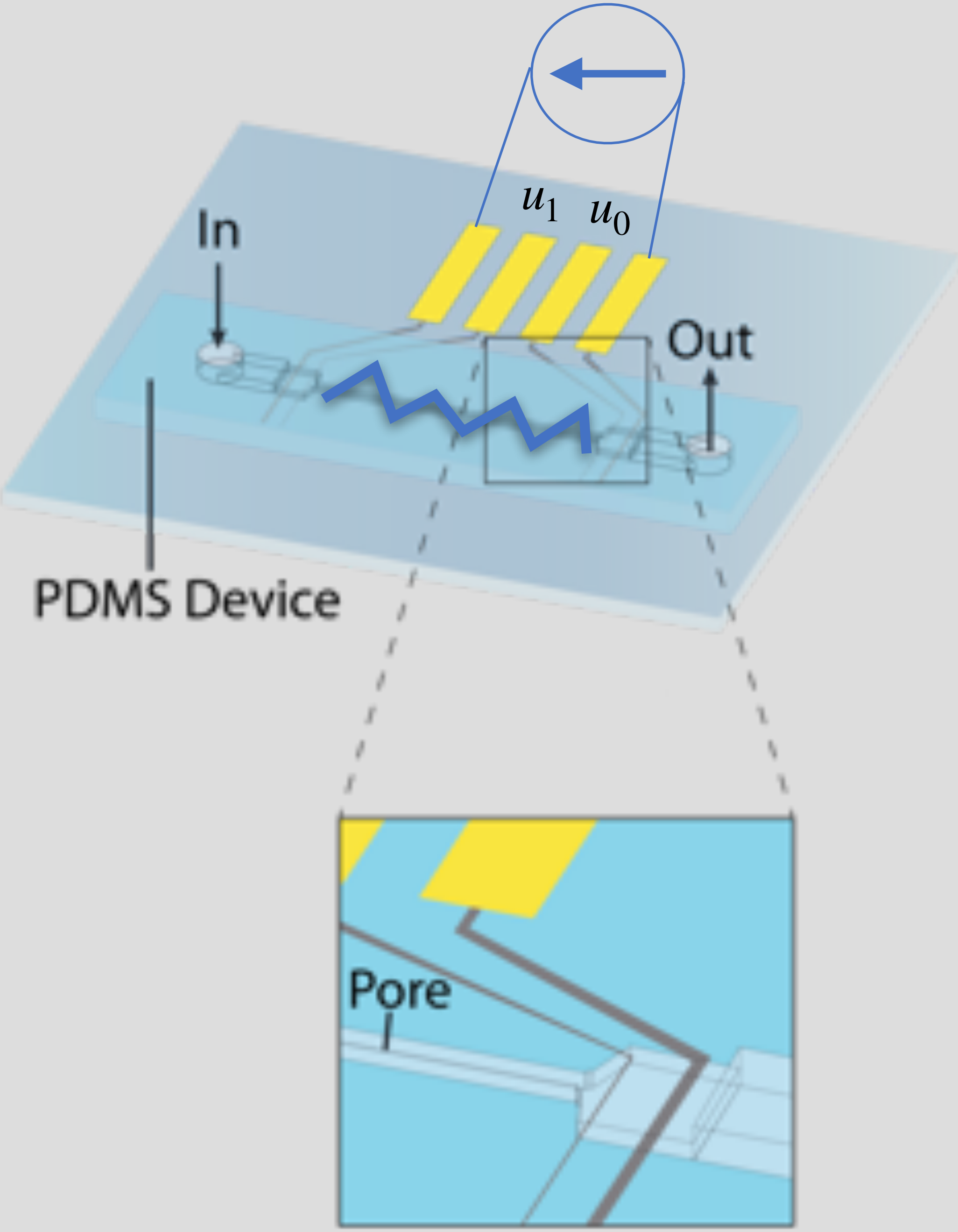

2022

Lecture 13B

Least Squares Apps

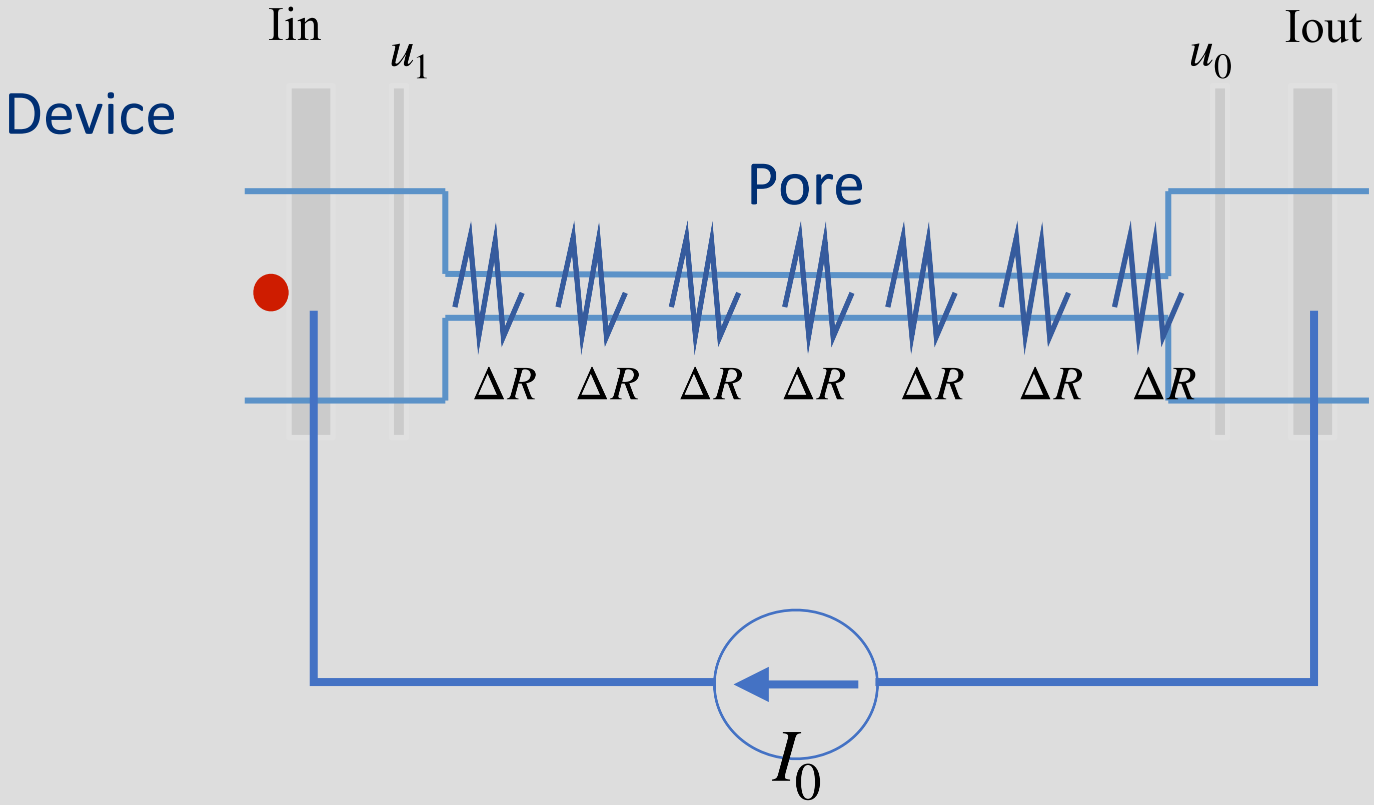
Resistive Pulse Sensing





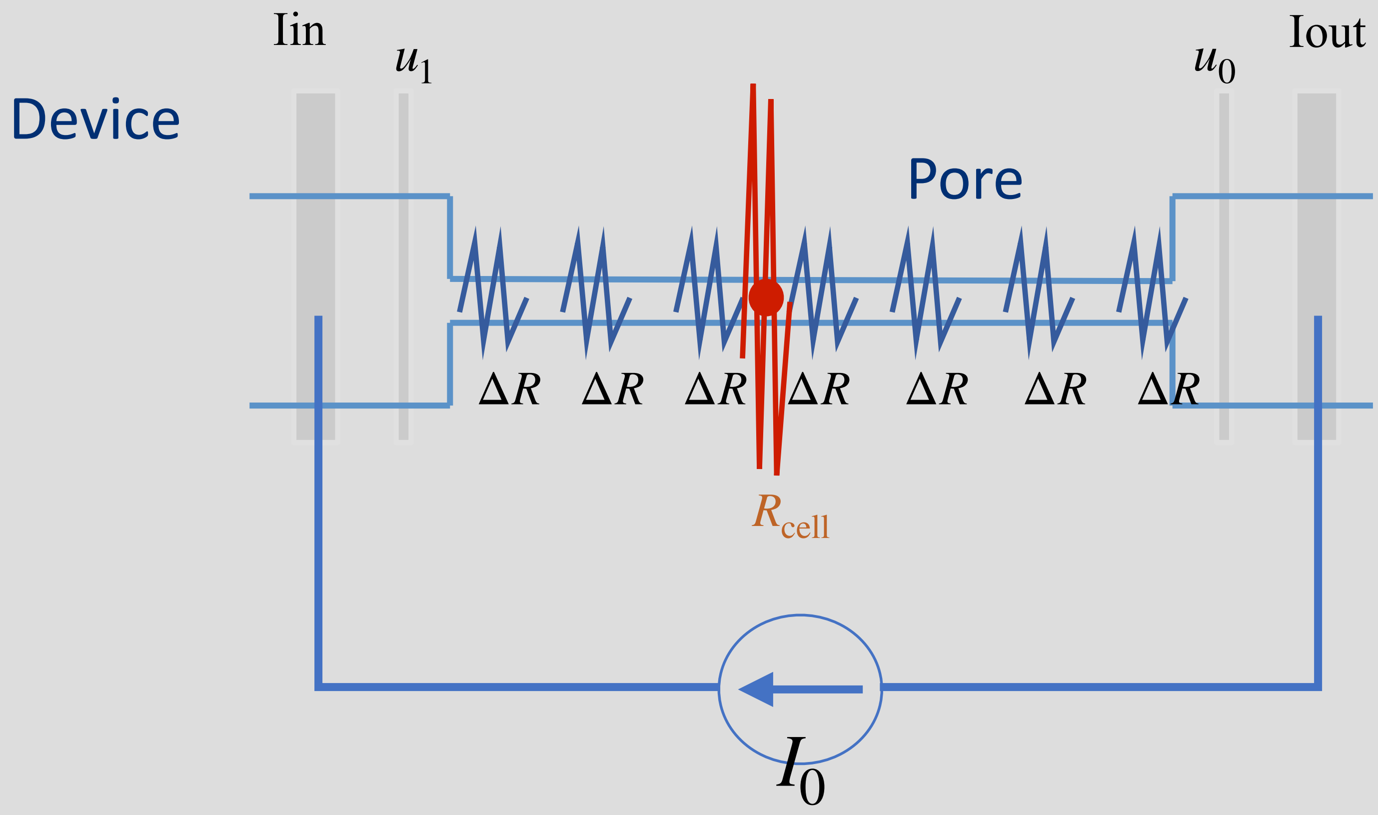
Prof. Lydia
Sohn M.E.

