Image Processing Techniques

Image Processing are a collection of method used to perform operations on an image to enhance it or to extract useful information from it. It involves various techniques and algorithms that process images in a digital format.

There are major Image Processing Techniques listed below:

**1. Image Enhancement**

- Contrast Adjustment: Improves contrast between edges by enhancing pixel intensity. Light pixels become lighter, dark pixels become darker, producing more distinct edges and lines.

- Noise Reduction: Removes random variations in brightness or colour (noise) while preserving important details. Methods include median filtering, Gaussian smoothing, and bilateral filtering.

**2. Image Restoration**

- Deblurring: Restores sharpness in images blurred due to camera shake, motion, or out-of-focus issues. Common methods: inverse filtering, Wiener filtering.

- Inpainting: Reconstructs missing or damaged regions in an image. Used in restoring old photos or removing unwanted objects. Techniques include patch-based methods and partial differential equation based methods.

**3. Image Segmentation**

- Edge Detection: Identifies boundaries between objects or regions using gradients. Techniques include Sobel, Canny, and Prewitt operators.

- Region-Based Methods: Groups similar pixels into regions based on predefined criteria.

**4. Image Compression**

- Lossy Compression: Reduces file size by discarding some data (e.g., JPEG), which can slightly degrade quality.

- Lossless Compression: Reduces file size without any loss of data (e.g., PNG), allowing perfect reconstruction.

**5. Feature Extraction**

- Texture Synthesis and GAN-Based Generation: Creates new textures or images from existing samples, often using neural networks like GANs (Generative Adversarial Networks).

- Shape and Texture Analysis: Extracts geometrical and surface properties of objects.

**6. Morphological Processing**

- Dilation and Erosion: Dilation adds pixels to object boundaries (expands objects); erosion removes pixels (shrinks objects).

- Opening and Closing: Compound operations to remove noise and smooth objects. Opening = erosion followed by dilation; Closing = dilation followed by erosion.

Sharpening and Blurring of Images

Image Effect is referred to as the process of altering the image through various algorithms to provide it an artistic or real-life look.

Some of the most popular Image Effects are Sharpening (Making Edges more defined) and Blurring (Averaging the Intensities among the neighbourhood of pixels).

Sharpening:

It Is the process of enhancing the edges of an image to make them appear clearer by increasing the contrast between edges i.e. dark pixels become darker and light pixels become lighter.

Blurring (Smoothing):

It is the process of replacing each pixel’s intensity with the average value of itsneighbouring pixels within a fixed region (called a kernel, e.g., 3×3 or 5×5). This is achieved by convolving the image with the kernel. The larger the kernel size, the stronger the blur effect because more neighbours are averaged.

**>> Algorithms:**

**All Image Effects are Convolved using the formula:**

Where;  
I (x+I, y+j) = Intensity of the input image pixel   
K = Kernel  
G = New Intensity

Note: In Image Effects, it does not really matter what the formula used is, rather it is the type of kernel used that bring alteration in the formation and the intensities of pixels.

>> Laplacian Filter: (Sharpening)

**>> Gaussian Blur: (Blurring)**

Image Compression and Format Conversion

>> Image Compression:

Image Compression is the process of optimising/reducing the file size of the image by application of various algorithms for the purposes of either:

1) **Freeing up disk memory** on older computer with minimal memory storage units.

2) Decreasing the image computational processing time which **decreases load on servers**, renders images faster on websites allowing for **increased user retention** and **improves SEO** **Rankings** (Search Engine Optimisation).

3) Reduces the time period required for sharing of images over Internet/Servers.

>> Lossy vs Lossless Compression:

The Image Compression can be classified on the basis of loss of memory or detail from the image.

1. **Lossy Compression**: In this type of Conversion, there is certain loss of details from images which is not noticeable to the viewer. This is achieved through algorithms designed to discard various elements of images which does not change/alter the perception of image heavily for the viewer. Examples: JPEG, HEIC, WebP.
2. **Lossless Compression**: In this type of Conversion, there is no loss of details from the images. This is achieved through algorithms designed to reduce redundancies by identifying regular/common patterns in images. Examples: PNG, GIF, BMP.

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| Image Formats | Uses | Algorithms Applied for Compression | Limitations |
| JPEG  (Joint Photographic Experts Group) | Web images, Email Attachments | **DCT** | Doesn’t support animations |
| PNG  (Portable Network Graphics) | Graphics, logos, icons | **DEFLATE** | Requires more memory space |
| HEIC  (High-Efficiency Image Coding) | IOS Devices | **HEVC** | Lack of Compatibility |

>> Various Image Formats & Their Compression Algorithms:

**>> Format Conversion: (PNG, JPEG and HEIC)**

Image Format Conversion is the process of transforming image file types into another for the purposes of optimisation of files, compatibility with software and devices, and efficient storage management.

Example of why image file conversion maybe be required:

**JPEG → PNG:** Used when a photo needs smaller size for web/email.

**HEIC → PNG:** Used when transferring images from an iOS device to another device (Android).

**>> Process of Image Conversion**  
During a conversion process from one format to another (Example: HEIC → PNG):

1. The source image is decoded by the software and encoded as raw pixel data, which is stored in memory.
2. Certain processes like colour conversion, transparency handling, scaling, cropping, and resizing occur. Most of the data loss in case of conversion to a lossy format occurs here.
3. The data is then encoded into the final image by a certain algorithm depending on the format of the final image. It is **DEFLATE** in the case of PNG.
4. The image is finally in PNG format and can be saved and stored.

**>> Limitations of Conversions:**

1. **Loss of Information:** If converting from a lossless to a lossy image format, quality may degrade.
2. **File Size Increase:** In certain conversions, like from HEIC to PNG, file size increases.
3. **Transparency:** Certain formats like JPEG do not support specific colour depths; therefore, colour can be lost on conversion.
4. **Compatibility:** Some formats are not widely supported by older computers and devices.

References

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