Implementation of Medical Image Segmentation using Virtex FPGA kit

R.Hemalatha, MIEEE
PG Scholar (ME- VLSI Design),
Knowledge Institute of Technology,
Salem, Tamilnadu.
hemarcha@gmail.com

N.Santhiyakumari, MIEEE
Professor and Head of Department/ ECE,
Knowledge Institute of Technology,
Salem, Tamilnadu.
santhiyarajee@rediffmail.com

S. Suresh,
Director,
Mediscan systems,
Chennai,
mediscan@gmail.com

Abstract— **In the decade of technological advancement, the image processing techniques has made it possible to save lives of several beings. The diagnosis of cardiovascular involved in complex procedures whereas the analysis of blood vessels carried out. The image segmentation technique is used to eliminate such complexities in Ultrasound carotid image diagnosis. In this paper the implementation of segmented intima-media interface of the common carotid artery image has been proposed in real time Virtex Field Programmable Gate Array. The intima-media interface has been extracted using threshold segmentation technique. The pre-processing step is used to remove speckles present in the ultrasound carotid image and the morphological techniques can be used in segmentation algorithm with the aid of Aphelion Dev software. The resulting image has been implemented in Virtex which provides minimum hardware resources and low power consumption and is desirable for real time medical applications and analysis.**

Keywords— Common carotid artery (CCA); Virtex Field Programmable Gate Array; Intima-media layer; Threshold segmentation technique; Aphelion Dev.

I. INTRODUCTION

In recent years, the diagnosis of medical image becomes more complicated with the existing systems. In clinical practice, segmentation scheme is considered to analyze the medical image. Mostly, it is used in the analysis of carotid artery images to predict the abnormalities in vessels. In case of image analysis in medical field, segmentation is considered as an important note which can be used to detect the features, surgery with the guidance of image and register the different images.

The classical image segmentation method uses the relevant data with particular texture, size and connectivity between the pixels for better performance of less noise images. However, while considering the medical field there is much complexity in the analysis of image. Bastida-Jumilla M.C.et al. [1], suggested the segmentation method which is used to measure the IMT by using anisotropic diffusion or geodesic active contours. Chan, R.C. et al [2], developed a technique for ultrasound image, it considers the information about an image which is used for analysis and suppressing the noise. Now it is used for 3D carotid artery and also for RF ultrasound image in the removal of noise.

Dana E. ilea [4], developed a fully automated segmentation method for common carotid artery which comprises of automatic threshold technique to detect the region of interest and Gaussian filtering scheme in order to remove the speckles and artifacts from the image.

Faita, F. et al [5], developed a method to evaluate the Intima-media thickness based on the First Order Absolute Moment and the result has compared using regression analysis and Bland Altman analysis. The segmentation method based on Hough Transform has been developed by Golemati et al [6] which is non-user intervention method. It is used for longitudinal as well as transverse mode ultrasound images without user intervention to extract the Intima-media interface. But it can identify only the horizontal and vertical vessels. However, B-mode ultrasound images consist of curved and inclined CCA.

Ilea D.E. et al. [7], described an algorithm that can be used to segment the intima-media interface based on continues spatial method and also used to calculate the intima-media thickness of ultrasound carotid images. Here the extraction of intima-media interfaces has been done in an automated way. The different generation of segmentation methods and the software used for medical image segmentation has been described by Koles1, Z.J. [8]. In order to reduce the manual tracing problem in segmentation, various technique have been described to perform automated Intima-media segmentation such as a multiscale dynamic programming developed by Liang Q. et al. [9] it requires retraining whenever the change takes place in the characteristics of image.

The snake segmentation method is used to detect the far wall intima-media interface of ultrasound carotid image was developed by Loizou C.P.et al.[10]. It requires manual intervention to select the interested region. Maulik, U. [11] described about the various uses of genetic algorithms (GA) in medical image segmentation. GAs is used in the methods based on contours, texture, knowledge, listening and model. If it is considered as a manual method, which requires more experience.

Molinari, F. et al [12], described an efficient segmentation method which is an integrated approach used to extract the carotid adventitial walls. It is a completely automatic layer recognizing technique for detecting the carotid artery in ultrasound images. There are several segmentation method used for diagnosing ultrasound carotid artery images which are used in both fully automatic and semi-automatic manners [14-16].

