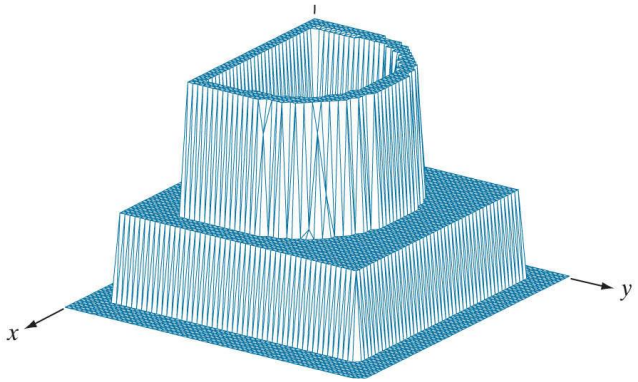
15EEE337 Digital Image Processing

Sarath T.V.

Last Lecture

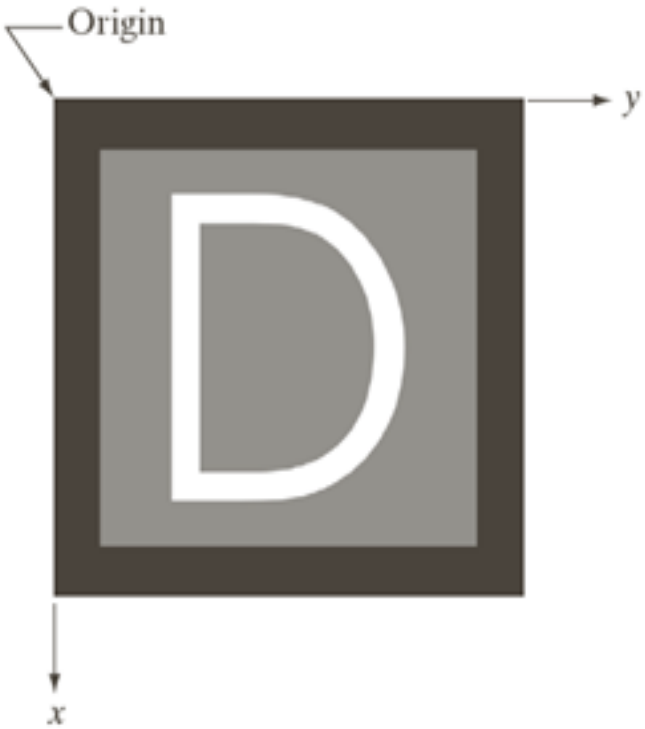
- Image acquisition
  - Single sensor
  - In-line sensor
  - Sensor array
- Sampling and quantization.

Digital image representation



- Surface plot
- As plot/graph with spatial location *(x,y)* as two axes and third axis being the intensities at that specific spatial coordinates.
- Easily infer the structure,
- For complex images its very difficult to interpret from such plot.

Digital image representation



- Visual Intensity array.
- more common.
- Intensity of each point is proportional to the value of *f* at that point.
- Eg-only three equally spaced intensity values.
- Normalized to [0,1],values can be either 0, 0.5, 1.
- A monitor /printer converts these values to either black, gray or white respectively.

Digital image representation

- Displaying the numerical values of *f(x,y)* as a array.
- For large images ,complete array values to be displayed is tedious and nothing much can be inferred from it.
- Only parts of the image are printed as numerical values.

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}$$

- Continuous image to Digital image.
- *f(s,t) -> f(x,y)*
- Matrix representation- M rows & N columns.
- For Image digitization –values of M,N and L (the number of discrete intensity levels) need to be chosen.
- M,N –positive integers.
- L value- depends on digital storage and quantizing hardware considerations
- L is taken as integer power of 2

- Terms - Dynamic range.
- Ratio of maximum measurable intensity to the min detectable intensity level.
- Saturation and noise.
- Highest value beyond which all intensity values are clipped.

