Abstract

The technology Field Programmable Gate Array (FPGA) has become a main target for the implementation of real time algorithms suited to video image processing applications. Here this work is presenting, an implementation of linear and morphological image filtering using a FPGA, Xilinx, Spartan 3, xc3s200 with educational purposes. Morphological processing is constructed mainly with operations on sets of pixels. Binary morphology uses only some set membership and is indifferent to the value, such as gray level or color, of a pixel. Here We will examine some basic set operations and their usefulness in image processing. We will deal here only with morphological operations for binary images. This is very important to provide a basic understanding of the techniques. More sophisticated mathematical development required for Morphological processing for gray scale images. Morphological processing is almost described entirely as operations on sets. In this discussion, a set is a collection of pixels in the context of an image.

1. Introduction

A binary image is a digital image that basically has only two possible values for each pixel. Typically the two colors used for a binary image that are white and black though any two colors can be used. The color used for the objects in the image is mainly the foreground color while the rest of the image is the background color. In the document-scanning industry this is often referred to as "bi-tonal". Binary images are called bi-level or two-level as it is meaningful. This means that each pixel is stored as a single bit i.e., a 0 or 1.
The names black-and white, also called B&W, monochrome or monochromatic are often used for this concept, but may also designate any images that have only one sample per pixel, such as gray scale images. In Photoshop parlance, a binary image is the same as an image in "Bitmap" mode. Binary images often arise in digital image processing as masks or as the result of certain operations such as segmentation, threshold, and dithering. Some input/output devices, such as laser printers, fax machines, and bi-level computer displays, can only handle bi-level images. A binary image can be stored in memory as a bitmap, a packed array of bits. A 640x480 image requires 37.5 KB of storage. fax machine and document management solutions usually use this format. Because of the small size of the image files.

2. Problem Statement

The structuring element is binary image, always small, which is passed over the target image, in a similar manner to a filter in grey scale image processing. Since the pixels can only have two values, the morphological operations are dilation (any set pixels within the structuring element cause the pixel to be set) and erosion (any unset pixels within the structuring element cause the pixel to be unset). The most important operations are morphological opening and morphological closing which consist of erosion followed by dilation and here dilation followed by erosion, respectively, using the same structuring element. Opening leads to enlarge small holes, it also removes small objects, and separate objects. Closing removes holes, retains small objects, and joins objects. The distance transform is a very important characteristic of a binary image that gives the distance of every set pixel from the nearest unset pixel. The distance transform can be efficiently calculated which allows efficient computation of Voronoi diagrams, where each pixel in an image is assigned to the nearest of a set of points. It also allows skeletonization, which differs from thinning in that skeletons allow recovery of the original image. For determining the center of the object, and for matching in image recognition, the distance transform is also useful.

The gathering orientation-free metrics is another class of operations. This is often important in image recognition. The orientation of the camera needs to be removed in image recognition. Orientation-free metrics of a group of connected or surrounded pixels include the Euler number, also the perimeter and the area, the compactness, the area of holes, the maximum radius the minimum radius, and the maximum radius. Binary images are images that have been quantized to two values, usually denoted 0 and 1, but most probably with pixel values 0 and 255, representing black and white. Binary images are the simplest to process hence used in many applications, but they are such an impoverished representation of the image information that their use is not always possible. However, they are useful where all the information you need can be provided by the silhouette of the object and when you can obtain the silhouette of that object easily. Sometimes it happens that the output of other image processing techniques is represented in the form of a binary image, for example, the output of edge detection can be a binary image (edge points and non-edge points). Binary image processing techniques can be very useful for subsequent processing of these output images.

3. Image Processing Algorithm

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grey scale
images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood. Mathematical morphology is a set- and lattice-theoretic methodology for image analysis, which aims at quantitatively describing the geometrical structure of image objects. It was initiated in the late 1960’s to analyze binary images from geological and biomedical data as well as to formalize and extend earlier or parallel work, on binary pattern recognition based on cellular automata and Boolean/threshold logic. In the late 1970’s it was extended to gray-level images. In the mid 1980’s it was brought to the mainstream of image/signal processing and related to other nonlinear filtering approaches. Finally, in the late 1980’s and 1990’s it was generalized to arbitrary lattices. The above evolution of ideas has formed what we call nowadays the field of morphological image processing, which is a broad and coherent collection of theoretical concepts, nonlinear filters, design methodologies, and applications systems. Its rich theoretical framework, algorithmic efficiency, easy implement ability on special hardware, and suitability for many shape-oriented problems have propelled its widespread usage and further advancement by many academic and industry groups working on various problems in image processing, computer vision, and pattern recognition.

Figure 1: Probing of an image with a structuring element

(White and grey pixels have zero and non-zero values, respectively). A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image. The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one:

- The matrix dimensions specify the size of the structuring element.
- The pattern of ones and zeros specifies the shape of the structuring element.
- An origin of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element.

