

**Automated ovarian masses extraction in CT images  
based on division of image**

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**Abstract**

Medical image processing is the most challenging field now a days. Processing of CT ovarian images is one of the part of this field. The goal of this work is to present a method for detection of ovarian mass from Computed Tomography Image and determine location as well as calculation area of it. Preprocessing of the CT image includes image resizing, conversion to gray and enhancement makes it ready for applying the processing phase which applied operations on processed image by histogram and marker controlled watershed segmentation to segment it to a set of segment that collectively cover the entire image ,then apply morphological operations to visualize only parts of masses in CT images. Because of the nature of ovarian CT images which contain left and right lobes, a proposed algorithm to division the images after extraction the masses into two images and then apply algorithm to calculate the area of mass in each parts of image. when execute the proposed method, the results obtained are good compared with calculation area of the mass of the ovarian extracted by the region of interest algorithm (ROI) using cursor. A detailed procedure using Matlab (R2010a) software is written to extract mass region in CT Scan ovarian Image.

**Keywords**

Ovarian mass, CT (Computed Tomography), Denoising, Segmentation, Morphological Operations, Canny technique.

**I. Introduction**

Ovarian cancer continues to pose a major challenge to physicians and radiologists. It is the third most common gynecologic malignancy and estimated to be fifth leading cancer cause of death in women, constituting 23% of all gynecological malignancies[1]. Ovarian cancer is cancer that begins in the ovaries. Ovaries are reproductive glands found only in women. The ovaries produce eggs (ova) for reproduction. The eggs travel through the fallopian tubes into the uterus where the fertilized egg implants and develops into a fetus. The ovaries are also the main source of the female hormones estrogen and progesterone. One ovary is on each side of the uterus in the pelvis. Many types of masses can start growing in the ovaries. Most of these are benign (noncancerous) and never spread beyond the ovary. Benign masses can be treated successfully by removing either the ovary or the part of the ovary that contains the mass. Ovarian masses that are not benign are malignant (cancerous) and can spread (metastasize) to

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other parts of the body [2]. Imaging plays an important role in the diagnosis of ovarian cancer. Various imaging modalities including ultrasound (US), Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and positron emission tomography (PET) have been used for evaluation. The widespread use of CT in the evaluation of abdominal and pelvic pathology has resulted in the detection of an increasing number of incidental ovarian lesions. CT has not traditionally been used for characterization of adnexal masses mainly because of its poor tissue contrast [3].

Computed Tomography (CT) is a medical imaging method employing tomography. Digital geometry processing is used to generate a three dimensional image of the inside of an object from a large series of two dimensional X-ray images taken around a single axis of rotation. CT is probably the most common source of 3 dimensional data. CT uses an X-ray radiation source to image the patient. CT is a sensitive method for diagnosis of abdominal diseases. It is used frequently to determine stage of cancer and to follow progress. CT test may be used to: Study blood vessels, identify masses, including cancer and Look for infections, kidney stones, or appendicitis [4].

The purpose of this work is to develop a computer-aided system to facilitate the identification of ovarian cancer from CT images. This paper is structured as follows: section-I gives a brief introduction of ovarian mass and in Section II we present review of the selected researches in medical images. Section-III we describes numbers of basic principles in image processing are used to extract ovarian mass. Section-IV description the images which used in this work, while explains the proposed methodology in the section V. The experimental results discussed under section VI. The conclusion and the scope for future improvement is given under section VII.

## **II. Related works**

This section, presents review of the selected researches in medical images.

Saurabh Srivastava et al. in 2005 [5] modeled the cellular-level structure present in these images as texture and extracted features based on first-order statistics, spatial gray-level dependence matrices, and spatial-frequency content. Selection of the best features for classification was performed using traditional feature selection techniques including stepwise discriminant analysis, forward sequential search, a non-parametric method, principal component analysis, and a heuristic technique that combines the results of these methods. The best set of features selected was used for classification. Shi et al. in 2009 [6] employed neural networks for medical image processing, including the key features of medical image preprocessing, segmentation, and object detection and recognition. The study employed Hopfield and feed-forward neural networks. The feed-forward and Hopfield neural networks are simple to use and easy to implement. Yang et al. in 2010 [7] proposed an algorithm for medical image denoising by soft thresholding using wavelet transform followed by enhancement using nonlinear histogram equalization. Besides enhancing the ROI, histogram equalization also enhances the noise contents of the image which is undesirable. Yu Masuda et al. in 2011 [8] proposed a new method to detect tumors automatically in CT image. By using contrast enhancement with PDFs of different tissue classes in a newly devised histogram transformation method, and enhanced the image contrast by using the EM/MPM algorithm. Sonali Patil and Udipi in 2012 [9] described the pre-processing method consisting of two phases. In the first phase we remove the film artifact by using median filter. In the second phase we introduce an algorithm that uses morphological operations to remove unwanted skull/ribcage portion. This reduces the false positive results in the later stages of

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processing in the computer-aided diagnostic systems. The second algorithm has an effect of skull portion removal in brain images and, effect of ribcage portion removal in CT images of Thorax and Abdomen. Rajendra Acharya et al. in 2013 [10] extracted several texture features based on first order statistics, Gray Level Co-occurrence Matrix and run length matrix.

The significant features selected using *t*-test are then used to train and test several supervised learning based classifiers. They evaluated the developed framework using 1300 benign and 1300 malignant images, and used 11 significant features in KNN/PNN classifiers.

