What is an image? - The bitmap representation

* Also called “raster or pixel maps” representation
* An image is broken up into a grid

Original picture \( f(x, y) \)

Digital image \( I[i, j] \) or \( I[x, y] \)

What is an image? - The vector representation

* Object-oriented representation
* Does not show information of individual pixel, but information of an object (circle, line, square, etc.)

Circle(100, 20, 20)
Line(x1, y1, x2, y2)
Line(x1, y1, x2, y2)
Line(x1, y1, x2, y2)
Line(x1, y1, x2, y2)
Comparison

* Bitmap
  - Can represent images with complex variations in colors, shades, shapes.
  - Larger image size
  - Fixed resolution
  - Easier

* Vector
  - Can only represent simple line drawings (CAD), shapes, shadings, etc.
  - Efficient

How did it start?

* Early 1960s
* NASA’s Jet Propulsion Laboratory (JPL)
* Process video images from spacecraft (Ranger)
* IBM 360 Computer


Why image processing?

* Application
  - Fingerprint retrieval
  - Automatic target recognition
  - Industrial inspection
  - Medical imaging
  - and more...

* Can commercial software do all the work?
Histogram Equalization

GLG in HSI space – better than Photoshop result

GLG in RGB space

Photoshop “Auto Contrast” result

Some clarification

* Image & Graphics
* Image processing & Computer vision
* Image processing & Image understanding
* Image processing & Pattern recognition
  – Image Processing: ECE472, ECE572
  – Pattern Recognition: ECE471, ECE571
  – Computer Vision: ECE573
  – Computer Graphics: CS494, CS594

Goals of image processing

* Image improvement
  – Improving the visual appearance of images to a human viewer
* Image analysis
  – Preparing images for measurement of the features and structures present
What to learn?

- Image Acquisition
- Image Enhancement
- Image Restoration
- Image Compression
- Image Coding
- Morphological Image Processing
- Wavelet Analysis
- Image Improvement
- Image Analysis
- Image Segmentation
- Representation & Description
- Recognition & Interpretation
- Knowledge Base

Image acquisition

- Video camera
- Infrared camera
- Range camera
- Line-scan camera
- Hyperspectral camera
- Omni-directional camera
- and more …

Some simple operations
Image enhancement

Movie film restoration

Image restoration
Image correction

- Geometric correction
- Radiometric correction

Image warping – geometric transformation

Image warping – another example

From Joey Howell and Cory McKay, ECE472, Fall 2000
Image segmentation

Image description

- OCR – optical character recognition, license plate recognition

Beyond

- Content-based image retrieval
- Human identification
- Multi-sensor data fusion
- Hexagonal pixel
- Steganography
Image processing for fine arts

Real-world reasoning demo

How to address pixels of an image?

```c
int i, j, k;
int nr, // number of rows
    nc, // number of columns
    nchan; // number of channels

nr = 128; nc = 128; nchan = 3;
for (i=0; i<nr; i++) {
    for (j=0; j<nc; j++) {
        for (k=0; k<nchan; j++) {
            // do the processing on (i, j, k);
            ...
        }
    }
}
```
Types of neighborhoods

* Neighbors of a pixel

\[(i, j), (i, j+1), (i, j-1), (i-1, j), (i+1, j), (i+1, j+1), (i+1, j-1), (i-1, j-1)\]

Closedness ambiguity

The Image library

* /include: the header file
  - Image.h
  - Dip.h
* /lib: image processing routines
  - Image.cpp
  - colorProcessing.cpp
  - imageIO.cpp
  - matrixProcessing.cpp
  - cs.cpp
* /test: the test code
The course website

* [http://web.eecs.utk.edu/~qi/ece472-572](http://web.eecs.utk.edu/~qi/ece472-572)

Course information
* Official language: C++
* Pre-homework assignment
  – Subscribe to mailing list, dip@aicip.ece.utk.edu
* Grading policy: 72 late hour rule

What to do?
* Subscribe to the mailing list
  – dip@aicip.ece.utk.edu
* Apply for an account in FH417
* Get started on project 1
  – Start early and finish early