COMPUTERIZED SYSTEM FOR BREAST CANCER MONITORING AND GRADING OF ABNORMALITY IN MEDICAL THERMOGRAM

By

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FINAL REPORT

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved:

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(Dr Aamir Saeed Malik)
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

_____

(Mohd Syafiq Mohamed Osman)

ABSTRACT

Breast cancer is the most common form of cancer affecting women in the world. With the advanced improvement in thermal imaging technology, dynamic digital thermography can be applied to medical procedures for early detection of many health conditions including breast cancer often before they can be picked up by standard medical tests. Digital thermography is a totally non-invasive, non-contact clinical imaging procedure that diagnoses abnormal areas in the body by measuring heat emitted from the skin surface and expressing the measurements into a thermal map called thermograms. It could assist in medical imaging procedure for detecting and monitoring of various diseases and physical injuries. The usage of breast thermogram as a detection tool of cancerous cell growth is being investigated nowadays. It can detect the cancerous growth in its early age, then later to be confirmed by mammography or any other technique. Mammography alone cannot detect cancerous cell in its early age and the usage of digital thermography alone cannot pinpoint exactly at where the cancerous cell location for further treatment, thus both of them work in harmony. This project attempts to ease the work of clinician to analyze data extracted from thermogram by developing a computerized system for early detection of breast cancer, monitoring and grading of abnormality in medical digital thermogram.

ACKNOWLEDGEMENT

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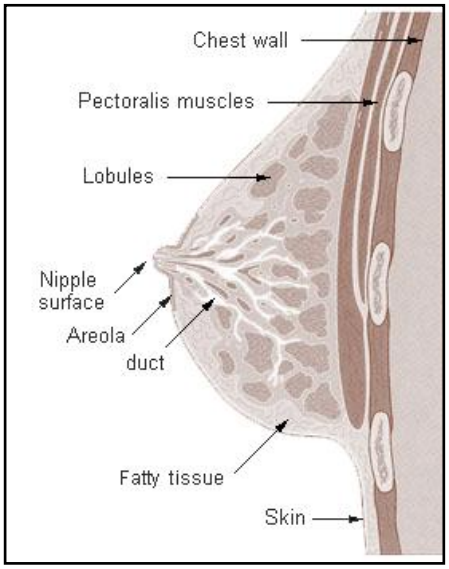
INTRODUCTION

1.1 Background of Study

Breast cancer is the most common form of cancer affecting women in Malaysia. About 1 in 19 women in this country are at risk, compared to 1 in 8 in Europe and the United States [1].

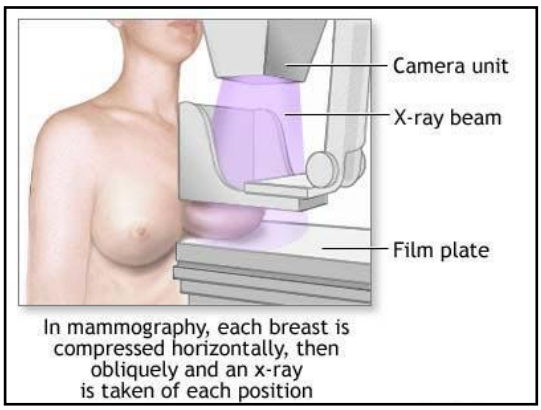
Breast cancers emerge due to a combination of genetics, carcinogens, immune responses, hormones, and tissue composition. The breasts are composed of lobes, lobules, ducts, glands, and a high concentration of blood vessels and fat cells. (Refer Figure 1). Many of these tissues in the breast have receptors for the hormone estrogen, which makes them a target for the hormone's influence. Fat cells both produce and breakdown estrogen. The chemical breakdown reaction (known as aromatization) of estrogen produces carcinogenic (cancer causing) byproducts. As a result, the carcinogens affect the DNA of nearby cells which can cause them to mutate into cancers. Research has shown that some women's breasts are more susceptible than others to the effects of estrogen and its byproducts.



*Source: *http://www.celtnet.org.uk*

Figure 1: Human breast anatomy

There are several methods one can use to diagnose breast cancer. The common techniques that most people know are mammography. The other common techniques for screening or diagnose is Self Breast Examination, Ultrasound, Magnetic Resonance Imaging (MRI) (Figure 2), and Biopsy (removing a sample of breast cells for testing).



*Source: *http://www.nlm.nih.gov*

Figure 2: Mammography

In September 2000, a large-sample, long-term Canadian study proved that an annual mammogram was no more effective in preventing deaths from breast cancer than periodic physical examinations for women in their 50s.

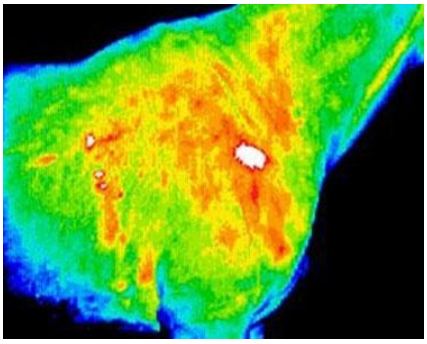
With the usage of breast thermogram, cancer can be detected earlier before mammogram can detect a mass of cancerous cell. However, thermography does not have the ability to pinpoint the exact location of a tumor for operation. Consequently, digital thermography role is as in addition to mammography and physical examination.

Thermography has been approved by the United States Food & Drug Administration (FDA) since 1983 for the adjunctive screening of breast cancer. Recent studies have shown thermography to be effective in women with health breasts at 97% sensitivity.

Thermography is able to detect a pre-cancerous state of the breast, or signs of cancerous growth at an extremely early stage. This is possible because of its unique ability to see and monitor any changes in heat and temperature. These hot spots are signs of functional changes or more blood flows that are produced during the earliest stages of tumor development [2].

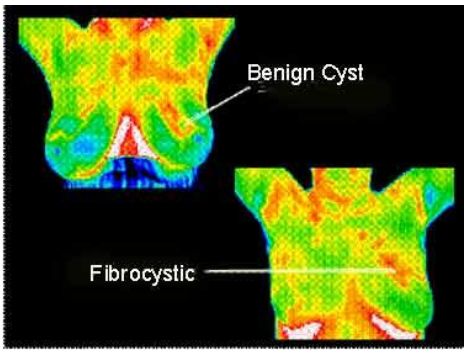
1.2 Problem Statements

Using thermogram image to detect breast cancer have some problems. First it cannot pinpoint the exact location of cancerous image. Plus thermogram picture acquisition based on emitted heat from the subject. It detects heat emitted from human skin, animal, and everything that produces heat (Figure 3). It would be confusing to distinguish whether the unhealthy breast is cancerous or have any other type illnesses as in Figure 4.



**Source: http://www.paintreatmentcenter.net*

Figure 3: Thermogram image of wounded horse



**Source: http://www.paintreatmentcenter.net*

Figure 4: Thermography images of human breast showing different types of tumor

The other problem is it is hard to differentiate types of tumor or cancer using thermogram image only. Thermogram picture is unique for a person, and often, the doctor will ask the person who took breast thermogram screening to take it more than once. As stated before, many health centre just using thermography image as reliable adjuct tool to mammography. [2]

And lastly, due to weakness of human vision, human eye can get tired after certain time and likely to misinterpret or overlook possible cancerous or tumor sign from the images. It is proven by a research that manual diagnosis can lead to different results; vary due to unique judgment methods.

1.3 Objectives of Study

The objective of this project is to develop an algorithm for computerized system for breast cancer monitoring and grading of medical thermograms. The input images will be segmented into meaningful region and consequently will be graded based on the level of heat emitted from the region.

Approaches:

1. To determine feature showing breast abnormality.
2. To grade severity level of tumor in region of interest.

1.4 Scope of Study

Image analysis is performed on thermogram images of healthy breast and thermogram images of cancerous breast using MATLAB to study the results generated by the two different cases. The output images then will be graded based on severity level based on temperature emitted and area of coverage.

CHAPTER 2
LITERATURE REVIEW

2.1 Breast Cancer Diagnose Methods

There are many methods to diagnose breast cancer. Following are several of them:

1. Mammogram - A mammogram is an X-ray of the breast. Mammograms are commonly used to screen for breast cancer. If an abnormality is detected on a screening mammogram, doctor may recommend a diagnostic mammogram to further evaluate that abnormality.

