Introduction to Image Processing

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What is an Image?

- A digital representation of a real-world scene. (Graphics is the digital representation of an imaginary scene.)
- Composed of discrete elements generally called picture element (or pixels for short)
- Pixels are parameterized by
  - position
  - intensity
  - time
- In all combinations, these parameters define still images, video, volume data and moving volumes

Digital Photographs

- Two spatial parameters
  - x, or horizontal position
  - y, or vertical position
- Three intensity parameters
  - Red
  - Green
  - Blue

Ultrasound

- Two spatial parameters – x and y
- One intensity parameter – ultrasound reflection
- One time parameter (ultrasound printouts don't show this, but the exam does)

image from http://whyfiles.org/coolimages/images/csi/ultrasound.jpg

Digital X-ray

- Two spatial parameters – x and y
- A single intensity parameter – x-ray attenuation

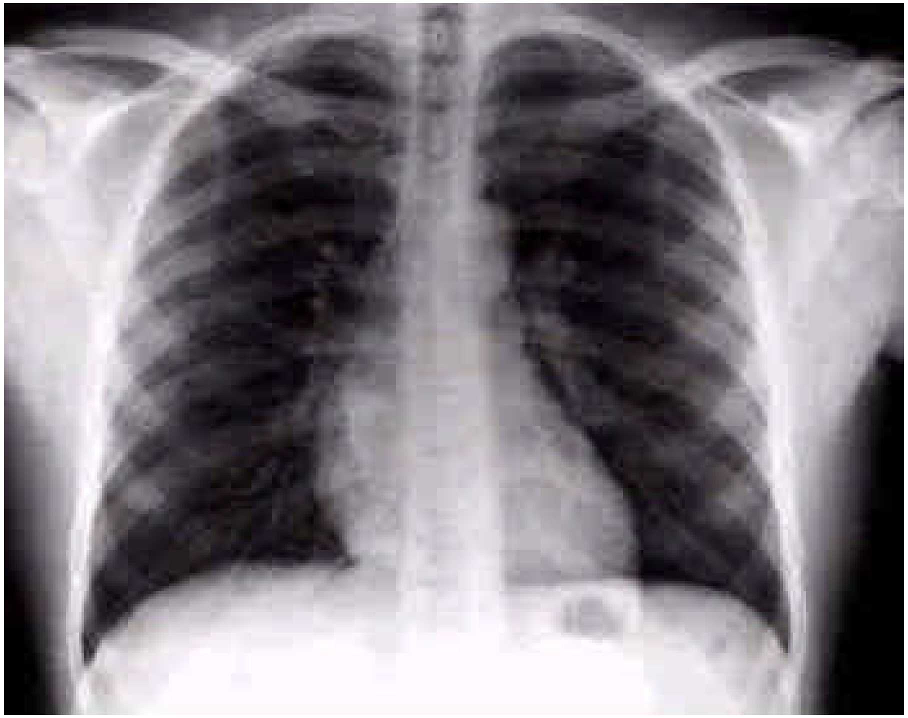


image from http://www.smm.org/heart/lessons/jpgs/full/xray.jpg

Digital Video

- Two spatial parameters
  - x, or horizontal position
  - y, or vertical position
- Three intensity parameters
  - Red
  - Green
  - Blue
- One time parameter – frame #

Other Kinds of Images

- Computed Tomography – 3 dimensional x-ray images of the human body
- Satellite images – 4 intensities – red, green, blue and infrared
- Functional Magnetic Resonance Images – 3 dimensional images of the human body over time
- Not all images represent visual phenomena but a visualization can be a very effective way to understand the phenomena

Talking about a Pixel

- Give the image a name; usually I or f
- Specify all the parameters (space, time) of your image
- The result is the intensity
- For example, a digital image I might have intensity (23, 23, 97) at pixel I(32,215)
  - intensity 23 in red
  - intensity 23 in green
  - intensity 97 in blue
  - at the 32nd column
  - at the 215th row
- A CT image f might have intensity 255 at f(67, 95, 13)

