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Using Image Processing for Tumor Area Allocation in PET and Color Hybrid Scan Images (PET/CT)

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استخدام معالجة الصور لتخصيص منطقة الورم في صور التصوير المقطعي المحوسب (PET) وصور المسح الهجين الملون (PET/CT)

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ABSTRACT

Background: In clinical oncology, precise segmentation of the target tumor is essential. The positron emission tomography (PET)/computed tomography (CT) scanner effectively combines anatomical information from computed tomography with functional information from PET for accurate tumor identification, which can comprehensively describe tumor volumes, cancer is an acute disease that kills a large number of people around the world, so early detection is a vital need.

Materials and Methods: In this study, proposed techniques, hybrid 2 and the HSV-based hybrid techniques are presented to isolate and extract abnormal regions in PET and PET/CT images, these methods were implemented on eight, images.

Results: Results showed that the applied methods were sufficient to detect, isolate and extract areas of tumor.

Conclusion: The calculated tumor area was compared with that of the radiologist delineation it was most percent relative differences are acceptable, for PET and PET/CT images.

Keywords: PET/CT; Segmentation; Tumor; Color; Image.

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INTRODUCTION

The positron emission tomography (PET) imaging modality is a kind of molecular imaging that has emerged as an essential diagnostic tool [1, 2], is commonly used. Even at a low radiation exposure, PET can produce quantitative images of biological processes. PET has demonstrated to have higher sensitivity and better spatial resolution [1, 3]. Given that radioactive tracers are used in PET to aid in diagnosis, it falls under the category of nuclear medicine. Many isotopes are taken into consideration, including 18-F, 11-C, 77-Br, 76-BR, 68-Ga, 86-Y, 64-Cu and 124-I. The method is divided basically into two steps. A radioactive tracer that has a short half-life is injected in the patient's blood in the first stage. The tracer moves across the body around the areas of interest so there is a little waiting period. The chosen Tracer is determined by the variable being measured or evaluated [4]. Fluor deoxy glucose (FDG) is the most widely utilized molecule because it accumulates near the tissue which has a 1-hour waiting time. The second component is the scan itself. It is excellent for diagnosis. Instead of being performed over many days, it can be performed within a few hours because the molecules utilized in this method have a very short half-life. It produces a positron as the molecule decays and therefore it is also called the positive beta decay process. As for the positron, it contains a positive charge and gamma rays are generated when the positron ascends and interacts with an electron. A photomultiplier tube collects the light as it approaches the scintillator which is positioned within the scanning device. The scanner detects this particularly. The procedure is extremely reliant on detecting photons that are not received in pairs [1, 4].

Since its invention, PET has seen considerable usage in the detection and staging of tumors. Recently, PET has been employed for early therapeutic response monitoring and treatment planning [2]. PET uses positron emission radioisotopes (tracers) created by a cyclotron to study molecular metabolic processes in the body. ^{18}F-fluorodeoxyglucose is a typical metabolic PET tracer for activation investigations [4]. Positron emission tomography (PET) integration has become a critical component of radiation treatment planning for numerous tumor entities, including head and neck cancer brain tumors and many others [5].

Positron emission tomography (PET)/computed tomography (CT) imaging is a prominent multimodality imaging technique that is vital for the prognostic assessment and therapy planning of cancer patients. The radioactive Fluoro-18-deoxyglucose (^{18}F-FDG) a glucose analogue is used as a tracer is used to monitor the degree of metabolic activity throughout the body in ^{18}F-fluorodeoxyglucose positron emission tomography (FDG-PET). With increased glucose uptake a cancerous tissues are hypermetabolic tissues. In comparison to FDG-PET, this is important for localization because CT has a higher spatial resolution. Using combined PET/CT, hypermetabolic tumors with related anatomic data may be identified [6]. The combination PET-CT results in complicated, comprehensive and significant medical reports notably for malignancies [7, 8]. A CT scan captures X-rays from different parts of the body to build a 3-D image, while a PET scan utilizes a small amount of radioactive medicine to analyses regions of the body where cells are more active than typical [7]. The use of PET and CT scans together is considered to yield more accurate and trustworthy cancer diagnosis results. PET-CT scans are used to detect various cancers. They may in fact, aid in determining the severity of a disease as well as the stage of a certain cancer. Furthermore, such scans are important in deciding whether or not a procedure to remove the cancer is viable, as well as the finest possible drug for treating

the disease. PET-CT scans may help tell whether a previously removed tumor has returned. They may also be used to plan radiation treatments and track the progress of cancer healing. Scarring is also likely to persist as a consequence of cancer therapy. If the cancer has not been completely removed, this may cause worry. PET-CT scans can determine whether or not the scarring is caused by an active cancer [8]. Fluorodeoxyglucose-positron emission tomography (^{18}F-FDG) Investigations has been used to assess response to therapy in many cancer types. Data have indicated ^{18}F-FDG PET/CT may be utilized to differentiate between responders and non-responders. Is a technique that can provide metabolic information on live cancer cells ^{18}F-FDG PET/CT [9].

In this study, eight images of abnormal cases were adopted, to be segmented in order to extract the tumor area by implementing the proposed techniques are second Hybrid Technique and HSV-Based Hybrid Technique. Then, its area was calculated.

The Second Hybrid Technique (Hybrid Techniques-2)

The second hybrid technique (Hybrid Techniques 2) was proposed in the present study to improve the discrimination ability for making segmentation and allocation for tumor regions in the image. In this technique, detection based on thresholding of the darkest area with neighbor similarity measure was adopted; the preprocessing implies the following:

Thresholding

The thresholding method is one of the most basic ways of segmentation. The structure of these approaches is basically to split the image following specified gray-scale boundaries into a binary image. In this method the threshold is compared with every single pixel, if its value is bigger than the threshold the pixel is classified as “foreground”, otherwise, it is classified as “background”. These methods are typically supplemented by additional approaches such as morphological operators. The general methodology for optimal thresholding is to choose a threshold that is closer in value to the mean of the pixels of the foreground than the mean of the pixels of the background [10]. Adaptive Thresholding It is not always possible to segment an Image using a single global threshold, especially when the background differs widely. Adaptive thresholding, as opposed to implementing a single global threshold to all pixels in the image, modifies the threshold dynamically over the image. For lesion images, segmentation may be produced by comparing each pixel’s color with the threshold. If a pixel is darker above the threshold, it is regarded as active (lesion). This stage produces a binary image. After that morphological post-processing is utilized to fill in the gaps and choose the binary image's most connected component [11].

Histogram Processing

Histogram is a graphical depiction of data distribution. That is, it depicts the number of pixels in the image as a function of its intensity. Histograms are quite simple to compute in both hardware and software implementation. Histogram equalization: Because of its simplicity and elegance, is one of the most commonly used techniques for improving the look of digital photographs is the histogram equalization. Histogram equalization is a technique for stretching a given image's histogram. The key aim is to have identical pixels in all grey levels, not only to increase the dynamic range; this is known as histogram equalization. If the grey levels at the dark end were extended out to give a flatter image, the image would become much clearer, evenly distributed histogram [11, 12].

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Histogram Equalization

This method distributes the grey areas to create a unified histogram. In this case, the integral histogram replaces each pixel. Histogram equivalent is an image processing method that uses an image histogram to set image contrast. The intensity of the histogram distribution can be improved with this adjustment. Because of this, areas with less contrast will be affected by areas with more contrast. Histogram equivalent frequently performs this act, by effectively developing the majority of intense values. In images with a dark or light background and foreground in images this method is used. To adjust the contrast, the histogram equivalent is used and as a result is more visible image disorders [13].

