**Evaluation of Filter Effectiveness on Noisy Image (Gaussian Filter)**

**1. Introduction**

This evaluation aims to assess the performance of a Gaussian filter in denoising a salt-and-pepper noised image ("Barbara.jpg") using quantitative image quality metrics. The parameters considered include PSNR, MSE, SSIM, edge preservation, and noise reduction ratio.

**2. Parameters and Results**

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| **Metric** | **Noisy Image** | **Denoised Image** | **Interpretation** |
| PSNR (dB) | 21.00 dB | 23.93 dB | An increase in PSNR indicates that the Gaussian filter improved the image quality. A PSNR above 30 dB is ideal, but the rise here confirms significant denoising. |
| MSE | 516.2239 | 263.2405 | The Mean Squared Error reduced after filtering. Lower MSE values imply reduced distortion. |
| SSIM | 0.4894 | 0.6682 | Structural similarity increased, showing improved preservation of image structure. SSIM > 0.9 is ideal, but the increase reflects positive progress. |
| Edge Preservation (Correlation) | — | 0.5445 | A moderate correlation (~0.54) between the edge maps of the original and denoised images indicates partial retention of edge details. |
| Noise Reduction Ratio | — | 1.97 | The variance of noise before and after filtering shows the Gaussian filter reduced noise by nearly 2x, demonstrating decent noise suppression. |

**3. Analysis and Interpretation**

* The Gaussian filter shows noticeable improvement in all major metrics over the noisy input.
* PSNR and MSE indicate a clear enhancement in image quality, although results suggest there's still room for better denoising.
* SSIM shows moderate structural preservation, meaning the Gaussian filter preserves some but not all fine details.
* Edge correlation at ~0.54 indicates partial edge blurring, which is a known limitation of Gaussian filtering due to its smoothing nature.
* The Noise Reduction Ratio of 1.97 is a strong indicator of effective noise removal.

**4. Conclusion**

* The Gaussian filter moderately enhances image quality in the presence of salt-and-pepper noise. It effectively reduces random noise and improves structural integrity and overall quality but tends to blur edges, which affects fine detail. This makes it a good choice for general denoising, though not optimal for applications where edge sharpness is critical.
* For better performance, especially in preserving structure and edges, hybrid filters or edge-preserving filters like Bilateral or Non-Local Means should be considered.