VLSI Realization of Image Segmentation using Legion Algorithm

G. Bhargavi[1] and S. Philomina[2*]

[1]Department of Electronics and Communication Engineering, Jerusalem College of Engineering, Chennai - 600100, Tamil Nadu, India; bhargavi.sekaran@yahoo.com
[2]Department of Electronics and Communication Engineering, Bharath University, Chennai - 600073, Tamil Nadu, India; philomina.ece@bharathuniv.ac.in

Abstract

This paper proposes a realization of digital algorithm for gray scale image segmentation with some modification on LEGION algorithm. LEGION is one of the best algorithms for digital image segmentation. It is based on region growing method and has all the advantages of region growing approach. This algorithm was simulated in model-sim5.8 C and realized using Xilinx 6.3 tools. The segmented image results were verified by using MATLAB.

Keywords: Gray Scale, Leader Cell, Legion Algorithm, Oscillator Network, VLSI

1. Introduction

Image segmentation is the process by which the original natural image is partitioned into meaningful regions. In other words image segmentation is segregating the interested parts from the original image.

Image segmentation is very important while processing the image in higher levels such as object tracking, the image is not segmented, and the tasks said above take complicate manipulations and very long Processing time unnecessarily. After segmentation, only interested parts undergo processing and the processing time will be reduced and manipulation also be simplified. Several image segmentation algorithms have already been proposed and can be classified into five groups[6], namely,

- Pixel classification.
- Edge-based approaches.
- Region based approaches.
- Modal based approaches.
- Hybrid approaches.

The hybrid approach combines both region-based approach and model based approach.

2. Locally Excitatory and Globally Inhibitory Oscillatory Networks- LEGION

2.1 Description

LEGION stands for Locally Excitatory Globally Inhibitory Oscillatory Network[1]. Image segmentation using this method, has some advantages when compared to other models. LEGION is composed of the following elements: A model of a basic oscillator (each pixel in an image represents one oscillator). Local excitatory connections to produce phase synchrony within each object. A global inhibitor that receives inputs from the entire network and feeds back with inhibition to produce de-synchronization of the oscillator groups representing different objects.

2.2 LEGION Model

LEGION was proposed by Term an Wang as a biologically plausible computational framework for image segmentation and has been used successfully to segment

---

* Author for correspondence

binary and gray-level image data. It is a network of relaxation oscillators, each constructed from an excitatory unit 'X' and an inhibitory unit 'Y' as shown in Figure 1.
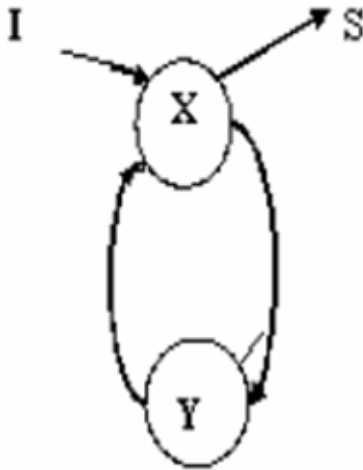

Figure 1. Diagram of single oscillator.

Unit 'X' sends excitation to unit 'Y' which responds by sending inhibition back to unit 'X' When external input stimulus 'I' is continuously applied to 'X', this feedback loop produces oscillations[2]. Neighboring oscillators are connected via mutual excitatory coupling, as well as the global Inhibitor. In this Figure 1 a single oscillator with an excitatory unit 'X' and an inhibitory unit Y in a feedback loop. A triangle indicates an excitatory connection and a bubble indicates an inhibitory connection. 'I' indicate external input and 'S' indicates the coupling with the rest of the network. Figure 2 shows a 2D architecture with 4-neighborhood coupling. The global inhibitor, shown with a black circle, is coupled with the entire network[3–5]. The white circle represents oscillators.
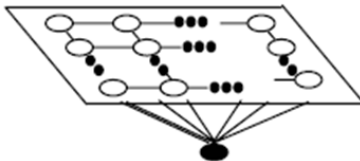

Figure 2. 2D architecture with 4-neighbour hood coupling.

3. Digital Image Segmentation Algorithm

The algorithm has six functional steps with some modification on LEGION[3] described above. They are given below.

- Initialization.
- Calculation of Leader cell.
- Self excitation of Leader cell.
- Calculation of dependent cell.

3.1 Initialization Step
- The global inhibitor 'G 'is initialized as zero.
- The image is stored in 'I 'matrix which has dimension of 2D. In this matrix, I (a, b) represents the intensity value of the pixel in 'a' throw and 'b 'th column.
- Calculation of connection weights: Weight matrix is a 4D one. It represents the weight value between pixels. It is calculated by using the following formula,

a) Gray scale images

$W (a , b , c , d) = Imax/[1+ | I(a , b) – I(c , d)|]$

Where W (a, b, c, d) represents the weight value between pixel (a, b) and pixel (c, d).