Selzer, H.et al [17], developed the computerized edge-tracking multi frame technique that automatically determine the arterial diameter and highly reproducible. In case of semi-automated method there is a need of manual intervention which causes error in measurement. Stanley Osher et al. [19], suggested the segmentation methods which contains television regularized energies. For the mean curvature motion problem, the Split Bregman approach is found to be more efficient than other methods, including techniques based on graph-cuts. In addition to its speed, the Split Bregman approach has the

advantage that it can solve isotropic segmentation problems, and does not require any regularization.

Recently, FPGA technology is used in the implementation of algorithms for image processing. Chetan, S. [3], developed real time hardware for segmenting the image in which Adaptive Median Filter (AMF) has been used to minimize the resource utilization. The edge can be detected using sobel operator and the resource utilization of segmentation is 50% less compared to the AMF.

The implementation of image processing algorithm in dedicated hardware create several advantages particularly in terms of resource, power consumption, quality of the results and costs. Ratnayake, K. et al.[13], developed a technique for segmenting the video objects based on Field Programmable Gate Array implementation to achieve increased performance. The obtained result shows that the speed of processing is 133 MPixels/s which avoids the re-design of architecture.

Taouil,K. et al [20], described the implementation of watershed transform segmentation algorithm on Virtex-5. The result shows that the hardware utilization is about 78% for the size of 256x256 images and the performance of this design is 150MHz.

Torres-Huitzil, C. [21], developed the process of building neural systems for image segmentation implementing on FPGA. The large networks of spiking neurons are handled by flexible solutions. The segmentation of gray images have been implemented with the standard Network architecture which contains the fixed point representation of 12-bit to performing the arithmetical operation in serial manner. The result shows that a 16x16 configuration of LEGION network consumes 99% of slices, 83% of Look up Tables and 35% of flipflops. The estimated maximum clock frequency is 50MHz. The FPGA implementation of colour segmentation based object tracking algorithm has been described by T. Jhonson, C. [22]. Here the hardware resources utilization is lower than 10% for tracking object. It has implemented with colour Thresholding method.

In this paper, the implementation of segmented intima-media layer of ultrasound common carotid artery image using Aphelion Dev real time software with a dedicated hardware of Virtex Field Programmable Gate Array has been proposed. The main focus of this paper is to implement the segmented image in hardware which offers the advantage of minimum resource utilization and consumes less power. The modifications to the algorithm are made if needed, so that it provides reconfigurable aspect.

II. METHODOLOGY

A. Image Acquisition

The ultrasound scanner used to acquire the data consists of array of transducers which employs to record the motion of arterial wall and video recorder assists in recording the movements. In order to obtain the similar images, transducer has situated at the beginning of ramification of common carotid artery. Then video is converted into sequence of frames and the obtained images are stored in a PC for further processing.

B. Histogram Equalization

The ultrasound image has low contrast trouble in between the anatomical structures due to undetermined echoes response of ultrasound. It results that the subjects such as blood and tissue are not described easily. In order to get better and meaningful segmentation need to improve the quality of images. The Histogram Equalization method [14] has been used to improve the appearance of the CCA image by adjusting intensity values without an error in the structure of intima-media layer.

C. Detection of Interested Region

The Interested region defines the position of Intima-media layer in the castigate area of ultrasound image. The region presented at the surroundings of interface has been considered as region of interest which distinguish the blood and tissue of carotid artery. Parameters concern to the lumen and the Intima-media considered to identifying ROI correctly. A semi-automated technique has been used to detect the ROI which requires manual intervention to discover the far wall of the CCA.

The Flow diagram of developed technique is shown in Fig.1.

