Comparative Analysis of Adaptive Recursive Filters for Noise Reduction in C-Arm Fluoroscopic X-Ray Images

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Abstract— It is well known that noise on medical image (MI) resulting in low image quality has largely limited the diagnostic usefulness. This makes the noise reduction in medical imaging very significant. However, any kind of medical imaging is purely a visual expression of biological information of tissues at a certain time. The quality of output image is reduced due to various kinds of noises. So there is a need for noise reduction in medical imaging equipments. Therefore, the primary goal of medical image processing is to develop effective image processing methods to provide information and help doctors to evaluate different treatment therapies on disease. Image enhancement as noise reduction by software is useful and is necessary for next edge differential enhancement particularly for digital medical X-ray images.

Key words: Comparative Analysis, Adaptive Recursive Filters, C-Arm Fluoroscopic

I. INTRODUCTION

A special case of nonlinear filters which is used widely for smoothing signals and images is Median Filter (MF). One of the useful characteristics of the MF in image processing is its ability to image noise reduction without blurring and edge destruction. Also, simplicity with low computation burden of MF causes that the MF is known as an efficient filter in image noise reduction. To improve the performance of MF, many modifications of MF are proposed, e.g., Recursive Median Filter (RMF), Weighted Median Filter (WMF) and etc. Also, by using intelligent methods (e.g., fuzzy logic, neural network and etc.), another classes of MF which perform better in some applications is proposed. MF is implemented to a noisy image using a window which is moved across the input image and the canter pixel/sample of the window is replaced by the output of MF which is the median value of the pixels within the window. One of the most efficient modifications of MF is Recursive Median Filter (RMF). In the RMF, similar to MF, the canter pixel/sample of the window is replaced by the median value of all the pixels inside the window but the obtained values (i.e., previous outputs of RMF) for some pixels of window are used instead of the pixel values. Then the median value of window is obtained. The recursive property of RMF causes that the RMF has stronger noise attenuation capability than its non-recursive version (e.g., the MF).

The size of moving window has an important effect on the RMF performance in image noise reduction. When a small moving window is used and the image is corrupted with high density of noise, the probability of selection of noisy pixel as the output of RMF increases. Furthermore, using a large moving window can lose the details of image and provide a vague image. Hence, choosing the optimal size of moving window is important and can increase the RMF performance.

II. METHODOLOGIES

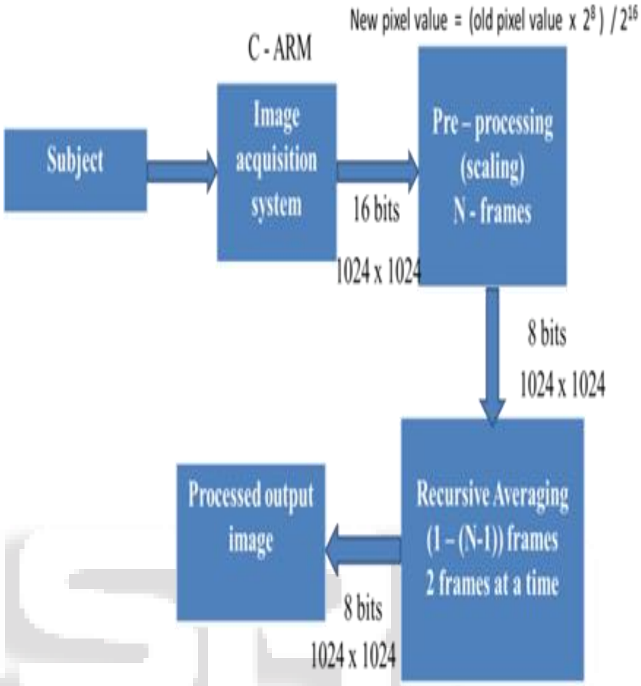

Fig 1: Block diagram of Recursive Averaging Filter.