3.2 Calculation of Leader Cell
Define a Leader cell matrix 'L' and initialize it as zero.
For each pixels (a, b) in matrix 'I 'Initialize Wt = 0;
For all neighbor pixel (c, d)

Wt = Wt + W (a, b, c, d)
If Wt > th1 then L (a, b) = 1   Else null;

Where th1 is a pre-defined threshold and now the matrix' L 'contains leader cells, which have the value 1 in the 'L' matrix.

3.3 Self Excitation of Leader cell
The leader cells have the capability of self-oscillatory. Define a 2D matrix 'E' containing the oscillatory pixels and initialize to all zeroes. For all pixels (a, b) in the matrix 'L', If (excitable cells = false) then stop;

//all leader cells are analyzed. So stop.

//If a leader cell is got then it is self excited. The global inhibitor 'G 'made 1.

//Else if (find leader () == (a, b) and L (a, b) ==1)

Then

E (a, b) = 1; G = 1;
Go to next step.
Else go to self – excitation step;

3.4 Calculation of Dependent Cell
If pixel (c, d) is a neighbor and W (a , b , c , d) > th2 then pixel (c, d) is a dependent cell.

4. Segmentation Chip Model

The chip consists of six blocks namely,

- Input ROM block.
- Weight calculation block.
- Leader cell block.
- Locally Excitatory block.
- Segregation and Inhibition block.
- Output RAM down window on the left of the MS Word Formatting toolbar.
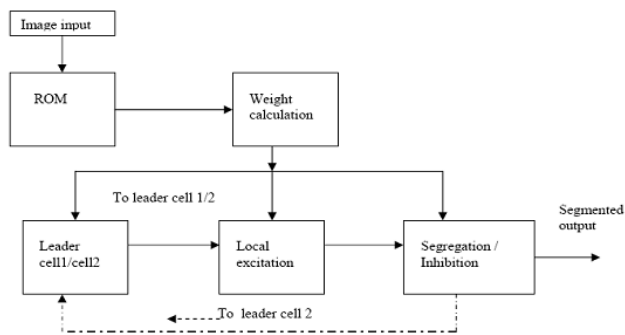
Figure 3. Blocks of the segmentation chip model.

4.1 Input RAM Block

VHDL[7] deals with only numbers and not images. However, image can be treated as a 2D matrix consisting of integer values. The integer values can be varied from 0 to (2 power n)-1 for a' n 'bit gray image. For example, an 8 bit gray image has integer values 0 to 255, where 0 represents the dark and 255 represents the bright. The intensity values in between has the proportion of the dark and bright.

4.2 Weight Calculation Block

The second block of image segmentation is weight calculation block. VHDL process starts from here. The input of weight calculation block is the intensity values from input ROM. The weight is calculated by the given formula

$$Wt = W(a , b , c , d) = Imax/[1+ | I(a , b) – I(c , d)|]$$

At the time of calculating a weight of a pixel, the weight values between the pixel and its spatial neighbors are calculated and added.

4.3 Leader Cell 1

The input to the leader cell is the weight values of the pixels from weight calculation block and a threshold value. The processing of leader cell 1 is simple. It merely compares the weight value of a pixel with the given leader threshold value. If the weight value exceeds the threshold then a '1' is stored for the pixel in an array. If the weight value is less than the threshold then a '0' is stored for the pixel in the array. After processing the array consists of 1's and 0's.

4.4 Local Excitation Block

The input to the local excitation block is ROM input, leader cell output and a local threshold value. This block starts to scan the leader cell from the top of the array and goes to the bottom of the array. If it encounters a 1 in leader cell array then the pixel is made as 1 in its output array[8]. Then the intensity value of that pixel and the spatial neighbor pixels are getting from the input ROM and calculate the weight value. Then compare the weight value with the local threshold value. If it is greater than the local threshold value, then the neighbor pixel is made as '1' in its output array. Otherwise, the neighbor pixel is made as '0' in the output array. In the same manner, all the neighbor pixel values are stored in output array of local excitation block. If the leader cell value is other than 1, the pixel won't eligible for local excitation. The process repeats row size times in order to make sure all the neighboring cells are excited in a segment[9].

