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Significance of Noise Reduction in Medical Datasets for Accurate Diagnosis

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Keywords: Computed tomography; Positron emission tomography; Magnetic resonance imaging; Digital subtraction angiography; Magnetic resonance

Abbreviations: PET: Positron Emission Tomography; MRI: Magnetic Resonance Imaging; CT: Computed Tomography; DSA: Digital Subtraction Angiography; MR: Magnetic Resonance

Medical Image Denoising

Noise reduction or noise elimination is a challenging task in non-invasive radiological technologies such as Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Digital Subtraction Angiography (DSA) and X-Ray [1]. Image denoising is a pre-processing task for the better visualization and interpretation of the medical data. In the above mentioned non-invasive medical technologies, image degradation effects such as blurring or prevalence of noise is an ever prevailing issue due to hardware restrictions. Noise elimination aims at not only suppressing the noise but also to preserve important features such as edges, corners, textures and sharp structures. The noise elimination leads to high imaging quality which aids the patient care by improving the medical imaging diagnosis [2-4].

Noise is a random fluctuation in the local features of an image like color information and brightness. These fluctuations can lead to significant reduction of image quality and hinders the performing of high-level vision task such as medical image segmentation, retrieval and recognition tasks [5]. The commonly types of noises are Gaussian noise, Poisson noise, Impulse noise, Speckle noise and Brownian noise. These noises can occur during image acquisition and while transmission over communication channel. The most prevalent noise in medical images is Gaussian noise which is additive in nature. MR (Magnetic Resonance) images are usually corrupted with Rician noise which is considered as Gaussian noise in some special cases. Similarly ultrasound images are corrupted with speckle noise which is multiplicative in nature. CT images are corrupted with structural salt and pepper noise [6].

The prevalence of noise in medical image can highly reduce the image quality and can complicate the medical diagnosis and treatment. The noise can also be perceived as artefacts in medical images can lead to false diagnosis. Besides this it is extremely trivial to recover and enhance fine details and edges in order to provide concrete data to the radiologists to read. Hence it can said that image denoising is an extremely crucial as the noise can significantly degrade image quality and also baffle the identification of the disease. Therefore there arises a huge dependability on image denoising algorithms. So far a plethora of image denoising algorithms have been presented in literature. Image noise can be either dealt in spatial domain or in transform domain [7,8]. The basic methodology of the medical image denosing can be understood from Figure 1.

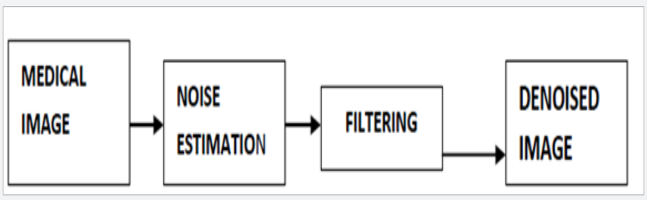

Figure 1: Basic methodology for Image denoising.

Besides these various other domains are machine learning is sparse representation. In spatial domain the image is processed at the pixel level. Spatial filters which can be further classified as linear or non-linear filters are used to denoise images which smooth the image pixels as well as blur the edges. Several improved filters have also been reported in literature to effectively remove the noise and preserve important features like edges and contours. Some of the state-of-the-art spatial domain filters are bilateral filter, Non-local mean filter, anisotropic filters, Weiner filter, Biotonic filter and so on [9-11]. Another way of image denoising is mapping the image pixels into in the transform domain and thresholding the high frequency noisy component.

The most popular transform domain techniques include Wavelet transform, BM3D (Block matching and 3D filtering), BLS-GSM (Bayesian least square Gaussian scale mixture, Framelets, sparse representation and Shearlet transform [12-14]. These days the researchers are inclined towards the hybridisation of the spatial and transform domain techniques to harness the attributes of both the domains. Some of the hybrid techniques reported in [15] has obtained exemplary results in the literature. Besides significant development in the image denoising algorithms they suffer from drawbacks like shift variance, aliasing, artefacts and blurring etc. therefore a lot a research work is still on to abridge the margins left in between.

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