Resistive Pulse Sensing



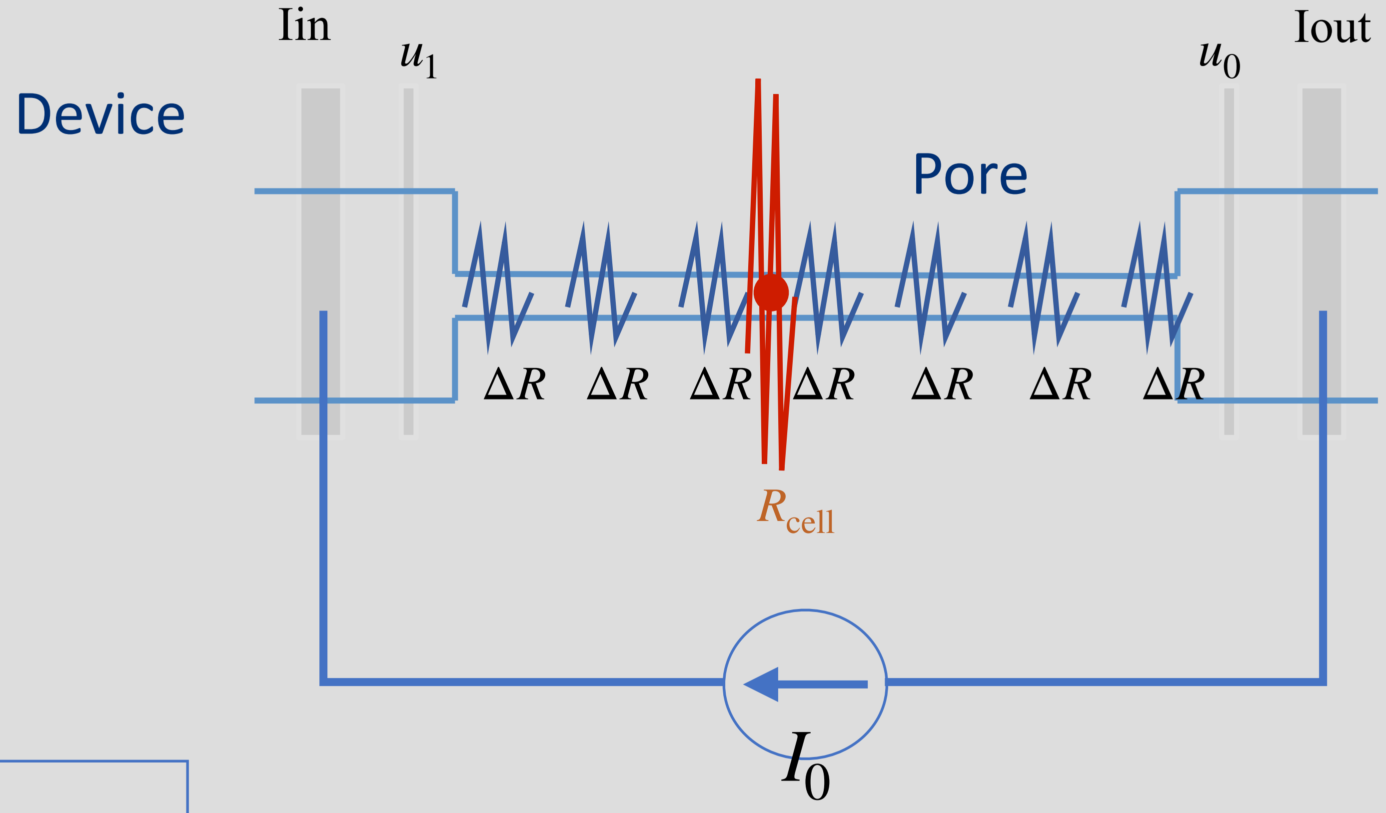
$$u_1 - u_0 = I_0 R$$

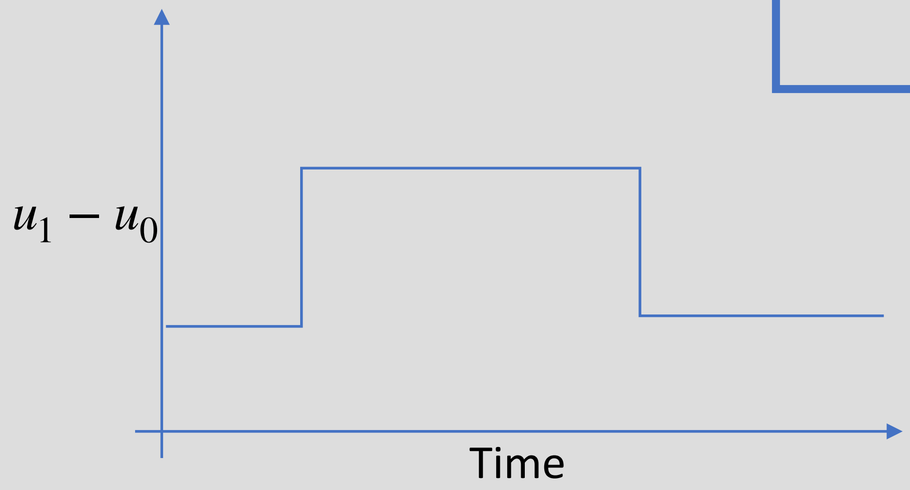
Resistive Pulse Sensing



$$u_1 - u_0 = I_0 R$$

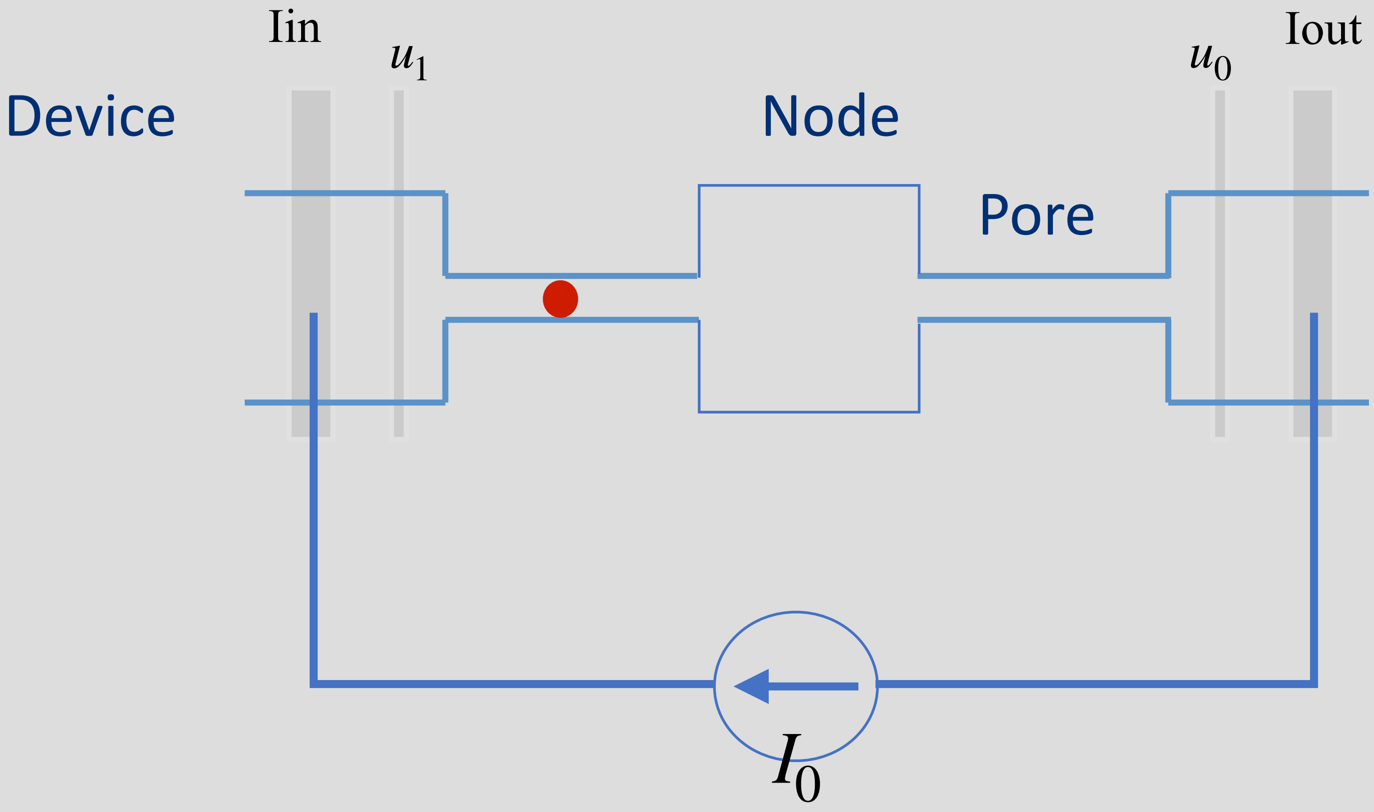
Resistive Pulse Sensing

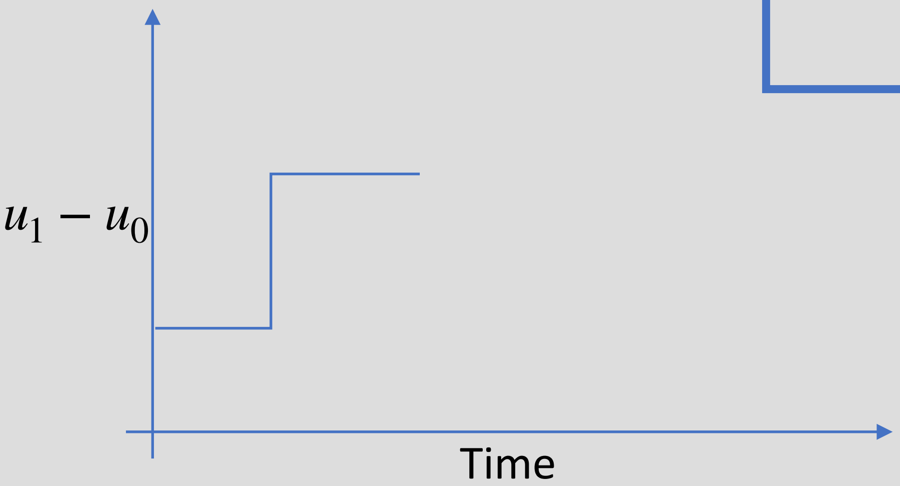




$$u_1 - u_0 = I_0(R + R_{cell})$$

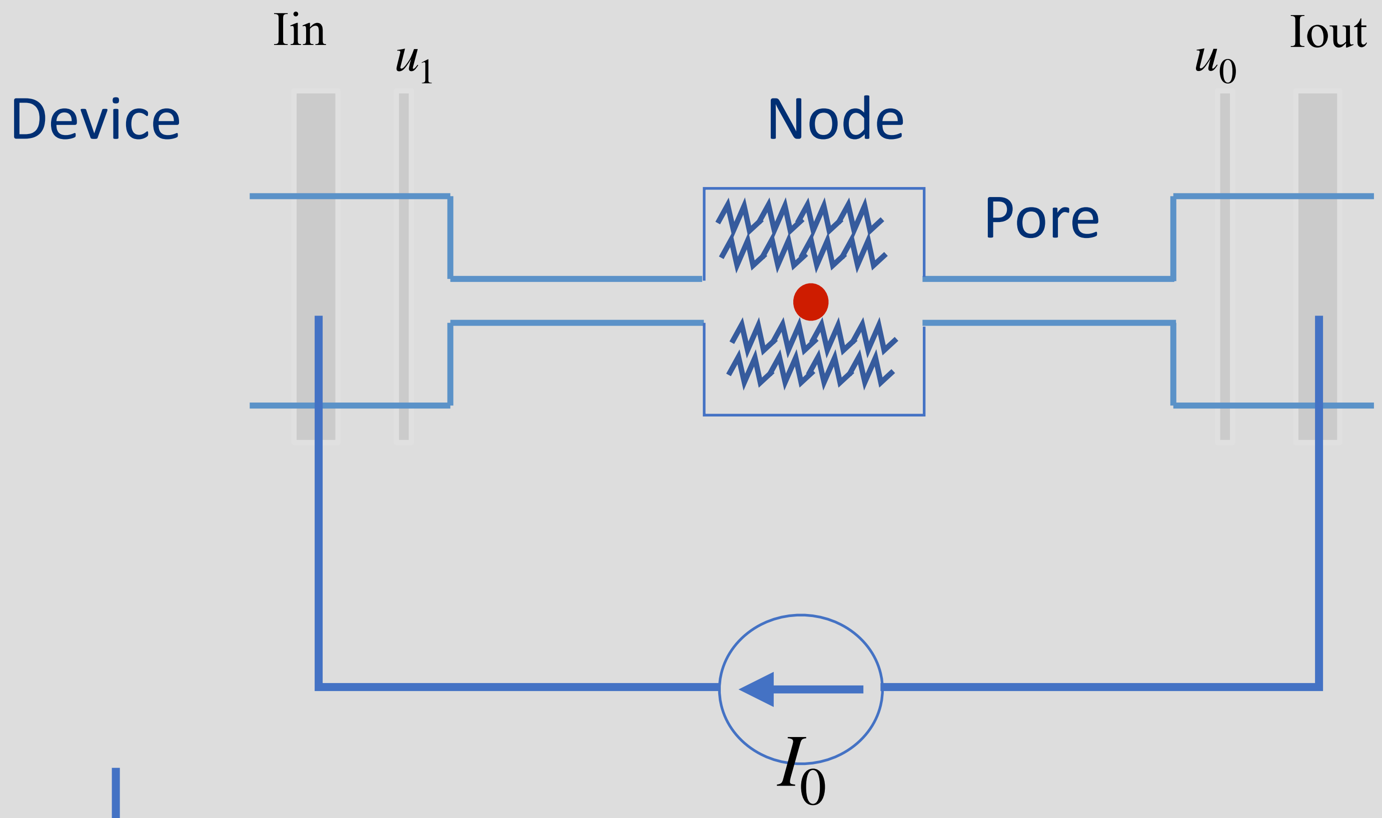
Node-Pore Sensing

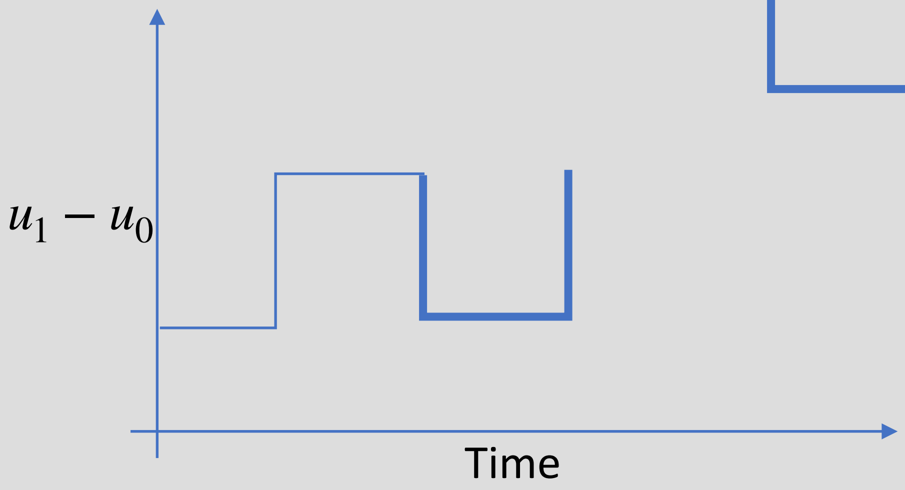




$$u_1 - u_0 = I_0(R + R_{cell} + R_{node})$$

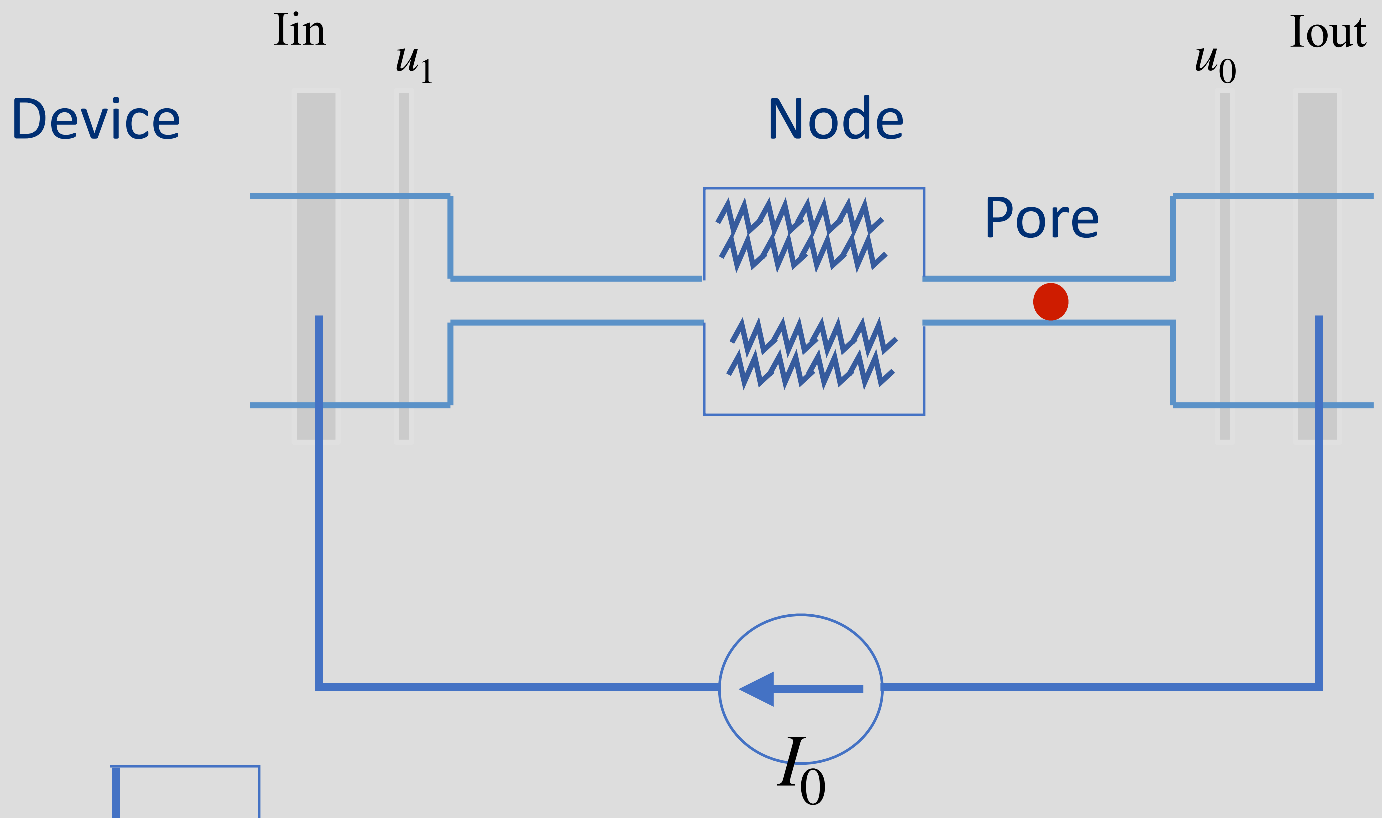
Node-Pore Sensing

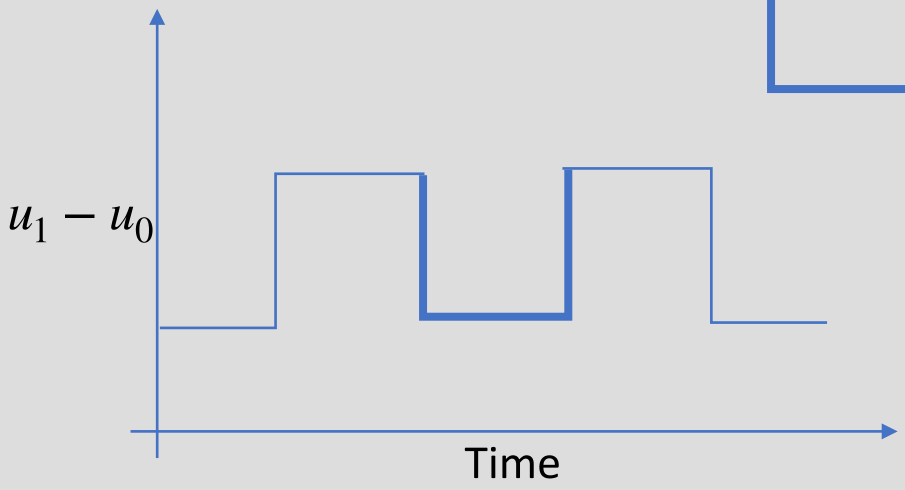




$$u_1 - u_0 = I_0(R + R_{cell} \| R_{node})$$

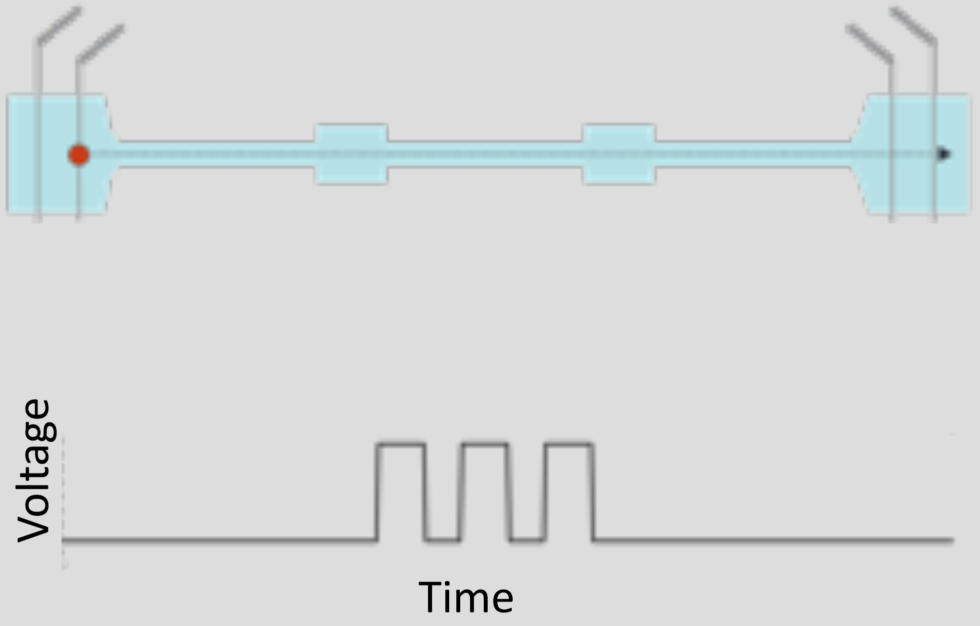
Node-Pore Sensing

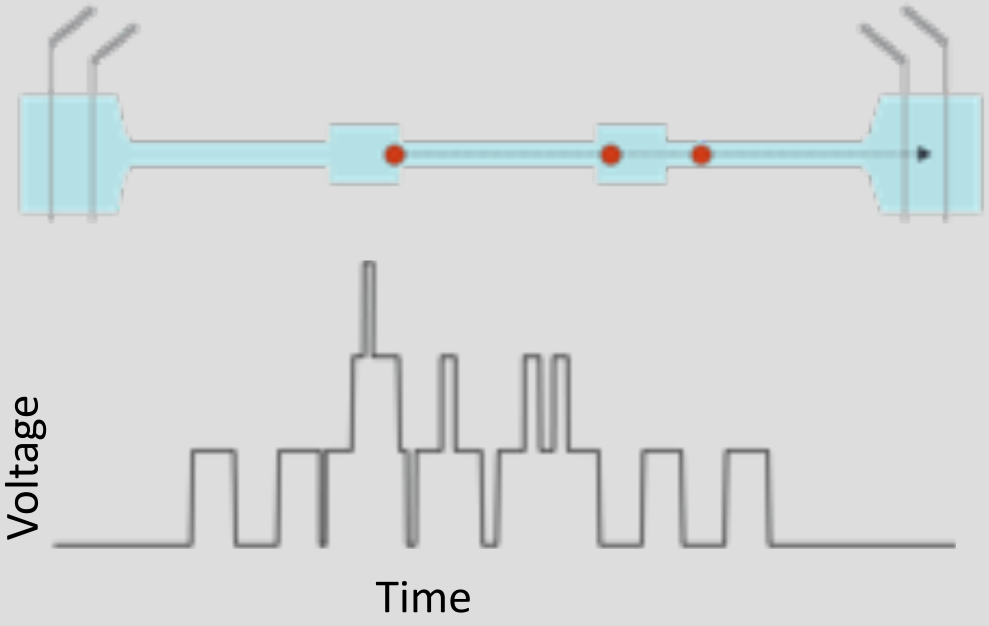




$$u_1 - u_0 = I_0(R + R_{cell} + R_{node})$$

Sensing Complexities

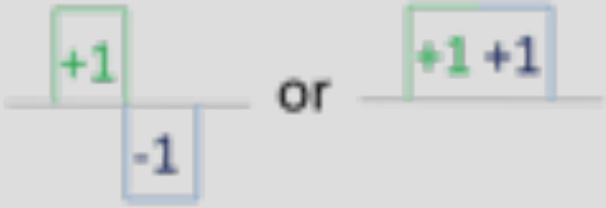




Barker Codes

- 9 uniques sequences

Barker 2 : +1 −1 or +1 +1 ->



Barker 3 : +1 +1 −1

Barker 4 : +1 +1 −1 +1 or +1 +1 +1 +1 −1

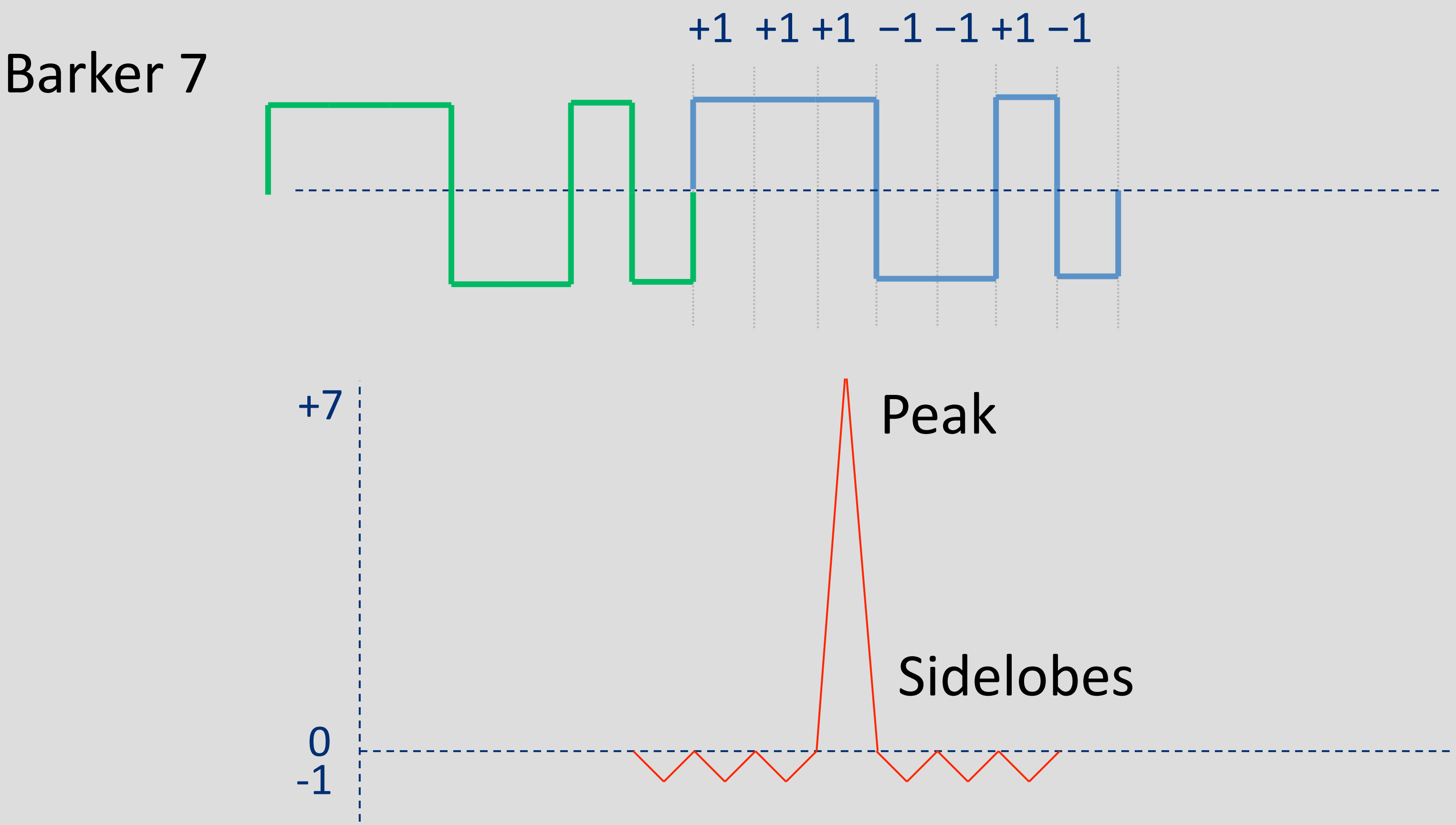
Barker 5 : +1 +1 +1 −1+1

Barker 7 : +1 +1 +1 −1 −1 +1 −1

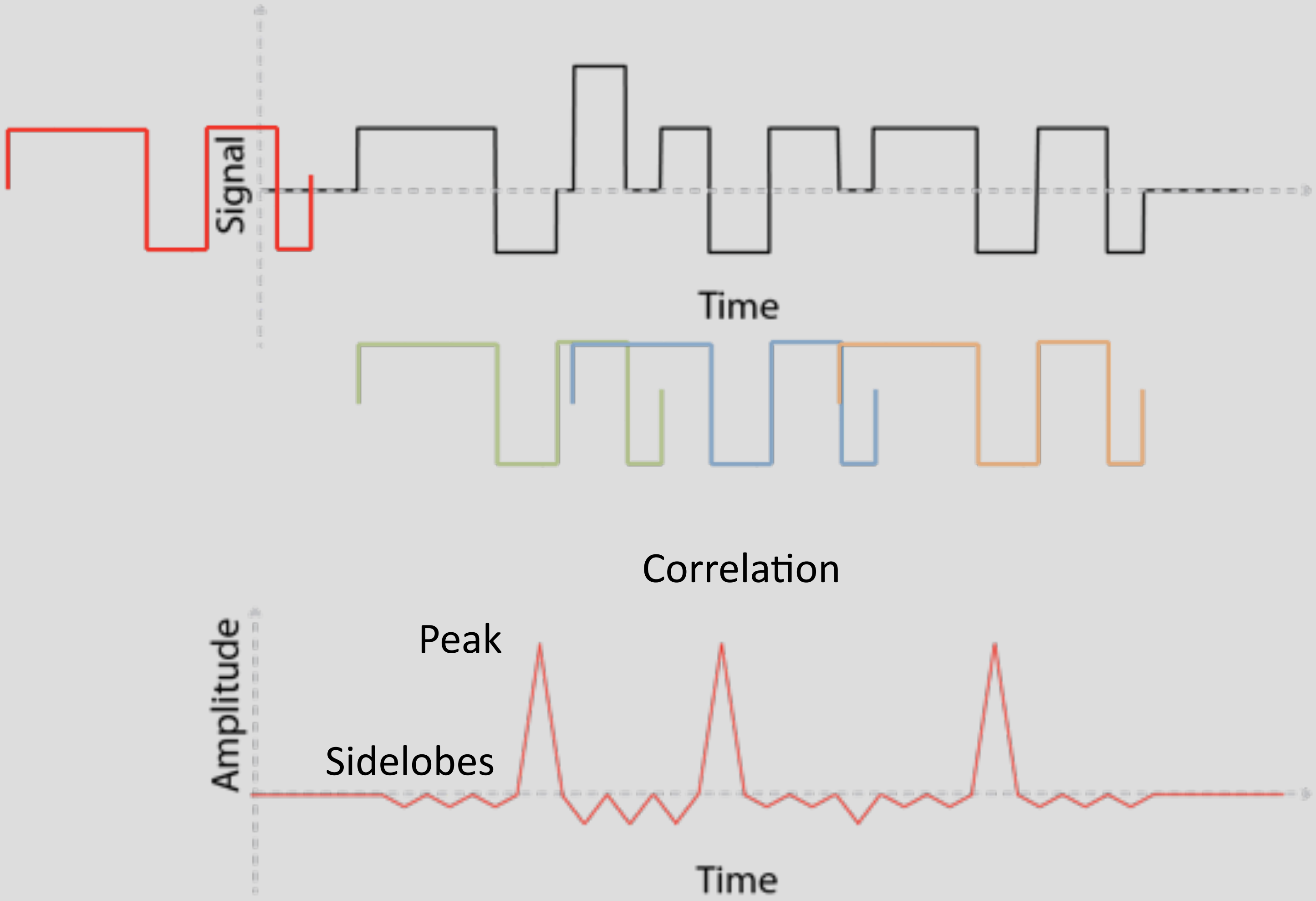
Barker 11 : +1 +1 +1 −1 −1 −1 +1 −1−1 +1 −1

