

Unit 3: Images and Graphics (5 LH)

3.1 Digital Image Representation

A digital image is a numerical representation of a two-dimensional visual object. It is composed of individual elements called **pixels** (picture elements), each having a specific location and color value.

Key Concepts in Digital Image Representation

1. Pixels:

- The smallest unit of a digital image.
- Represented as points or squares arranged in a grid.
- Each pixel has an intensity value that determines its color or shade.
- Higher resolution images have more pixels, providing greater detail.

2. Resolution:

- Number of pixels in an image, usually specified as width × height (e.g., 1920 × 1080).
- Higher resolution means more detail but requires more storage space.

3. Color Models:

- **Grayscale:** Images with shades of gray ranging from black (0) to white (255 for 8-bit images).
- **RGB (Red, Green, Blue):** Most common model for colored images. Each pixel has three values (R, G, B).
- **CMYK (Cyan, Magenta, Yellow, Black):** Used in printing.
- **YUV/YCrCb:** Used in video and TV broadcasting.

4. Bit Depth:

- Determines the number of colors or shades per pixel.
 - Example:
 - **1-bit:** Black and white only.
 - **8-bit:** 256 shades of gray or colors.
 - **24-bit:** Over 16 million colors (8 bits for each of RGB).
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Image Formats and Storage Formats

Digital images can be stored in various formats, depending on the required quality, compression, and intended application.

1. Raster Formats (Pixel-Based):

Store images as a grid of colored pixels.

- **Examples:**
 - **BMP:** Uncompressed; large file size; used for simple storage.
 - **JPEG:** Compressed format; supports lossy compression; commonly used in photography.
 - **PNG:** Lossless compression; supports transparency.
 - **GIF:** Supports animation; limited to 256 colors.

Example: PNG vs. JPEG

- PNG: Higher quality, larger file size, supports transparency.
- JPEG: Compressed, smaller file size, no transparency support.

2. Vector Formats (Mathematical Representation):

Store images as geometric shapes, paths, and text rather than pixels.

- **Examples:**

- **SVG:** Scalable Vector Graphics, commonly used for web and UI design.
- **EPS:** Used in professional printing.

3. Hybrid Formats: Combine raster and vector data.

- **Example:** PDF (Portable Document Format).

Image Storage Formats

1. Raw Formats:

- Captures unprocessed image data from devices like cameras.
- Example: **RAW**, **DNG**.

2. Compressed Formats: Reduce file size by eliminating redundancy.

- **Lossy Compression:** Reduces quality but significantly decreases file size (e.g., JPEG).
- **Lossless Compression:** Maintains original quality (e.g., PNG, GIF).

3. Application-Specific Formats: Designed for specific applications.

- Example: **TIFF** for printing and publishing.

3.2 Image and Graphics Formats

Image and graphics formats define how visual information is stored, compressed, and presented digitally. Each format is designed for specific use cases, balancing factors like quality, file size, compatibility, and intended application.

Categories of Image and Graphics Formats

1. Raster Formats

- Represent images as a grid of pixels, where each pixel has a color value.
- Best suited for photographs and images with complex details.

2. Vector Formats

- Store images as mathematical paths, shapes, and text rather than pixels.
- Ideal for illustrations, logos, and designs that require scalability.

3. Hybrid Formats

- Combine features of both raster and vector formats for specific applications.
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Common Image and Graphics Formats

1. Raster Formats

- **BMP (Bitmap):**
 - Stores uncompressed images pixel by pixel.
 - Large file sizes and high quality.
 - Use Case: Basic image editing, older applications.
- **JPEG (Joint Photographic Experts Group):**
 - Compressed format with lossy compression.
 - Reduces file size at the cost of some quality.
 - Use Case: Digital photography, web images.
- **PNG (Portable Network Graphics):**
 - Supports lossless compression and transparency.
 - Use Case: Web design, images with sharp edges or text.
- **GIF (Graphics Interchange Format):**
 - Limited to 256 colors but supports animation.
 - Use Case: Simple animations, memes.
- **TIFF (Tagged Image File Format):**
 - High-quality format, supports lossless compression.
 - Use Case: Professional printing, image archiving.

