Digital Image Processing ECSE 4540

Lecture 1

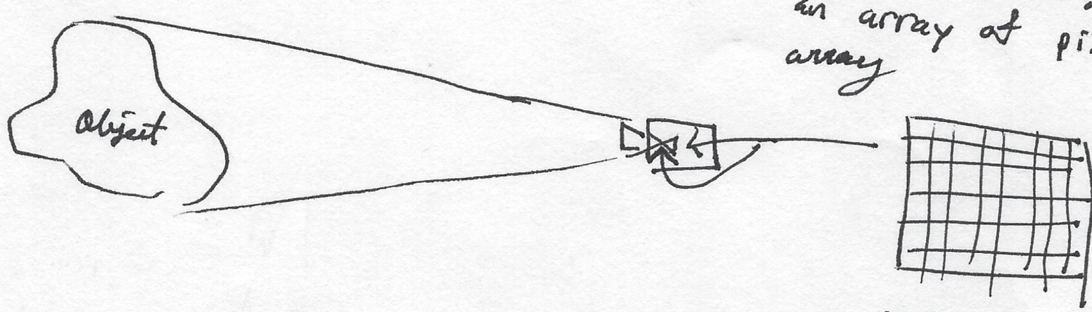
also called Introduction to Image processing

- Where do digital Images come from? 1
- What is digital Image processing?

To answer 1, there are lots of ways to acquire Images that don't use a digital camera or from something that you would think ~~wouldn't~~ not be a camera at all → these still form a 2D or 3D array ~~of~~ pixes that we may treat as a digital Image.

Lets focus ~~d~~ on ~~Digi~~ Digital Camera's

Inside the digital camera is an array of pixes, usually a CCD array



CCD ARRAY "PiXELS"

<u>Note</u>: There are ways to get Digital Images that don't involve this notion of a physical object in 3D space that uses visible light to pass through a lens onto a CCD Array.

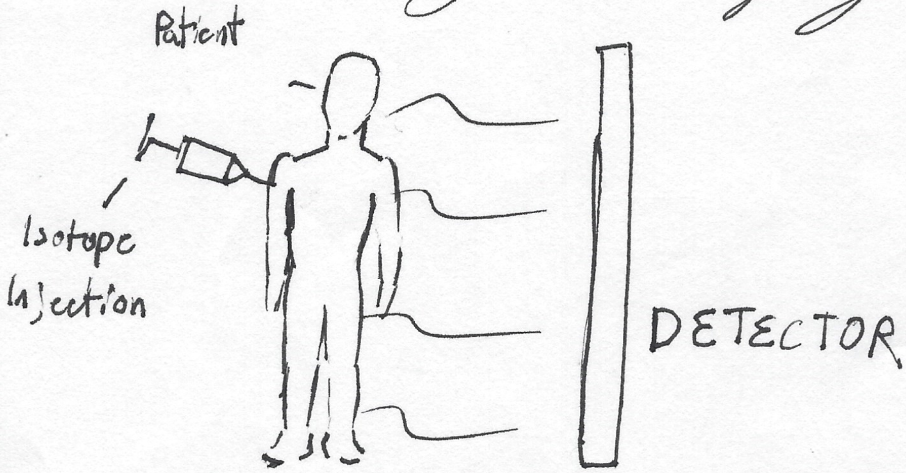
There are other ways to get digital Images → that are outside of the visible spectrum.

all across the Electromagnetic spectrum are ways to acquire Image-like objects.

Examples are
- Medical diagnostics for treatment
- baggage screening or cargo analysis

As for a truck passing through a checkpoint, they are not using a digital camera, they are using a fancy spectral imaging visual advanced device.

Gamma Ray Imaging (10^5-10^6 eV)



After the patient has been injected, they give off gamma rays that are received by a 1D or 2D detector.

