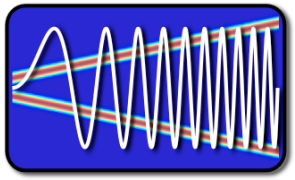
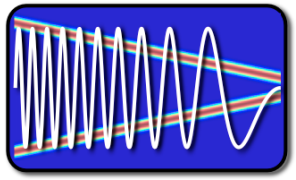


EE123



Digital Signal Processing

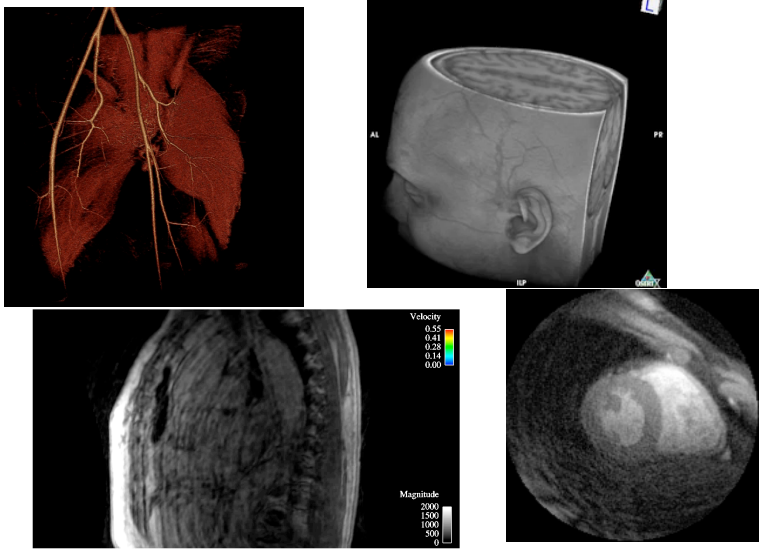
Miki Lustig

Electrical Engineering and Computer Science, UC Berkeley, CA

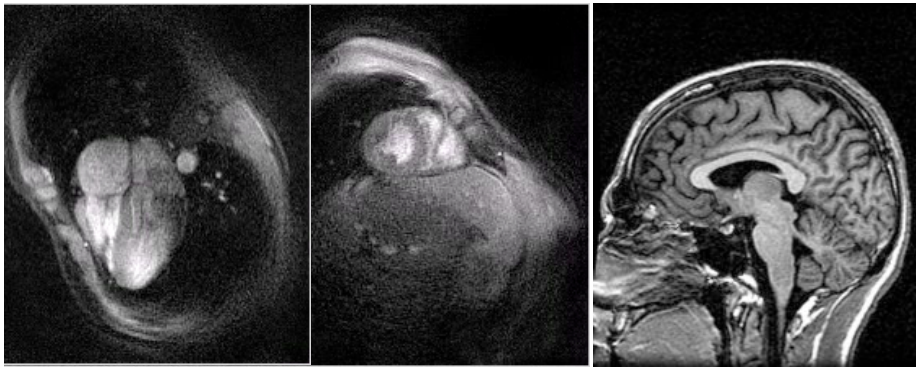
Information

- Class webpage:
  - http://inst.eecs.berkeley.edu/~ee123/fa12/

My Research

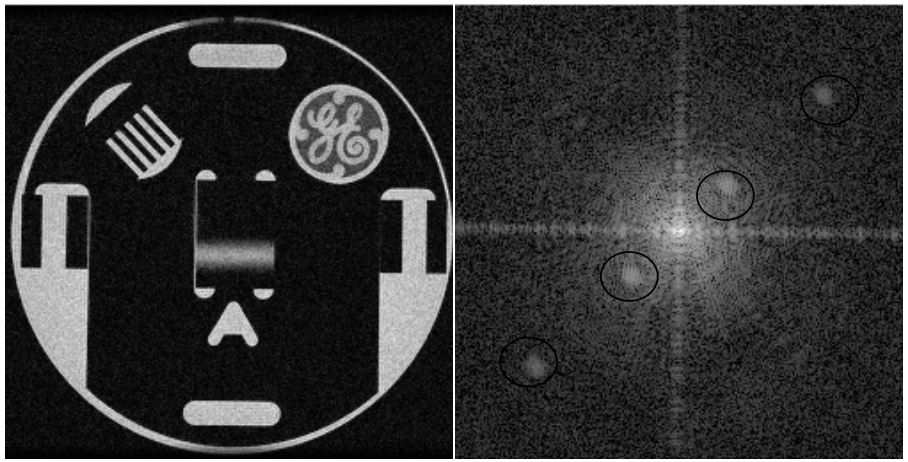


Me - Exposed



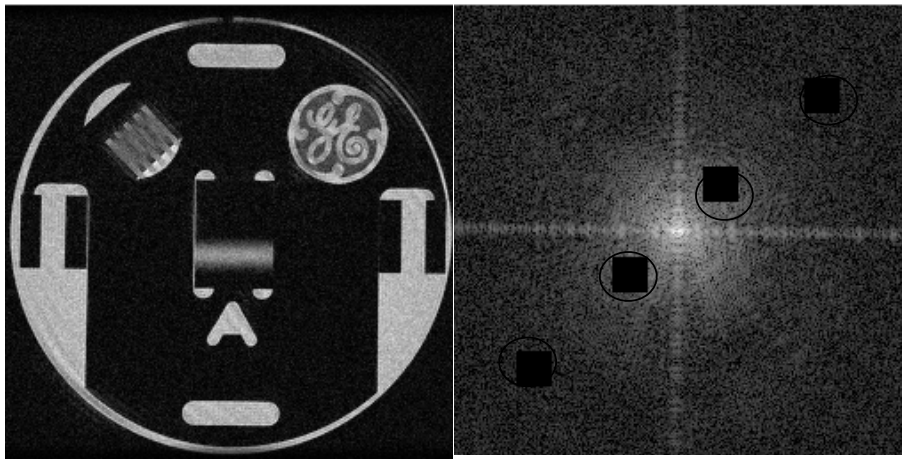
MRI Image of a
Water/plastic phantom

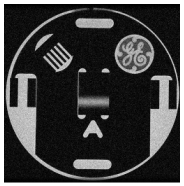
MRI Raw-data
(2D Fourier transform)



