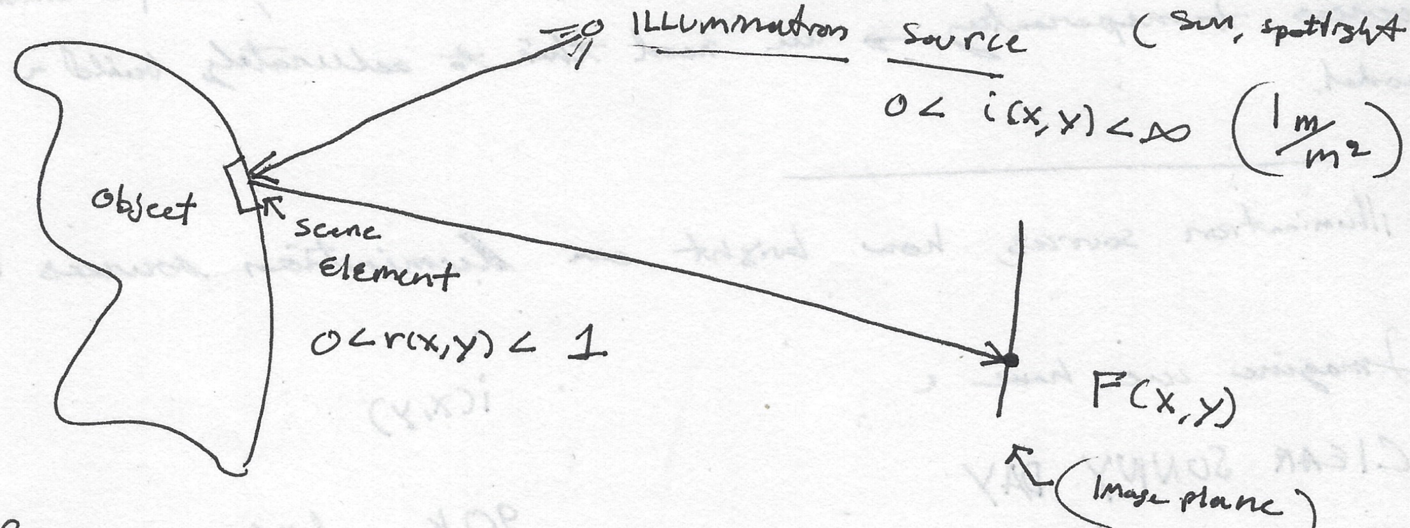
29:25



# Illumination Model

How much light energy is reaching the array?




So we want to know how much light is arriving at point $F(x,y)$ (of F) on this Image plane.

So the amount of energy / light that gets recorded on the sensor → combination of the strength of the Illumination source and inherent color of the object

- the Illumination source can have infinite brightness, $\left(\frac{lm}{m^2}\right)$ $\frac{\text{lumens}}{(\text{meter})^2}$

- The scene element has some inherent reflectance. → Inherent reflectance is a measurement of how shiney the object is.

→ fundamentally what I receive at this point on the sensor is $F(x,y) = i(x,y)\, r(x,y)$ → highly simplified

(10) → we are assuming that the color / intensity is only comming from one point in the scene to one pixel

we did not take into account for shadows, multiple illumination sources, transparentcy → we need this to accurately build a model.

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Illumination sources, how bright can illumination sources be?

Imagine we have a

| | $i(x,y)$ | |
|---|---|---|
| CLEAR SUNNY DAY | 90K | lm/$m^2$ |
| CloudY Day | 10K | l/$m^2$ |
| INDOORS | 1K | lm/$m^2$ |
| Full moon | 0.1 | lm/$m^2$ |

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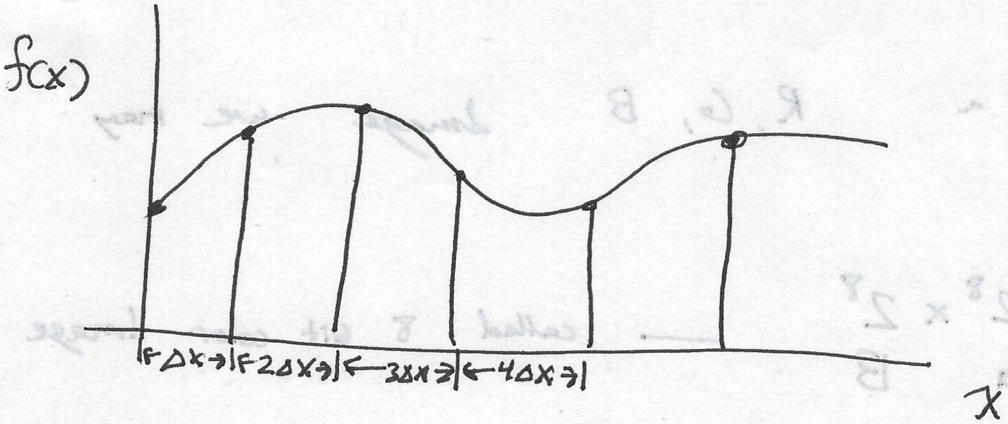
So how reflective can the surface be? $r$?