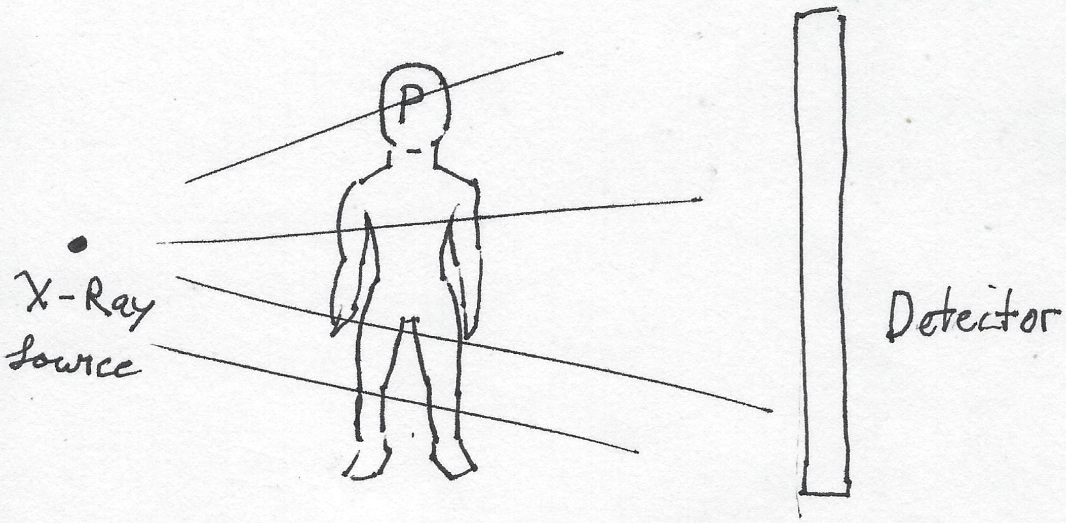
Good for detecting infections, tumors for things like Bones,

Heard ~~of~~ of SPECT Imaging?
→ Single-photon emission CT → computed tomography

PET, Positron emission tomography

We may get the Image of the bones from the CT scan, and we get the abnormalities from the gama Ray Imaging and we super Impose the two to get the location of the abnormality In relation to the bones, Gamma radiation is used for astro physical Imaging, celestial bodies give off radiation able to be detected from gamma Rays

X-Ray Imaging $(10^3 - 10^4\ eV)$



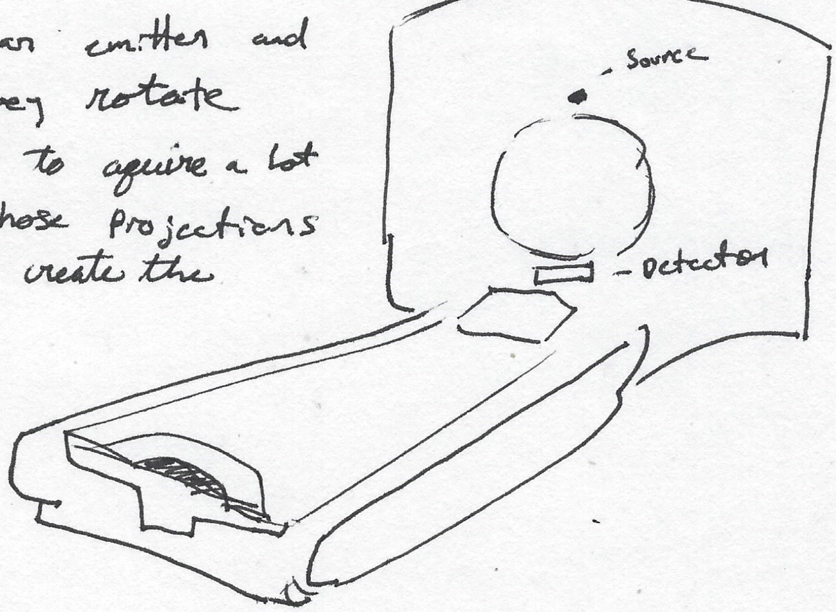
A PROJECTION of Absorbed X-RAYS AS they Pass through a Patient.

