Hybrid CAD Scheme for Lung Nodule Detection in PET/CT Images

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ABSTRACT

Lung cancer is the leading cause of death among male in the world. PET/CT is useful for the detection of early lung cancer since it is an imaging technique that has functional and anatomical information. However, radiologist has to examine using the large number of images. Therefore reduction of radiologist's load is strongly desired. In this study, hybrid CAD scheme has been proposed to detect lung nodule in PET/CT images. Proposed method detects the lung nodule from both CT and PET images. As for the detection in CT images, solitary nodules are detected using Cylindrical Filter that we developed. PET images are binarized based on standard uptake value (SUV); highly uptake regions are detected. FP reduction is performed using seven characteristic features and Support Vector Machine. Finally by integrating these results, candidate regions are obtained. In the experiment, we evaluated proposed method using 50 cases of PET/CT images obtained for the cancer-screening program. We evaluated true-positive fraction (TPF) and the number of false positives / case (FPs/case). As a result, TPFs for CT and PET were 0.67 and 0.38, respectively. By integrating the both results, TPF was improved to 0.80. These results indicate that our method may be useful for the lung cancer detection using PET/CT images.

Keywords: PET, CT, Computer-aided detection (CAD), Lung nodule

1. INTRODUCTION

Lung cancer is the leading cause of death among males in the world and its incidence is continuing to increase. To reduce lung-cancer-related deaths, it is necessary to detect and treat the cancer at an early stage. Recently, PET/CT has been adopted as a mass-screening tool for cancer diagnosis, because it improves the ability to detect tumors at an early stage. PET/CT combines in a single system both a PET and a CT, so that images acquired from both devices can be taken sequentially, in the same section from the patient. Thus, functional imaging obtained by PET, which depicts the spatial distribution of metabolic or biochemical activity in the body can be more precisely aligned. X-ray CT has anatomical information; it is used for lung nodule detection widely [1-3]. X-ray CT image compensates the anatomical information, which was lacking from the pure PET system.

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Medical Imaging 2011: Computer-Aided Diagnosis, edited by Ronald M. Summers, Bram van Ginneken,
Proc. of SPIE Vol. 7963, 796335 · © 2011 SPIE · CCC code: 0277-786X/11/$18 · doi: 10.1117/12.877104

However, PET/CT generates a large number of images that must be manually examined by a radiologist, and therefore, it is necessary to reduce this load. Computer-aided detection (CAD) provides a computer output as a 'second opinion' to assist radiologists in diagnosing various diseases from medical images. We focus on the lung nodule detection using whole-body PET/CT images. With regard to the detection of lung nodules, many researchers have developed CAD schemes using CT [4-9] or PET [10] images. A technique for detecting the nodules using both images has not yet been reported. In this study, we develop an automated scheme for lung nodule detection using PET/CT images.

2. METHODS

The proposed scheme detects lung nodules from both CT and PET images. Flow chart of our CAD scheme is shown in Fig.1.

2.1 Detection using CT images

In the detection using CT, the lung region is detected and a nodule in the lung region is enhanced using a cylindrical filter we developed [8]. The enhanced image is binarized, and then, nodule candidates are obtained using three-dimensional (3D) labeling. Finally false positives (FPs) are reduced using seven characteristic features and support vector machine.

2.2 Detection using PET images

In the detection using PET, image is binarized using a predetermined threshold. In this study, the pixel value in which the standard uptake value (SUV [11]) became 2.0 is selected as a threshold. Then, 3D labeling is applied to the binary image, in order to distinguish the highly uptake regions. FPs outside the lung region are eliminated using extracted lung region determined by the CT images.

2.3 Integration of detection results

Finally, integration process counts nodules if nodules are detected by at least modality in PET or CT. These are considered to be the automated detection result of the lung nodule.