Barker 13 : +1 +1 +1 +1 +1 −1 −1 +1 +1 −1 +1 −1 +1

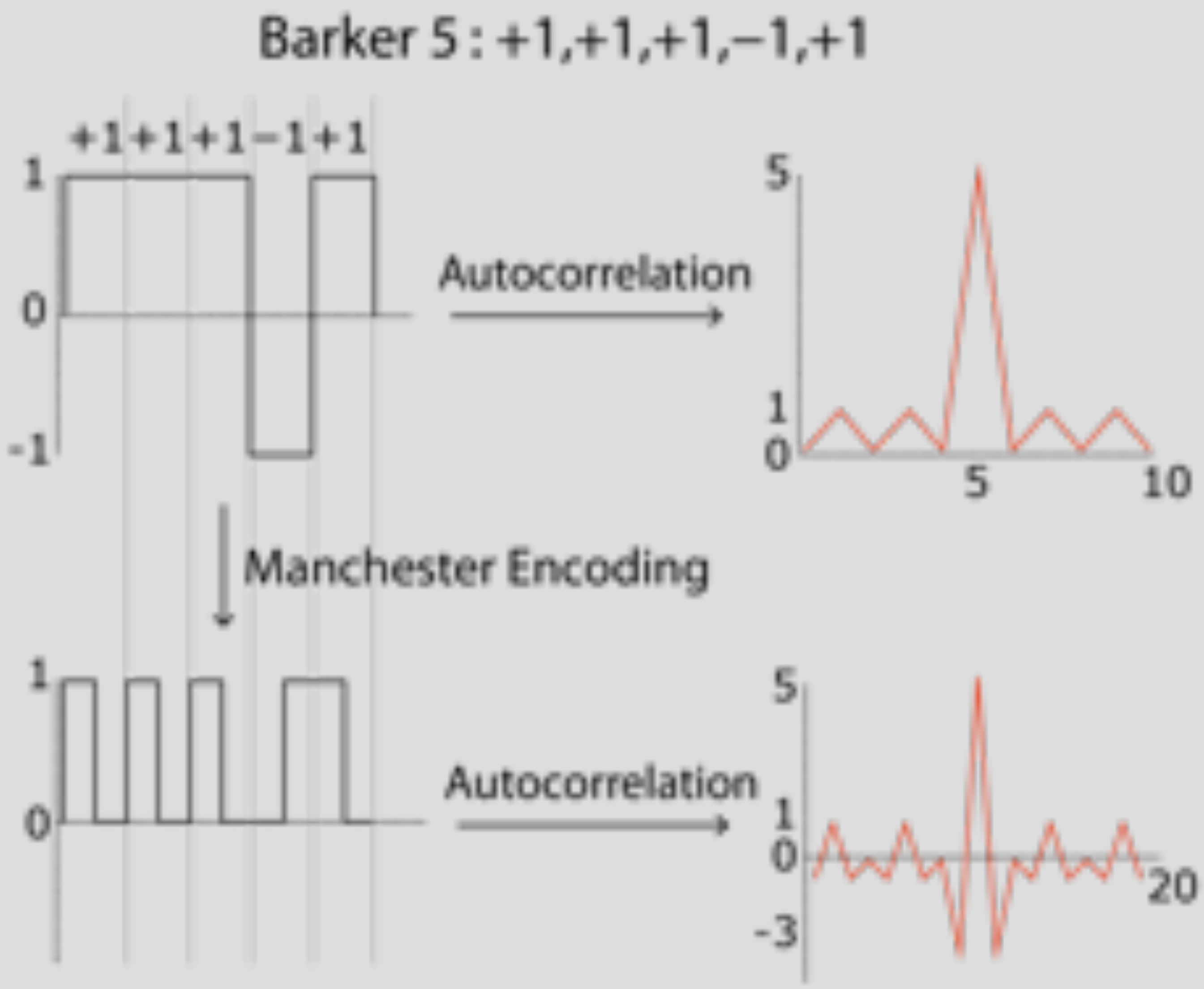
Auto-Correlation of Barker Codes



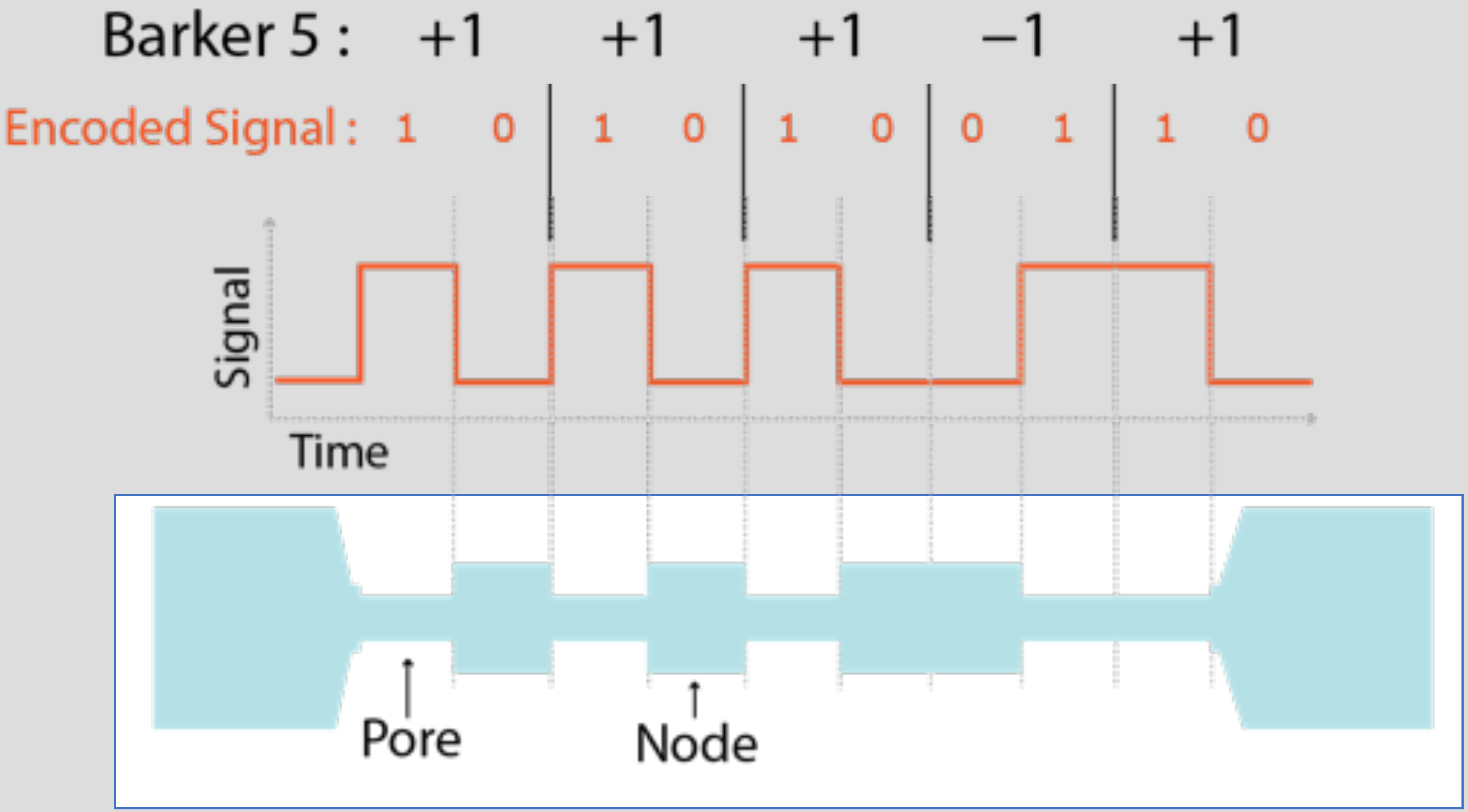
Cross Correlation with Barker Codes



Implementing Barker Codes in NPS



Encoding a Channel

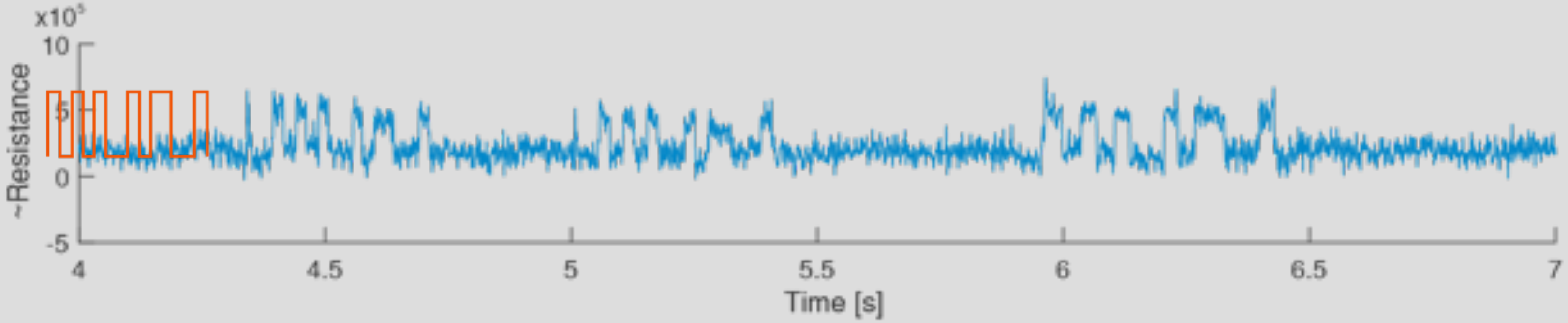


(Kellman et. al IEEE Sens. J 18(8):3068-79)

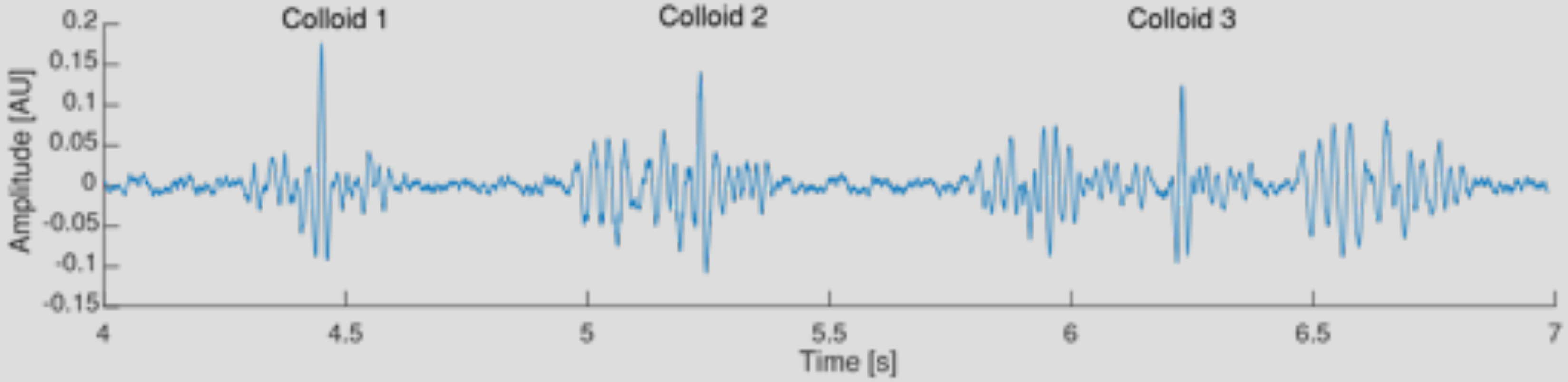
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6034687/

Real Data

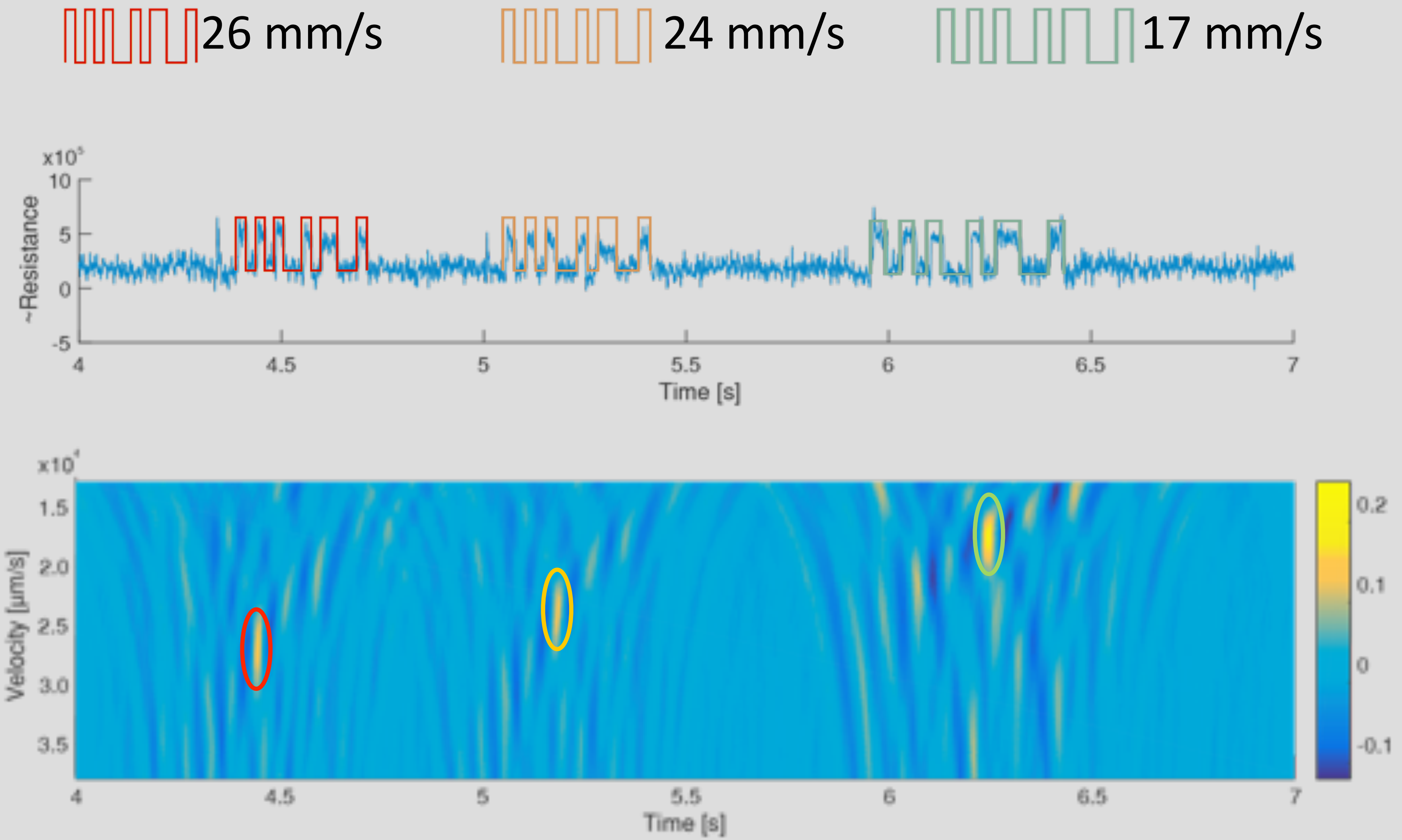
26 mm/s



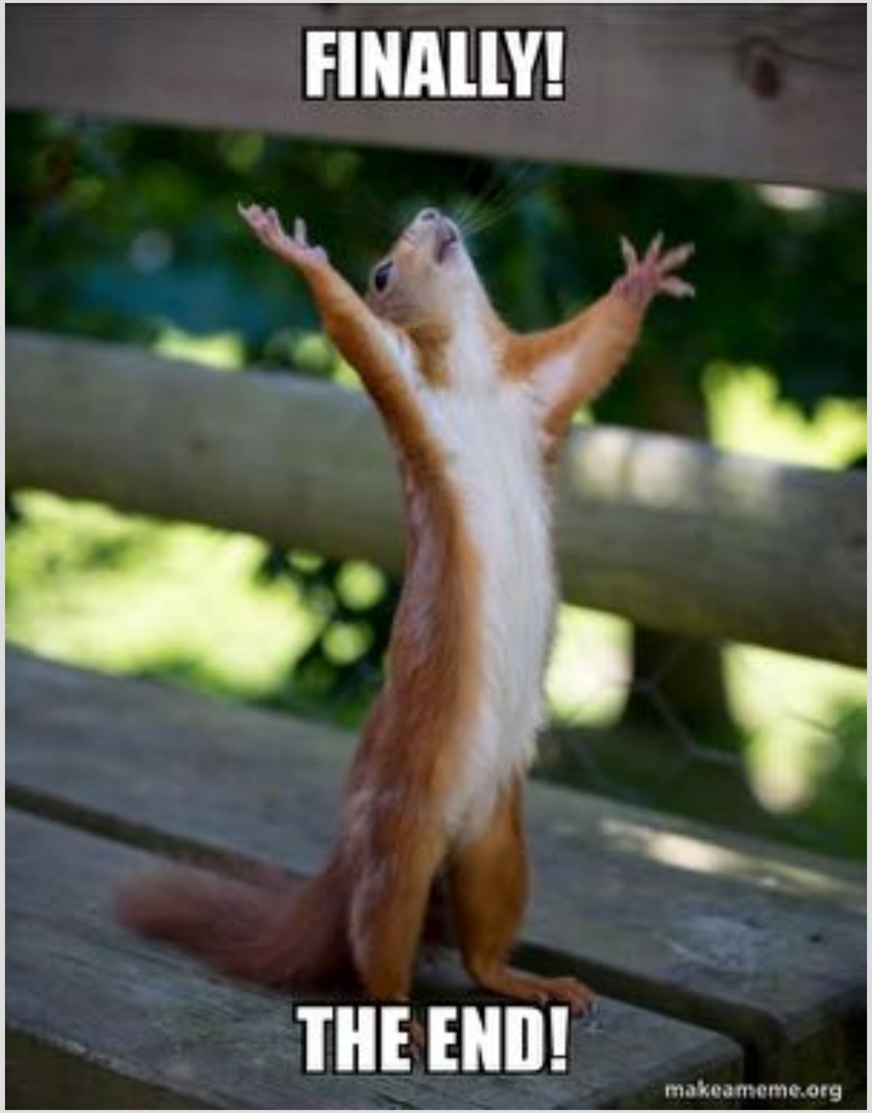
Correlation plot



Speed and Time

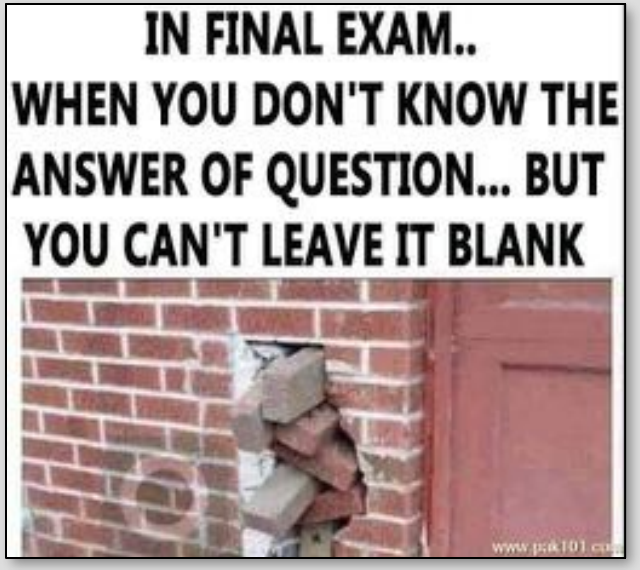


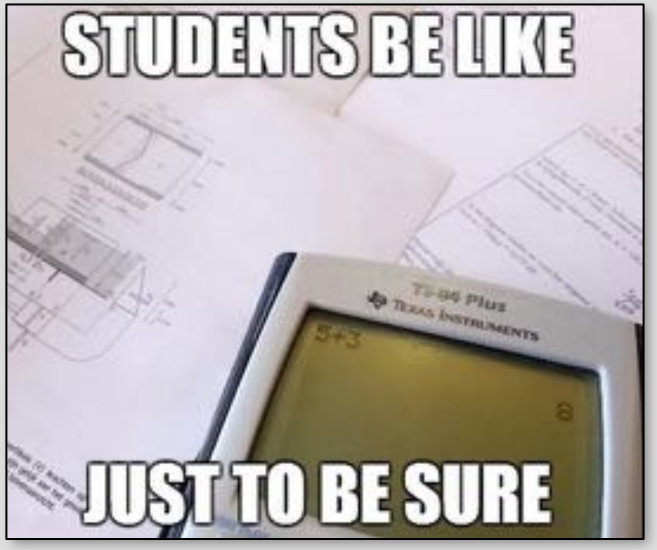

YOU DID IT!!!!