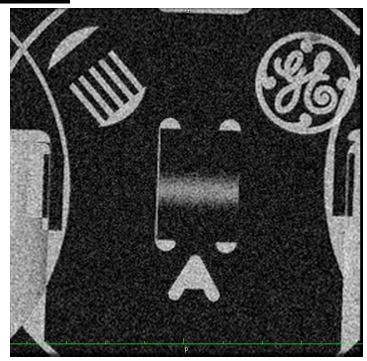
MRI Image of a
Water/plastic phantom

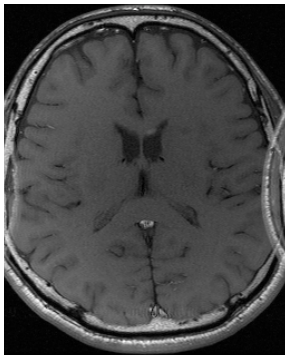
MRI Raw-data
(2D Fourier transform)



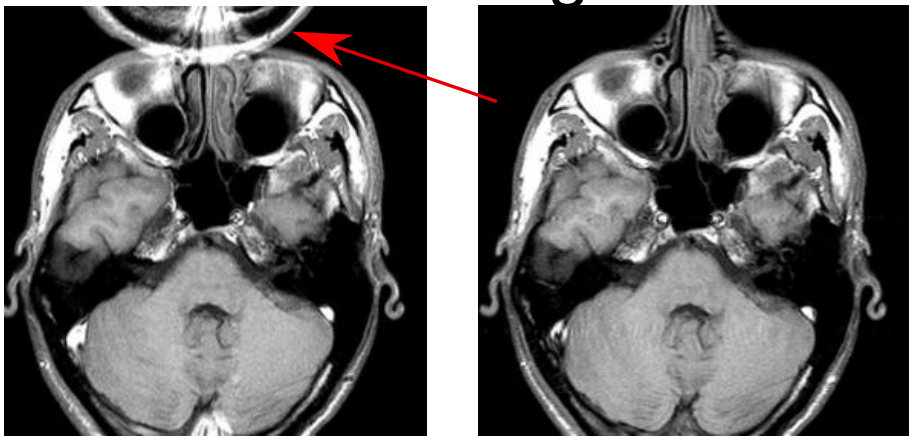


“Aliasing”





“Aliasing”



Signal Processing in General

- Convert one signal to another (e.g. filter, generate control command, etc.)
- Interpretation and information extraction (e.g. speech recognition, machine learning)

Digital Signal Processing

- Discrete Samples
- Discrete Representation (on a computer)
- Can be samples of a Continuous-Time signal: $x[n] = X(nT)$
- Inherently discrete (example?)

