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FPGA Implementation of Edge Detection using Modified Canny Edge and Adaptive Threshold

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Abstract : *Digital image processing is a widely used field in technology. In most of the cases the processing of image is done through computer simulation techniques. This will make the implementation easier. But as the complexity of the algorithm/architecture increases the simulation time also increase accordingly which makes the architecture is unsuitable for real time high speed applications. To overcome from this problem mainly hardware architecture is used. In this paper we propose an FPGA implementation of edge detection architecture using modified Canny edge algorithm and adaptive threshold technique. To obtain optimization in both hardware and output accuracy we change the total architecture in suitable way. The comparison results shows that the proposed design is better than existing.*

Keywords : *Adaptive threshold Calculation, Edge Detection, FPGA Implementation, Image Processing etc.*

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I. Introduction

Edge detection is one of the significant sections of the image processing algorithms which have many applications like image morphing, pattern recognition, image segmentation and image extraction etc. As the edge is one of the major information contributors to any image, hence the edge detection is a very important step in many of the image processing algorithms. Edge detection is defined as it is a set of mathematical methods from those methods detecting the edges of the image, particularly at edges the pixel value changes more sharply and it has more discontinuities. It represents the contour of the image which could be helpful to recognize the image as an object with its detected edges. In the ideal case, by applying the edge detector to an image gives the different edges that are connected to form the outline of the object. Edge detection detects all edges present in the image with various orientations. The edge detections are mainly used in to detect important events from any image sequences. Any edges occurs to any image depending upon irregularities in depth,, irregularities in the orientation of any surface, Variation in the properties of any material and Differences in the illumination of an image scene. Edges are basically depicted into four sorts in any image. They are step edge, ramp edge, roof edge and line edge [1] as Gradient Based and Laplacian Based. The Gradient based edge detection is also known as the first order derivative based because the gradient is calculated by differentiating an image. The Laplacian method computes the second order derivative of an image for the edge detection. Canny edge detector is a standard edge detection algorithm for many years among the present edge detection algorithms. An image consists of different information of a scene such as the size, color, orientation of different objects present in that scene. An interesting point is that first the object is separated from background then all the edges has to be detected to get the outline of the object. This is the reason, the edge detection become important in computer vision and image processing.The image processing applications like image segmentation, video surveillance mainly requires the information about change in pixel value of an image. As in the image segmentation, image enhancement applications the major step is image interpretation. The edge detected image indicates only outline of the object shape, which removes the background and keeps only the important information. The edge map of an image has the outline of the objects present in that image.

II. Literature Survey

Mohamed Nasir et al., [3] proposed the real time hardware image processing framework improvement. This depends on FPGA. The algorithm utilized on the image processing as a part of this work is edge location. Here Verilog HDL was utilized as the programming dialect for the real time picture edge identification. The

resulted edge identification of a image is improved and designed on Altera Cyclone-II FPGA for the image processing. The extra step can be actualized on improvising the edge location should be possible by including high performed end FPGA, for example, Stratix-II FPGA than the Cyclone-II FPGA utilized here for the higher frequencies with bigger number of programmable elements. This additionally gives the advantages of approaches to execute new image processing algorithms to enhance the execution with high memory space for the further image processing and storage techniques. Instead of using CMOS camera one can utilize a different type of camera. The CMOS camera has demerit of getting effectively influenced by the encompassing light. The CMOS camera influences caught live image by changing the brightness of the picture. This prompts disgraceful edge detection of the live image caught. This work demonstrates that the capacity of FPGA to execute the real time processing of images. This research work presents constraint in executing the image processing methods on FPGA as it acquires larger number of computing components and larger number of memory components for the usage of the real-time processing of images.Ferdous Hossain et al., [5] projected adaptative cagey edge recognition rule has been place forwarded and it's a helpful strategy for edge recognition through active thresholds. the sting recognition is that the primary task in recognizing associate degree object from an image, it's basically necessary to understand the preferences and weaknesses of each edge detection filters. during this analysis work, largely it's targeted on the sting recognition techniques of the Gradient-based. the sting recognition procedures area unit contrasted with discourse investigation of recognizing a unique reasonably image. The computer code is dead utilizing C#. Gradient based mostly calculations have demerit in sensitive to noise. The kernel filter measurements and its coefficients area unit cannot be adjusted and static to a given image. The paper work of edge-identification rule is to present a while not mistake resolution that's versatile to the various noise levels of the pictures to assist in acknowledge the valid image substance delivered by noise. The presentation of the adaptative cagey rule depends totally on the dynamical parameters those area unit variance for the Gaussian filter, and its threshold values.

