Design of Decision Based Recursive Weighted Median Filter With Exponential Weights

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Abstract: The prescribed algorithm for removing impulse noise effectively even under high noise densities without causing any loss of image details. Hence a cascaded section of median filters that involves a Decision-based Median Filter followed by a Recursive Weighted Median (RWM) Filter employing exponential weights are used. The median controlled algorithm is employed to calculate the exponential weights. In the algorithms that were proposed in earlier which involves a cascaded section of the median with the RWM filters provided lesser Peak Signal/Noise Ratio (PSNR) and greater Mean Square Error (MSE) values. Hence the output appeared to be distorted for higher noise levels. These drawbacks have been eliminated in this proposed algorithm.

Keywords: Recursive Weighted Median (RWM), Decision based Median Filter, Mean Square Error (MSE)

1. Introduction

This paper is all about designing an II phase algorithm employing median filters for removal improvement of impulse noise performance for image processing. The cascaded filter section [1],[2],[9] employs a Decision based median filter[4] in the first phase followed by a RWM[6] in the second phase. The weight for the RWM filter is selected by using the Median Controlled Algorithm [8]. As design parameter, the exponential weights of RWM filters are used in the feedback path. The considered algorithm can attain pointedly improved image eminence than fixed weight or the centre-weighted Median filters [3]. There are two stages involved in the algorithm, which are the Decision based Median filter in the first stage and the RWM filter in the next stage. The initial stage is the Decision-based filter. By this filtering algorithm, it is decided at each signal position whether or not to change the pixel value. Impulse rejecting filters are based on the very simple but effective idea: In every position, first, it is to be decided whether or not an impulse is found. If one is found it is filtered else that particular pixel is left unchanged. In case of the Recursive weighted median filters, the determination of the weights is very important. Earlier researchers suggest many new algorithms for the determination of weights, which are more complex to compute. The weight calculation by the median controlled algorithm is easy to compute. In this paper the corrupted image is first filtered with median filter and then is filtered through the decision-based median filter in phase II. This output signal is taken as the reference signal. The difference between this reference signal and output of weighted median filter is found and its exponential value is obtained which is applied as the weights for the signal in the feedback path. The existing algorithm was the Design of RWM filter using Median controlled algorithm, which employs a cascaded section of a median filter and a RWM filter. But the
The main drawback of that algorithm was the inability to remove the noise at higher noise levels i.e., noise levels greater than 50%. To eliminate this drawback and to remove the higher noise levels, a Decision based median filter can be placed at the input side instead of the median filter. This paper, the Design of a Decision based Recursive Median filter using exponential weights suggests a two-phased removing scheme for the pepper and salt noise. In the initial phase, identification of pixels can be done by decision median filter are prospective to be polluted by noise. Further in next phase, the filtered image by RWM filter whose weights are calculated using the Median Controlled Algorithm. The following diagram can represent this overall concept behind this proposal,

Fig. 1 Flow chart representation of the proposed algorithm

2. Implementation

There are two phases in the project with the first phase being the Decision-based Median Filter the second being the Recursive Weighted Median Filter employing exponential weights, which is calculated using the median controlled algorithm.

2.1 Phase I: Decision Based Median Filters

The motivation for this paper of such filters is such that processing should not change those pixel values, which are uncontaminated by noise. The clue is to practice a nonlinear filter as the decision-maker or in other words as a predictor. By doing so the output is either the input pixel or the combination of linear input and output pixels. The output image is pointedly better-quality when related to that of the median filter output and minor particulars and well consistencies are plentiful improved. The first stage is the Decision-based filter. By this filtering algorithm, it is decided at each signal position whether or not to change the pixel value. Impulse rejecting filters are based on the very simple but effective idea: In every position, first it is to be decided whether or not an impulse is found. If one is found it is filtered else that particular pixel is left unchanged. Filter output for a noise level of 50% with MSE =16.89dB and PSNR= 30.93 is shown below.