X-Rays are blasted through the Patient, like for the Gamma Rays, there are detectors (A Reflector to ~~other~~ observe how much has been absorbed by the patient). If the X-Ray arrive at full strength to the detector, (They passed through air). If the rays Pass through Solid bone, they are blocked by the patient with a less of a response on the detector,

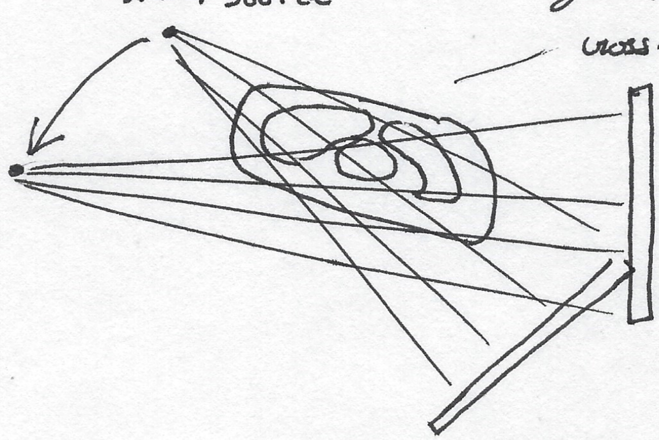
The Lung has air inside, so the Image will appear dimmer than ~~something that~~ ~~passs~~ passes through bone. this is what the Digital Image appears, ~~to~~ the Detector "sees" a stronger response from the lung as opposed to bone which is a very weak response, CT SCANNING → Varient of X-Rays

- Still using Xrays (Lots of X rays Sent through the patient at different angles)

There is an emitter and a detector and they rotate Around the patient to aquire a lot of projections. Those Projections are contructed to create the inside of the Patient.



IMPortant USE of X-RAYs!
CT (Computed tomography) ~~Scanning~~ Scanning



3D IMAGE of Object is Reconstructed from many ~~Images~~ Projections.

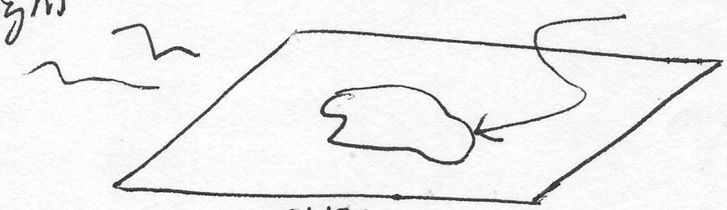
You can constroct a 3D Diagram of what's inside the patient with this process.

PAUSED 15:11

ultra violet Imaging (10-100 eV)

fluorescence microscopy   take a sample on a slide

UV Light



SAMPLED TREATED with Fluorescent DYE

SLIDE

"green fluorescent protein" → very common ~~time~~ DYE.

- Shine UV light on to the sample, what comes off is visible light – that's what fluorescence is, ~~lower~~ lower energy photons given off.

  going down from UV to ~~[illegible]~~ visible light.

→ common in biological Imaging of cells

→ inject samples with this stuff, thats glows green (in different components of the cell) the green will be picked up at different densities

→ different colors for different cells or different colors for different parts of the cells.

Visible - Band imaging (1eV)

- smart phones (Previous Example was a microscope image

- consumer Digital IMAGING

- LIGHT MICROSCOPE
  (The sample may uptake dye at different rates to show what's going on)

- Remote sensing (SATELLITE) Big Issue
  (Also Infrared)

→ Imaging a satellite image (from above) [way up] you can superimpose a infrared image that can identify the terrain. The terrain gives off different information.