4.5 Segregation Block

There may be more possibilities for two or more entirely different regions are clustered in a pass. But if those different regions are segmented as it is, then there is no meaning for segmentation. Those regions should be segregated before producing the output. The job of segregation block is to segregate the different regions and inform the previous blocks about the actions. Then only in the next pass the leader cell block will consider the non-outputted pixels for considering the leader cell again. The inputs to the segregation block are the input ROM values, the output array of local excitation block and a segregation threshold value. It has two outputs. One is segmented output and the second one is an array-consisting the details of outputted pixels. The no outputted pixels have value 0 in this array. The outputted pixels having values other than zero. The process of segregation block is as follows. It scans the output array of local excitation block for a 1 value[10]. It scans from the top to bottom in the one dimensional array which is equal to scan from top left to bottom right of the 2D image. If it encounters a

'1' immediately it collects the corresponding pixels ROM value and memorized it. The scanning process will be terminated as soon as it reaches a 1 value. Since, it scans from the top of the array the '1' which is in the top has higher priority. A designer can choose his own priority. In this paper the priority was given to the top pixel. Now, again the scanning process begins. Again it looks for 1's. But the process is not terminated after encountering the first '1'. It goes until it reaches the bottom most, last value in the array. If it meets a '1' in this pass, it collects the intensity value of the corresponding pixel and it compares the value with the memorized intensity value. If the difference between the two intensity values within the segregation threshold, the pixel is made as '1' in its output array, otherwise it is made as '0'. If the pixel value is made as '1', its intensity value is stored in another output array and otherwise a default value is stored[11].

Figure 4. Output images.

In this paper, the default value is chosen as 255. Similar to local excitation block, if the input array has value other than '1', then the pixel is discarded and in output label array the same input value stored and in output intensity array the default value is stored. Now the output label value is given to leader cell 2 blocks and output intensity array is given to output RAM. The cells with label '0' only considered for next pass and other cells won't consider for next segmentation. So, segregation block is doing the job of inhibition also.

5. Segmentation Results

In the following images, the top one represent original images and bottom three represent segmented images.

Figure 5. Output images using LEGEON approach.

6. References

1. Kimio T, Natarajan G, Hideki A, Taichi K, Nanao K. Higher involvement of subtelomere regions for chromosome rearrangements in leukemia and lymphoma and in irradiated leukemic cell line. Indian Journal of Science and Technology. 2012 Apr; 5(1):1801–11.
2. Cunningham CH. A laboratory guide in virology. 6th ed. Minnesota: Burgess Publication Company; 1973.
3. Sathishkumar E, Varatharajan M. Microbiology of Indian desert. In: Sen DN, editor. Ecology and Vegetation of Indian Desert. India: Agro Botanical Publishers; 1990. p. 83–105.
4. Varatharajan M, Rao BS, Anjaria KB, Unny VKP, Thyagarajan S. Radiotoxicity of sulfur-35. Proceedings of 10th NSRP; India. 1993. p. 257–8.
5. 01 Jan 2015. Available from: http://www.indjst.org/index.php/vision
6. Wang DL, Terman D. Locally excitatory globally inhibitory oscillator networks. Neural Networks. 1995; 6(1):283–6.
7. Kumar S, Das MP, Rebecca LJ, Sharmila S. Isolation and identification of LDPE degrading fungi from municipal solid waste. Journal of Chemical and Pharmaceutical Research. 2013; 5(3):78–81. ISSN: 0975–7384.
8. Koide T, Morimoto T, Harada Y, Mattausch HJ. Digital gray- scale/color image-segmentation architecture for cell-network-based real-time applications. Proceedings, IEEE Asia-Pacific Conference (ASIC); 2002. p. 237–40.
9. Laljee RP, Muddaiah S, Salagundi B, Cariappa PM, Indra AS, Sanjay V, Ramanathan A. Interferon stimulated gene -

ISG15 is a potential diagnostic biomarker in oral squamous cell carcinomas. Asian Pacific Journal of Cancer Prevention. 2013; 14(2):1147–50. ISSN: 1513-7368.

10. Wang DL, Terman D. Image segmentation based on oscillatory correlation. Neural Computation. 1997; 9:805–36.

11. Palaneeswari MS, Ganesh M, Karthikeyan T, Manjula Devi AJ, Mythili SV. Hepcidin-minireview. Journal of Clinical and Diagnostic Research. 2013;7(8):1767–71. ISSN: 0973-709X.

12. Edgbaston KC, Wang DL. A dynamically coupled neural oscillator network for image segmentation. Neural Networks. 2002; 15(3):423–39.

13. Thomas J, Ragavi BS, Raneesha PK, Ahmed NA, Cynthia S, Manoharan D, Manoharan R. Hallermann-streiff syndrome. Indian Journal of Dermatology. 2013; 58(5):383–4. ISSN: 0019-5154.

14. Ando H, Morie T, Nagata M, Iwata A. A nonlinear oscillator network for gray-level image segmentation and PWM/PPM circuits for its VLSI implementation. IEICE Trans Fundamentals. 2000; E83(2):329–36.

15. Subhashini V, Ponnusamy S, Muthamizhchelvan C. Growth and characterization of novel organic optical crystal: Anilinium D-tartrate (ADT). Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy. 2012; 87:265–72. ISSN: 1386-1425.

16. B. Jahne. Digital Image Processing. 5th revised and extended Springer.