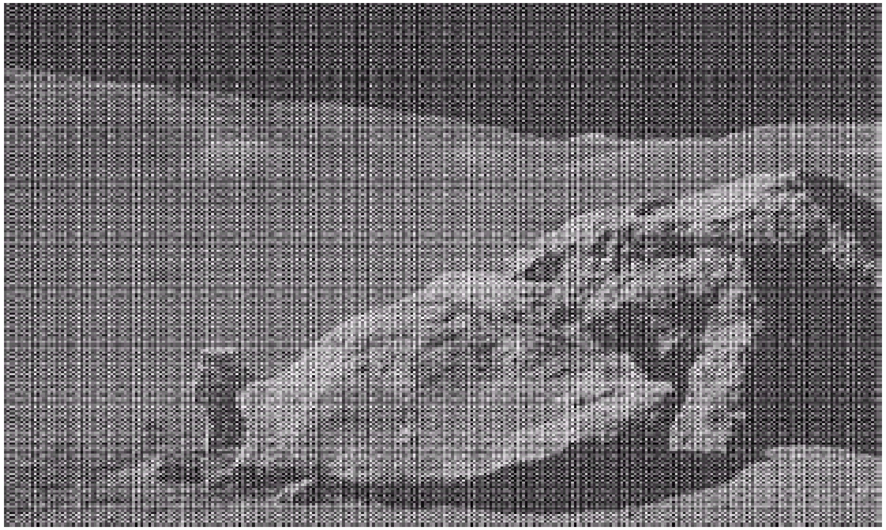
What is Image Processing

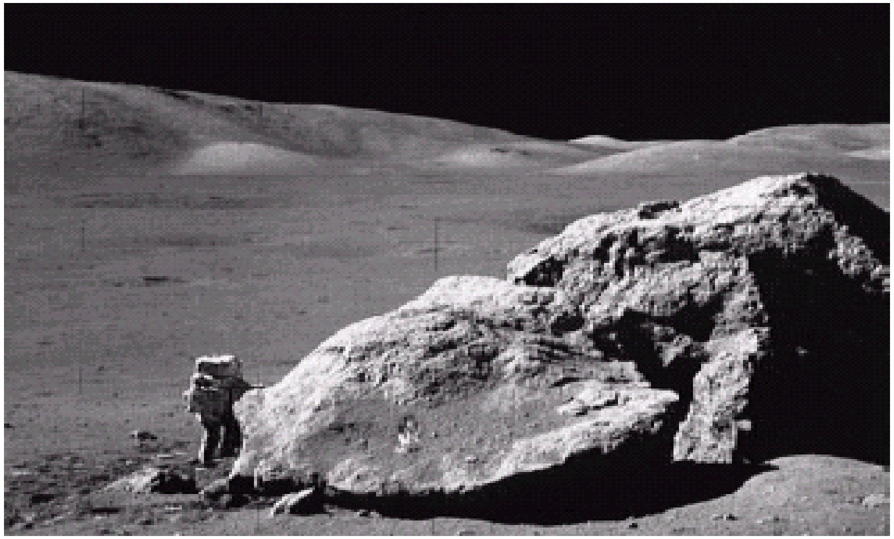
- Image processing typically attempts to accomplish one of three things
  - restoring images
  - enhancing images
  - understanding images
- Restoration takes a corrupted image and attempts to recreate a clean original
- Enhancement alters an image to makes its meaning clearer to human observers
- Understanding usually attempts to mimic the human visual system in extracting meaning from an image

Image Restoration

- Image restoration is important for two main applications
  - removing sensor noise
  - restoring old, archived film and images
- Many sensors are subject to noise, thus producing corrupted images that don't reflect the real world scene accurately
- Old photograph and film archives often show considerable damage

Restoration Example





Images from Digital Image Processing, Gonzalez and Woods

Restoration Example

Images from http://www.screengenes.com/drest_3.html

Image Enhancement

Images courtesy of Tobey Thorn
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- Often used to increase the contrast in images that are overly dark or light
- Enhancement algorithms often play to humans’ sensitivity to contrast
- More sophisticated algorithms enhance images in a small neighborhood, allowing overall better enhancement.