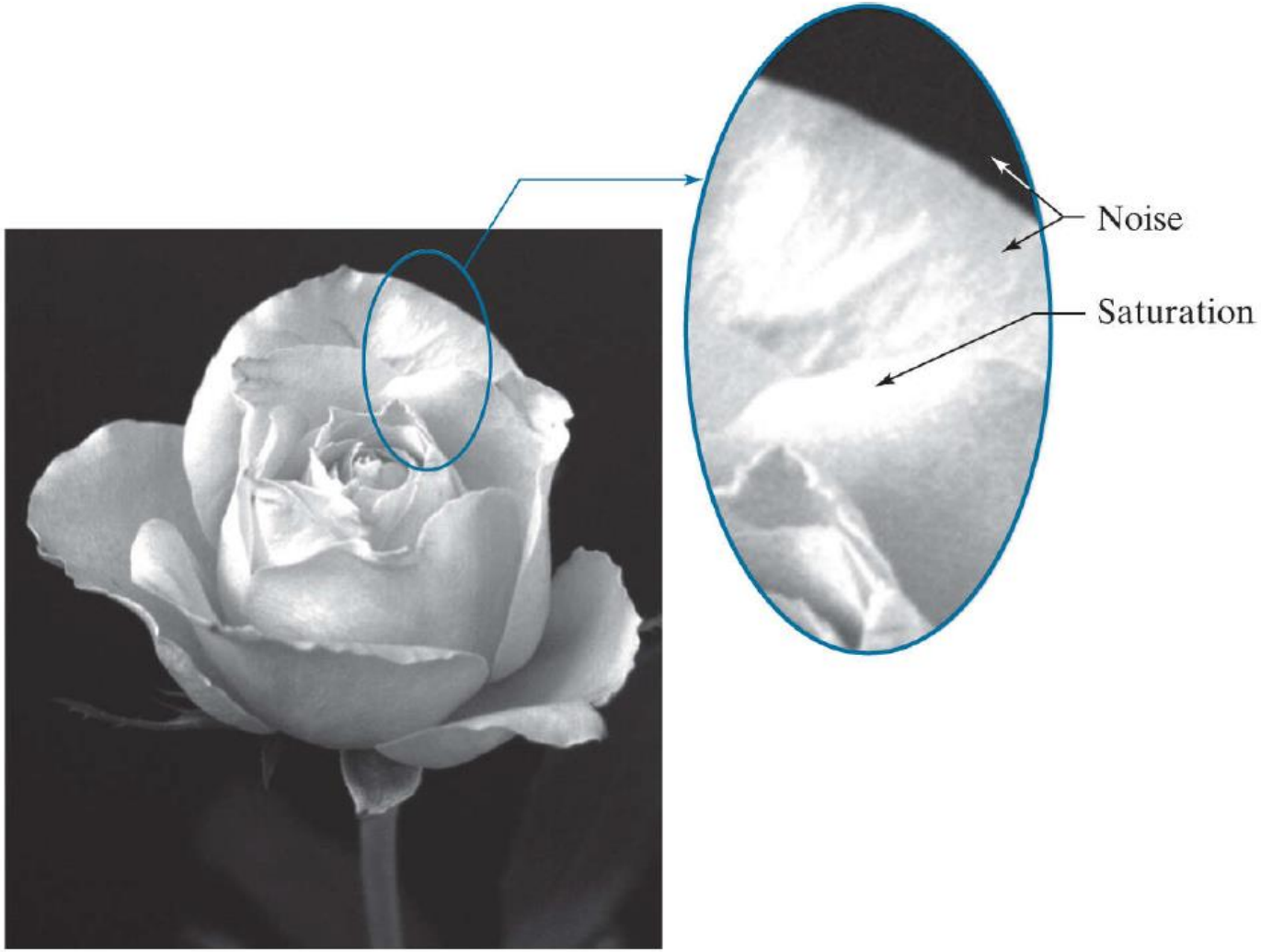

Noise
Saturation

Image Contrast

- Difference in intensity between the highest and lowest intensity level in an image.
- Contrast ratio – highest/lowest intensity level in an image.
- Image with high dynamic range→ expect high contrast.
- Image with low dynamic range→ dull washed out gray look.

