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Improvement of automated image stitching system for DR X-ray images

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ABSTRACT

The full bone structure of X-ray images cannot be captured in a single scan with Digital radiography (DR) system. The stitching method of X-ray images is very important for scoliosis or lower limb malformation diagnosing and pre-surgical planning. Based on the image registration technology, this paper proposes a new automated image stitching method for full-spine and lower limb X-ray images. The stitching method utilized down-sampling to decrease the size of image and reduce the amount of computation; improved phase correlation algorithm was adopted to find the overlapping region; correlation coefficient was used to evaluate the similarity of overlapping region; weighted blending is brought in to produce a panorama image. The performance of the proposed method was evaluated by 40 pairs of images from patients with scoliosis or lower limb malformation. The stitching method was fully automated without any user input required. The experimental results were compared with previous methods by analyzing the same database. It is demonstrated that the improved phase correlation has higher accuracy and shorter average stitching time than previous methods. It could tackle problems including image translation, rotation and small overlapping in image stitching.

1. Introduction

In the clinical diagnosis, it is often necessary to produce panoramic X-ray images with the purpose of observing the full bone structure of the patient, such as full-spine and lower limb. However, the existing Digital radiography (DR) system can only image part of the structure in a single scan; it is important to stitch several radiographs into a panoramic image. Currently, the commonly used technology in image stitching is based on grids [1], in which the grids are attached to the image detector. The images acquired by this method are shaded by the grids, which may misinform the doctors with their observation and diagnosis results, or even lead to misdiagnosis. Another stitching method is on account of exterior characteristic [2], by which markers are set on CR cassettes and then the overlapping area of the two images are marked. Though this method is simple, it is not applicable for DR X-ray equipments. In addition to that, there are some stitching methods based on X-ray ruler [3,4], which is placed along the edges and is parallel to the bones. All of this kind of methods depend on X-ray ruler which could affect observation and diagnosis. Parallax-free long bone stitching method was proposed by Wang and Traub [5] using a C-arm rotating around its X-ray source. This method can generate a parallax-free panoramic X-ray image without the requirement of any overlapping in the X-ray images. However, the method is based on C-arm system and needs a planar marker pattern. In other words, it is not applicable for CR systems.

Recently, many researchers use stitching software to stitch X-ray images of chest [6] or use template matching [7]; it is slow and not applicable for full-spine or leg. Grieser et al. [8] also adopt image stitching program to stitch full-spine images and a significant blending line in images was produced which could lead to false diagnosis. Supakul et al. [9] take on metallic ruler as a marker and Philips software to stitch the images, whereas this method does not improve the performance of image stitching for full-spine X-ray images, and stitching software results in assessed anatomical errors in digitally stitched scoliosis films. Apart from stitching software, Kumar et al. [10] propose a stitching method for X-ray images using histogram matching and mutual information, the problem is that their technique has increased complexity and does not satisfy rotation invariant. Samsudin et al. [11] bring in minimum average correlation energy filters to identify and merge pairs of X-ray images of hand. They claim that their proposed method outperforms the normalized cross-correlation (NCC) method [12] in classifying and merging the overlapping and non-overlapping medical images, but

