EE123 Digital Signal Processing

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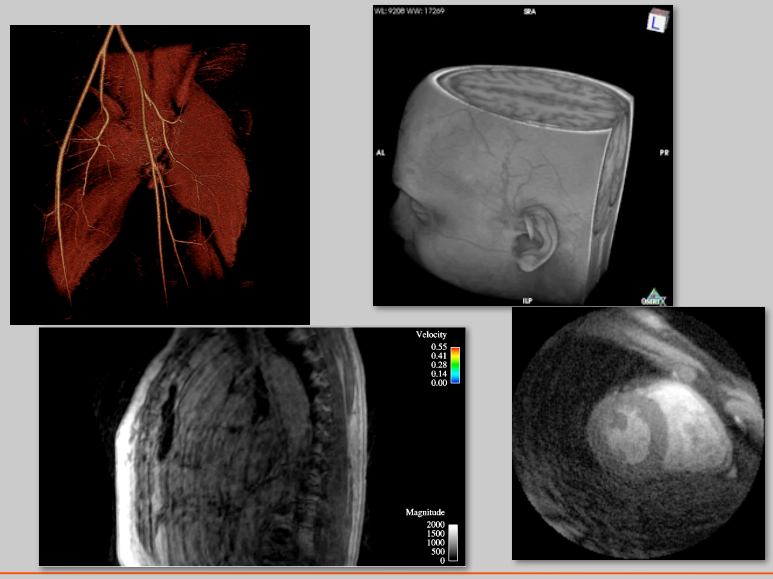
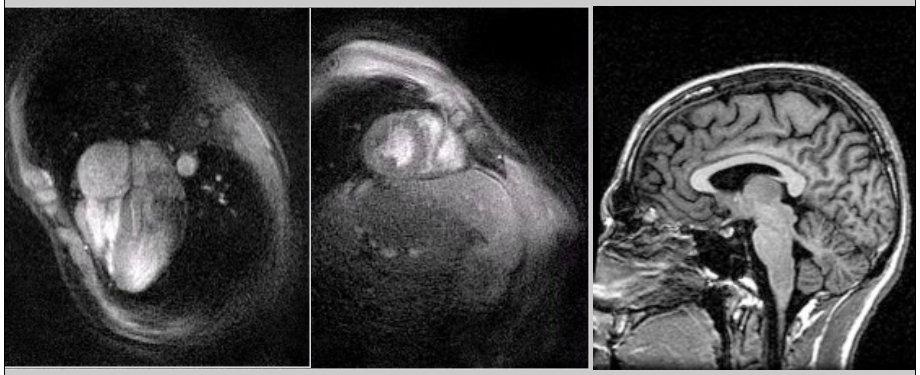
Information

- Class webpage:
  - http://inst.eecs.berkeley.edu/~ee123/sp14/

My Research



Me - Exposed



Go Bears!

Bear with us! The moment when an enormous grizzly undergoes an MRI scan after suffering seizures

By DAILY MAIL REPORTER

PUBLISHED: 13:04 EST, 20 January 2014 | **UPDATED:** 14:29 EST, 20 January 2014

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A young Montata grizzly was beary well behav
Statue University

Scientists at the Veterinary Teaching Hospital
causing her to have seizures.

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

Historical Forms of Compression

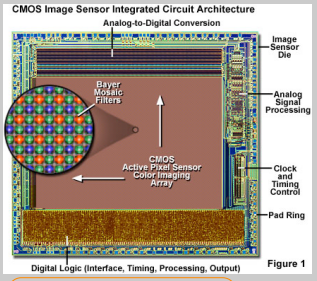
- Morse code: dots (1 unit) Dashes (3 units)
  - –Code Length inversely proportional to frequency
    E (12.7%) = . (1 unit) Q (0.1%) = --.- (10 units)

- "92 Code" - Used by Western-Union in 1859 to reduce BW on telegraph lines by numerical codes for frequently used phrases
  - –1 = wait a minute
  - –73 = Best Regards
  - –88 = Loves and Kisses