- Manufacturing / INSPECTION

- SPACECRAFT IMAGING

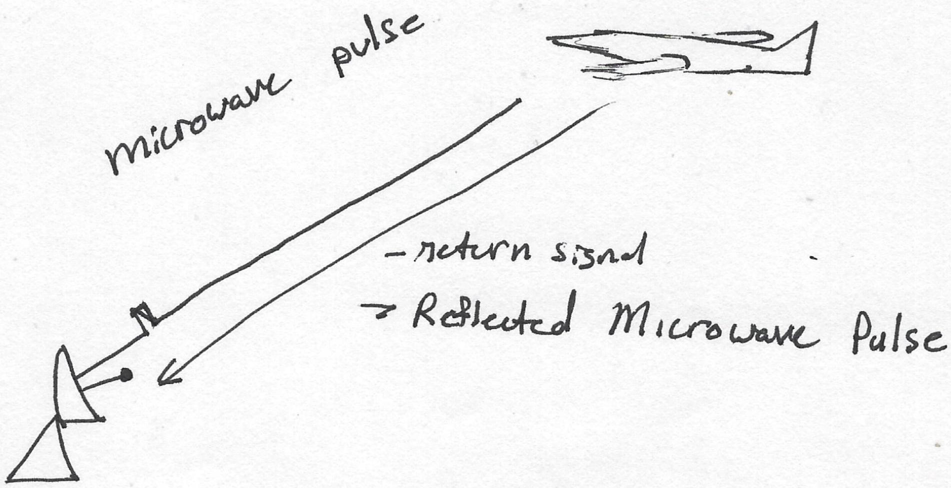
- LICENSE PLATE RECOGNITION.

- Biometrics

→ 21:07

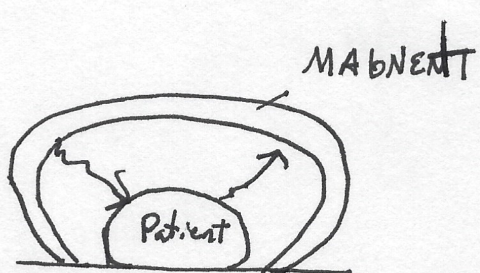
millimeter wave (THz) IMAGING — $10^{-1} - 10^{-2}$ eV
Terra Hertz (Just below visible spectrum)

MICROWAVE Imaging ($10^{-2} - 10^{-6}$ eV)
RADAR



Based on whether it returns or the time and delay of the return, you can infer what's out in the sky.
→ We can also use this to know what's on the ground.

RADIO-BAND IMAGING ($10^{-6} - 10^{-9}$ eV)
MRI (MAGNETIC RESONANCE IMAGING)

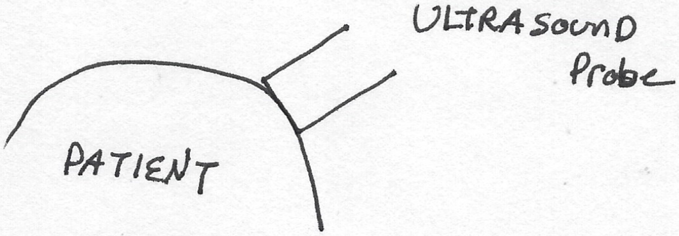


→ The magnet is pulsing radio waves into the patient and those waves are being reflected and detected.

The way the Radio waves are reflected and the strength at which they are reflected allows us to generate a 3D model of the details inside the body.

ULTRASOUND (IMAGING without photons)

before, we had a photon with some sort of energy involved to create an image, here there are no photons at all.

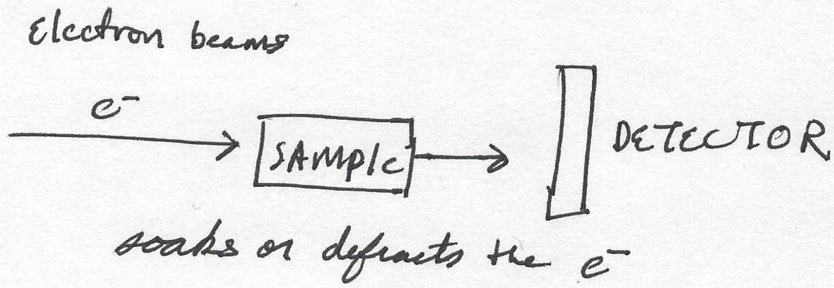


← Pulsing sound waves (That you can't hear) inside the patient and the object inside the patient (like organs perhaps) are bouncing back to the detector

<u>NOTE</u>: The quality is less than a CT. SCAN or an MRI scan, but it's much quicker to get. <u>Think</u> quick-and-dirty way of getting a usable ~~image~~ image.

