Gradation Processing Algorithm of Digital Radiological Chest Image

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Gradation processing technology can enhance display contrast of interested region by using linear or non-linear transform. Current algorithms generally calculate transform parameters depended on experimental statistical values or some simple image processing method such as histogram analysis. They cannot accord with the human subjective vision mechanism nor can they intelligently acquire required parameters. Therefore, processing results are not very accurate or reliable. We propose a gradation processing algorithm of digital radiological chest images based on region growing segmentation technology. It combines self-adapted segmentation with prior knowledge of directed segmentation, and its computation cost is low. It can perform contrast enhancement of the interested regions more accurately, and accords with the human subjective vision mechanism better.

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Fig 1. Original image.

GRADATION PROCESSING technology, which can enhance display contrast of an interested region using linear or nonlinear transformation, is now widely applied in clinical diagnosis. Current algorithms generally calculate transform parameters depending on experiential statistical values or some simple image processing method such as histogram analysis.^{1,2} The primary disadvantage of these methods is that they are not in accord with the human subjective vision mechanism and cannot intelligently acquire required parameters. Thus, processing results are not very accurate or reliable. We propose a gradation processing algorithm of a digital radiologic chest image, which can overcome these shortcomings.

Our algorithm is based on region growing segmentation technology, ie, separating the thoracic frontal image into several regions including background, lung, mediastinal, vertebral column, and remaining thoracic regions. First, we sampled the original image (Fig 1), which is $2,500 \times 3,000$ size, and obtained the 100×120 sampled image shown in Fig 2A; this method can greatly improve image processing speed and avoid the general disadvantage of region growing methods, ie, computing too slowly. Second, we calculated pixel grads and according to the grads threshold divide all pixels into two types of points including region center points and region edge points. As shown in Fig 2B, seed regions appeared. The neighboring

regions having similar average gray value were then merged (Fig 2C). Further extending the seed regions to annex region edge points resulted in the image shown in Fig 3A. At this point the self-adapted segmentation procedure is finished. Third, using prior knowledge of the thoracic frontal image, we merged all regions until only three regions existed: background, lung, and remaining thoracic region (Fig 3B). Then according to relative position and size between lung, mediastinal, and vertebral column, we further obtained all regions of interest (Fig 3C). Segmentation is complete. Finally, we performed nonlinear contrast enhancement separately to the regions of interest using an S-shaped curve based on their own gray distribution range, ie, got the gray look-up table. We used the common sigmod function in the neural network to express the S-shaped curve. Thus, in proper

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Fig 2. First step processed image.

Fig 3. Region segmented image.

Fig 4. Global enhanced image.

Fig 5. Local enhanced image.

order, we obtained the whole thoracic region enhanced image (Fig 4), then the lung region enhanced image (Fig 5A), the mediastinal region enhanced image (Fig 5B), and the vertebral column region enhanced image (Fig 5C). In order to accord with physicians' reading habits, our image processing method also simultaneously displays the uninterested regions, although are not clear, because it can provide doctors enough background information. Therefore, we generally set enhancement degree of interested regions only up to 90%.

Compared with existing gradation processing algorithms, our method can perform contrast enhancement of the regions of interest more accu-

rately and accords with human subjective vision mechanism better. Moreover, we give a practical combined region segmentation algorithm, which is a combined self-adapted segmentation with prior knowledge directed segmentation, and its computation cost is very low. This algorithm belongs to one kind of display enhancement technology of digital radiologic imaging, but can be also adapted to other types of x-ray images.

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