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Simulation of Morphological Processing-Erosion using Xilinx EDA Tool

Kapilavai.Rahul[1], Addela.Likhith Reddy[2] and R.Ganesh[3]

[1,2] UG Student, CVR College of Engineering/ECE Department, Hyderabad, India

[3] Assoc. Professor, CVR College of Engineering/ECE Department, Hyderabad, India

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Abstract -The present Artificial Intelligence and Machine learning systems with digital domain and image processing applications require the information extraction from the images. These images may be extracted from processing of the image streams or video streams of different frame rates and resolution without any human interaction [1].

Hence, for the present image based applications, there is a requirement for high speed image data extraction processing system. This process is performed by using different digital image processing techniques on images and one such processing is done by using morphological processing. The morphological image processing considers the image as structures of small pixel element matrices that are handled by mathematical theory. This processing is normally applied on binary(black and white) images. The morphological process performs operations like opening, closing, erosion and dilation etc.

In real life , most of the images are having some portions as blurred or unclear ,which leads tobad image visualization. Initially, these images are considered for preprocessing after that convert these RGB images to binaryimagesand then pixel matrices using MATLAB software. The pixel matrix which is obtained from MATLAB is applied as the input in the erosion filteringthrough a Verilog HDL code using the XILINX EDA tools.

This paper describes the process of morphological image processing on 8x8 pixel matrix using erosion operation with the help of 3x3 structuring element Then the desired eroded output matrix is obtained.Hence,byusingerosionfilteringmethoda new form ofpixelmatrix is usedtocreateabettervisualized image.Finally, the outputmatrixcanbereconstructedasanimage.Thefinaloutputimagewillbe free ofblurred/unnecessary pixels.

***Key Words*:**Morphological Processing, Dilation, Erosion, Xilinx Vivado, Zynq Zed Board

1.INTRODUCTION

The present Artificial Intelligence and Machine learning systems applications require the image information extraction from the video streams or image streams.

This image extraction focuses on two major tasks i.e. the improvement of pictorial information forhuman interpretation and Processing of image data for storage, transmission and representation forautonomous machine perception. This extraction processing opens new application fields in image processing like computer vision, safety, and security surveillance applications. [2]

The block diagram of processing of extracted image is shown in Figure 1. [3]

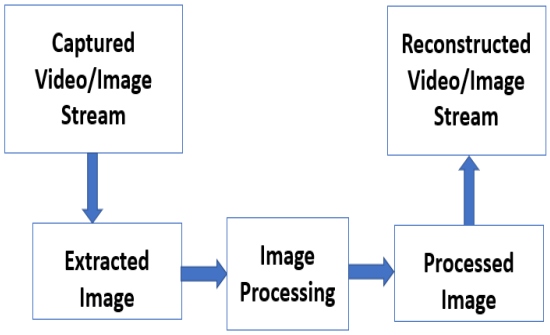

Figure 1: Block diagram of Processing of Extracted Image

This extracted image processing is done on captured video or image stream that are received from the complex images or photographs or video frames.

This extracted image processing considers all the images as two dimensional pixel matrix values on which different image processing techniques or algorithms are performed [4]. After performing the image processing on extracted image, an output two dimensional processed image will be generated from which the output video or image stream will be reconstructed as per the image processing techniques or algorithms.

The image processing is used to convert either color or gray scale images into digital form by using different image extraction methods. This image feature extraction will be done by using Morphological image processing. The block diagram of the corresponding system is shown in Figure 2.

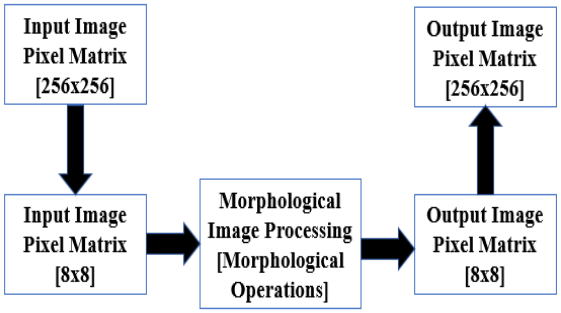

Figure 2: Block diagram of Morphological Image Processing

The 256x256 input pixel matrix is used to extract the 8x8 input pixel matrix. This 8x8 input matrix is used for Morphological Image Processing with the help of different morphological operations. These Morphological operations uses structuring element along with the input matrix. The output pixel image matrix will be generated by using the output 8x8 matrix after the morphological processing [5].

