ABSTRACT

Impulse noise is a special type of noise which can have many different origins. Images are often corrupted by impulse noise caused by transmission errors, faulty memory locations or timing errors in analog to digital conversion. The impulse noise can be broadly classified into salt and pepper noise (or fixed valued impulse noise) and random valued impulse noise. The salt and pepper noise can corrupt the image, where the noisy pixels can take only the maximum and minimum gray values in the dynamic range. But the random valued impulse noise can take any value between the maximum and minimum gray values in the dynamic range. Since, linear filtering techniques are not effective in removing impulse noise, non-linear filtering techniques are widely used in the restoration process. Median filters are well known for their capability to remove impulse noise as well as preserve edges. The main drawback of a Standard Median Filter (SMF) is that it is effective only for low noise densities. At high noise densities, SMFs often exhibit blurring for large window sizes and insufficient noise suppression for small window sizes.

When the noise density is over 50%, the edge details of the original image will not be preserved by the median filter. However, most of the median filters operate uniformly across the image and thus tend to modify both noise and noise free pixels. Consequently, the effective removal of impulse noise often leads to images with blurred and distorted features. Ideally, the filtering should be applied only to corrupted pixels while leaving uncorrupted pixels intact.

Adaptive Median Filter (AMF), decision based algorithm or switching median filters have been introduced with this objective. Possible noisy pixels are identified and replaced by using median value or its variant while leaving uncorrupted pixels unchanged. The AMF performs well at lower noise density levels, due to the fact that there are fewer noisy pixels that are replaced by median values. At high noise densities, the number of replacements of noisy pixel increases considerably; increasing window size will provide better noise removal performance; as a consequence, the images details are blurred. The main drawback of decision based and switching median filter is that defining a robust decision measure is difficult, because the decision is usually based on predefined threshold value. Also these filters will not take into account the local features as a result of which details and edges may not be recovered satisfactorily, especially when the noise density is high.

Chen introduced a new algorithm to overcome this problem, which consists of two stages. The first stage is to classify the noisy and noise free pixels by using AMF and in the second stage, regularization method is applied to the noisy pixels to preserve the edges and suppress the noise. The drawback of this method is that for high impulse noise density, it requires large window size of 39 x 39, and additionally requires complex circuitry for the implementation and determination of smoothing factor β to get good results. Srinivasan and Ebenezer proposed an algorithm, in which the noisy pixels are replaced by median value for the fixed window size of 3 x 3 resulting in lower computation time and good edge preservation. The main drawback of this algorithm is the neighborhood pixels of the processing pixel are noisy; it is replaced by the previous resultant value, which introduces the streaking effect.

To overcome this drawback, the Adaptive Decision Based Median Filter (ADBMF) algorithm for the restoration of gray scale and color images that are highly corrupted by salt and pepper noise is proposed in this thesis. Some of the neighboring pixels are noisy free; the noisy processing pixel is replaced by trimmed median value of the selected window. The mean value of the neighboring pixels replaces the processing noisy pixel when all the neighboring pixels are 0's and 255's only. The ADBMF algorithm gives better denoised image quality for different noise densities of salt and pepper noise than the existing algorithms. If all the neighborhood pixels in the selected window is only '0' or '255', then the mean value of the selected window is '0' or '255' respectively, which is again noisy. This drawback is overcome by the Trimmed Mean Filter (TMF), in this method; the global trimmed mean value replaces the noisy pixel. The calculation of global trimmed mean value is computational cost when compared to ADBMF algorithm.

The Fuzzy Adaptive Decision Based Median Filter (FADBMF) is proposed to overcome the drawback of the above mentioned algorithms. The FADBMF algorithm contains many classifications. This classification gives much improved result in the denoised image than the existing one. At very high noise density, the results of the FADBMF algorithm fails to retain both fine details and smoothness of the original image. To overcome this drawback, Recursive Spline Interpolation Filter (RSIF) method is introduced in this thesis. In this approach it is possible to retain the smoothness of the original image at very high noisy densities. The smoothness of the original image is retained well by RSIF algorithm when compared to other denoising algorithms. The RSIF algorithm effectively removes the salt and pepper noise and efficiently retains the smoothness of the original image. Smoothness of this method, it fails to retain the fine details at low noise density. Therefore, this algorithm is suitable for high noise density of salt and pepper noise removal. Also the computational time for this algorithm is very high when compared to existing algorithms. At very high noise density (i.e., greater than 95%) this approach introduces the streaking effect. An attempt is made to minimize the streaking effect using bilateral filter.

The bilateral filter is close to Gaussian filter, but it is edge preserving filter. Tomasi and Manduchi proposed the bilateral filter, which is a nonlinear one. This filter removes Gaussian noise while preserving image details. The weighting function gives high priority to those pixels that are both near the processing pixel and similar to the processing pixel. The bilateral filter cannot be used directly to remove the salt and pepper noise, because the range detection weight matrix depends on the processing pixel. The Adaptive Decision based Improved Bilateral Filter (ADIBF) is proposed in this thesis to remove the impulse noise and retain the fine details of the original image. The ADIBF algorithm, the noise detection is based on the decision based algorithm and the reduction is done by the improved bilateral filter. The smoothness of the original image is retained very well by ADIBF algorithm when compared to other denoising algorithms. The ADIBF algorithm effectively removes the salt and pepper noise and efficiently retains the image details of the original image.

Detection of random valued impulse noise in images is a challenging task. In this thesis, the ADIBF is attempted to remove the random valued impulse noise in images. The study reveals the fact that ADIBF work well for 60% random valued impulse noise. The algorithm needs to be tuned further to minimize high density random valued impulse noise. This thesis is an attempt to minimize the impact of impulse noise.