# CIRCULAR PATTERN DETECTION BY HOUGH TRANSFORM IN A TRANSPUTER BASED SYSTEM, FOR MEDICAL APPLICATION

**Maria Stela Veludo de Paiva**[1]
**Mark Nixon**[2]

[1]EESC-USP - Escola de Engenharia de São Carlos
Departamento de Engenharia Elétrica
Av. Dr. Carlos Botelho, 1465
São Carlos , SP, Brasil

[2]University of Southampton
Dept. of Electronics and Computer Science
Southampton, SO95NH - England

**ABSTRACT.** This paper describes the detection of an artery by Hough transform, developed on a PC-based system which hosts a transputer-based Harlequin framestore. This work is part of a programme of research in ultrasound image processing aimed to translate feature extraction into a cost effective implementation. The project aims to provide three dimensional vascular reconstruction via non-invasive ultrasound, to improve surgical planning and diagnosis of arterial disease.

## 1.Introduction

Blood disease can lead to stroke and since stroke has caused many deaths much research has concentrated on tools for better diagnosis and for planning to aid corrective surgery. Ultrasound has become a popular assesment techniques. It is a low cost solution and a non-invasive technique and has become more popular by its ability to indicate stenosis as well as its ability not to give false indications. Its disadvantage compared with the invasive techniques like angiography is that it lacks the refinements and high quality images of these techniques resulting in difficulty in diagnostic analysis. On the other hand invasive techniques are relatively complex to implement and have the associated risks [Nixon-Martin-de Paiva (1992)].

In this paper the Hough transform is used to detect the position of an artery, in a ultrasound image. The Hough transform was introduced in 1962 as a technique for detecting lines in digitised images. Since then, it has improved and extended to detect other parametrically defined shapes and arbitrary shapes. Its popularity has increased steadily owing mainly to its robustness and ability to cope with image noise [Muamar-Nixon (1991)].

In this work the position of the artery is identified by a circular approximation. This circle is extracted from the edge magnitude information. The circle is located using an implementation of the Hough transform tailored to determine the contour which best fits the arterial data. The detection of the artery is the first stage for the 3D modelling. Three dimensional(3D) modelling of arteries using non-invasive ultrasound aims to improve visualisation of the artery under consideration and in particular the detection of disease within it [Martin (1990), Nixon-Martin-de Paiva(1992)].

This work was developed on a PC-based Harlequin framestore comercially available from Quintek. This is a low cost system compared with workstation and systems like VAX computer, and can still satisfying the computational processing requirements becoming of great interest to diagnostic clinical work. The system has major advantages over others targeted to provide a similar solution which include: improved resolution, diagnosis via purely extra arterial means and ease of use.

## 2. The Hough Transform for Circles

A traditional implementation of the Hough transform first uses an edge detection operator to provide a gradient version of the original image [Muamar-Nixon (1989)]. This can then be thresholded to form a binary image. If the object is to search for circles, then the following identity can be used:

$$(x-a)^2 + (y-b)^2 = r^2$$

where (a,b) is the center of the circle and r is the radius.

Edge points in the binary image vote for the

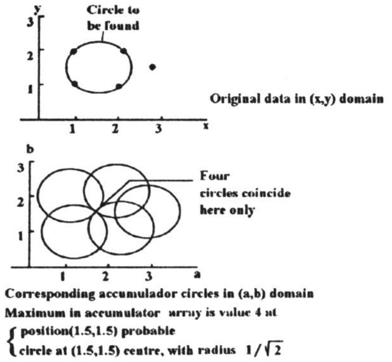


**Figure 1** - Illustration of Hough Circle Transform

presence of circles or circular arcs, by incrementing cells in an accumulator array. If the circle radius and centre are unknown, a three dimensional accumulator array (a,b,r) is necessary. Bresenham's circle drawing algorithm can be used to increment the circles element quickly. To complete the Hough transform process is investigated the highest value in the (a,b,r) array corresponding to the parameters of the best circle. Figure 1 illustrates this technique [Low (1991)].

There are a number of techniques used to extract circles based on the Hough transform [Yven-Princen-Illingworth (1990)]. Extensions have improved speed by a different approach [Muamar-Nixon (1989) and (1991)] or by a more efficient implementation [Gerig-Klein (1986)]. Some of the extentions are based on using edge direction and are inappropriate here owing to the noise prevalent in ultrasound images. Other techniques address the partitioning of the Hough technique but do not lend themselves readily to a parallel implementation. Some of the Hough implementations for circle extraction have been reviewed in application [Iven-Princen- Illingworth (1990)].This study was based on a standard version of the Hough transform since the refinements to speed its implementation were of no consequence.

## 3. Arterial Wall Detection

A primary stage in feature detection is the reliable extraction of edge data from images. The Canny operator requires pre-filtering by convolution of a low-pass template across the entire image. In this application where features whithin the image change slowly and where a small amount of filtering around a central point is required, a mask size of 5 pixels with a standard deviation of 1.0 pixel provided suitable results. The edge strengh is then thresholded by a global strengh threshold. In the resulting binary image is applied the Hough transform to derive the best match to a circle.