### III. Basic Principles

- 1- **Image Denoising**:-It is a procedure in digital image processing aiming at the removal of noise, which may corrupt an image during its acquisition or transmission, while retaining its quality. The important property of a good image denoising model is that it should completely remove noise as far as possible as well as preserve edges [11].
  
- 2- **Image Segmentation**:- The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. It is based on the division of the image into regions. Division is done on the basis of similar attributes. Similarities are separated out into groups. Where, the basic purpose of segmentation is the extraction of important features from the image. There are many segmentation techniques, we explain two of them which used in this search:
  - a. **Threshold**: The simplest method of image segmentation is called the thresholding method. This is a non-linear operation that converts a gray-scale image into a binary image where the two levels are assigned to pixels that are below or above the specified threshold value. It is the simplest technique and it can be based on local or global image information like the histogram of grey levels. In both cases we can consider only one threshold for the whole image (global thresholding) or on the contrary we can establish different thresholds for each sub-region of the original image. it is one of the widely methods used for image segmentation and it is useful in discriminating foreground from the background. By selecting an adequate threshold value  $T$ , the gray level image can be converted to binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest (foreground). The advantage of obtaining first a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification[12].

b. **Watershed:** Watershed transformation is one of the most powerful tools for image segmentation. It is one of the best methods to group pixels of an image on the basis of their intensities. Pixels falling under similar intensities are grouped together[13]. Starting from a gradient, the classical paradigm of watershed segmentation consists in determining markers for each region of interest. The markers avoid the over-segmentation (a region is associated to each minimum of the function) and moreover, the watershed is relatively robust to marker position. The markers-based watershed is appropriate for interactive segmentation. Several watershed-based hierarchical approaches allow addressing fields where the markers cannot be easily defined (e.g., multimedia applications). Mainly, two hierarchical techniques can be distinguished: 1) non-parametric waterfalls algorithm and 2) hierarchies based on extinction values, which allows to select the minima used in the watershed according to morphological criteria (dynamics, surface area and volume)[14].

3- **Morphological operations:**-They are collection of non-linear operations related to the shape or morphology of features in an image, which are affecting the structure or shape of an object[15]. There are two basic morphological operators: erosion and dilation, opening and closing are two derived operations in terms of erosion and dilation [16]. Dilation allows objects to expand, thus potentially filling in small holes and connecting disjoint objects. Erosion shrinks objects by etching away (eroding) their boundaries. These operations can be customized for an application by the proper selection of the structuring element, which determines exactly how the objects will be dilated or eroded[15].

4- **Canny edge detection** :-It involves the smoothing of image. That is removal of noise from the image, then gradient of the image is computed by feeding the smoothed image through convolution operation with the derivative of the Gaussian in both the vertical and horizontal directions. After this, non maximum suppression is applied. The purpose of this step is to convert the blurred edges in the image of gradient magnitude to sharp edges. This is basically done by preserving all local maxima in the gradient image and deleting everything else [17].

#### **IV. Dataset description**

Database in this work contain numbers of Images for women patients are obtained from radiologists using CT scan and scanned images are displayed in three dimensions matrices having pixels as its element. Images are scanned with different sections of ovarian, then these images are stored as database as JPEG image format in Matlab. Images have information about 100 women patients ( 60 malignant, 40 benign) with different ages ranged between 20 to 45 years old were examined.

**V. Methodology**

This section describes proposed method which contain numbers of steps to extract mass from CT ovarian images as the following steps, and the system design of proposed method is shown in figure (1) :-

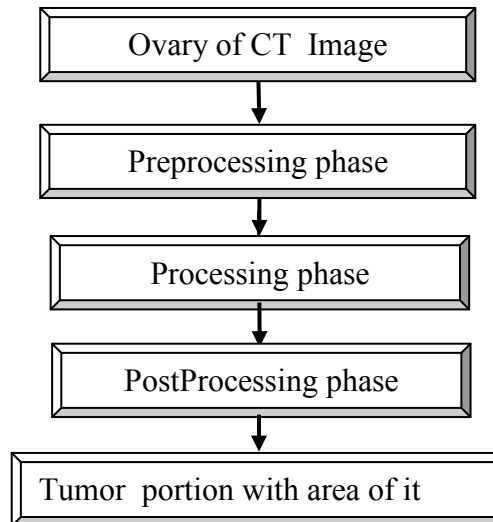


Figure (1) Flow chart of our proposed work

1. **Preprocessing phase**:-It is the initial steps that used for noise reduction and images enhancement. This phase involves two steps which explain as follows:-

a) **Resizing**: This step is important because the images received from the CT scans are different sizes. So must unite all images in one size, where the size difference does effect on the results that we obtain, so that we can easily be used in the MATLAB environment. The syntax used for this purpose is:

A = imresize (I, [ rows, cols], 'nearest');.....1

Where A represent the image after resize operation, I represent the image before resize.

b) **Image Format Conversion**:-The images received from the CT scans must be converted to the Gray scale image because though the images are in gray matter the Red Green Blue components are not visible in the image. Thus removing of this RGB component will help to perform the operations easily. This RGB images are converted to grayscale images by eliminating the hue and saturation information while retaining the luminance. Thus making the property of the image 512 x 512 x 3 to 512 x 512. Because the images were in 3D format, the commands of MATLAB could not be used on them. Therefore, to work on the images, we have been converted to JPEG format, so that we can easily be used in the MATLAB environment. The syntax used for this purpose is:

A=rgb2gray(B);.....2

Where A represent the gray image and B represent the RGB image

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c) **Enhancement Image**:-It is the most obvious part of medical image processing. In this step, the image in gray scale format is enhanced and noise is removed from it. Enhancement will result in more prominent edges and a sharpened image is obtained, noise can be reduce thus reducing the blurring effect from the image. Most commonly used noise reduction and enhancement techniques are implemented that can give best possible results, two of filters are used here for this purpose:

- **Denoising**:- Images may contain different types of noises; removing noise from image is often the most step in image processing. So, in this work, *imfilter* function in MATLAB is used to computes the value of each output pixel using double-precision, floating-point arithmetic.
- **Median Filter**:-It is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. A median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges. In this work, *medfilt2* function in MATLAB is used which is calculated by sorting all pixel values of input image by their size, then selecting the median value as the new value for the pixel.

2. **Processing phase**:-It is the second step in proposed method which involves numbers of operations applied on the resultant image from previous phase. It's used to segment it by two segmentation methods and then apply morphological operations to extract the mass from the image as explain in the following steps:

a) **Segmentation**:-Image segmentation is the first step and also one of the most critical tasks of image analysis by partition the image into multiple segments. It is used to distinguish objects from their background. Here, two segmentation methods are used on the result image from preprocessing phase as the following:-

- **Histogram Threshold Segmentation**:- This includes segmentation of an image based on thresholding of histogram features and gray level . the basic concept of this method to seprate objects from background based on multiple threshold. This threshold selected based on histogram of this image to convert the gray image to binary image format.
- **Marker-controlled watershed Segmentation**:- Segmentation using the watershed transform works better if you can mark foreground objects and background locations. The resultant image from thresholding is segmented by using Marker-controlled watershed segmentation based on select marker region to compute foreground and background markers to segment the objects and then compute the watershed transform.

The result of segmentation methods that used it in this work , is a set of segment that collectively cover the entire image. Each of pixels in a region are similar with respect to some characteristic such as intensity, color .

**b) Morphological Operations:-**After ending of segmentation processed, some of morphological operations are applied on the converted binary image. The morphological operations are basically applied on some assumptions about the size and shape of the mass and in the end the mass cells are mapped onto the original gray scale image with 255 intensity to make visible the mass in the image. Many morphological operations have been applied using structural element of 'diskshape', these operations are:

- 1-Erosion: applied on the binary image.
- 2-Dilation: applied on the resultant image from the previous step.  
The dilated image then convolutes with the input reduced intensity image.

**d) Edge Detection:-** In this step, the canny operator is implemented on the resultant image from the previous steps, followed by filling process to represent the final image of the mass. so that we can easily be used in the MATLAB environment.

The syntax used for this purpose is: `A = edge (I,'canny',0.1);.....3`

Where A represent the image after canny operation, I represent the image before canny. The steps of preprocessing and processing phase are explain in algorithm **3.1**.

**3. Post-processing Phase:-**It is most important phase in this work, because of that varies consist of left and right lobes, and each site lobes may contain mass on it, therefore identify the mass found in any part in the ovaries and calculate the area of every important when doctors need to determine whether surgery can be done for the patient or not. So we offered an algorithm to divide the image into two parts (right, and left) and then we have an algorithm to calculate the area of a mass. This phase involves two steps which explain as follow:-

**a. Division:-** In this step, we divide the image result from previous phase with only masses into two parts (right, and left) based on its pixels which show it in algorithm **3.2**. The purpose of this steps is to determine location of mass then calculate area of it which explain in the next step.

**b. Calculate Area of the mass:-**Calculate the area of mass is most task after extraction of masses in abnormal images to determine the degree of disease, So we presented algorithm to calculate area of mass in automatically method as explain in algorithm **3.3**, while manually method by cursor using region of interest algorithm (ROI) is explain in algorithm **3.4** .

### 3.1 Algorithm Detecting Ovarian Mass

**Input:** Ovary CT image.

**Output:** Mass portion.

Step1:- Read the input CT ovary image.

Step2:- Converts input image into grayscale image.

Step3:- Resize image (step2) into  $200 \times 200$  image matrix.

Step4:- Pass grayscale image (step3) to two filters, *imfilter* and *medfilt2* for enhancement.

Step5:- Converts an enhancement image (step4) to a binary image by segment it using two segmentation methods(a histogram threshold and controller based watershed).

Step6:-Compute the morphological operations on image (step5) by using three commands in matlab (strel, imerod, imdilate) with `diskspace=1`.

Step7:-Convert binary scale image (step6) to gray scale by using the following steps:

Store the size of the image (step6) into size1 and size2

Each pixels in image(size1,size2) test the following step:-

If step6 image (i,j) == 1 then step2 image (i,j) = 255

Else step2 image (i,j) = step6 image (i,j) \* 0.9

Step8:- Compute edge detection of image (step7) by using canny edge detection technique.

Step9: Convert binary image (step8) into an RGB color image for the purpose of visualizing labeled regions by using command (label2rgb) inmatlab .

### 3.2 Algorithm division image of ovarian mass

**Input:** Masses portion of the image.

**Output:** Image right ovary (IRO), Image left ovary (ILO).

Step1:- :- Read the input image (output image from previous algorithm (3.1)).