73 --... ...-- 19units

Best Regards -... . ... - / .-. . --. .- .-. -.. ... 59units

Example II: Digital Imaging Camera



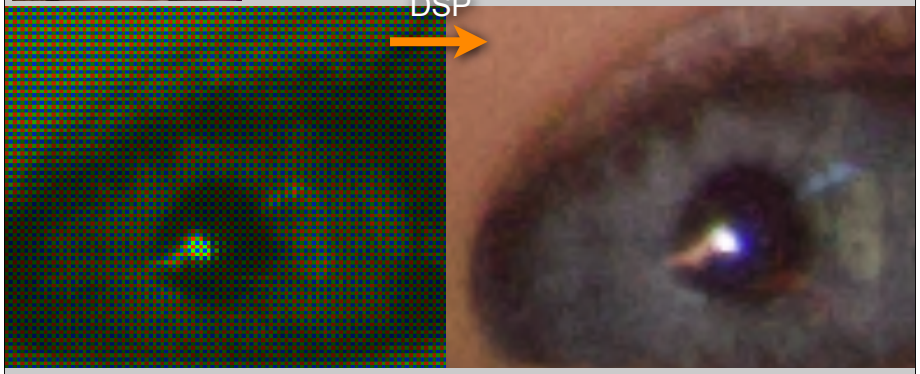
Focus/exposure Control → preprocessing → white-balancing

demosaic → Color transform → Post-processing → Compression

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

Example II: Digital Camera

DSP



Example II: Digital Camera

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

DSP

Image Processing - Saves Children

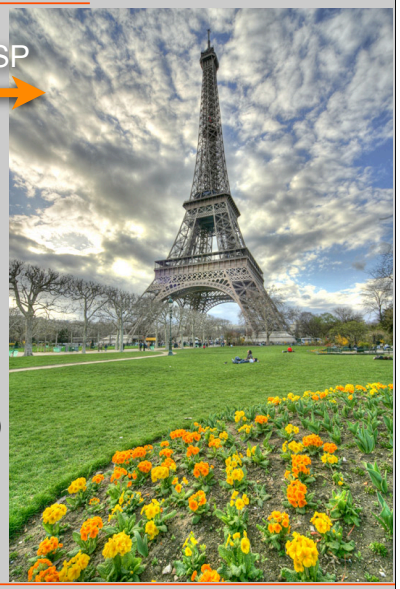
Canadian 'swirl face' pedophile jailed in Thailand

August 15, 2008

Images released by Interpol in 2007 show the 'unswirling' of the internet pictures that led to the capture of Christopher Paul Neil.