Median Filter

This is the most often used noise cancelling approach. A 'non-linear' filtering technique; derived from the greyscale image this is used to get rid of the 'salt and pepper noise '[13, 14]. The median filter is based on the average pixel value. The median filter is effective in reducing "salt and pepper" noise and speckle noise [13]. The median filter not only removes noise but also keeps the image's edges. There are three kinds of median filters: weighted median filters, maximum median filters and center weighting median filters. Increasing the size of the window in the median filter improves the filter's noise reduction efficiency [14].

Gaussian Blur technique.

This function is used to minimize image noise. This may be accomplished by blurring the image using the Gaussian function. The low spatial frequency of the Image is kept by blurring it and the noise in the image is decreased by deleting some of the image's undesired information. Equation (2) offers the Gaussian blur formula, where X is the direction of the run at the moment and s is the Gaussian distribution's standard deviation. This two-pass Gaussian filtering approach needs less computations and is hence often used in implementation [15].

$$g(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2}{2\sigma^2}} \quad \ldots..(2)$$

where:

$g(X)$: Gaussian blur, X: It represents whichever direction the run is being made at the time, S: It represents standard deviation of the Gaussian distribution, π: is the mathematical constant, e: is the Euler's number.

The following steps summarize the procedure algorithms of this for proposed second Hybrid Technique, are as follows:

1. Load image data.
2. Make clipping from the four sides (left, right, top, bottom), i.e., keeping the region of Interest
(ROI), such that determining clipIImg wid, clipImg hgt.
3. Calculate the histogram
4. Determine the threshold that cover the brighten
5. Apply initial thresholding to produce binary image
6. Determine the statistical features (mean & std) in order to re-determine threshold value
7. Re-apply thresholding using statistical attributes
8. Apply region growing based on local similarity.

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HSV-Based Hybrid Technique

The implemented This HSV (Hue, Saturation, Value) -based hybrid technique to segment the images in order to detect, isolate and extract the abnormal regions. The following steps summarize the procedure of this technique proposed hybrid:

Color Models and spaces

The color model is known as a mathematical model in which colors are represented as three or four integer color components or values. Therefore, express the collection of colors as the "color space." when the color model is paired with an accurate description of how circumstances are seen and components inferred. To characterize human color vision modeling the color space may also be used. Color models and color space are rarely closely matched. Multiple color spaces exist including HSV, RGB, CMY, CMYK, HSI and NTSC. An any color space may be used to transform the Image using any conversion function, although the RGB color space is the most fundamental type of image representation. But different color spaces may be more useful in certain situations [16].

In the suggested approach for the segmentation procedure to extract the seed, the HSV color system is employed, since it produces better results than the RGB color space.

RGB

The color space (Red, Green, and Blue) RGB is commonly used in computer graphics [17, 18]. A tridimensional coordinate system is used to represent the three major additive colors of red, green and blue. Image brightness values were obtained by three distinct filters (blue, green, and red filters) to represent the three components according to the following equations 1: [17].

$$\left.\begin{aligned} R &= \int_{\lambda} E(\lambda) S_R(\lambda) d\lambda \\ G &= \int_{\lambda} E(\lambda) S_G(\lambda) d\lambda \\ B &= \int_{\lambda} E(\lambda) S_B(\lambda) d\lambda \end{aligned}\right\} \quad \ldots\ldots (1)$$

Where: SR, SG, SB represent color filters, E(λ) represent incoming light radiance, λ is the wavelength.

Hue Saturation Value

The value was represented by the letter V in this model. HSV are employed in the segmentation process of computer vision and image analysis [19]. The HSV (hue, saturation and value) color system is much closer to the RGB cooler space, and in turn is used to understand and describe colors [16, 10]. Humans are therefore attracted to color as the dominant color. Saturation also refers to the amount of white light those changes with color. The value represents the brightness/intensity. Abbreviation for tint is a Hue, abbreviation for shadow is saturation and abbreviation for tone is value. as a geometric cone A HSV color space may be represented, with the angular dimension indicating Hue(H), red at 0°starting with primary, proceeding to primary green at 120° primary blue at 240° and finally returning to red at 360°. Saturation (S) is the

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distance from the HSV cone's center axis. A saturation number that is approaching the outer boundary indicates that the colorfulness value for the hue is nearing its maximum. The Value (V) is the HSV color space's central vertical axis, going with brightness or value 0 from black at the bottom to white at the top with value1 or lightness [16].

HSV color space has the advantage of being closer to human mental understanding of colors. Color is well recognized to give powerful information for image retrieval methods nevertheless, the human eye cannot see a large variety of colors at the same time, but it can differentiate related colors well [20].

The following steps summarize the procedure of this proposed HSV-Based Hybrid Technique, are as follows:

1- Input image.
2- Implementing HSV-Based Hybrid Technique (Hue, Saturation, Value) on PET/CT images.
3- Cutting background.

4- Choose the colored seed value the adopt the histogram principle, then calculated the mean and standard deviation of the points.

5- To specify the region tumor: the threshold= mean + threshold* α

Min. value =mean- α* stander deviation

Max. value = mean+ α* stander deviation

6- Each pixel is classified as a PET/CT, note its nearest neighbors, if they are close, count them as a PET/CT.

7- Calculating the area of the extracted tumors regions.

8- Output image.

previous relevant research and studies, many researchers have worked in this PET and PET/CT images , for example,

In this study car dose generated anomaly maps for healthy controls patients at various stages of Alzheimer‟s the researcher disease and distinct front temporal dementia syndromes based on analysis PET images investigated largely visually. There were no anomalies seen in healthy controls and the abnormalities found in dementia patients aligned with locations where aberrant absorption would be predicted. He also validated the proposed framework using anomaly maps as input to a classifier and obtained a higher classification accuracy than when using the same PET images as input, demonstrating that the proposed method can automatically identify and characterize dementia-related areas in PET images [21].

In this study, they presented a new deep learning tool for segmenting hypopharyngeal tumor in fluorodeoxyglucose- positron emission tomography/ Computed Tomography (FDG-PET/CT) images using probability maps that is biased toward clinical application. They used individual width-based clustering to estimate the uncertainty related to inter-patient variability multi-view averaging-based clustering is performed to combine the information learned in each individual view to obtain a single final prediction, they conclusion is that the proposed method identifies the

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primary tumor in correspondence with the highest agreement among the trained models and that the performance is similar to published deep learning (DL) methods for identifying head and neck tumors [22].

In this study, the researcher introduced a new gaussian blurring hue saturation value (GBHSV) Leak approach for segmenting and classifying acute lymphoblastic leukemia (ALL) cancer cells. Two stages make up GBHSV-Leak. The first step comprises preprocessing, which blurs noise and reflections in the image using gaussian blurring (GB). The second step comprises segmentation utilizing hue saturation value (HSV) and morphological techniques to distinguish foreground and background colors enhancing prediction accuracy. The suggested technique achieves 96.30% accuracy on the private dataset and 95.41% accuracy on the ALL-IDB1 public dataset [23].

MATERIALS AND METHODS

The working steps can be summarized in Figure (1) block diagram.

