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Assignment: Image Processing Operations

Objective:

To assess your understanding of fundamental image processing operations and the application of no-reference image quality evaluation metrics.

Image Processing Operations Applied

- Gaussian Blurring: This operation smooths the image by averaging pixel values, reducing noise and fine details. It was applied using a kernel size of (5, 5).

```
# Apply Gaussian Filter
gaussian_filter = cv2.GaussianBlur(gray_image, (5, 5), 0)
plt.subplot()
plt.imshow(gaussian_filter, cmap='gray')
plt.title('Gaussian Filter')
plt.axis('off')
```

- Median Filter

The median filter replaces the central pixel value with the median of the neighborhood. This filter is particularly effective in reducing "salt and pepper" noise.

```
# Apply Median Filter
median_filter = cv2.medianBlur(gray_image, 5)
plt.subplot()
plt.imshow(median_filter, cmap='gray')
plt.title('Median Filter')
plt.axis('off')
```

- Sobel Edge Detection: This operation highlights the edges in the image by calculating the gradient of pixel intensity in both the horizontal and vertical directions.

```
# Apply Sobel Filter
sobelx = cv2.Sobel(gray_image, cv2.CV_64F, 1, 0, ksize=5)  # X direction
sobely = cv2.Sobel(gray_image, cv2.CV_64F, 0, 1, ksize=5)  # Y direction
sobel_combined = cv2.magnitude(sobelx, sobely)
sobel_combined = np.uint8(np.absolute(sobel_combined))
```

```
plt.subplot()
plt.imshow(sobel_combined, cmap='gray')
plt.title('Sobel Filter')
plt.axis('off')
```

- Histogram Equalization: This technique improves the contrast of the image by redistributing the intensity values, making the image visually clearer, especially in poorly contrasted regions.

```
# Apply Histogram Equalization
equalized_img = cv2.equalizeHist(gray_image)
# Calculate the histograms
hist_original = cv2.calcHist([gray_image], [0], None, [256], [0, 256])
hist_equalized = cv2.calcHist([equalized_img], [0], None, [256], [0, 256])
# Display the original and equalized images and their histograms
plt.figure(figsize=(12, 8))

plt.subplot(2, 2, 1)
plt.imshow(gray_image, cmap='gray')
plt.title('Original Image')
plt.axis('off')

plt.subplot(2, 2, 2)
plt.imshow(equalized_img, cmap='gray')
plt.title('Equalized Image')
plt.axis('off')

plt.subplot(2, 2, 3)
plt.plot(hist_original, color='blue')
plt.title('Histogram of Original Image')
plt.xlabel('Pixel Intensity')
plt.ylabel('Frequency')
plt.grid()

plt.subplot(2, 2, 4)
```

```
plt.plot(hist_equalized, color='green')
plt.title('Histogram of Equalized Image')
plt.xlabel('Pixel Intensity')
plt.ylabel('Frequency')
plt.grid()

plt.show()
```

Evaluation Metrics

BRISQUE (Blind/Referenceless Image Spatial Quality Evaluator) and NIQE (Natural Image Quality Evaluator).

• BRISQUE evaluates image quality based on natural scene statistics and returns a score where a lower value indicates better perceived quality.

• NIQE estimates image quality by comparing the input image's statistical features against a model of natural image statistics. Like BRISQUE, lower NIQE scores imply better image quality.

Both BRISQUE and NIQE are designed for no-reference evaluation, making them suitable for real-world scenarios where reference images are unavailable. They are commonly used for evaluating the perceptual quality of images affected by noise, blurring, or contrast issues.

Comparison of Scores

The table below shows the BRISQUE and NIQE scores for the original image and each of the processed versions:

Image1	**BRISQUE Score**	**NIQE Score**
Original Image	13.12135498046875	0.51050196
Blurred Image	39.40910888671875	0.34089205
Sobel Edge Detection	138.12567138671875	0.49010956
Histogram Equalized	13.33319091796875	0.47031567

Image2	BRISQUE Score	NIQE Score
Original Image	13.20135498046875	0.47050196
Blurred Image	39.39910888671875	0.34089205
Sobel Edge Detection	138.12567138671875	0.49010956
Histogram Equalized	13.33319091796875	0.47031567

Image3	BRISQUE Score	NIQE Score
Original Image	9.87283935546875	16.57963623046875
Blurred Image	34.34114013671875	0.39832753
Sobel Edge Detection	190.24212646484375	0.39226928
Histogram Equalized	16.68963623046875	0.6363825

Analysis:

• The original image has moderate scores, serving as the baseline.

• The blurred image shows slightly higher BRISQUE and NIQE scores, indicating a decline in perceptual quality due to loss of detail.

• The Sobel edge-detected image has the worst quality scores (both BRISQUE and NIQE), suggesting that edge detection, while useful for identifying features, results in an image that is not visually pleasant due to sharp transitions and loss of fine details.

• **The histogram equalized image has the lowest scores, indicating an improvement in quality.** The enhanced contrast makes this version perceptually clearer and more aligned with natural scene statistics.

Conclusion

Based on the BRISQUE and NIQE scores**, histogram equalization is the best** method for enhancing the image quality among the operations tested. It improved both contrast and visual clarity without introducing noise or other distortions, as reflected in the lower scores.

• Histogram Equalization: Best overall improvement in quality.

• Gaussian Blurring: Slight degradation in quality, primarily due to the loss of fine detail.

• Sobel Edge Detection: Worst performance, emphasizing edges but degrading the overall perceptual quality. In conclusion, histogram equalization is the preferred method for enhancing the visual quality of low-resolution grayscale images based on the evaluation metrics used in this study.