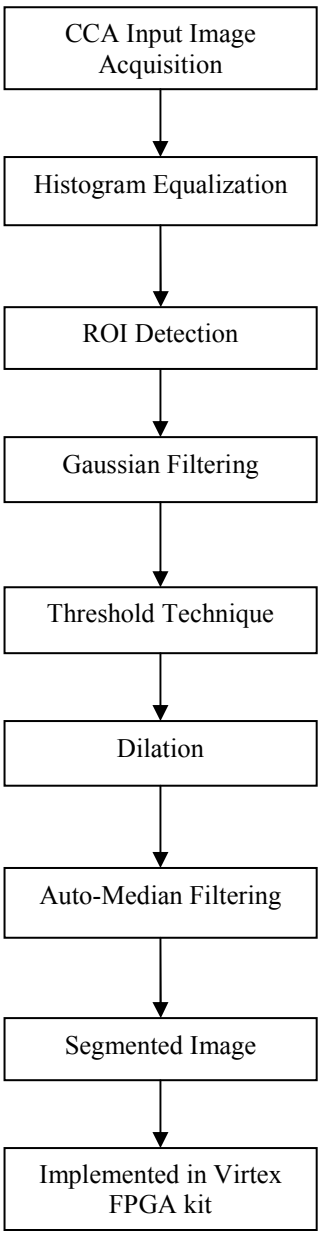


Fig.1. Flow diagram for the segmentation algorithm with the hardware implementation

D. Gaussian Filtering

The image obtained from previous step has been pre-

filtered earlier to threshold technique. This step is used to attenuate speckle noise which presents in the ultrasound image without disturbing any important features of the image. The Gaussian filtering technique [4] has been used in the removal of speckles. It results the smoothed image of common carotid artery far wall. The filtering has been performed based on a convolution using a kernel with a Gaussian shape of 3.

E. Threshold Technique

The thresholding algorithm is enforced to discover the interface of two main image classes such as lumen and carotid artery tissues. The pixels are partitioned depending on their intensity value. It results that the binary image where lumen and tissue classes are formed based on pixel values 0 and 255. The value 0 represents the blood class and value 255 represents the arterial tissue. The thresholding operation forms a binary image as

$$f(x,y) = \begin{cases} 255 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) \le T \end{cases} \quad (1)$$

where f(x,y) denotes the intensity value of input image at the location of (x,y) and the value of T varying from 85 to 120 which extracts the lumen-intima interface.

F. Dilation

Dilation of image is a basic operation of mathematical morphology. It uses horizontal structure element for examining and flourishing the intimal layer contained in the threshold image to provide continuity between the pixels of lumen-intima interface. The number of iteration has to be set as 4 in order to obtain continuity.

G. Auto-Median Filtering

The median filter used to remove noise presents in dilated carotid artery image. This noise reduction is a typical post-processing step to improve the results of threshold image. When considering the contextual information of image, auto-median filtering has the capable to conform based on image content. Size of 9x9 structuring element should be considered for removing the artifacts which present in the dilated image.

H. Implementation in Virtex FPGA kit

The Virtex series of FPGA is desirable for implementing the image processing algorithm. The hardware implementation provides the advantage of the high parallelism in the algorithm. Moreover, various discrepancies support the same hardware by transferring a new approach onto the FPGA. This will enable the use of flexible image segmentation method in applications where the real time performance is necessary. The modifications to the algorithm are made if needed, it also provides reconfigurable aspect.

The Virtex-4 as shown in Fig.2 has the following specifications

Device Used : XC4VSX25-10FF668
Logic Cells : 23,040
No of Slices : 10,240
Extreme DSP Slices : 128
Block RAM : 128
Block RAM (Kbits) : 2,304
Dedicated Multiplier: 104
DCMs : 4
Max Select I/O : 320
Onboard configuration serial PROM
JTAG Connector