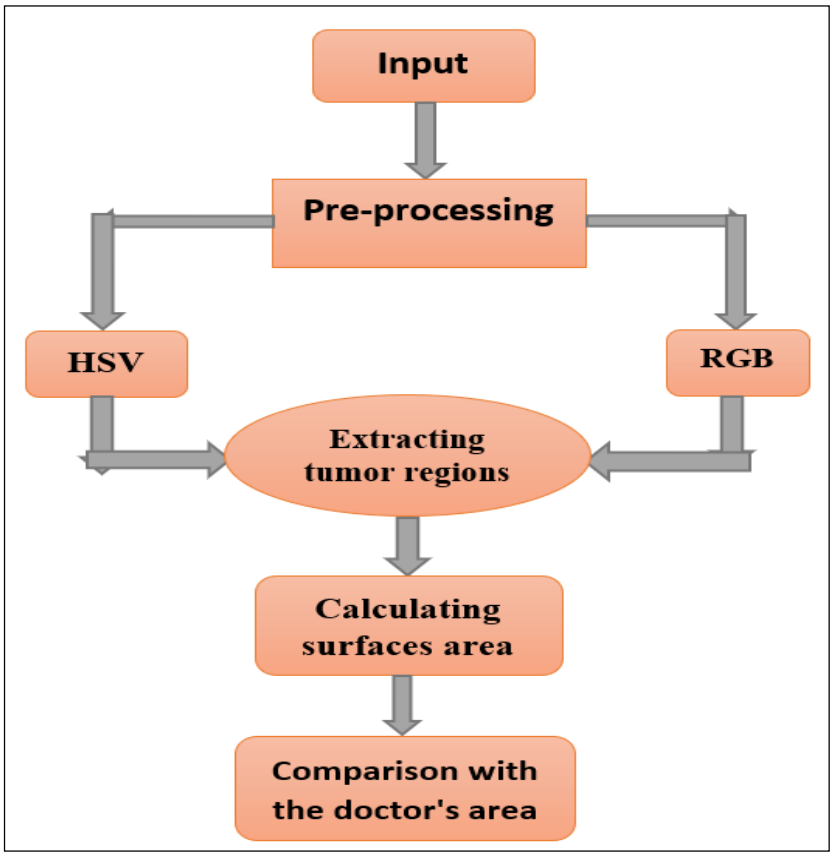

Figure (1): The block diagram of the procedure.

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The Experimental images are acquired from Amal Al-Hayat Hospital for Oncology and Hematology, Iraq. The adopted images are for abnormal cases, as shown in the Figures (2) and (3).

Figure (2): Experimental images in technique of PET scan.

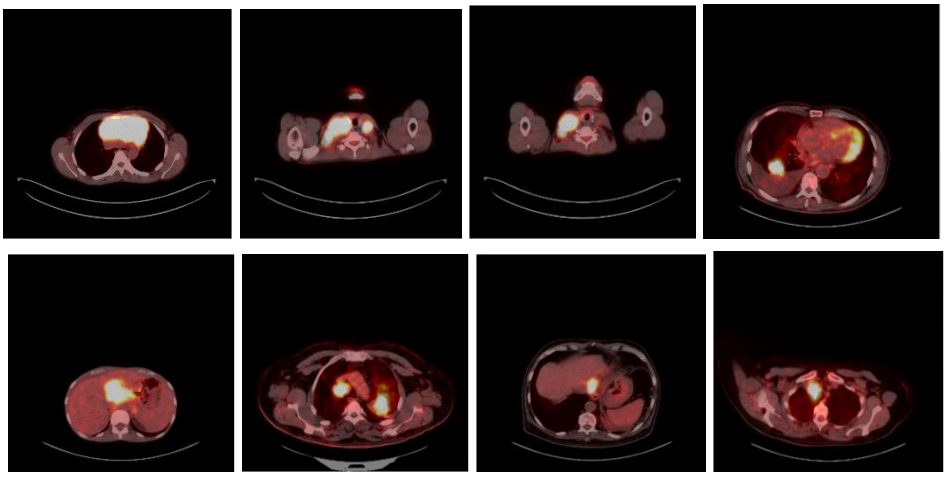

Figure (3): Experimental images of the PET/CT scan.

RESULTS AND DISCUSSION

In this section, the results of the adopted techniques for detecting, isolating, and extracting the affected areas are presented as follows:

Firstly: The Second Hybrid Technique

Hybrid technique 2 was implemented on PET images to isolate the tumor areas and then extracted it by the steps mentioned previously. The results of this technique of the adopted images for detecting and extracting the tumor are presented in Figure (4).

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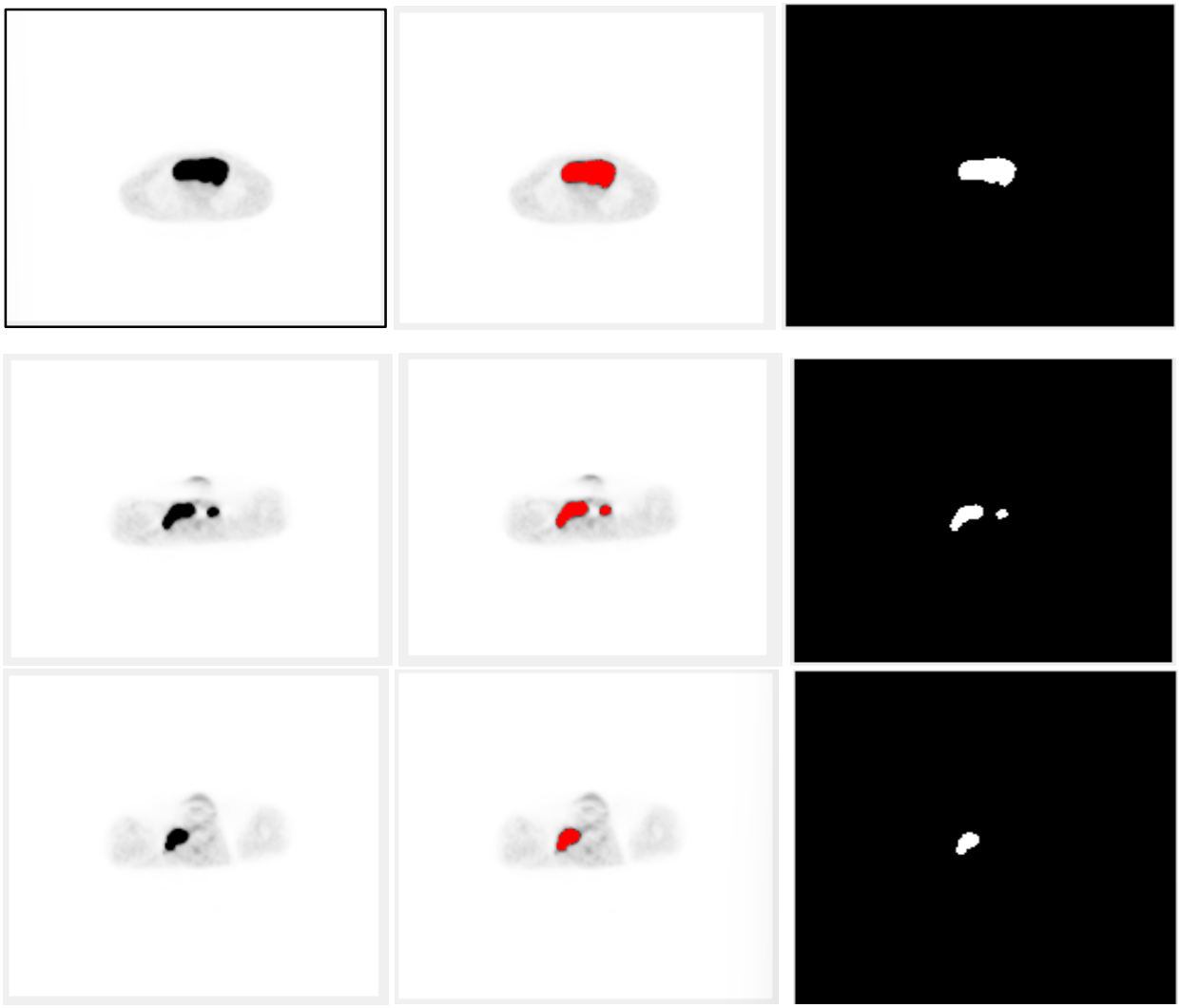