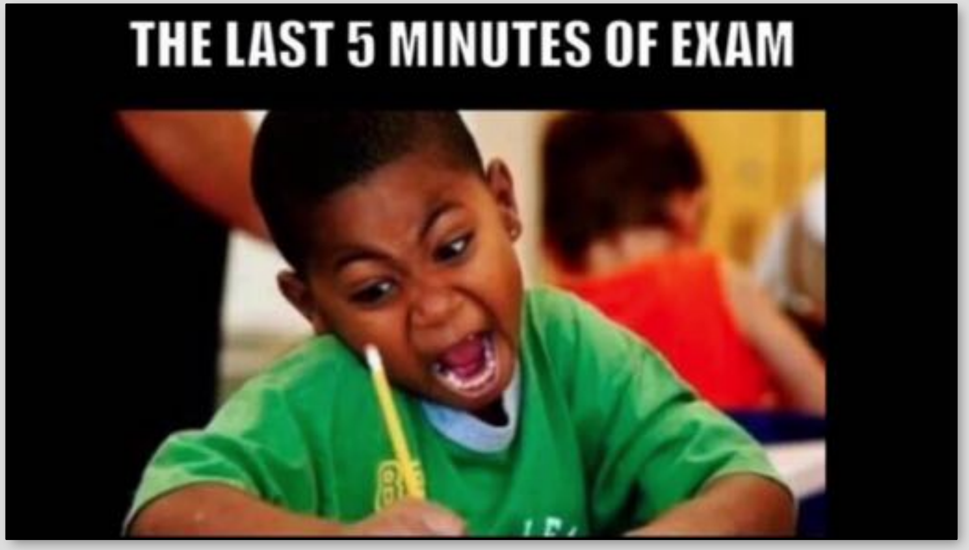


The End

Oh, except for the final exam…







Learning Goals

Stuff We did:

EECS 16A

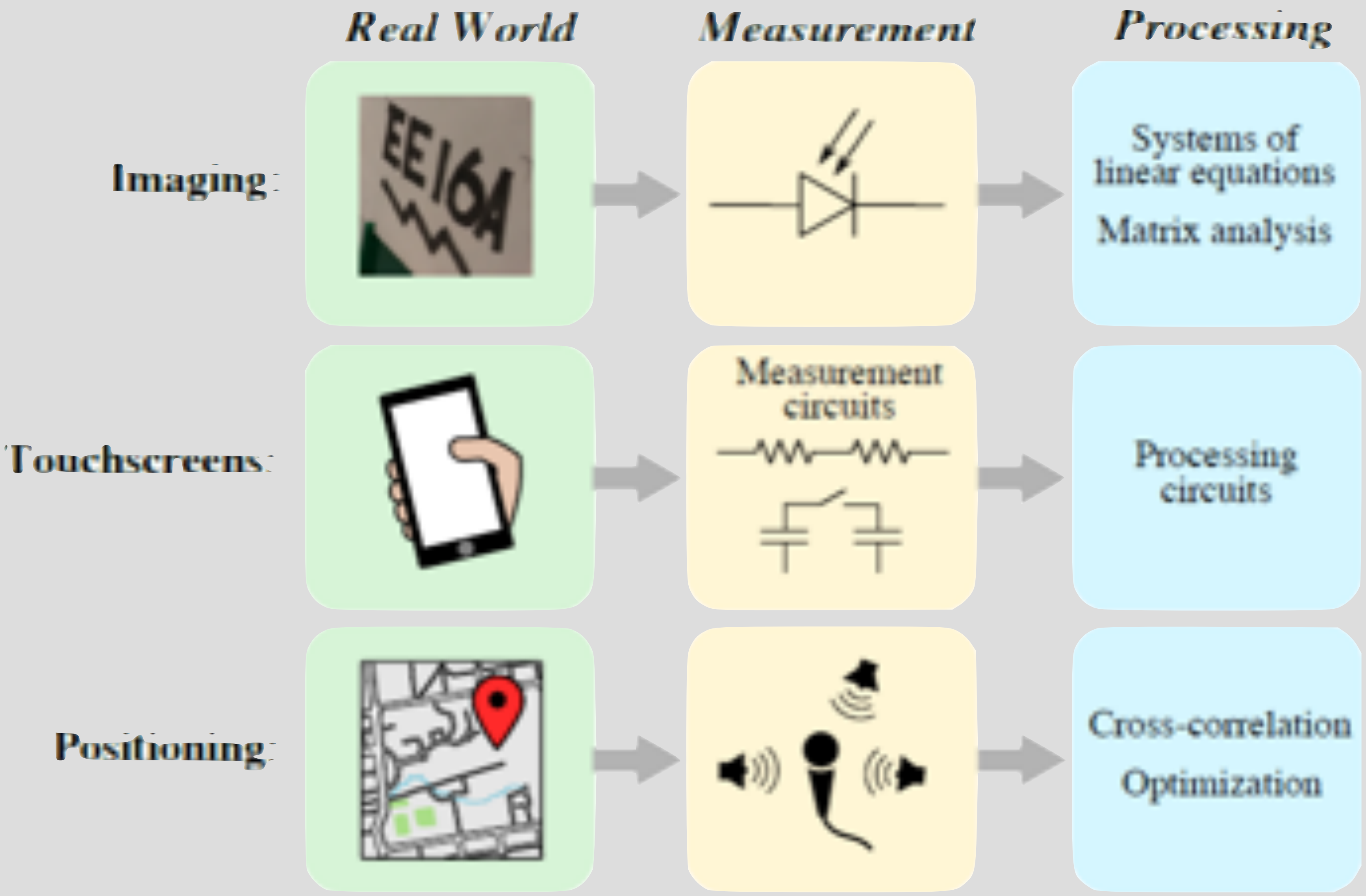
- Module 1: Introduction to systems
    - How do we collect data? build a model?
- Module 2: Introduction to circuits and design
    - How do we use a model to solve a problem
- Module 3: Introduction Signal Processing and Machine Learning
    - How do we “learn” models from data, and make predictions?

Stuff you will do next

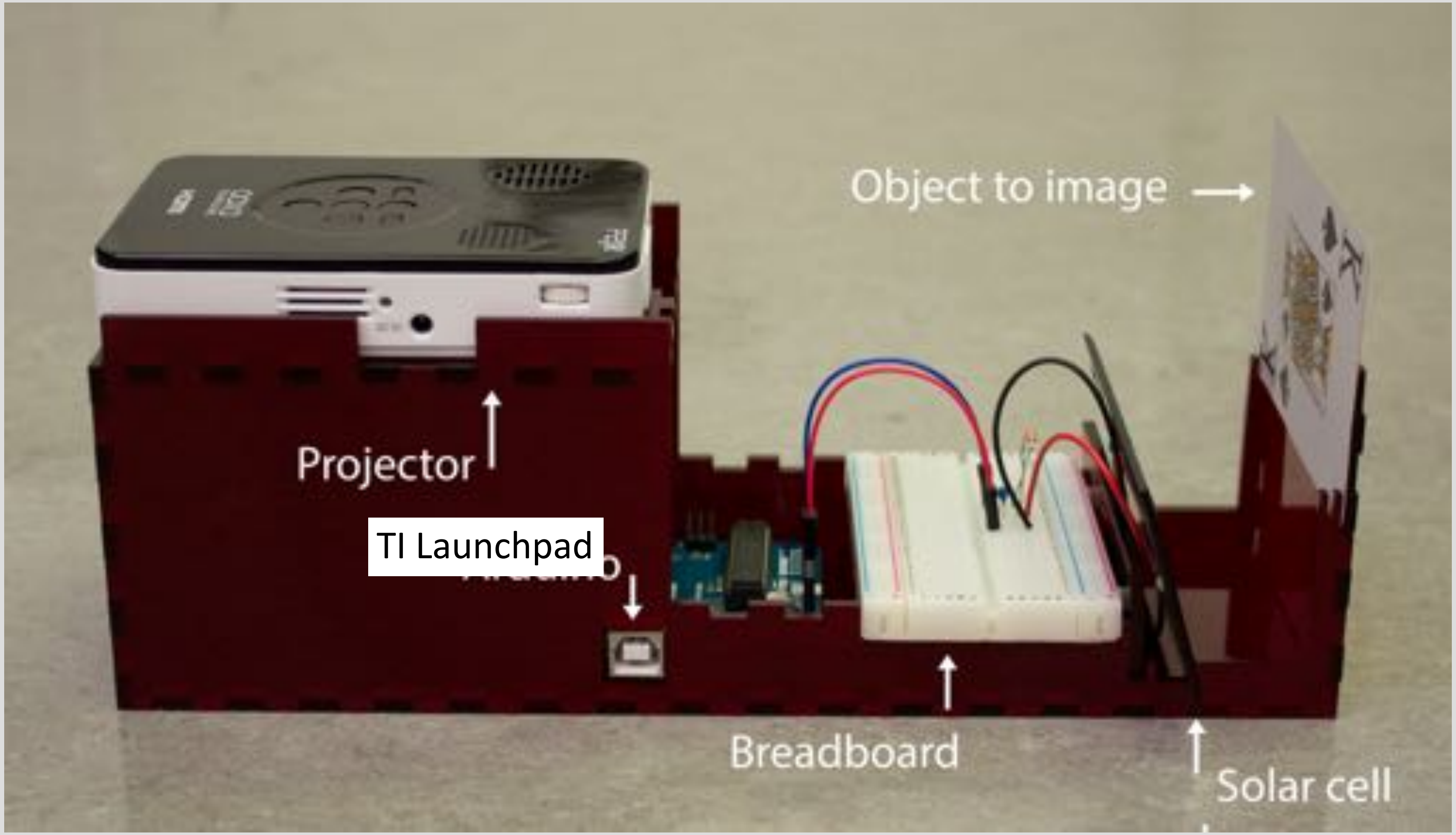
EECS 16B

- Module 4: Advanced circuit design / analysis
- Module 5: Introduction to control and robotics
- Module 6: Introduction to data analysis and signal processing

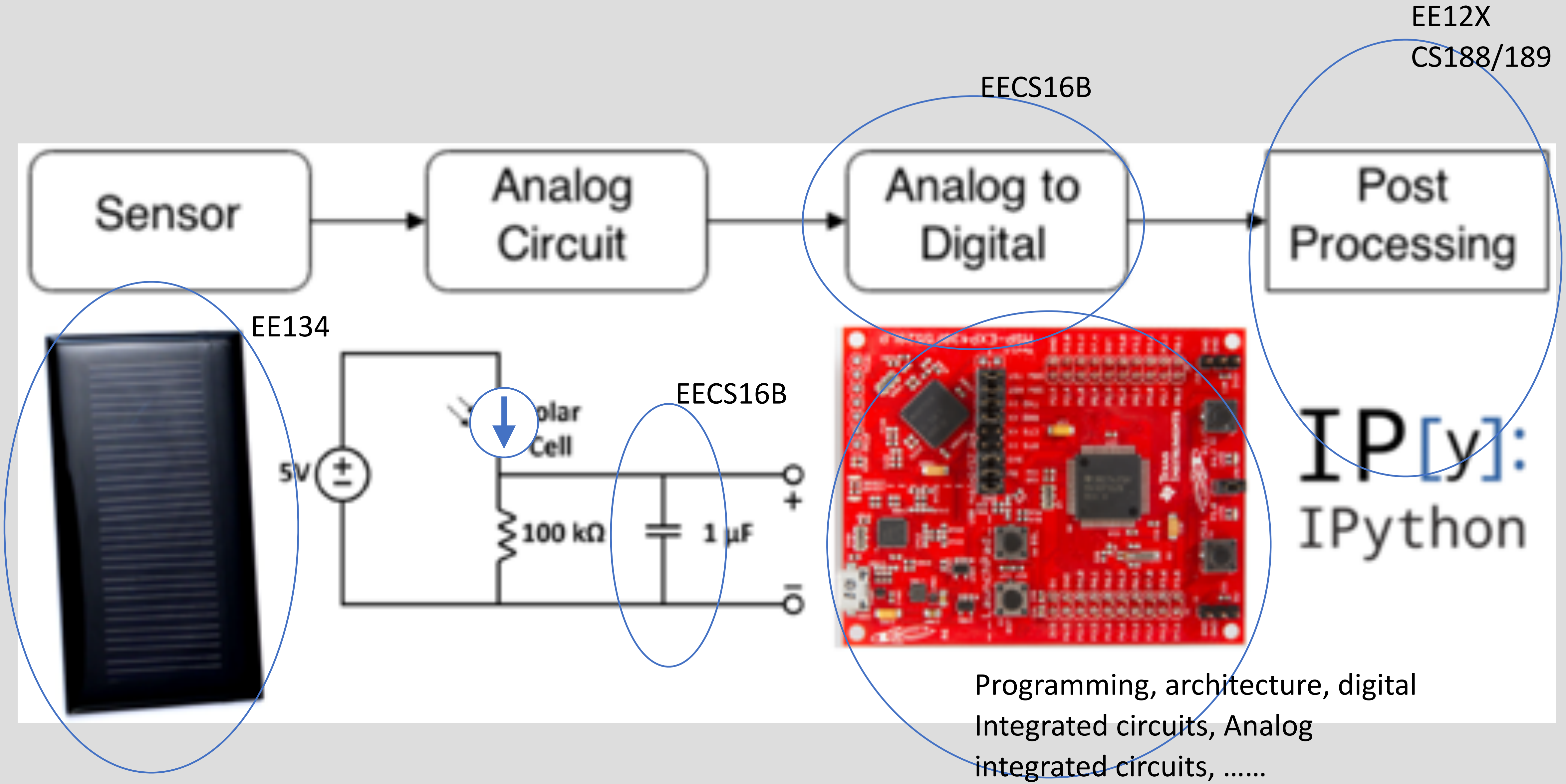
What you built:



Back to Imaging Lab #1

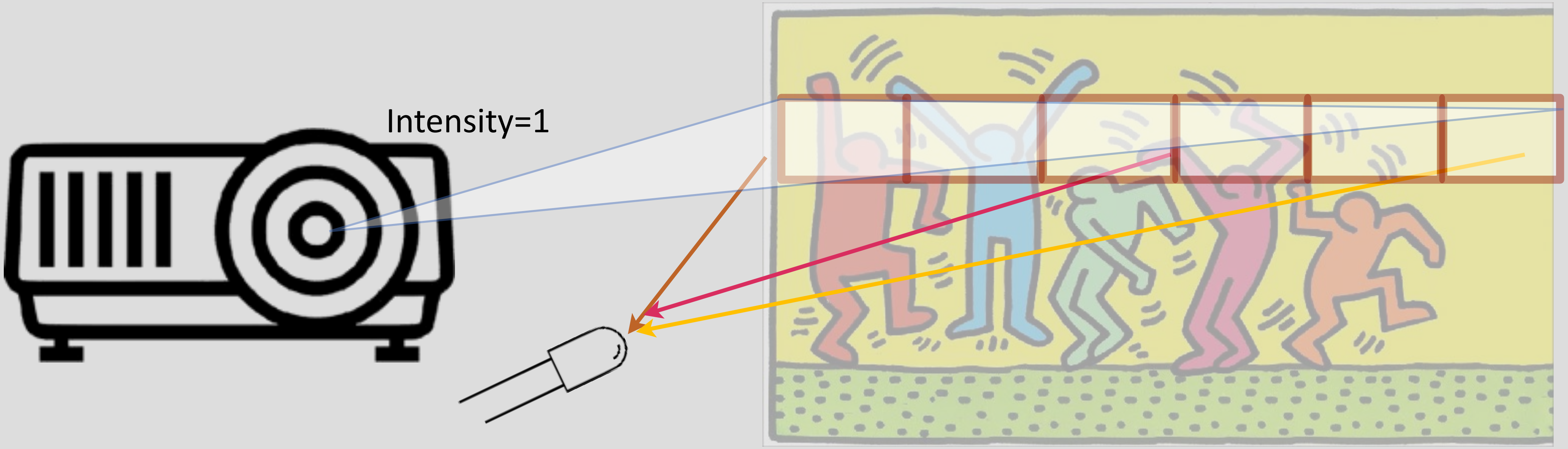


Imaging Lab #1



Non-moving Single Pixel Camera

- Use a projector to illuminate several pixels!
- Sense reflected light with a sensor
- Make many measurements and solve the equations!

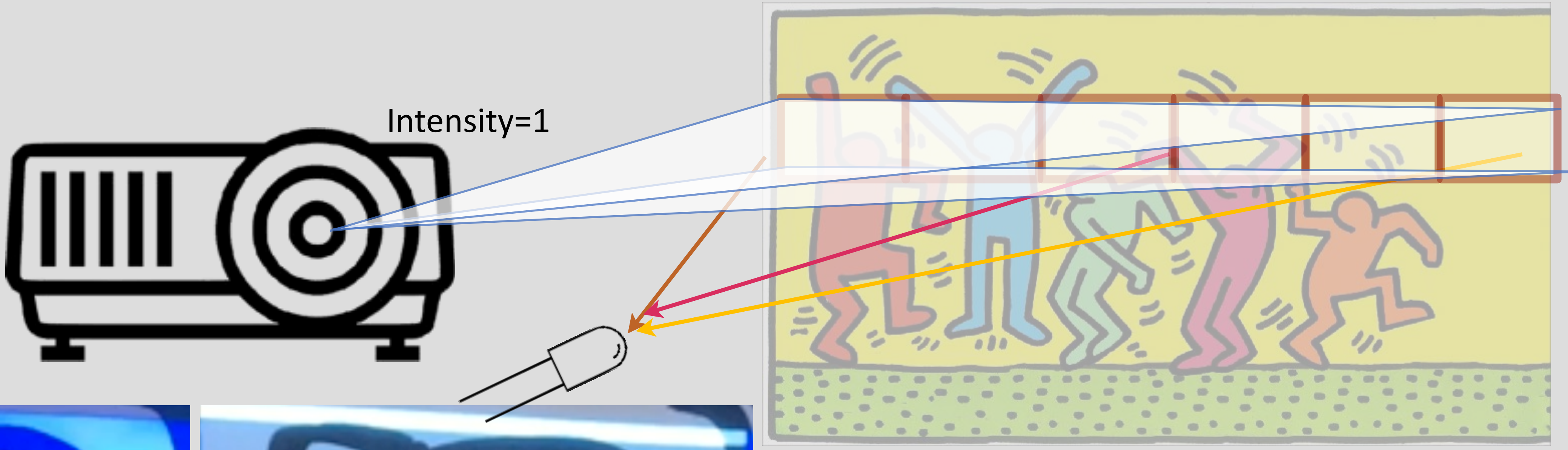


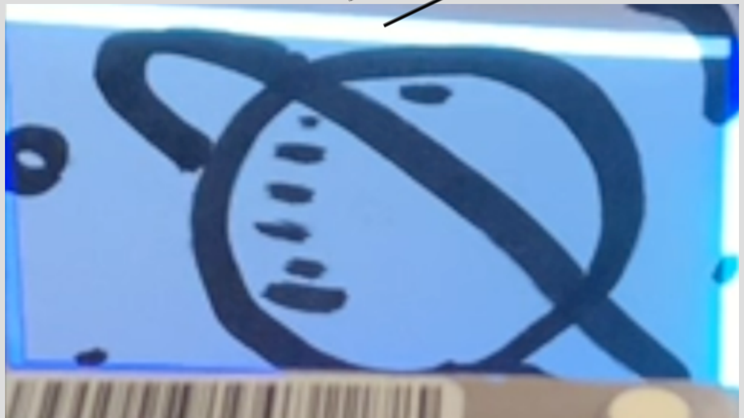
$$y_1 = x_1 + x_2 + x_3 + x_4 + x_5 + x_6$$

Similar math as Tomography!

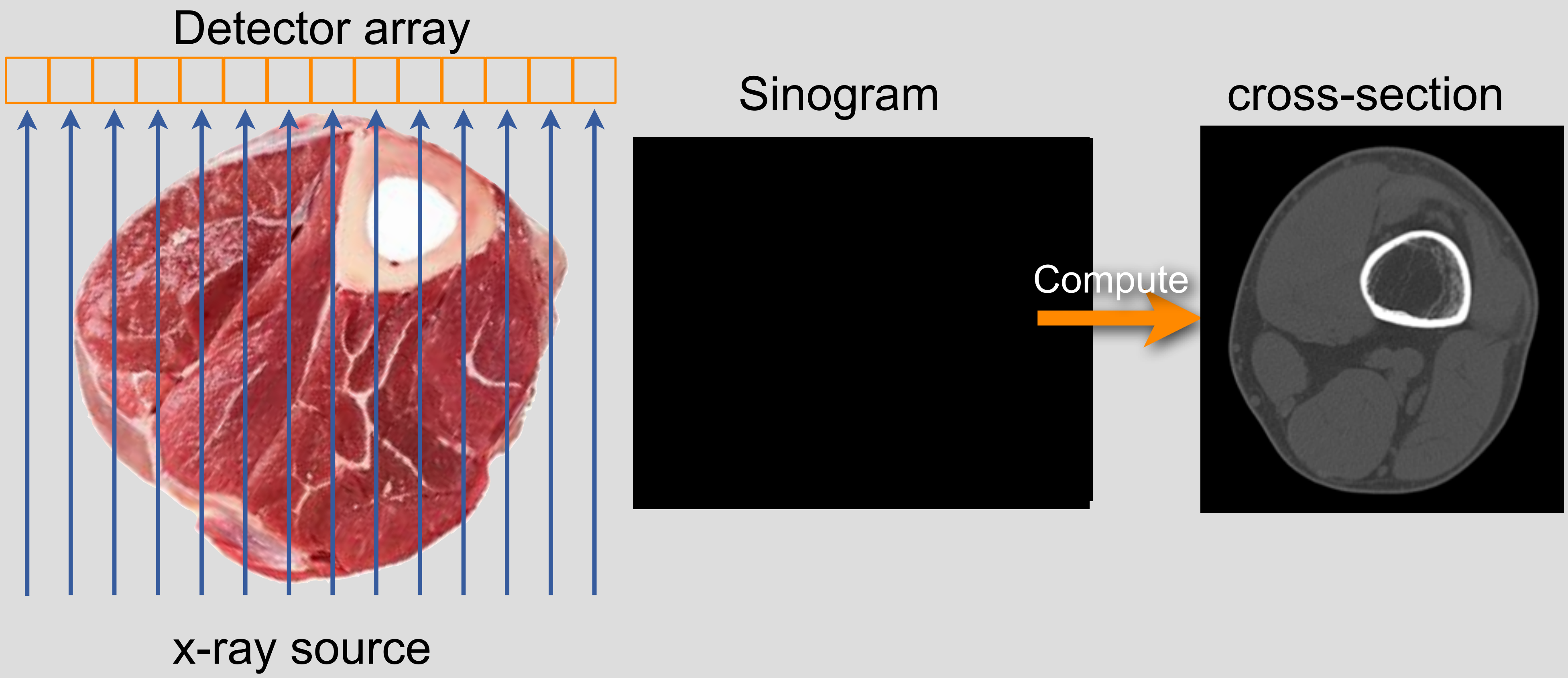
Non-moving Single Pixel Camera

- How many measurements do you need?
- What are the best patterns?