An essential part of the dilation and erosion operations is the structuring element used to probe the input image. A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size. The pixels with values of 1 define the neighborhood. Two-dimensional, or flat, structuring elements are typically much smaller than the image being processed. The center pixel of the structuring element, called the origin, identifies the pixel of
interest -- the pixel being processed. The pixels in the structuring element containing 1’s define the neighborhood of the structuring element. These pixels are also considered in dilation or erosion processing. Three-dimensional, or non-flat, structuring elements use 0’s and 1’s to define the extent of the structuring element in the x- and y-planes and add height values to define the third dimension. The morphological functions use this code to get the coordinates of the origin of structuring elements of any size and dimension.

\[
\text{Origin} = \text{floor}\left(\frac{\text{size}(\text{nhood})+1}{2}\right)
\]

4. VLSI Design

Digital systems are highly complex at their most detailed level. They may consist of millions of elements i.e., transistors or logic gates. For many decades, logic schematics served as thing franca of logic design, but not anymore. Today, hardware complexity has grown to such a degree that a schematic with logic gates is almost useless as it shows only a web of connectivity and not functionality of design. Traditional paper and pencil and capture and simulate methods have largely given way to the described UN synthesized approach. For these reasons, hardware description languages have played an important role in describe and synthesis design methodology. They are used for specification, simulation and synthesis of an electronic system. This helps to reduce the complexity in designing and products are made to be available in market quickly. The components of a digital system can be classified as being specific to an application or as being standard circuits. Standard components are taken from a set that has been used in other systems. MSI components are standard circuits and their use results in a significant reduction in the total cost as compared to the cost of using SSI Circuits. In contrasts, specific components are particular to the system being implemented and are not commonly found among the standard components.

5. System Model

![Figure 2: Block diagram of system model](image)

**JTAG**

This JTAG header consists of 0.1-inch stake pins, located toward the top edge of the board, directly below the two expansion connectors. The low-cost parallel port to JTAG cable fits directly over the header stake pins, as shown in Figure. When properly fitted, the cable is perpendicular to the board. You must make sure that the signals at the end of the JTAG cable align with the labels listed on the
board. The other end of the cable connects to the PC's parallel port. The cable is directly compatible with the Xilinx impact software.

![Figure 3: JTAG Interfacing with Spartan-3 (FPGA)](image)

**FPGA**

FPGA is an integrated circuit designed to be configured by the customer or designer after manufacturing hence "field-programmable". The FPGA configuration is generally specified using a hardware description language (HDL), similar to that used for an application-specific integrated circuit (ASIC) (circuit diagrams were previously used to specify the configuration, as they were for ASICs, but this is increasingly rare). FPGAs can be used to implement any logical function that an ASIC could perform. The ability to update the functionality after shipping, partial re-configuration of the portion of the design and the low non-recurring engineering costs relative to an ASIC design (notwithstanding the generally higher unit cost), offer advantages for many applications. FPGAs contain programmable logic components called "logic blocks", and a hierarchy of reconfigurable interconnects that allow the blocks to be "wired together" somewhat like many (changeable) logic gates that can be inter-wired in (many) different configuration.

1) **Erosion:**

The erosion of a binary image \( f \) by a structuring element \( s \) (denoted \( f \oplus s \)) produces a new binary image \( g = f \ominus s \) with ones in all locations \( (x,y) \) of a structuring element's origin at which that structuring element \( s \) fits the input image \( f \), i.e. \( g(x,y) = 1 \) is \( s \) fits \( f \) and 0 otherwise, repeating for all pixel coordinates \( (x,y) \).

![Figure 4.a: Greyscale image](image)  ![Figure 4.b: Binary image by thresholding](image)  ![Figure 4.c: Erosion: a 2x2 square structuring element](image)

**Dilation:**

With \( A \) and \( B \) as sets in \( Z^2 \), the dilation of \( A \) by \( B \) is defined as

\[
A \oplus B = \left\{ z \left| \left( \tilde{B} \right)_z \cap A \neq \emptyset \right. \right\}
\]

This equation is based on reflecting \( B \) about its origin and shifting this reflection by \( z \). The dilation of \( A \) by \( B \) then is the set of all displacements \( z \), such that and \( A \) overlap by at least one element. Therefore, the dilation can also be expressed as...
$A \oplus B = \left\{ z \mid \left( \hat{B} \right)_z \cap A \subseteq A \right\}$

As before, we assume that $B$ is a structuring element and $A$ is the set (image object) to be dilated. There are other definitions of dilation too. However, the preceding equations are more intuitive when viewing the structural element as a convolution mask. We need to keep in mind that dilation is based on set operations and therefore is a nonlinear operation, while the convolution is linear. Unlike the erosion, dilation “grows” or “thickens” objects in a binary image. The manner and extent of this growth is image controlled by the structuring element.

6. Advantages

- Any size of the image can be processed with any Pixel.
- Binary image processing is used is state of the gray coding is used.
- Support multiple image processing operations such as dilation, erosion, closing and opening.
- Output is better due to Edge detection of Sobel filter is used for Smoothening of Image.
- Power Consumption of the board is 1.2V compared to 1.8V

7. Conclusion & Future Scope

The Proposed reconfigurable binary image processor was studied to perform real-time binary image processing. The processor performance has been increased by using the dynamic reconfiguration approach. The most complicated algorithms and basic mathematical morphology operations can be implemented easily on it because of its simple structure. The proposed processor, were characterized by high speed, simple structure, and used for wide application range, which suitable for binary image processing, like object recognition, object tracking and motion detection, computer vision, identification, and authentication. Onboard Display can be Implemented which would reduce Processing Time required due Transfer of Input Image File from PC to Xilinx Board (Spartan 3 EDK) using JTAG & Output Image File from Xilinx Board (Spartan 3 EDK) to PC using RS 232.

References

[6] Mr. Mahesh C. Pawaskar, Mr. N. S. Narkhede and Mr. Saurabh S. Athalye “Detection Of Moving Object Based on Background Subtraction”