

Introduction to Image Analysis

Introduction to Image Analysis

Field: Computer Vision / Digital Image Processing

1. What Is Image Analysis?

Aspect	Description
Definition	The process of extracting meaningful information (features, patterns, measurements) from digital images.
Goal	Transform raw pixel data into higher-level knowledge (e.g., object detection, classification, scene understanding).
Typical Pipeline	Acquisition ? Pre-processing ? Feature Extraction ? Interpretation ? Decision / Output

2. Types of Images

Category	Examples	Typical Use-Cases
Gray-scale	Single channel (intensity) images	Medical imaging (X-ray), document analysis
Color	RGB, HSV, Lab, etc.	Natural scene analysis, remote sensing
Multispectral / Hyperspectral	>3 spectral bands	Agriculture, mineral detection
3D / Volumetric	CT, MRI, LiDAR point clouds	Biomedical volume analysis, robotics
Temporal (Video)	Sequence of frames	Motion tracking, activity recognition

3. Core Concepts & Terminology

Term	Meaning
Pixel	Smallest image element; stores intensity (gray) or color values (RGB).
Resolution	Number of pixels (spatial) – e.g., 1920×1080.
Bit depth	Number of bits per pixel (e.g., 8-bit = 256 gray levels).

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Term	Meaning
Noise	Random variations (sensor, transmission) that degrade image quality.
Contrast	Difference between dark and bright regions; essential for feature visibility.
Histogram	Distribution of pixel intensities; used for analysis and enhancement.
Edge	Boundary where intensity changes sharply; fundamental for shape detection.
Region	Set of connected pixels sharing similar attributes (intensity, color, texture).
Feature	Quantitative descriptor (e.g., edge, corner, texture, shape).
Segmentation	Partitioning an image into meaningful regions.
Classification	Assigning a label to an entire image or a region based on its features.

4. Pre-processing Techniques

Technique	Purpose	Typical Methods
Noise Reduction	Suppress random fluctuations	Gaussian blur, median filter, bilateral filter
Contrast Enhancement	Stretch intensity range	Histogram equalization, CLAHE (Contrast-Limited AHE)
Geometric Corrections	Align or rectify images	Rotation, scaling, perspective transform
Color Space Conversion	Simplify analysis	RGB → HSV/Lab/YCbCr (separate luminance from chrominance)
Normalization	Standardize intensity range across datasets	Min-max scaling, Z-score normalization

5. Feature Extraction

Category	Representative Methods	What It Captures
Edge / Corner	Sobel, Canny, Harris, Shi-Tomasi	Shape, object boundaries
Texture	Gray-Level Co-Occurrence Matrix (GLCM), Local Binary Patterns (LBP), Gabor filters	Repetitive patterns, surface properties
Shape	Hu moments, Fourier descriptors, contour analysis	Geometry, object outline
Color	Color histograms, color moments, color correlograms	Distribution of hues, saturation, brightness

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Category	Representative Methods	What It Captures
Keypoint / Descriptor	SIFT, SURF, ORB	