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Image processing lumbar spine to highlight the location of the herniated disc

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Abstract

Degenerative spondylolisthesis of the back is very common and requires a holistic evaluation. Abnormal MRI findings need to be associated with clinical practice because many patients are asymptomatic, but they may have abnormal MRI findings. The main objective of this paper is to automatically detect intervertebral discs in magnetic resonance imaging (MRI) with bounding boxes and their layers that can aid in MRI-based diagnosis of axial view in the lumbar position.

1 Introduction

Low back pain is a common disease. A common cause of this problem is a herniated disc in the lumbar spine. Lumbar disc herniation represents the displacement of the disc (annular fibrosis or medullary nuclei). While most cases, the pain will disappear in a few days to a few weeks; however, it can last for three months or more [1]. Detection and diagnosis are the two most important tasks in a computer-aided diagnostic system. In this article, we use images taken from the results of the MRI imaging of the patient (Figure 1). Through the use of image inversion to highlight the position of degenerative discs. This result wishes to provide a simple and inexpensive diagnostic image processing method to help doctors quickly determine the degree of disc herniation, the status of lumbar discs, they can give the appropriate treatment to the patient.

Figure 1: Original image

2 Material and method

From the MRI scan results of the lumbar spine, the image is processed by removing the excess areas around the spine. By inverting the image, the resulting black pixels become white and vice versa. Through adjusting the light intensity and selecting multiple ROIs, clear images are obtained. To make the herniated disc sites more visible, these images will be colored blue of the disc locations. This final result provides a clear image of disc abnormalities. This modeling is shown in figure 2.

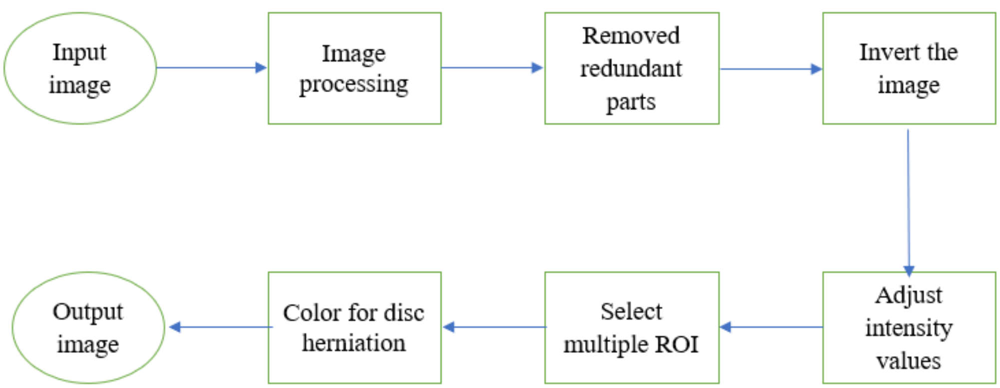

Figure 2: Image processing diagram

3 Results

We used the thresholding method to extract the discs from the MRI images of the lumbar spine. Initially, we perform logical operations between image standards is NOT (inversion) This inverts the image representation[2, 3]. In the simplest case of a binary image, the (black) background pixels become (white) foreground and vice versa. For greyscale and color images, the procedure is to replace each pixel value $I_{input}(i,j)$ as follows [2]:

$$I_{output}(i,j) = \text{MAX} - I_{output}(i,j)$$

Where MAX is the maximum possible value in the given image representation. Thus,for an 8-bit grey-scale image (or for 8-bit channels within a colour image), MAX = 255[2].

We determined that only the midsection of the image was the region of interest (ROI) because the intervertebral discs were in this region of the image. Therefore, we use a (560 × 200) pixel rectangle sliding over the spine image to remove the right and left excesses, to speed up the processing and simplify the analysis steps. Figure 3 shows the main image after removing the excess areas.

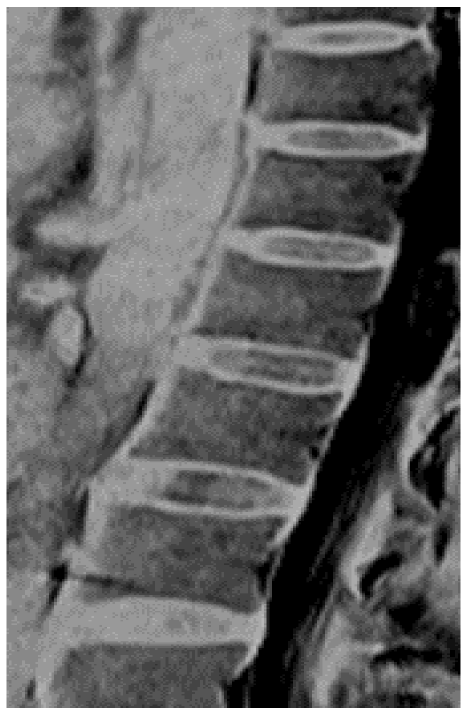

Figure 3: Image after gray level selection and redundancy removal

Image thresholding is a simple yet effective way to partition an image into foreground and background. Technical image analysis is a type of image segmentation that isolates objects by converting grayscale images into binary images [4].

