Design of Exponentially Weighted Median Filter Cascaded With Adaptive Median Filter

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Abstract. The objective of this paper is to design an II phase algorithm employing median filters for enlightening the performance in removing impulse noise during the processing of the image. The cascaded filter section employs an Adaptive median filter in the first phase followed by a Recursive weighted median filter (RWM) in the second phase. The RWM filter weight is selected with the Median Controlled Algorithm. As a design parameter, the exponential weights of RWM filters are used in the feedback path. The projected algorithm can achieve suggestively improved quality of image when compared to fixed weight or the Center Weighted Median filters.

Keywords: Recursive Weighted Median (RWM), Adaptive Median Filter(AMF), Median Controlled Algorithm, Center-Weighted Median Filter.

1 Introduction
The main aim of this paper is to remove the impulse noise using this cascaded section of median filters[1]. The median controlled algorithm is the simple method using which the weights for the RWM can be calculated[2]. In this algorithm, the median filtered output is taken as the reference signal. In the direction to upsurge the filters PSNR value, an adaptive median section is cascaded in the input side of the median filter[3]. In the algorithms that where proposed in earlier which involve a cascaded section of the median with the RWM filters provided lesser PSNR and greater MSE values[4]. Hence the output appeared to be distorted for higher noise levels. These drawbacks have been eliminated in this proposed algorithm. Identification of pixels by adaptive median filter (AMF), where the images are noised[5-7]. The structure of the adaptive filter ensures the detection of impulse noise not only at low level of noise but also at a high noise level for large size of the window. In case of the Recursive weighted median filters, the determination of the weights are very important[8]. Earlier researchers suggest many new algorithms for determination of weights, which are more complex to compute. The weight calculation by the median controlled algorithm[9], is easy to compute. In this paper the corrupted image is first filtered using the median filter and then is filtered by the decision based median filter in the phase II. This output signal is taken as the reference signal. Difference between this reference signal and the output of the weighted median filter[10], are found and its exponential value is obtained which is applied as the weights for the signal in the feedback path.

2 Proposed Algorithm
This paper demarcates a three-phased scheme for the process of removing the pepper and salt noise. In the opening stage, the adaptive median filter utilized for pixel identification, which are noised. In
another phase, the image filtration done by a median filter and coming to third phase the image is again filtered by RWM filter and the calculation of weights can be done with Median Controlled Algorithm. The previous existing algorithm was the RWM filter using median controlled algorithm. But the main drawback of that algorithm was the inability to remove the noise at higher noise levels i.e., noise levels greater than 50%. In order to eliminate this drawback and to remove the higher noise levels an adaptive median filter can be placed at the input side of the median filter. Hence by doing so the image gets filtered by using adaptive median filter and then by the RWM section.

This overall concept behind this proposal can be represented by the following diagram,

![Diagram of image filtration process](image)

**Fig. 1** Median filter algorithm

### 3. Implementation

There are three phases in the project with the first phase being the AMF the second being the Median Filter and third phase is the Recursive Weighted Median Filter.

#### 3.1 Phase I: Adaptive Median Filters

For identifying the pixels which are corrupted by noise, an AMF is used. If the size of the window is big enough, the structure of adaptive filter confirms that the maximum of the impulse noise is detected at more level of noise also. The noise population has been substituted by the median, but the leftover pixels have remained unchanged.

![Original Image, Noisy Image, Filtered Image](images)

**Fig.2** Filter output for a noise level of 40%

#### 3.2 Phase II: Median Filter

The well-known median filters show the efficacy of their ability for removal of impulse noise while keeping edges, than the mean filters due to its blurring effect. The median filtered output using a 3 X 3 window is given below for a noise of 10%.
3.3 Phase III: Recursive Weighted Median Filter Employing Exponential Weights
The key downside of the median filter is streaking problem along with the loss of small details in the image. The main reason for this is that the median filters use solitary the information of rank-order from the data input, and rejects the original time varying information of the data. In other words, in the median filter, each sample inside the filter window has the same influence on the filter output.

3.4 Calculation of weights
For every window, for example, samples of input that closest to the initial filtering operation result, exponential weighting capacity is more. Place the difference between the sample $X_i$ and the low pass filtering result $X'_i$ in the spot of same to be $|X_i - X'_i|$. Then this sample has the weight

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

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

here $\alpha > 1$. The weighted sum of the samples within the filter's moving window is the result of the initial median controlled filter iteration. This movable window does not have to be the same as the one used for weight calculations. By cascading all three phases we get the following results. The following results shows the output for 20% of noise.

4. Validation and Results
RWM filters are designed by using the different algorithms, and the results are graphed and tabulated by comparing it with various median techniques. When compared to other median kinds algorithms, RWM demonstrates that weights determined using the Median controlled method produce better results.
| Noise (%) | Median filter | Fixed median | Median controlled algorithm | Prescribed algorithm |
|-----------|---------------|--------------|----------------------------|---------------------|
| 10        | 18.8573       | 18.3643      | 18.5676                    | 18.2532             |
| 20        | 21.9880       | 20.8625      | 19.2301                    | 18.6181             |
| 30        | 25.7160       | 24.9829      | 20.6702                    | 19.2348             |
| 40        | 29.8961       | 28.8465      | 24.1458                    | 19.9855             |
| 50        | 32.8746       | 32.8806      | 28.4113                    | 20.6720             |
| 60        | 35.7845       | 35.7442      | 23.2510                    | 21.6215             |
| 70        | 38.0768       | 37.9543      | 35.7443                    | 22.9701             |
| 80        | 39.8797       | 39.9022      | 38.7094                    | 25.1897             |

Table 1 Comparison of the MSE (dB) of the several types median filters concerning noise percentage

| Noise (%) | Median filter | Fixed median | Median controlled algorithm | Prescribed algorithm |
|-----------|---------------|--------------|----------------------------|---------------------|
| 10        | 29.2735       | 29.7665      | 29.5632                    | 29.8776             |
| 20        | 26.1428       | 27.2683      | 28.9007                    | 29.5127             |
| 30        | 22.4148       | 23.1479      | 27.4606                    | 28.8960             |
| 40        | 18.2347       | 19.2843      | 23.9851                    | 28.1453             |
| 50        | 15.2562       | 15.2502      | 19.7196                    | 27.4588             |
| 60        | 12.3463       | 12.3866      | 15.8798                    | 26.5093             |
| 70        | 10.0540       | 10.1765      | 12.3865                    | 25.1607             |
| 80        | 8.2511        | 8.2286       | 9.4214                     | 22.9411             |
| 90        | 6.7677        | 6.7666       | 7.1979                     | 20.1322             |

Table 2 Comparison of the PSNR (dB) of the many types of median filters with respect to noise percentage
5. Conclusion and Future Scope

The proposed algorithm provides better results when related to the other types of median filters. The RWM filter that is designed using this algorithm has proved to eradicate the noise of impulse than the other existing median filters. The adaptive median filter at the input side of the median filter effectively removes the noise. The median controlled algorithm, which is utilised to compute the weights of RWM filter is less complicated than the other algorithms proposed for calculating the weight. Hence to conclude we can say that the nonlinear filters perform in a better way when compared to that of the linear filters. The adaptive median filter can be categorized under the decision-based median filters, which 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 obtained, it can be said that it the efficiency of this kind of filter is better than the other algorithms proposed earlier.

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