Characterizing Pulmonary Nodule Shape using a Boundary-Region Approach

William H. Horsthemke, Daniela S. Raicu, Jacob D. Furst
DePaul University
School of Computer Science
Chicago, IL 60604, USA
horsthemke@acm.org

Abstract

Using computer-calculated features to characterize the shape of suspicious lesions aims to assist the diagnosis of pulmonary nodules; however, these computerized features must agree with radiologists' interpretation of these visual, diagnostic characteristics. In the Lung Image Database Consortium (LIDC), there exists strong disagreement among the radiologists on the ratings of the shape diagnostic characteristics as well as on their drawn outlines of the extent of the nodules. Since shape is often considered a property of the object boundary and the manual boundaries are not consistent among radiologists, new methods are necessary to, first, define region-based boundaries that use radiologists' outlines as guides and, second, adapt computer-based shape measurements to use regions rather than the traditional nodule segmentation outlines. This paper introduces a method for defining a boundary region of interest by combining radiologist-drawn outlines (the pixel-set difference between the union and intersection of all radiologist-drawn outlines for a specific nodule), then adapts a radial gradient indexing method for use within image regions, and lastly predicts several composite ratings of sets of radiologists for shape-based characteristics: spiculation, lobulation, and sphericity. The prediction of the majority (mode) rating significantly outperforms earlier work on predicting the ratings of individual radiologists. The prediction of spiculation improves to 53% from 41%, lobulation increases to 44% from 38%, and sphericity improves to 58% from 43%. A binary version of the rating has high accuracy but poor Kappa agreement for all three shape characteristics.

1 Illustration of Boundary Region Method

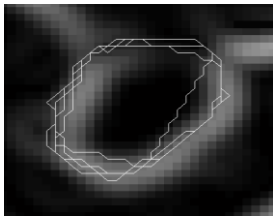

Figure 1-A

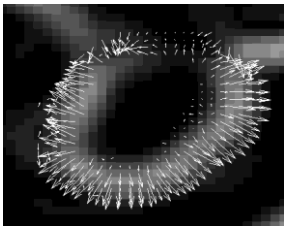

Figure 1-B

Figure 1. On a background of the gradient magnitude of the image, three (3) radiologist-drawn outlines are shown in Figure 1-A. In Figure 2-A, the white vectors indicate the direction and magnitude within the boundary region.

2 Results

Table 1. Results for predicting the median rating (1-5) for subsets of nodules based upon the number of radiologists who rated the nodule.

Performance for Predicting Median Rating on a Scale of 1-5										
	2 Raters		3 Raters		4 Raters		At Least 2 Raters		At Least 3 Raters	
	Accuracy	Kappa	Accuracy	Kappa	Accuracy	Kappa	Accuracy	Kappa	Accuracy	Kappa
Spiculation	36%	0.03	64%	0.25	50%	0.36	45%	0.19	53%	0.25
Lobulation	37%	0.03	55%	0.22	42%	0.27	34%	0.08	44%	0.20
Sphericity	60%	0.0	70%	0.39	54%	0.0	57%	0.0	58%	0.13

3 Conclusion

The results of this study show promise for rating shape-based diagnostic characteristics according to criteria formed from the combination of multiple expert radiologist opinion. The results are more promising when combining the opinions of at least three radiologists' opinions. The predictive performance is more consistent for the characteristics of spiculation and lobulation rather than sphericity. The union minus intersection approach for defining a boundary region of interest appears sufficient for capturing enough pixel data to measure shape-based image features. This method exploits the variability in radiologist-drawn outlines but will capture a small band of pixels when radiologists agree on the outline.

References

[1] Armato S.G., et al. “Lung Image Database Consortium: Developing a resource for the medical imaging research community”, Radiology, 232(3): 739-748 (2004).

[2] Horsthemke, W.H., D. S. Raicu, J. D. Furst. "Evaluation Challenges for Bridging Semantic Gap: Shape Disagreements on Pulmonary Nodules in the Lung Image Database Consortium", International Journal of Healthcare Information Systems and Informatics (IJHISI) Special Edition on Content-based Medical Image Retrieval (2009).

[3] Raicu D.S, Varutbangkul E., Cisneros J.G., Furst J.D., Channin D.S., & Armato III S.G., “Semantics and Image Content Integration for Pulmonary Nodule Interpretation in Thoracic Computed Tomography”, Proceedings of SPIE Medical Imaging (2007).