Introduction: What is Image Processing?

CS 4640: Image Processing Basics

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What is Image Processing?

Definition

Image processing is the study of any algorithm that takes an image as input and returns an image as output.

Includes:

- Image display and printing
- Image editing and manipulation
- Image enhancement
- Feature detection
- Image compression

Applications of Image Processing

Astronomy

Biology



Credit: Dartmouth Electron Microscopy Facility



Credit: NASA, Jeff Hester, and Paul Scowen (Arizona State) More info here

Applications of Image Processing

Medicine

Security, Biometrics





Credit: Dr. Janet Lainhart, UofU Psychiatry

Applications of Image Processing

Satellite Imagery



Credit: NASA

Personal Photos



Credit: Tom Fletcher

Example: Noise Removal

Noisy Image

Denoised Image





Example: Contrast Adjustment







Low Contrast

Original Contrast

High Contrast

Example: Edge Detection



Example: Region Detection, Segmentation



Example: Image Compression



Original, 2.1MB



JPEG Compression, 308KB (15%)

Example: Digital Inpainting

Damaged Image

Restored Image



Credit: M. Bertalmio, G. Sapiro, V. Caselles, C. Ballester: Image Inpainting, SIGGRAPH 2000

Relationship to Other Fields

- Image Analysis involves extracting meaningful information from an image
 - Image segmentation
 - Image matching and comparison
 - Medical diagnosis from an image
- Computer Vision strives to emulate the human visual system and interpret our 3D world from 2D images or video
 - Object recognition
 - Motion tracking
 - 3D shape from multiple 2D images



Computer Vision

Object detection, recognition, shape analysis, tracking Use of Artificial Intelligence and Machine Learning

Image Analysis

Segmentation, image registration, matching

Low-level

Image Processing

Image enhancement, noise removal, restoration, feature detection, compression

Relationship to Graphics and Visualization

- Computer Graphics and Visualization deal with the synthesis of images
- Image processing techniques are often used to improve the visual quality of synthesized images
- Examples:
 - Image enhancement
 - Compression
 - Image warping, blending and morphing

Graphics Example: Anti-aliasing



Aliased Rendering



Anti-aliased Rendering

Mathematics in Image Processing

- Calculus
- Linear Algebra
- Probability and Statistics
- Differential Equations (ODEs and PDEs)
- Differential Geometry
- Harmonic Analysis (Fourier, wavelets, etc)