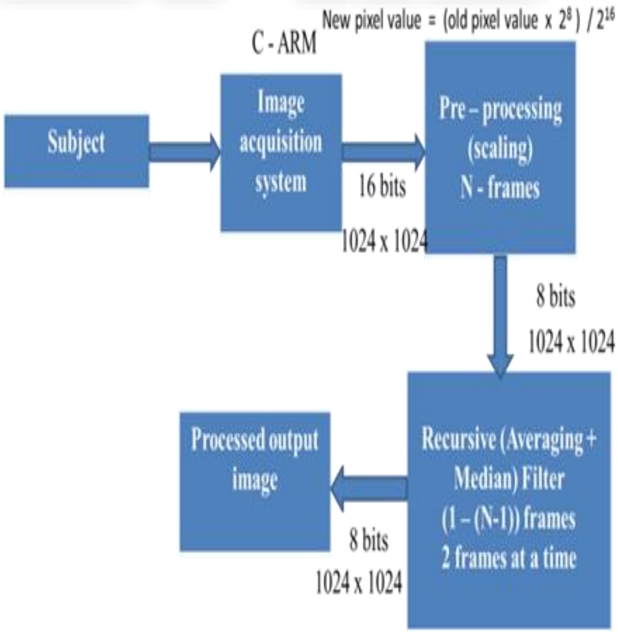

Fig 2: Block diagram of Recursive (Averaging + Median) Filter.

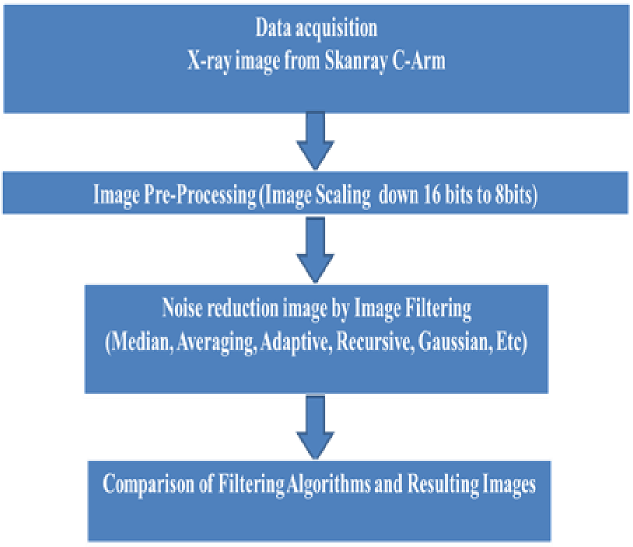

Fig 3: Functional block diagram of the proposed system.

A. Median Filtering (M.F) and Recursive Median Filter (RMF)

Median filtering is similar to using an averaging filter, in that each pixel is set to an average of the pixel values in the neighborhood of the corresponding input pixels. However with median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values. Median filtering is therefore better able to remove this outlier without reducing the sharpness of the image.

The Median Filter (MF) is a non-linear filter which is useful for the reduction of salt-and-pepper noise in an image. It is implemented for an image using a WH*WV window/mask which is moved across the input image, where WH denotes the horizontal and WV denotes the vertical size of the window in pixels. The center sample of the window is replaced by the median of the ranked pixels/samples values within the window. In other words, the one-dimensional MF is realized by passing a window over the image/data, ranking the values in the window, and taking the median as the output. If xi is the input, the output yi is given by

$$Y_i = \text{median}\ \{x_{i-N}, x_{i-N-1}, \ldots, x_{i-N}\} \text{--------(1)}$$

where the window contains 2N + 1 pixels. The current window is marked with white dashed square, the next window is marked with black dashed square; the new samples (which have to be processed to generate a new output) are dark grey.

The recursive median filter is the modification of median filter which is defined by equation (1). If we replace the pixel xi with the output of median filter before shifting the window to the next position, we have recursive median filter.

$$Y_i = \text{median}\ \{y_{i-N}, \ldots\ y_i, x_i, \ldots, x_{i-N}\} \text{-------------(2)}$$

III. Results and Discussion

The coding of this paper is done in eclipse GTKMM 2.4 in C++ language. The quality of the process is been measured by Mean Square Error (MSE), Signal to Noise ratio (SNR) and Peak Signal to Noise ratio (PSNR) using programming in MATLAB 2014.