In fact the arterial wall concerns not a circle itself but a deviation from a circle and the knowledge of the best circle to fit the data provides a basis for smoothing the inherently noisy wall data.

In the Hough transform procedure evidence for the existence of a circle accumulates in a array

parameter(xcentre,ycentre,radius)

where xcentre, ycentre and radius are within the expected range for these parameters. Evidence accumulates by voting based on the edge detected image as explained in item 2. The final stage of the Hough transform procedure is to determine the peak of evidence (essentialy the peak vote in the array) which locates the value of the parameters attributed to describe the best circle which fits the data. Since a small error in centre position and radius can be tolerated then just the peak in evidence is extracted.

Figure 3 shows an example result. The 100x100 pixels frames at the sides of the image contains the processed region of the image and show the edge detection, the threshold and the best match to a circle. The central picture shows the original image.

## 4. Equipment

The equipment used in this study was an Aloka ultrasound scanning system feeding a transputer-based Harlequin framestore (figure 2), hosted by a PC system. The Harlequin board provides 512x512 resolution display and incorporates an Inmos 32 bit T800 transputer with 1 Mbyte of dynamic RAM and two quarter Mbyte image buffers of VRAM.

The image presented in this paper at figure 3 is 512x512 pixels with 256 grey levels. It was grabbed in vivo, with the scanner normal to the point of interest and when the artery was at the peak of the systolic phase of the cardiac cycle.

Processing is based on a 100x100 region centred on a point of interest specified by the operator. This is the point where the operator expects the artery to lie since has proved impossible to segment automatically the artery from the image. This is due to the noise experienced in ultrasound images and to the presence of the vein close to the artery.

The software was implemented in parallel C , and uses functions from a image processing library, IPLIB. The computational performance can be improved including parallelism and the implementation offers facility for this.

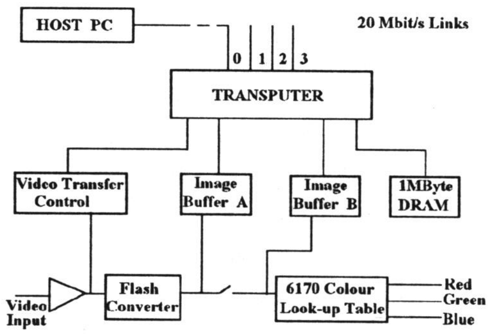


**Figure 2** - Transputer based Harlequin System.

## 5.Results

The figure 3 shows the results from applying the techniques described in vivo. The Canny edge operator has been used in conjunction with the Hough transform to extract a circular approximation to an artery. This will provide a basis for filtering the wall data in the arterial image and can provide an approximation even when wall data is missing. This leads to a template which with others extracted from a number of arterial slices will provide a 3d carotid model.

## 6. Conclusions

Feature extraction techniques in 3D artery modelling have been successfully translated to a low cost parallel processing system. This aims to meet the computational requirements with identical function but at low cost. The implementation also offers facility for inclusion of parallelism to further enhance the computational performance. The translated techniques serve to implement the Canny operator and the Hough transform and these techniques are shown applied to images on an artery to extract an approximation to the arterial wall.

## 7. References

[1] Duda, R. O. & Hart, P. E. - Use of Hough Transformation to Detect Lines and Curves in Pictures, Communications of the ACM, v. 15, n.o 1, Jan. 1972.

[2] Gerig, G. & Klein, F. - Fast Contour Identification Through Efficient Hough Transform and Simplified Interpretation Strategy, IEEE, 1986

[3] Pieroni, G. G. & Costabile - Detection Shapes Correspondences by Using the Generalized Hough Transform, IEEE, 1986.

[4] Muamar, H. & Nixon, M. - Approaches to Extending the Hough Transform, IEEE, 1989

[5] Yven, H. K. & Princen, J. & Illingworth, J. & Kitter, J. -Comparative Study of Hough Transform Methods for Circle Finding, v. 8, n.1, fev. 1990.

[6] Muammar, H. K. & Nixon, M. - Tristage Hough Transform for Multiple Ellipse Extraction, IEE Proceedings-E, vol. 138, n.o 1, January 1991.

[7] Perring, S. - The Segmentation of Medical Slice Images and Their Display as Pseudo Three - Dimensional Projections, Southampton General Hospital, Nuclear Medicine Department - 1990

[8] Lees, W. R., Lawrence, R., Gardener, J. - Intravascular Ultrasound with 3D Reconstruction - a New Way to Image Vascular Disease, Department of Radiology, Surgery and Medical Physics; The Middlesex Hospital and University College Hospital, London, 1990.

[9] Gardener, J. E. & Lees, W. R. - Techniques for Ultrasound 3D Imaging, Department of Radiology, Surgery and Medical Physics; The Middlesex Hospital and University College Hospital, London, 1990.

