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Implementation of Standard Mean Filter Using Bit Planes for Noise Removal in Images

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Abstract:

In this project, we proposed two Bit-plane architectures to implement the Mean functions to remove Salt and pepper, Gaussian noises. A Bit-plane consists of the bits corresponding to the same significant level in all the elements. In the Mean function architecture, three Bit-plane code look up tables are generated based on the weight of the bit-plane and no of 1's in that bit-plane. Binary addition of the three bit-plane codes gives the approximated mean value for the given array of image elements.

The experimental results show that the proposed architectures are performing equally well with the standard mean filters.

1. INTRODUCTION

Noise can be systematically introduced into images during acquisition and transmission. A fundamental problem of image processing is to effectively remove noise from an image while keeping its features intact. The nature of the problem depends on the type of noise added to the image. Fortunately, two noise models can adequately represent most of the noises added to images: additive Gaussian noise and impulse noise. Additive Gaussian noise is characterized by adding to each image pixel a value from a zero-mean Gaussian distribution. Such noise is usually introduced during image acquisition. The zero-mean property of the distribution allows such noise to be removed by locally averaging pixel values. Ideally, removing Gaussian noise would involve smoothing inside the distinct regions of an image without degrading the sharpness of their edges. Impulse noise is characterized by replacing a portion of an image's pixel values with random values, leaving the remainder unchanged. Such noise can be introduced due to transmission errors. The most noticeable and least acceptable pixels in the noisy image are then those whose intensities are much different from their neighbors.

Image processing is a very important field within factory automation, and more concretely, in the automated visual inspection. The main challenge normally is the requirement of real-time results. On the other hand, in many of these applications, the existence of impulsive noise and Gaussian noise in the acquired images is one of the most habitual problems. Mean filter for the Gaussian noise. In this project we proposed two Bit plane architectures to implement the Mean filter and these architectures are tested and can be used to implement in FPGAs.

2. MEAN FUNCTION USING BIT-PLANES

Linear filtering techniques have been used in many image processing applications, and their popularity mainly stems from their mathematical simplicity and their efficiency in the presence of additive Gaussian noise. Additive Gaussian noise is characterized by adding to

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each image pixel a value from a zero-mean Gaussian distribution. Such noise is usually introduced during image acquisition. Such noise can be removed by locally averaging pixel values that are using Mean filters[1] and [11]. A mean filter is the optimal filter for Gaussian noise. The mean function is an important function used in the field of image processing. The most prominent example of the use of the mean function is the standard mean (SM) filtering, which is a common technique used to suppress noise of a Gaussian nature. A mean filter acts on an image by smoothing it; that is, it reduces the intensity variation between adjacent pixels. The mean filter is nothing but a simple sliding window spatial filter that replaces the center value in the window with the average of all the neighboring pixel values including itself. By doing this, it replaces pixels , that are unrepresentative of their surroundings. It is implemented with a convolution mask, which provides a result that is a weighted sum of the values of a pixel and its neighbors. It is also called a linear filter. The mask or kernel is a square. Often a 3× 3 square kernel is used. The mean or average filter works on the shift-multiply-sum principle.

In this project a Bit-plane level architecture to implement mean function is proposed. It works on the Bit-plane information of an image. As explained in the median function each image elements ranges from 0 to 255. 8 bits are required to represent each element of an image. By separating each corresponding bit in to a separate plane 8 Bit-planes will form. A 3*3 window on the image gives 9 elements and these 9 elements are divided in to Bit-planes based on the no of 1's in the Bit-plane the proposed algorithm works. To get the mean value for the 9 elements only 3 MSB Bit-planes are used. Because the most 3 MSB planes consists the maximum information of an image. Based on no of 1's in each Bit-plane a separate unique Bit-plane code is generated. 3 Bit-plane codes are generated for 3 MSB planes based on the algorithm, the binary addition of these Bit-plane codes gives the mean value for the given 3*3 window elements. The procedure to generate Bit-plane codes is shown in the look up tables. The range of no of 1's in a plane is 0 to 9.Total 10 Bit-pane codes are generated for each bit plane.

3.1 Flow chart:

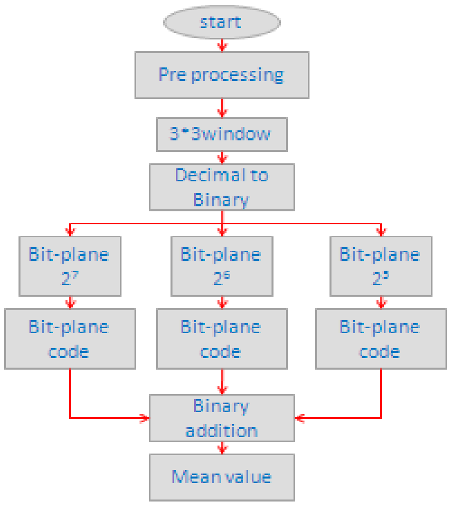

Figure 4.1 Flow chart of mean filter.

3.2 Assessment parameters

In order to test the proposed algorithm, experiments are performed at different noise levels on three different images viz. 'Lena' , 'Peppers' and 'water lilies' of size 256×256. To evaluate the image restoration performance, Mean absolute error (MAE), mean square error (MSE) and Peak signal to noise ratio (PSNR) are used as the criterion.