Fig. 2 Filter output for a noise level of 50%

2.2 Phase II: RWM Filter Employing Exponential Weights

The median filter drawback is streaking problem along with the loss of small details in the image. The main reason for this is that the median filters use only the information of rank-order from the input data, and throw-outs the unique information of temporal-order data. In other words, in the median filter, each sample inside the window of the filter has the same effect on the filter output. When a
median filter riddles a signal, almost all the values in the signal will change. Impulses will change dramatically, and variations are further profound close edges when compared to similar signal regions. Therefore, median filter is a meek detector of edges as well as impulses.\[5,7,9\] By giving weights to the samples according to how much they are changed by the low pass filter, a highly data-dependent filter. In the case of the RWM filters, the determination of the weights is very important. For calculating the weights an example is considered, for every window, the individual input samples, which are nearer to the output of the initial filtering process, could be weighted exponentially more. Consider the variance of the sample $X_i$ and low pass filtering result $X'_i$ at the similar position be $|X_i - X'_i|$. Then this sample has the weight

$$a_i = e^{-\alpha |X_i - X'_i|}$$

Weight $(i,j) = \exp\{-\alpha|\text{original}(i,j)-\text{Reference}(i,j)|\}$

Here $\alpha > 0$. First iteration of the median controlled filter output is attained samples weighted sum inside the filters movable window. This moving window does not have to be the same as the one used to calculate weights. Filter output for RWM using Median Controlled Algorithm for 50\% of noise level with MSE=14.36dB and PSNR= 16.89dB is shown below.

By cascading the two phases i.e., the decision based median filter section and the RWM filter section using the median controlled algorithm the following result can be obtained. The result shows the output for 40\% of noise.
3. Validation and Results
The PSNR and the MSE values of various types of median type filters are graphed and tabulated. The RWM developed utilizing the decision based median controlled algorithm produces superior results than the other median kinds algorithms, as seen in the tables and graphs.

| Noise (%) | Median filter | RWM filter | Decision based filter | Prescribed algorithm |
|-----------|---------------|------------|-----------------------|----------------------|
| 10        | 13.64         | 10.65      | 9.6245                | 12.79                |
| 30        | 24.53         | 24.95      | 14.08                 | 14.73                |
| 50        | 33.23         | 33.76      | 16.89                 | 16.69                |
| 70        | 38.76         | 39.34      | 20.13                 | 19.34                |
| 90        | 42.00         | 42.70      | 24.9                  | 24.17                |

Table 1 Assessment of the MSE (dB) of the various median types filters with respect to noise percentage

| Noise (%) | Median filter | RWM filter | Decision based filter | Prescribed algorithm |
|-----------|---------------|------------|-----------------------|----------------------|
| 10        | 34.48         | 35.47      | 38.29                 | 35.33                |
| 30        | 23.57         | 23.17      | 34.33                 | 33.39                |
| 50        | 14.89         | 14.36      | 30.93                 | 31.43                |
| 70        | 9.36          | 8.78       | 27.88                 | 28.78                |
| 90        | 6.12          | 5.42       | 23.16                 | 23.95                |

Table 2 Assessment of the PSNR (dB) of the various median types filters with respect to noise percentage
4. Conclusion and Future Scope

The proposed algorithm provides better results when related to the other type of median filters. The RWM filter that is designed using this algorithm has proved to eliminate the impulse noise than the other existing median filters. The decision based median filter at the input side removes the noise in an effective manner. The median controlled algorithm, is to calculate the RWM filter weights is less complicated than the other algorithms proposed for calculating the weight. By cascading the above said median filters, at higher noise densities the noise is suppressed in an efficient manner. Hence to conclude we can say that the nonlinear filters perform in a better way when compared to that of the linear filters. The decision based median filters has proved to produce better results than the ordered filters i.e., the median filters in particular. From the higher PSNR values that have been attained it can be said that it the efficiency of this kind of filter is better than the other algorithms proposed earlier. The results of simulation also show the better performance proposed filter is greater to that of the other median filters. The same algorithm can be extended for the 3D images also.

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