Boundary Detection of Digital Hand Radiograph Images

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ABSTRACT
In this paper, we describe the of automated analysis of digital hand radiograph. Rheumatoid Arthritis causes severe damage to the joints of the body. Generally the first sign of disease is seen in the joints of the hands and feet. In this paper we present how image processing technique is applied to find out joint space width. We focused our efforts on hand radiograph segmentation since for the radiologist it is difficult task to find the actual boundary and estimate the joint space width measurements. The measurement accuracy depends on accuracy of hand radiograph segmentation. The digital hand radiograph images are preprocessed using Gaussian filter and then segmentation is done by edge based approach and binarization technique. Morphological thinning is applied on binarized image. From original image and thinned image joint Space width is estimated.

General Terms
Image Processing, Computer vision

Keywords
Rheumatoid Arthritis, Osteoarthritis, Image segmentation, Joint Space Width

1. INTRODUCTION
Rheumatoid Arthritis is a model of inflammatory disease that affects 0.5-1% of the population worldwide [1]. To quantify the minimal JSW in hands in radiographs. The fully automatic image analysis software identifies all joints of interest and their corresponding surface borders [2]. Due to the number of hand joints ,analysis of is difficult task for the radiologists. is of two types, edge based and region based [3]. In edge based approach various edge detection operators are used for edge detection such as Canny [4], Sobel [5], Prewitt [6]. Boundary is extracted using edge information in edge based approach [7]. This method gives inaccurate results in case of noisy images. While in region based approach segmentation is done with the help of regional image data.

There are many techniques for detecting boundary in medical images. Such as automatic thresholding [8], region-growing and boundary detection, statistical segmentation, active contour model [9], geodesic active contours (GAC) [10] and many more. Problem in most of the algorithms is poor quality image. While snakes model fails in detecting a boundary of small and concave region. By the use of Active Appearance Model (AAM) [11] or Active Shape Model (ASM) it will be possible to determine location of bones and estimate the bone contours [12]. The features can be extracted based on texture and intensity using Gray Level Co-occurrence Matrix (GLCM). The feature information will be extracted using statistical features like mean, median, mode, standard deviation, variance and correlation from GLCM matrix [13].

This paper deals with the problems discussed above. Hand radiograph is a two dimensional digital image. Gaussian filter is used to reduce noise. Then the segmentation of hand-bone radiograph binarization is carried out using Otsu’s algorithm. Then morphological thinning is applied to binary image [2].

This paper is organized as follows. Section 2 consists of boundary detection algorithm. Section 3 shows results of the proposed technique. Section 4 is conclusion.

2. METHODOLOGY
The hand bone structure is complex and thus very difficult to segment. Hand bone radiograph analysis starts with the detection of boundary of bones. Image segmentation is the process of distinguishing foreground objects from background. Bone segmentation is challenging task due to high noise level and low contrast with non-uniform and complex intensity distribution of radiographic image. Better segmentation than traditional methods is essential, since accuracy in segmentation determines the eventual success or failure of image analysis. Challenges are often related to low contrast and presence of noise.

In general the steps of hand radiograph analysis will be as follows

2.1 Image Pre-processing
First step will be image pre-processing where contrast improvement, noise reduction. The de-noising technique should not deteriorate or destroy the information content in the image. The objective will be to remove background noise while preserving the edge information.

Gaussian filtering is used to blur images and remove noise and detail.

In one dimension, the Gaussian function is:

$$g(x) = \frac{1}{(\sqrt{2\pi}\,\sigma)} . e^{-\frac{x^2}{2\sigma^2}} \quad .....(1)$$

Where σ is the standard deviation of the distribution.

The distribution is assumed to have a mean of 0.

Shown graphically, we see the familiar bell shaped Gaussian distribution.

Step 2. Segmentation of bone and non-bone region:
The second is to detect region of interest that will be bones and their joints in hand radiograph. The efficiency of hand radiograph analysis depends on effective segmentation. In case of severe joint damage it will be very difficult to detect region of interest. Image segmentation will be an initial step before performing high-level tasks such as object recognition and understanding. Image segmentation will be typically used to locate objects and boundaries in images.

Otsu's method is used to automatically perform clustering based image thresholding or the reduction of a grey level image to binary image. minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_{\omega}^{2}(t)=\omega_1(t)\sigma_1^{2}(t)+\omega_2(t)\sigma_2^{2}(t) \quad .....(2)$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and σ_i^2 variances of these classes. Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance

$$\sigma_b^{2}(t)=\sigma^{2}-\sigma_{\omega}^{2}(t)=\omega_1(t)*\omega_2(t)[\mu_1(t)-\mu_2(t)]^{2} \quad .....(3)$$

which is expressed in terms of class probabilities ω_i and class means μ_i.

The class probability $\omega_1(t)$ is computed from the histogram.

$$\omega_1(t)=\Sigma_0^{t}\ p(i) \quad .....(4)$$

whereas the class mean $\mu_1(t)$ is:

$$\mu_1(t)=[\Sigma_0^{t} p(i)\ \chi(i)] / \omega_1 \quad .....(5)$$

where $\chi(i)$ is the value at the center of the ith histogram bin. Similarly, you can compute $\omega_2(t)$ and $\mu_2(t)$ on the right-hand side of the histogram for bins greater than t.The class probabilities and class means can be computed iteratively.

Thinning algorithm is a Morphological operation that is used to remove selected foreground pixels from binary images. It preserves the topology (extent and connectivity) of the original region while throwing away most of the original foreground pixels.

Step 3. Feature Extraction

After the objects within the image have been determined, measurements are carried out like JSW measurement, erosion estimation, classification of bone structure and morphologic assessment.

3. RESULTS

Figure 1shows digital hand X-ray image. Figure 2 shows the result of extraction of bone and non-bone regions. Thus the boundary of hand is detected. Figure 3 shows the result of morphological thinning applied to binary image.

Figure1. Original image

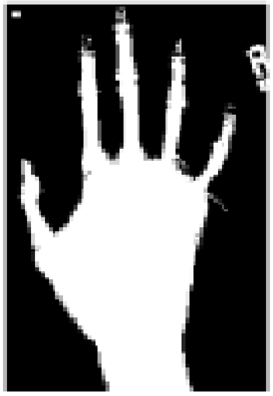

Figure 2. Binarized image

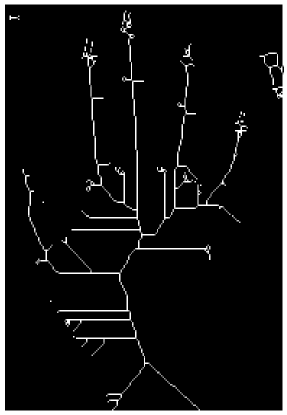

Figure 3. Thinned image

Table 1. JSW measurement in pixels

Finger	Joint name	JSW in pixels
Middle finger	DIP	11.02
	PIP	12.01
	MCP	16..74
Ring finger	DIP	10.04
	PIP	8.56
	MCP	15.21

4. CONCLUSION

The method introduced in this paper is a fully automated system to detect and measure the joint space width accurately.

The result is satisfying, moreover joint space width measurement in thumb and little finger is in progress.

This system may fail if joints are infected by disease to the extent that the joint space is no longer observable in the X-ray photo.

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