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Median Filter Algorithm Implementation on FPGA for Restoration of Retina Images

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Abstract

Diabetic Retinopathy is one of the most complicated diseases and it is caused by the changes in the blood vessels of the retina. Extraction of retina image through medical camera sometimes produces poor contrast and noises. Detection of blood vessels in the retina is complicated. So pre processing is needed to reduce the noise in the image. In this paper a novel algorithm is used to remove the noisy pixel in the retina image.

To solve the contradiction between the noise reducing effect and the time complexity of the standard median filter algorithm, this paper proposed an improved median filter algorithm. The paper focuses on a 3x3 image window filtering in which the sorting network of the filter was able to produce the desired result within the shortest time possible. That means, the sorting network was able to exercise resemblance in processing the image pixel and the number of the required hardware maintained minimal. The algorithm shows that the sorting network will be able to produce the result within the required time.

The new improved filter algorithm was implemented using Hardware Description Language Verilog, simulated using Xilinx isim it was loaded on to Xilinx FPGA. The hardware result showed that this proposed algorithm has better output result as compared to previous algorithm (standard median algorithm as well as adaptive median algorithm). It has a good application prospect in real-time image processing

Keywords: MedianFilter,FPGA,MATLAB

1. Introduction

In our body, one of the most important organs is eye; it gives vision. Eye is protected by external coverage known as eyelids and inside the eye it is clustered by number of sockets of bones and these sockets are called as orbit . There are several tissues present in the eye ,they are cornea, iris, lens, vitreous gel, retina and optic nerve and it has several functions. In these tissues, most important functionality tissue is retina; it is one of the nerve tissues inside the eye. They are several diseases in the retina; diabetic retinopathy is one of the diseases

Median filtering is considered a popular method to remove impulse noise from images. This non-linear technique is a good alternative to linear filtering as it can effectively suppress impulse noise while preserving edge information. The median filter operates for each pixel of the image and assures it fits with the pixels around it. It filters out samples that are not representative of their surroundings; in other words the impulses. Therefore, it is very useful in filtering out missing or damaged pixels of the image.

The complexity in implementation of median filter is due to the large amount of data involved in representing image information in digital format. General purpose processor as an implementation option is easier to implement on but not time-efficient due to additional constraints on memory, I/O bandwidth and other peripheral devices. Full custom hardware designs like Application Specific Integrated Circuits (ASICs) provide the highest speed to application but at the same time they have very less scope for flexibility.

Digital Signal Processors (DSPs) and Field Programmable Gate arrays (FPGAs) are two choices under the category of semi custom hardware devices. These devices give a balanced solution for performance, flexibility and design complexity. DSPs are best suited to computationally intensive applications.

This paper will study methods to implement new Median Filter Algorithm on Field Programmable Gate Arrays (FPGAs). FPGAs are integrated circuits (ICs) that can be configured to implement a specific function after the chip has been manufactured. The advantages of using FPGAs are their reprogrammable nature, ease of prototyping, rapid time to market, and minimal non-recurring engineering (NRE) cost compared to custom IC designs.. Its parallel processing characteristic increases the speed of implementation .The proposed noise removal algorithm is shown to achieve good performance compared to existing standard median filter in terms of performance metrics such as PSNR and minimizes the other hardware resources.

2. Existing Methodologies

The existing standard median filter algorithm utilize onlythe fifth pixel, if the fifth pixel is corrupted by the noise then it is replaced by the median value. But this proposed extended median filter for retina image restoration is more efficient,because first it check the fifth pixel, then diagonal element,vertical and horizontal element. In standard median filter, first extracts the 3 ×3 sliding window from the retina image, in that sliding window, check the fifth pixel, if it noisy pixel then it is replaced by the median value of the first extracting sliding window. Then it switchover to extract the second sliding window and again check the fifth pixel of the second sliding window and if it is noisy replaced by the median value of the second sliding window, the same process is repeated for all extracting sliding window from the retina image. But extended

median filter algorithm is different from the Standard median filter, that it first extracts the median value from the sliding window 3 ×3, if the fifth pixel is noisy, then the noisy pixel is

corrupted by the median value, then it extract the diagonal elements from the sliding window, if the diagonal value is noisy then it is replaced by the median of the diagonal value. The same process is repeated for the vertical and horizontal pixel for the first sliding window. After this process, it extracts the second sliding window from the same retina and repeats the same process. Proposed algorithm sorted all the pixels from the sliding window, but in existing median filter extracts the fifth pixel only.

The standard median filter does not perform well when impulse noise is Greater than 0.2, while the adaptive

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median filter can better handle these noises.

3. Proposed Methodology

With the use of a sliding window, the number of comparison units for vertical sorting is reduced Each block is a comparison unit, and by using registers in between each stage, the median filter is a highly optimized and pipelined which delivers one pixel per cycle.

Due to the movement of the sliding window, previous columns can be retained for reuse in future windows. For a k × k sliding window, k – 1 previous columns will be reused for the window surrounding the following pixel, which means that the sorting done on those columns need only be completed once and saved instead of resorting the columns for each new window.