Step2:- Converts image of step1 into grayscale image (A).

Step3:- Divide image (A) into two equal images by using the following steps:

Store the size of the image(A) into size1 and size2..

Each pixels in image A, test the following step:-

If ((i>=0 and i<=200) AND (j>=0 and j<=100)) then IRO(i,j) = A(i,j);

Else If ((i>=0 and i<=200) AND (j>=100 and j<=200)) then ILO(i,j-100)=A(i,j)

Step4:-Display the image right ovary (IRO) and image left ovary (ILO).

### 3.3 Algorithm for area calculation of mass

**Input:** Mass portion.

**Output:** Area of the mass.

Step1:-Read the input images IRO,ILO (output images from previous algorithm (3.2))

Step2:- Calculate area of image(IRO) of step1 by using the following steps:

Store the size of the image(IRO) into size1 and size2.

Initialize a variable AT1 =0

Each pixels in image IRO(size1, size2), test the following step:-

If IRO (i,j)==255 then AT1=AT1+0

Else AT1=AT1+1



Step3:- Calculate area of image(ILO) of step1 by using the following steps:  
 Store the size of the image(ILO) into size1 and size2.

Initialize a variable AT2 =0

Each pixels in image ILO (size1, size2), test the following step:-

If ILO(i,j)==255 then AT2=AT2+0

Else AT2=AT2+1

Step4:-Display the Area of mass (AT1,AT2).

### 3.4 Algorithm for detecting ovarian mass using ROI and area calculation of it.

**Input:** Ovary CT image.

**Output1:**Mass portion, **Output2:**Areaof the mass.

Step1:- Read the input CT ovary image.

Step2:- Converts input image in to grayscale image.

Step3- Specify a polygonal region of interest by using matlab command (roipoly) ,where the cursor can be used to create a polygon.

Step4- Define the region of interest based on a color by using matlab command (roicolor).

Step5- Create a binary mask by using Boolean indexing.

Step6- Apply edge detection using canny algorithm.

Step7- Subtract the output image of step6 from the original image of step2.

Step8:- Store output at (step7) into array B.

Step9:- Compute numbers of rows and column in pixels by [r c] = size (B)

Step10:- Initialize a variable AM =0

Step11:- Each pixels (r,c) in image B, test the following step:-

If B(i,j)==1 then AM = AM +1

Else AM = AM +0

Step12:-Display the Area of the mass (AM).

## VI. Results and Discussion

In this section, sample of results are shown which obtained it after execution the program of ovary CT image.

- a. The system consist of three phases (pre-processing , processing , post-processing ), so that we will explain all the phases and the results as the following:-

1. **Preprocessing phase results:-** In this phase , the image convert to grayscale, after that apply denoise and filter techniques to enhancement it, as see in flow figure (2):-

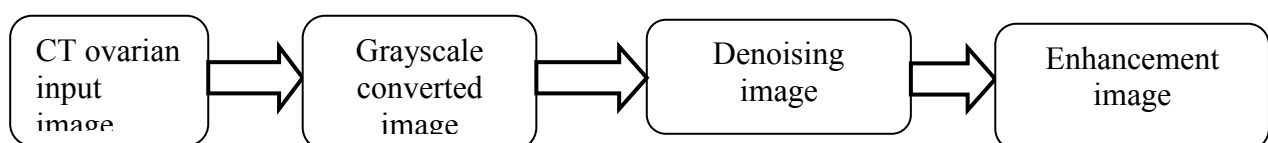
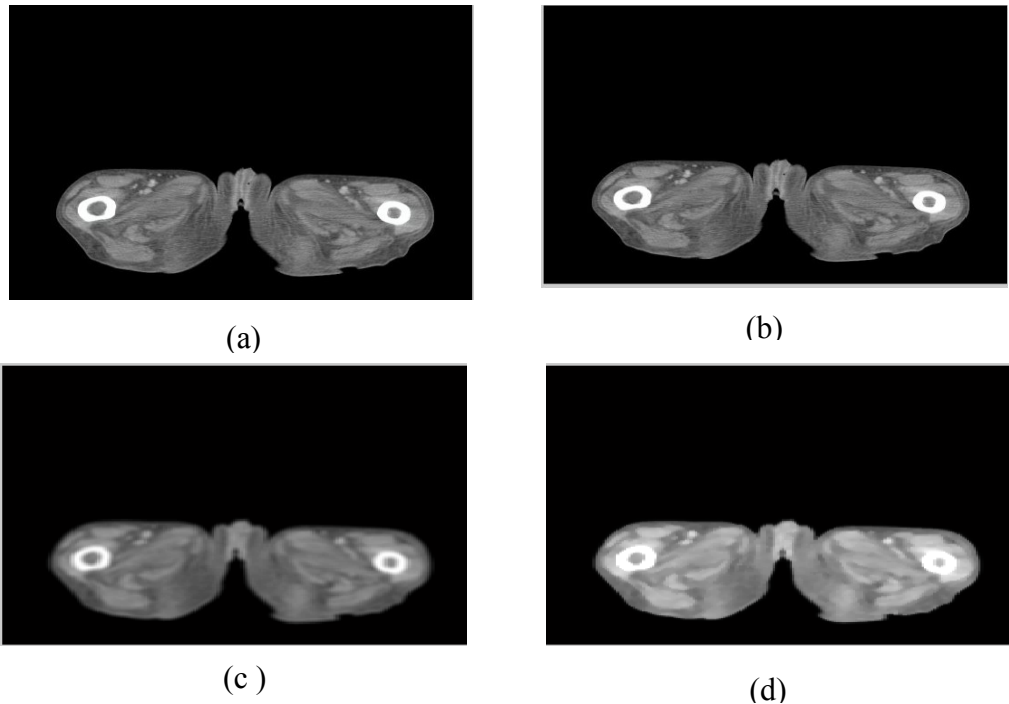


