What is Image Preprocessing?

It is a step in computer vision where images are changed into a version that is acceptable by machine learning algorithms. To explain this in a simpler approach, it is called “cleaning of the data”. The key objective in this process is to enhance features by extracting the required data from the image by applying necessary filters and reducing noise to make the image more acceptable for further processing.

**General Image Preprocessing Techniques**

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| Image Technique | Functionality | Application |
| Image Resizing | Resizes image by changing size | * Helps the ML algorithm to train over smaller images, ensures equal dimensionality * Avoids distortion by keeping the same aspect ratio |
| Grayscale Conversion | Converts image to grayscale | * Reduces image complexity -> helps assess pixels better * Pixel reduction -> allows only two colors to be recognized and reduces computations |
| Histogram Equalization | Changes contrast of an image, so that the intensities of the image are balanced | * Contrast enhancement * Distributes the image over equal intensities * Corrects any lighting issues with the image |
| Gaussian Blur | Gives a filter like effect that causes image smoothening | * Reduces noise * Brings focus to critical points of image * Reduces high contrast at edges (chromatic aberration reduction) * Softens Image |
| Median Filter | Non linear filter that helps in reduction of intensity of noise from image | * Edge preservation whilst removing noise * Resolves filtering of salt and pepper noise * Adjusts intensity to be equalized throughout the image |
| Bilateral Filter | Also a non linear filter which smoothens images | * Weight is based on Gaussian filter * Preserves sharp edges * Depends on color intensities |
| Sharpening | Enhances edge contrast of the image by increasing brightness of pixels which involve changes in color | * Removes blur to enhance detail * Applies mostly to JPEG files * Compensates for motion blur/camera shakes |
| Thresholding | Segments an image into binary regions based on a specified threshold. Pixels above the threshold are set to one value, while pixels below the threshold are set to another. | * Used in object detection * Extracts features of different intensities |
| Edge Detection | Identifies boundaries/edges within the image | * Essential for object recognition -> bounding box concepts * Feature extraction |
| Rotation | Rotates images by the required angles that are specified – eg 45, 90, 180 etc | * Helps with orientation and alignment of image |
| Flipping | Mirroring of image | * Data augmentation -> creates mirrored images for variety in training data |
| Scaling | Resizing of image through dimensional adjustments | * Removes irrelevant features of the image, such as certain parts of the background |
| Cropping | Removes unwanted parts of the image | * Focuses on important parts of the image and improves image for analysis |
| Color Conversion – RGB to HSV | Converts RGB images to HSV images | * Color segmentation -> separating images through color * Identification of specific color ranges |
| Super Resolution | Enhances image resolution from a lower quality to a higher quality | * Improves details of image * Enhances quality of footage in surveillance situations * Refines medical images |

**Masking Filters Preprocessing Techniques:**

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| Image Technique | Functionality | Application |
| Averaging Filter | Smoothens image by replacing pixel values with a pixel average which is applied throughout the image | Real time video surveillance – improves overall video quality |
| Order Statistics | Applies filters based on statistical measures such as median, min, or max to enhance or modify pixel values. | Real time medical imaging -> remove noise to preserve important details of X-Ray |
| Adaptive Filters | Adjusts filter parameters based on local image characteristics, allowing for adaptive noise reduction or enhancement. | Dynamically adjust various lighting conditions, enhancing facial features for real-time facial recognition systems. |
| Sharpening Filters | Enhances the edges and fine details in an image, emphasizing transitions between intensity levels. | Edge enhancement and details in real-time video streams, leading to improved visual quality in video conferencing or streaming applications. |
| Edge Detection | Identifies abrupt changes in intensity, highlighting edges and boundaries. | Real-time object detection in the surroundings of autonomous vehicles, helping them identify obstacles and navigate safely. |
| Image Blurring | Reduces the sharpness of an image, smoothing pixel transitions. | Image blurring techniques can be used in real-time AR applications to blend virtual and real-world elements seamlessly, creating a more natural visual experience. |
| Double Exposure Effect | Blends two or more images to create a composite with characteristics from each input. | Double exposure effects can be applied in real-time during live event broadcasting, enhancing the visual appeal and artistic quality of the video feed |

**Noise Preprocessing Techniques:**

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| Image Technique | Functionality | Application |
| Gaussian Noise | Adds random values sampled from a Gaussian distribution to pixel intensities. | Useful in MRI to model random variations and uncertainties in the imaging process. |
| Salt and Pepper | Introduces randomly occurring bright and dark pixels in an image. | Test the robustness of image transmission algorithms under packet loss conditions. |
| Shot Noise | Simulates Poisson distribution-based noise, often observed in photon-limited imaging conditions. | Used in low-light imaging scenarios such as astrophotography, affecting the quality of captured celestial objects. |
| Random Noise | Adds random values to pixel intensities without a specific distribution. | Used for video conferencing applications to help evaluate the performance of noise reduction algorithms in real-time communication. |
| Fixed Pattern Noise | Introduces consistent patterns of noise across an image. | Detect imperfections in manufacturing processes, such as those found in camera sensors. |
| Banding Noise | Variations in intensity in the form of stripes or bands. | Document scanning applications, helping assess the impact of noise on OCR (Optical Character Recognition) accuracy. |
| Luminance Noise | Overall brightness or intensity of the image | Used in digital cinema to understand how noise impacts the quality of projected images. |
| Color Noise | Variations in color channels | Multimedia Streaming Applications – evaluates video compression and transmission algorithms |

Link to Code files

[https://github.com/jothivarshini/capstone- project/tree/main/Image%20Preprocessing%20Techniques](https://github.com/jothivarshini/capstone-%20project/tree/main/Image%20Preprocessing%20Techniques)