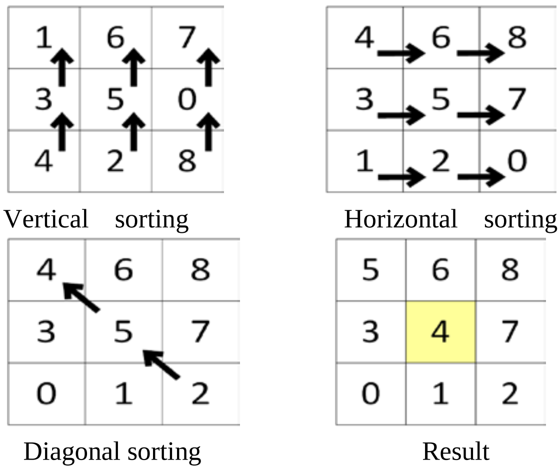

Figure 1: Example of median filtering using sorting

By saving previously sorted columns, we reduce the required number of comparisons and comparison units in our architecture. Our sorting-based approach uses the algorithm to find the median filter, with an example of the usage of the algorithm using a 3×3 window in Figure 1

The architecture is based on a Triple Input Sorter as shown in Figure 2 and consists of the following stages

Step 1: Read an input image
Step 2: Define 3x3 array for 3x3 window to take 9 corresponding pixels from input image.
Step 3: In this step, all three rows scan in 3x3 window will find maximum, median and minimum values from each rows and will arrange as given sequence.
Step 4: Similarly all three columns then scan for finding maximum, median and minimum values and arrangement.
Step 5: Now window will find same 3 values from all scanned maximum, medium and minimum value. Principle diagonal of 3x3 square window to find median from those three values.
Step 6: Similarly in other diagonal all three values scan except a centre value in that diagonal replace by result of previous step.
Step 7: Now this 3x3 window continues to scan input image until all pixels of image scanned.
Step 8: Finally, we get output image without impulse noise by using median filter.

It gives us one of the efficient ways to get median value from 3x3 window.
Only three results are guaranteed to be placed in the right place: the maximum, the minimum and the median; this saves a great deal of logic. The main component in this design is a Triple Input Sorter (which is based on a dual input sorter), Triple Input Sorter based algorithm (TIS) which is an optimized version of the Bubble sort algorithm for the special case of a 3x3 window size which is as shown in Figure.

During the median filter neighbouring pixels including the centre pixel are assigned to three row extractors for shortening the searching time of the median value. At first, each row extractor extracts the median value of three pixels in its row. The three row extractors work in parallel, which is one operation level parallel. Then, the final median extractor calculates the median value of the output values of three row extractors. This improvement will greatly expedite the process of median searching

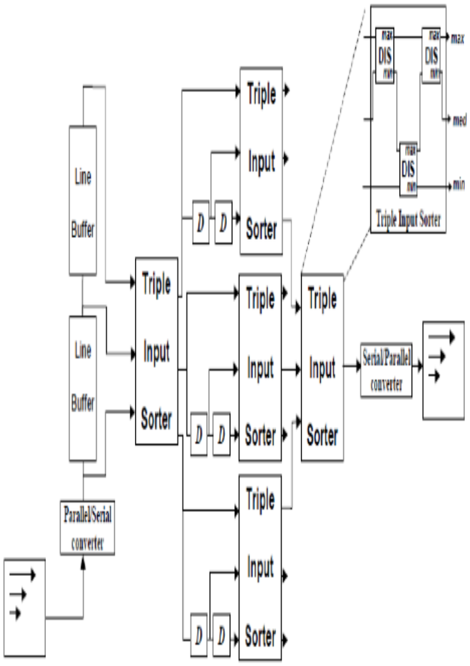

Figure 2:3×3 Triple input sorter based median filter design

The basic 2D (3 * 3) median filter is characterized by the following equation:

OUTPUT(x, y) = MED{ PI, **P2, P3 ,P4, P5, P6, P7, P8, P9)**

OUTPUT(x, y), which is the median **data of** these nine pixels, will replace the central point **P5.**

OUTPUT(x, y) = MED { MIN[S], **P5 ,** MAX[S] **}**

Where S is the set of samples surrounding the central point except its horizontal neighbors (P4, **P6),**

S = {PI, *P2, P3, P7, P8, P9)*

MIN[S] is the minimum data of S, and MAX[S] is the maximum data of *S.*

The hardware structures of the 4 comparators are given in Figure 3. the processing element is basic processing unit, which is designed for comparing 2 input data. D stands for D flip-flop, whose function is to make a single-circle delay. It is used for synchronizing the calculation here.

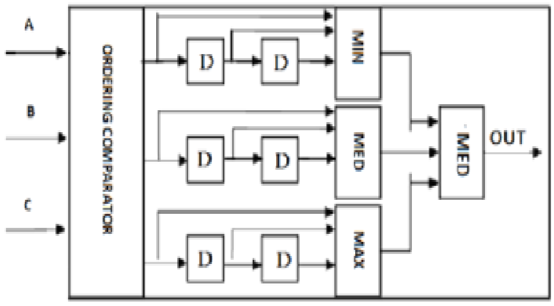

Figure 3: Hardware structure of 4 comparator

Because the proposed algorithm needs to storage two groups temporary data in current processing, we design two D flip-flops to realize this function. The data's will be sent to the ordering comparator ordinally for data ordering, and the results will be send to next different comparators.

