INTRODUCTION

Accuracy of the image processing algorithm is high when the input image is noise free. But during the acquisition and transmission images are corrupted with the noises. Many filter structures are proposed to remove the noise pixel present in the images. Filter structures are widely classified as Linear and nonlinear filters. Linear filters are the filters in which output of filter structure has linear relationship with the input value. Linear filters efficiently remove the Gaussian noise present in the image. Non Linear filters are the filters in which output does not have linear relationship with the input values. Non Linear filters efficiently remove the salt and pepper noise.

Mean filter is widely used linear filters. Input image is processed in window by window. To replace noisy pixel mean value calculated from the pixel values present in the window. Mean value can introduce a new pixel value which is not present in the input window. Due to the introduction of pixel value the edge pixel values are lost. In the case of nonlinear filters the filter will not introduce any new pixel values. Median filter is widely used nonlinear filter structure. Median of the values present in the windows is calculated to replace the noisy pixel. No new pixel is introduced due to which the edge information is preserved. But the major drawback of filter structure is inefficient in removal of the Gaussian noises present in the images.

Standard Median filter act as nonlinear smoother while retaining the edges in the images. Filter structure are easy to implement and consumes very less area. Power consumption of the circuits used for the median filtering operation is also less. But the efficiency of standard median filters in removal of the Gaussian noise very poor.

Mean filters have easier to implement and used to eliminate the short tailed noise occurring in the images. But major disadvantage of the filter structure is loss of edge from the image and also the filter structure are insensitive to the impulse noises present in the images.

New filter structure shown in this paper combines the feature of both linear as well as nonlinear filter structure. Edges values are preserved using edgedetection logic. Preserved edges are combined with the filtered output to improve the image quality. Due to the combination of the two filter structures the IEF value of the image got increased.

The paper is structured as following sections Section II we introduce the new filter structure. Section III briefs about the implementation of filter structure in Xilinx. Results and discussions are presented in section IV. Conclusions are presented in section V.

Filter Structure:

Filter structure consists of alpha trimmed mean filter to remove Gaussian noise. Impulse noise from...
the input image is removed with the help of the median filter. Edges are preserved with the help of the high pass filter arrangement. The filter structure is shown in the Fig. 1.

Alpha trimmed mean filter removes the maximum and minimum values from the processing window. Mean values are computed on the remaining pixels present in the window. The alpha trimmed filter equation is given in equation 2.1

\[
\text{Mean} = \frac{1}{(M+N)-p} \sum_{i=p}^{(M+N)-p} A_i 
\]  

Where p is the alpha pixels needed to be removed.
M is the number of rows in window
N is the number of columns in window
Ai is the pixel value.

**Fig. 1: Filter Structure.**

Median filter removes the noises by using the similarity of neighborhood pixels. Intensity of the image at a particular point will not have much variation with the neighboring point. Based on the above logic the image is processed in the window. Median value is calculated from the processing window.

Sudden change in the intensity values are considered as edges in the images. Threshold value is used to identify the sudden change in the intensity of the image pixels. When the pixel value is greater than the threshold value then the pixel value is stored separately.

Balanced histogram technique computes threshold based on the computation of mean values in images. When the pixel value is greater than the mean value then it is separated in one group. Mean value is calculated for the group. Similarly the pixel value greater than the threshold values are separated as another group. Mean is calculated for the new group. New mean computed by taking average of the two separate mean values.

Combiner structure is used to merge the preserved edges and the mean filtered output. When the preserved edges values other than zero then the particular pixel value is replaced with the preserved edge values.

IEF is metric used to measure the sharpness of the image. IEF values are varied by varying the amount edge preserved. IEF value is calculated by using the following equation

\[
\text{IEF} = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} (N(i,j)-X(i,j))^2}{\sum_{i=1}^{N} \sum_{j=1}^{N} (Y(i,j)-X(i,j))^2} 
\]  

Where N (i, j) represents the noise pixel value
X (i, j) represents the pixel value of original image and
Y (i, j) represents the pixel value of denoised image.