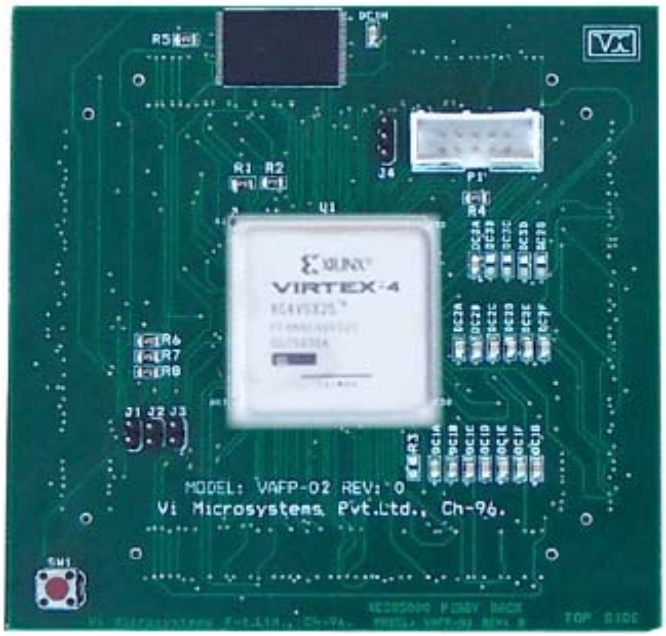


Fig.2. Virtex-4 Piggy Back Board

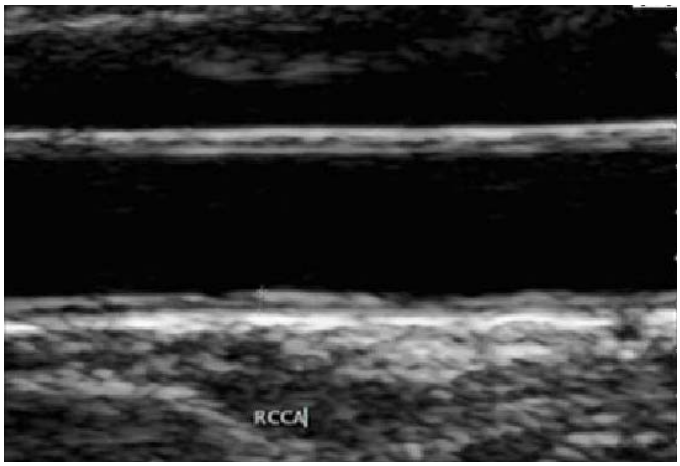
It uses JTAG (Joint Test Action Group) serial mode configuration which is configured by adulterating the specified application data into internal memory. The Xilinx FPGA configuration memory is liable to lead sudden change. It must be configured each time whenever power is on. A bit stream is loaded into the device through special configuration pins. Boundary-scan port is available in FPGA board which is independent of mode selection during the configuration. The presence of Boundary-Scan mode turns off other modes.

VVSM - 09 boards have a 2x16 character Liquid Crystal Display (LCD) which used to displays a binary image. The FPGA controls LCD via the 8-bit data interface pin. After enabled, the LCD is display a variety of information such as image using standard ASCII and custom characters. The Character Generator ROM contains the font bitmap for each of the predefined characters that the LCD screen can display. The character code stored in RAM for each character location subsequently references a position with the CG ROM.

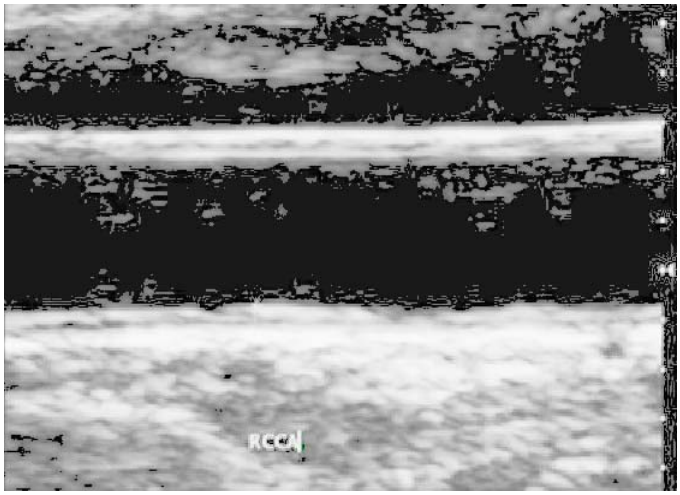
III. RESULTS AND DISCUSSION

The common carotid artery image is extracted from ultrasound scanner and the steps given in the flow diagram have been followed. The single frame has been acquired and used for further analysis. The longitudinal section acquired input image as shown in Fig.3a. Figure.3b shows the Pre-processed image, it is used to enhance the contrast of input image. The lumen has low intensity pixels surrounded by higher intensity pixels of carotid wall layers such as Intima-media identified as ROI which is shown in Fig.3c. The Gaussian filtered (Pre-filtered) ROI image as shown in Fig.3d. It is used to remove the speckles which present in image region due to low echoes of US scanner. Fig.3e shows the threshold segmented image with T varying from 85 to 120 which impart the lumen-intima interface. The resulting image from previous step has much discontinuity. In order to reduce this trouble the morphological technique (dilation) is used to

extend the horizontal structure elements of the interface as shown in Fig.3f.



