DETECTION OF JOINT SPACE NARROWING IN HAND RADIOGRAPHS

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Background: Computer-aided or fully automated measurement of radiographic joint damage may help to overcome the limitations of such measurements by human experts.

Objectives: To design an automated method for measuring the joint space width with a higher sensitivity to change than manual methods. The large variability in joint shapes and textures, the possible presence of joint damage, and the effects of projection make it difficult to detect joint margins accurately. Our project aims at an fully automated analysis of joint damage caused by arthritis in hand and foot joints.

Methods: We used 100 digital scans of single hand radiographs with a pixel size of 50 micron. We determine eight regions of interest (ROI) near the center of the MCP and PIP joints 2-5 with our previously developed segmentation algorithm (Moens, 2005). The ROIs are positioned parallel to the direction of the midline of the proximal phalanges. These regions of interest are then extracted for further processing. Fifty images from our dataset were used to create active shape models (Cootes, 1994) of the joint margins. 25 equidistant markers are used to describe the possible shapes of each joint margin. The pixel values in the area around the markers are used to train a Mahalanobis classifier that is used for margin detection. The active shape search is initialized with the mean shape of the joint margins of the training set in the center of the ROI. By scanning perpendicularly to the joint margins with the Mahalanobis classifier possible margin candidates are found. To detect the most plausible margins, we use a dynamic programming approach. Since the shapes are constrained by a model of the joint margins, only plausible margin shapes can be detected.

Results: We tested our algorithm on a set of 50 radiographs from patients that were not in the training set. The detected joint margins were compared to manually outlined margins by an expert. The absolute differences were within 0.065 mm for the automated method, and 0.20 mm for manual readings for 90% of the measured joints. These results were comparable for the various PIP and MCP joints. Others have developed automated methods for detecting joint margins (Angwin, 2001; Duryea, 2000; Sharp, 2000). New in this work is the use of shape models to constrain the shapes of the margins and the use of a Mahalanobis distance classifier for edge detection

Conclusion: The described method for detecting joint margins is robust and accurate in cases where the joint margin is clearly visible. For cases where the joint space has disappeared due to severe joint damage, the algorithm is unable to estimate the margins correctly. From these, it would be necessary to use a different method to quantify joint damage. The constraints set by the shape models prevent the detection of false edges, but also limit the possibility of detecting unusual margin shapes and small erosions.

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