Computed Tomography



Modeled sensing as $\vec{y} = A\vec{x}$, which are inner products!

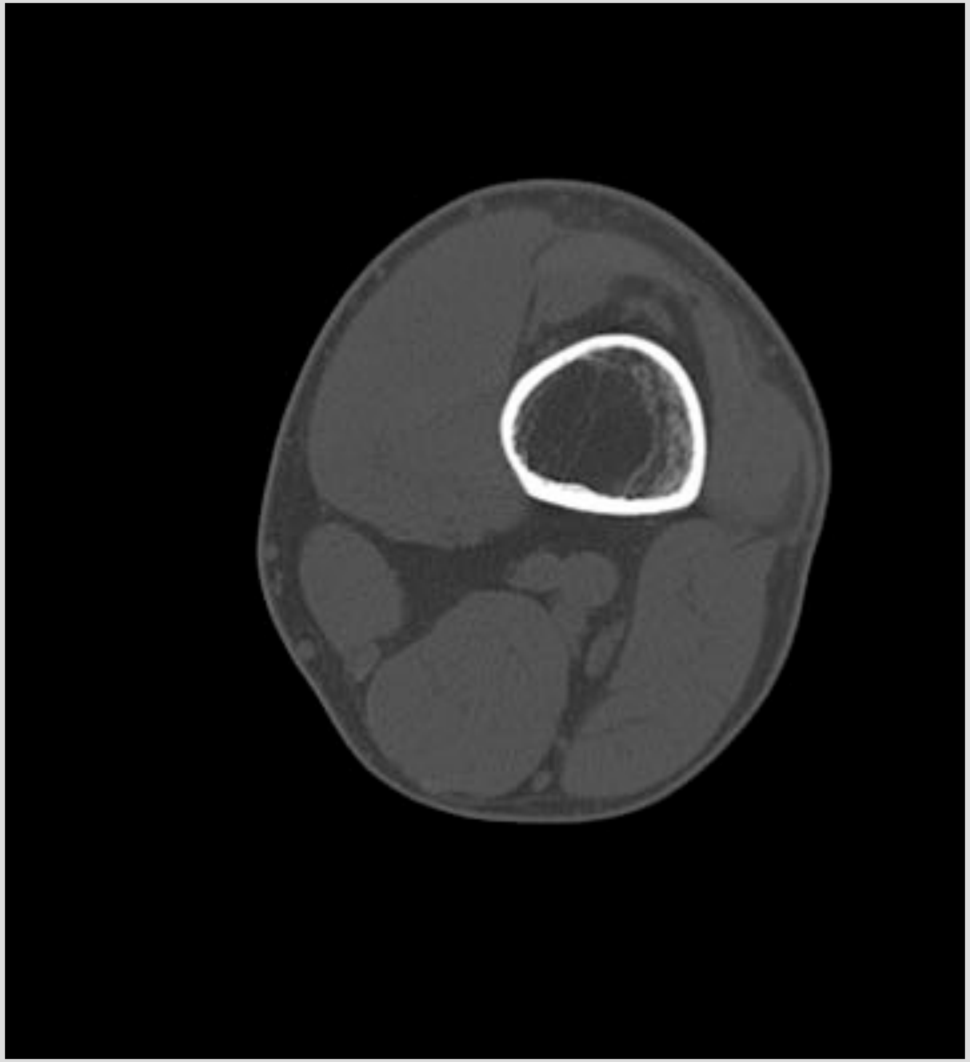
Studied when there is a solution for $\vec{y} = A\vec{x}$, (range, null space, Eigen-values, linear dependence)

Now, know how to solve $\vec{y} = A\vec{x}$, when you have more measurements — that are inconsistent!

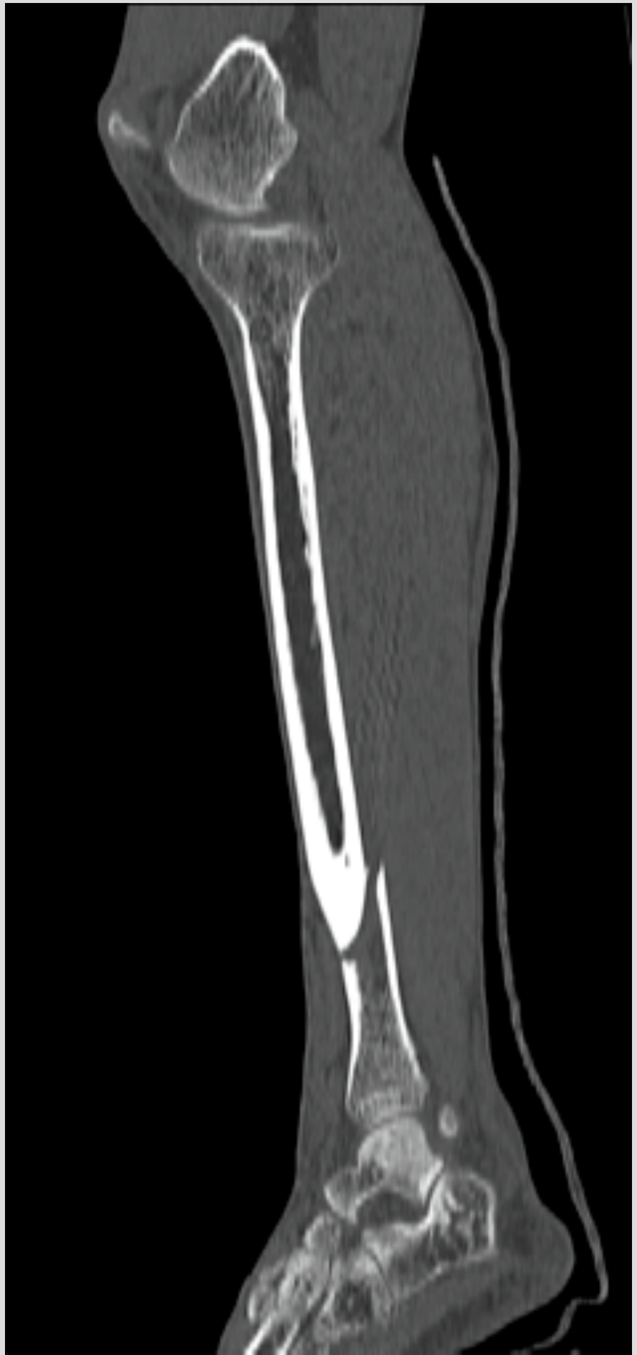
From Projections

Projections

Axial Slices

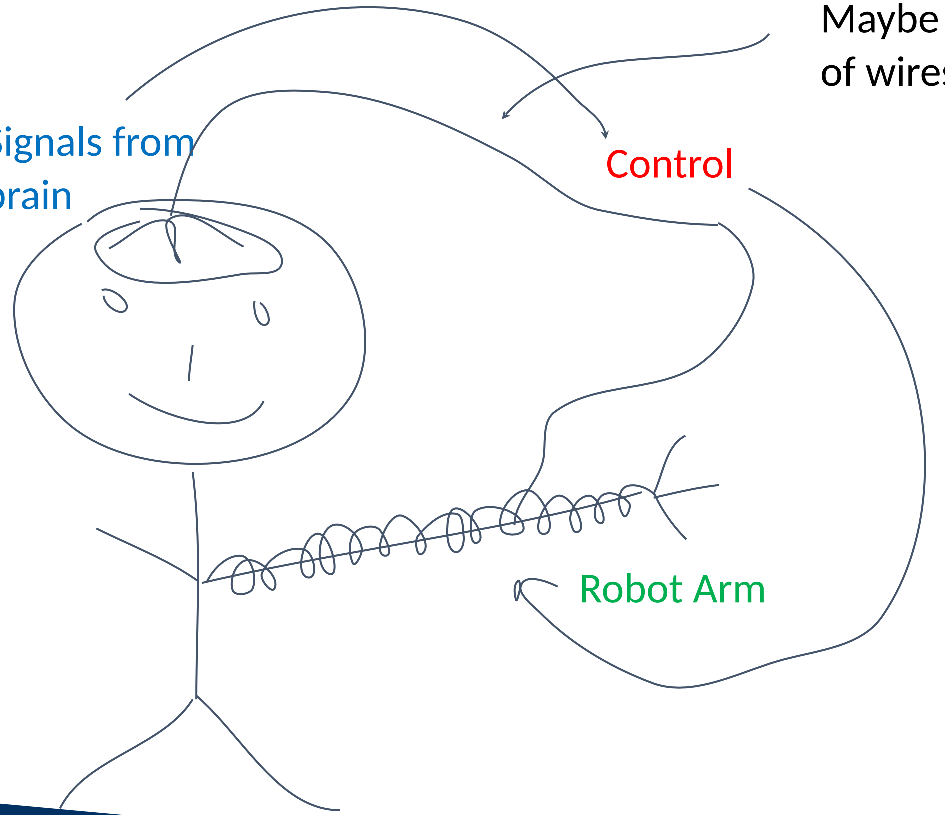


Sagittal Slices



EECS16B: Designing Information Devices and Systems II

Big goal: Get signals from brain and interpret them



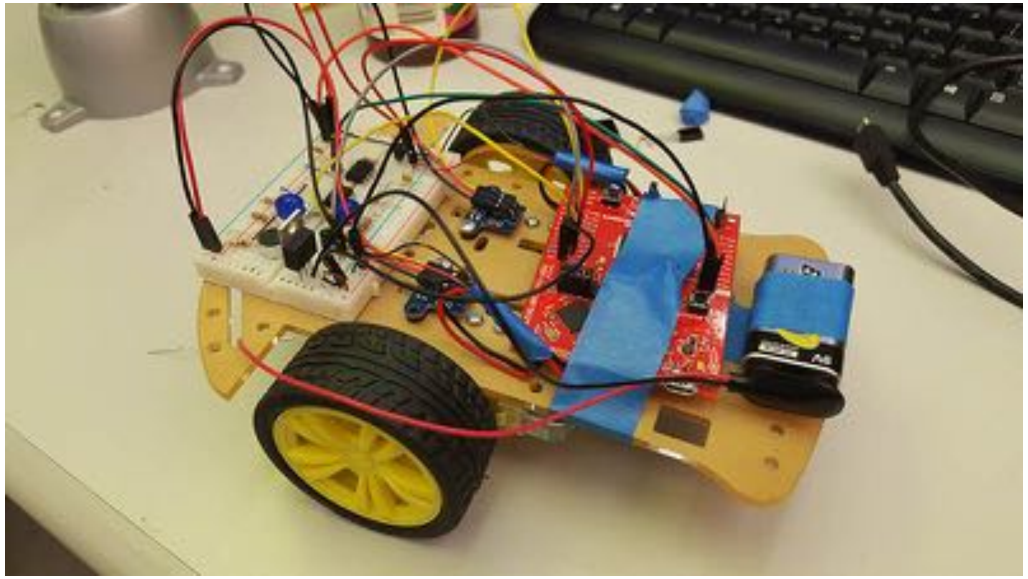
Module 1 – Circuits: Interfaces (brain, voice)

Module 2 – Control: Controls (feedback, stability)

Module 3 - Classification: Figuring out the intention

Voice controlled robo car lab project – from scratch!

OpAmp Filters,
ADCs/DACs,
uController,
SysID,
Feedback,
SVD, PCA



Demo video

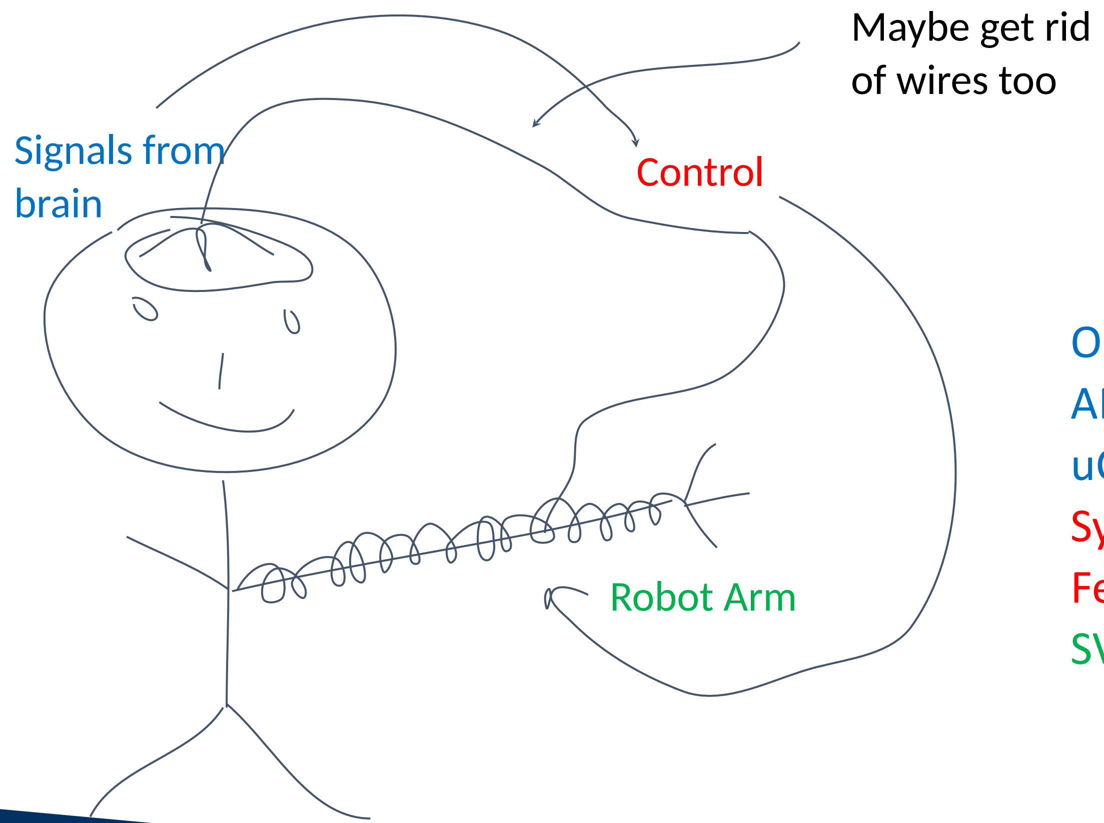
Design Contest
(make our SIXT33N better!)

Berkeley
UNIVERSITY OF CALIFORNIA

Profs. Murat Arcak and Vladimir Stojanović, Spring 2022
fav song “Under Pressure”, Queen

EECS16B: Designing Information Devices and Systems II

Big goal: Get signals from brain and interpret them



Module 1 – Circuits: Interfaces (brain, voice)

Module 2 – Control: Controls (feedback, stability)

Module 3 - Classification: Figuring out the intention

OpAmp Filters,
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uController,
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Feedback,
SVD, PCA

Voice controlled robo car lab project – from scratch!

Demo video

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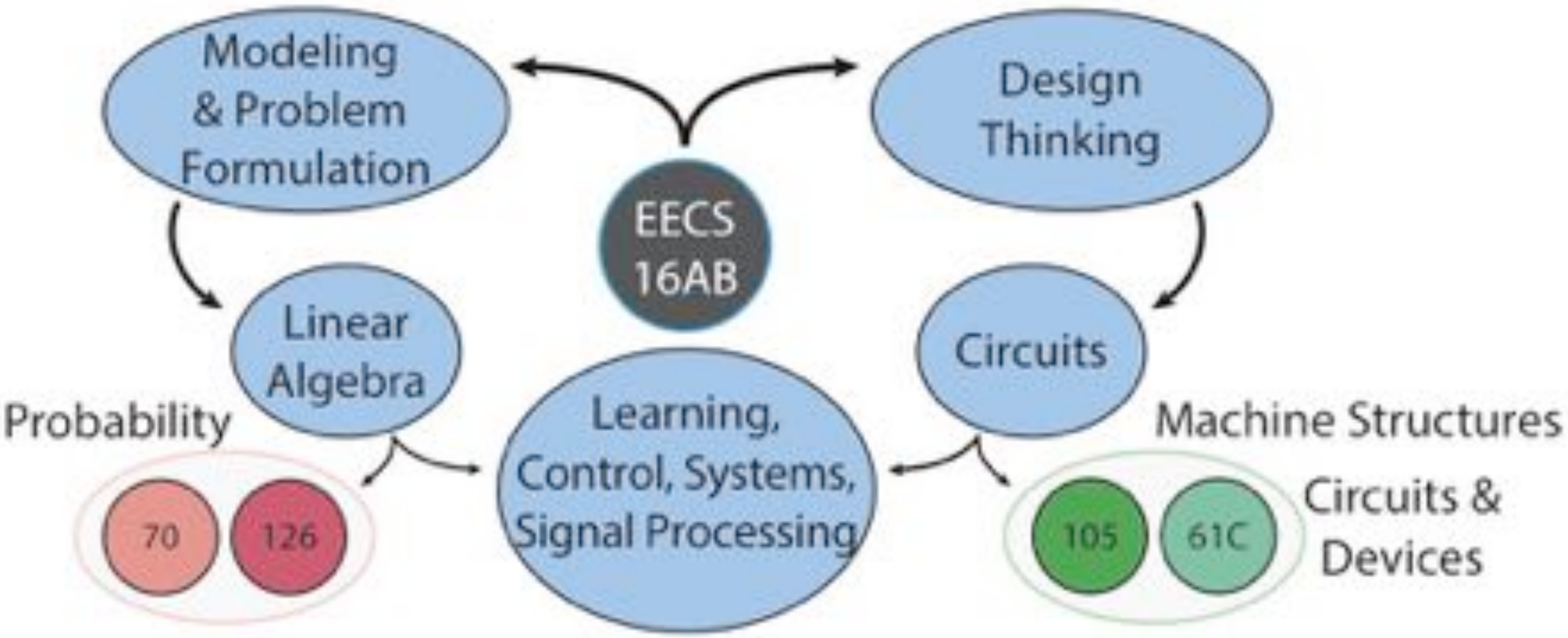
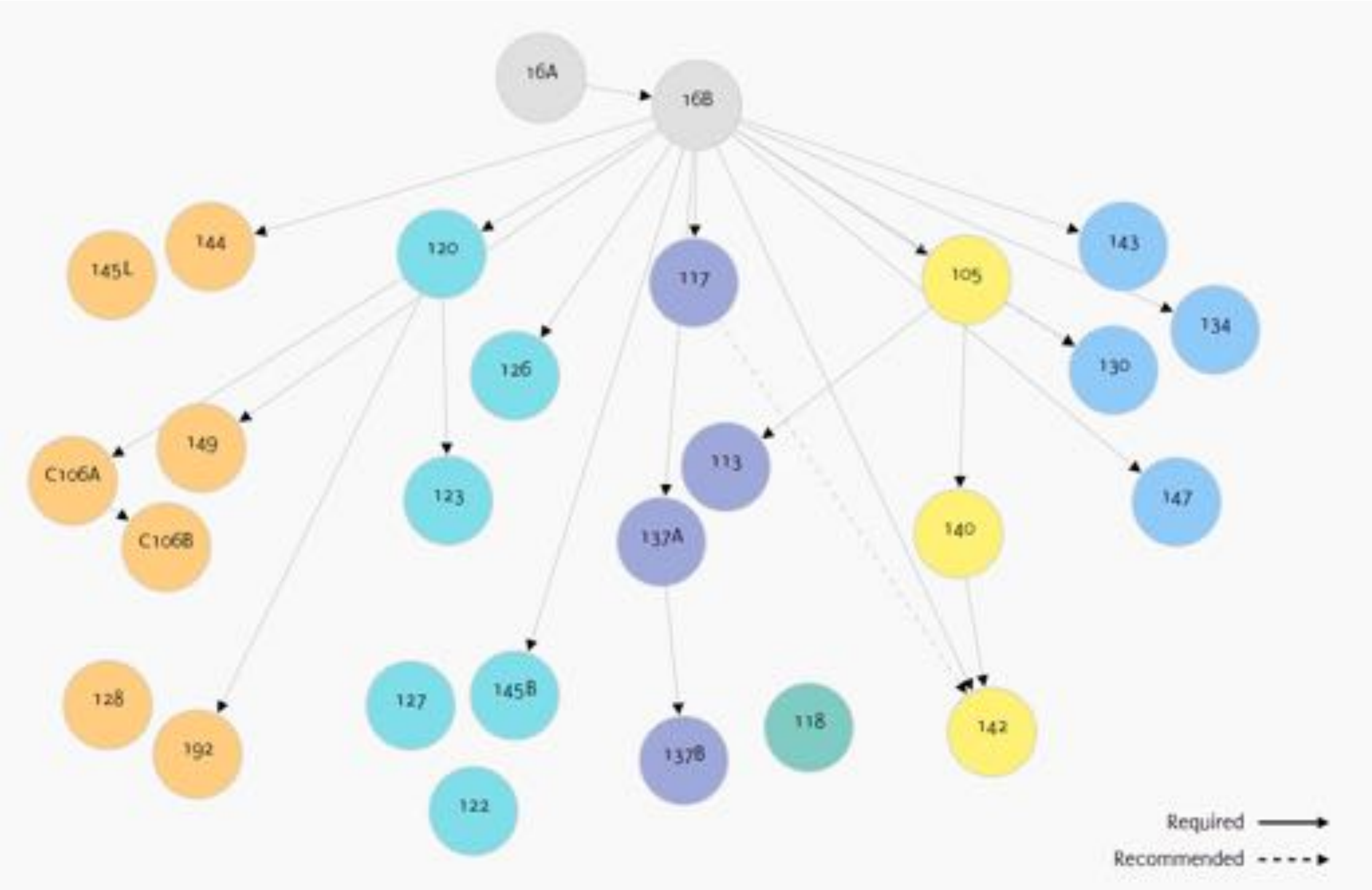


