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AUTOMATIC ANALYSIS OF MR SEQUENCES FOR THE DIAGNOSIS OF LIGAMENT LESIONS

L. S. Dooley*, F. Höwing**,*** and D. Wermser**

*Monash University, School of Computing and I. T., Churchill, Victoria 3842, Australia
**Fachhochschule Braunschweig/Wolfenbüttel, FB E, Wolfenbüttel, Germany
***University of Glamorgan, School of Electronics, Pontypridd, UK

laurence.dooley@infotech.monash.edu.au

Abstract: To date the diagnosis of carpal instabilities due to ligament lesions relies on a qualitative examination of the patient’s wrist. This paper presents a novel system where sequences of magnetic resonance images are automatically analysed to measure the motion of seven wrist bones. Resulting motion graphs provide a quantitative basis for diagnostic as well as scientific purposes. As the imaging method is non-invasive up to twelve wrist positions can be measured giving a detailed insight into the bone’s motion.

Introduction

In many cases articular damages cannot be diagnosed through an examination of a single image. A motion analysis of a joint’s bones might be necessary to make a reliable diagnosis [1,2]. Examples are lesions of the ligaments and cartilage of the knee or in the cervical and lumbar regions of the vertebral.

This paper presents a novel system to diagnose lesions of the ligaments of the wrist (carpal instabilities [3]). The method is particularly well-suited to aid in the diagnosis of the scapho-lunate instability. This damage is a common injury after accidents involving the wrist. The lesion occurs when the ligaments between the Scaphoid and the Lunate are torn [4].

Methods

Motion graphs (Fig. 1) show the rotation as well as the translation of the carpal bones. The measurement is performed relative to an anatomic co-ordinate system defined by the distal end of the Radius.

Compared to other applications [5] a motion analysis of wrist bones is more difficult because there are many bones with a similar shape which complicates their identification. Furthermore some of the bones may tilt, that is they may rotate around axes not perpendicular to the view plane. This results in a varying appearance of the bones in the sliced magnetic resonance (MR) images.

The overall system comprises the following components:

• **Image acquisition** – For each wrist position 12 layers of the hand are acquired.

![Figure 2: Motion graph – Collection of measurement results for several wrist positions. This graph shows the rotation of the wrist bones for a healthy patient. The rotation of each bone is normalised to its angle at the wrist’s neutral position.](image-url)
• **Layer selection** – An approach based on the Fourier-Mellin transform [6] allows for the selection of an MR layer which is best suitable for the measurement by comparing the input layers with a reference image.

• **Segmentation** – An adaptive threshold is applied to an automatically selected region of interest (ROI). To obtain a higher precision the algorithm is applied in two stages to the ROI of the wrist and to smaller ROIs of the individual bones.

• **Identification of the bones** – Constrained by their possible motion the relevant bones are identified through an analysis of the shape and position of a set of candidate bones.

• **Measurement of translation and rotation** – For each bone its major axis and centroid is determined (Fig. 2).

• **Motion graphs** – The measurement results of usually about 8 different positions of the wrist are collected (Fig. 1).

A good segmentation was also obtained for other carpal bones, allowing the system to be applied to the diagnosis of other carpal instabilities as well.

**Discussion**

Based on the measurements the system delivers it is now possible to prepare highly relevant statistics which will provide a comparative basis for future diagnosis and generally to investigate the normal kinematics of the wrist as well as its pathomechanics. Unlike other approaches where markers are implanted in cadaveric specimens [7] the method presented in this paper is non-invasive, produces no radiation and hence allows for a more realistic analysis of a large number of healthy as well as pathological wrists beyond the application of a diagnostic tool.

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