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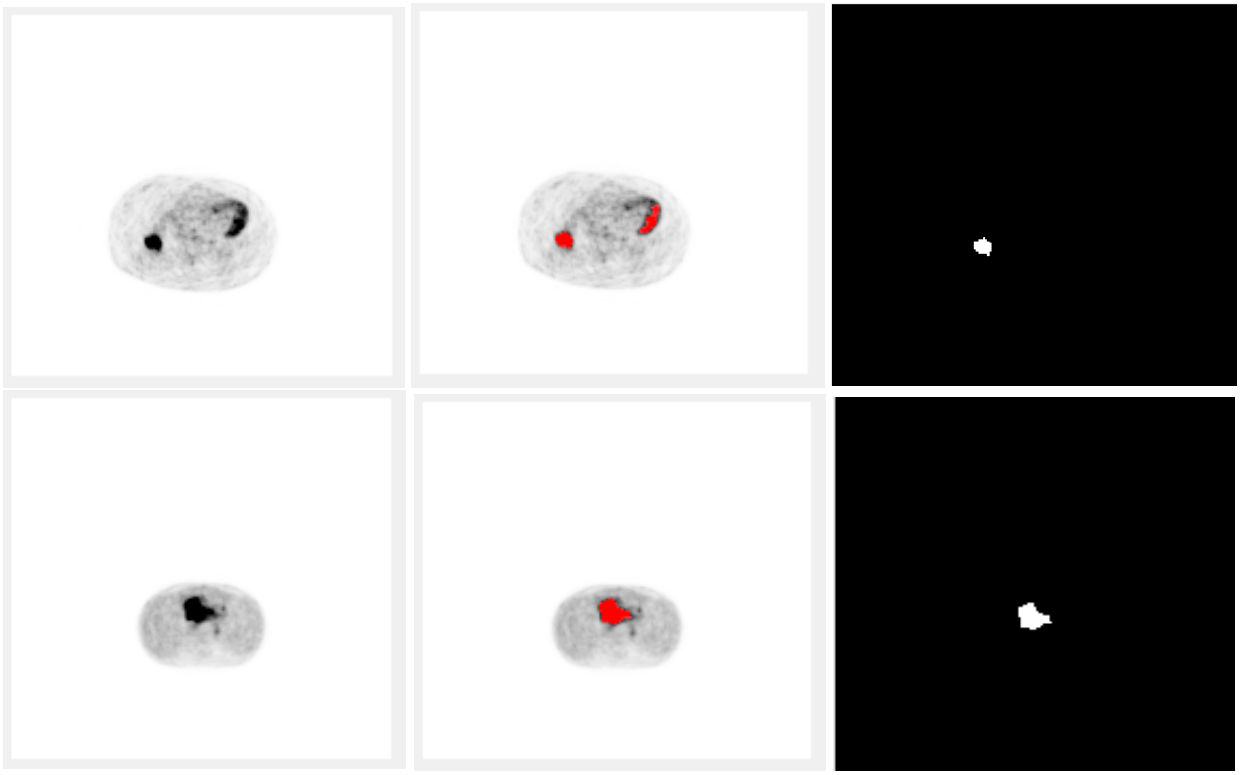

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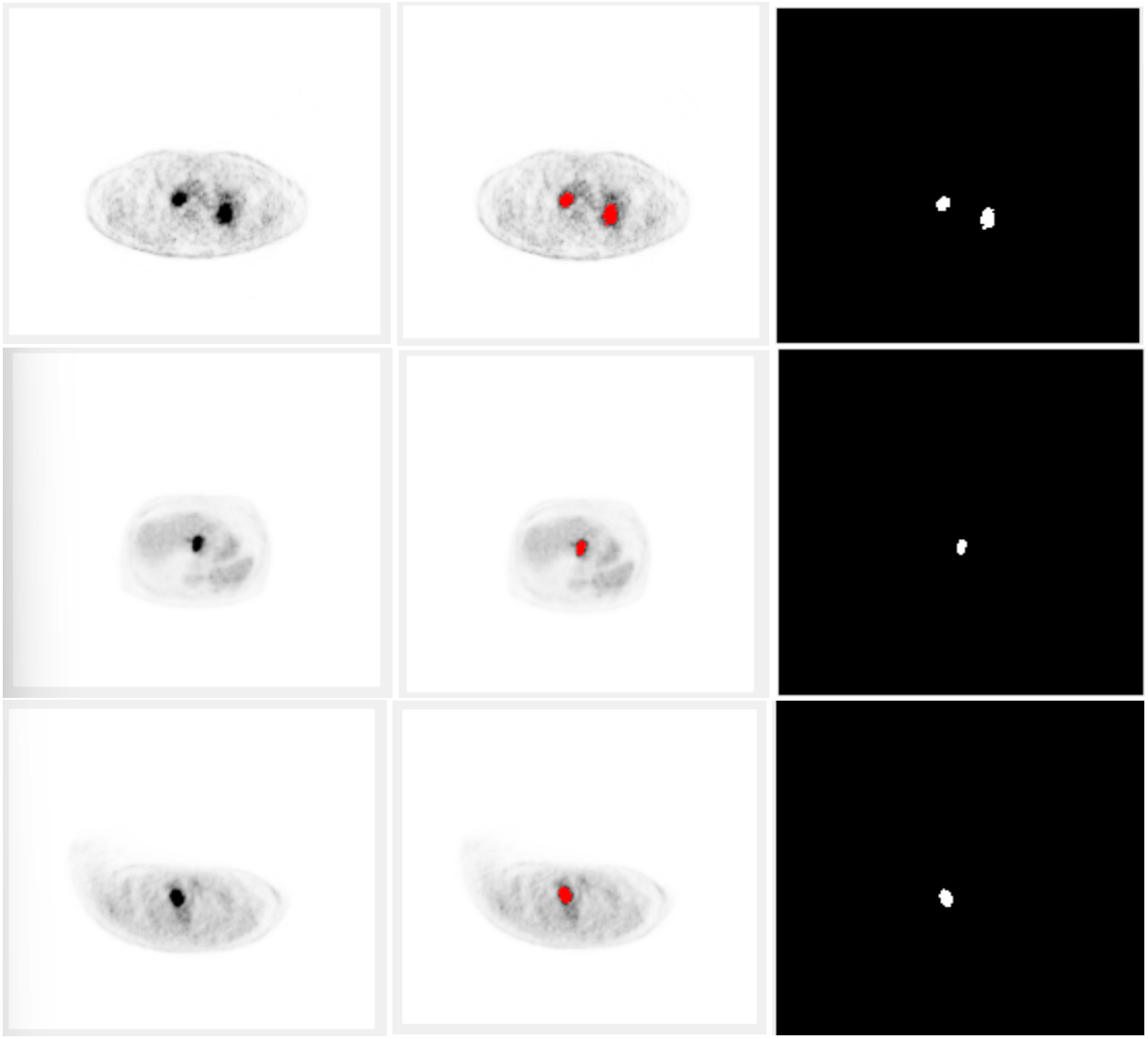

a **b** **c**

Figure (4): The results of applying the hybrid 2 technique of PET images.

secondly: **HSV-Based Hybrid Technique**

HSV-based hybrid technique implemented on PET/CT images, for detecting, isolating and extracting the affected areas it by the steps mentioned previously. The results of this proposed hybrid technique is presented in Figure (5).

