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Automated Vertebrae Extraction Using Watershed Segmentation and Tree-based Modelling Approach ⋆

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Abstract

Vertebra segmentation and extraction are essential steps for automated vertebrae fracture assessment system. This study focuses on vertebra segmentation, which is a challenging task due to high noise and poor contrast of X-Ray images. The objective of this study is to develop and test an automated cervical vertebrae extraction to facilitate the medical researchers and physicians. The novelty of the proposed method is the combination of watershed segmentation and tree-based modelling algorithm. The proposed method has been successfully applied to a set of 50 cervical X-Ray images. Five performance metrics are calculated, which are accuracy, sensitivity, specificity, correlation and error where the best obtained results are 0.9886, 0.0655, 0.99, 0.7246 and 0.01135, respectively.

Keywords: Medical Imaging; Cervical Vertebrae; Segmentation; Watershed; Tree-based Modelling

1 Introduction

Medical Imaging (MI) technology has become part of diagnostic tools to facilitate and assist medical professional in providing medical treatment accurately and efficiently. MI also plays an important role to detect many orthopaedic conditions, such as vertebrae fracture and osteoporosis. It allows the experts to see the finest details of the images which are difficult to distinguish with the naked human eyes. Thus, Biomedical Image Processing (BIP) has become more important in medical treatment, as it offers additional information on the patient's health which can be used by the medical professionals to diagnose the disease just by investigating the medical images [1,2]. In addition, BIP allows fast check-up screening compared to the guide book procedures [3]. Moreover, BIP also enhances the features and characteristics of the disease for clearer judgement by the medical professionals [4]. There are various types of medical imaging modalities, for example, Computed Tomography image (CT scan), X-Ray image, Magnetic Resonance Image (MRI), Single

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Photon Emission Computed Tomography (SPECT), Position Emission Tomography (PET) and Digital Radiography [5,6]. X-Ray image is one of the earliest and oldest photographic films used in medical diagnostic and treatment. It is a very valuable modality that facilitates the physicians and doctors in determining and evaluating the vertebra related diseases. The spine or also known as vertebral column is one of the most significant structures inside human body where it primary functions is to support the upper limb. Human vertebral column consists of four major segments of vertebrae, namely, cervical, thoracic, lumbar, and sacral & coccyx as shown in Fig. 1.

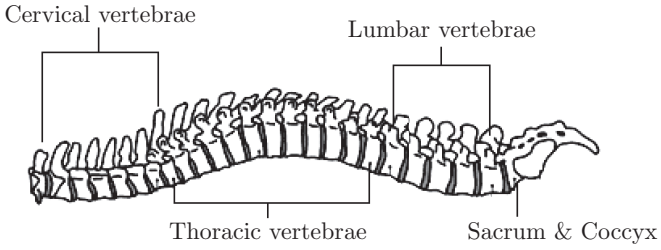

Fig. 1: Different regions of the vertebral

Specifically, for spine disease, X-ray image has been used as an excellent indicator to determine the vertebrae fracture. Normally, vertebra fracture can fall under one of the following categories, which are Anterior Osteophytes (AO), Disc Space Narrowing (DSN), subluxation, and spondylolisthesis [7]. In order to develop an automated vertebra fracture detection system, a good vertebrae segmentation module is needed. In this case, segmentation is a process, which the contour of the cervical images are identified and marked for further action and examination [8]. The aim of vertebra segmentation is to use only the valuable details and information for better image interpretation [9]. Those details are important especially for detection for traction or claw of the AO [10]. Even though, vertebrae can be observed by the naked eyes in the X-ray image but segmenting and extracting the vertebrae automatically is a challenging task. This is due to noise and complex shape where each patient has different appearance and vertebra shape [11]. Hence, the goal of this study is to develop vertebra segmentation and extraction system that automatically determine the location of the cervical vertebra. The main novelty lies on the combination of watershed algorithm and tree-based modelling approach. The organization of this paper is as follows; section II describes the literature review on the previous works; section III explains on the general framework and details out the proposed method; section IV presents the experimental results and discussion, while the last section concludes the study and describes some future works.

2 Literature Review

Vertebra segmentation is an important task to determine the location of the cervical vertebrae. There are various segmentation methods have been proposed on vertebrae extraction, such as active shape model [9], Generalized Hough Transform (GHT) [12] and level set [13]. Mustapha et al. [14] has developed an Automatic Vertebral Fracture Assessment System (AVFAS) for vertebral pathologies diagnosis based on radiography X-ray image. They segmented the vertebrae using ASM model to obtain the boundary shape. Two schemes were used to outline the vertebra shape; 9-anatomical Point Shape (9-APS) and B-Spline technique (B-SR). The features were then extracted based on the vertebrae shape, which are eigenvector, Gabor wavelets, Gray-Level Co-Occurrence Matrix and orientation histogram. The original Active Shape Model (ASM) in