Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Special Issue 4, April : 2024

A REAL-TIME EDGE DETECTOR: AN EFFICIENT VLSI IMPLEMENTATION

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ABSTRACT: In this paper we present a very large scale integration (VLSI) architecture of a new edge detection algorithm, which has a very regular computational structure. The new algorithm detects weak edges and produces single-pixel localized edges. Due to its highly pipelined structure, the VLSI implementation of the algorithm outputs one edge-pixel every clock cycle. In this study, we present an optimized Laplacian Edge Detection algorithm tailored for efficient implementation in hardware. Leveraging approximation methodologies and strategic pipelining, we streamline complex operations, thereby reducing latency and resource consumption. Our implementation, realized through the Verilog Hardware Description Language (VHDL), stands as a testament to the efficacy of our approach.

INTRODUCTION

The VLSI architecture is a complete realization of the algorithm, where no degradation is introduced to the ASIC output when compared to edges produced by the algorithm.At its essence, edge detection embodies the essence of visual interpretation, seeking to identify the defining features that distinguish one element from another withinan image. Just as we effortlessly recognize the edges of objects against contrasting backgrounds, these algorithms meticulously scrutinize pixel intensities, searching for abrupt changes that signifytransitions between objects, textures, or surfaces. In the broadspectrum of image processing applications, edge detection holds unparalleledsignificance. It serves as the

initial step in a myriad of tasks, from autonomous vehicle navigation to medical diagnosis and beyond. Much like how our brains rely on edges toparse complex scenes and make sense of our surroundings, edge detection algorithms provide the foundational framework for machines to interpret and understand visual information.

Through this project, we embark on a journey to unravel the intricacies of edge detection, striving to bridge the gap between human perception and computational analysis. By delving into the theoretical underpinnings, exploring novel methodologies,and optimizing algorithms for hardware implementation, we aim to unlock new frontiersin visual intelligence.

In the vast landscape of image processing, edge detection emerges as a beacon of significance, guiding the way for numerous applications across various domains. Its importance transcends mere computational analysis, encapsulating the essence of humanperception and understanding.

PROPOSEDSYSTEM

Laplacian edge detection is a popular technique used in image processing to identify edges by computing the second derivative of pixel intensities. Unlike gradient- based methods, which detect edges by analyzing changes in intensity gradients, Laplacian edge detection focuses on detecting points of maximum intensity change within an image. In Laplacian edge detection, the Laplacian operator is applied to the image, which highlights regions where the intensity changes rapidly. This operator computes the sum of the second derivatives of pixel intensities in both the horizontal and vertical directions. By convolving the image with the Laplacian kernel, areas of rapid intensity change, corresponding to edges, are enhanced

TL Design (Verilog or VHDL)

Convolution kernels: Implement edge detection kernels like Sobel, Prewitt, Canny, or Laplacian operators as finite state machines and line buffers to representspatial image filtering.

Thresholding and edge refinement: Apply thresholding to the convolution results to identify strong edges. You may also implement non-maximum suppressionto thin the edges.

AXI Interfaces: Use AXI-Stream interfaces to transfer image data in and out of your edge detection IP block, making it easier to integrate with a larger system.

The implementation of the edge detection uses the both MATLAB and

Vivado in our case. Since we use the MATLAB tool to convert the image that we want into a text file consisting of the values of the pixelsone per each line.

LITERATURE SURVEY

1. Siva Sankari B, Dr Viji.(2021) A. An Efficient VLSI Implementation Of Edge Detection Algorithm For Image Processing Application
2. Edge detection is that the core research area among different fields such as; image processing.

   Computer vision, machine learning, pattern recognition. In object detection,the primary obligatory step is to work out the perimeters of an object during a better waythat's further used for processing. The feature vector comprises nothing but key point description, which provides the data of edges. Edge detection is that the key to success and is somehow or the opposite passionate about it.
3. Kishor Kumar, Dr. Vijaya Lakshmi.

   D. (2022) An Efficient Implementation OfEdge Detection Algorithm For Image Processing Using FPGA
4. Edge detection is an important and growing area in different fields such as image patternrecognition, machine learning and processing, and Computer vision. Edge detection of an image of the object is the main goal for different Edge detection algorithms. In Edge detection, the most important step is to identify the edges of an image of the object and pixel information of the Image In every edge detection algorithm. There will be 2 types of masks one in the horizontal direction and the other in the vertical direction. The kernelor mask is a convolution vector of the nXn matrix which is multiplied by the sub-windowof an image. The effective and efficient performance of a digital system mainly depends on the delay, area, and power consumption. These parameters decide the efficiency of any digital core system. This project converts the image pixel information to binary for processing with different edge detection algorithms like Canny, Sobel, Prewitt, and Roberts.
5. T. P. Lavanya, S. Premkumar (2014) An Efficient Approach for Edge DetectionHardware Accelerator for Real Time Video Segmentation using Laplacian Operator
6. An Efficient Approach for Edge Detection Hardware Accelerator for Real Time Video Segmentation using Laplacian Operator Video

segmentation is a very important one in video image processing application that deployed by video surveillance system. The high computation speed is required to support real time performance.