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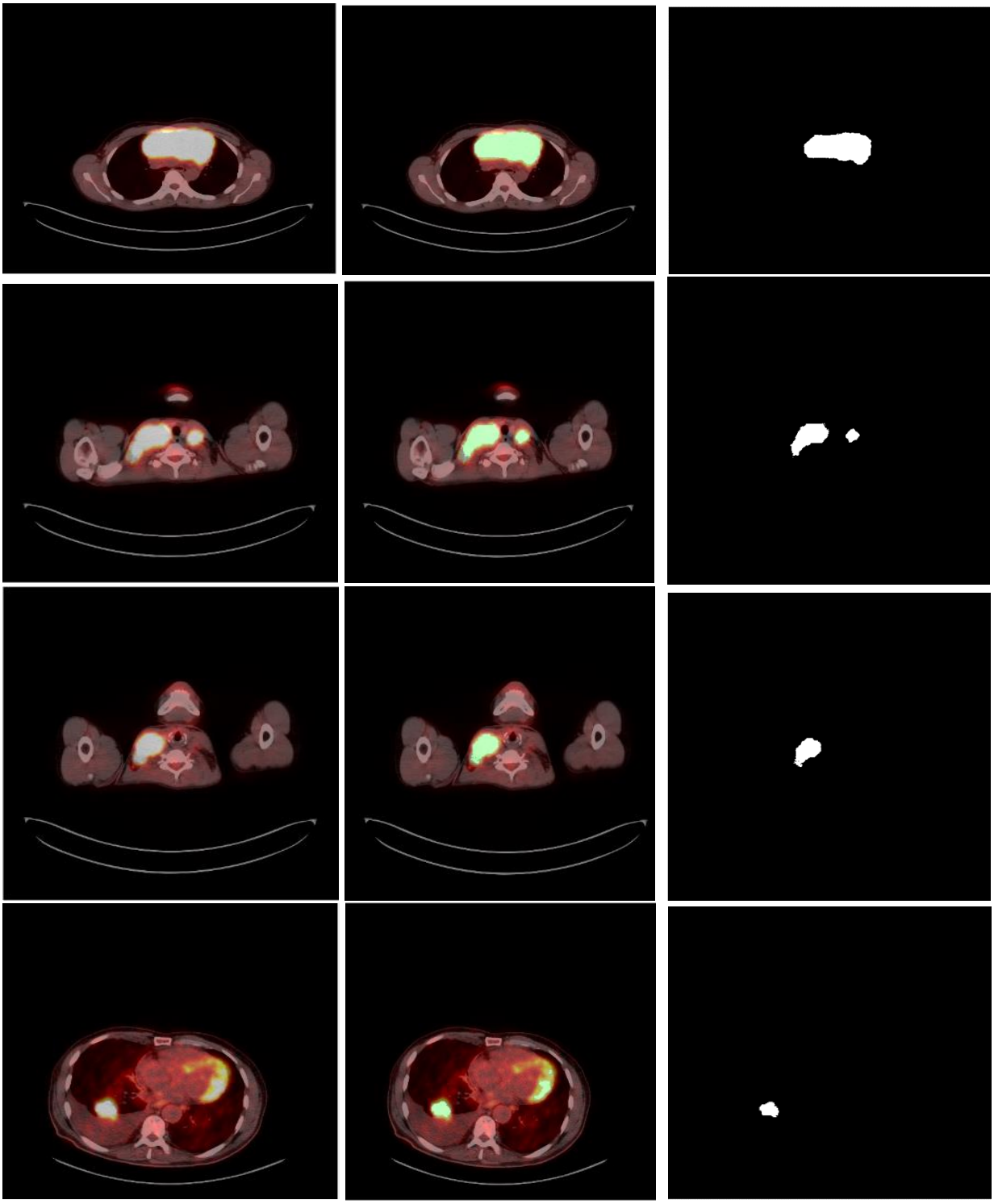

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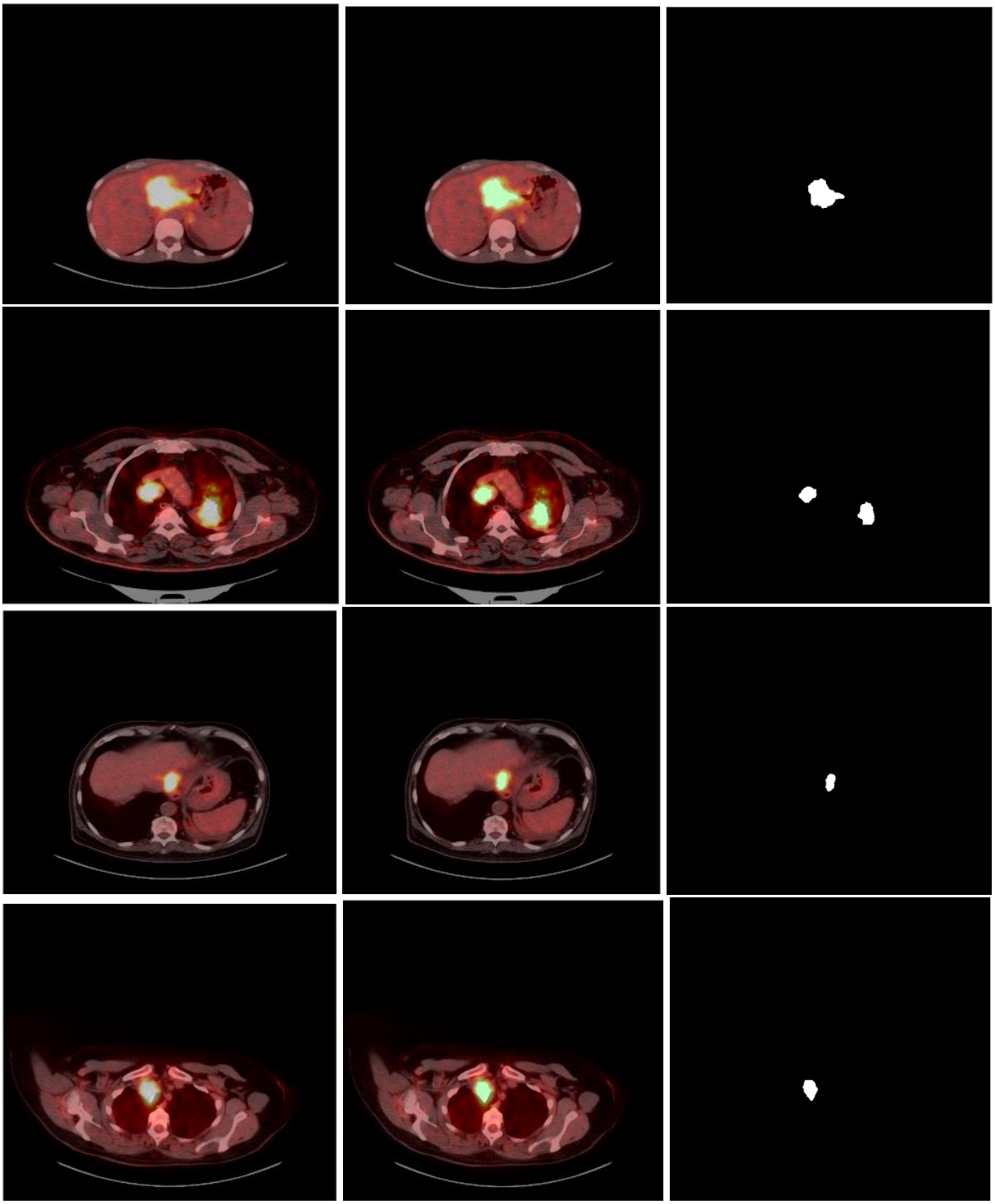

a b c

Figure (5): Results of implementing HSV-based hybrid technique on PET/CT images.

