Compare the effectiveness of traditional filters (such as averaging and Gaussian filters) with edge-preserving filters (such as the median filter) in reducing noise while preserving important image features in medical imaging. Discuss scenarios where each type of filter might be preferred, considering factors such as image quality, computational complexity, and impact on diagnostic accuracy. How do these filtering techniques perform in preserving edges and fine details crucial for accurate medical diagnoses?

Mean Filters

There are a few varieties of mean filters; local mean, percentile mean, bilateral mean….

* Local mean: all pixels belonging to the filter support are averaged and set to the pixel at the center of the filter. Percentile and usual mean filters yield similar results; they smooth the whole image. B

Image features that are smaller than the kernel size; are strongly reduced, while features much larger than the kernel; are less impacted. The extent of noise reduction depends on the kernel size, with larger kernels providing stronger suppression.

In the images below image (b) is image with Gaussian white noise. Noise is removed; image (c) with 3 x 3 mean filter; but some blurring occurs.

Gaussian filter

Gaussian smoothing uses a “point-spread” gaussian distribution to the center of the filter frame. Points three standard deviations away are set to zero intensity. Once a suitable kernel has been determined, since the kernel is symmetric, a 2-D convolution is performed by first convolving with a 1-D Gaussian in the x-direction followed by another convolution with a 1-D Gaussian in the y direction. Like the mean filter, the effect of the Gaussian filter is smooth an image which proportional to the standard deviation of the Gaussian. In contrast to the mean filter uniformly weighted average, the Gaussian filter outputs a weighted average of each pixel’s neighborhood; with more average weight applied to the central pixel.

Median filter:

On each center of the kernel frame, pixel (i,j); it computes the median values of all the pixels present within the kernel filter. Compared to the average or Gaussian filter; it is less effective in noise removal and images can look less smooth. However, edges are not as much filtered by the median filter compared to the mean filter; and the median filter is particularly efficient in the removal of specific type of noise; like “pepper-and-salt noise”.

A 3 x 3 median filter applied to the same image (a) above is less efficient in removing the noise; however the edges are more preserved. The same filter removes efficiently the “pepper-and-salt noise” added: image (b), and render an image of good quality: image (c).

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(Paranjaoe, Fudamental Enhancement Techniques, 2009) https://doi.org/10.1016/B978-012373904-9.50008-8.