Why Learn DSP?

- Swiss-Army-Knife of modern EE
- Impacts all aspects of modern life
  - Communications (wireless, internet, GPS...)
  - Control and monitoring (cars, machines...)
  - Multimedia (mp3, cameras, videos, restoration ...)
  - Health (medical devices, imaging....)
  - Economy (stock market, prediction)
  - More....

Advantages of DSP

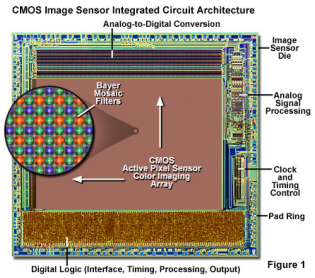
- Flexibility
- System/implementation does not age
- "Easy" implementation
- Reusable hardware
- Sophisticated processing
- Process on a computer
- (Today) Computation is cheaper and better

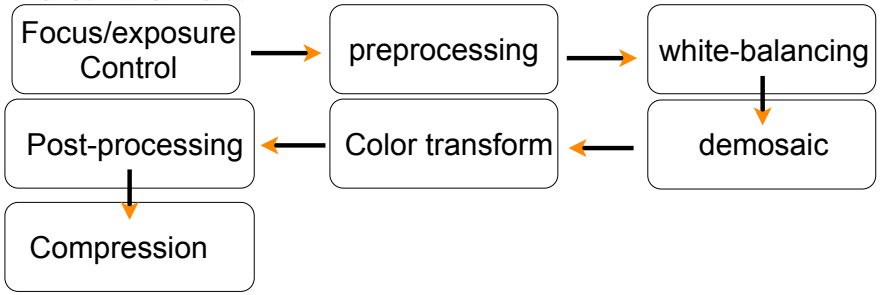
Example I: Audio Compression

- Compress audio by 10x without perceptual loss of quality.
- Sophisticated processing based on models of human perception
- 3MB files instead of 30MB -
  Entire industry changed in less than 10 years!

CD mp3 Error x10

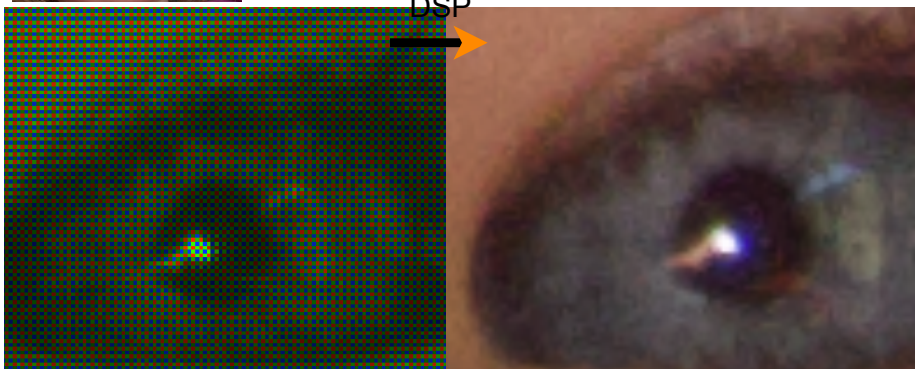
Example II: Digital Camera





http://micro.magnet.fsu.edu/primer/digitalimaging/cmosimagesensors.html

Example II: Digital Camera



Example II: Digital Camera

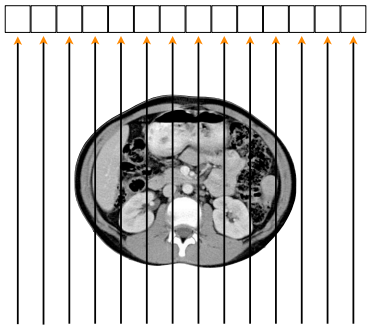
- Compression of 40x without perceptual loss of quality.
- Example of slight overcompression: difference enables x60 compression!