The image feature extraction is done by using different algorithms with the help of MATLAB software. These algorithms will be further improved in terms of high speed realization by using either FPGA or ASIC hardware. The prototype realization will be done by using FPGA. Hence, here the FPGA is chosen, and the main aim of this paper is to design and simulate the erosion morphology operation on the extracted image.

The section 2 gives the analysis of the Morphological Image processing. The section 3 gives the design algorithm and model for Morphological Image Processing-Erosion operation. The section 4 shows the synthesis results, and the section 5 give the Morphological Processing-erosion simulation results. The section 6 gives the conclusion followed by References.

2. ANALYSIS OF MORPHOLOGICAL IMAGE PROCESSING

The video stream or image stream will be used to get an input image for the image processing. The basic design steps for processing of an image is shown in Figure 3. This input image along with the structuring element is converted into pixel matrix by using MATLAB software. The extracted input pixel matrix is applied for the erosionfilteringthroughaVerilog HDL codeintheXILINX Vivado EDA tool. Then using this FPGA processing thedesirederoded output matrix will be generated [6]. Hence, by using erosion filtering method the pixel matrix is generated and usedtocreateabettervisualizedimage.Finally, theoutput pixels canbe used to reconstruct the outputimage.Thefinal outputimagewillbe free ofblurred/unnecessarypixels.

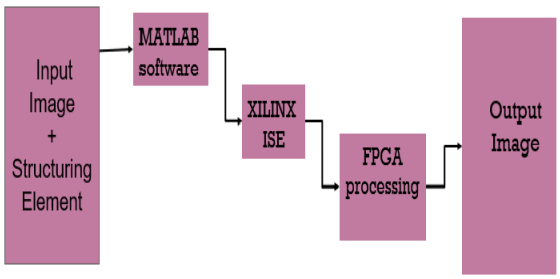

Figure 3: Basic steps for Processing of an Image

The Morphological image processing performs the basic image processing operations like opening, closing, dilation and erosion etc. by using the different mathematical equations. All these operations works on 8x8 images by using the structuring element of sizes 3x3, 5x5 etc. The block diagram of the Morphological Image Processing with Erosion operation is shown in Figure 4.

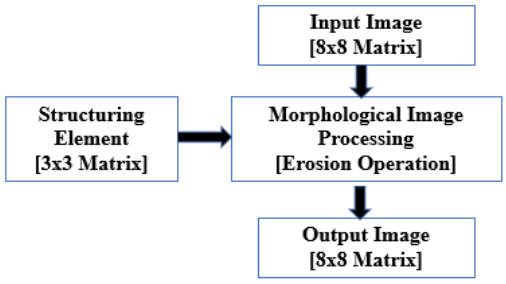

Figure 4: Block diagram of Morphological Image Processing with Erosion

The Morphological image processing with erosion is used to generate an 8x8 output image pixel matrix by using the 8x8 input image pixel matrix and 3x3 structuring element. This operation of erosion on 8x8 input image pixel matrix gives an output image pixel matrix of 8x8 size by eroding the foreground and background pixels using 0's and 1's.

Structuring Element:

The Structuring elements are small sets in matrix form, or a sub image used to interact with the imagetobeprobed.Ithelpsustodefinesomearbitraryneighborhoodstructures.Theprecisedetailscanbeobtainedbychoosingsuitablestructuringelements.Usually,thestructuringelementisrepresentedasarectangularmatrixofodddimension.Thoughtheorigincanberepresentedinthe center of the matrix, it is not restricted to represent in the center. It is observed in some structureelements that the representation of origin is present outside the rectangular matrix. The binarystructuring element is composed of zeros and ones since all the elements have values.[7].

The 3x3 structuring element matrix for a binary morphological operation with 3x3 matrix is shown in below Figure 5.

S0	S1	S2
S3	S4	S5
S6	S7	S8

Figure 5 : 3x3 General Structing Element

The morphological output image performance will be decided based on the selection of S0 to S8 values of the structuring element. Each pixel value is used in the morphological operation by using the neighboring pixels. The dilation and the erosion are the basic morphological operations, in which the dilation uses a concept of adding the pixels using structuring element and the erosion is the concept of removing the pixels using the structuring element.[6]

The erosion operation is a complement of the dilation operation in context with the operationeffect. That is, erosion operation causes objects to lose their size. The erosion of an image A bystructuring element B is defined as the erosion of image A by structuring element B is the set ofall points z such that the structuring element B translated by z is a subset of the image.
Thisoperationresultsinlossofboundarypixelsoftheobject.Theerosionprocessenlargesthenumber ofpixelswithvaluezero(background)andshrinksthenumberofpixelswithvalueone(foreground). The erosion operation removes those structures which are lesser in size than that ofthe structuring element. So, it can be used to remove the noisy 'connection' between two objects.Since the unwanted pixels are 'erased' the net effect is sharpening of the object in an image. Theerosion operation is analogous to sharpening high pass filters that are used in linear filtering ofimages.