3.2.1 Mean Absolute Error

$$MAE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x_{ij} - y_{ij}\right|$$

Where x_{ij} and y_{ij} denote the pixel values of the original image and the restored image, respectively.

3.2.2 Mean Square Error

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x_{ij} - y_{ij}\right|^2$$

MSE indicates average square difference of the pixels throughout the image between the original image x_{ij} and Denoised image y_{ij}. A lower MSE means that there is a significant filter performance.

3.2.3 Peak Signal to Noise Ratio

The PSNR is most commonly used as a measure of quality of reconstruction in image compression and image denoising etc[6]. The PSNR is given by

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$$PSNR = 10 \log_{10}\left(\frac{L^2}{MSE}\right) = 10 \log_{10}\left[\frac{L^2}{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}|x_r - y_r|^2}\right]$$

L: Dynamic range of pixel intensity
$L = 2^B - 1$, where B is the number of bits to represent a pixel
For 8bits/pixel gray-scale image → $L = 255$
Larger PSNR values signify better signal restoration.

Once the visual quality of images restored by the proposed median filter had been confirmed, we concentrated on directly comparable, quantitative measures of signal restoration. In particular, we measured the peak signal-to-noise ratio (PSNR).

Using this technique we can find the approximated value for the given array of image elements. This technique works efficient at the higher image gray elements compared to the lower gray elements. It can be observed from the given examples given for higher gray image elements the difference between the actual mean value and the Bit plane mean value is very less and is negligible. Where for lower gray image elements the difference between the actual and the bit plane mean value is not less but it is negligible because the lower values of gray elements represents the black pixels and the resultant also the black pixel , so visually we cannot find the difference. Our eye cannot distinguish the difference it the neighbored pixels differs less than 32.

Therefore the proposed technique can be used to find the mean values using bit planes.

4. SIMULATION RESULTS

In this chapter the results obtained by the proposed Bit plane technique for the test images Lena at different noise ratios (2%,10% and 20%) are given in tabular form and in graphical form. Noisy, denoised images after processing are given in the fig [5.1-5.5].

Additive Gaussian noise is characterized by adding to each image pixel a value from a zero-mean Gaussian distribution. Such noise is usually introduced during image acquisition. Such noise can be removed by locally averaging pixel values that are using Mean filters. In this project the proposed Mean filter using the Most three MSB Bit planes, is tested for the test images of size 256x256. Gaussian noise is artificially injected in these images at 2%,10% and 20% noise ratios. The denoised figures using the standard Mean and proposed Mean filter are shown in the figures [5.2-5.3]. The assessment parameter values obtained are quantized in the tables [5.3-5.5]. From the graphical figures [5.3-5.5] we can observe that the proposed filter is performing equally even better than the standard Mean filter. Therefore these architectures can be used for implementing Median and Mean filters in FPGAs (where logic gates works only on bits 1 and 0) so that the processing speed of the operation increases.

5.6 Denoised images
Median filter results

Figure 5.1 a) original image (b) 2% salt and pepper noise (c) denoised image using Bit-plane method. (d) denoised image using Bit-plane method.

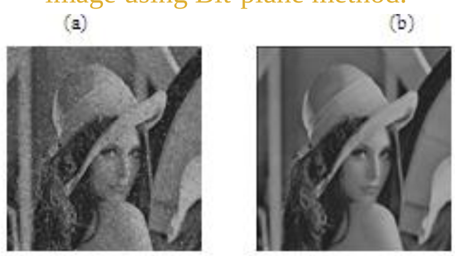

Figure 5.2 a) 10% salt and pepper noise (b) denoised image using Bit-plane method

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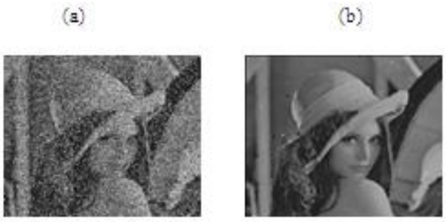

Figure 5.3 a) 20% salt and pepper noise (b) denoised image using Bit-plane method.

Mean filter results

Figure 5.9 (a) original image,(b) 2% Gaussian noise added to the original image.(c) Denoised image using standard mean filter.(d) Denoised image using Bit-plane method

Figure 5.4(a) original image, (b) 10% Gaussian noise added to the original image. (c) Denoised image using standard mean filter. (d) Denoised image using Bit-plane method

Figure 5.5 (b) original image, (b) 20% Gaussian noise added to the original image. (c) Denoised image using standard mean filter. (d) Denoised image using Bit-plane method

5. CONCLUSIONS AND FUTURE SCOPE

In this project the proposed bit plane method for noise removal in images, for various noises like Gaussian and Impulse, as given very much encouraging results at different noise levels. In present day scenario of digitization, makes the data available in the form of binary digits. Therefore our proposed noise removal methods can be very easily realizable using FPGAs. The advantage in implementing noise removal methods using PLD's is not only accuracy and also the speed of operation. As the sensors send data to PLD, like FPGA, output is available after gate delays in the PLD with removed noise. This reduces drastically the processing time of noise removal for any signal especially for images. So this work can be continued in future for implementing our proposed bit plane techniques for removing Gaussian noise and salt & pepper noise in FPGAs. The same can also be extended for remaining any other noises, like speckle which is multiplicative noise.

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