Before the second comparing, the data need 2 circle delay to distinguish the circle order of input data by two D flipflops. The second comparing results will be sent to the final median comparator to get the final result.

The median value will be the middle value of the sorting network. It utilize 3×3 masks, which means that processing each pixel, as the pixels in the boundary of each section, needs eight pixels around it. In order to deal with the boundary problem, each section contains four more rows of pixels than half input image. The four extra rows are responsible for processing a boundary row.

4 FPGA Implementation '

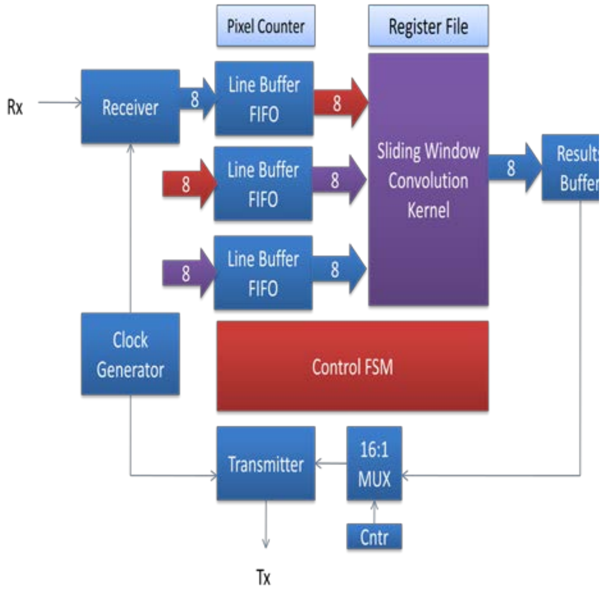

Figure 4: Block diagram for FPGA Implementation

The top level block diagram as shown in the Figure 4 consists of Reciever, Line buffer, Sliding window, Clock generator, Control FSM , Multiplexer and Counter. Retina Images capture from medical camera is taken and store it in the PC. Since coding is done using verilog, it can not read j.peg images directly . hence we need a tool to convert j.peg images to verilog readable language. Matlab is a tool used for this function.

5. Results

This algorithm is applied for 3x3 median filter on a real time image. since median filter Is very effective in removing the salt and pepper noise more effectively in gray scale the real time color image is converted to gray scale and the processing is carried out.

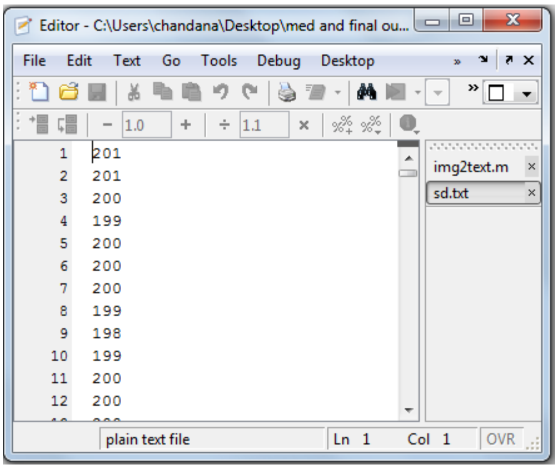

Figure 5 :Text format of grayscale image

Figure 5 shows the text format of the gray scale image done in Matlab, which is then given as input to FPGA for median filtering.

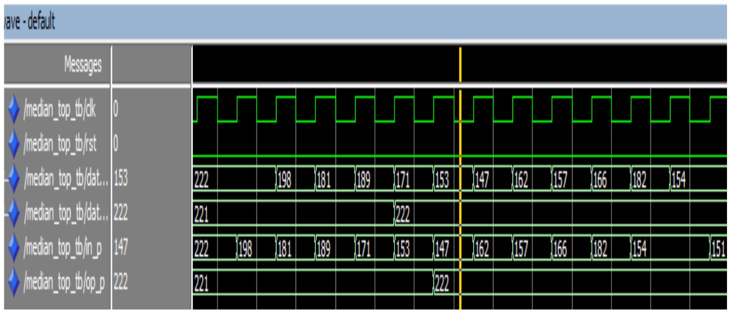

Figure 6:simulation results of grayscale image

Figure 6 shows the simulation results of the median value calculation with very less computation from the first output to the last output, which has the great impact on the speed of image processing on real time application.The computation time from reset output to the first output available is comparatively smaller than the standard median filtering algorithm.

6. Conclusion

In this paper, a new proposed algorithm for the removal of noise in the retina image. This method is used to preprocess the retina image, that it eliminates the noise. The proposed algorithm not only obtained the better image quality, but also preserves

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the edges. In this paper, simulation results are obtained for fixed 3×3 sliding window from the retina input image. Extensive simulation result proves that the proposed Extended Median filter provides better performance than the standard median filter in terms of noise suppression.

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