

Chapter 5

Semi–Automatic Vertebra Segmentation

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ABSTRACT

*The efficient content-based image retrieval of biomedical images is a challenging problem of growing interest in the research community. This book chapter describes a framework with two segmentation methods to analyze **X-ray images** of the **spinal columns** in order to extract vertebra regions and contours. The authors describe an application of the proposed methods which consists on an evaluation of vertebra motion induced by their movement between two or several positions. Their framework permits to extract the parameters determining **vertebral mobility** and its variation during flexion-extension movements. The first approach on our framework consists of a new contour vertebra detection technique using a **polar signature** system combined with a **template matching** process. This approach is based on a preliminary selection of vertebra regions. The second approach of our framework is based on automatic corner points of interest detection using the Harris **corner detector**.*

INTRODUCTION

Most of the existing research in **medical image segmentation** has focused on magnetic resonance (MR) and computed tomography (CT). Much less work has been done in the segmentation of **X-ray images**. Nevertheless, medical specialists often examine **X-rays images** of spinal columns to determine the presence of abnormalities or dysfunctions and

to analyse the **vertebral mobility**. To help them to establish a good diagnosis, there exist medical image processing and analysis applications to automate different tasks dealing with the interpretation of these images. In our work, we use X-ray image instead of other kinds of medical images like CT—computed tomography—or MR—magnetic resonance—in order to avoid the high level of radiation received by the patient in the case of magnetic resonance or computed tomography. Another reason is the large quantity of information to be acquired and

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processed, and the cost of these methods which make them less functional.

In this work we propose a framework for **vertebral mobility** analysis using vertebra orientation angles applied to X-ray images of the cervical, lumbar and dorsal **vertebrae**. The purpose of the diagnosis is to extract some quantitative measures of particular changes between images acquired at different moments.

Extraction of **vertebra contours** from X-ray images is an important first step in computer analysis applied to medical images of the spinal column. Several methods have been applied to vertebra segmentation (Duncan & Ayache, 2000). Techniques using Hough Transform (Howe, Gururajan, Sari-Sarraf, & Long, 2004; Tezmol, Sari-Sarraf, Mitra, Long, & Gururajan, 2002), deformable models (Pham, C., & Prince, 2000) such as active contour (Kass, Witkin, & Terzopoulos, 1987), active shape models (Cootes, Hill, Taylor, & Haslam, 1994), and level set methods (Sethian, 1996; Lam & Yan, 2007) are some examples of the various approaches developed.

Several methods have been proposed in the literature to analyse and to extract **vertebra contours** from X-ray images (Rico, Benjelloun, & Libert, 2001; Benjelloun, Tellez, & Mahmoudi, 2006). Extensive research has been done by Long et al. (Long R., L., & G.R., Thoma, 2000) and (Long R., L., & G.R., Thoma, 2001) to automatically identify and classify spinal vertebrae, where they formulate the problem of spine vertebra identification in three levels of processing: in the first stage a heuristic analysis combined with an adaptive thresholding system is used to obtain basic orientation data, providing basic landmarks in the image; in the second stage, boundary data for the spine region of interest is defined by solving an optimization problem; in the third a deformable template processing is used to locate individual vertebra boundaries at finely grained level. The main drawback of this approach is the requirements in terms of greyscale thresholding. Stanley and Long (Stanley, Long, Antani, S, GR, & Edward, 2004) proposed a new method

of subluxation detection. They used the spatial location of each vertebra in the spinal column and the variation in its position. They applied a second order spinal column approximation by using the vertebral centroid. The goal of their approach was to quantify the degree to which vertebra areas within the image were positioned on their posterior sides. In another work, Rodney and Thoma (Long R., L., & G.R., Thoma, 1999) described a reliable method for automatically fixing an anatomy-based coordinate system in the image with an adaptive thresholding system.

In this work, we propose to investigate a framework with two segmentation methods. The first is based on a **polar signature** system combined with a **template matching** process. The second one is based on Harris **corner detector** allowing determining the corner points of interest in order to extract spine position.

These two methods proposed are implemented in order to compare their performance and to select the most appropriate one. Each method presents a different semi-automatic computer based technique. The goal of this framework is to extract some parameters characterizing each vertebra, related to their form, position and orientation. Among these parameters, the anterior faces of the vertebrae allow to determine the mobility of each vertebra compared to others in the same image, as well as the corresponding vertebrae between several images. Indeed, it is easier to work with the anterior face representation rather than work with the complete vertebra contour. The reason is the noise located inside vertebra.

We remark that the X-ray images used for our experiments correspond to real patients and were provided by radiologists, Figure 1. For each patient three images were taken, after this we proceed to the segmentation of each one. Each image corresponds to a different position: neutral, flexion and extension, Figure 2.

This paper is organized as follows: In sections 2 and 3 we present the principles of the two segmentation methods proposed in this framework.

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