

Auto Alignment of intervertebral disks

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Introduction

The automation of positioning the double oblique slices for scanning the intervertebral disks or bodies is highly requested this day's due to the large amount of slipped disks and similar pathologies. The requirements for such a method is as usually for automated procedures a high reliability and reproducibility with few interactions. The new approach consists of two sequential steps, first the acquisition of a myelogram for the segmentation of the cerebro-spinal fluid in the spinal cord and afterwards the acquisition of a T2-weighted image for the calculation of the disk positions along the spine. Both steps are done for sagittal and coronal slice orientation in order to gain two angles for the double oblique positioning on the following scans.

Materials and Methods

Data acquisition:

Measurements were performed on healthy volunteers. All images were acquired on a 1.5T scanner (Siemens Sonata). The protocol consisted of sagittal and coronal HASTE scans to acquire the myelogram and a T2-weighted TSE. The FOV is set identically for both sequences to readoutFOV=280mm and phaseFOV=80%. The parameters for HASTE are TR=2800ms, TE=1100ms, slice thickness=60-70mm. The parameters of the T2-weighted TSE are TR=4570ms, TE=109ms, slice thickness=5-6mm and number of slices =10.

Data analysis:

In the first step the histogram of the myelogram is calculated and the logarithm is taken. After smoothing the histogram with a low pass filter it can be characterized as bimodal. A threshold between the two peaks is calculated and applied on the myelogram to segment objects, which represent fluid. Dependent on the amplitude of the fluid signal this might result in more than one object. Finding a closed line along the spine eliminates non-spine objects (fig. 1 and 2). The coordinates of the line and the slice orientation data are transferred via hard disk to the second step.

Out of the slice volume of T2-weighted images the slice with the same geometrical data as the myelogram is selected. After registration of both images the coordinates of the spine (step 1) are drawn as overlay on the T2-weighted image (red line in fig.3-5). The different size of the disks along the spine is taken into account with a scaling factor, which is effective on all following processing steps. Three parallel projections (green lines in fig.3), which represent the pixel intensities along the spine are smoothed with a low pass filter. Then the derivatives are calculated and the inflection points are searched for each projection and are matched. The maximal inflection points initialise the positions of the disks (small red lines in fig.3). As in the first step a threshold between background and objects is calculated in the T2-weighted image. It is used for masking the image in a ROI for each initial position along the spine (figure4). After applying morphological operators and confined region growing the final mask is taken for each position. Each centre of gravity of the mask represents a final disk position and is interpreted as origin of a straight line. The slope of the straight line is fitted with linear regression and χ^2 is the quality factor. Over all positions χ^2 is accumulated and should be minimized. Thus the whole procedure starting with the projections and ending with positions is iterated over the scaling factor. The scaling factor for example downsizes the distance of the projections and the size of the ROI. The minimal χ^2 out of all scaling factors determines the final positions and the slopes of the straight lines define the angles of the disks (figure 4 and 5). Finally the results are converted into the coordinate system of the scanner and serve as input for slice positioning on the intervertebral disks in the following scans.

Results

All parameters in the processing are calculated independent of any interaction. The method was tested on 20 volunteers for the sagittal slice orientation and has shown a high reliability in finding disks positions and orientations. The slice positions and angles from one volunteer calculated in prescans from different scan sessions were highly reproducible and the slice prescription can't be differentiated visually on the exam viewer.

Discussion

The new approach can prescribe double oblique slices for scanning the intervertebral disks automatically with high reliability and reproducibility. Two prescans for each slice orientation and a short calculation time are necessary ahead of the normal clinical protocol for positioning several slices. Beside the common approach the slices are tilted in 2 dimensions and thus produce very accurate images in patients with for example scoliosis.

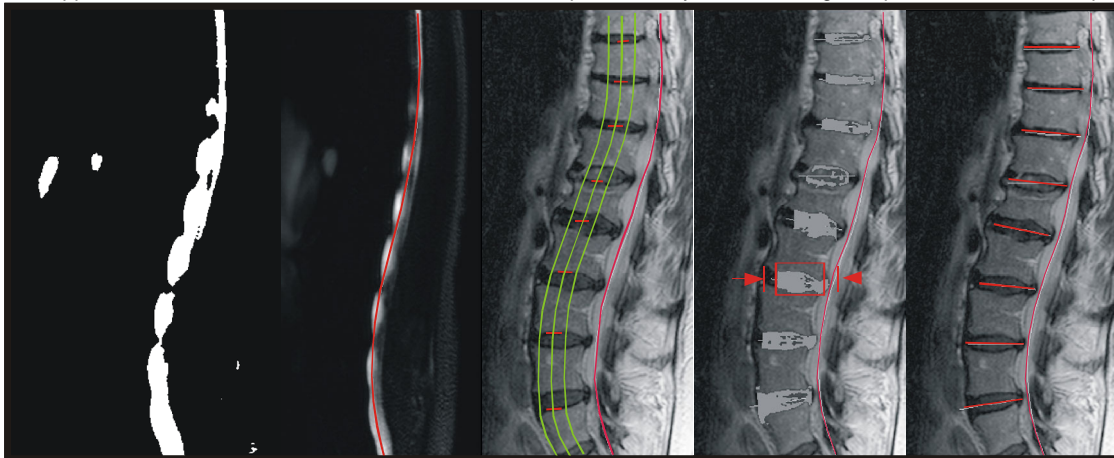


fig1: objects after segmentation

fig2: overlaid spine on myelogram

fig3: projections on T2- image and initial positions

fig4: example ROI and masks

fig5: final positions and angles in 2D