**HDL Implementation:**

Modules are developed with the help of HDL. Image is converted to hex values and the converted values are fed as inputs to the HDL module.

**Mean Filter:**

Mean filter removes the noise by computing mean values between the pixels. Nine pixels processed at each clock cycle. Nine pixel values are arranged in the ascending order. Alpha value pixels are discarded from the input pixels. Two pixels are discarded from nine pixels. Mean value is computed for the remaining seven pixels

<table>
<thead>
<tr>
<th>Pixel Values</th>
<th>Sorted</th>
<th>Sorted</th>
<th>Sorted</th>
</tr>
</thead>
<tbody>
<tr>
<td>161</td>
<td>159</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>159</td>
<td>171</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>95</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>154</td>
<td>159</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>161</td>
<td>168</td>
<td>171</td>
<td></td>
</tr>
</tbody>
</table>

Pixel values 67 and 171 are discarded and mean value is calculated. Mean value = 139
**Median Filter:**
Median Filter removes the noise by computing the median value. Window consists of nine pixels. For each and every clock pulse nine samples are processed. Nine pixels are arranged in an ascending order. Fifth value corresponds to the median value of the filter structure. Median value calculation is illustrated below.

![Median Filter Diagram]

Median value = 159

**High Pass Filter:**
High pass filter preserves the edges by using the specialized structure. Difference between two neighboring pixels is calculated. When the difference between the two pixel values is greater than the threshold value then the pixel is considered as the edge pixel. Edge pixels are alone retained remaining values are changed as zero.

**Combiner Structure:**
Combiner structure is used to combine the filter output with the preserved edges. For each and every clock cycle the system checks the preserved edge pixel values. When pixel value is other than the zero then the filtered value is replaced with the preserved edge value. Simple comparator and mux structure is used to implement combiner structure. Combiner structure compares the values with zero it produces output as ‘1’. When the output is 1 the mux selects the pixel value from the filtered output image.

**Balanced Histogram Technique:**
Threshold value to separate the edge values are calculated using the balanced histogram technique. Mean value is computed from the image in a single clock pulse. Separation of pixel values into groups is carried in next clock pulse. New mean values are calculated in the next clock pulse. Iteration of the process is carried for the next fifteen cycles to obtain the accurate mean values from the image.

**Simulation Results:**
Various images are given as inputs to the filter structure and the corresponding IEF values are calculated using XILINX. The simulation flow is given in the figure.

![Simulation Flow Diagram]

**Table 1: IEF values.**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Image</th>
<th>Threshold</th>
<th>IEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boat</td>
<td>43</td>
<td>9.2731</td>
</tr>
<tr>
<td>2</td>
<td>Lena</td>
<td>44</td>
<td>8.3322</td>
</tr>
<tr>
<td>3</td>
<td>Rose</td>
<td>39</td>
<td>13.0521</td>
</tr>
</tbody>
</table>

Image is converted to hex files with the MATLAB and it is given as input to the HDL modules in a text file format. Output values are written as hex values and converted as images with the help of MATLAB.

![Images ofconverted images]

**Fig. 3.1:** Preserved Edge and reconstructed Lena image.

256X 256 images is processed through HDL coding. Sample output for a single 3X3 window is shown in the below figures. Similarly the entire image is processed through the XILINX ISIM simulator.

![Sample Output Diagram]

**Fig. 3.2:** Alpha Trimmed Filter Output.


**Conclusion:**

Filter comprises both linear and nonlinear filtering technique. Removes efficiently both Gaussian and the impulse noise present in the image. IEF values are calculated for the different images. The filter structure is simulated using the XILINX ISE tool. IEF values are higher since the filtered image contains more edge details present in the images. Filter removes the noise values without loss of edge details present in the image. Thresholding to separate the edge pixels are dynamically obtained from the image due to which the IEF value is improved when compared to the manual thresholding technique.

**REFERENCES**