(a)



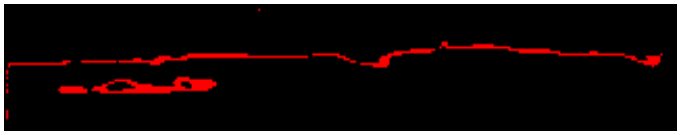
(b)



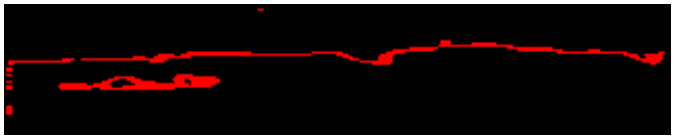
(c)



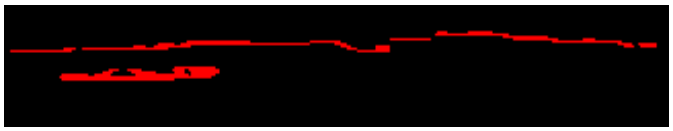
(d)



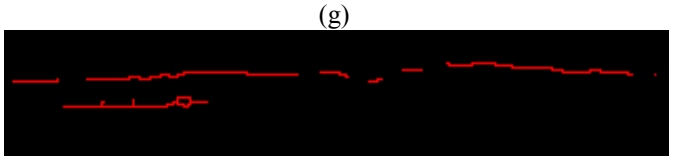
(e)



(f)



(g)



(h)

Fig.3.a. Input CCA Image. b. Pre-Processing Image. c. ROI Detection. d. ROI Pre-Filtering image. e. Threshold segmented image. f. Dilating image. g. Post processing image. h. Segmented output image.

The resulting image of post-processing is shown in Fig.3g, which improves the result of dilated image. Finally the morphological thin operation has been performed and the segmented output as shown in Fig.3h.

The obtained results from Aphelion Dev software have been implemented in Virtex platform. It utilized minimum hardware resource for implementing the segmented intima-media layer as shown in table.1.

Table.1. Resource utilized by segmented result

Resource	Used	Available	Usage (%)
I/O pins	12	320	3.8
Logic cells	75	12288	0.6

The total power consumption for implementing the system is 0.168W.

IV. CONCLUSION

The segmentation of ultrasound carotid artery image with the identified region has been implemented in Virtex Field Programmable Gate Array hardware. The speckles in the ultrasound carotid artery image have been attenuated by Gaussian filtering which results the noiseless image. The extraction of lumen-Intima interface should be facilitated with the help of threshold technique. The segmentation of single frame carotid image has been obtained using Aphelion Dev real time software. It is used to reduce the complexity of hardware implementation with the minimum hardware resources and low power consumption. The segmented image has been desirable for employ in real time medical applications to examine the presence of abnormalities.

Acknowledgment

The authors wish to thank Dr. S. Suresh, Mediscan systems, Chennai for giving the required images to complete this work.

References

[1] Bastida-Jumilla, M.C. Morales-Sanchez, J. Verdu-Monedero, R. Larrey-Ruiz, J. and Sancho-Gomez, J.L. (2010) 'Detection of the intima and media walls of the carotid artery with geodesic active contours', in IEEE Proc. 17th Int. Conf. Image Processing, pp. 2213 -2216.

[2] Chan, R.C. Kaufhold, J. Hemphill, L.C. Lees, R.S. and Karl, W.C. (2000) 'Anisotropic edge- preserving smoothing in carotid B-mode ultrasound for improved segmentation and intima media thickness (IMT) measurement', Comput. Cardiol., vol. 27, pp. 37–40.

[3] Chetan, S. Deokar and Baru, V. B., (2011) 'VLSI Implementation of Image Segmentation with Resource Optimized Adaptive Median Filter', International Conference on VLSI, Communication & Instrumentation, pp. 14-18.

[4] Dana E. ilea, Caoimhe Duffy. Liam Kavanagh,Alice Stanton and Paul F. Whelan, (2013) 'Fully Automated Segmentation and Tracking of Intima Media Thickness in Ultrasound Video Sequences of the carotid artery', IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 60, no. 1, pp. 158-176.

[5] Faita, F. Gemignani, V. Bianchini, E. Giannarelli, C. and Demi, M. (2006) 'Real-time measurement system for the evaluation of the intima media thickness with a new edge detector', in Proc. 28th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., pp. 715–718.