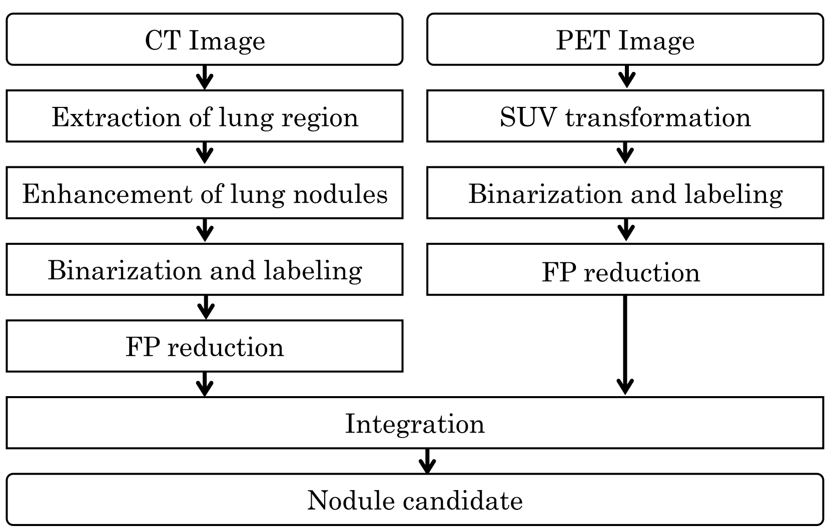


Figure 1. Flow-chart of our proposed lung-nodule detection scheme for PET/CT images

3. EXPERIMENTS

The detection ability was evaluated using PET/CT images of 50 cases. These images were acquired using a PET/CT scanner (True Point Biograph 40; SIEMENS) at the East Nagoya Imaging Diagnosis Center (Nagoya, Japan) for a cancer-screening program. The spatial resolution of the PET image was $4.0 \times 4.0 \times 2.0$ mm^3 and that of the CT image was $0.97 \times 0.97 \times 2.0$ mm^3. 100 nodules were found in 50 cases.

Using these data, the FP per case and true positive fraction (TPF) were evaluated. Table 1 shows the evaluation results. The TPF for detecting nodules using only the PET images was 0.38 and that using only the CT images was 0.67. However, by combining both results, the TPF was improved to 0.80. As for the FP/case, combination result was 6.6. With regard to the FPs in CT detection, they were mainly detected at the turning-point of the blood vessel.

Figures 2 and 3 show the results that nodules were detected correctly. In Fig.2(b), PET image do not have high metabolic information. However, CT image has 1.3-cm nodule in left upper lobe (Fig.2(a)); proposed method detected the nodule using CT image. In Fig.3(a), nodule was not detected using CT image because the nodule adhered to the thoracic wall. On the other hand, big nodule was detected using PET image (Fig.3(b)) since nodule has highly uptake. Thus, it was shown that complemented detection was performed using both PET and CT images.

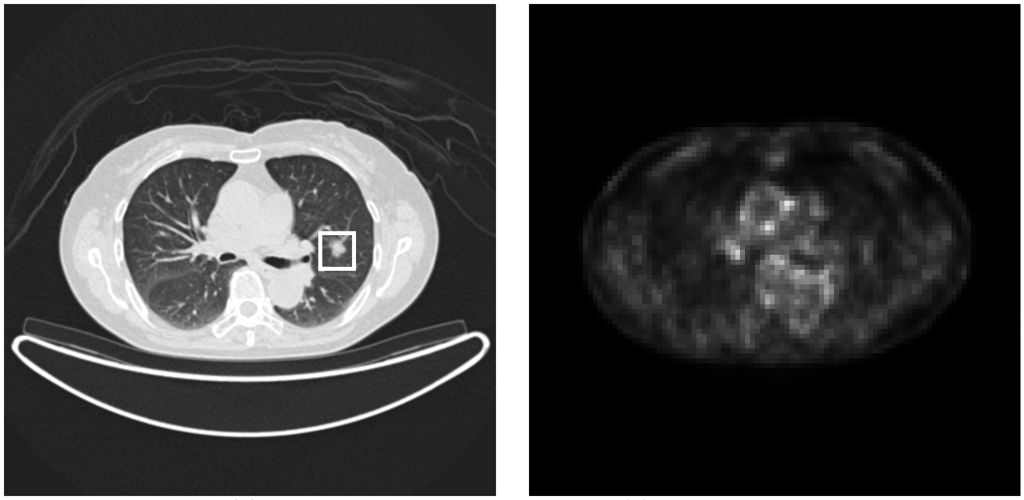
Figures 4 and 5 show the results that nodules were remained undetected. One is the GGO nodule (Fig.4), and the other is the one adhered to the thoracic wall (Fig.5).