2. Breast ultrasound - Ultrasound uses sound waves to produce images of structures deep within the body. Usually a doctor may recommend an ultrasound to help determine whether a breast abnormality is likely to be a fluid-filled cyst rather than a breast tumor.

3. Breast magnetic resonance imaging (MRI) - An MRI machine uses a magnet and radio waves to create pictures of the interior of breast. An injection of dye is required before a breast MRI.

4. Biopsy - A biopsy to remove a sample of the suspicious breast cells helps determine whether cells are cancerous or not. The sample is sent to a laboratory for testing. A biopsy sample is also analyzed to determine the type of cells involved in the breast cancer, the aggressiveness (grade) of the cancer and whether the cancer cells have hormone receptors.

   Other tests and procedures may be used depending on health situations.

Once the doctor diagnosed breast cancer, the doctor will determine the extent of cancer. Knowing cancer's stage helps determine suitable prognosis and treatment options. Complete information about cancer's stage may not be available until after patient undergo breast cancer surgery. Not all patient need all of these tests and procedures, depending on doctor advice. [9]

Tests and procedures used to stage breast cancer may include:

1. Blood tests, such as a complete blood count
2. Mammogram of the other breast to look for signs of cancer
3. Chest X-ray
4. Breast MRI
5. Bone scan
6. Computerized tomography (CT) scan
7. Positron emission tomography (PET) scan

The popular international standardized grading system used is Marseille System of Classification, provides strict criteria for rating breast thermography scans. The scans are reported on a scale of TH-1 to TH-5:

TH-1: Normal tissue
TH-2: Normal tissue with some metabolic dysfunction
TH-3: Atypical tissue with areas not responding to cold challenge and maintaining higher heat areas
TH-4: Abnormal tissue activity with areas not responding to cold challenge and maintaining higher heat areas
TH-5: Severely abnormal tissue activity with areas not responding to cold challenge and maintaining higher heat areas.

All scans ratings except TH-1 require further appropriate preventive therapies. Additionally, scan ratings TH-3 to TH-5 require immediate referral for ultrasound and other screening methods along with professional examination. [10]

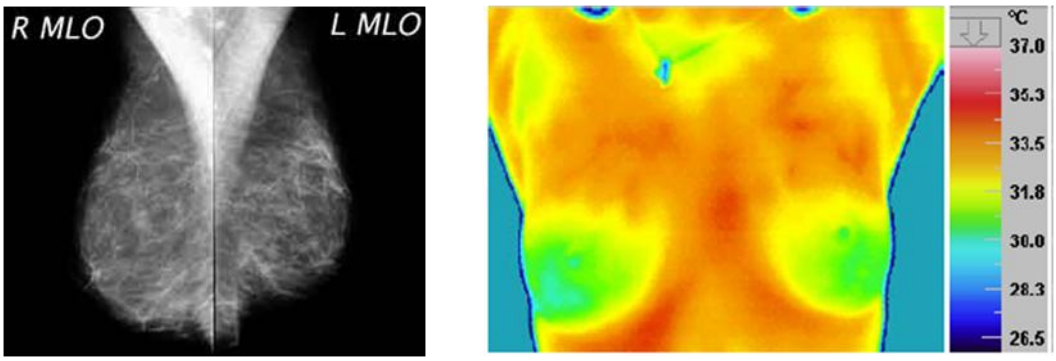
2.2 Digital Thermal Imaging as screening method

2.2.1 Behavior of cancerous cell

Before a cell can become cancerous, the tissues surrounding it start to create new blood vessels. A constant supply of nutrients is needed to sustain the rapid growth of these pre-cancerous cells. In order to maintain this supply, the cancerous cells release chemicals into the surrounding area, which keep existing blood vessels open, awaken dormant ones, and create new ones. This is also known as Angio-genesis which means New Blood Vessel Growth. The rich vascular beds in the breast provide the conditions necessary for the growing tumor's needs. These blood vessels work hard and fast to carry nutrients to the newly formed cancer cells. All that work feeding nutrients to these new cancer cells produces additional heat creating hot spots. These hot spots occur long before any tumor cells even begin to grow. [2]

2.2.2 Digital Thermal Imaging

The ideal early warning system would detect both the pre-cancerous changes occurring in the breast and the first cancer cell formations. Digital Thermal Imaging, or Breast Thermography has the ability to detect the temperature and see the hot spots associated with chemical and blood vessel changes in pre-cancerous as well as cancerous breast tissue. Consequently, Breast Thermography can be the first indicator that a cancer may be forming or present; and in many cases from 4-10 years before it can be detected by any other method, including mammography. [2]



**Source: http://www.ceessentials.net*

Figure 5:(a) Healthy breast mammography image (b) Healthy breast thermal image

2.2.3 Advantage of Using Thermal Imaging in Breast Screening

Many breast cancer cases were detected using Self Breast Examination (SBE). Usually it is detected after tumor has been growing for about 8 years. To make it worst, patient usually does not undergo any screening method until a palpable lesion is felt.

As a stand-alone screening test, mammography misses approximately 20% of all cancerous tumors. The majority of breast cancers revealed by mammography are already late. Most cancers take 8-10 years to grow to 1 cm in size, but it only takes 1.5 years more to grow to 3.5 cm. Mammography examination also can cause discomfort due to compression of the breasts.

Usually by the time a tumor has grown to a sufficient size to be detect by either a mammogram or a physical examination, it has been growing for several years, and achieved more than 25 doublings of the malignant cell colony.

In most women, there are areas of the breast that cannot be visualized with mammography. Studies show up increase in survival rate when breast thermography and mammography are used together.

Thermography is able to detect a pre-cancerous state of the breast, or signs of cancerous growth at an extremely early stage. This is possible because of its unique ability to see and monitor any changes in heat and temperature. These hot

spots are signs of functional changes or more blood flow that are produced during the earliest stages of tumor development.

Young women, women with small breasts, women with breast implants and women in general have a screening test available which provides a safe, pain-free, and highly accurate digital technology adjunct to mammography. [11]

2.2.4 Breast Thermal Imaging Disadvantage and Problem

Thermography does not have the ability to pinpoint the exact location of a tumor for further action which needs precise location such in medical operation. Another problem in the interpretation of the breast thermography is the complexities of the vascular pattern, and the existence of cold tumor. With strict standardized interpretation protocols having been established for over 15 years, infrared or thermography technique for the breast has obtained an average sensitivity and specificity of 90%. [13]

Many doctors agree of digital thermography role is as addition to mammography and physical examination. Proper use of breast self-exams, physician exams, thermography and mammography together provide the earliest detection system available to date. If treated in the earliest stages, cure rates greater than 95% are possible. [12]

Digital Thermal Imaging is not a substitute for mammography. Breast Thermography is a way of monitoring breast health over time. Every human has its own unique thermal pattern that should not really change over time. Thermography detects physiologic or actual functional changes while mammography detects anatomic or structural changes like tumors and cysts. Physiologic changes always come before anatomic changes, and thermography thus offers an opportunity for early detection, intervention and prevention. [2]

Thermography and mammography are complementary because they are looking at different aspects of breast health. Thermograms are looking for the physiologic changes in breast tissue; which may indicate a risk of developing cancer in the future. Mammograms search for tumors and growths that have already developed but may not yet be noticed during a self-breast examination.

2.3 Breast Thermography Image Analysis

One of breast thermal image analysis is done by Charles. A. Lipari, Jonathan F. Head. It is about asymmetry analysis of breast thermogram with morphological image segmentation. The goal is to observe asymmetry in the heat pattern due to temperature differences and or the areas of observed vesicular structure and other hot spots. Temperature and hot spot area differences are computed between the patient's left and right breasts and structurally matched breast quadrants. The approach is designed to generate objective measures for determining the patient's cancer risk.

The basic analysis is applied the frontal view of the patient, a view chosen to minimize the perspective and scale distortions. Three modes of analysis were used:

1. Comparative statistical measures on complete areas,
2. Comparative statistical measures on breast quadrants,
3. Hot-Spot area analysis.

The statistical measures were obtained by digitizing the separate breast image regions and then determining region quadrants. The quadrants were formed using unique points of reference: chin, lowest point of breast, rightmost point of breast and leftmost point of the breast as shown in figure below.