The magnitude of the Gaussian filter is overseen by the quality deviation price. the upper size creates additional level of smoothness, that is needed for clattering pictures, and additionally discovering larger edges. adaptative cagey operator for the foremost half connected to totally different circumstances for examine the sting clearly. To reinforce its execution, here they explored the computation of gradient magnitude and gradient direction taking into consideration on eight neighbor hoods, and makes the adaptative calculation of the brink of adaptative cagey operator. The experimental outcome represent the sting recognized by the adaptative cagey operator has additional continuity, and better signal to noise proportion relating to to different leading edge techniques.Mina Asaduzzaman et al., [7] given adptive clever edge recognition formula is projected. adaptie clever formula is employed to expand the truth of output objects . In customary clever ought to set 2 threshold values physically, therefore there square measure some imperfections to varied photos but this paper advances a adaptational threshold values taking into consideration mean and median values. Our projected adaptational clever edge recognition strategy will acknowledge edges effectively that is divided into some stages. Initially, mathematician filter is employed to sleek and take away noise. Second, gradient magnitude is computed. Third, non-maximum suppression is applied during which the formula removes pixels that aren't a part of a footing. Finally, physical phenomenon thresholding is connected that utilizes 2 threshold values, higher and lower. A pel are set apart as a footing within the event that it's gradient lies within the middle of lower and higher threshold values. A pel are disposed of within the event that it's gradient is below the lower or on top of the higher threshold values. Eventually, the pixels gradient is between the 2 threshold values are associated as marked edge. The trial results demonstrate the viability of the projected strategy. Here a strong technique for edge identification through dynamic thresholds of adaptational clever calculations. the sting recognition is that the essential enterprise in identifying AN object from a image, it's crucially important to grasp the favorable circumstances and hindrances of each edge identification filters. this can be a completely unique edge-location formula is to relinquish AN perfect answer that's versatile to the distinctive noise levels of those pictures to assist in identifying the substantial image substance. This work has been accomplished for the sting discovery techniques of the Gradient-based. the sting identification strategies square measure contrasted with case study of identifying AN alternate type of image. The code was dead utilizing C#. Gradient-based calculations have major drawbacks in delicate to noise. adaptational clever operator is connected to varied circumstances for determine the sting signally. so as to boost its execution, we have a tendency to propose the estimation of gradient magnitude and gradient direction supported eight neighborhoods, and makes the adaptational calculation of the brink of adaptational clever operator. The experimental results demonstrate that the sting known by the improved clever operator has a lot of continuity, and a lot of distinguished signal to noise proportion.The utilization of prototyping tools like matlab and Xilinx system generator gets to be imperative owing to its chance to promote needs [9]. This exploration work introduces a procedure to implementing DSP applications on a reconfigurable logic platform utilizing Xilinx system generator for Matlab. The strategy enhances the look verification effectiveness for advanced system. It offers AN design for color house transformation for video process it utilizes Xilinx system generator. The configuration was dead in a very spartan3 and subsequently a

virtex2. At that time results square measure contrasted and alternative style. to make pc vision algorithms Xilinx system generator is exceptionally valuable tool. Contrasted with VHDL or Verilog hardware description languages, system generator is characterised as a profitable in making snug approach. The principle reason for the analysis work was to demonstrate the utilization of system generator to actualize a system that utilizes RGB to YCbCr transformation for the video process application. This was existent in Spartan-3 and Virtex-2 professional.