Figure (2) flow diagram of preprocessing phase

The results of ovary images in preprocessing phase are shown in figure (3):



**Figure (3): (a) Original CT ovary image, (b) Grayscale image, (c) Denoising image using imfilter, (d) Enhancement image using medfilt2.**

2. **Processing phase results** :- We used the images after apply preprocessing on it. Since in this phase, we used segmentation techniques (Histogram Threshold, Controlled Watershed) to segmentation images, and then we used morphological operation to reduced intensity images. Finally we used canny edge detection technique to extract mass portion and then convert the images into an RGB space to visualizing labeled regions.

The flow diagram of this phase is shown in figure (4) :-

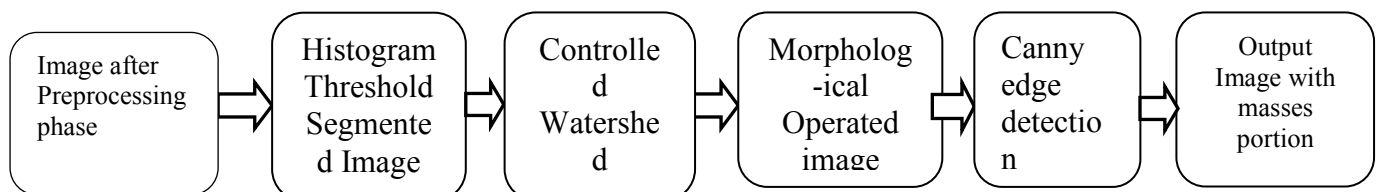


Figure (4) Processing phase diagram

The results of proposed work are shown as following in figure (5):

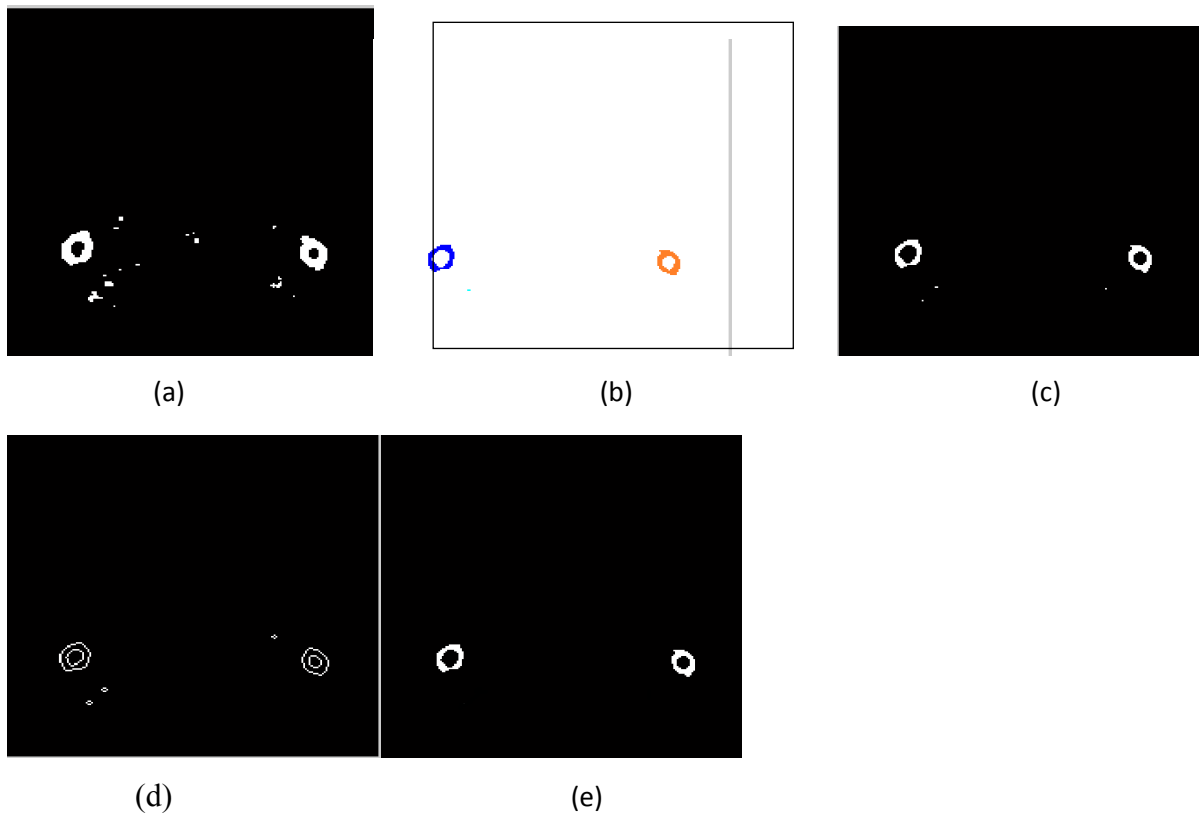


Figure (5): CT images processing phase in proposal algorithm, where: (a) Compute threshold segmentation, (b) Compute watershed segmentation, (c) Morphological operation, (d) Canny edge detection, (e) Output image with masses portion.