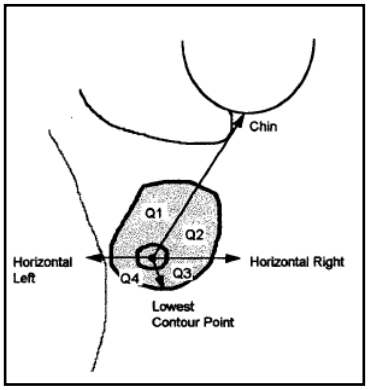
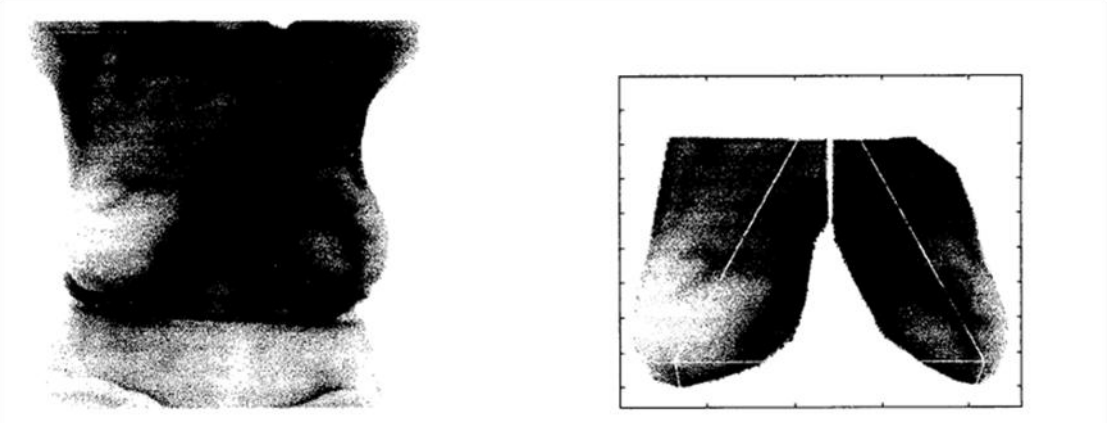


Figure 6: Determination of breast quadrants

Pixel statistics (mean, standard deviation, median, maximum, and minimum) were then computed on each complete breast region and region quadrant. Percent differences in temperature between each breast region and corresponding quadrant pair were calculated. The quad analysis was used to take into account the different mean temperatures at the bottom and the top of the breast, while giving a better model of breast structure. The hot-spot analysis utilized image enhancement to improve the visual contrast. The bottom part of each breast tends to be much hotter than the top, which would indicate that a



wider range of temperatures is needed than is currently being used. The breast regions were then thresholded to mark the areas of high relative heat. The areas over each breast of the regions of high heat were then calculated and compared such as figure below.

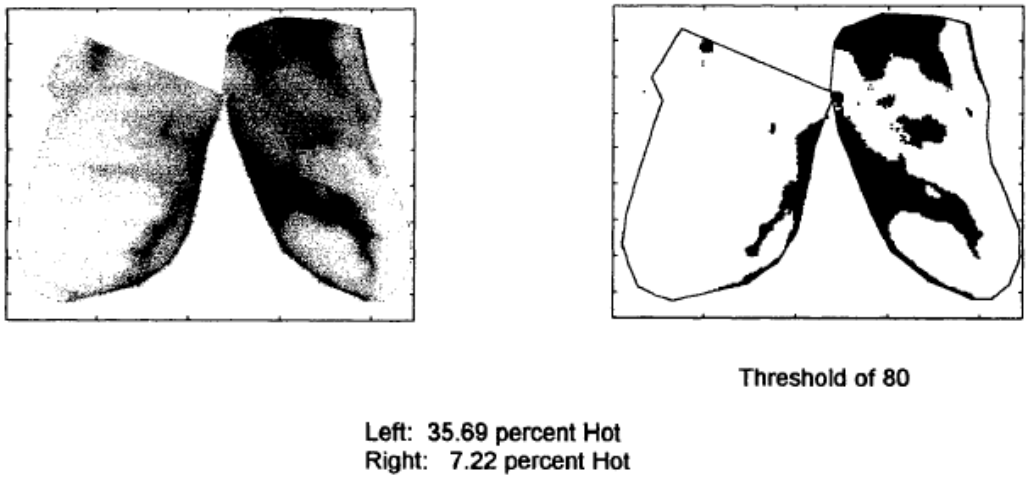


Figure 8:Hot Spot Analysis by Thresholding Contrast Enhanced Pixel Values a) Left/Right Segmentation b) Thresholded image

CHAPTER 3
METHODOLOGY

3.1 Tools

The software used to perform simulation is the MATLAB software. The source code for each algorithm were written and validated in MATLAB. MATLAB is a tool for doing numerical computations with matrices and vectors. It can also display information graphically. Developed by The MathWorks, MATLAB allows matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. MATLAB is widely known and was used by more than one million people across industry and the academic world [15].

3.2 Research Methodology 1

This study use breast thermogram images as input images and the output is image processed. These are the methods that will be use throughout the project.

1. Input Image
2. Image Resizing.
3. Image Smoothing.
4. Image Resizing.
5. Image Segmentation. .

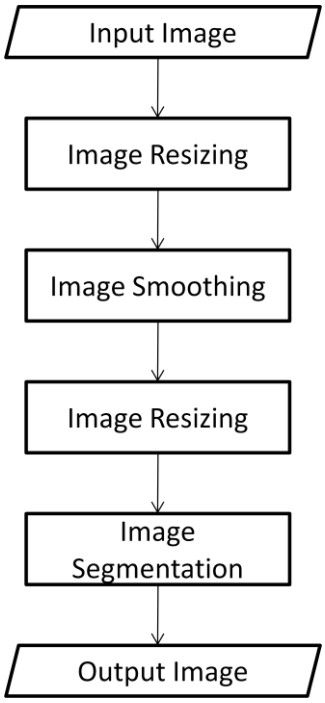


Figure 9: Flow chart of research methodology.

3.2.1 Image Resizing

The image is being resized 2 times using bicubic interpolation before reducing back to its original size. The function is to preserve 1 width feature before using image smoothing. This is important because during filtering, some data from the image might be erased. And we need to resize its back to its original form after median filter to avoid misinterpret data.

3.2.2 Image Smoothing

Smoothing is often used to reduce noise within an image or to produce a less pixelate image. Most smoothing methods are based on low pass filters. Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value. Depending of the

image output, type of filter is being determined. Median filtering is used through out the project.

3.2.3 Image segmentation

Image segmentation is the process of segmenting region of interest from the image. In computer vision, segmentation refers to the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze.

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

Region growing is one of segmentation methods which make regions grown from seed to adjacent points depending on a threshold or criteria we make. The threshold could be made by user. It could be intensity, gray level texture, or color.

Since the regions are grown on the basis of the threshold, the image information is important. The process keeps examining the adjacent pixels of seed points. If they have within the tolerance value with the seed points, it will classify them into the seed points. It is an iterated process until there are no changes in two successive iterative stages.

3.3 Research Methodology 2

The second methodology will use a 2D image of breast thermal image for analysis. The objective of this process is to analyze asymmetry on breasts. This method generally will aim for a method proposes by Charles Lipari et. al:

1. Comparative statistical measures on complete areas,
2. Comparative statistical measures on breast quadrants,
3. Hot-Spot area analysis.

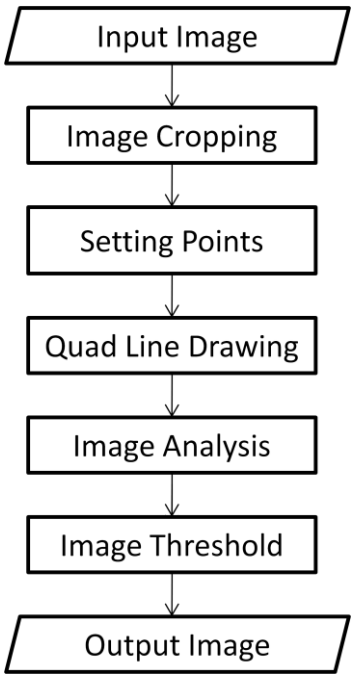


Figure 10: Flow chart of Research Methodology 2

3.3.1 Input Image

This time the input image is a 2D image from thermal camera as well. The reason why some thermogram images are in color is because the image is enhanced to help people distinguish between different temperatures of image taken. It is hard to be done on monochrome image [17]. The process of coloring the image is called pseudo coloring. A pseudo-color image is derived from a grayscale image by mapping each pixel value to a color according to a table or function set up [18].