2. Vector Formats

- **SVG (Scalable Vector Graphics):**
 - XML-based, allowing scalability without losing quality.
 - Use Case: Web graphics, icons, logos.
- **EPS (Encapsulated PostScript):**
 - Supports both vector and raster elements.
 - Use Case: Professional design and printing.
- **PDF (Portable Document Format):**
 - Versatile format combining text, vector, and raster graphics.
 - Use Case: Document sharing, printing.

3. Hybrid Formats

- **PSD (Photoshop Document):**
 - Proprietary format for Adobe Photoshop.
 - Supports layers and multiple elements.
 - Use Case: Advanced image editing.
- **RAW:**
 - Captures unprocessed image data from digital cameras.
 - Requires post-processing.
 - Use Case: Professional photography.

Comparison of Key Formats

Format	Type	Compression	Transparency	Scalability	Best Use Case
BMP	Raster	None	No	No	Basic image editing
JPEG	Raster	Lossy	No	No	Photos, web graphics
PNG	Raster	Lossless	Yes	No	Transparent images, web design
GIF	Raster	Lossless	Yes	No	Simple animations, memes
TIFF	Raster	Lossless	Yes	No	High-quality printing
SVG	Vector	None	Yes	Yes	Web icons, logos
EPS	Vector	None	Yes	Yes	Professional design
RAW	Hybrid	None	No	No	Professional photography

Choosing the Right Format

- Web and Digital Media:**
 - Use **JPEG** for photos and **PNG** for sharp images or transparency.
 - Print Media:**
 - Use **TIFF** or **EPS** for high-quality output.
 - Scalable Graphics:**
 - Use **SVG** for logos and icons that need to scale.
 - Animation:**
 - Use **GIF** for simple animated graphics.
 - Professional Photography:**
 - Use **RAW** for unprocessed, high-quality image data.
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3.3. Image Synthesis, Analysis, and Transmission

Image Synthesis

- Definition:** Image synthesis refers to creating images through computational techniques rather than capturing them with a camera.
- Techniques:**
 - Rendering:** Transforming 3D models into 2D images by simulating light and materials.

- **Ray Tracing:** Simulates light paths to create photorealistic images.
- **Rasterization:** Converts vector graphics into raster images for display.
- **Texture Mapping:** Adds details to 3D models by applying textures.
- **Applications:**
 - **Movies and Animation:** Creating CGI effects.
 - **Games:** Real-time rendering of scenes.
 - **Virtual Reality (VR):** Immersive environments.

Image Analysis

- **Definition:** Extracting meaningful information from images for interpretation or decision-making.
- **Key Techniques:**
 - **Edge Detection:** Identifying boundaries of objects.
 - **Segmentation:** Dividing an image into regions or objects.
 - **Pattern Recognition:** Identifying specific features or objects.
- **Applications:**
 - **Medical Imaging:** Analyzing X-rays or MRIs.
 - **Security:** Face or license plate recognition.
 - **Industrial Automation:** Defect detection in manufacturing.

Image Transmission

- **Definition:** The process of sending images across networks.
- **Key Concepts:**
 - **Compression:** Reducing image size to save bandwidth (e.g., JPEG, PNG).
 - **Protocols:** Ensuring data reliability (e.g., HTTP, FTP).
 - **Streaming:** Delivering images or videos in real time.
- **Challenges:**
 - Bandwidth limitations.
 - Latency during transmission.
 - Image degradation due to compression.