Image Understanding

- Image understanding includes many different tasks
  - segmentation
  - classification
  - interpretation
- Segmentation involves identifying objects in an image
- Classification assigns labels to individual pixels
- Interpretation extracts some meaning from the image as a whole
- Leads to such fields as image analysis, computer vision and visual computing

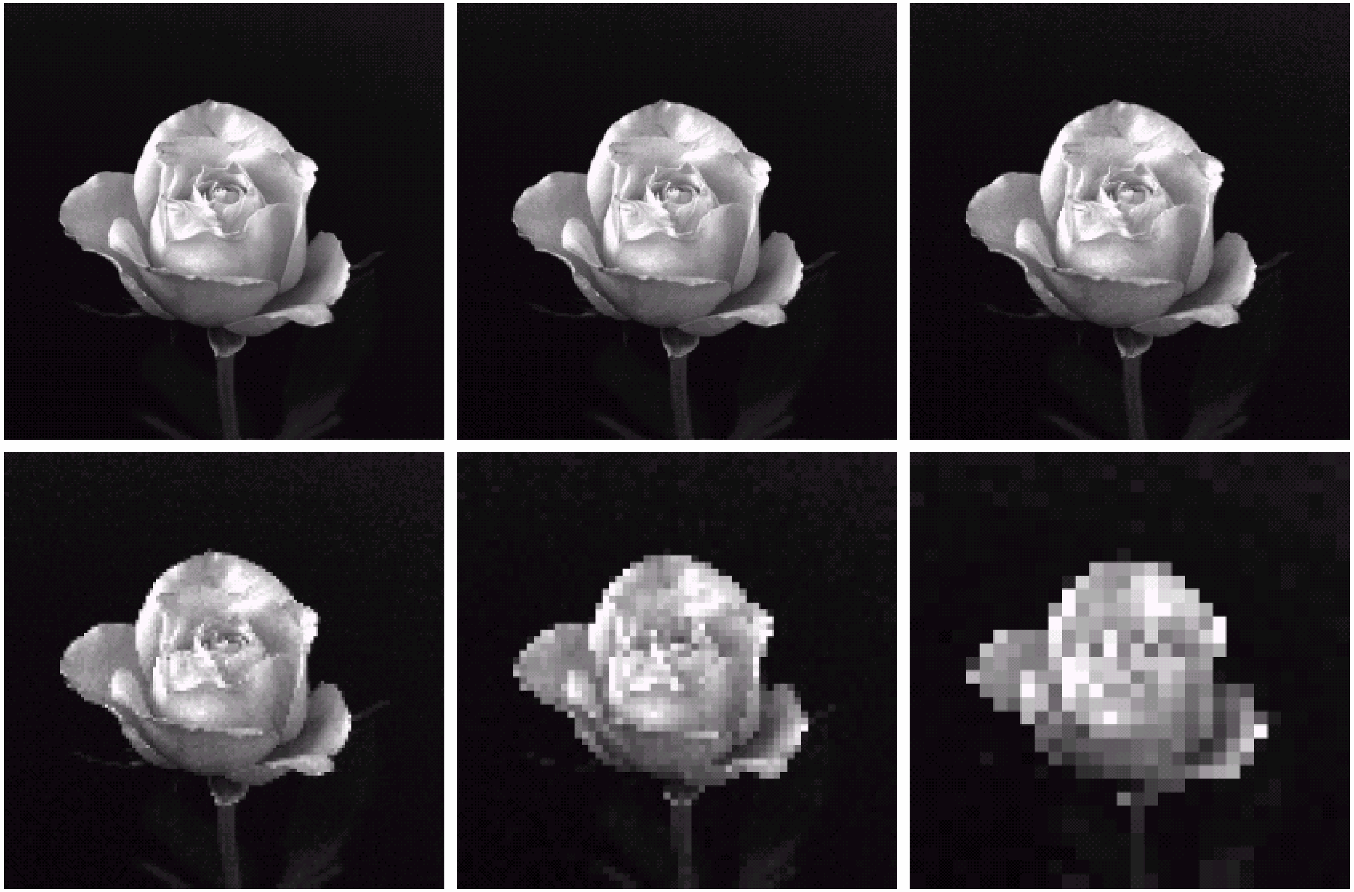
Creating Images

- The creation of images involves two main tasks
  - spatial sampling, which determines the resolution of an image
  - quantization, which determines how many intensity levels are allowed
- Spatial sampling determines what level of detail can be seen
  - finer sampling allows for smaller detail
  - finer sampling requires more pixels and “larger” images
- Quantization determines how “smooth” the contrast changes in the image are
  - finer quantization will prevent “false contouring” (artificial edges)
  - courser quantization allows for compressing images