Table 1. Evaluation result

	CT detection	PET detection	Combined
TPF	0.67 (67/100 nodules)	0.38 (38/100 nodules)	0.80 (80/100 nodules)
FP/case	5.6	1.0	6.6

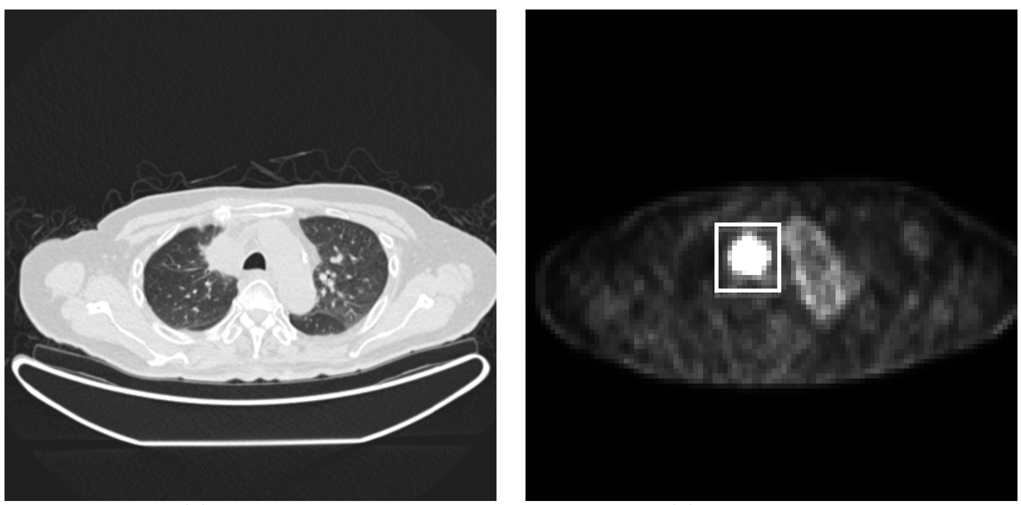
4. CONCLUSIONS

In this study, we proposed the novel method for automated lung nodule detection in PET/CT images. Proposed method detects the lung nodule from both CT and PET images. As for the detection in CT images, solitary nodules are detected using Cylindrical Filter that we developed. PET images are binarized based on standard uptake value (SUV); highly uptake regions are detected. FP reduction is performed using seven characteristic features and Support Vector Machine. Finally by integrating these results, candidate regions are obtained. In the experiments, we evaluated proposed method using 50 cases of PET/CT images obtained for the cancer-screening program. As a result, TPF of integration result was 0.80, it was much more desirable as compared to those obtained via independent detections using CT and PET images. In summary, these results indicate that our method may be useful for the lung cancer detection using PET/CT images.