ELECTRON MICROSCOPE

→ we send electrons at a sample and the sample absorbs or deflects the electrons with a detector



Like X-Ray with electrons instead.

There are also types of images we synthesize as humans.

* <u>Note</u> Radke is from Wisconsin → he calls the water fountain a ~~blubber~~ bubbler

These are known as Image Modalities!

AS AN Idea for the project, It does not have to do with Images from a phone. Radke welcomes project Not in the Visible spectrum, but he suggests we should get started on the project early. Question! where are you going to get the data to do that project?

→ for Example, CT SCANS, you can't just get some random scans on the web, → privacy concerns huge data sets, If we want to do that, we should talk to Radke and he will point us in certain professor's direction to get data.

31:08 → No here is when we talk about whats going to be ~~taught~~ in this class.

DIGITAL IMAGE PROCESSING

Low-Level Processing To Remove Noise, sharpen, or ENHance an Image

IMAGE → ☐ → IMAGE

Like sharpening a blurry Image

Mid Level! SEGMENTING AN IMAGE INTO REGIONS / OBJects ; Describing an Image Precisely

IMAGE → ☐ → (EDGES, Lines, Objects, Regions)

HIGH Level: MAKING SENSE OF AN IMAGE, IMAGE UNDERSTANDING, COMPUTER VISION

IMAGE Processing ~~helps~~ is the building block for ~~courses~~ Courses like Computer VISION.

We have to know how to push pixels around before we do Computer vision, Image understanding projects.
- maybe later in the course.
→ perhaps this could ~~be~~ have something to do with our project, as in, which group of pixels on an Image are a face.

AN EVEN higher level would be facial expressions recognition.

Major Categories for this course.

- Image acquisition (how does the human visual system work?) (A camera producing pixel values for a image)

- IMAGE MANIPULation and Enhancement
→ (I wish there was more contrast, adjust the Brightness, tilt the horizon line)
(we call this the Subjective process)
→ how do I make the image look better to me.

- IMAGE RESTORATION (OBJECTIVE)

IMAGE ~~RESTORATION~~ RECOSTRUCTION from Projections

- IMAGE COMPRESSION
- IMAGE SEGMENTATION (EDGES, LINES, Objects)
- IMAGE understanding / Computer Vision
- Advanced Topics (Last 3 or 4 weeks)

(visual effects)

next time, human visual system.

DIP #1

Spect Imagery shows the abnormalities

Gamma ray imaging shows something unusual

→ used to check cargo inspection (ports borders)

Detect radio active material (false positives, cat litter and bananas)

+ astrophysical imaging

X-rays Lungs are darker (Limited to 2D)
tumor can be picked up

Examples on Video

13:45, CT Example

14:50, CT Bag example

(2) 16:39 Example of fluorescence Microscopy

Image

Green blobs ~~of a~~ are a cell nucleus

16:48 , multiple different flourescences

17:30 visible microsopy

→ Visible - band Imaging (we see every day)

18:58 satelite Image Infrared (very hot something)

manufacturing/Inspection to see if ~~something~~ is very hot

industrial Imaging

20:14 - Biometrics example

getting info from pics of their body

ear pattern finger prints, hand shape

radar example

23:32 radar image from below (synthetic aperture radar)

Brain model

25:00 radio band Imaging EX

we aren't pumping radiation into patient

25:15 Functional MRI

Oxygen in blood

Spin of e^- is different for oxygenated blood

vs non oxygenated blood

→ overlayed on top of regular MRI Image

Real pain vs hypnosis induced pain

Examples ask if there's a difference

26:20 ultra sound

28:48 polutron (Electron microscope

4

32:13 blurry image

→ sharpen it up