Computational Photography

DSP

*www.hdrsoft.com

Example III: Computed Tomography

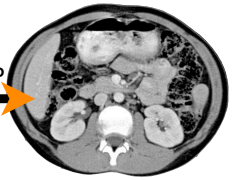


x-ray source

Sinogram

cross-section

DSP

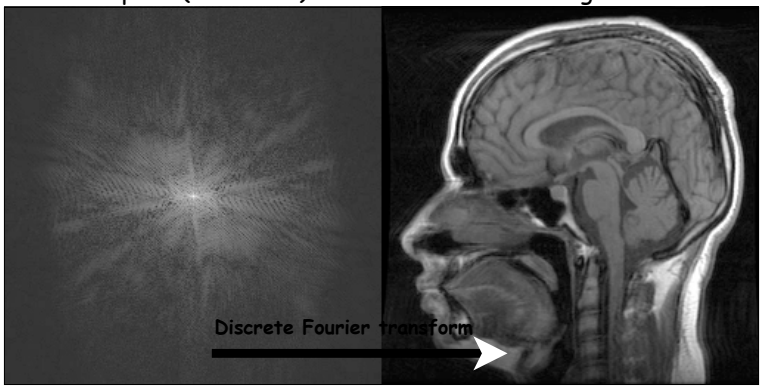


Example IV: MRI (again!)

Fourier

k-space (Raw Data)

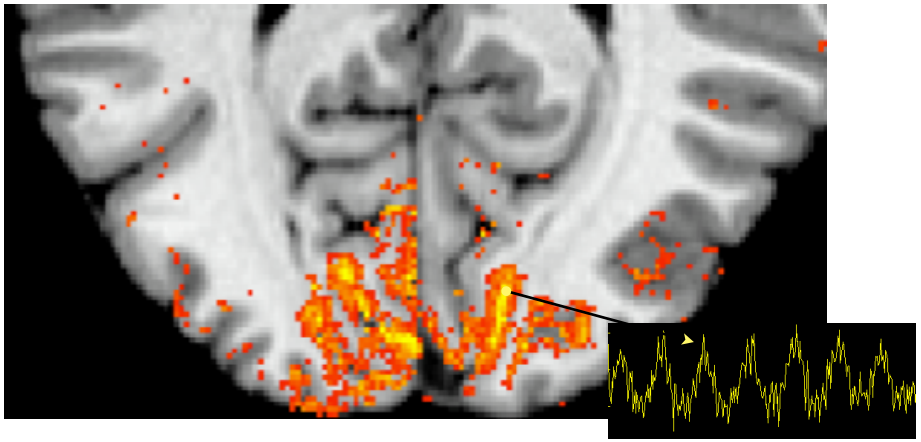
Image



Functional MRI Example

Sensitivity to blood oxygenation - response to brain activity

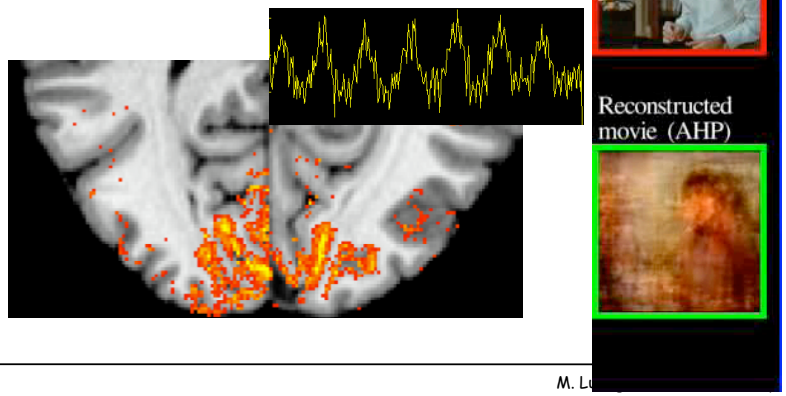
Convert from one signal to another



*Karla Miller, Oxford
*Brian Wandell, Stanford

Taking fMRI further

- fMRI decoding : "Mind Reading" Gallant Lab, UC Berkeley
- Interpretation of signals