K – bit image

Spatial resolution

- Spatial resolution :
  - measure of smallest observable detail in an image.
  - Line pairs per unit distance
  - Pixel (dots) per unit distance.
- dpi (dots per inch) unit in printing and publishing industry.
  - Newspaper -75dpi
  - Magazines - 133 dpi
  - Glossy brochure -175dpi
- Higher Image size means better image ??
  - 1024x1024 image vs 512x512

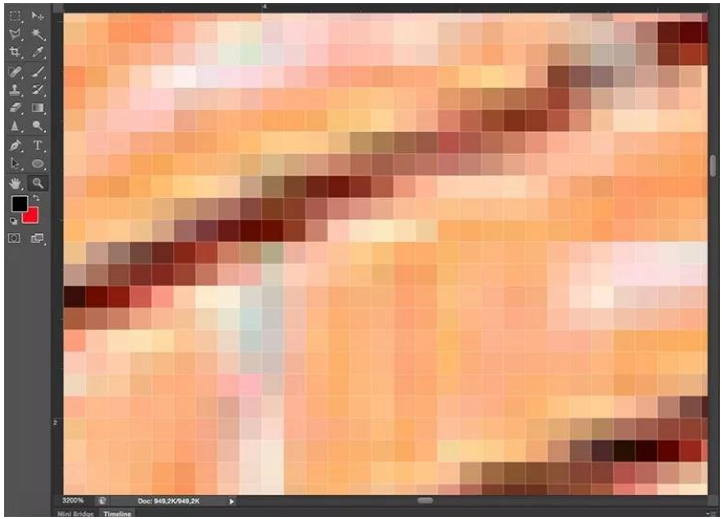
Image at left has a higher *pixel count* than the one to the right, but is still of worse spatial resolution.

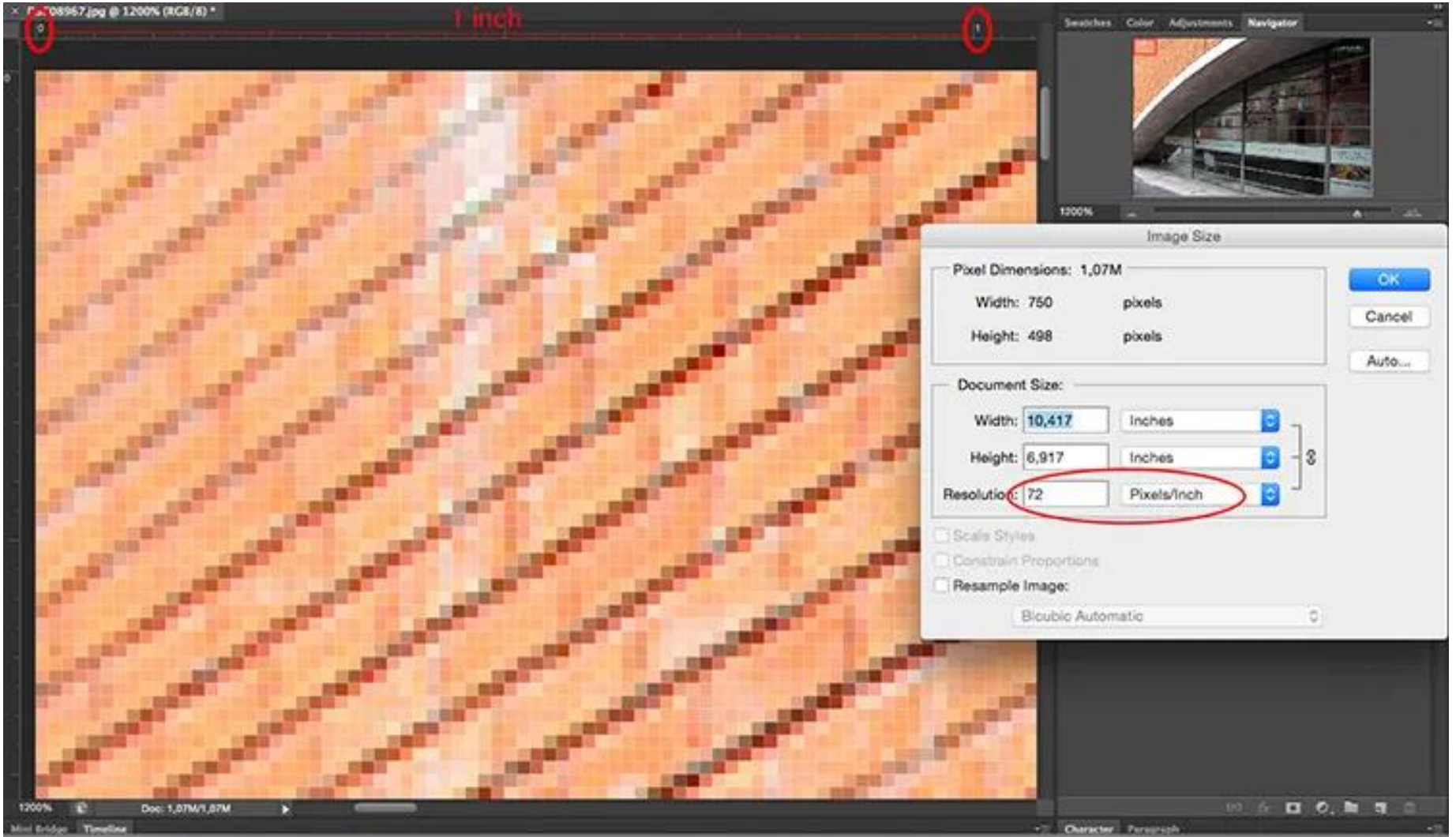
Just make out difference !
Spatial resolution $\neq$ Pixel count