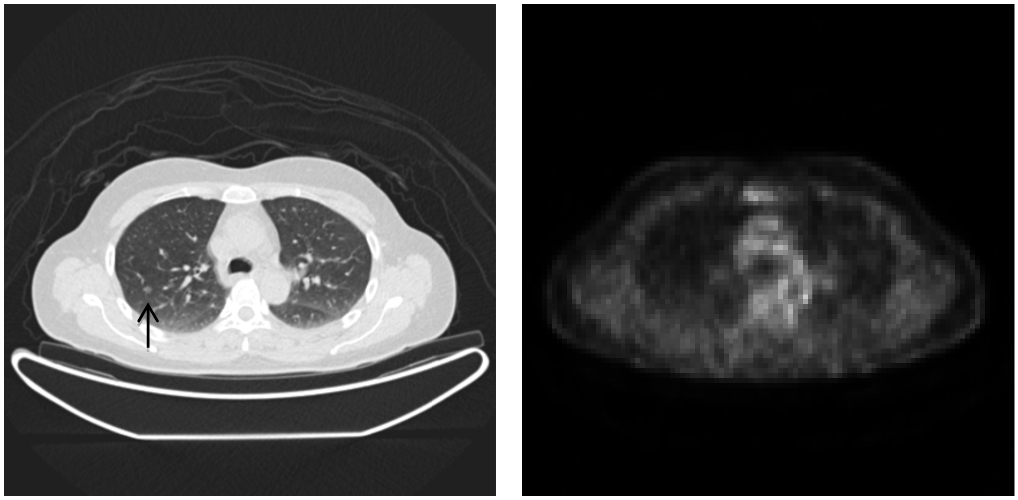
(a) CT image (b) PET image

Figure 2. Nodule detected by CT image. Box indicates the nodules detected by the proposed method. PET image does not have high metabolic information. However, CT image has 1.3-cm nodule in left upper lobe; proposed method detected the nodule using CT image.



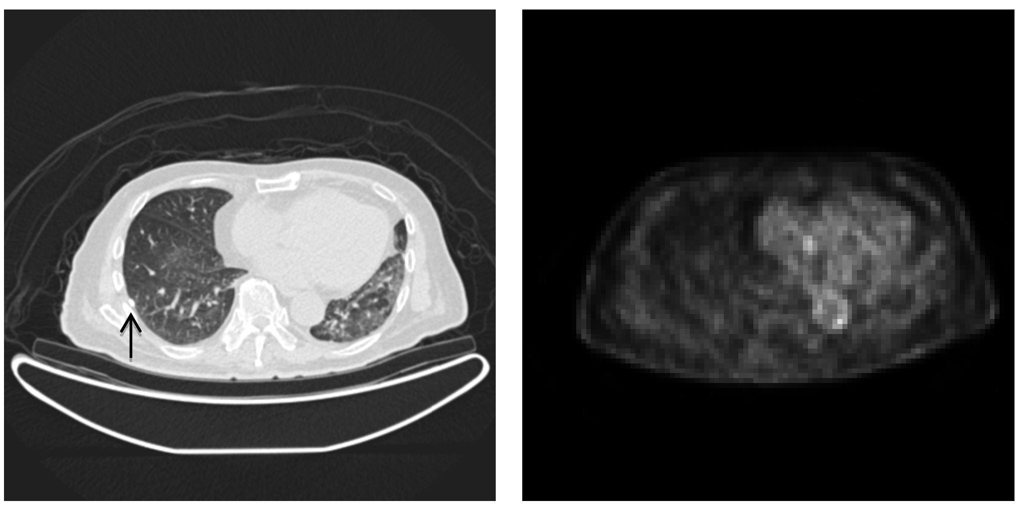
(a) CT image (b) PET image

Figure 3. Nodule detected by PET image. Nodule was not detected using CT image because the nodule adhered to the thoracic wall. On the other hand, big nodule was detected using PET image since nodule has highly uptake.



(a) CT image (b) PET image

Figure 4. Nodules remained undetected (GGO nodule). Allows show the nodules that the detection is expected.



(a) CT image (b) PET image

Figure 5. Nodules remained undetected (nodule adhered to the thoracic wall). Allows show the nodules that the detection is expected.

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