**3. Postprocessing phase results:-**The output image after determine the mass , division into two images to determine location mass (right,and left) and calculate area of mass .

The flow diagram of Post-processing in the proposed method is given in the figure(6), and the results of proposed work are shown in figure (7).

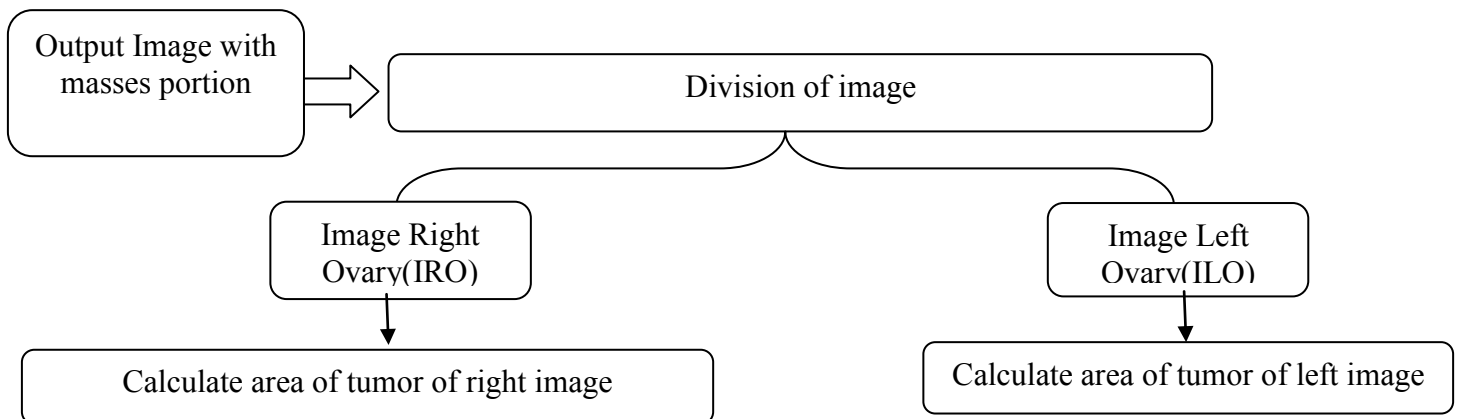


Figure (6) Post-processing diagram

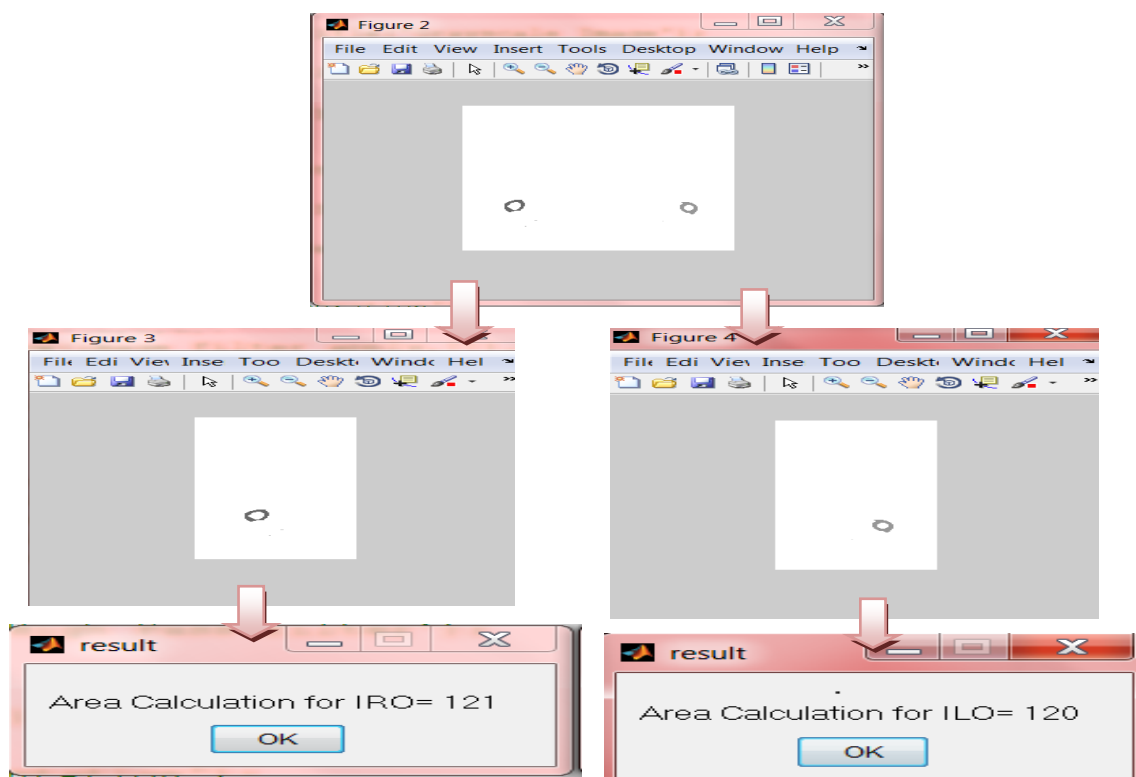


Figure (7) Calculation area of mass for image right ovary & image left ovary

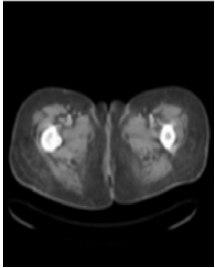

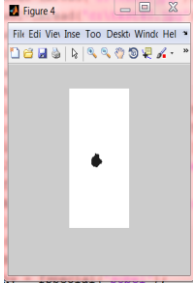
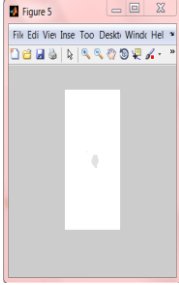

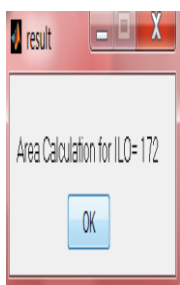
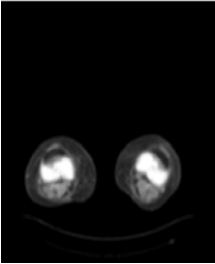

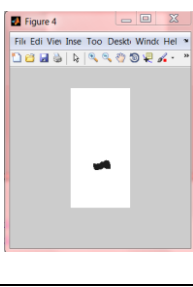
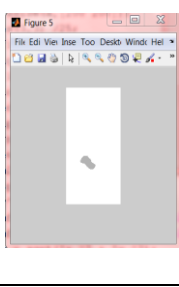


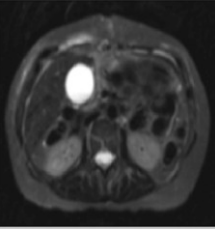

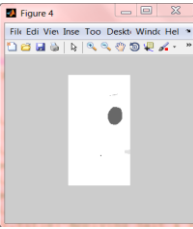
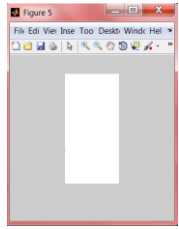
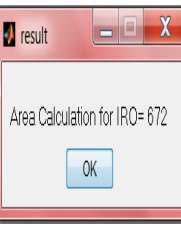
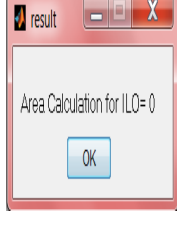
**b. Tabel1:** Contains image size with area mass in pixels when used automatically detection technique and area mass in pixels when used a cursor detection technique.

Image Name	Image Size	Mass size in pixels			
		By a cursor		Automatically	
		IRO	ILO	IRO	ILO
Image1	200*200	230	166	234	172
Image2	200*200	325	350	330	351
Image3	200*200	467	0	672	0

We noted in the Table1, the area mass extracted using automatically method is similar to the area mass when we used the a cursor method to extract it. This indicates to success of the

proposed algorithm that used for mass detection and account area. We also note that the automatic method to be more accurate than a cursor method

**Table 2:** The results of proposed work by using three different samples of ovary CT images

	Input CT ovarian image	Extract mass automatically	Division of image to		Calculate area for	
			IRO	ILO	IRO	ILO
Image1						
Image 2						
Image 3						

In table 2 , despite the different images(image1, image2, image3) shapes is divided into two parts (left and right), and then calculated for each part. It is also the part that does not contain the mass value calculate the area of a mass will be equal to zero.

- c. Some propose system results as show in window matlab , since we using three images, each image was scan in a different manner .