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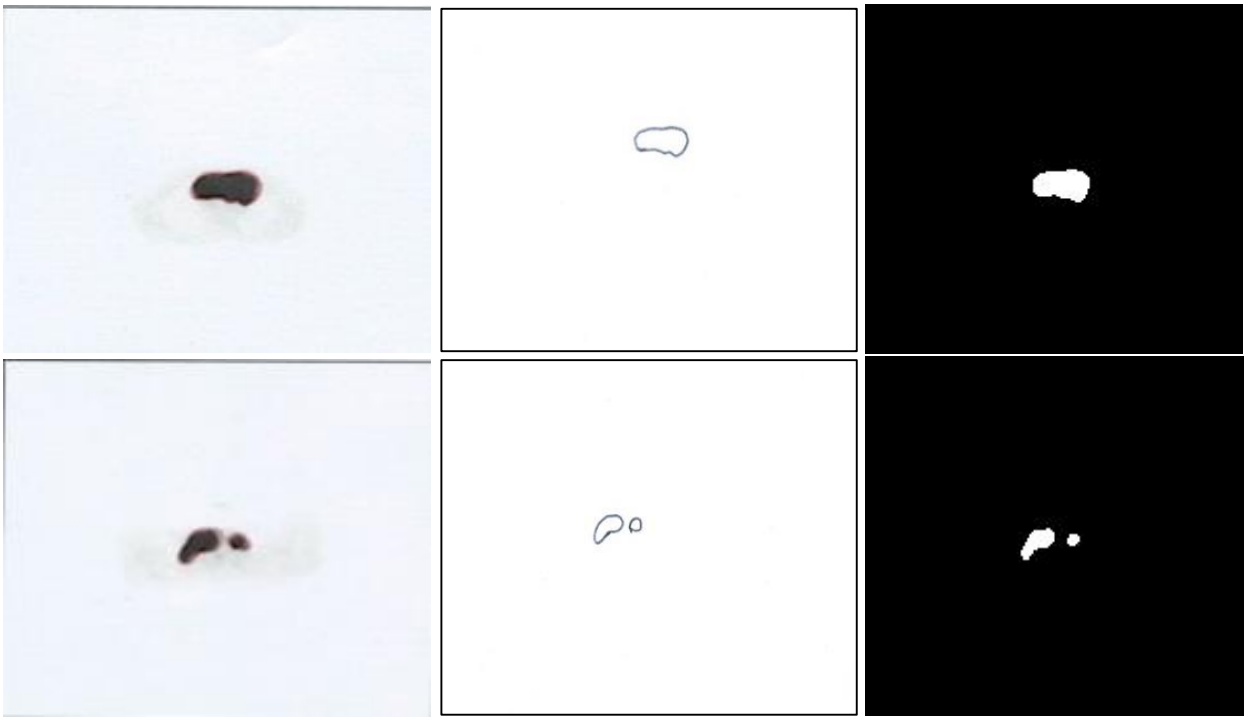
Figures (4 and 5) shows the results of implementing techniques adopted for PET and PET/CT images; the first column represents a input image; the second column presents the f segmented images and the last column presents the extracted tumor region. The results showed an adequate extraction of the infected regions according to the radiologist consultation.

Radiologist Delineation

The experimental PETand PET/CT images, were introduced for manual delineation of the abnormal regions by radiologist. The delineated images were processed to extract the contours border of the abnormal regions. Using suitable image processing functions to fill the contouring regions, these objects, representing abnormal regions (tumors), were extracted and the surface area of these regains, were calculated to use them as ground truth to investigate the performance quality the effeciencity of our proposed technique. Figures (6 and 7) show the results of these step for PETand PET/CT images respectively.



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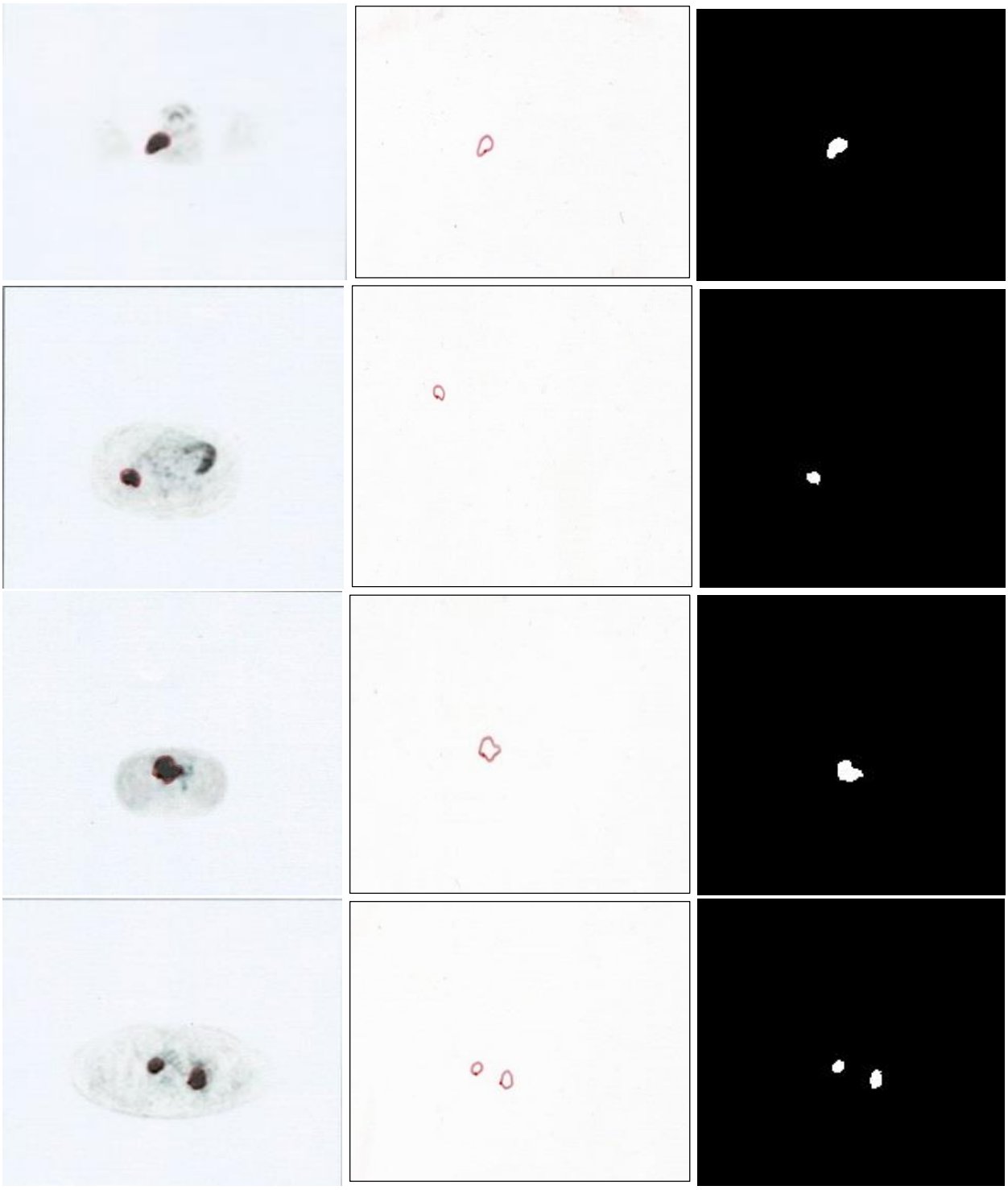