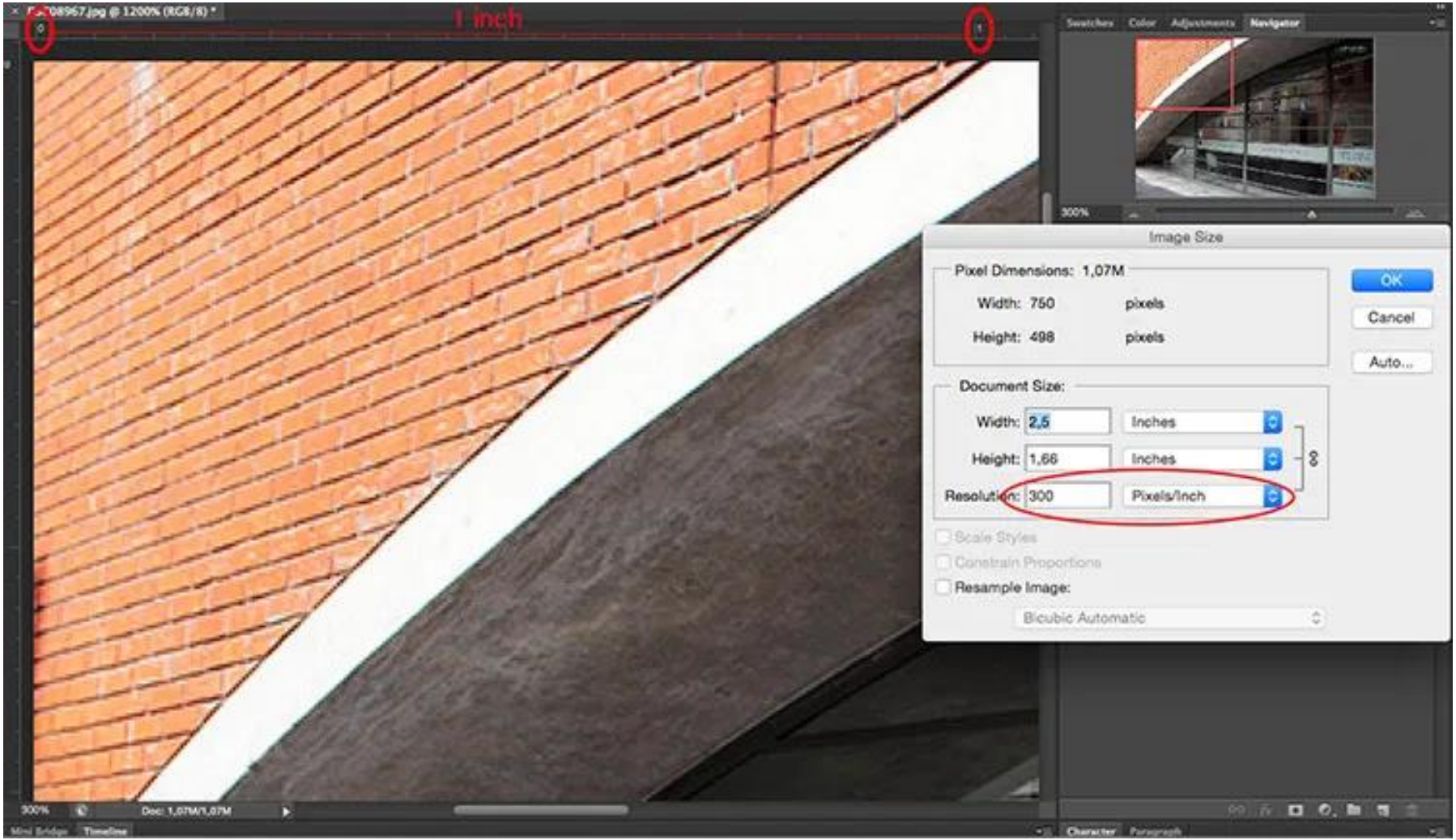
- Image size alone doesn’t mean ,it is a better image. The spatial resolution has to be considered also.