3.3.2 Image Cropping

User will define the breast area as area of interest by drawing polygon around each breast. Then the image is masked. This process is similar to segmenting area of interest from background and from pectoral muscle.

3.3.3 Setting Points & Quad Line Drawing

Quad line drawing aims to give a better comparison of asymmetry between breast regions. The quadrants were formed using 3 reference points: chin (or centre uppermost pixel in the image), left nipple and right nipple. By using these 3 points, 4 quadrants of breast automatically are produced as in Figure 15. The lower region of the breasts is separated by a line from the nipple to lowest point of cropped image.

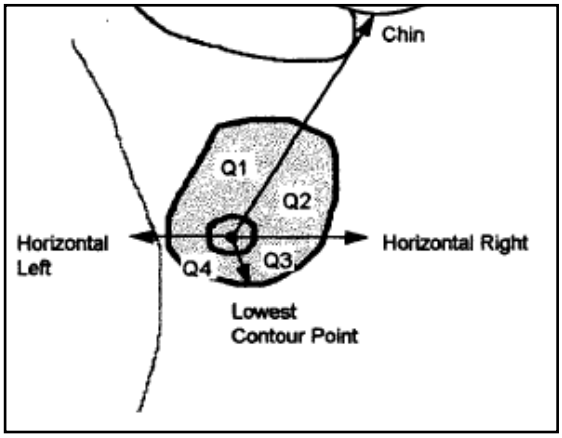


Figure 11: Breast quadrants and 3 reference points

3.3.4 Image Threshold

Later in the research methodology the image will be threshold using Otsu method to mark the areas of having high relative heat which is resulted from the heat of blood vessel regions that may be feeding the cancerous cell. The algorithm assumes that the image which will be threshold contains two classes of pixels then calculates the optimum threshold separating those two classes so that their gap between two classes is minimal [15].

This will aid user to see overall temperature distribution as it will divide region of interest into two regions: hot and cold region of the breast. Black indicate high temperature region while white indicate lower temperature region.

3.4 Research Methodology 3

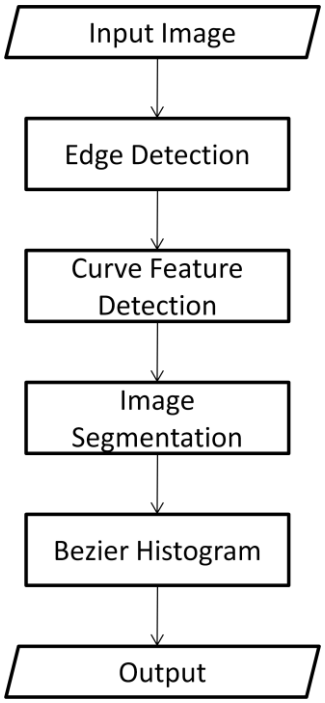


Figure 12: Flowchart of Research Methodology 3

The third methodology will use a 2D image of breast thermal image for analysis. The objective of this process is to develop automated segmentation and analyze asymmetry on breasts but using a different method developed by Hairong et al.

3.4.1 Input Image

2D thermogram images of patient diagnosed with having breast cancer and not having breast cancer is used in this method.

3.4.2 Edge Detection

Canny edge detector is being used in this method. Canny edge detector has a good detection criteria, it has low probability of not marking real edge points and falsely marking non-edge point.

3.4.3 Curve Feature Detection

Hough transform is used in this part to detect two parabolic curve of lower breast boundary. It will also detect two points of armpit, where the largest curvature occurs to mark where the breast region should end. Using image which have been subtract from background and with parabolic curve info, segmentation should be done successfully.

3.4.4 Bezier Histogram

Bezier histogram is a smoothed histogram. The aim of this method is to find asymmetry using histogram. Histogram is a graphical display of tabular frequencies. Histograms are used to plot density of data, and often for density estimation: estimating the probability density function of the underlying variable.

Note:

This method is also used for breast cancer detection but because lack of time, I have not been able to complete it.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Methodology 1

4.1.1 Image Resizing

Image interpolation works in two directions, and tries to achieve a best approximation of a pixel color and intensity based on the values at surrounding pixels. Nearest neighbor is the most basic and it considers only one pixel, the closest one to the interpolated point. This has the effect of pixelated image.

Bilinear interpolation considers the closest 2x2 neighborhood of known pixel values surrounding the unknown pixel. It then takes a weighted average of these 4 pixels to arrive at its final interpolated value. This results in much smoother looking images than nearest neighbor.

Bicubic interpolation considers the closest 4x4 neighborhood of known pixels resulting in 16 pixels surrounding the unknown pixel. This results in much smoother looking images than nearest neighbor. Bicubic produces noticeably sharper images than the previous two methods, and is perhaps the ideal combination of processing time and output quality. For this reason it is a standard in many image editing programs, printer drivers and in-camera interpolation [16]. Results are shown below.

Figure 13: Image resizing results using three different methods. Image is zoomed in to see the differences

4.1.2 Image Smoothing

Median filtering is a technique often used to remove noise from images or other signals. It is a common step in image processing. It is particularly useful to reduce speckle noise and salt and pepper noise. Its edge-preserving nature makes it useful in cases where edge blurring is undesirable [15]. Results of median filtering of original and zoomed image were shown in figure below.

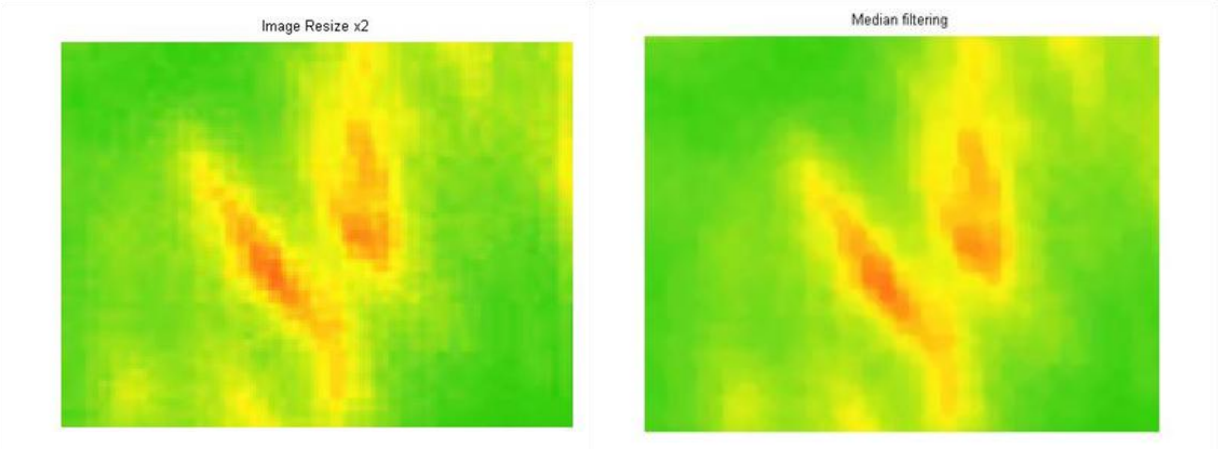


Figure 14: Results of Median Filtering (Large)