3. ALGORITHM AND DESIGN MODEL FOR MORPHOLOGICAL PROCESSING-EROSION

This section gives the algorithm and design steps of algorithm and design model for Morphological processing using erosion operation. The design model for Morphological processing using erosion is done by using MATLAB and XILINX Vivado EDA design tools using the following steps. [8]

MATLAB:

Step-1: Take the image(RGB) as the input from the internet using imread() function.
Step-2: Then convert this RGB image to grayscale image using the rgb2gray() function.
Step-3: Convert the RGB image to binary using imbw() function.
Step-4: Find the mean of this RGB image using mean() function.
Step-5: If the pixel value is greater than the mean, set the pixel to "1" else "0".
Step-6: Get the pixel matrix from this binary image.

XILINX:

Step-7: Create the "eros1"module in XILINX ISE and consider a structuring element (0:8 reg) .
Step-8: Declare an input 3*3 matrix " i " using [0:8]reg.
Step-9: If all the structuring element's values match/fit with the values of " i " then it gives the output 1 else 0 in all cases(partially hit and no hit cases).
Step-10: Now test this eros1 module using "testeros1" test bench module.
Step-11: Create a new module "maineros" which take the pixel matrix (i.e., from step-6) as an input.
Step-12: Now instantiate the "eros1" for each bit of the input matrix.
Step-13: Now get an 8*8 output pixel matrix. And test this module by testbench.
Step-14: Reconstruct the 256x256 image using the updated 8x8 pixel matrices for complete extracted image construction.

The Morphological processing using erosion on 8x8 image pixel matrix and 3x3 structuring element is shown in Figure 6. In this design the 3x3 structuring element is used as 110110000 to perform maximum erosion.

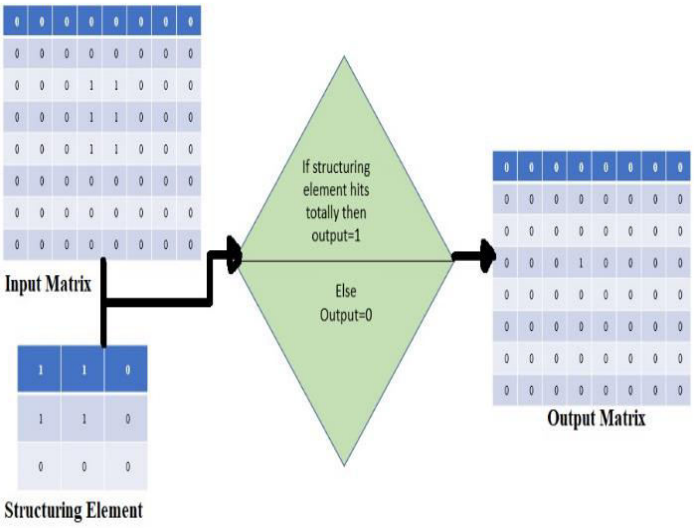

Figure 6 : Design model for Morphological Processing-Erosion

4. SYNTHESIS RESULTS OF MORPHOLOGICAL PROCESSING-EROSION

This section presents the synthesis results using Xilinx Vivado EDA tool and Zynq SoC Zed Board FPGA for erosion operation on one 3x3 input matrix. The block diagram of erosion operation is shown in Figure 7.

Erosion operation:

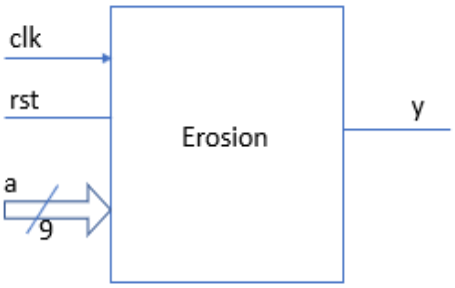

Figure 7: Block diagram of Erosion Operation

The erosion operation uses a 3x3 structuring element as nine input value. This input values are used to compute the erosion result using the structuring element and produces the output y. This erosion design block is used as the main basic building block for the Morphological image processing on 8x8 matrix. The synthesis RTL schematic result of erosion operation is shown in Figure 8.