[10] Humphries, K. N. & Reynolds, R. A. & Wilson, K. - Development of 2D Composite and 3D Ultrasound Angiographic Techniques: Preliminary Report, Royal Postgraduate Medical School Hammersmith Hospital, London, 1990.

[11] Strong, A. B. & Lobregt, S. & Zonneveld, F.W. - Applications of 3D Display Techniques in Medical Imaging, Journal of Biomedical Engineering - 1990

[12] Martin, P. K. - Arterial Reconstruction for Surgery, a report for the B. Eng. in Electronic Engineering in 11/05/90 - University of Southampton.

[13] Nixon, M. S. & Martin, P. & de Paiva, S. - 3D Arterial Modelling Using Feature Extraction in Ultrasound Images, International Conference on Image Processing and Its Applications, The Netherlands, 7 a 9 Abril, 1992.

[14] Low, Adrian - Introductory Computer Vision and Image Processing, McGraw Hill ,1991.

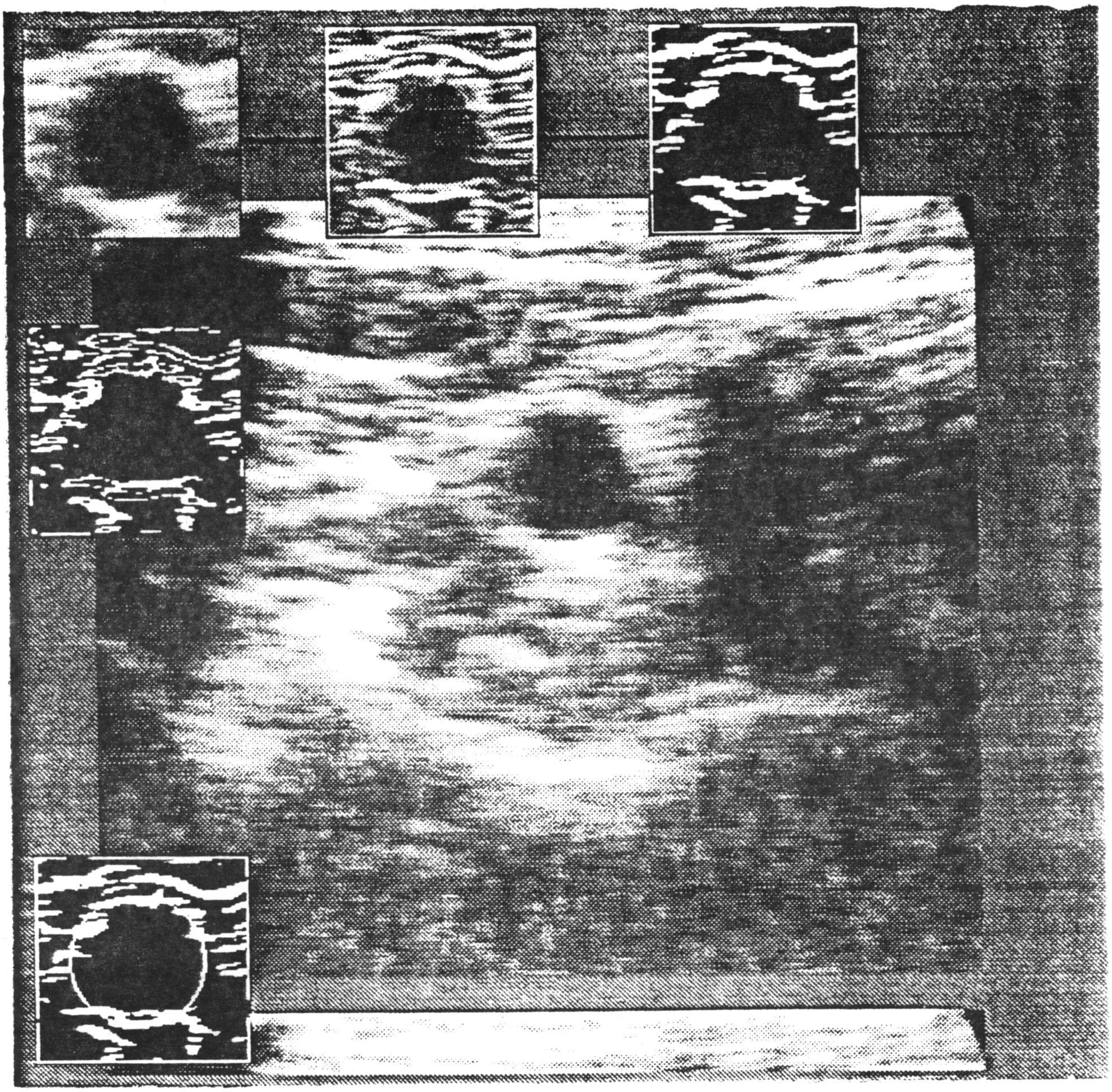

**Figure 3** - Image showing the detection of the artery by Hough transform