III. FPGA Architectures

The diagram of projected Canny Edge detection is shown in Fig.1

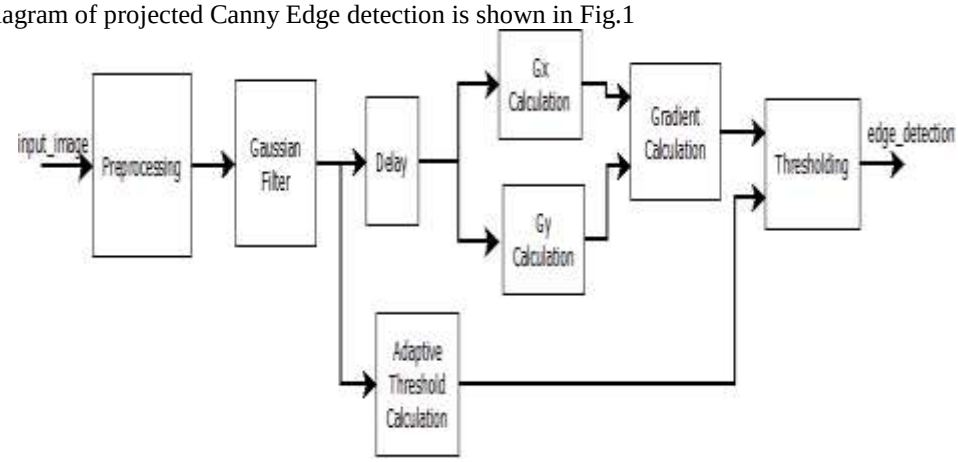

Fig. 1: Proposed Diagram

1.1. Preprocessing

In this stage the input image is resized to a suitable size (256x256) and color image is converted to gray level for hardware optimization purpose.

1.2. Gaussian Filter

The Gaussian filter is a two dimensional convolution operator used to remove noise from the image. Here the kernel matrix used is represents the Gaussian shape that is it is having bell shaped representation. The kernel [4] matrix used is

$$Gaussian\ Filter = \frac{1}{16}\begin{bmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{bmatrix} * \begin{bmatrix}d_0 & d_1 & d_2\\ d_3 & d_4 & d_5\\ d_6 & d_7 & d_8\end{bmatrix} (1)$$

Where, d0 to d8 are the 3x3 image sub-matrix pixel values.

The moving window architecture to implement 3x3 image sub-matrix is shown in Fig.2.

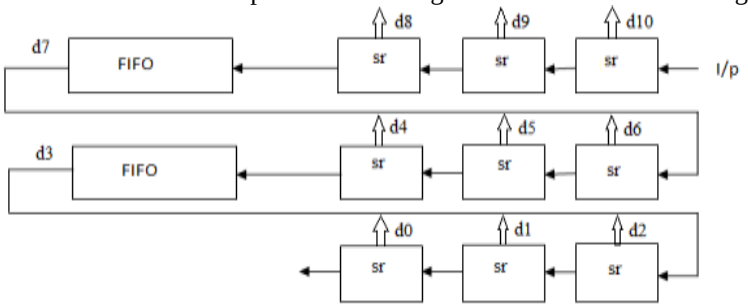

Fig 2 moving window architecture (3x3 pixel generation)

1.3. Adaptive Threshold Calculation

Image thresholding is the frequent task in many computer applications like computer and graphics. The objective of the image thresholding is to indicate pixels as 'dark' and 'bright'. This technique is used or it is suitable for video streaming. Based on the intensity value or pixel value the image is segmented as 'dark' and 'bright'. In most basic thresholding technique threshold value is fixed and it is compared with the image pixel values if the threshold value is less than the pixel value then that pixel value is considered for the edge detection

it is called fixed thresholding. However this method may fail because of the variation in the intensity value in the image. Here the adaptive thresholding block is utilized to calculate threshold value from the image to detect edges in the image. If the pixel value is larger than the threshold value then that pixel value is considered for the edge detection otherwise it is treated as zero. To calculate adaptive thresholding value the equation is as follows

$$S = \sum_{i=1}^{N} \frac{(A_i)^2}{8N} \quad (2)$$

Where S is the summation, N is the total dimension of input image (N=256x256) and A1, A2…AN are the actual image pixel intensity values after filtering.

1.4. Modified Canny Edge Detection

Edge detection is important step in object identification. It is the process of finding the drastic discontinuities. The drastic variation in the pixel intensity which shows boundaries of things in an image. So in short it can be summarized as finding the line drawing of an image which specify the feature extraction in image processing and it is utilized in computer vision algorithms such as recognition, tracking and in medical applications.The edge detection method includes the use of operators like two dimensional filter. In an image an edge appears whenever the gradient value is more. There are so many operators are present to find out the edges in the image. The Modified Canny operator uses two 3x3 kernel matrix one is horizontal gradient and one is vertical gradient [10]. They are as follows:

$$G_x = \begin{bmatrix} -\frac{1}{4} & 0 & \frac{1}{4} \\ -1 & 0 & 1 \\ -\frac{1}{4} & 0 & \frac{1}{4} \end{bmatrix} \quad (3)$$

$$G_y = \begin{bmatrix} \frac{1}{4} & 1 & \frac{1}{4} \\ 0 & 0 & 0 \\ -\frac{1}{4} & -1 & -\frac{1}{4} \end{bmatrix} \quad (4)$$