1 Computer Image Processing

- **Definition:** Manipulation and enhancement of images through computational algorithms.
 - **Types of Processing:**
 - **Image Enhancement:** Improving image quality (e.g., brightness adjustment).
 - **Image Restoration:** Removing noise or recovering lost data.
 - **Image Transformation:** Operations like rotation, scaling, and warping.
 - **Tools:** MATLAB, OpenCV, and image-editing software.
 - **Applications:** Medical imaging, astronomy, and fingerprint recognition.
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2 Dynamics in Graphics

- **Definition:** Refers to the changes or motion within a graphical system over time.
- **Techniques:**
 - **Keyframing:** Setting key points and interpolating frames between them.
 - **Physics-Based Animation:** Simulating real-world physics like gravity or collisions.

- **Motion Capture:** Recording and applying human movement to models.
 - **Applications:**
 - Animation movies.
 - Realistic simulations in games.
 - Training simulations (e.g., flight simulators).
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3 Framework of Interactive Graphics Systems

- **Definition:** A combination of hardware and software that allows users to interact with and manipulate graphical content.
 - **Components:**
 - **Input Devices:**
 - Mouse, keyboard, touchscreens, styluses.
 - Advanced devices like VR controllers.
 - **Processing Unit:**
 - Central Processing Unit (CPU) for calculations.
 - Graphics Processing Unit (GPU) for rendering.
 - **Output Devices:**
 - Monitors, projectors, VR headsets.
 - **Examples:**
 - OpenGL and DirectX for rendering.
 - Frameworks like Unity and Unreal Engine.
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4 Graphics Input/Output Hardware

- **Input Hardware:**
 - **2D Devices:** Mouse, graphics tablets.
 - **3D Devices:** Joysticks, VR gloves, 3D scanners.
 - **Output Hardware:**
 - **Displays:** LCD, OLED, and CRT monitors.
 - **Printers:** For physical copies of graphics.
 - **Specialized Hardware:** VR/AR devices, holographic projectors.
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5 Dithering

- **Definition:** Simulating shades of colors by arranging pixels in patterns, used in images with limited color palettes.
 - **Methods:**
 - **Ordered Dithering:** Uses a pre-defined matrix to determine pixel intensity.
 - **Error Diffusion:** Spreads quantization error to neighboring pixels (e.g., Floyd-Steinberg algorithm).
 - **Applications:**
 - Reducing file sizes.
 - Creating artistic effects in digital art.
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6 Image Analysis

- **Definition:** Processing and examining images to extract information.

- **Steps:**
 1. **Preprocessing:** Noise reduction, image resizing.
 2. **Segmentation:** Partitioning the image into meaningful regions.
 3. **Feature Extraction:** Detecting patterns like shapes or colors.
 4. **Classification:** Assigning categories based on extracted features.
 - **Applications:**
 - Remote sensing, medical diagnostics, and biometric systems.
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7 Image Recognition

- **Definition:** The process of identifying objects or patterns within an image.
 - **Key Technologies:**
 - Machine learning: Convolutional Neural Networks (CNNs).
 - Feature detection: SIFT, HOG algorithms.
 - **Applications:**
 - Face recognition (e.g., unlocking phones).
 - Optical Character Recognition (OCR) for text.
 - Identifying defects in manufacturing.
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8 Image Recognition Steps

1. **Image Acquisition:** Capturing or importing the image.
 2. **Preprocessing:** Enhancing image quality (e.g., filtering).
 3. **Segmentation:** Dividing the image into regions of interest.
 4. **Feature Extraction:** Identifying distinctive properties like edges or shapes.
 5. **Classification:** Using models (e.g., neural networks) to assign categories.
 6. **Post-Processing:** Refining results for interpretation.
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9 Image Transmission

- **Definition:** Transfer of image data from one device to another.
 - **Processes:**
 - **Encoding:** Compressing data for transmission (e.g., JPEG, PNG).
 - **Transmission Protocols:** TCP/IP for reliable delivery.
 - **Decoding:** Reconstructing the image on the receiver's side.
 - **Challenges:**
 - Ensuring image quality with limited bandwidth.
 - Minimizing latency for real-time applications (e.g., video conferencing).
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