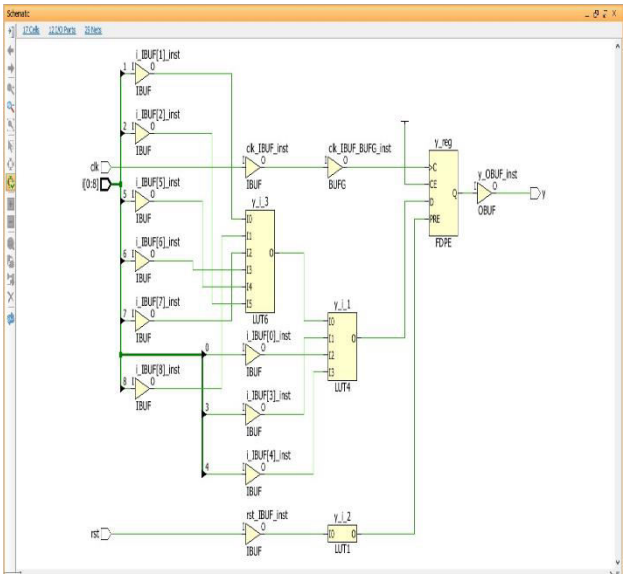

Figure 8 : Synthesis Result of Erosion Operation

The synthesis result of erosion schematic utilizes the 17 cells, 12 I/O ports and 29 nets from the targeted Zynq SoC FPGA.

Morphological Processing using Erosion Operation:

The Morphological processing with erosion operation for 8x8 input pixel matrix is designed and synthesized by using Xilinx Vivado EDA tool. The overall 8x8 input image pixel matrix along with the structuring element is used to generate 8x8 output image pixel matrix for Morphological processing using erosion.

The design block diagram and corresponding schematic diagram is shown in Figure 9 and Figure 10, respectively. The Morphological processing with erosion has 8x8 input pixel matrix values as 64-bit input with the structuring element as 3x3 pixel matrix with 9 values. The erosion operation is performed on the 64-bit input pixel matrix and the 9-bit structuring element. The schematic diagram consists of 114 cells, 130 I/O ports, and 155 nets from the synthesis output.