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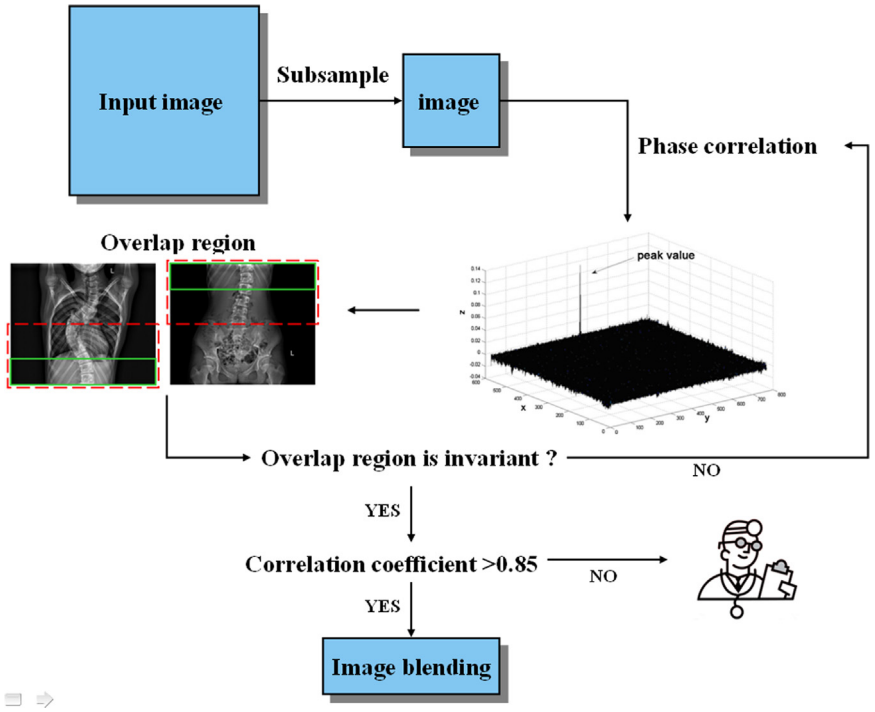

Fig. 1. Work flow diagram of X-ray images stitching method.

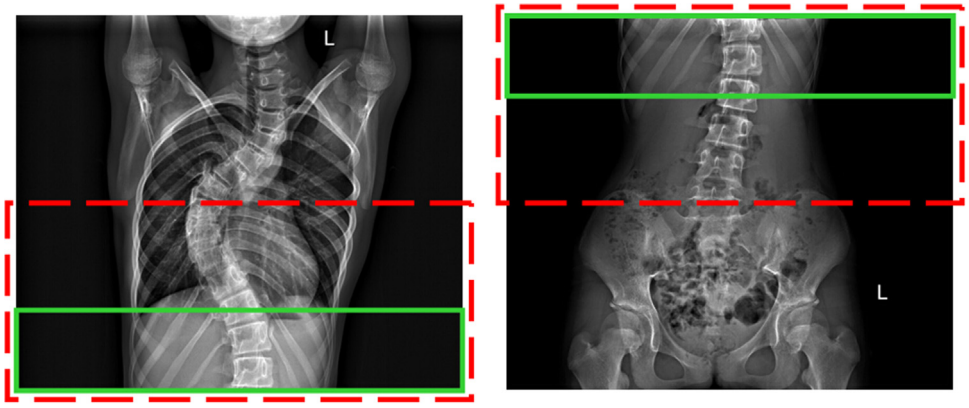

Fig. 2. The overlapping region of two images: red section (dashed line) is acquired by the first time phase correlation; green section (solid line) is acquired by the second time phase correlation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

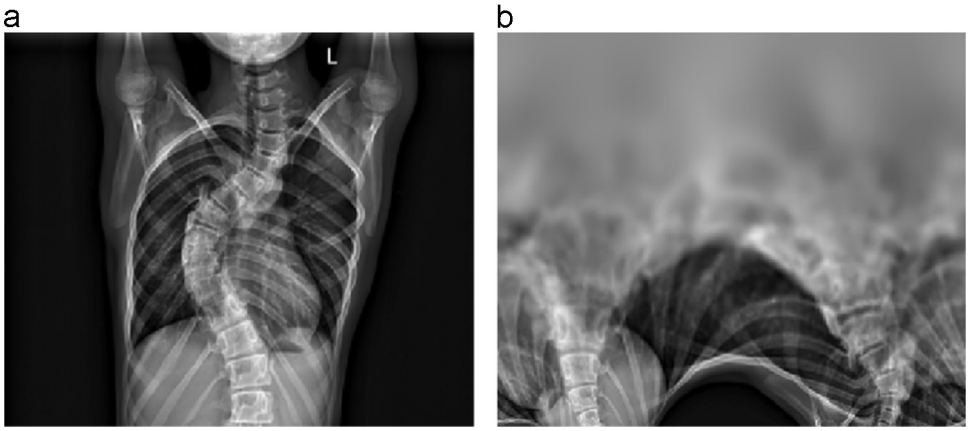

Fig. 3. (a) Original image and (b) the log-polar transformed image of (a).