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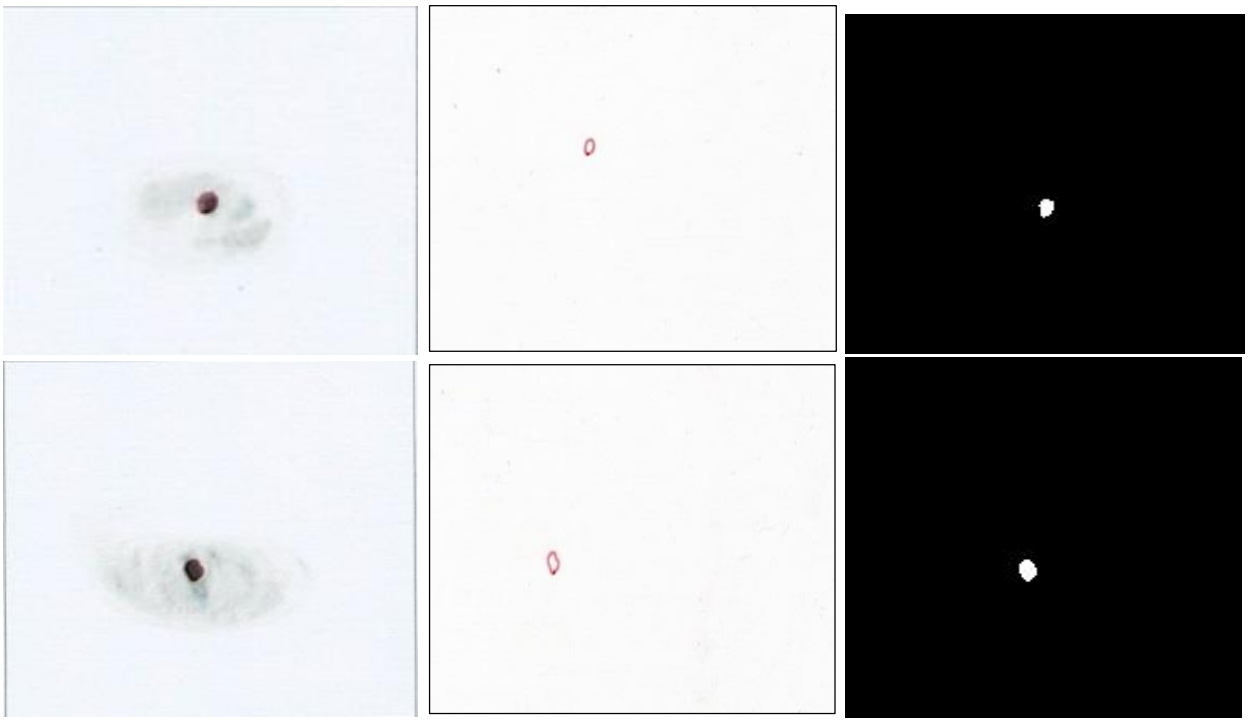

a b

c

Figure (6): Radiologist delineation of the tumor regions in blue and red color on PET/CT images.

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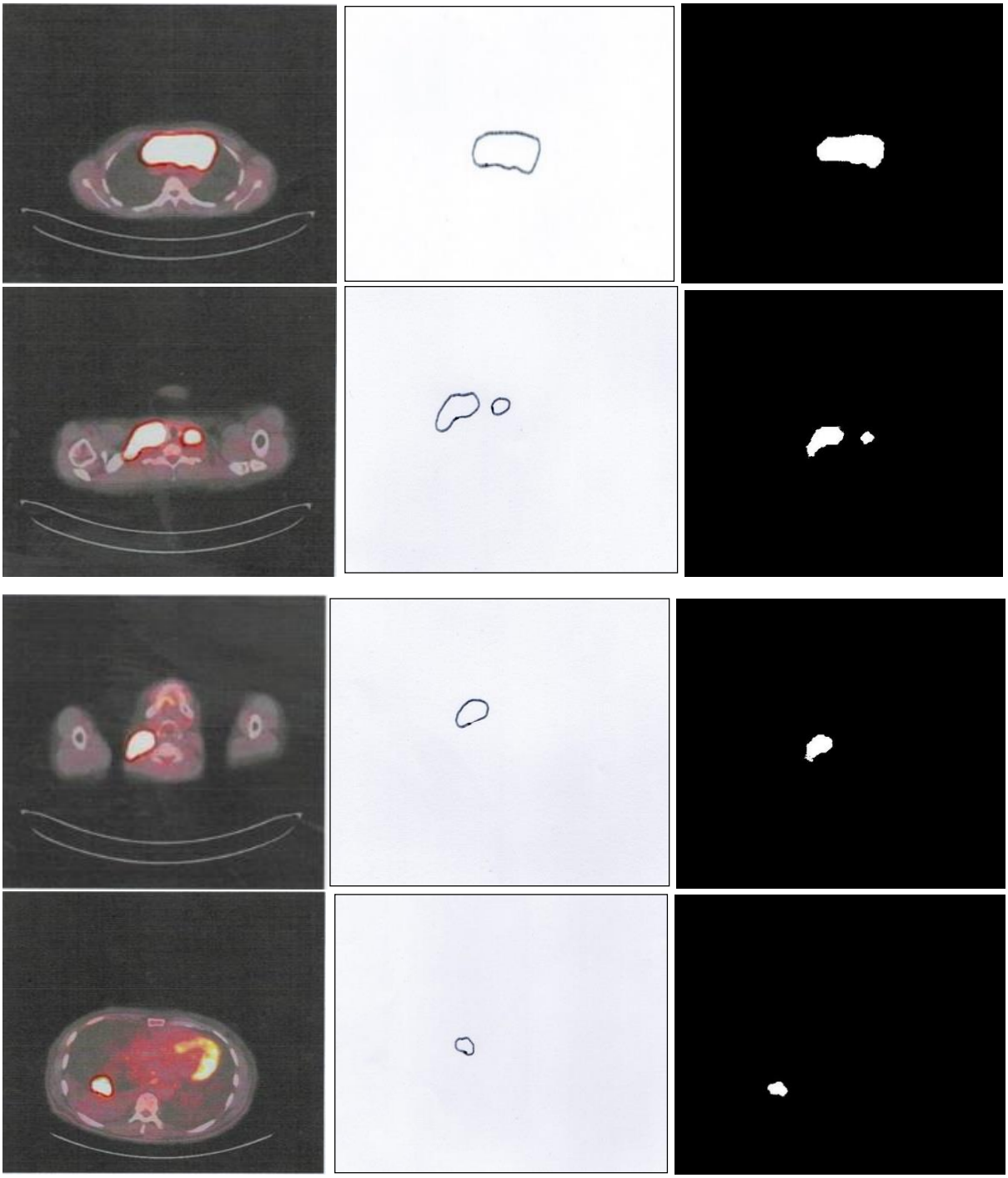