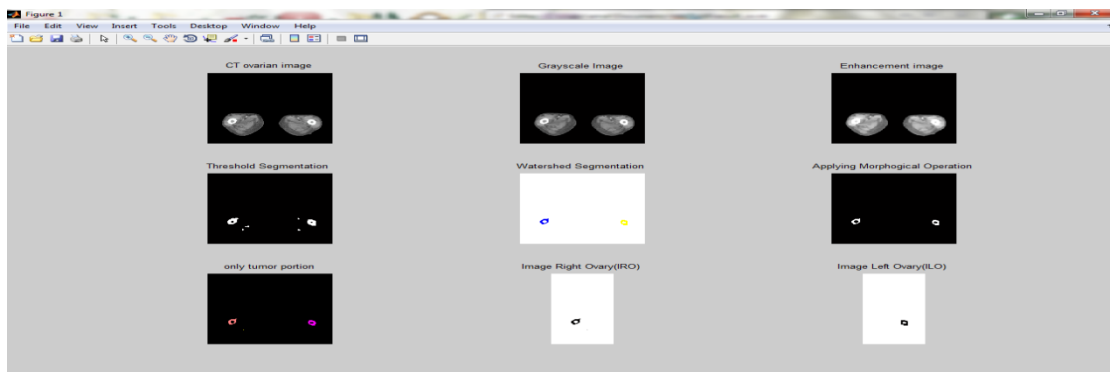
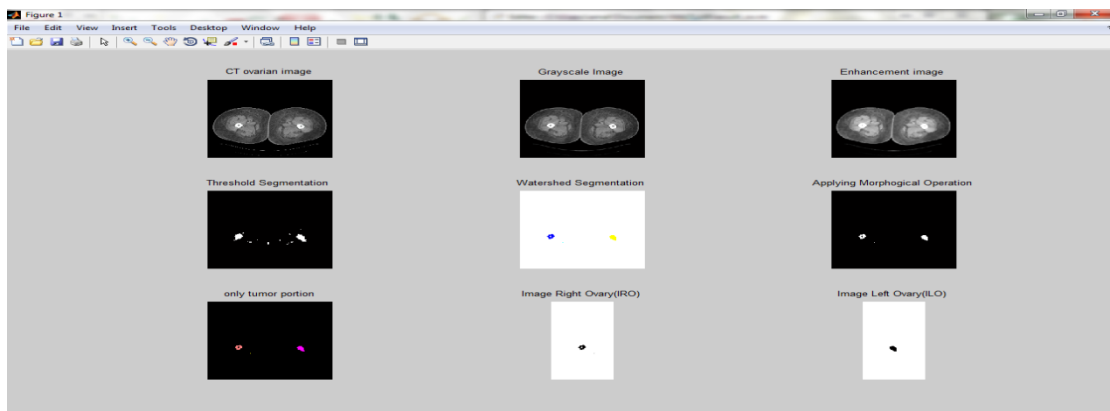
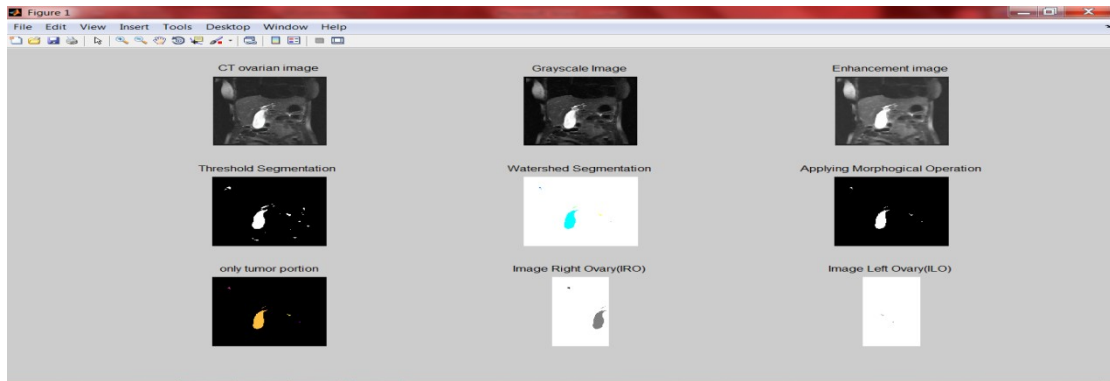


Figure (8) Some propose system results

## VII. Conclusion

Detection of ovarian masses disease is one of the tasks and challenges in the field of medical image processing. Because of the dangerous represented by this disease, which threatens a large proportion of women, so early and proper detection for ovarian mass is one of important task in the early treatment to control the spread of the disease. So , in this paper presented new method to extract masses from ovarian CT image ,then dividing the image after extraction mass from it into two parts(left and right) then calculated area of masses in each part. The segmentation methods which have been used in our presented method gave

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good results in abstract the objects from background. Our database which applied on system contain different images for different sections for ovarian images that involve different volumes and shapes for masses in it. Due to the little number of researches in extraction masses from ovarian CT image, we compare the system results with the results we have obtained manually using cursor, then we offered these results to specialists doctors to ensure the validity and accuracy of the results, and based on our findings the results were good. Planning for future work, this work can be extended to classify the masses using any of intelligent techniques such as neural networks, fuzzy logic and hidden markov model, or using symmetry analysis to detect ovary mass and also used k-means algorithm to calculate the area of the mass portion . Finally we can be applied proposed system to extract mass from CT lung images.

### **VIII. References**

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## الاستخلاص الآلي لأورام المبيض في الصور المقطعية بالأعتماد على تقسيم الصورة

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### المستخلص

يعد حقل معالجة الصور الطبية من أكثر الحقول تحدياً هذه الأيام. وتعتبر معالجة الصور المقطعية للمبيض جزء من هذا الحقل. يهدف هذا البحث إلى تقديم طريقه للكشف عن أورام المبيض في الصور المقطعية ثم تحديد موقعه وحساب مساحته.

عمليات ما قبل المعالجة للصور من نوع CT تتضمن تغيير حجم الصورة، تحويلها إلى اللون الرمادي، وتحسينها لجعلها جاهزة للتطبيق في مرحلة المعالجة التي فيها يتم تطبيق بعض العمليات مثل التقطيع باستخدام طريقتين هما (histogram and watershed) لتقطيع الصورة إلى عدد من المقاطع ومن ثم تطبيق العمليات الصرفية (morphological operations) عليها لإظهار جزء الورم. وبسبب طبيعة المبيض واحتواءه على جزئين اليمن وأيسر، قمنا باقتراح خوارزميه لتقسيم الصور بعد استخراج الأورام إلى صورتين ومن ثم تطبيق خوارزمية لحساب مساحة الورم في كل جزء من الصورة. عند تنفيذ الطريقة المقترحة حصلنا على نتائج جيدة مقارنة مع حساب مساحة الورم يدوياً باستخدام المؤشر في خوارزمية (ROI). البرنامج تم كتابته باستخدام لغة ماتلاب نسخه (R2010a) لاستخراج منطقة الورم في صور الأشعة المقطعية للمبيض.