How to approach something unfamiliar
and systematically build understanding

Linear Algebra: conceptual tools to model
Circuits: How to go from model to design, grounded in physical world

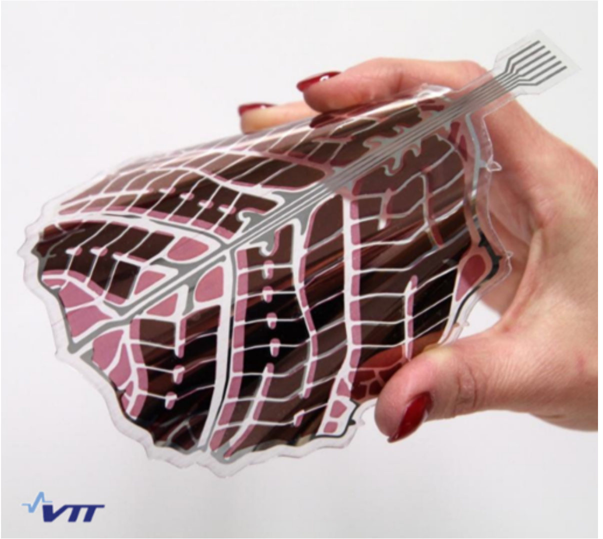
Intro to foundational concepts in Machine Learning

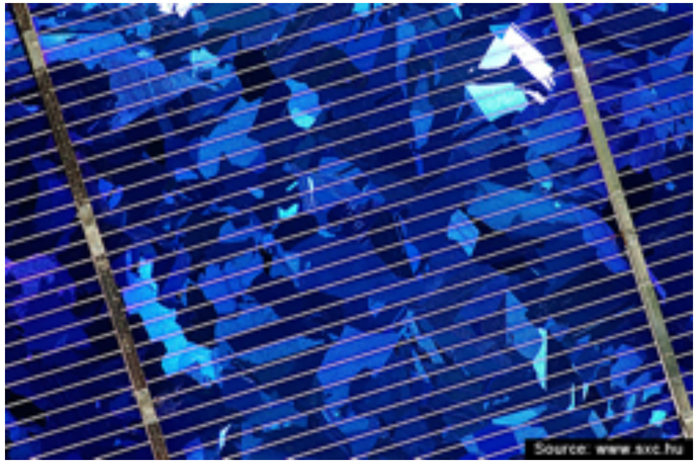
EECS course map



Fundamentals of Photovoltaic Devices
EE134

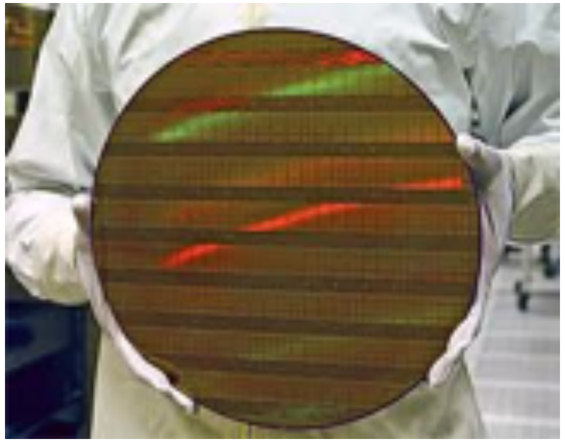
- Introduction to solar energy conversion, applications and technologies – **1 week**
- Fundamentals of Solar Radiation – **2 weeks**
- Electrons and holes in Semiconductors – **1 week**
- Charge generation and recombination – **1 week**
- Junctions – **1 week**
- Monocrystalline Solar Cells – **2 weeks**
- Thin Film Solar Cells – **2 weeks**
- Managing light – **1 week**
- Strategies for High Efficiency– **2 weeks**
- Economic Considerations – **1 week**





Microfabrication Technology
EE143

- IC and MEMs fabrication principles
- Hands on experience on fabrication and characterization of micro-structures
- Clean room experience

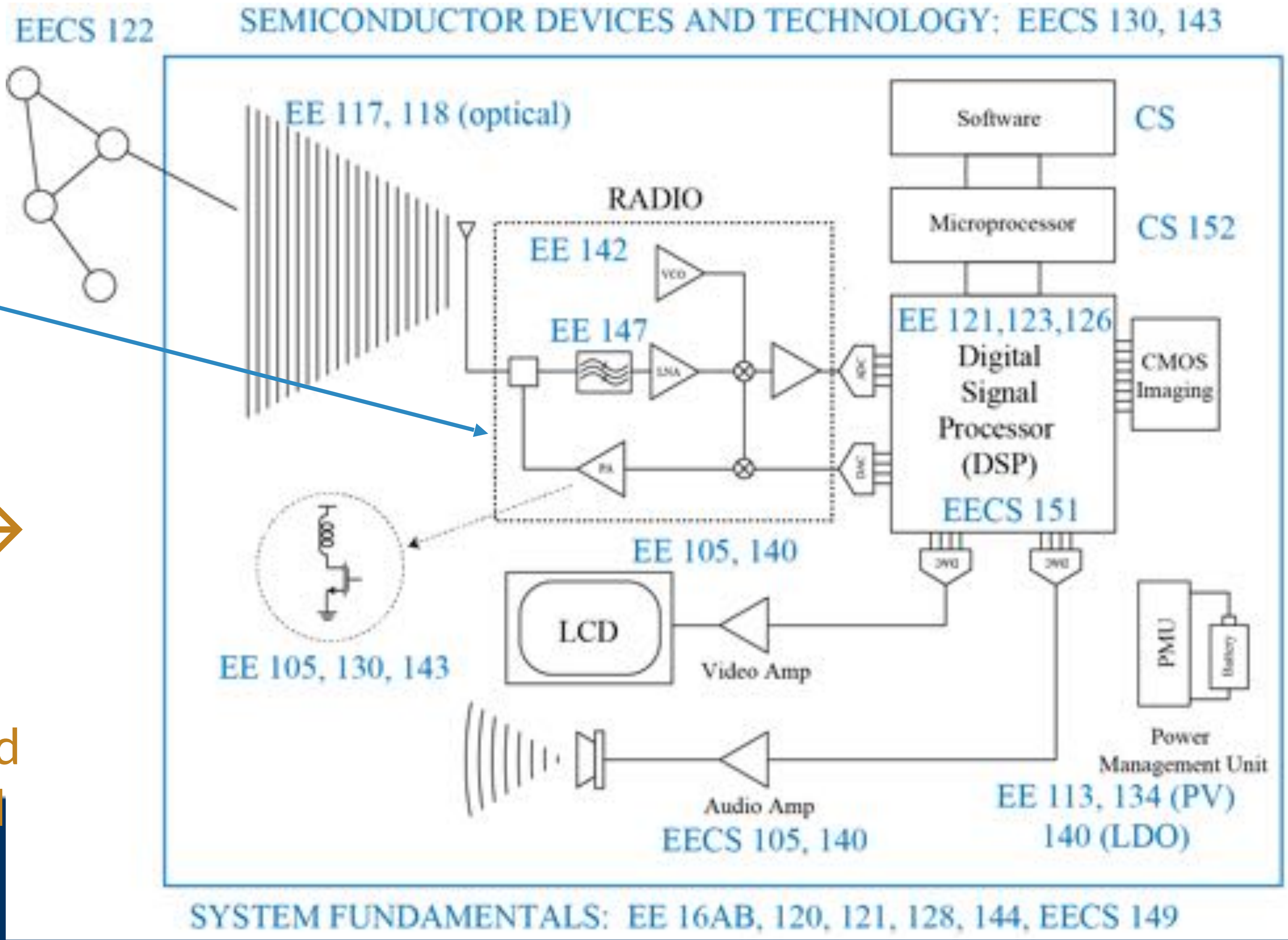


- Introduction to Materials and Processing (1-2 weeks)
- Photolithography (1 week)
- Etching (1 week)
- Oxidation (1 week)
- Deposition (1 week)
- Diffusion (1 week)
- Ion Implantation (1 week)
- Metallization/CMP (1 week)
- Simulation/Layout (1 week)
- Process Integration (1 week)
- Introduction to Devices and other patterning techniques (2 weeks)
- Nanolithography and Nanofabrication (1 week)

EE142 in the grand scheme of things:

EE142: 16AB→ 105 → 140* → 142**

* 140 recommended
** 120 is also useful



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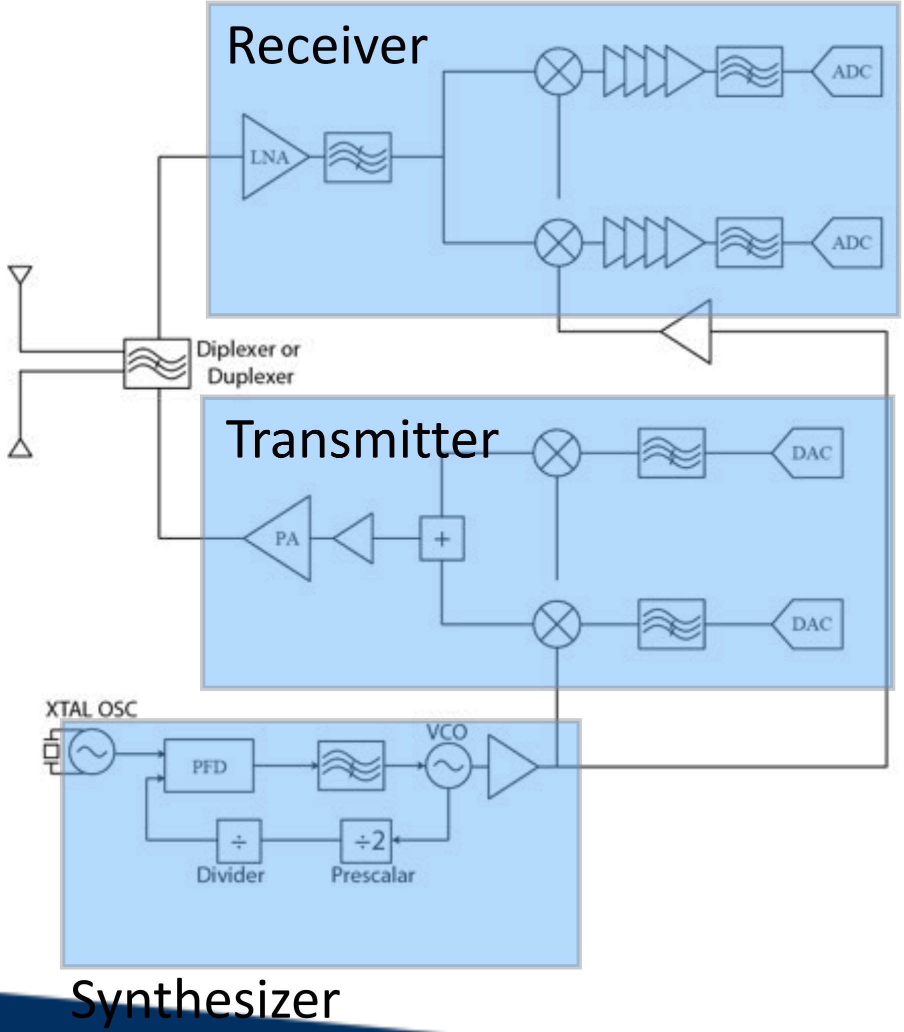
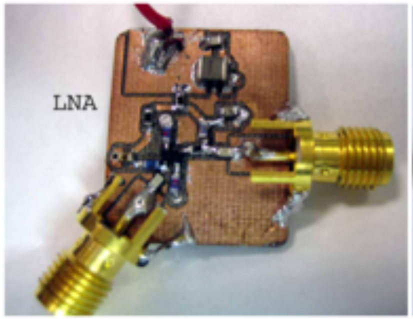
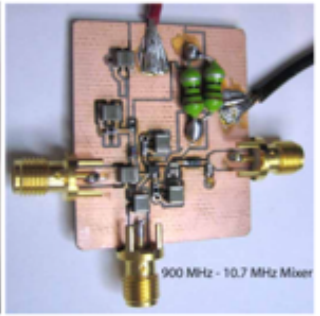
Systems:

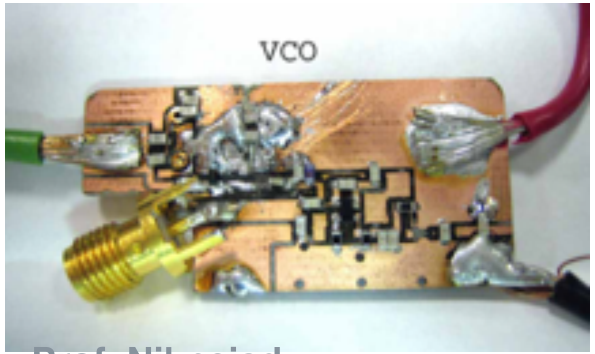
Course Content:



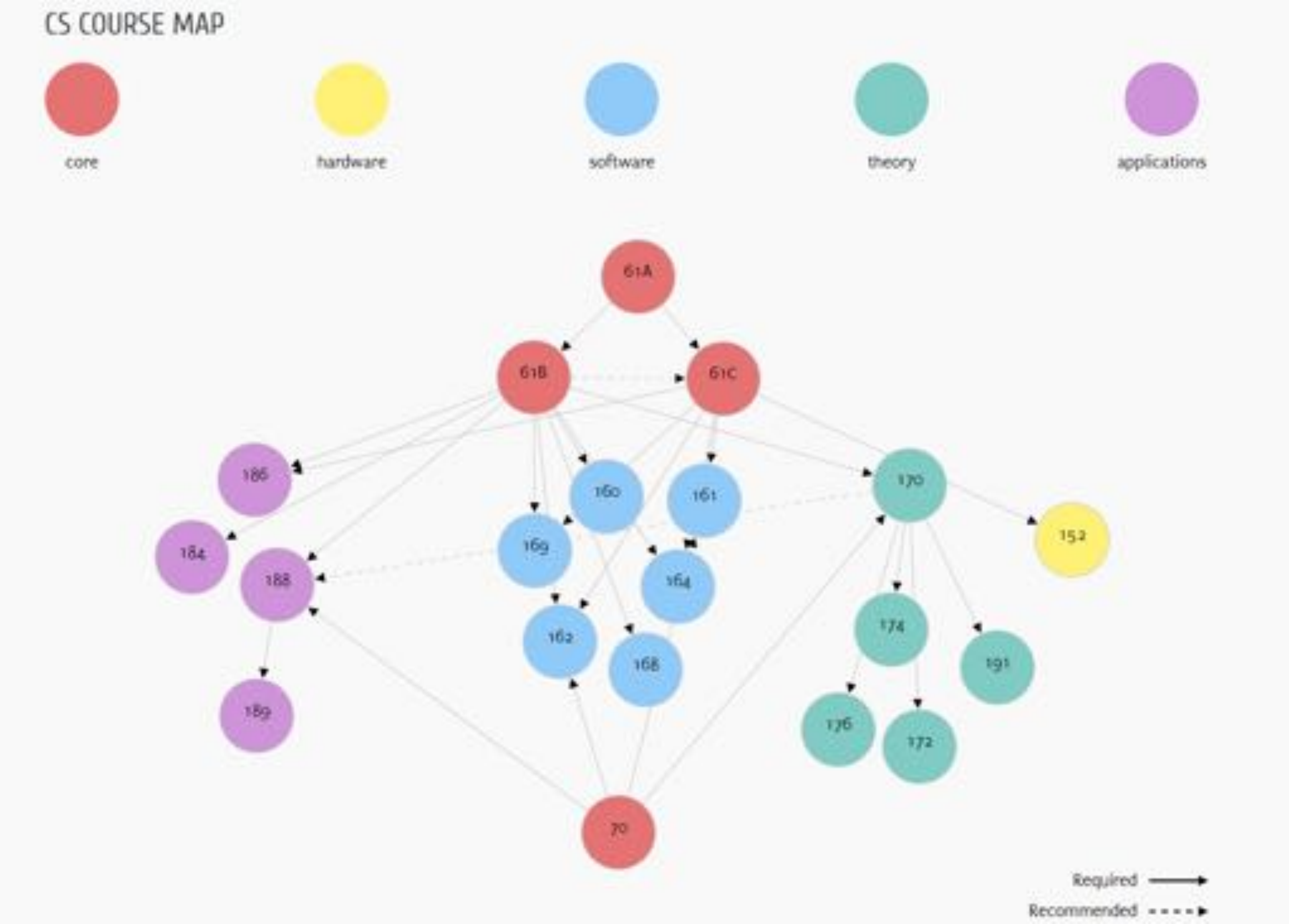
Results:



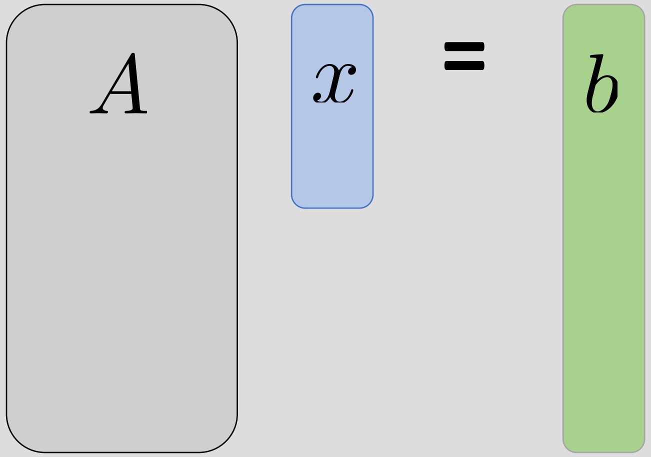


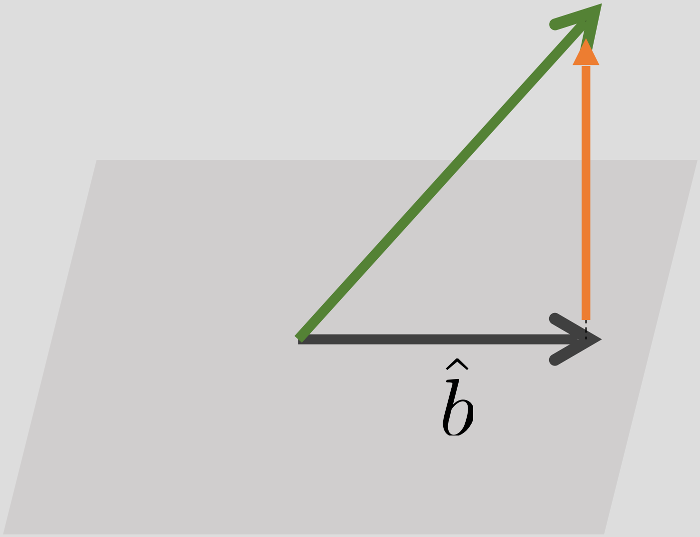


Prof. Niknejad
Offered: Spring semester
In-person lab ! Hands on training with RF test and measurement equipment.


