

Implementation of Pipelined Median and Binary Thresholding Filtering on Max-10 FPGA

Digital Circuits Lab

EE-214

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1 Abstract:

In this project Pipelined Median and Binary Thresholding Filtering is used to detect underwater gas pipelines using Xen-10 board. The uni-color gas pipeline detection in a 128x128 pixels Red-Green-Blue(RGB) Image is proposed in this project. The 128x128 pixel RGB Image is converted into the binary format and stored inside Block RAMs (BRAM). When data is stored inside the BRAM, then 3x3 kernel is transferred in each clock cycle to the Pipelined Median Filter using Intermediate Line Buffers between BRAM and the Pipelined Median Filter. After Median Filter operation, data is stored in BRAM and Binary Thresholding Filtering is done for gas pipeline detection. The data is extracted from BRAM after Binary Thresholding Filtering and compared with the MATLAB software simulated results.

2 Introduction:

Median filtering is a widely used image processing technique that is effective in reducing noise while preserving the edges and fine details of an image. It's a non-linear filtering method that replaces the value of a pixel with the median value of the pixels within a certain neighbourhood around that pixel. This helps to eliminate outliers and random noise that can distort the appearance of an image. Here's how median filtering works:

Neighbourhood Selection: A sliding window or kernel of a specified size moves across the image. The size of the kernel determines the area around each pixel that will be considered for calculating the median. Common kernel sizes are 3x3, 5x5, and 7x7.

Pixel Sorting: For each position of the kernel, the pixel values within the kernel are collected and sorted. Sorting these pixel values from lowest to highest helps in finding the middle value, which is the median.

Median Replacement: The median value is then assigned to the centre pixel of the kernel, effectively replacing the original value of that pixel. The main advantage of median filtering lies in its ability to effectively preserve edges and fine details, making it well-suited for images with sharp transitions and intricate textures.

Binary thresholding is a fundamental technique in image processing used to segment images by converting them into binary images. In binary images, each pixel is either classified as an object (foreground) or as the background, based on a specified threshold value. This technique is particularly useful for separating objects of interest from the background when there's a distinct difference in pixel intensities between them. Here is an introduction to binary thresholding and how it works:

Thresholding Process: Binary thresholding involves comparing the intensity of each pixel in an image to a predefined threshold value. If the pixel intensity is above the threshold, it's assigned a high value (typically 1 or 255), representing the foreground (object). If the pixel intensity is below the threshold, it's assigned a low value (typically 0), representing the background.

3 Weekly Milestones to be followed by Students

1. Week 1:

- (a) Literature Survey of Median Filter, Binary Thresholding and Line Buffers. Perform Median and Binary Thresholding Filtering on a 128x128 RGB Test image on MATLAB. Extract Raw Image data in binary format of a Test image using MATLAB.
- (b) Implementation of Pipelined Median Filter and Binary Thresholding. Access On-chip Dual Port RAM using Altera-IP and store the raw data in the RAM
- (c) Implementation of 4-Line Buffers for achieving Hardware Acceleration. Design Datapath Controller for Controlling the data Path
- (d) Store pixel data back to memory after filtering operation Perform RTL Simulation, extract memory data and plot it on MATLAB.

2. Week 2:

- (a) Compare MATLAB and RTL Simulation Image Perform RTL Simulation, extract memory data and plot it on MATLAB
- (b) Verify the same functionality of each block that is implemented in Week-1 on Xen-10 Board.
- (c) Perform Scanchain based Testing after integrating all blocks.
- (d) Integrate UART for accessing on chip memory data, plot image data and compare with RTL and MATLAB simulated images.

4 References:

- [1.] K. Vasanth, S. N. Raj, S. Karthik and P. P. Mol, "Fpga implementation of optimized sorting network algorithm for median filters," INTERACT-2010, Chennai, India, 2010, pp. 224-229, doi: 10.1109/INTERACT.2010.5706144.
- [2.] A. H. Fredj and J. Malek, "Design and Implementation of a Pipelined Median Filter Architecture," 2019 IEEE International Conference on Design & Test of Integrated Micro & Nano-Systems (DTS), Gammarth, Tunisia, 2019, pp. 1-6, doi: 10.1109/DTSS.2019.8915329.