This paper presents the implementation of VLSI based hardware accelerator design for real time video segmentation system. The algorithm of Laplacian edge detection operatoris used to

7. develop this hardware accelerator. The NTSC standard definition video is digitized at 720x480 with a video rate of 30 frames per second.
8. T. Jagadesh (2020), Implementation of Prewitt Operator based Edge Detection Algorithm using FPGA
9. The main objective of my project is to find the edges of the grayscale image effectively with less computational complexity and also to reduce the thickness of the image edges. Edge of the image is one of the most fundamental and significant features.Edge detection is always one of the classical studying projects of computer vision and image processing field. It is the first step of image analysis and understanding. Edge detection is basic tool used in many image processing applications for extracting information from image. Prewitt edge detection is gradient based edge detection methodused to find edge pixels in image. We propose a design of a Prewitt edge detection algorithm to find edge pixels in gray scale image. The edges of the image is found and the computation complexity is calculated. The implementation of edge detection algorithms on a field programmable gate array (FPGA) is having advantage of using large memory and embedded multipliers

RELATED WORK

Menu Bar

The main menu bar provides access to Vivado IDE commands. Commonly-used commands always display (for example, File > Project > Open) while others display onlywhen design is active (for example, Reports > Report DRC). Some menu commands havea related keyboard shortcut that is listed next to the menu command.

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Main Toolbar

The main toolbar provides one-click access to the most commonly used commands in the Vivado IDE. When you hover the mouse cursor over a button, a tooltipappears that provides more information about the command.

Flow Navigator

The Flow Navigator provides access to commands and tools to take your design from design entry to bitstream creation. As you run these commands and tools, the design data,graphical windows, and results windows update.

Data Windows Area

By default, this area of the Vivado IDE displays information related to design sourcesand data, such as:

Sources window

Netlist window

Properties window

Menu Command Quick Access Search Field

To the right of the menu commands, the menu command Quick Access search field enables you to locate and execute a command from the menu bar. In the search field, typea few letters of a command name. The list of commands that appear is based on the current design context in the project. For example, an open elaborated design offers a different set of commands than an open implemented design.

Workspace

The workspace displays windows with a graphical interface and those that require morescreen space.

Project Status Bar

The project status bar displays the following:

Current status of the active design

Descriptions for menu commands and toolbar buttons that you hover over

Information about the selected text file that you are editing, including line numbers and modes.

Position of elements that you hover over in the Device and Package windows

Layout Selector

The Vivado IDE provides predefined window layouts to facilitate various tasks in the design process. The layout selector enables you to easily change window layouts. Alternatively, you can change layouts using the Layout menu in the menu bar.

Status Bar

The status bar displays the following information:

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Detailed descriptions for menu and toolbar commands appear on the lower leftside of the status bar when you access the command.

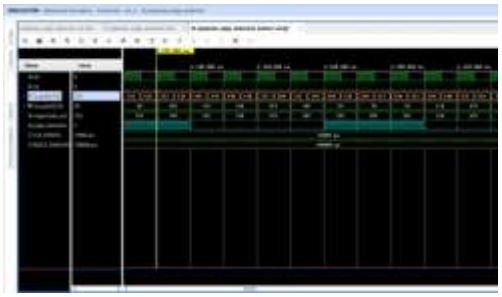
During placement and constraint creation in the Device and Package windows, constraint type and validity appear on the left side of the status bar, and site coordinates and type display on the right side.

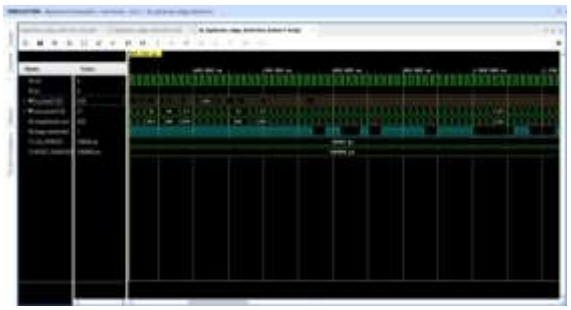
Results Windows Area

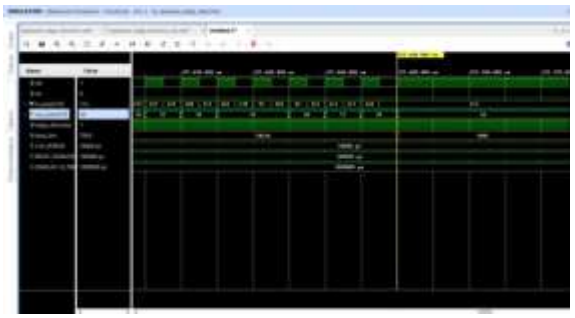
The status and results of commands run in the Vivado IDE display in the results windowsarea, a set of windows grouped at the bottom of the viewing environment. As commandsare run, messages are generated, and log files and report files are created, the related information appears in this area.

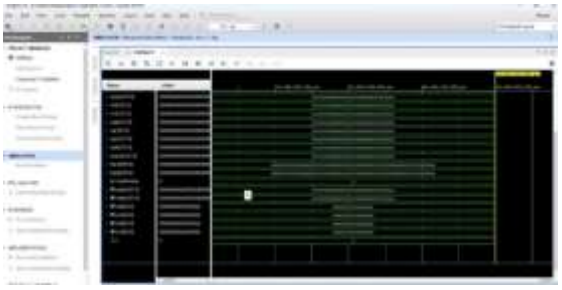
The Various Features of Xilinx Vivado IDE is clearly presented in this section. The methodology of traffic light control and street light system will be discussed in the next section.

SAMPLE RESULTS









CONCLUSION

our project has meticulously crafted and optimized a Laplacian EdgeDetection algorithm tailored for efficient hardware implementation. By employing sophisticated approximation

methodologies and strategic pipelining techniques, we havesuccessfully streamlined complex operations, significantly reducing latency and resource consumption. Implemented using the Verilog Hardware Description Language (VHDL),our solution exemplifies the fusion of computational accuracy and hardware efficiency crucial for edge detection in object recognition.

Throughout our research, we underscored the pivotal role of edge detection across various domains, particularly in object detection, where precise delineation of image perimeters underpins subsequent analysis and decision-making processes. By enhancingthe efficiency and accuracy of edge detection algorithms, we propel advancements in fields like computer vision, robotics, autonomous systems, and medical imaging.

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