

A feasibility study on computer classification of benign and malignant tumors in lung cancer diagnosis from chest X-ray CT images
– The case of solid type of tumors –

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Abstract : In this paper, we present the result of discriminating benign tumors from malignant tumors using a feature which quantifies the similarity of tumor to sphere, and a feature which measures the clearness of the peripheral region of tumor. Various methods have been proposed including the authors' methods for the discrimination of benign and malignant tumors. But the ability of discrimination is not enough. In the clinical diagnosis, medical doctors classify tumors into the solid type and the air-containing type before the discrimination of benign from malignant tumors. Accordingly, we tried to introduce this two-class classification into computer aided diagnosis using two features that we developed. We show by the experiment using real 3D chest X-ray CT images that by doing this the performance of abnormality detection was improved significantly.

Keywords : Solid and air-containing types, Discrimination between benign and malignant tumor, Computer aided diagnosis, Chest X-ray CT image

1. INTRODUCTION

Usefulness of 3D CT images for lung cancer detection has now been demonstrated in several reports[1-3]. As the step following the detection of abnormal shadows, it is required to develop the methods to classify tumor shadows into benign and malignant tumors. Although several methods to discriminate between benign and malignant lung tumor shadows from chest X-ray CT images have been

proposed[3-5], the higher performance is required now. We notice here that medical doctors often claim that tumors are classified into two types –the solid and the air-containing types, and that features of shadows are different between benign and malignant tumors for each type. Therefore, it is thought that the ability of discrimination is improved if the classification into those two types is carried out preceding to the benign vs. malignant classification. In this paper, we present the result of preliminary experiments of discrimination for the solid type of tumors.

2. MATERIAL AND METHOD

2.1 Specification of chest X-ray CT images

Fifty-four real chest X-ray CT images taken by the X-ray helical CT scanner(TCT-900s/Super Helix) were used in the experiment. The voxel size in a slice is 0.29-0.42mm, the reconstruction pitch is 1.0mm, the size of a slice is 512 x 512 pixels, and the numbers of slices are 60-63. We assume that the positions and rough sizes of tumors are given. The set of the CT images contained the solid type of the benign tumor(hamartoma, granuloma and sclerosing hemangioma), the solid type of malignant tumor(part of adenocarcinoma, small cell carcinoma and squamous cell carcinoma), and the air-containing type of tumor. Table 1 shows the details of cases. Figure 1 is an example of the CT images used in this experiment.

2.2 Features for discrimination between benign tumors and malignant tumors

2.2.1 Coincidence degree of the tumor region and its inscribed sphere

At first, the tumor regions R_t are extracted using the methods such as thresholding and distance transformation *etc.* Figure 2 is an example of an extracted tumor region.

It is known that the shapes of begin tumors(especially hamartoma and granuloma, both the solid type) are almost spherical usually. On the other hand, malig-

Table 1. Details of cases

	benign	malignant	total
solid type	19	21	40
air-containing type	1	13	14
total	20	34	54

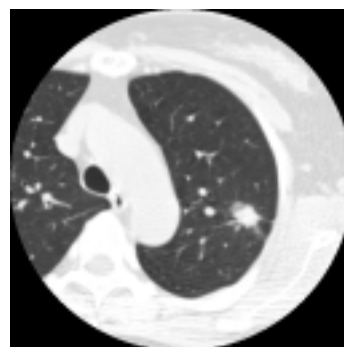
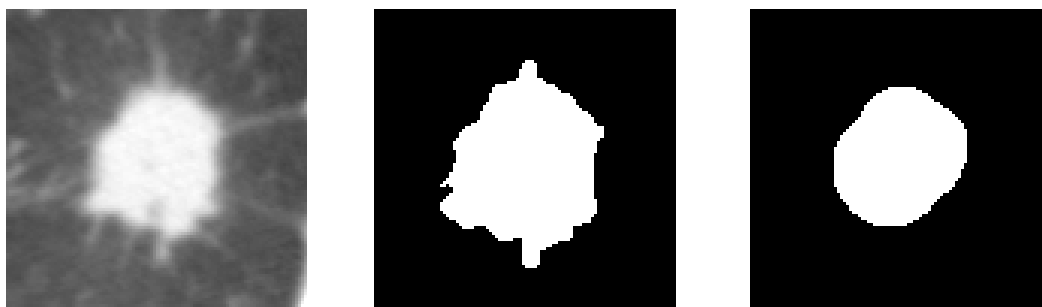


Figure 1. Example of CT images



(a) Tumor on a CT image (b) Tumor region (R_t)

Figure 2. Tumor on a CT image and the extracted tumor region

Figure 3. An inscribed spheres of tumor (R_r)

nant tumor is characterized by its unevenness in the shape. To quantify this feature, the degree of coincidence between the tumor region and the roughly approximated outline is calculated. The coincidence degree is obtained using the following steps of procedures:

[Step 1] Distance transformation of the tumor region R_t .

[Step 2] Inverse distance transformation of local maximum voxels. The obtained region is called R_r (Figure 3).

[Step 3] Calculation of the ratio R_r to R_t as the coincidence degree

It is thought that the coincidence degree takes a higher value if the tumor is benign, and the degree takes a lower value if malignant.