Averaging Image Frames	MSE	SNR	PSNR
Avg1-2	5.6727	25.3024	40.6082
Avg2-3	6.6995	24.5564	39.8704
Avg3-4	6.6153	24.604	39.9253
Avg4-5	6.4681	24.6994	40.023
Avg5-6	6.1673	24.79	40.2299
Avg6-7	6.0453	24.8275	40.3166
Avg7-8	5.9084	24.908	40.4161
Avg8-9	5.8984	24.926	40.4235
Avg9-10	5.7262	25.0119	40.5521
Avg10-11	5.6355	25.1311	40.6215
Avg11-12	5.617	25.1525	40.6358
Avg12-13	5.6889	25.0854	40.5805
Avg13-14	5.6906	25.0915	40.5792
Avg14-15	5.2238	25.6291	40.9509
Avg15-16	4.593	26.2731	41.5098
Avg16-17	4.7891	26.0994	41.3282
Avg17-18	5.2426	25.7166	40.9322
Avg18-19	5.5307	25.498	40.7034
Avg19-20	5.706	25.3237	40.5675
Avg20-21	5.5584	25.4936	40.6813
Avg21-22	4.8956	26.0581	41.2329
Avg22-23	4.8211	26.1391	41.2994
Avg23-24	5.1503	25.8638	41.0124
Avg24-25	4.6691	26.2984	41.4385
Avg25-26	4.007	26.9709	42.1027

Table 1 Comparison of sequence images with MSE,SNR&PSNR for Averaging Image Frames

Table 1. Comparison of sequence images with MSE, SNR&PSNR for Averaging Image Frames.

Median Filtered Image Frames	MSE	SNR	PSNR
Med1-2	4.5975	26.1708	41.5056
Med2-3	5.7432	25.2076	40.5392
Med3-4	5.7048	25.2258	40.5684
Med4-5	5.5464	25.344	40.6907
Med5-6	5.3549	25.5005	40.8433
Med6-7	5.2337	25.5907	40.9427
Med7-8	5.1188	25.6793	41.0391
Med8-9	5.0924	25.7082	41.0616
Med9-10	4.9978	25.8368	41.143
Med10-11	4.9127	25.9427	41.2176
Med11-12	4.8205	26.0162	41.2999
Med12-13	4.8709	25.9971	41.2547
Med13-14	4.8978	26.0092	41.2308
Med14-15	4.3268	26.563	41.7691
Med15-16	3.7143	27.1772	42.432
Med16-17	3.896	26.9716	42.2246
Med17-18	4.3438	26.5203	41.7521
Med18-19	4.6285	26.1	41.4764
Med19-20	4.8028	26.104	41.3159
Med20-21	4.6372	26.2556	41.4682
Med21-22	3.9982	26.956	42.1122
Med22-23	3.9596	26.9804	42.1543
Med23-24	4.2787	26.6569	41.8177
Med24-25	3.7775	27.1918	42.3587
Med25-26	3.1471	28.0052	43.1517

Table 2 Comparison of sequence images with MSE,SNR&PSNR for Median Filtered Image Frames

Table 2. Comparison of sequence images with MSE, SNR&PSNR for Median Filtered Image Frames.

Mean square error (MSE):

$$MSE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(g_{i,j}-f_{i,j})^2$$

Signal-to-noise ratio (SNR):

$$SNR=10\log_{10}\left(\frac{\sigma_g^2}{\sigma_e^2}\right)$$

Peak Signal-to-Noise Ratio (PSNR):

$$PSNR=10\log_{10}\frac{(2^n-1)^2}{MSE}=10\log_{10}\left(\frac{255^2}{MSE}\right)$$

Parameters	**Recursive Averaging (25 – 26) frames**	**Recursive (Averaging + Median) (25 – 26) frames**
MSE	4.0070	3.1471
SNR	26.9709	28.0052
PSNR	42.1027	43.1517
Table 3 Comparison between Filters		

Table 3. Comparison between Filters.

IV. Conclusion

For a good quality of images MSE should be low, SNR & PSNR should be high. As the number of frames increases the performance of recursive filters also increases. Using the same set of images different image filtering algorithm is compared to identify which algorithm provides better result. From the above table conclude that recursive averaging plus median filters provides low MSE, high PSNR & SNR than compared to averaging method.

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