CS COURSE MAP
core
hardware
software
theory
applications
61A
61B
61C
186
184
188
189
160
161
169
164
162
168
170
152
174
191
176
172
70
Required
Recommended

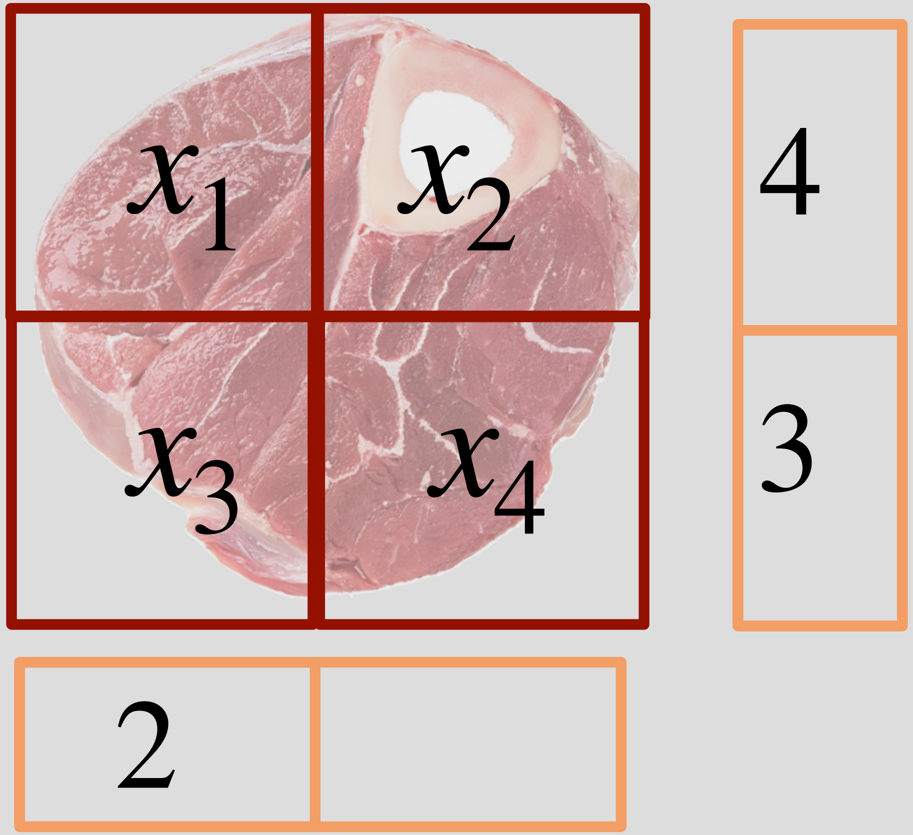
*<u>Over</u>*determined system: use least squares





- the least-squares solution “minimally perturbs” b

Back to Tomography

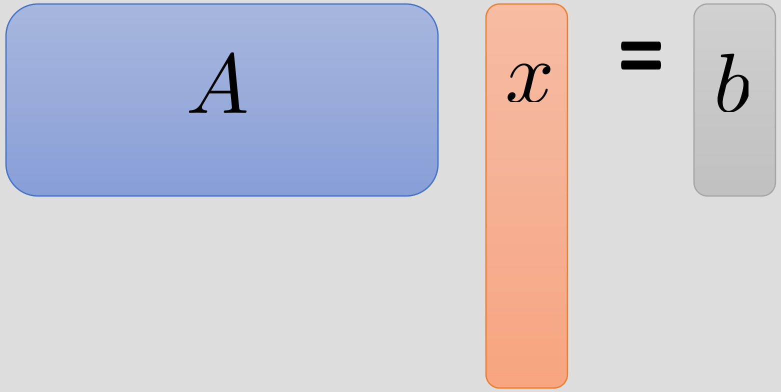


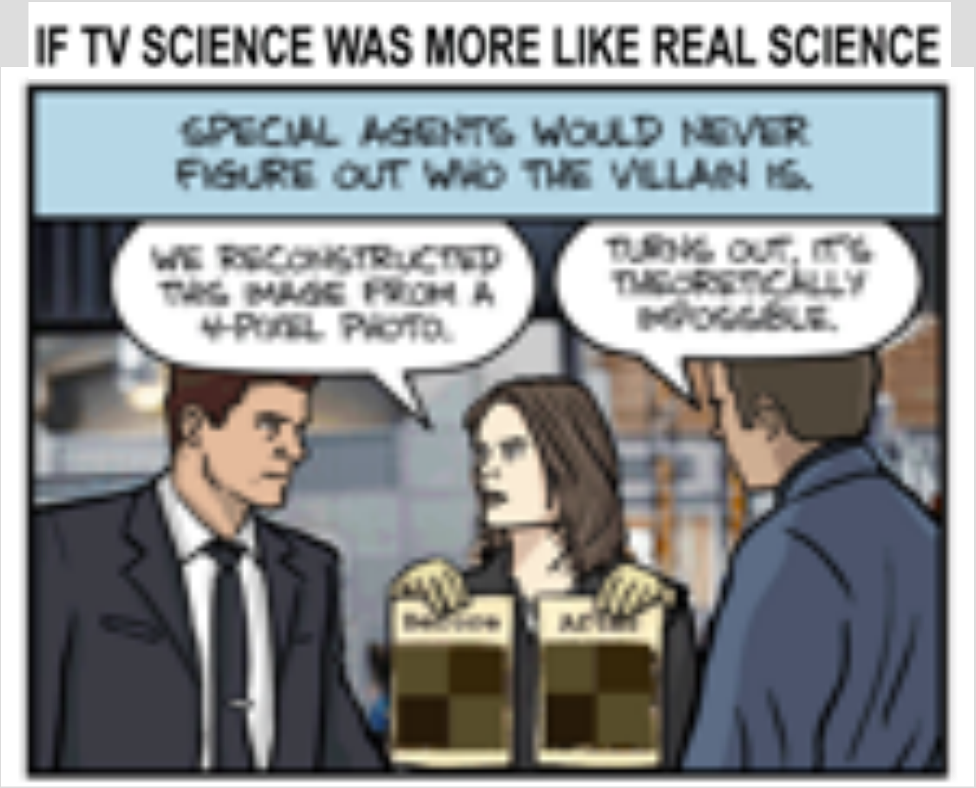
$$1 \cdot x_1 + 1 \cdot x_2 + 0 \cdot x_3 + 0 \cdot x_4 = 4$$
$$0 \cdot x_1 + 0 \cdot x_2 + 1 \cdot x_3 + 1 \cdot x_4 = 3$$
$$1 \cdot x_1 + 0 \cdot x_2 + 1 \cdot x_3 + 0 \cdot x_4 = 2$$

$$\left[\begin{array}{cccc|c} 1 & 1 & 0 & 0 & 4 \\ 0 & 0 & 1 & 1 & 3 \\ 1 & 0 & 1 & 0 & 2 \\ & & & & \\ & & & & \end{array}\right]$$

How do we solve it?

*Under*determined system: ????





Computational MRI

Joint optimization:

- Data Acquisition
- Image reconstruction
  - System/data modeling
  - Algorithms
  - Computation

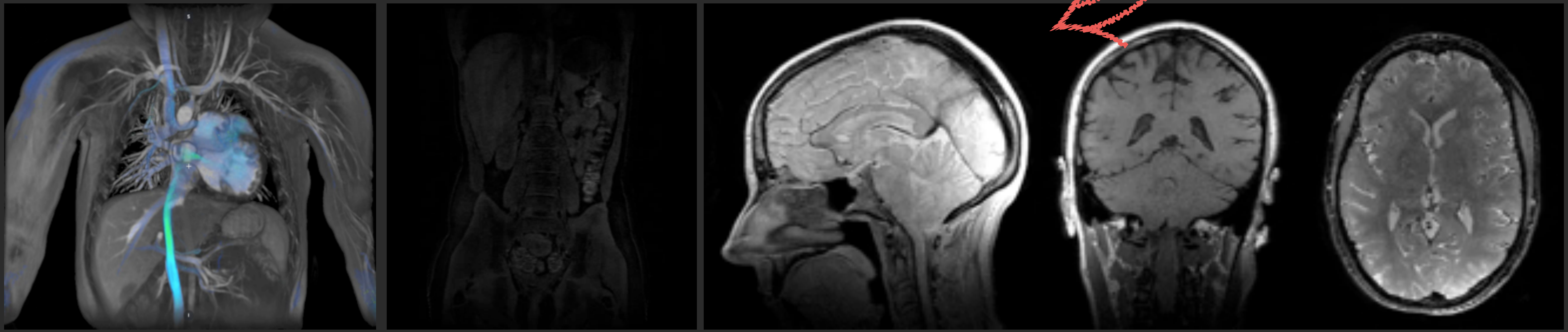


Image Compression

Natural signals/images are compressible

- Standard approach: First collect, then compress

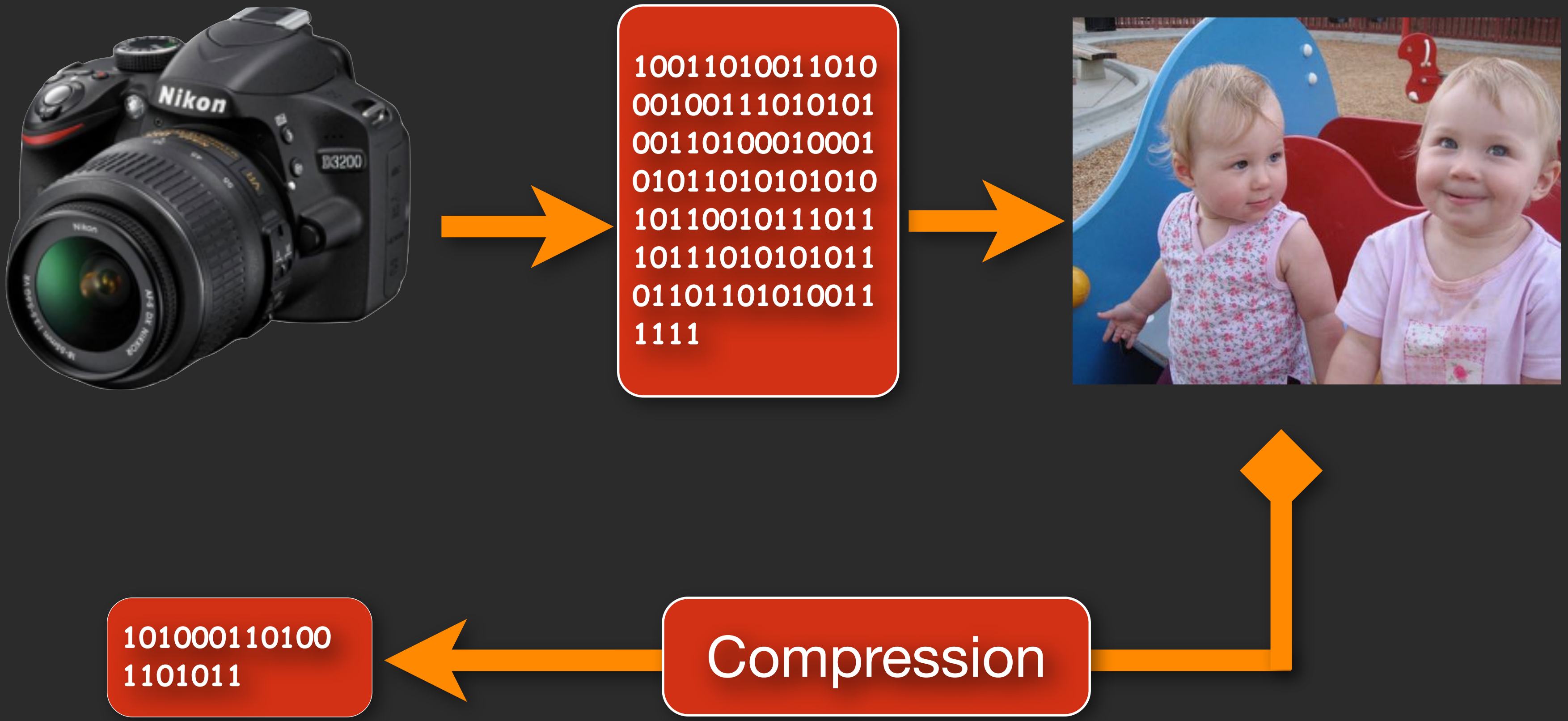


Image compression

- Non compressed:
  - 3024 x 4032 x 3 colors = 36 Mb
- Compressed = 2 Mb

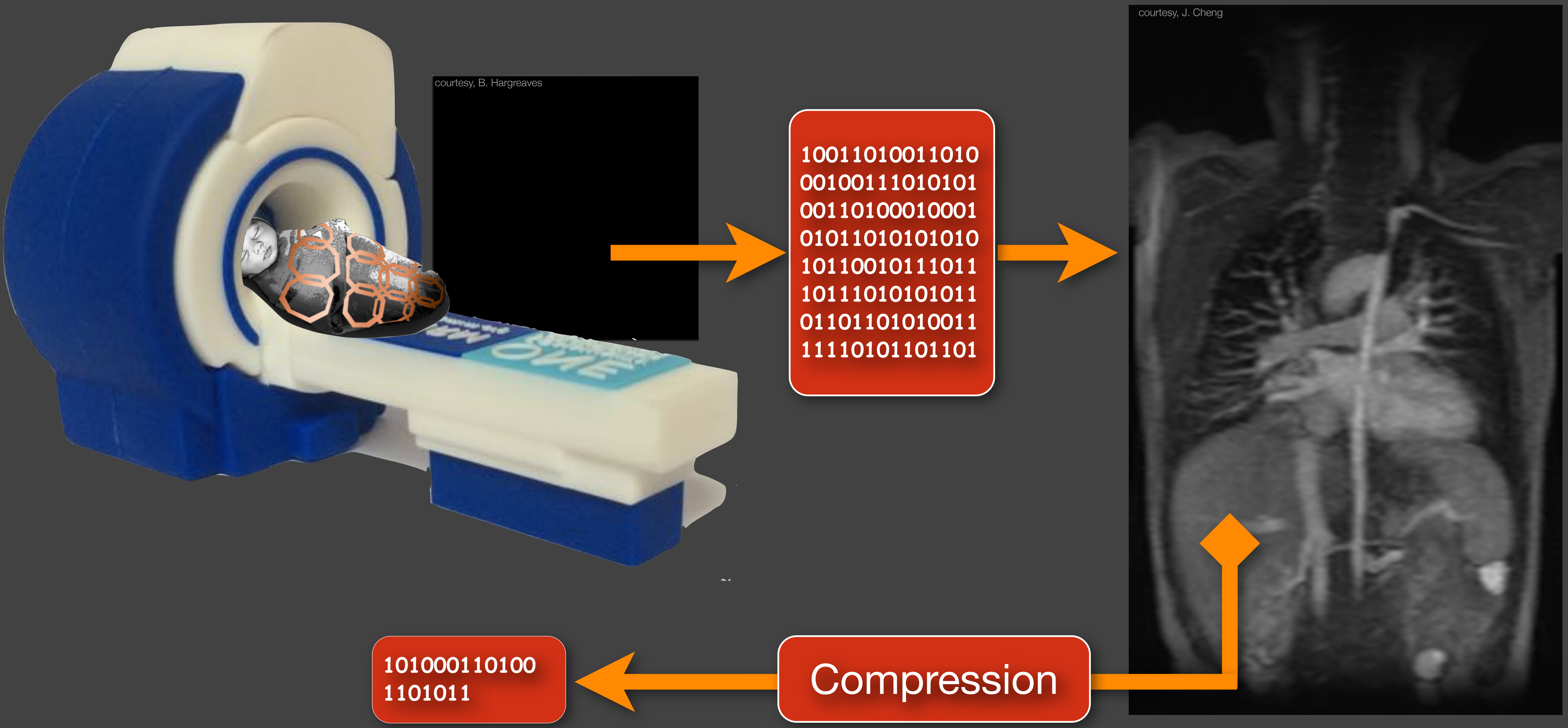
- 18x Compression ratio

Video Compression

- HD Video
  - 1920 x 1080 x 30FPS x 3 colors x 54 second = 10 Gb
- Compressed = 71.6 Mb

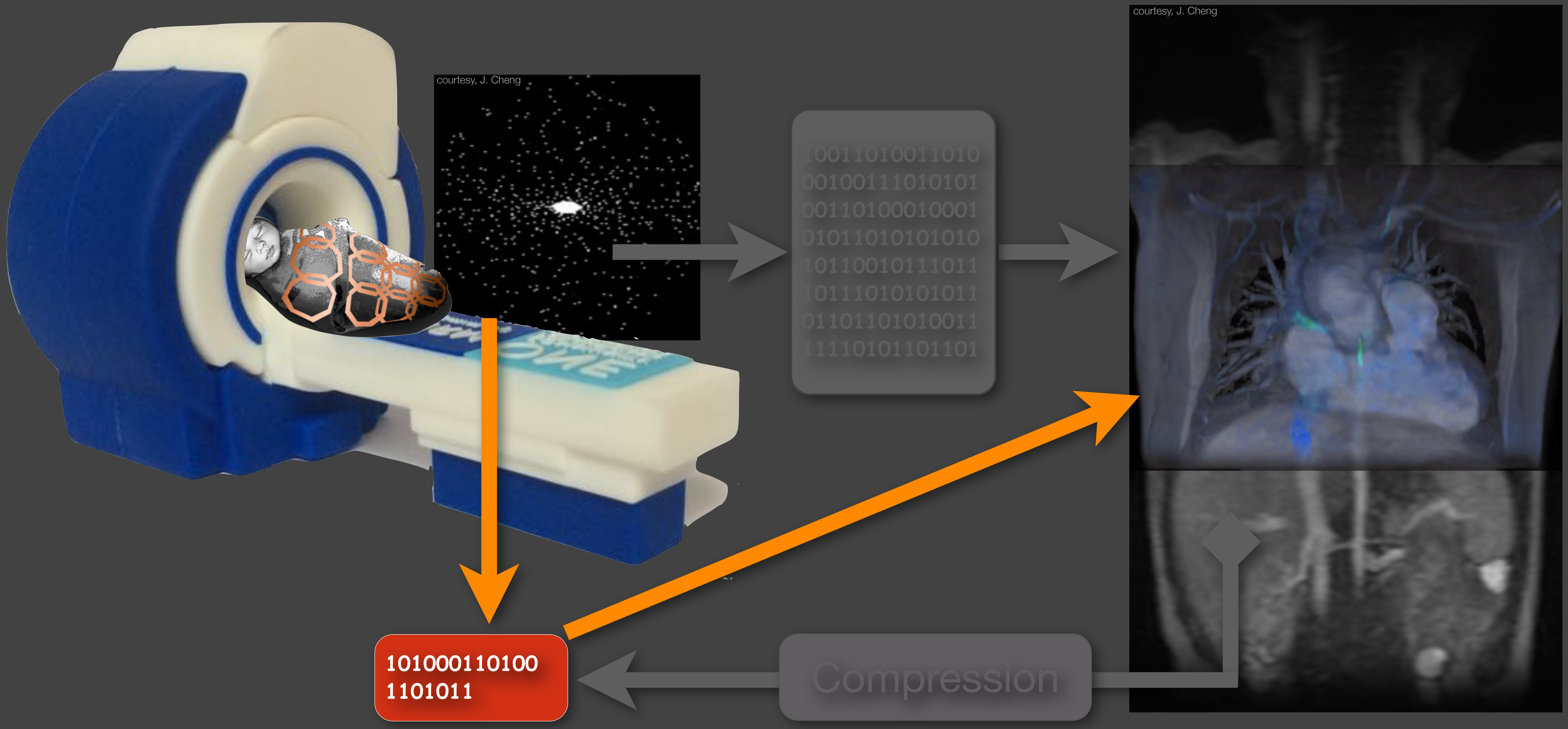
- x140 Compression!

Magnetic Resonance Imaging



Candes, Romberg, Tao 2006
Lustig, Donoho Pauly 2007

Compressive Imaging



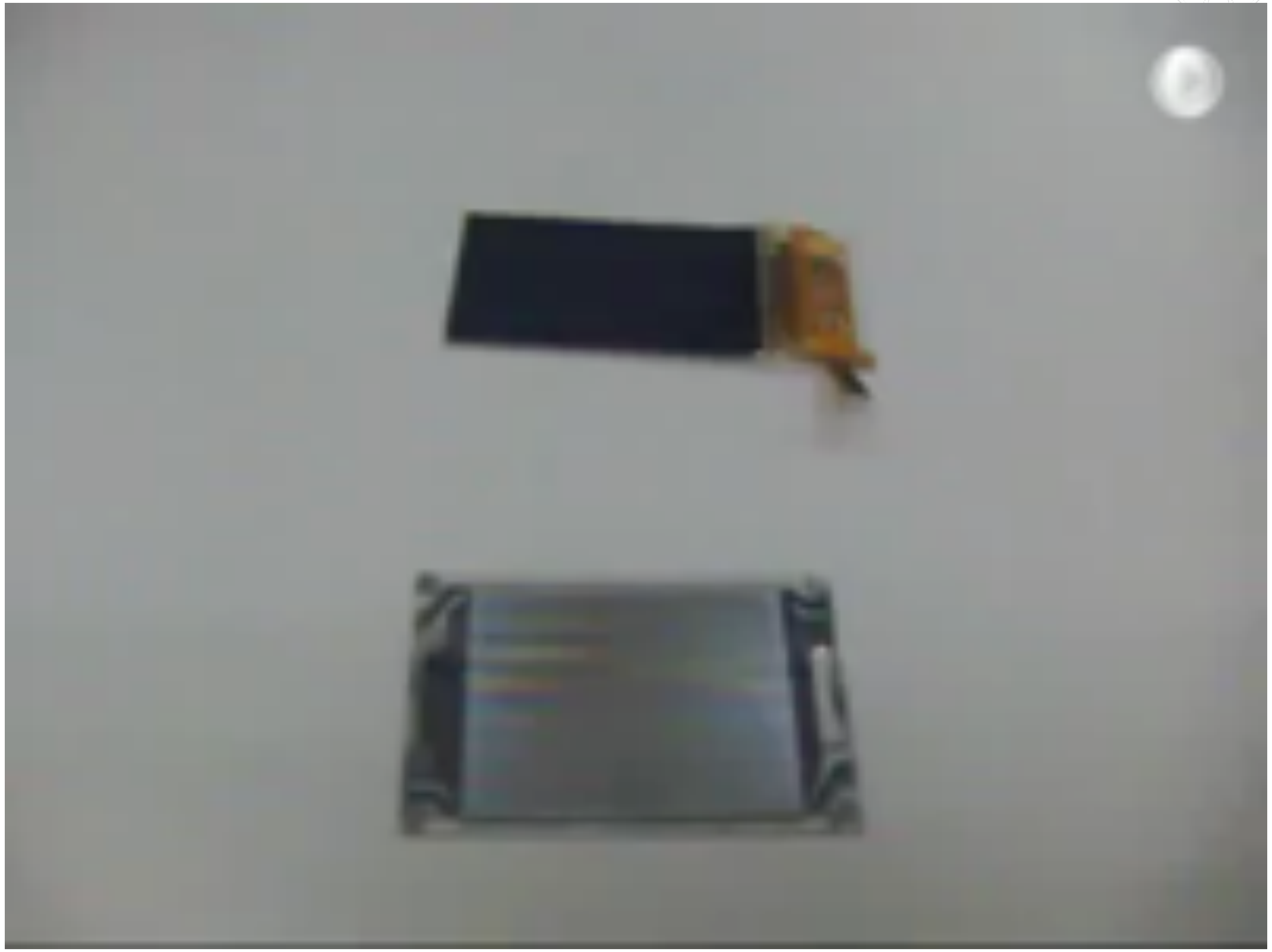
Candes, Romberg, Tao 2006
Lustig, Donoho Pauly 2007

Enhancing an Image Hollywood Style

from:

- You got an image enhancer ?....
- This software is state-of-the-art
- With the right combination of algorithms...