Next step, using morphometric operations including contrast enhancement and noise type, we made this image smoother.

Then, we partition the image using a pair of double thresholds to achieve a suitable grayscale image. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one[5]. After studying all the threshold values, by trial and error method, we got the desired result.

This method is based on pairs of threshold values T1 and T2 will map the intensity values of the original image into the new. If g(x, y) is a thresholded version of f(x, y) at some global threshold T [5] [6]:

$$g(x,y)=\begin{cases}1 & T1\le if(x,y)\le T2\\ 0 & otherwise\end{cases}$$

In which (x, y) is the intensity value at each pixel. If the intensity at each pixel is greater than T1 and less than T2 then it will map to values from 0 to 1[5].

Figure 4 depicts the obtained binary image and figure 5 after performing morphological operations.

Figure 4: Image after processing to clarify disc

In the next step, by approaching the position of each disc, another rectangular region of size (140 × 70) pixels is placed on the image in such a way that it covers the entire disc. The process of exploiting the position of the disc is as follows in figure 5.

Figure 5: After the entire disc is covered by the rectangular region

When an overlap occurs between the rectangular area and the white pixels of the binary image, the location of a disc is found (figure 6).

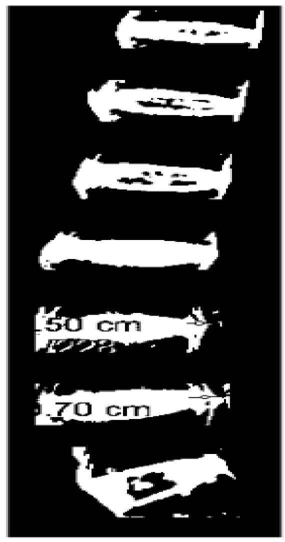

Figure 6: After identifying discs

We will colorize the discs and we can extract the discs from this image (figure 7).

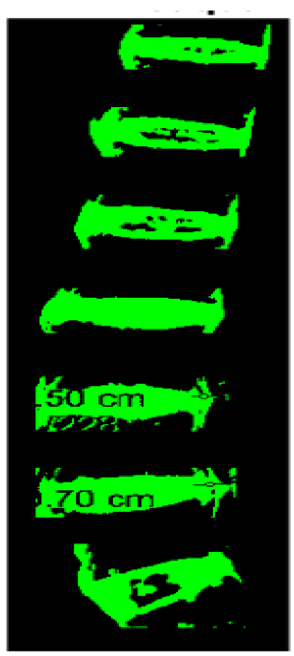

Figure 7: Discs are highlighted in green

After coloring the positions of the discs in green, the herniated positions become more obvious, making it easier to diagnose the extent of the patient's disc herniation.

4 Conclusions

MRI examination of the lumbar spine is often limited to the fact that images need to be examined statically with a relatively intermediate spine position. In addition, the injection of contrast agent is only for cases that need to be investigated for tumor pathology, vascular malformations, in cases where the spine survey is not necessary. Because the cost of an MRI with contrast injection is quite expensive, there will be patients who cannot afford it. By coloring the position of the discs, we can better see the condition of the discs to help doctors make a more accurate assessment of the degree of lumbar degenerative disease, saving a part of treatment costs for patients.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgment

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References

[1] Hồ Hữu Lương, *Đau thắt lưng và thoát vị đĩa đệm*. Hà Nội: Nhà xuất bản Y học, 2012.
[2] *Fundamentals of Digital Image Processing*. John Wiley & Sons, Ltd, 2011.
[3] E.R.Davies, "Chapter 4 - Thresholding Techniques," in *Computer and Machine Vision (Fourth Edition)*, E.R.Davies, Ed. Boston: Academic Press, 2012, pp. 82-110.
[4] M. A. Siddique, R. Arif, and M. M. R. Khan, *Digital Image Segmentation in Matlab: A Brief Study on OTSU's Image Thresholding*. 2018, pp. 1-5.
[5] B. S. Morse, "Lecture 4: Thresholding.," *Brigham Young University,* 2000.
[6] J. Rogowska, "Chapter 5 - Overview and Fundamentals of Medical Image Segmentation," in *Handbook of Medical Image Processing and Analysis (Second Edition)*, I. N. Bankman, Ed. Burlington: Academic Press, 2009, pp. 73-90.