The image is convolved with horizontal and vertical gradient. And the magnitude is calculated from the below equation

$$Gradient\ (G) = |G_x| + |G_y| \quad (5)$$

From the moving window architecture pixel values are taken and those are convolved with the horizontal and vertical gradient filter. The hardware structure is implemented by using only shifters and adders/subtractors.

1.5. Thresholding

After gradient calculation there are many edges exist due to light intensity variations. To remove those unwanted edges we use thresholding. The equation for thresholding is given as

$$Thresholding = \begin{cases} input\ value; if\ input\ data \geq adaptive\ threshold \\ 0; Otherwise \end{cases} \quad (6)$$

II. FPGA IMPLEMENTATION

The propod\sed architecture is implemented on Digilent ATLYS Board which having Spartan-6 (xc6slx45-2csg324) FPGA. The elaborated schematic is given in Fig. 3 as

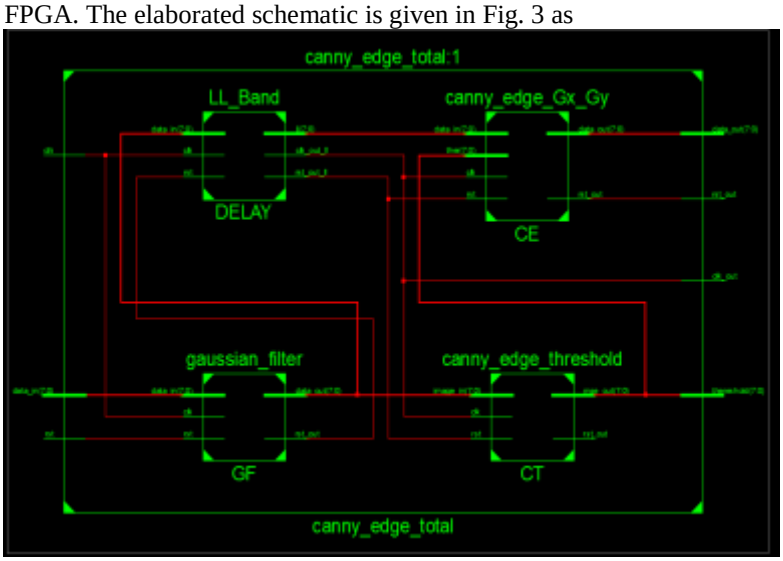

Fig. 3. Elaborated RTL Schematic of Total Module

Any FPGA will map all logics in terms of LUTs and flip-flops pairs. The technology schematic shows the internal implementation of the proposed model in terms of LUTs and flip-flops pairs. The technology schematic is shown in Fig. 4 below

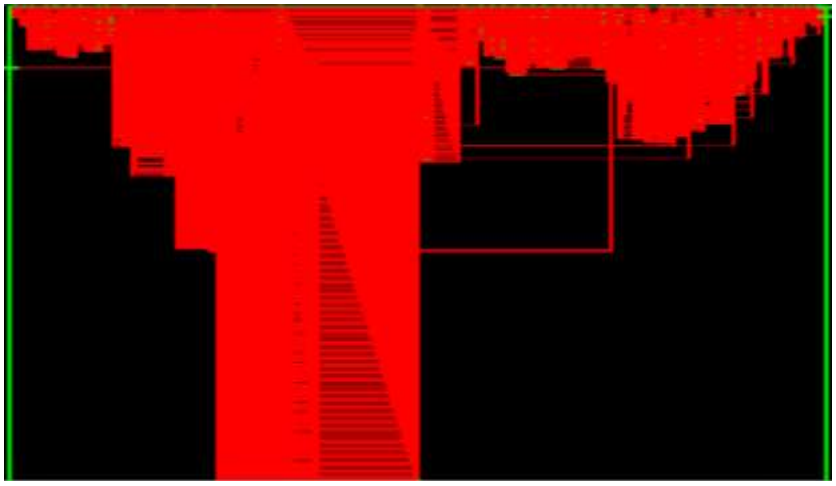

Fig. 4. Technology Schematic of Total Module

The simulation waveform of the proposed block are shown in Fig. 5.

