

Unit-5

Image Processing & Computer Vision

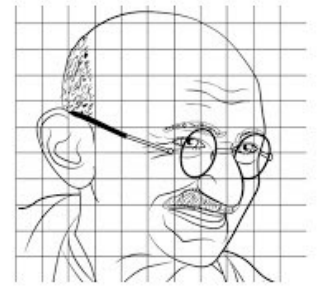
Outline

- Introduction to image processing
- Image noise
- Removal of noise from images
- Color enhancement
- Edge detection

Introduction to image processing

- Image processing is the manipulation of images using mathematical operations and algorithms in order to improve their quality or extract information from them.
- It is a broad field that encompasses techniques for image enhancement, restoration, compression, segmentation, and recognition.
- The goal of image processing is to improve
 - the quality of images
 - extract useful information
 - create new images.

Introduction to image processing



- Digital images are made up of a grid of pixels
 - each of which represents a specific color or shade of gray.
 - Image processing algorithms can manipulate the values of these pixels to achieve different effects.
 - For example, some techniques can adjust the brightness or contrast of an image, while others can remove noise or blur.

The process of image processing usually involves four main steps

- **Image Acquisition:** This involves capturing the image from a source device such as a camera, scanner or satellite.
- **Image Pre-processing:** This step involves the application of various filters and techniques to remove noise, adjust contrast, and enhance the image quality.
- **Image Analysis and Manipulation:** This step involves the application of algorithms and mathematical techniques to extract useful information from the image, classify the image, segment the image, or manipulate the image
- **Image Display:** This step involves displaying the processed image on a device such as a computer screen or a printer.

Image processing applications

- Image processing has a wide range of applications in various fields
 - such as medicine, engineering, astronomy, and entertainment.
- In medical imaging
 - image processing techniques can help doctors detect and diagnose diseases
- In engineering
 - it can be used to analyze images of materials and structures for quality control
- In astronomy
 - it can help researchers analyze images of celestial bodies to understand their properties and behavior.
- Overall, image processing is a powerful tool for analyzing and manipulating images to extract information and create new visual content.

Image processing tools

- Image processing can be performed using software tools
 - Matlab
 - OpenCV
 - Python.

These tools provide a wide range of functions and libraries to perform various operations on images.

Image Noise

- Image noise refers to random variations of brightness or color in an image
- Noise can degrade the quality and clarity of the image.
- Noise can be introduced into an image due to a variety of factors
 - poor lighting conditions
 - high ISO settings
 - long exposure times
 - issues with the camera sensor.

Types of noise

- Gaussian noise
 - This type of noise appears as a random variation of brightness or color that follows a Gaussian distribution
 - is more likely to occur near the middle range of brightness or color and less likely to occur at the extremes
- Salt-and-pepper noise
 - This type of noise appears as isolated bright or dark pixels scattered randomly throughout the image
 - caused by errors in the camera sensor or during image transmission

Types of noise

- Poisson noise
 - This type of noise is caused by the random distribution of photons in the image acquisition process
 - typically appears as a variation in brightness.
- Speckle noise
 - This type of noise appears as a granular pattern of bright and dark regions in the image
 - caused by interference in the image acquisition process, such as from ultrasound or laser imaging
- Removing noise from an image is an important task in image processing
 - can improve the clarity and visual quality of the image
 - make image is more suitable for further analysis or use in applications.

Techniques for removing noise

- Gaussian blur
 - If the noise in the image is Gaussian noise
 - Gaussian blur can be used to smooth out the noise.
 - This technique involves convolving the image with a Gaussian filter
 - which replaces each pixel value with a weighted average of its neighboring pixels.
- Median filtering
 - Median filtering is a non-linear filtering technique that can be used to remove salt-and-pepper noise
 - This technique replaces each pixel value with the median value of its neighboring pixels
 - which is less sensitive to outliers than the mean value.

Techniques for removing noise

- Wavelet denoising:
 - Wavelet denoising is a signal processing technique that can be used to remove noise from images while preserving important features such as edges and textures.
 - This technique decomposes the image into multiple levels of detail using a wavelet transform, and then selectively removes noise from each level based on its statistical properties.
- Total variation denoising
 - Total variation denoising is a technique that can be used to remove noise from images while preserving sharp edges and fine details.
 - This technique minimizes the total variation of the image, which measures the sum of the absolute differences between neighboring pixels.
- Deep learning-based denoising
 - With the recent advancements in deep learning, there are many neural network-based approaches that can be used for denoising images.
 - These methods involve training a neural network on a large dataset of noisy and clean images
 - then using the trained network to remove noise from new images.

Color enhancement

- Color enhancement
 - is a technique used in image processing to improve the quality of an image by increasing the color saturation, contrast, and brightness.
 - The goal of color enhancement is to make an image more visually appealing and easier to interpret.

Methods for color enhancement

- Histogram equalization
 - adjusts the intensity levels of an image to enhance its contrast and brightness.
- Contrast stretching
 - expands the contrast range of an image by mapping the darkest pixel to black and the lightest pixel to white, with the intermediate values linearly scaled between them.
- Color balance
 - adjusts the relative amounts of each color channel in an image to produce a more balanced and natural color appearance.

Methods for color enhancement

- Color mapping
 - maps the colors of an image to a different color space to produce a different color appearance.
 - For example, the red-green-blue (RGB) color space can be mapped to the hue-saturation-value (HSV) color space to enhance the color saturation of an image.
- Sharpening
 - enhances the edges of an image by increasing the contrast between adjacent pixels.

Edge detection

- Edge detection is a fundamental concept in digital image processing, computer vision, and machine learning.
 - It refers to the process of identifying boundaries or discontinuities in an image, which correspond to sharp changes in intensity, color, or texture.
- Edge detection algorithms typically work by convolving an image with a filter
 - such as a Sobel, Prewitt, or Canny filter, that emphasizes edges and suppresses noise.
 - The resulting output image highlights the locations of edges in the original image.