LABORATORY OF BIOLOGICAL DIVERSITY

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Image processing methods significantly contribute to visualization of biomedical targets acquired from a variety of imaging techniques, including: wide-field optical and electron microscopy, X-ray computed tomography, magnetic resonance imaging, and mammography. Quantitative interpretation of the deluge of complicated biomedical images, however, poses many research challenges. We have developed new computational methods based on mathematical morphology for quantitative image analysis. One of the most important purposes of image processing is to derive meaningful information, which is expressed as image structural properties. Mathematical morphology is a nonlinear image processing method based on set theory and is useful for the extraction of the structural properties from an image. It can be used as a fundamental tool to analyze biomedical images.

I. Novel image processing method based on mathematical morphology

Image processing is a crucial step in the quantification of biomedical structures from images. As such, it is fundamental to a wide range of biomedical imaging fields. Image processing derives structural features, which are then numerically quantified by image analysis. Contrast enhancement plays an important role in image processing; it enhances structural features that are barely detectable to the human eye and allows automatic extraction of those features. To effectively recognize a region of interest, specific target structures must be enhanced while surrounding objects remain unmodified. A contrast enhancement technique which used mathematical morphology enables selective enhancement of target structures. Based on set theory, mathematical morphology applies shape information to image processing.

Mathematical morphology operates by a series of morphological operations, which use small images called structuring elements (typically, a single structuring element is used). The structuring element acts as a moving probe that samples each pixel of the image. Since the structuring element moves in a fixed direction across the image, some intricate images (in particular, those whose structural details contain a variety of directional characters) may not be properly processed. Consequently, an artifact in the shape of structuring elements may be generated at the object periphery. Since objects in biomedical images consist of delicate structural features, this drawback is an especially serious problem.

To overcome this problem, we have proposed an extension of conventional mathematical morphology called rotational morphological processing (RMP). The RMP based morphological filters have been applied to a wide variety of biomedical images, including electron micrographs, light micrographs and medical images such as mammographic images and chest X-ray images.

In this study, we have developed a novel RMP-based contrast enhancement method. The method uses a top-hat contrast operator, a well-known and commonly used morphological operation for extracting local features from a low-contrast image. Two types of top-hat operations exist; white top-hat (*WTH*) and black top-hat (*BTH*). *WTH* and *BTH* extract structures brighter and darker than the surrounding areas, respectively. In the proposed method, these RMP-based top-hat operators are computed in parallel. We applied the proposed method to enhancement of structural features in medical images: a mammographic image and a chest radiographic image. The performance of the method was subjectively and quantitatively evaluated by the contrast improvement ratio (*CIR*). The efficiency of the method was clearly demonstrated. Figure 1 shows chest radiographic images enhanced by the proposed method.

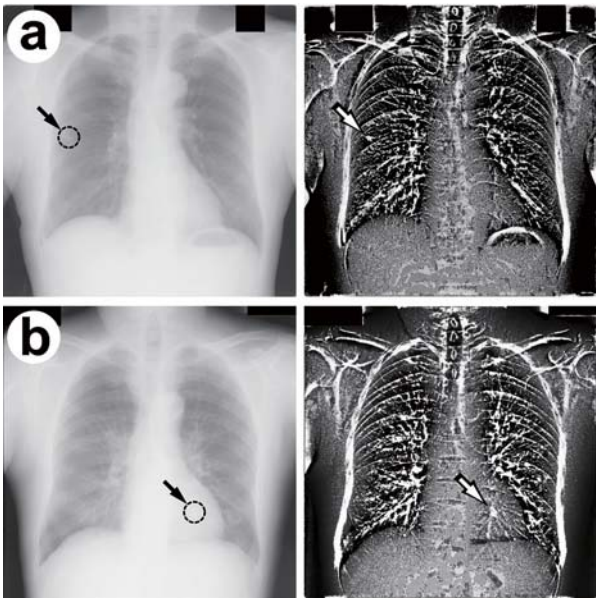

Figure 1. Enhancement of chest radiographic images. Left panel: Original chest radiographic images ((a): JPCLN80, (b): JPCLN152). Arrow in each image indicates nodule. Right panel: contrast enhanced images obtained by the proposed method. Chest radiographic images were obtained from the standard digital image database (Japanese Society of Radiological Technology).

Publication List

〔Original papers〕

- Kimori, Y. (2013). Morphological image processing for quantitative shape analysis of biomedical structures: effective contrast enhancement. J. Synchrotron Rad. *20,* 848-853.
- Kimori, Y., Baba, N., and Katayama, E. (2013). Novel configuration of a myosin II transient intermediate analogue revealed by quick-freeze deep-etch replica electron microscopy. Biochemical J. *450,* 23-35.