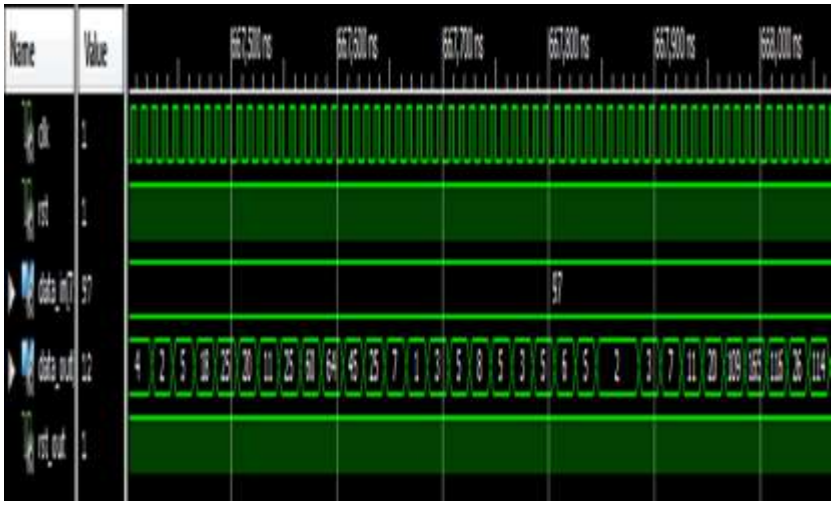

Fig. 5. Simulation Waveform of Total Module

The synthesis results of the proposed block are shown in Table 1.

Table 1: Synthesis Results of Total Module

Parameters	Utilizations
No of Slice Registers	533
No of Slice LUTs	5478
No of fully used LUT-FF pairs	373
No of bonded IOBs	28
No of BUFG/BUFGCTRLs	4
No of DSP48Es	1

IV. Comparisons With Existing Techniques

The proposed architecture is compared with existing architecture. In the Fig. 6. the existing technique [10] detect many unnecessary edges whereas the proposed technique does not having those un-necessary edges.

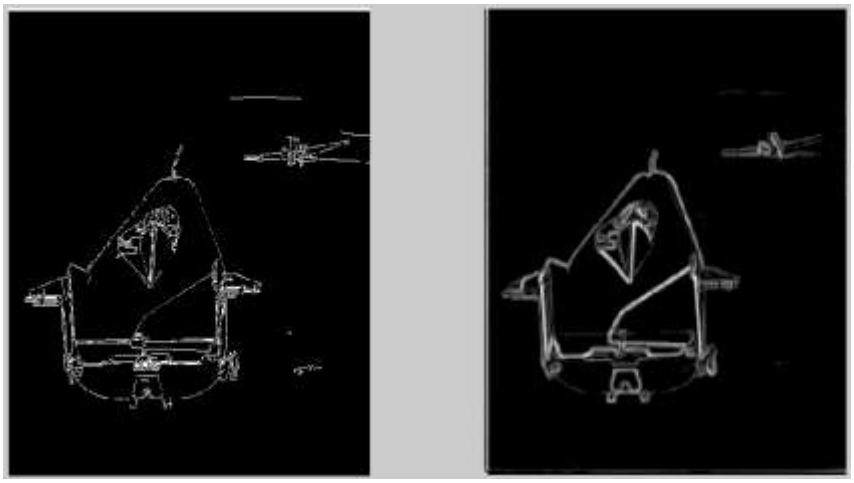

Fig. 6. Accuracy comparison of proposed technique with existing

III. CONCLUSION

In this paper we implement FPGA Implementation of edge detection using Canny edge and Adaptive Threshold technique which is used to detect the edge of any image as a complete image without dividing it into blocks. The proposed Block level Canny Edge detector has overcome the limitation of existing edge detection algorithms by reducing the delay and area. The design of Block Level Canny Edge Detector is coded in VHDL language. The simulation and synthesis of the design is carried out using Xilinx ISE 14.5 tool. The proposed method takes less area and less computational time result of this decreases latency and increases throughput. In Future, it can be possible to propose dynamic based edge detection algorithm which can adapt for different variations of lighting conditions in image and also can be extended to video processing in detection of real time edges required for broadcasting.

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