Example V: Software Defined Radio

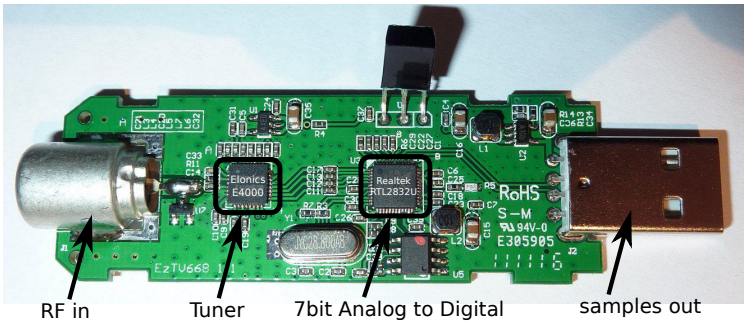
- Traditional radio:
  - Hardware receiver/demodulators/filtering
  - Outputs analog signals or digital bits
- Software Defined Radio:
  - Uses RF font end for baseband signal
  - High speed ADC digitizes samples
  - All processing chain done in software

Software Defined Radio

- Advantages:
  - Flexibility
  - Upgradable
  - Sophisticated processing
  - Ideal Processing chain - not approximate like in analog hardware
- Already used in consumer electronics
  - Cellphone baseband processors
  - Wifi, GPS, etc....

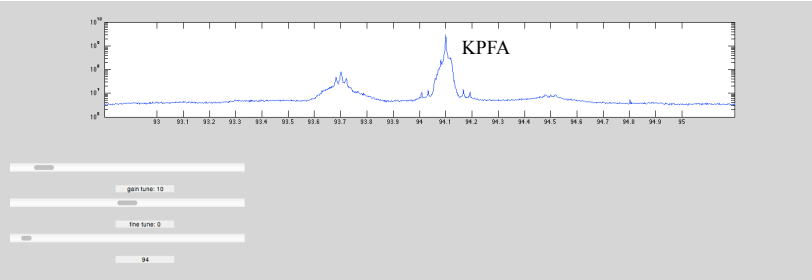
RTL-SDR

- Inexpensive TV dongle based on RTL2832U and E4000 chipset can be used as SDR



SDR & You

- Will provide easy interface to Matlab
  - -> soc = rtl_sdr_connect;
  - > rtl_sdr_setFreq(soc,94000000);
  - > rtl_sdr_setRate(soc,24000000);
  - > samps = rtl_sdr_getData(soc,4e6);



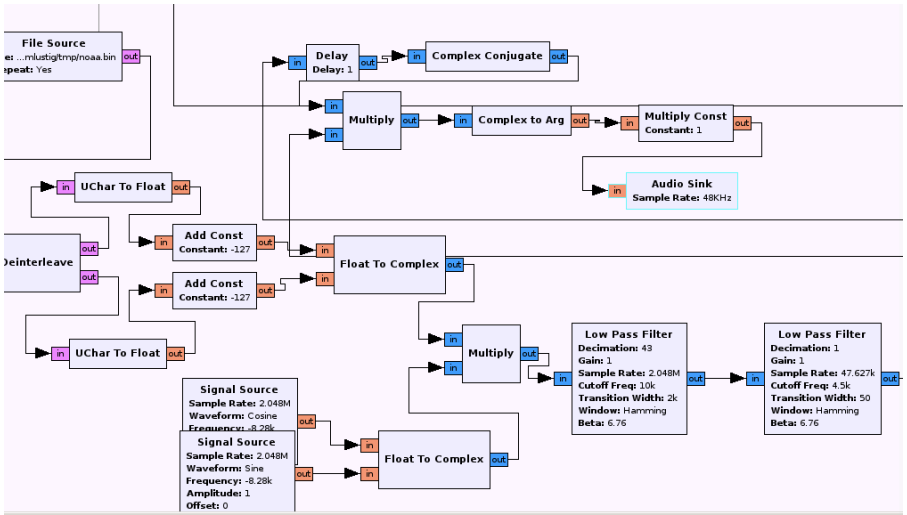
In class

- Each student will be given a device
- Homeworks/Labs based on the device
- Final Project - implementation of:
  - Police Scanner
  - FM stereo receiver
  - Decode digital weather information

@ Home

- Many Free available software to have fun!
  - GNU radio
  - SDR#
  - Airprobe (GSM receiver)
  - QtRadio
  - Many more.....
- Have a "Hack" of a time....
  - http://www.radioreference.com

GNU Radio Companion



Demo

Course Objective

- Develop skills for
  - Analyzing and synthesizing algorithms and systems that process discrete-time signals
  - Emphasis on realization and implementation