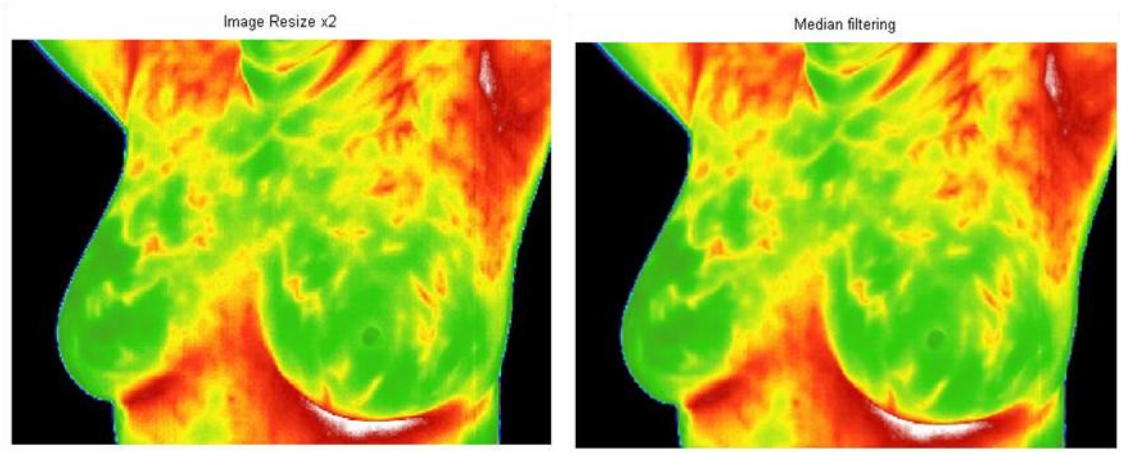


Figure 15: Image smoothing using Median filtering

4.1.3 Image segmentation

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic. [11]

Figure below shows the result of region growing with multiple seed defined by users. Blue dots in left image show seed points whereas in the right image show the result. Clearly we can see that all adjacent area which connected to seed points is joined together thus defined as hot-spot areas.

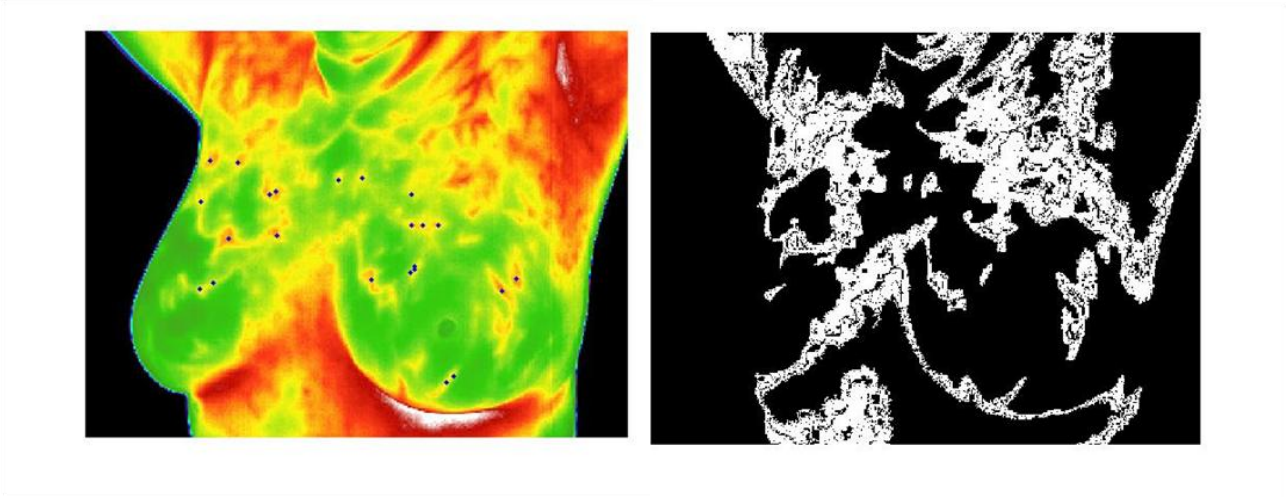


Figure 16: Image hot area segmentation, using region growing method with multiple seeds

4.2 Methodology 2

4.2.1 Image Cropping

Region of interest is being separated using image cropping to separate breast area from pectoral muscle.

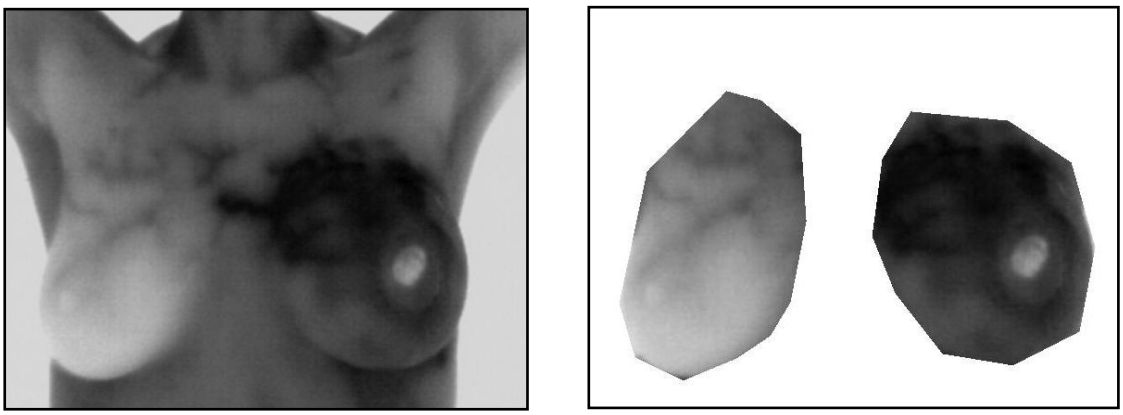


Figure 17: Input Image and cropped image

4.2.2 Setting Points & Quad Line Drawing

Quad line drawing aims to give a better comparison of asymmetry between breast regions. The quadrants were formed using 3 reference points: chin (or centre uppermost pixel in the image), left nipple and right nipple. By using these 3 points, 4 quadrants of breast automatically are produced as in Figure 15. The lower region of the breasts is separated by a line from the nipple to lowest point of cropped image.

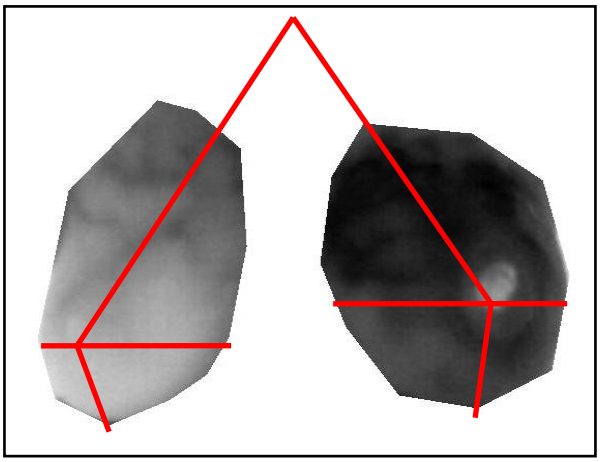


Figure 18: Breast quadrants segmentation

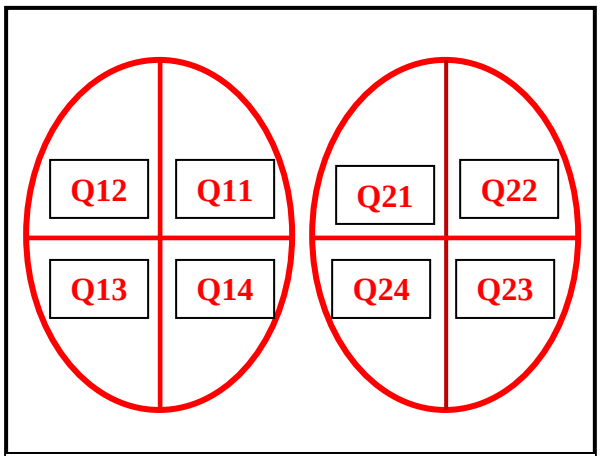


Figure 19: Quadrant Labeling

As being seen in the Figure 16, the 4 quadrants is being form using 3 points which user will set manually. Q11 quadrant will be compared to Q21, Q14 compared to Q24 and so on.