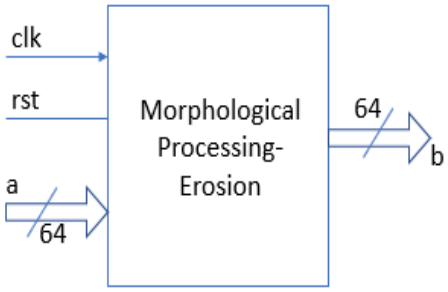

Figure 9 : Block diagram of Morphological Processing-Erosion Operation

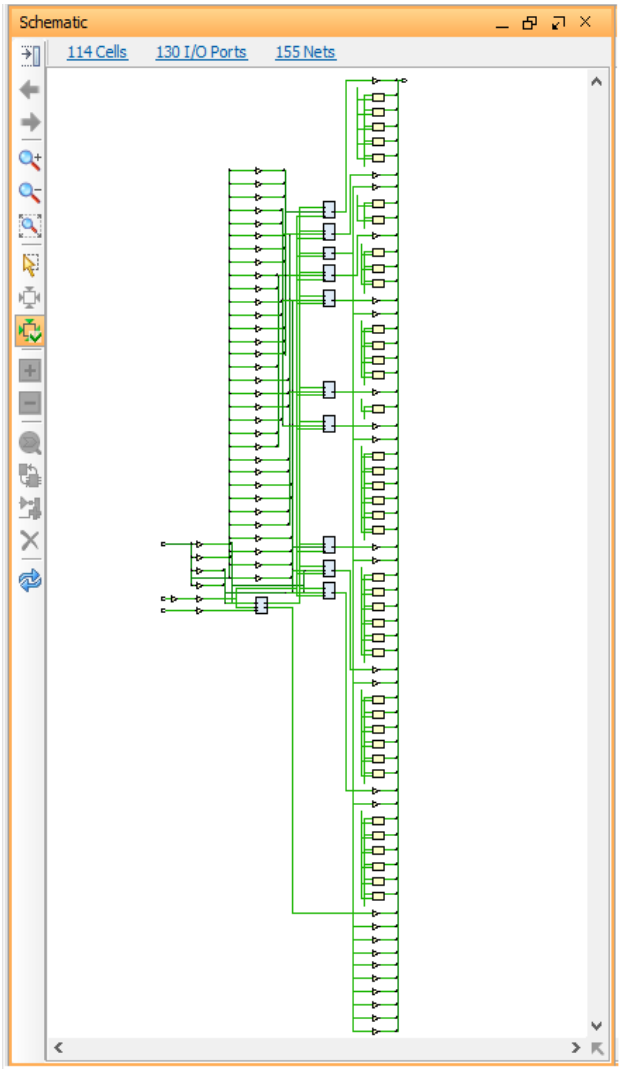

Figure 10 : Synthesis Results of Morphological Processing-Erosion Operation

5. SIMULAITON RESULTS OF MORPHOLOGICAL PROCESSING-EROSION

This section presents the simulation results using Xilinx Vivado and Zynq FPGA Evaluation board for erosion operation on one 3x3 input matrix. The overall 8x8 input image pixel matrix is used t generate 8x8 output image pixel matrix for Morphological processing using erosion.

The simulation result of erosion operation using one 3x3 matrix is shown in below Figure 11.

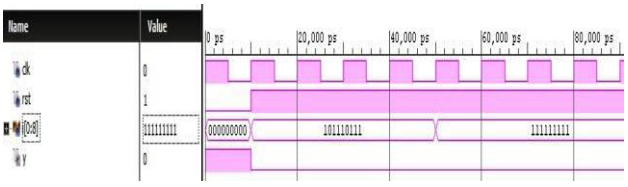

Figure 11 : Simulation Result of Erosion Operation

The erosion operation is tested for the input 'i' as 000000000, 101110111 and 111111111. For input 'i' as all one's the corresponding output has two cases i.e. first, when rst=0, irrespective of the input 'i' the output 'y' is considered as binary-1. This condition is used to reset or initialize the output signal. Second, when rst=1, then the erosion operation will be performed on input 'i' and as the input is matching with the structuring element process, the output is binary '0' as shown in the above Figure 11.

The simulation waveform result information for Morphological Processing using different 8x8 input pixel matrix along with the erosion operation of 3x3 matrix is shown in below Figure 12.

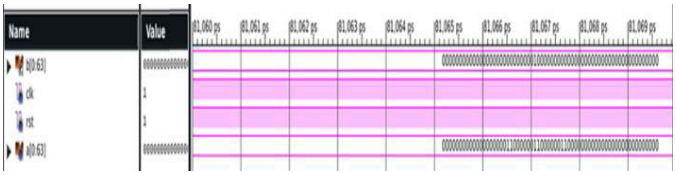

Figure 12 : Simulation Wave form of Morphological Processing using Erosion Operation

The simulation waveform test case inputs and outputs are analyzed with the textual results information for Morphological Processing using different 8x8 input pixel matrix along with the erosion operation of 3x3 matrix. The different test case inputs are shown below.

Test case -1:
000000000000000000011000000110000001100000000000000000000000000

Test case -2:
111011011001011011110011000000111100001010111001000111000010000

Test case -3:
011011011000011011011011000000111111001010111001011111000111000 0

Test case -4:
011011011000011011011011000000111111001010111001011111000111000 0

Test case -5:
111111111111111111111111111111111111111111111111111111111111111

The complete input and output 8x8 pixel matrix before and after erosion operation using Morphological image processing is shown in below Figure 13.

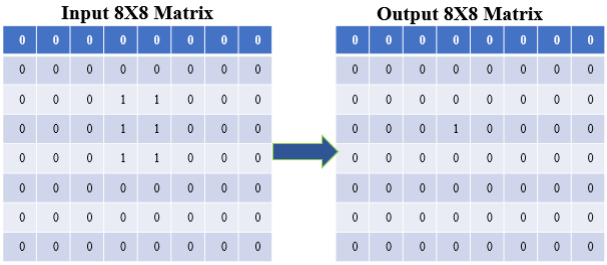

Figure 13 : Input and output matrix of Morphological Processing before and after Erosion Operation

6. CONCLUSION

The erosion operation of mathematical morphological image processing on 8x8 input pixel matrix with the help of 3x3 structuring element is designed and synthesized by using Xilinx Vivado EDA tool with Verilog HDL targeting Zed board Zynq Evaluation and Development kit. The synthesized design of erosion operation has 17 cells, 12 I/O ports and 29 nets. Similarly, the synthesized design of Morphological Image processing system with erosion operation has 114 cells, 130 I/O ports and 155 nets. The erosion operation and the entire Morphological system is tested and simulated for different 8x8 pixel matrix elements and the results are observed and analyzed.

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