Effect of Spatial Sampling

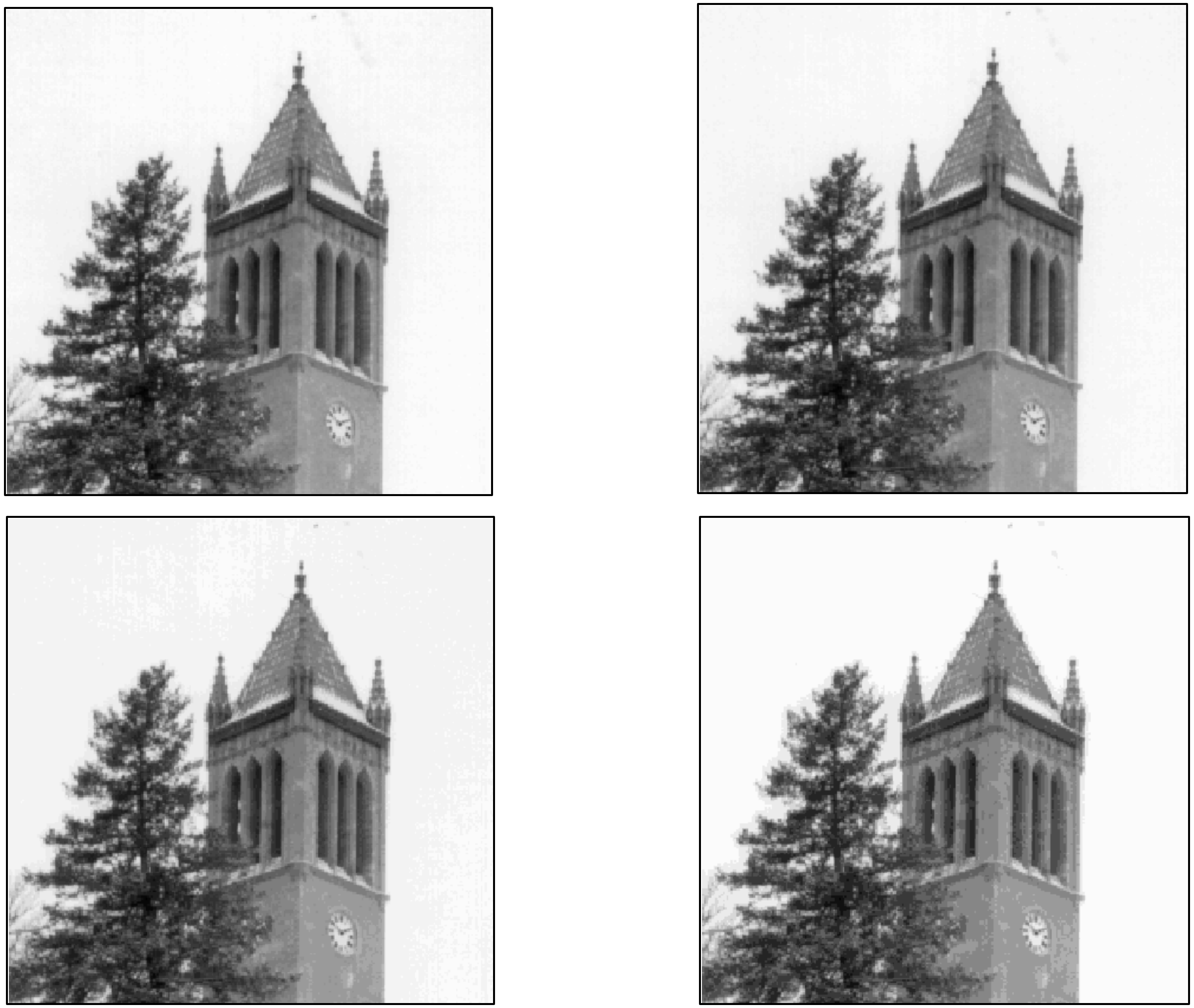
Images from Digital Image Processing, Gonzalez and Woods

Effect of Spatial Sampling



Images from Digital Image Processing, Gonzalez and Woods

Effect of Quantization



Images from Digital Image Processing, Gonzalez and Woods

Effect of Quantization

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