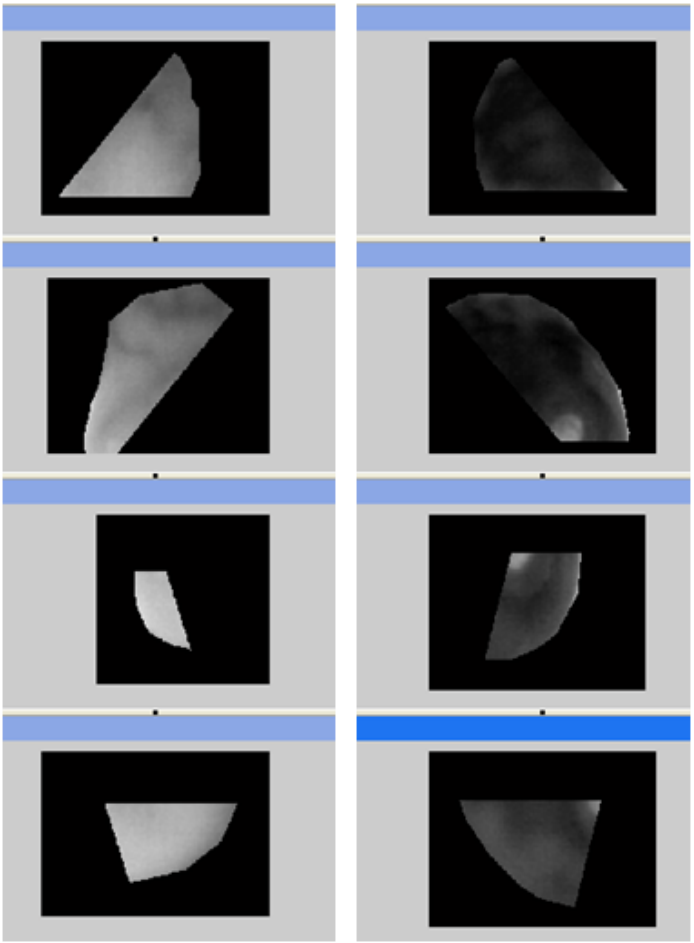


Figure 20: Image of Breast Quadrants; from left: Left Breast, Right Breast

4.2.3 Image Analysis

				Percent Difference
Q11		**Q21**		**1st Quadrant**
Mean value	0.5013	Mean value	0.1071	39.42%
Max value	0.7255	Max value	0.5255	20.00%
Min value	0.2706	Min value	0.0196	25.10%
Q12		**Q22**		**2nd Quadrant**
Mean value	0.4887	Mean value	0.1525	33.62%
Max value	0.8431	Max value	0.702	14.11%
Min value	0.2627	Min value	0	26.27%
Q13		**Q23**		**3rd Quadrant**
Mean value	0.7601	Mean value	0.2467	51.34%
Max value	0.8471	Max value	0.6314	21.57%
Min value	0.4196	Min value	0.1216	29.80%
Q14		**Q24**		**4th Quadrant**
Mean value	0.6476	Mean value	0.2436	40.40%
Max value	0.7843	Max value	0.5961	18.82%
Min value	0.3059	Min value	0.1255	18.04%
Left Breast*		**Right Breast***		**Overall**
Mean value	0.549	Mean value	0.1773	37.17%
Max value	0.8471	Max value	0.702	14.51%
Min value	0.2627	Min value	0	26.27%

* From user view

Figure 21: Image analysis of breast thermogram

Black = Hot = 0

White = Cool = 1

For the analysis, the lowest the value, the blacker the pixel, is indicating as having higher temperature than brighter pixel. Mean value goes for average temperature for the region. The analysis is done on each quadrants and whole breast as well.

From the analysis, each quadrant in right breast have large temperature gap compare to left breast quadrants, indicating asymmetry of heat pattern of breast in quadrants, which is sign of cancerous region. The image used is the image of

patient diagnoses as having inflammatory carcinoma type of cancer and thus approving the data analysis.

4.2.4 Image Threshold

Image is being threshold using Otsu's method; dividing region of interest into two parts: Higher temperature area and Lower temperature area. Black indicates higher temperature area while white area indicates lower temperature area. The right hand side breast overall is hotter than left hand side breast.

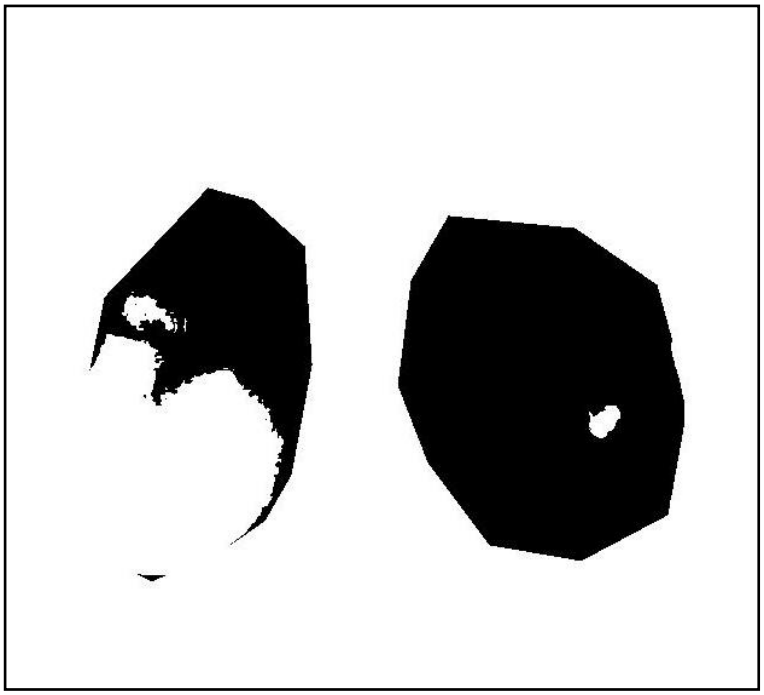


Figure 22: Threshold Image

4.3 Methodology 3

4.3.1 Edge Detection

Canny edge detector is being used in this method.