| | $r(x,y)$ |
|---|---|
| Snow | 0.93 |
| FLAT White wall | 0.80 |
| stainless steel | 0.65 (Like dishwasher if you have a nice one) |
| BLACK VELVET | 0.01 |

# SAMPLING AND QUANTIZATION




In our digital image we have a series of discrete pixels. We don't have a <u>continuous</u> <u>world</u> when it comes to real world image processing.

→ we do have a continuous realm for a film

→ Digital images have these rigid "boxed in" pixels

<u>Note</u>: We may not be able to represent the intensity / color of the pixel ~~world~~ with <u>floating point precision</u>.

the samples we have are <u>rounded</u> to the nearest <u>Quantization level</u>.

The energy arriving on the sensor is <u>quatized</u>.

→ resizing pixels and adjusting gray levels

→ videos around 40i mms M.

– false contouring

(12) We often use 8 BITS → 256 levels per color channel

So if we have a R, G, B Image we may say

$$\underset{R}{2^8} \times \underset{G}{2^8} \times \underset{B}{2^8}$$ ___ called 8 bit color Image

Jpeg has this

Lesson is,

* Lower the sampling rate → Blockiness
  (Lower resolution)

* Lower the number of levels → False contouring
  Low detail

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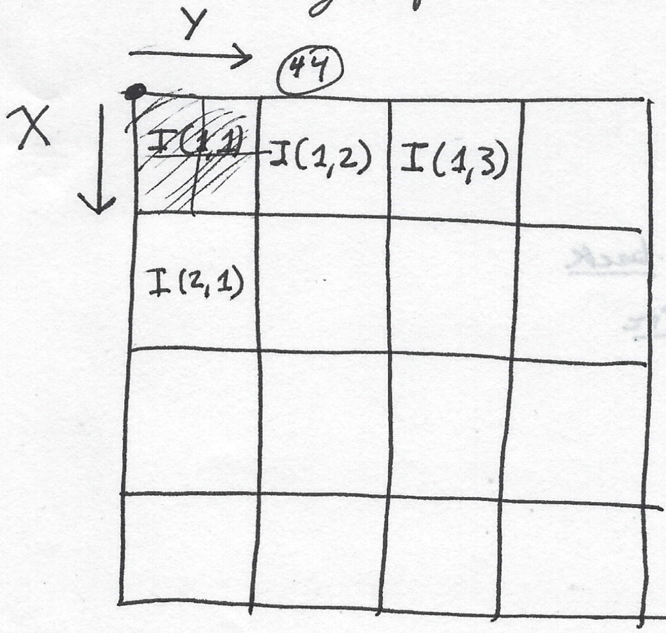
In this class
we think of an image as a 2D array of Numbers

→ we will use gray scale for the concept building.

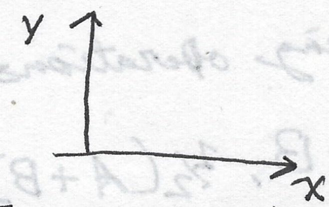
2D array of Numbers




I (Row, column)

I (X , Y)

we may run into problems when we run into cartesian coordinates




→ explain this convention. sometimes the middle is the origin instead of the ~~right~~ left-hand corner

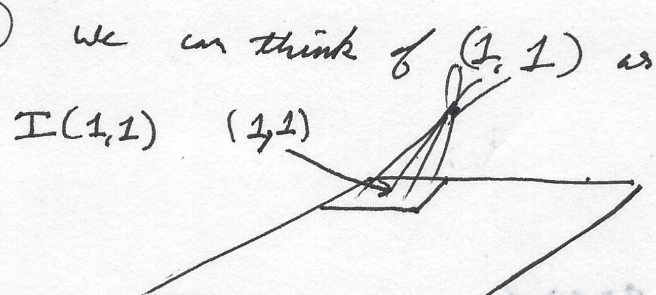
→ Take note of the CCD, we stated the origins of the image to be the center.