Understanding resolution

- Pixels
- The amount of these pixels and the way they are distributed are the two factors that you need to consider to understand resolution.
- **Pixel count**
- **Pixel density**
- *“a rubber band, you can stretch it or shrink it but you’re not changing the composition of the band, you’re not adding or cutting any of the rubber.”*




1 inch
Swatches
Color
Adjustments
Navigator
1200%
Image Size
Pixel Dimensions: 1,07M
Width: 750 pixels
Height: 498 pixels
OK
Cancel
Auto...
Document Size:
Width: 10,417 Inches
Height: 6,917 Inches
Resolution: 72 Pixels/Inch
Scale Styles
Constrain Proportions
Resample Image:
Bicubic Automatic
1200%
Doc: 1,07M/1,07M
Mini Bridge
Timeline
Character
Paragraph


1 inch
Swatches
Color
Adjustments
Navigator
300%
Image Size
Pixel Dimensions: 1,07M
Width: 750 pixels
Height: 498 pixels
OK
Cancel
Auto...
Document Size:
Width: 2,5 Inches
Height: 1,66 Inches
Resolution: 300 Pixels/Inch
Scale Styles
Constrain Proportions
Resample Image:
Bicubic Automatic
300%
Doc: 1,07M/1,07M
Mini Bridge
Timeline
Character
Paragraph

Last Lecture

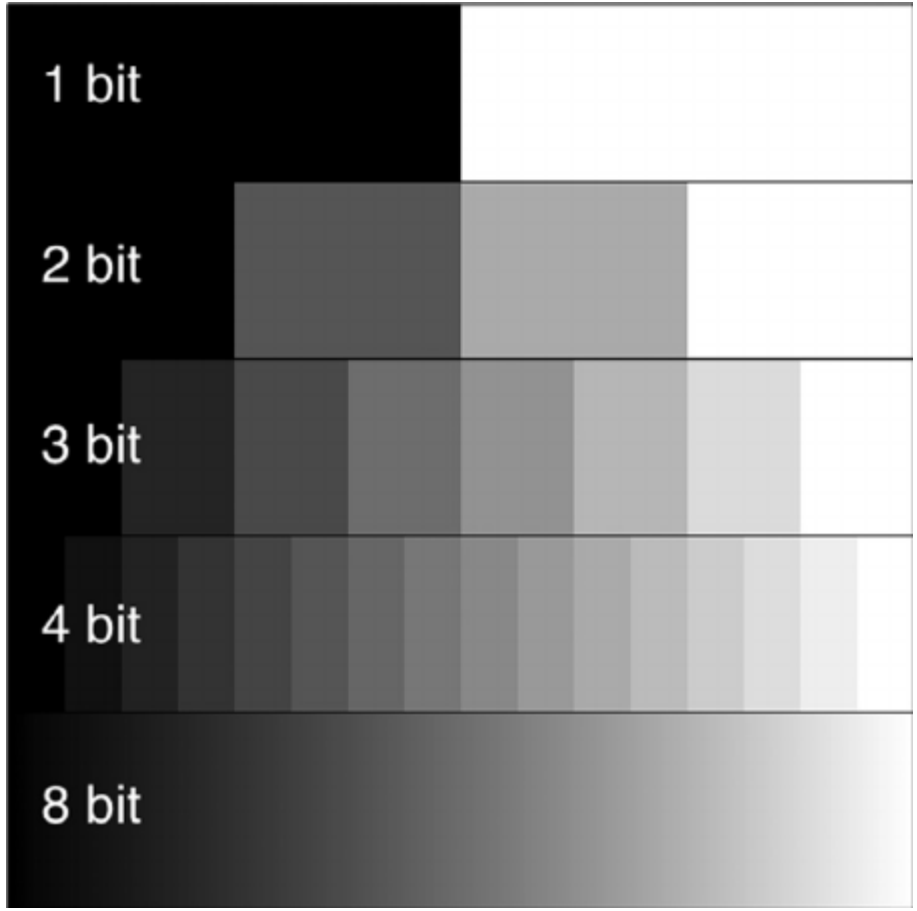
- Digital image representation.
- Dynamic range
- Contrast
- Spatial resolution