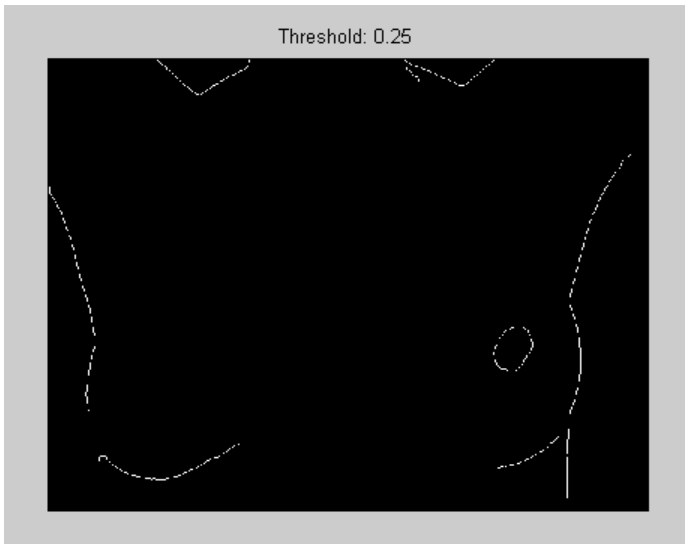


Figure 23: Canny Edge with threshold value of 0.25

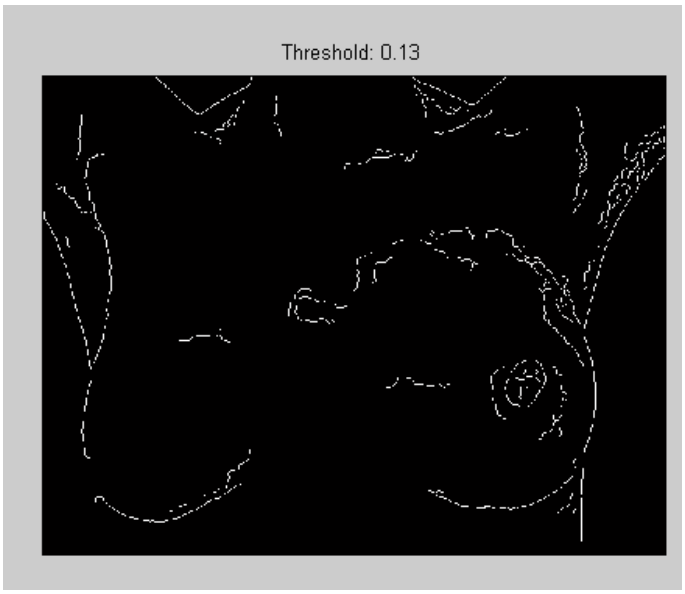


Figure 24:Canny Edge with threshold value of 0.13

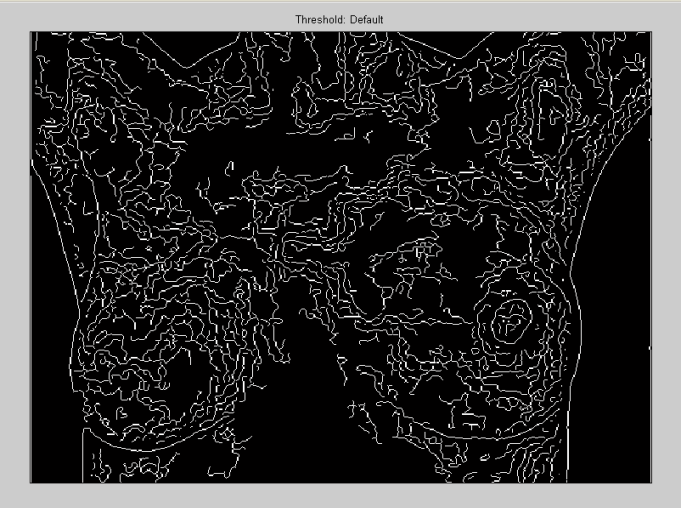


Figure 25: Canny Edge with threshold value of Otsu Method

To segmenting patient body with background, high threshold value is chosen. Then using the same method, but with lower threshold value, we will get a slight edge of lower breast boundary.

Note:

The methodology discussed before is also used for breast cancer detection but because lack of time, I have not been able to complete it.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the first methodology developed, this project proposes resizing of the image. Then median filtering is used to smooth out the image. Finally, I use region growing to segment the hot area out of region of interest. However this method does not provide satisfying results.

In second method, I used the method used as proposed by Charles A. Lipari et al. Input image is cropped manually using polygon tool to segment it from background image and from pectoral muscle. Then 3 points will be set by user to perform quad analysis of breast region for hot spot area analysis. Comparison of asymmetry is done and proving significant percentage differences for the breast quadrants and whole breast. Lastly, the image is being threshold using Otsu Method to mark areas of having high relative heat.

5.2 Recommendation

In term of acquiring the thermogram image has many problems in itself. There is problem of temperature distortion of medical thermography which results from different infrared radiant intensity of points detected by infrared detector was discussed. Further the difference of the radiant intensity is caused by that of projecting angles of points [19].

There is also a protocol that has been set up by professional that must be obeyed by those who want to perform the thermography analysis, including clinical layout, patient physical profile, patient pre-examination preparation, patient cooling (equilibration), and how to perform the examination [20].

Advance technique of breast thermography analysis could be performed using artificial neural network [21]. Furthermore, for acquiring image, lens distortion and composition must be taken into consideration if we want to perform asymmetry analysis.

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APPENDICES

APPENDIX A: GANTT SCHEDULE CHART

Gantt Chart of FYP 1 and FYP 2

Task	July	August	September	October	November	December	January	February	March	April	May	June
Literature Review, Planning	X	X	X	X								
Image smoothing				X	X							
Contrast Enhancement					X	X	X	X				
Segmentation							X	X	X	X		
Grading of severity									X	X	X	X

APPENDIX B: REGION GROWING MATLAB CODING

```
function     output = rg(im, tolerance, ylist, xlist)
%Region Growing - Allows selection of connected groups of pixels
whose colors
%            are within a predefined tolerance of some seed
pixels.
%Program can be used for both grayscale and rgb images
% SYNTAX
%    (1) output = rg(im, tolerance, ylist, xlist);
%    (2) output = rg(im, tolerance);
%
%    If xlist and ylist are omitted, the user is prompted to
choose them
%    interactively from the current figure.

%    The output is automatically displayed in a different figure.
%
% INPUT
%   im:        input image RGB
%   tolerance: distance to reference pixels
%   ylist:     vector of row cordinates    (seed pixels)
%   xlist:     vector of column cordinates (seed pixels)
%
% OUTPUT
%   output: binary mask of selected regions


getPoints = 0;

if nargin == 3,
    error('Not enough input data');
elseif nargin < 3,
    getPoints = 1;
end


% Get points interactively
imshow(im)
if getPoints==1
    but   = 0;
    ii    = 0;
    xlist = [];
    ylist = [];
    hplot = [];
    hold on
    disp ' '
    disp('Select points with LEFT mouse.')
    disp('Hit RIGHT mouse to terminate. (this point is not
included)')
    disp ' '
    while but ~= 3,
        ii = ii + 1;
        [x, y, but] = ginput(1);
```

```
        xlist(ii)   = round(x);
        ylist(ii)   = round(y);
        hplot(ii)   = plot(x,y,'.');
    end
    xlist(end) = [];
    ylist(end) = [];
    %delete(hplot);
    hold off
end

% Check points validity
if isempty(xlist) || isempty(ylist),
    error('Point list is empty');
end

H = size(im, 1); % image height
W = size(im, 2); % image width


k = ylist > 0 & ylist <= H;
k = k & xlist > 0 & xlist <= W;

if ~any(k),
    error('Coordinates out of range');
elseif ~all(k),
    disp('Warning: some coordinates out of range');
end

ylist = ylist(k);
xlist = xlist(k);

N = length(ylist); % Number of reference pixels


%Create the binary mask
color_mask = false(H, W);

if isgray(im)==1,
    g = double(im);
    for i = 1:N,
        ref = double(im(ylist(i),xlist(i)));
        color_mask = color_mask | (g - ref).^2 <= tolerance^2;
    end
elseif isrgb(im) == 1,
    c_r = double(im(:, :, 1)); % Red channel
    c_g = double(im(:, :, 2)); % Green channel
    c_b = double(im(:, :, 3)); % Blue channel
    for i = 1:N,
        ref_r = double(im(ylist(i), xlist(i), 1));
        ref_g = double(im(ylist(i), xlist(i), 2));
        ref_b = double(im(ylist(i), xlist(i), 3));
        color_mask = color_mask | ...
            ((c_r - ref_r).^2 + (c_g - ref_g).^2 + (c_b -
ref_b).^2)...
             <= tolerance^2;
    end
```

```
end

% Connected component labelling
[objects, count] = bwlabel(color_mask, 8);


[y x v] = find(objects);
segList = [];

for i = 1:N,
    k = find(x == xlist(i) & y == ylist(i));
    segList = [segList; v(k)];
end

segList = unique(segList);


LUT = zeros(1,count+1);
LUT(segList+1) = 1;
output = LUT(objects+1);



% Output
TAG = 'Binary image result of region growing';
obj  = findobj('tag',TAG);

if isempty(obj),
    h = figure;
    set(h,'tag',TAG);
    Name = ['Fig ', num2str(h), ': ', TAG];
    set(h,'NumberTitle','off','Name',Name);
else,
    figure(obj);
end

clf
imshow(output);
```

APPENDIX C: MEDIAN FILTER MATLAB CODING

```
Image=imread('Breast.jpg');

%Resizing Image;
Image_big=imresize(Image,2,'bicubic');
figure,imshow(Image_big);
title('Image Resize x2');
Gray1=rgb2gray(Image_big);

%Separating channel, make 2d image
Red=Image_big(:,:,1);
Green=Image_big(:,:,2);
Blue=Image_big(:,:,3);

%Median filtering
Red=medfilt2(Red);
Green=medfilt2(Green);
Blue=medfilt2(Blue);

%Combining image
Image_big2=cat(3,Red,Green,Blue);
figure,imshow(Image_big2);
title('Median filtering big');

%Resize image
Image_small=imresize(Image_big2,0.5,'bicubic');
figure,imshow(Image_small);
title('Median filtering small');
imwrite(Medianfiltering,'Breast2.jpg');
```