→ be mindful of the convention we are using

size 800×600 the old origin may be (-400, -300)

→ explained around 48 - 52 minutes ~~in the~~ into the video

44 we can think of (1, 1) as being the center of pixel




$$I(1,1) = \iint_{\text{SENSOR}} i(x,y)\, r(x,y)\, dx\, dy$$

(14) MATLAB commands

imread

imshow

imshow( . , [ ])   image specified

↳ scale smallest value to back

Largest value to white

rgb2gray

Image processing operations

$A+B$, $A-B$, $\frac{1}{2}(A+B)$

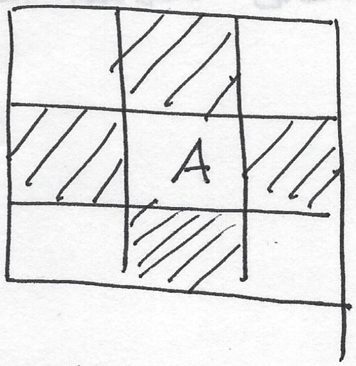
we need to remember a matlab unsigned 8 bit integer uint8 vs double

$$\begin{bmatrix} 0 \\ \vdots \\ 255 \end{bmatrix} * \begin{bmatrix} 1 & \cdots & 1 \end{bmatrix}$$

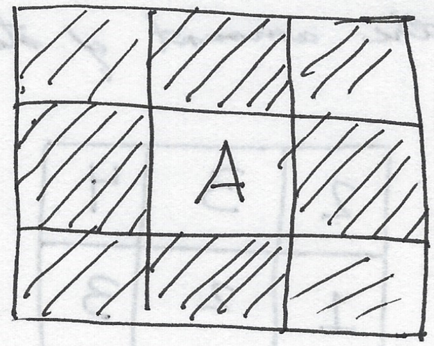
im1 = [0:255]' * ones(1,256);

look at video around 1 in

1:08.25



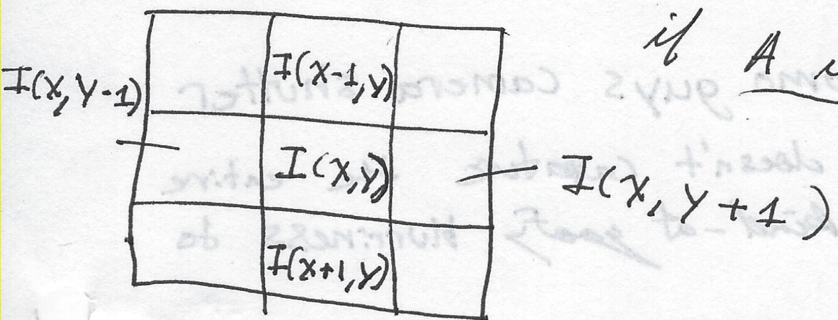

<ins>4 neighbors</ins> of A




8-neighbors of A

As an excersise we may write,

if A is I(x, y)

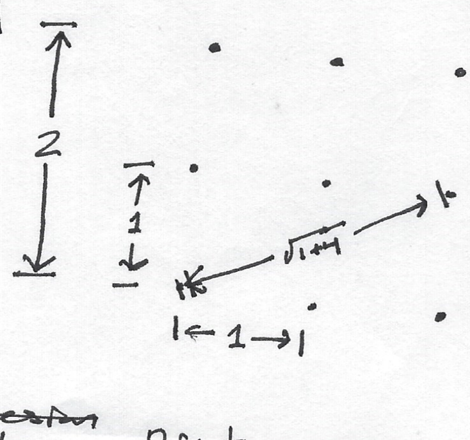



→ we may talk about <ins>distance</ins> <ins>measures</ins>

| | | |
|---|---|---|
| 2 | $\sqrt{5}$ | $2\sqrt{2}$ |
| 1 | $\sqrt{2}$ | $\sqrt{5}$ |
| 0 | 1 | 2 |

→ Think that the centers of the pixel of the start point

with this, we see that




call it ~~cartesian~~ euclidean Distance

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Some times we may talk in a discrete world to refer ~~the~~ to the amount of steps

| | | |
|---|---|---|
| 2 | 3 | 4 |
| 1 | 2 | 3 |
| 0 | 1 | 2 |

"MANHATTAN" City - block

→ Watch on <u>youtube</u> ; slomo guys camera shutter

→ An Image that doesn't capture the entire scene at <u>once</u>. We get a kind-of <u>goofy</u> blurriness to it.