Computational Photography

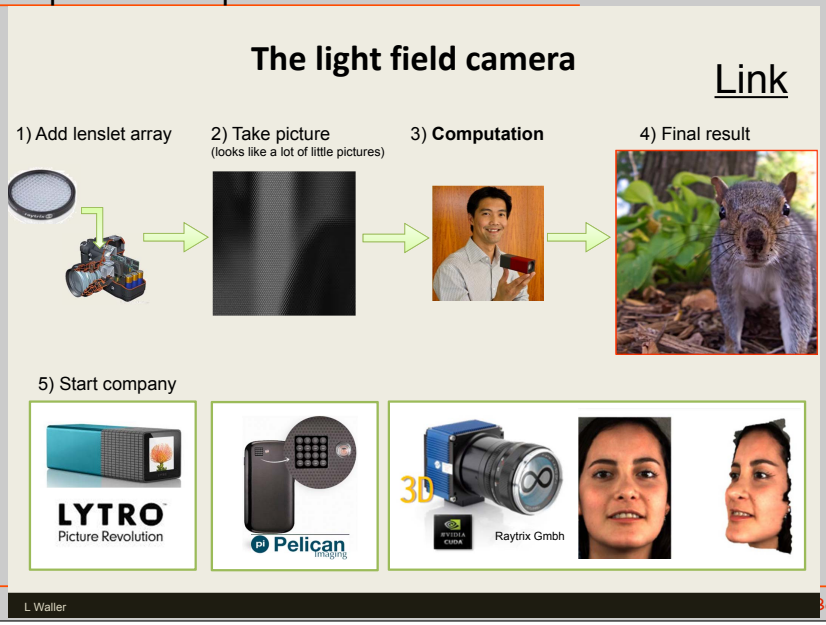
DSP



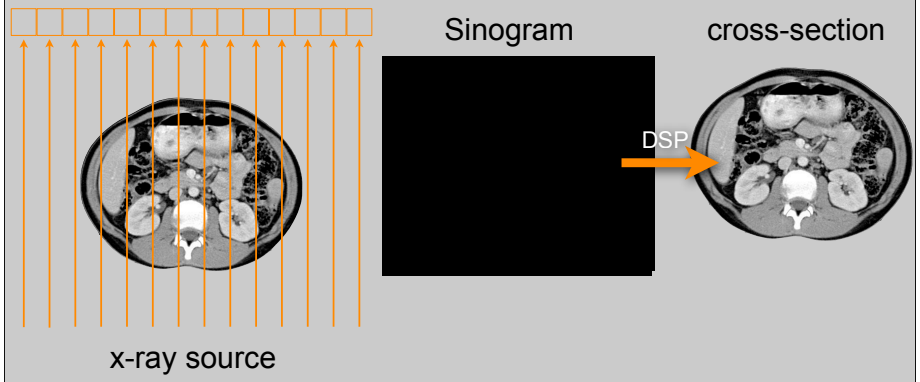
Now implemented in smart phones (HDR)

*www.hdrsoft.com

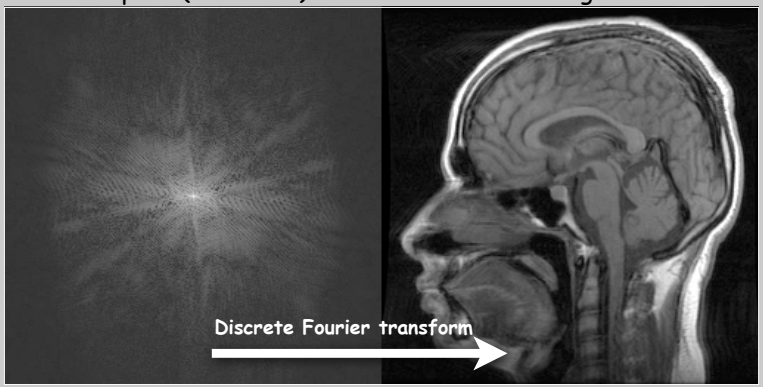
Computational Optics



Example III: Computed Tomography

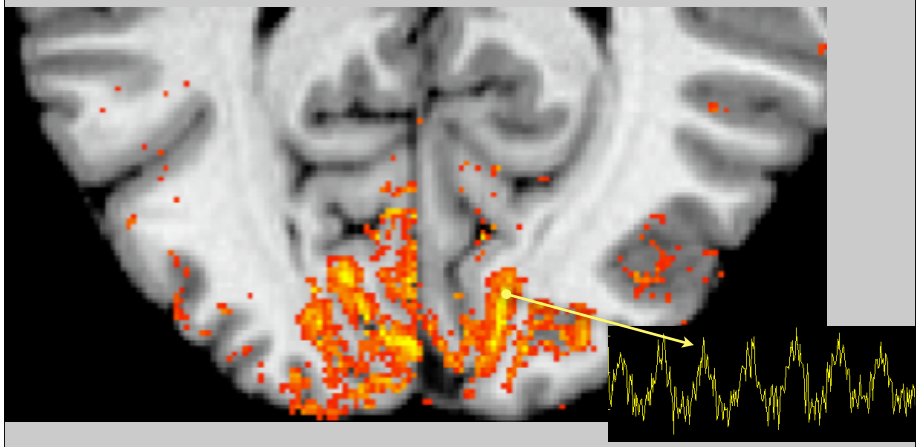


Example IV: MRI (again!)