Effect of reducing spatial resolution

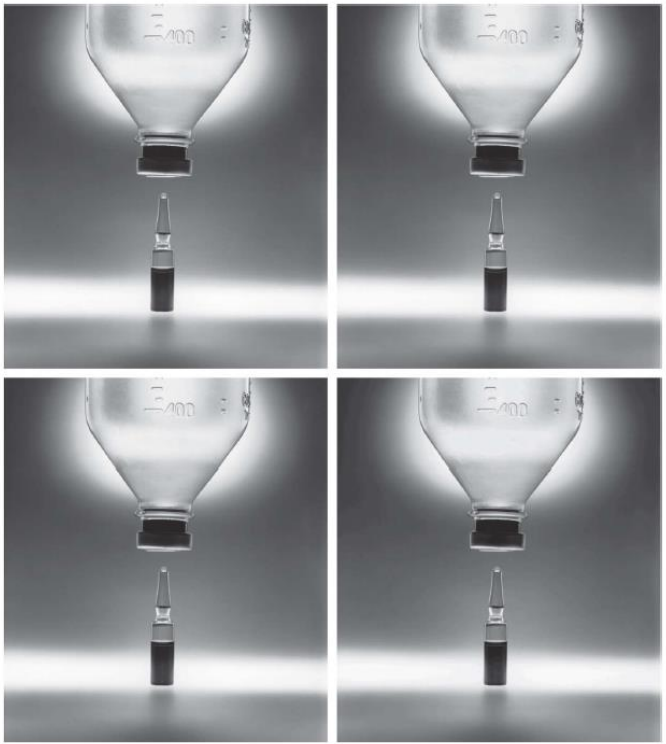
- 1250,300,150 and 72 dpi.
- Slight distortion in the large black needle in the first two images.
- As the resolution reduces the difference in quality or degradation of the image is more visible.