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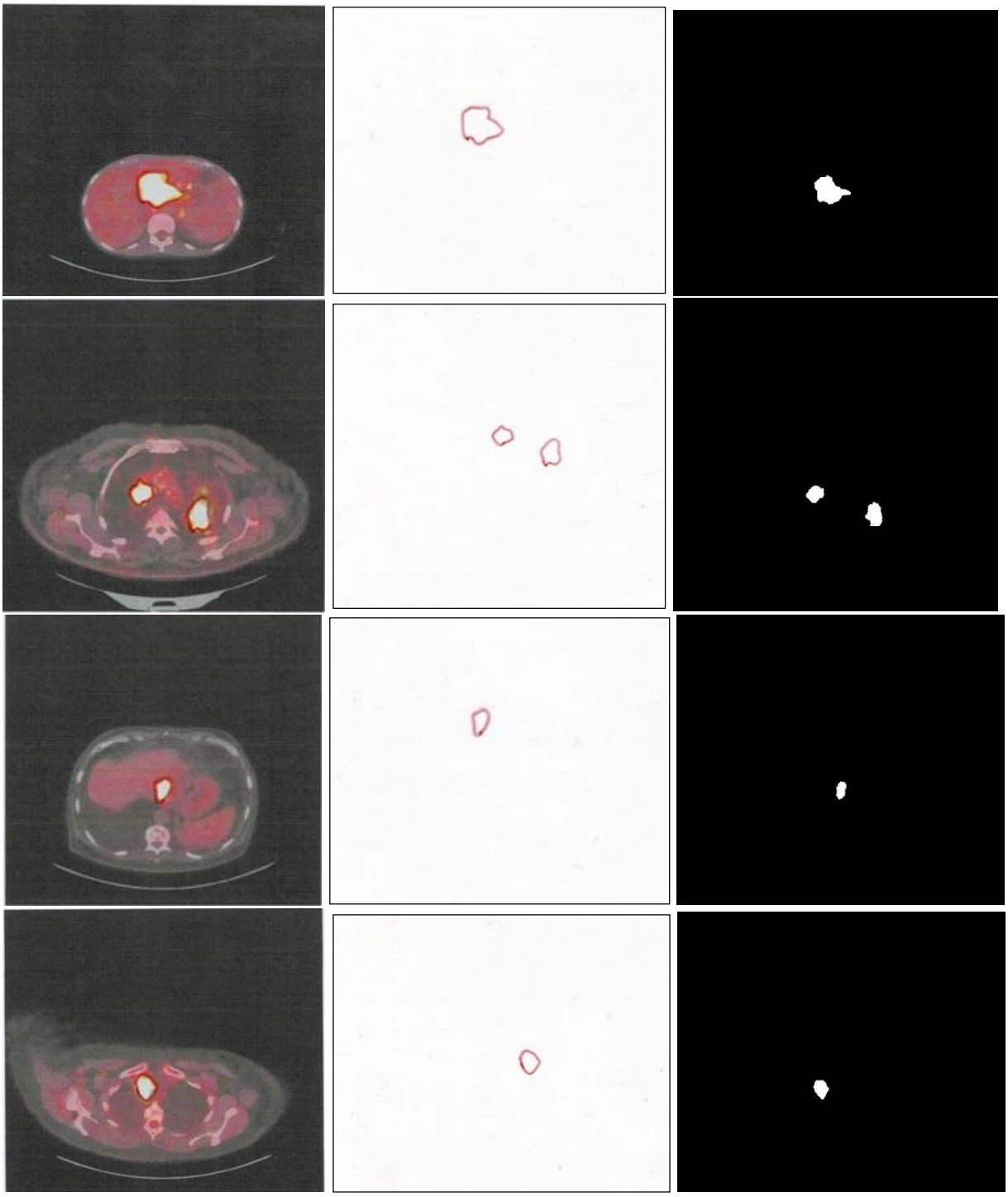

Figure (7): Radiologist delineation of the tumor regions in blue and red color on PET/CT images.

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In Figures (6 and 7), the first column shows the radiologist delineation of the abnormal regions, and the second column represents the delineation contour only. In contrast, the last column illustrates the filled delineation of abnormal regions after implementing some image processing functions. The second and third columns result from processing operations on the images of the first column.

In this step, the surface (in pixels) areas calculated for tumor and elapsed time (in seconds) of implementing the results of applying the Auto detection based on thresholding of darkest area with neighbor similarity measure.The relative differences were calculated between the extracted tumor applying the proposed methods and the radiologist's assignment of the PET and PET/CT images, presented in Tables (1) and (2).

Table(1): Elapsed time (in seconds) of implementing the proposed techniques on PET and PET/CT images.

Images No.	**PET**	**PET/CT**
	Hybrid 2	HSV-Based Hybrid Technique
im1	0.511	0.702
im2	0.535	0.674
im3	0.562	0.630
im4	0.535	0.638
im5	0.510	0.618
im6	0.543	0.638
im7	1.200	0.948
im8	0.829	0.696

By a close inspection of Table (1), it clears that the time to implement adopted techniques was appropriate for the PET and PET/CT images.

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Table (2): the calculated values surface area for extracted tumor area and radiologist delineation specialist demarcation area, relative differences of extracted tumor.

Image No.	Hybrid 2			HSV-Based Hybrid Technique		
	Surface Area	Area of Radiologist	Relative. Difference of Area %	**Surface Area**	Area of Radiologist	Relative. Difference of Area %
im1	311	304	2.302	4893	6790	27.938
im2	157	168	6.547	2123	3757	43.492
im3	84	98	14.285	1221	1815	32.727
im4	49	49	0	572	793	27.868
im5	120	129	6.976	1679	3407	50.719
im6	106	124	14.516	1314	2115	37.872
im7	31	41	24.390	369	1146	67.801
im8	48	60	20	570	1119	49.061

By a close inspection of Tables (1) and (2), it that bests the percent relative difference percent reduction for PET images ranging from (0-14.516) %. As for the for PET/CT images, the percentages are ranging from (27.868-32.727) %.

As for the values that gave a high error rate, there are several reasons, including: can be, if the used disk is not suitable for morphological operations, or the, radiologist leaves extra space, or can the planning pen take up more space.

ACCURACY, SENSITIVITY AND SPECIFICITY OF SEGMENTATION METHODS

The accuracy, sensitivity, and specificity of the implemented segmentation methods were calculated; the results are shown in Table 4.

Table 4. Accuracy, sensitivity and specificity of segmentation methods

Methods	**Accuracy %**	**Sensitivity %**	**Specificity %**
Hybrid technique 2	85	85	15
HSV-based hybrid technique	75	75	25

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Conclusion

In this work, proposed techniques have been applied Hybrid technique 2 and HSV-based hybrid technique to extract abnormal regions in PET and PET/CT images. The results showed that the applicable proposed techniques could extract the tumor regions results showed an adequate extraction of the infected regions according to the radiologist consultation. The delineation Radiologist area was calculated for the proposed techniques and compared to our extracted tumor areas; it was most percent relative differences are acceptable. For PET and PET/CT images.

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CONTRIBUTIONS SECTION

They author E.B.S confirms the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation, L.E.G. suggested the approved techniques. R.S.A. and L.E.G. contributed to the final version of the manuscript and supervised the project.

Conflict of interests.

There are non-conflicts of interest.

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الخلاصة

المقدمة: في علم الأورام السريري، يعد التقسيم الدقيق للورم المستهدف أمرًا ضروريًا. يجمع ماسح التصوير المقطعي بالإصدار البوزيتروني (PET)/التصوير المقطعي المحوسب (CT) بشكل فعال بين المعلومات التشريحية من التصوير المقطعي المحوسب والمعلومات الوظيفية من التصوير المقطعي بالإصدار البوزيتروني (PET) لتحديد الورم بدقة، والذي يمكن أن يصف بشكل شامل أحجام الورم، والسرطان مرض حاد يقتل عددًا كبيرًا من الأشخاص. في جميع أنحاء العالم، لذا فإن الكشف المبكر يعد حاجة حيوية

طرق العمل: في هذه الدراسة، تم تقديم تقنيات المقترحة التقنية الهجينة 2 والتقنية الهجين المعتمدة على HSV لعزل واستخلاص المناطق غير الطبيعية في صور PET و PET/CT، وقد تم تنفيذ هذه الطرق على ثماني صور.

النتائج: أظهرت النتائج أن الطريقة المطبقة كانت كافية لكشف وعزل واستخلاص مناطق الورم.

الاستنتاجات :تمت مقارنة مساحة الورم المحسوبة بتلك التي حددها أخصائي الأشعة، وكانت معظم النسب المئوية للاختلافات النسبية مقبولة، بالنسبة لصور PET و PET/CT.

الكلمات المفتاحية: التصوير المقطعي بالإصدار البوزيتروني /التصوير المقطعي المحوسب، التجزئة، الورم، اللون، الصورة.

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