Functional MRI Example

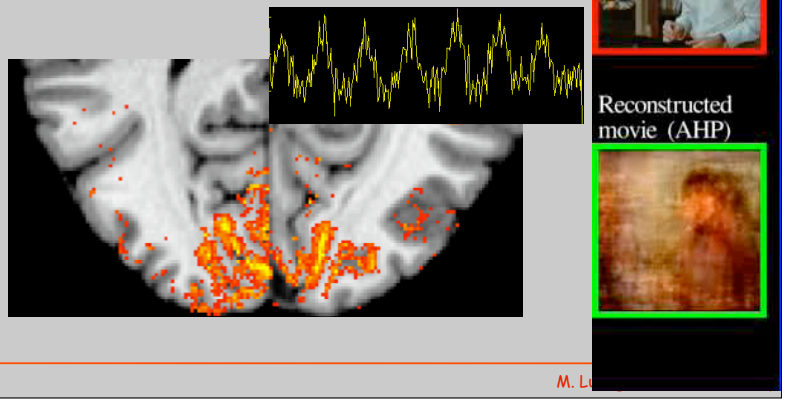
Sensitivity to blood oxygenation - response to brain activity
Convert from one signal to another



*Kamil Ugurbil, Minnesota
*Peter Bandettini, NIH
*Nancy Kanwisher, MIT
*Karla Miller, Oxford
*Brian Wandell, Stanford

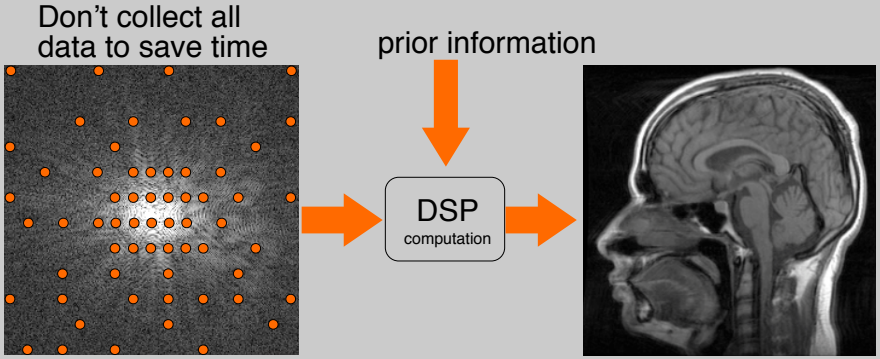
Taking fMRI further

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



Compressive Sampling

- Compression meets Sampling



Example V: Software Defined Radio

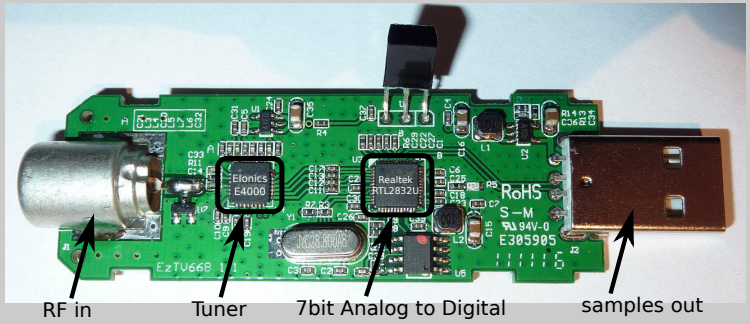
- Traditional radio:
  - – Hardware receiver/demodulators/filtering
  - –Outputs analog signals or digital bits
- Software Defined Radio:
  - –Uses RF font end for baseband signal
  - –High speed ADC digitizes samples
  - –All processing chain done in software

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 /820T chipset can be used as SDR



SDR & You

- Will provide easy interface to Python
  - Each student will be given a device
  - Homeworks/Labs based on the device
  - Final Project will use SDR

```
> sdr = RtlSdr()
> sdr.sample_rate = 240000
> sdr.center_freq = 94.1e6
> sdr.gain = 36
> samples = sdr.read_samples(480000)
```


SDR Demo

Ham Radio

- All students will get FCC license in class
- Each student will get a Handheld radio
- Radios will be used for Digital Signal Processing and communication Labs and Project.

- HAM is a wonderful way to learn about more complex EE/CS topics -- play with hardware, software, processing, E&M with a broad diverse community