Flexible Electronics



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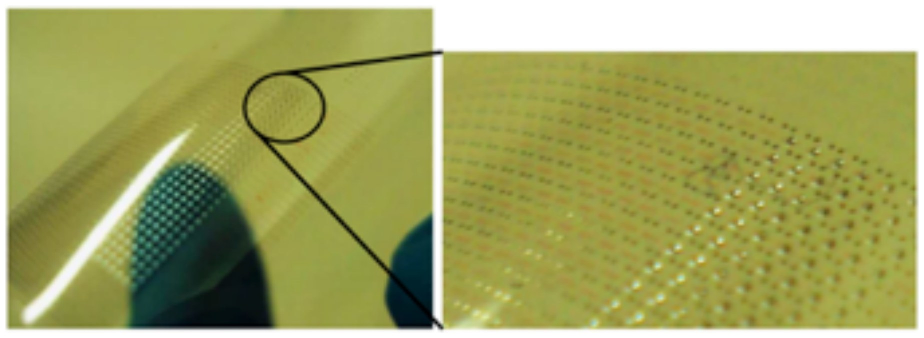
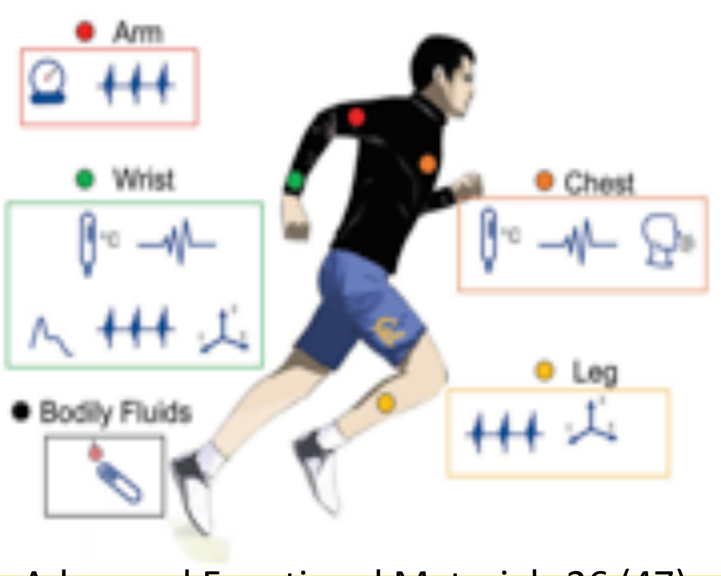
Flexible, Large-Area Electronics

Large-Area Sensing



Nature Photonics 11 (3), 193-199 (2017)

Medical Devices



Advanced Functional Materials 26 (47), 8764-8775 (2016)

Power Sources

Science Advances 3 (6), e1602051 (2017)

vs. conventional rigid electronics:

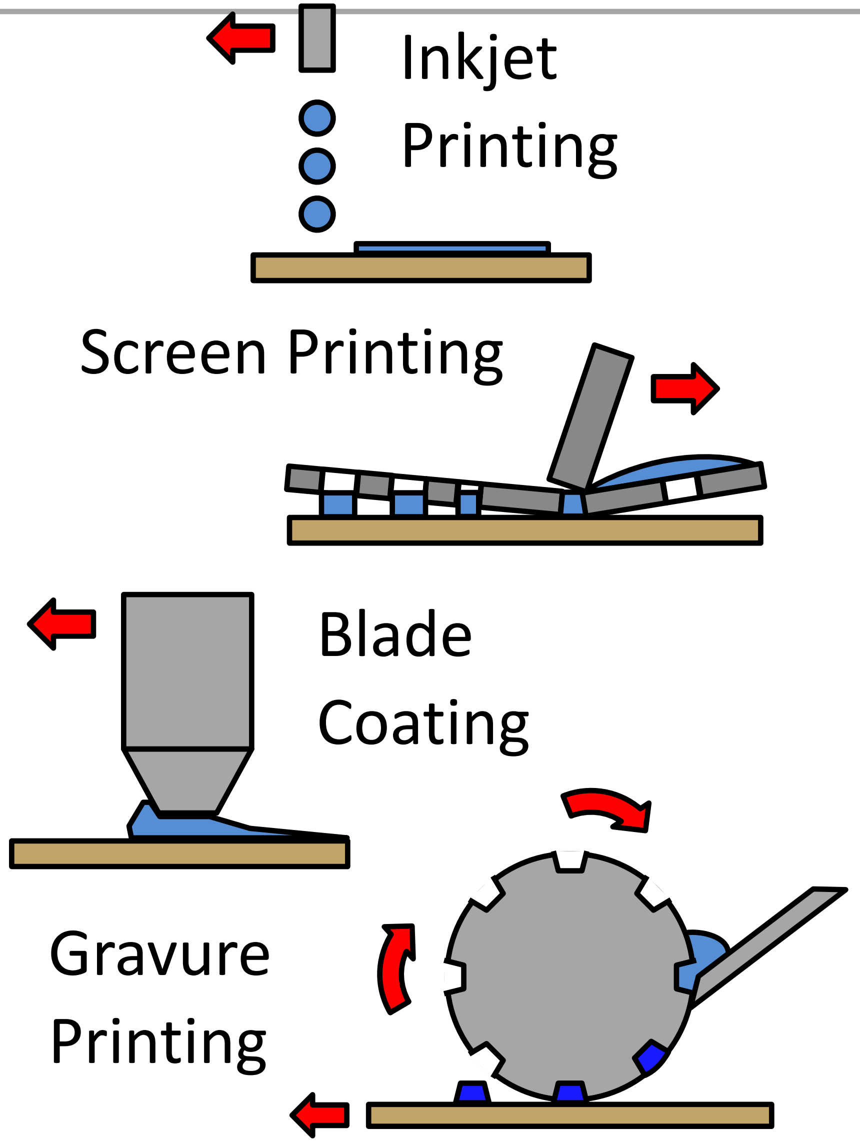
- ✓ Less bulky
- ✓ Improved comfort for wearables
- ✓ Improved signal quality

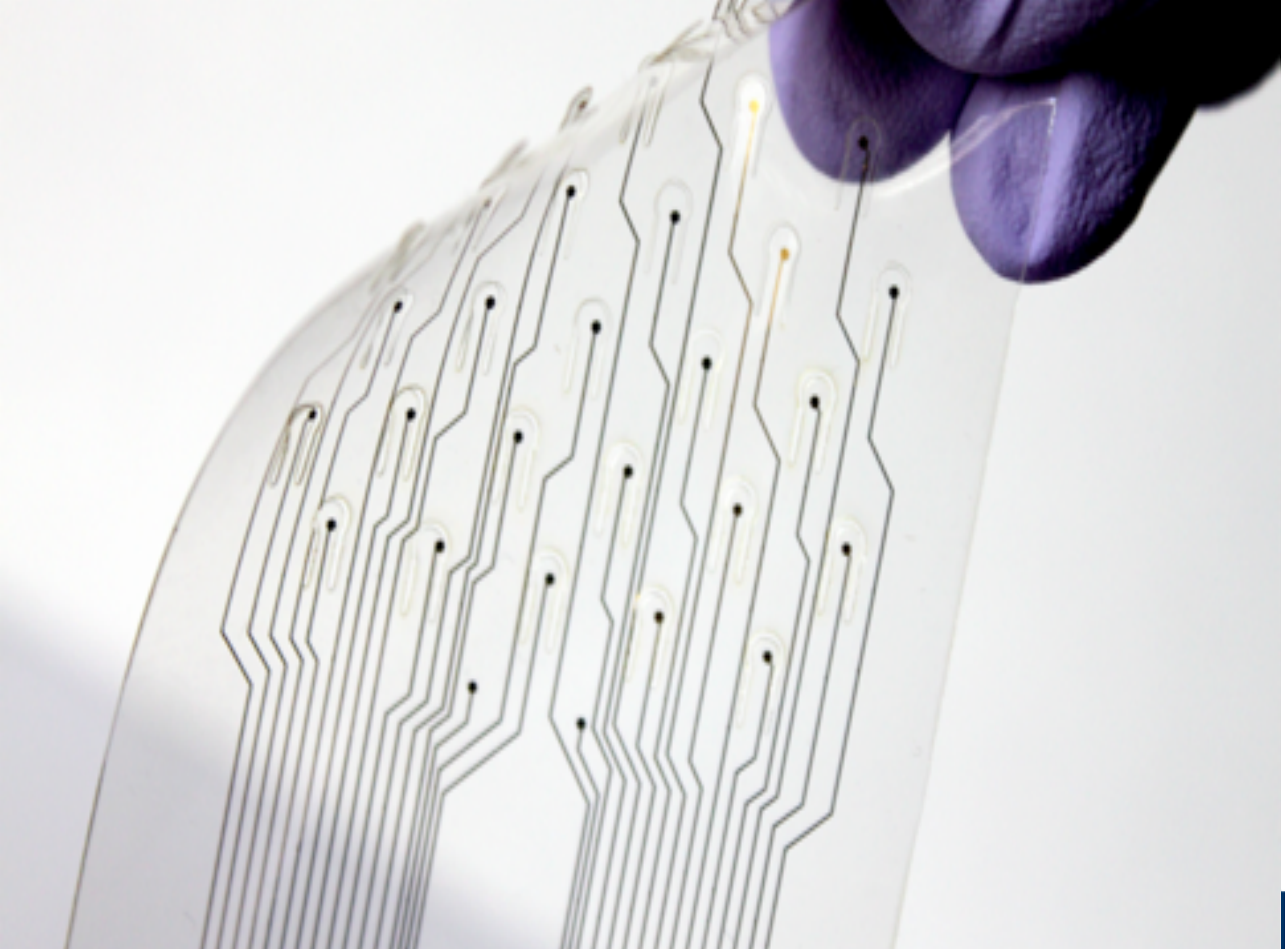
Printing for materials deposition

- Electronic materials are directly deposited on flexible substrates using additive printing processes

- Printing enables customization and coverage of large areas at high speed

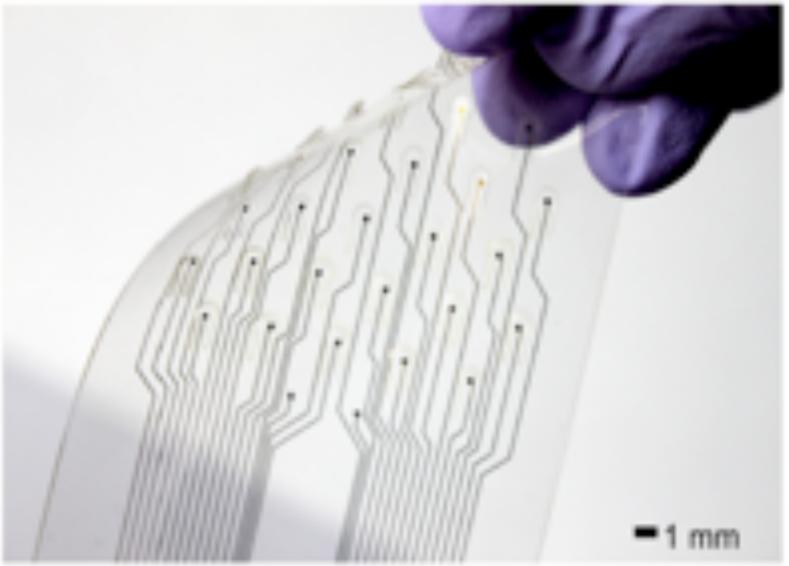
- Hybrid electronic systems use a combination of printed and conventional (e.g. silicon) devices

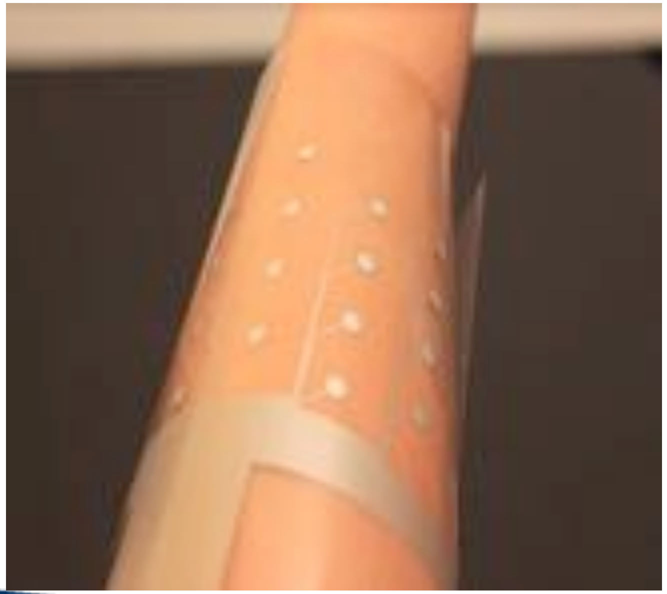




Move away from one size fits all

Form Factor





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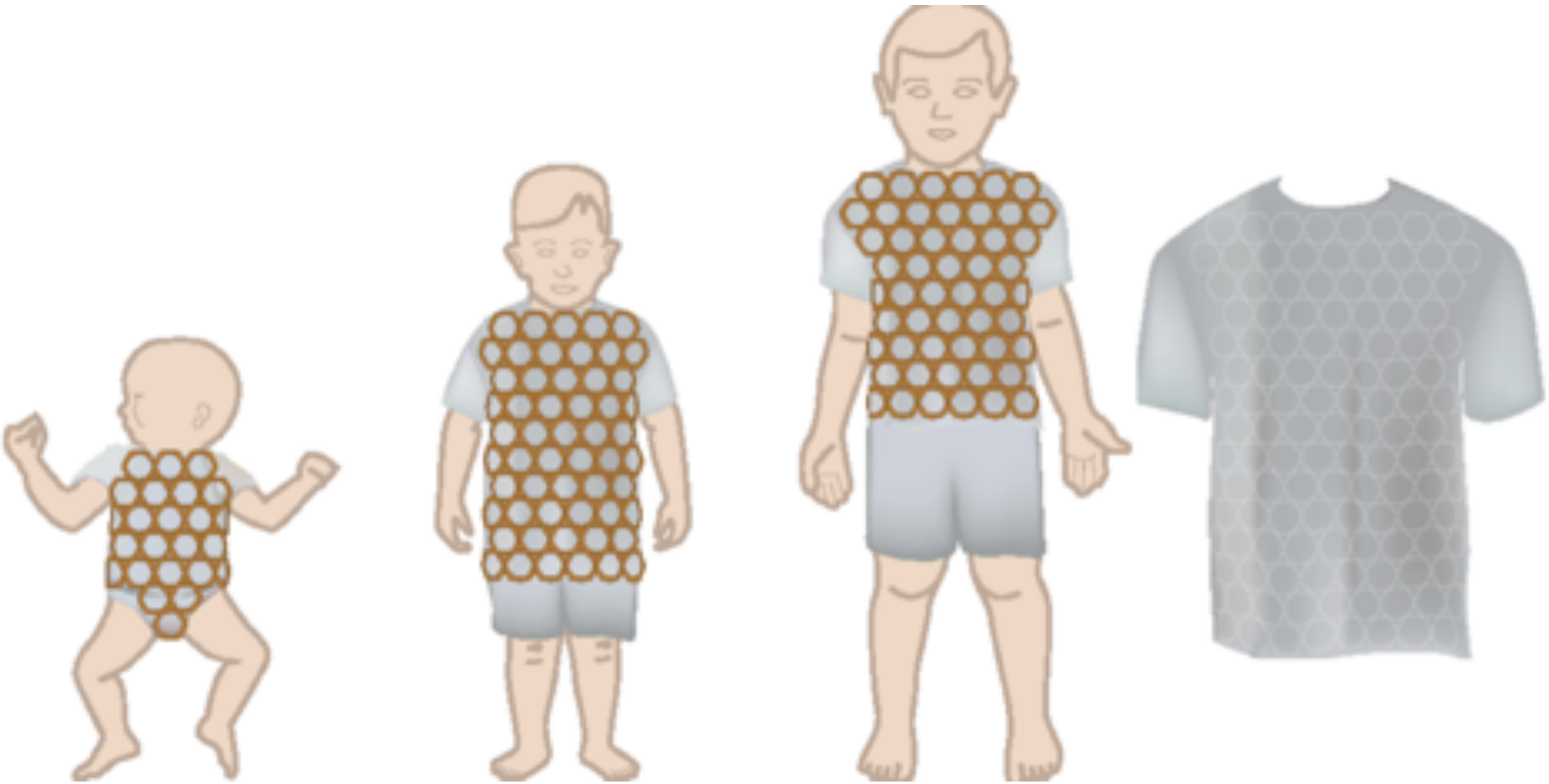
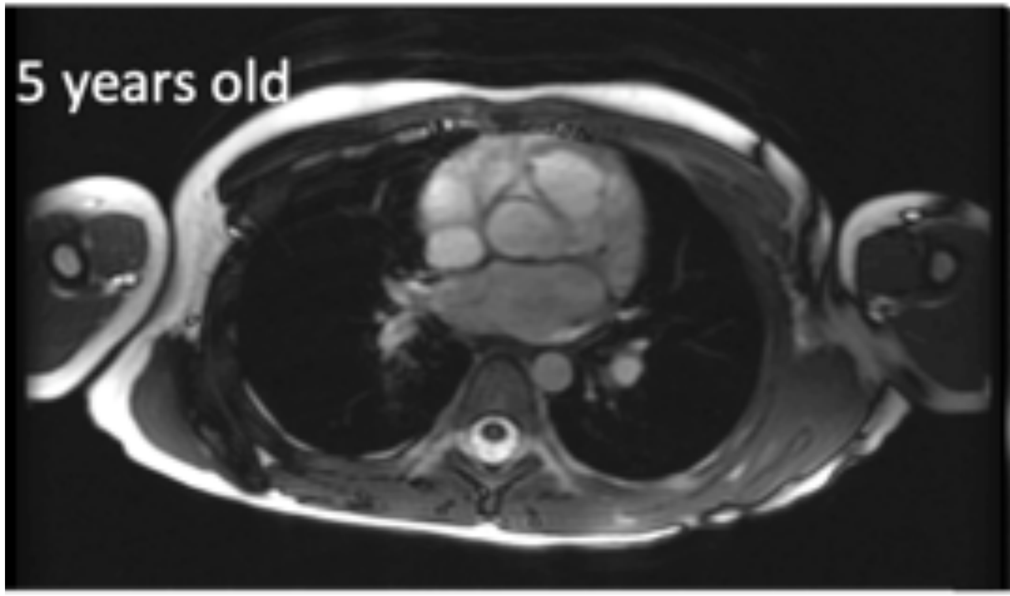
Magnetic Resonance Imaging (MRI)

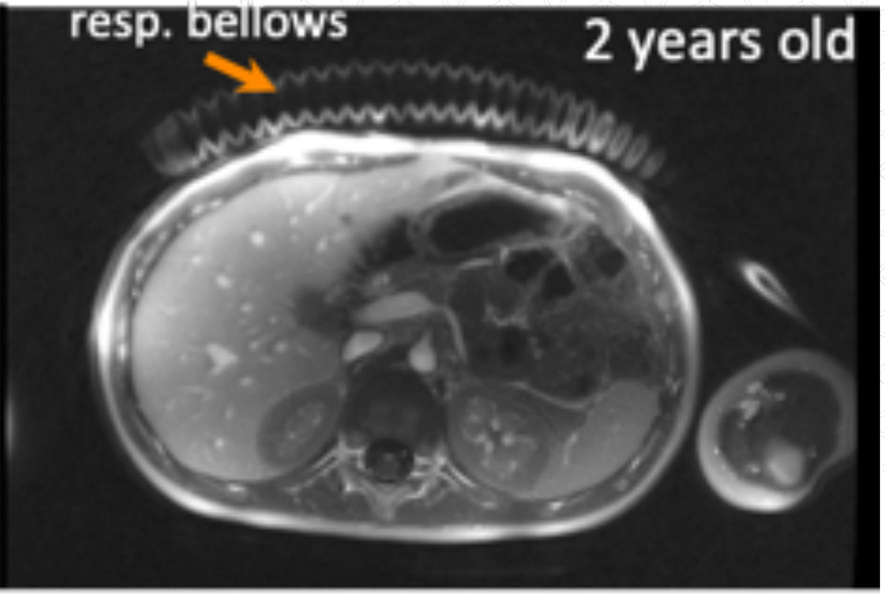
Design Mind Set

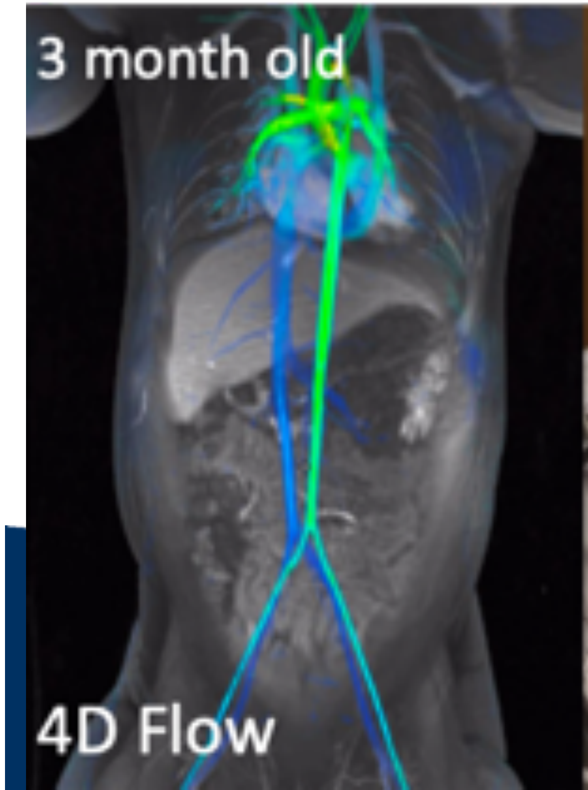
The Vision



3 kg, 10 week old patient


5 years old


resp. bellows
2 years old


3 month old
4D Flow


2 years old

Precision Agriculture

Sensor Node Concept