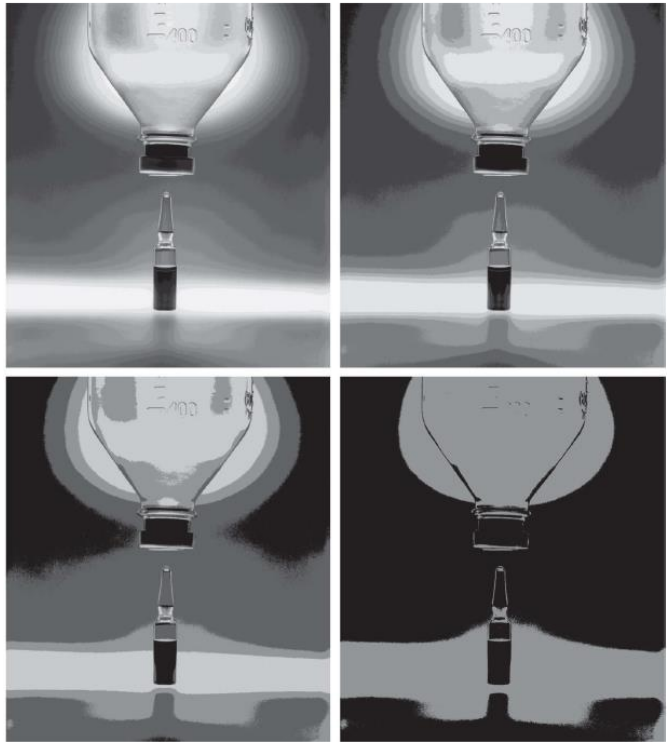
Intensity resolution

- Intensity resolution : Smallest observable change in intensity level.
- Number of bits used to quantize intensity.
- The number of intensity levels is an integer power of 2 .
- Image that is quantized into 256 levels has 8 bit intensity resolution.
- Most common no of bits is 8 bit.
- Capturing small levels of brightness : intensity resolution high.
- For a Intensity profile
- Coarse discretization ,smooth variation /transitions will not be detected properly.


1 bit
2 bit
3 bit
4 bit
8 bit

Effect of intensity resolution reduction





Quantity equals quality ??

- People think that megapixels equal quality
- On top of the quantity you should also consider the depth of the pixels, this is what determines the amount of tonal values that your image will have.
- For example,
  - a 2-bit depth can store only black, white and two shades of grey,
  - With an 8-bit photo (2 to the power of 8 = 256) you'll have 256 tones.

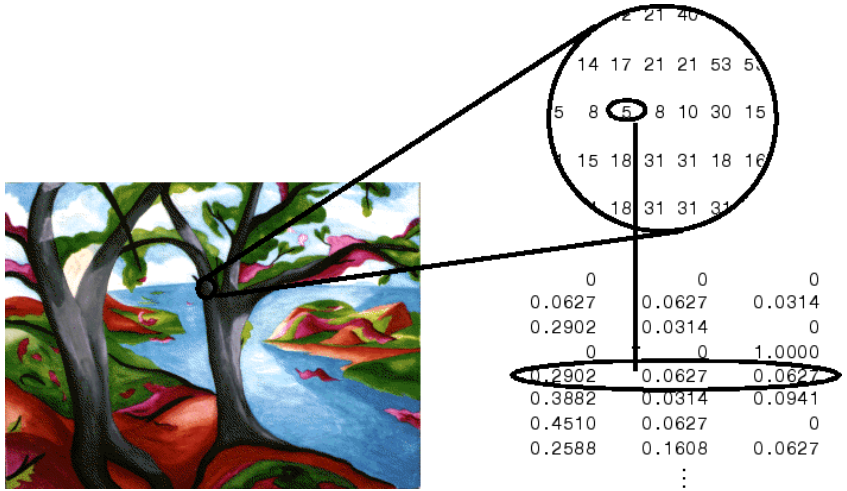
Role of image size

- Higher resolution means a sharper image??
- True only if all images were the same size. But hardly it’s the case.
- Quality of image depends –density and image size.
- Pixels in a images – fixed.
- If we try to change physical size of image- changes number of pixels per inch.→ lower dpi.