APPENDIX D: METHODOLOGY 2 MATLAB CODING

```
function output=lipari;
%function output=lipari(Image);

Image=imread('Thermogram.tiff');
%RGB=imread(Image);
%Crop_RGB=imcrop(RGB);
%Grey=rgb2gray(RGB);

%Create Cropping Mask
Grey_Dbl=im2double(Image);
%Grey_Dbl=im2double(RGB);
disp('Enter Mask 1')
mask1=roipoly(Grey_Dbl);
Grey_Dbl_2=Grey_Dbl;
disp('Enter Mask 2')
mask2=roipoly(Grey_Dbl);
mask=mask1|mask2;
Grey_Dbl(mask~=1)=1;
bw=im2bw(Grey_Dbl);
figure,imshow(bw);title('Final Image');
figure,imshow(Grey_Dbl);title('Masked Image');
figure,imshow(Image);title('Gray Image');



%Region segmenting
% a)Get points interactively
H = size(Image, 1);
W = size(Image, 2);
%Chin
disp('Mark Chin Point')
[x,y] = ginput(1);
xa=round(x);
ya=round(y);
%Left Nipple
disp('Mark Left Nipple Point')
[x,y] = ginput(1);
xb=round(x);
yb=round(y);
%Right Nipple
disp('Mark Right Nipple Point')
[x,y] = ginput(1);
xc=round(x);
yc=round(y);
```

```
%b)Segmentation Lipari
%XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
%XXXXX  |   XXXXXXXXXXXXXXX   |  XXXXXXXXXXXXX
%XXXX   |    XXXXXXXXXXXX     |    XXXXXXXXXXX
%XX     |      XXXXXXXXX      |     XXXXXXXXXX
%X Q12  |   Q11 XXXXXXXX Q21  |  Q22 XXXXXXXXX
%X______|_______XXXXXXXX______|_______XXXXXXXX
%X      |       XXXXXXXX      |       XXXXXXXX
%XX Q13 |   Q14 XXXXXXXXX  Q24|   Q23 XXXXXXXX
%XXX    |       XXXXXXXXXX    |      XXXXXXXXX
%XXXXX  |     XXXXXXXXXXXXX   |     XXXXXXXXXX
%XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
%XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

%Q11
c11=[xa xb W];
r11=[ya yb yb];
BW11=roipoly(Image,c11,r11);
Q11=BW11&mask1;
%Q12
c12=[0 xa xb 0];
r12=[0 ya yb yb];
BW12=roipoly(Image,c12,r12);
Q12=BW12&mask1;
%Q21
c21=[xa xc 0];
r21=[ya yc yc];
BW21=roipoly(Image,c21,r21);
Q21=BW21&mask2;
%Q22
c22=[W xa xc W];
r22=[ya ya yc yc];
BW22=roipoly(Image,c22,r22);
Q22=BW22&mask2;

%Breast 1 lower region
B1lr=mask1&(~(Q11|Q12));
RB=bwlabel(B1lr);%Right breast=RB
RBpxl=regionprops(RB,'PixelList');
allRBPixel=[RBpxl.PixelList];
[MaxY2,X2]=max(allRBPixel(:,2));
LowestPoint1=allRBPixel(X2,:);
Xll=LowestPoint1(:,1);
Yll=LowestPoint1(:,2);

%Breast 2 lower region
B2lr=mask2&(~(Q21|Q22));
LB=bwlabel(B2lr);
LBpxl=regionprops(LB,'PixelList');
allLBPixel=[LBpxl.PixelList];
[MaxY2,X2]=max(allLBPixel(:,2));
LowestPoint2=allLBPixel(X2,:);
Xlr=LowestPoint2(:,1);
```

```
Ylr=LowestPoint2(:,2);

%Q14
c14=[xb Xll W W];
r14=[yb Yll Yll yb];
BW14=roipoly(Image,c14,r14);
Q14=BW14&mask1;
%Q13
Q13=(~Q14)&B1lr;
%Q24
c24=[xc Xlr 0 0];
r24=[yc Ylr Ylr yc];
BW24=roipoly(Image,c24,r24);
Q24=BW24&mask2;
%Q23
Q23=(~Q24)&B2lr;

%Right & Left Breast
LB=Q11|Q12|Q13|Q14;
RB=Q21|Q22|Q23|Q24;

%Grey Image Duplicate
Grey_Q11=Grey_Dbl_2;
Grey_Q12=Grey_Dbl_2;
Grey_Q13=Grey_Dbl_2;
Grey_Q14=Grey_Dbl_2;
Grey_Q21=Grey_Dbl_2;
Grey_Q22=Grey_Dbl_2;
Grey_Q23=Grey_Dbl_2;
Grey_Q24=Grey_Dbl_2;
Grey_LB=Grey_Dbl_2;
Grey_RB=Grey_Dbl_2;

%Masking : Logical ----> Double
Q11=double(Q11);
Q12=double(Q12);
Q13=double(Q13);
Q14=double(Q14);
Q21=double(Q21);
Q22=double(Q22);
Q23=double(Q23);
Q24=double(Q24);
LB=double(LB);
RB=double(RB);

%Discard Background Value
Q11(Q11==0) = NaN;
Q12(Q12==0) = NaN;
Q13(Q13==0) = NaN;
Q14(Q14==0) = NaN;
Q21(Q21==0) = NaN;
Q22(Q22==0) = NaN;
Q23(Q23==0) = NaN;
Q24(Q24==0) = NaN;
LB(LB==0) = NaN;
RB(RB==0) = NaN;
```

```
%Grey Image Masking
filter_Q11 = Grey_Q11.*Q11;
filter_Q12 = Grey_Q12.*Q12;
filter_Q13 = Grey_Q13.*Q13;
filter_Q14 = Grey_Q14.*Q14;

filter_Q21 = Grey_Q21.*Q21;
filter_Q22 = Grey_Q22.*Q22;
filter_Q23 = Grey_Q23.*Q23;
filter_Q24 = Grey_Q24.*Q24;

filter_LB = Grey_LB.*LB;
filter_RB = Grey_RB.*RB;

%Analysis: Heat Value
%Q11
mean_value_Q11 = mean(filter_Q11(~isnan(filter_Q11)))
max_value_Q11 = max(filter_Q11(~isnan(filter_Q11)))
min_value_Q11 = min(filter_Q11(~isnan(filter_Q11)))
%Q12
mean_value_Q12 = mean(filter_Q12(~isnan(filter_Q12)))
max_value_Q12 = max(filter_Q12(~isnan(filter_Q12)))
min_value_Q12 = min(filter_Q12(~isnan(filter_Q12)))
%Q13
mean_value_Q13 = mean(filter_Q13(~isnan(filter_Q13)))
max_value_Q13 = max(filter_Q13(~isnan(filter_Q13)))
min_value_Q13 = min(filter_Q13(~isnan(filter_Q13)))
%Q14
mean_value_Q14 = mean(filter_Q14(~isnan(filter_Q14)))
max_value_Q14 = max(filter_Q14(~isnan(filter_Q14)))
min_value_Q14 = min(filter_Q14(~isnan(filter_Q14)))

%Q21
mean_value_Q21 = mean(filter_Q21(~isnan(filter_Q21)))
max_value_Q21 = max(filter_Q21(~isnan(filter_Q21)))
min_value_Q21 = min(filter_Q21(~isnan(filter_Q21)))
%Q12
mean_value_Q22 = mean(filter_Q22(~isnan(filter_Q22)))
max_value_Q22 = max(filter_Q22(~isnan(filter_Q22)))
min_value_Q22 = min(filter_Q22(~isnan(filter_Q22)))
%Q13
mean_value_Q23 = mean(filter_Q23(~isnan(filter_Q23)))
max_value_Q23 = max(filter_Q23(~isnan(filter_Q23)))
min_value_Q23 = min(filter_Q23(~isnan(filter_Q23)))
%Q14
mean_value_Q24 = mean(filter_Q24(~isnan(filter_Q24)))
max_value_Q24 = max(filter_Q24(~isnan(filter_Q24)))
min_value_Q24 = min(filter_Q24(~isnan(filter_Q24)))

%LB
mean_value_LB = mean(filter_LB(~isnan(filter_LB)))
max_value_LB = max(filter_LB(~isnan(filter_LB)))
min_value_LB = min(filter_LB(~isnan(filter_LB)))
std_deviation_LB=std(filter_LB(~isnan(filter_LB)))
%RB
```

```
mean_value_RB = mean(filter_RB(~isnan(filter_RB)))
max_value_RB = max(filter_RB(~isnan(filter_RB)))
min_value_RB = min(filter_RB(~isnan(filter_RB)))
std_deviation_RB=std(filter_RB(~isnan(filter_RB)))
```