2.2.2 Clearness of the peripheral region of tumor

The average of CT values inside the peripheral region of a tumor takes high value, if the profile of CT value distribution on a slice has the sharp edge around the peripheral of a tumor. On the other hand, it takes lower values, if the profile is smooth. It is known that in many cases of benign tumors the outlines look clear, and they are vague in many cases of malignant tumors. Therefore, the average quantifies the clearness of the outline of a tumor and is useful for discrimination. We defined the peripheral region of tumor as the set of voxels within 2mm distance from the boundary of the tumor extracted in 2.2.1.

3. RESULTS

The scatter diagram of features for all samples (including the solid type and the air-containing type) is given in Figure 4(a). This corresponds to the discrimination of benign and malignant tumors without classification of the solid and the air-

containing type. The scatter diagram of only the solid type of tumor was also shown in Figure 4(b). This demonstrates the case of benign-malignant discrimination with the type classification. It was confirmed that the distributions of benign cases and malignant cases overlap each other in the scatter diagram without classification of the solid and air-containing type. After the type classification, two classes (the benign and malignant classes) were separated better. Therefore, it is expected that the ability of discrimination of benign and malignant tumors can be improved significantly, if tumors are precedingly classified into the solid and air-containing type.

4. DISCUSSION AND CONCLUDING REMARKS

Let us first define the following numbers to represent classification results :

TP(True Positive) : The number of malignant cases correctly decided as malignant
 TN(True Negative) : The number of benign cases correctly decided as benign

FP(False positive) : The number of benign cases erroneously decided as malignant

FN(False Negative) : The number of malignant cases erroneously cases decided as benign

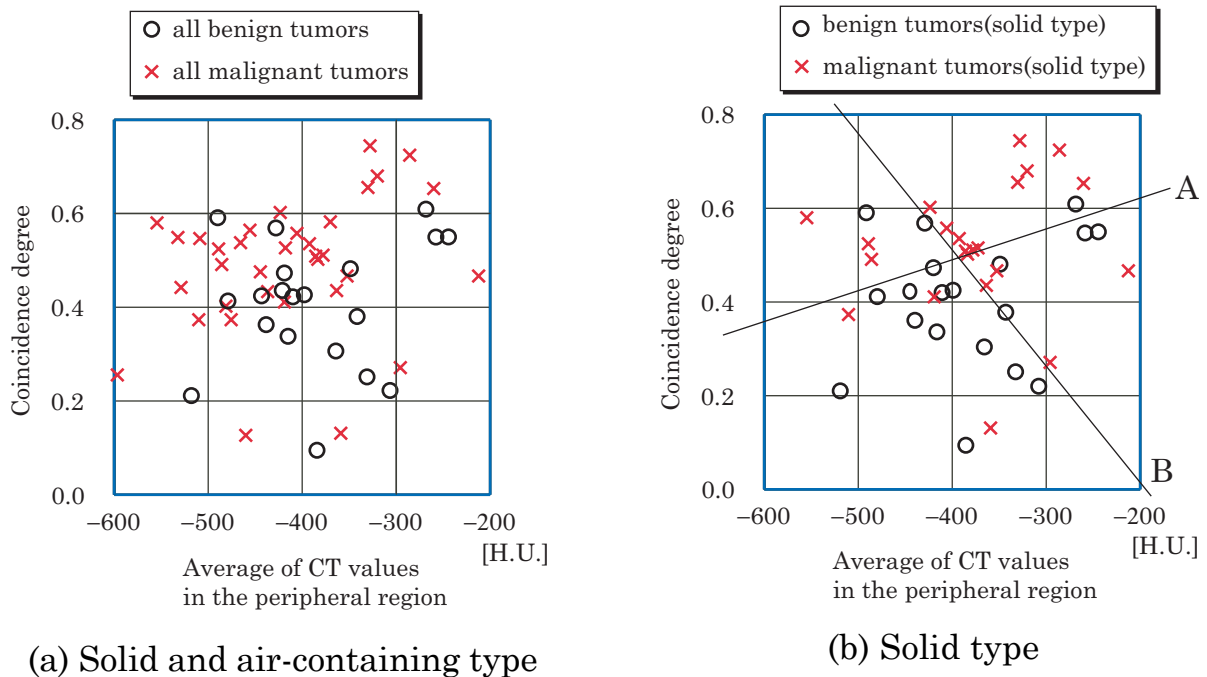


Figure 4. Scatter diagrams

Sensitivity : The ratio of TP to the number of all malignant cases

Specificity : The ratio of TN to the number of all benign cases

Then, if the linear decision boundary is selected as line A in Figure 4(b), FP is 3, FN is 7, the sensitivity is 84.2%, and the specificity is 66.7%. For the line B in Figure 4(b), FP is 5, FN is 6, the sensitivity is 73.7%, and the specificity is 71.4%. The result of applying the k-NN(k-nearest neighbor) decision rule under the Leave-one-out method, for the solid type of tumors, FP is 7, FN is 9, the sensitivity is 63.1%, and the specificity is 66.7%. For the all tumors, FP is 11, FN is 10, the sensitivity is 45.0%, and the specificity is 70.5%. We set k at 3 in this experiment. The specificity when the all tumors are used is better than the specificity when only the solid type of tumors are used. But the sensitivity is better when only the solid type of tumors are used, and the disparity of the sensitivity is greater than the disparity of the specificity.

It was shown that the performance of the tumor classifier into benign and malignant cases would be improved by classifying tumor shadows preceedingly into the solid and the air-containing type.

The future work includes the similar experiment for the air-containing type of tumors, validation of the results using a larger number of CT images, development of new features for discrimination, and development of the method for classification into the solid and the air-containing type. For the last problem we already have the preliminary results suggesting the promising performance.

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