Reducing number of pixels

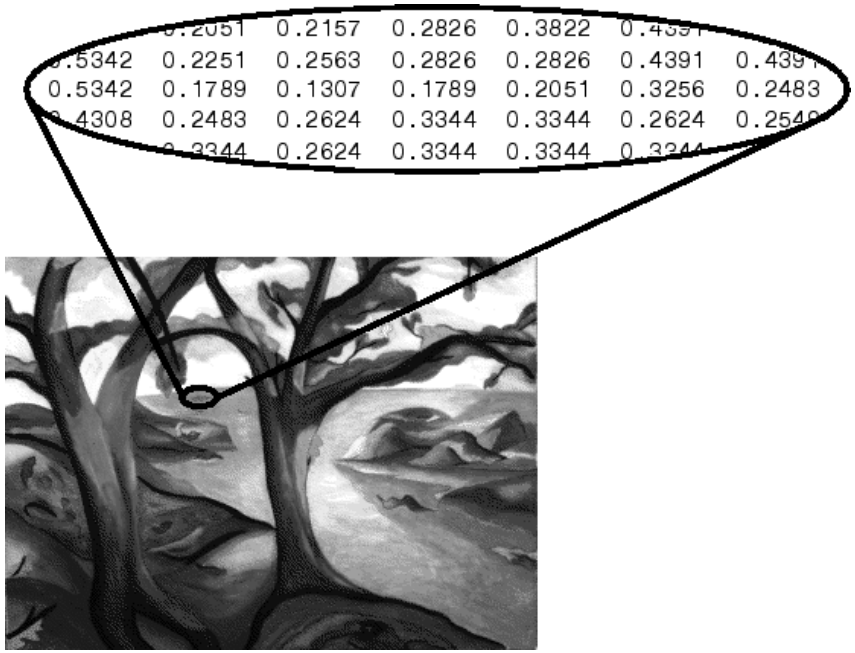
Types of images

- **Indexed Images**
- An indexed image consists of a data matrix, X, and a colormap matrix, map. map is an m-by-3 array of class double containing floating-point values in the range [0, 1].
- Each row of map specifies the red, green, and blue components of a single color.
- An indexed image uses “direct mapping” of pixel values to colormap values.
- The color of each image pixel is determined by using the corresponding value of X as an index into map. Values of X therefore must be integers. The value 1 points to the first row in map, the value 2 points to the second row, and so on



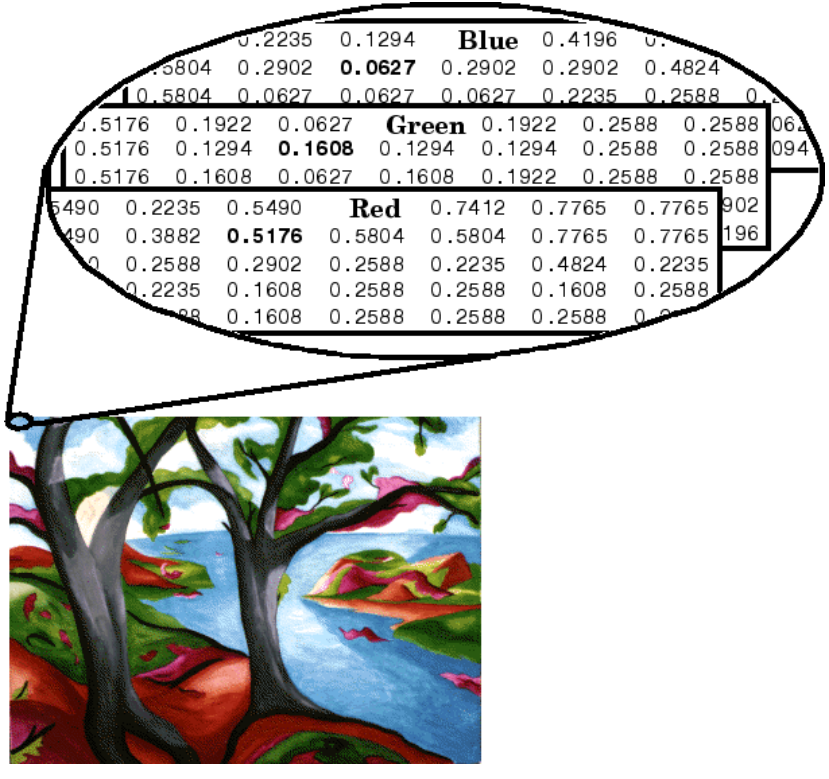
Grayscale (Intensity) Images

- A grayscale image, sometimes referred to as an intensity image, is a data matrix I whose values represent intensities within some range.
- A grayscale image is represented as a single matrix, with each element of the matrix corresponding to one image pixel.



RGB (Truecolor) Images

- An RGB image, sometimes referred to as a truecolor image, is stored as an *m-by-n-by-3* data array that defines red, green, and blue color components for each individual pixel.
- The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location.




THANK
YOU