[6] Golemati, S. Stoitsis, J. Sifakis, E.G. Balkizas, T. and Nikita, K.S. (2007) 'Using the Hough transform to segment ultrasound images of longitudinal and transverse sections of the carotid artery', Ultrasound Med. Biol., vol. 33, no.12, pp.1918–1932.

[7] Ilea, D.E. Whelan, P. F. Brown, C. and Stanton, A. (2009) 'An automatic 2D CAD algorithm for the segmentation of the IMT in ultrasound carotid artery images', in Proc. 31st Annu. Int. Conf. IEEE Eng. Med. Biol. Soc.: Engineering the Future of Biomedicine, pp.515–519.

[8] Koles1,Z.J. and Withey, D.J. (2007), 'Medical Image Segmentation: Methods and Software'IEEE Trans. on NFSI & ICFBI., pp.140-143.

[9] Liang, Q. Wendelhag, I. Wikstrand, J. and Gustavsson, T. (2000) 'A multiscale dynamic programming procedure for boundary detection in ultrasonic artery images', IEEE Trans. Med. Imaging, vol. 19, no. 2, pp. 127–142.

[10] Loizou, C.P. Pattichis, C.S. Pantziaris, M. Tyllis, T. and Nicolaides, A. (2007), 'Snakes based segmentation of the common carotid artery intima media', Med. Biol. Eng. Comput., vol. 45, no. 1, pp. 35–49.

[11] Maulik, U. (2009) 'Medical Image Segmentation Using Genetic Algorithms', IEEE Transactions on information technology in biomedicine, Vol. 13, No. 2, pp.166-173.

[12] Molinari, F. Zeng, G. and Suri, J. S. (2010) 'Intima-media thickness: Setting a standard for a completely automated method of ultrasound measurement', IEEE Trans. Ultrason. Ferroelectr. Freq. Control, vol. 57, no. 5, pp.1112–1124.

[13] Ratnayake, K. and Aishy Amer, (2006), "An FPGA-based implementation of Spatio-Temporal Object Segmentation" IEEE Trans. on ICIP, pp. 3265-3268.

[14] Santhiyakumari, N. Rajendran, P. Madheswaran, M. (2010) 'Medical Decision-Making System of Ultrasound Carotid Artery Intima–Media Thickness Using Neural Networks', J Digit Imaging, Society for Imaging Informatics in Medicine, pp.1112-1125.

[15] Santhiyakumari, N. Rajendran , P. Madheswaran, M. and Suresh, S. (2011) 'Detection of the intima and media layer thickness of ultrasound common carotid artery image using efficient active contour segmentation technique', International Federation for Medical and Biological Engineering, vol.49, no. 11, pp. 1299-1310.

[16] Santhiyakumari, N. Madheswaran, M. (2008) 'Non-invasive evaluation of carotid artery wall thickness using improved dynamic programming technique',pp. 183-193.

[17] Selzer, R. H. Mack, W. J. Lee, P. L. Kwong-Fu, H. and Hodis, H. N. (2001) 'Improved carotid elasticity and intima-media thickness measurements from computer analysis of sequential ultrasound frames', Atherosclerosis, vol.154, no.1, pp. 185–193.

[18] Silva, J. Rocha, R. Campilho, A. Azevedo, E. and Santos, R. (2010) 'Segmentation of the carotid intima-media region in B-mode ultrasound images', Image Vis.Comput., vol.28, no.4, pp.614–625.

[19] Stanley Osher, Tom Goldstein, Xavier Bresson,, (2010) 'Geometric Applications of the Split Bregman Method: Segmentation and Surface Reconstruction', J Sci Comput, pp. 272–293.

[20] Taouil,K. Smaoui Zghal, N. and Dorra Sellami Masmoudi, (2011) 'Implementation of an Improved Watershed Algorithm in a Virtex 5 Platform' ,International Journal of Computer Applications, Vol. 21, No.1, pp.40-45.

[21] Torres-Huitzil, C.and Bernard Girau, (2006) 'FPGA implementation of an integrate-and-fire LEGION model for image segmentation' ESANN'2006 proceedings - European Symposium on Artificial Neural Networks Bruges (Belgium), pp.173-178.

[22] C.T. Johnston, D.G. Bailey, K.T. Gribbon, (2005) 'Optimisation of a colour segmentation and tracking algorithm for real-time FPGA implementation',Image and Vision Computing Newzealand, pp.422-427.