Title:
Towards the development of an accurate and repeatable method for assessing the progression of osteoarthritis from standard radiographs

Authors:
M. Seise, S.J. McKenna, I.W. Ricketts, C.A. Wigderowitz

Address:
Division of Applied Computing, University of Dundee, Dundee, Scotland, DD1 4HN

Orthopaedic and Trauma Surgery, Ninewells Hospital and Medical School, Dundee, Scotland, DD1 9SY

Corresponding Author: M. Seise, mseise@computing.dundee.ac.uk

X-ray radiography is the most common modality for assessing progression of knee osteoarthritis. The primary radiographic sign is the apparent space between the tibial plateaux and femoral condyles. Further signs include osteophytes, subchondral sclerosis and cysts. Joint space narrowing when quantified using current techniques has large inter- and intra-observer variability [1] resulting in measurements of doubtful clinical significance [2]. Automated measurement of joint space width has been attempted [3] but objective methods for quantifying this and other radiographic signs with sufficient accuracy and reliability for standard clinical use are not available.

Software for automated segmentation of tibial and femoral contours was developed as an important step towards providing such methods. The core algorithm estimates statistical models of shape and appearance variation from annotated radiographs and subsequently uses these models for segmentation. It incorporates a novel extension to active shape models [4] that enables anterior and posterior contours of the tibial plateaux to be found simultaneously.

The method was evaluated on 30 digitised, standard clinical radiographs of non-osteoarthritic knees (1 pixel = 0.17 mm on the film) using leave-one-out validation. Segmentation accuracy for each radiograph was quantified as the mean point-to-boundary error. Medians of these errors were 3.3 and 2.3 pixels for tibia and femur respectively. Errors on tibial plateau and femoral condyle sections of the contours (of particular importance for joint space measurements) were 3.2 and 2.0 pixels for tibia and femur, respectively. Fractions of cases segmented with mean error less than 5 pixels were 23/30 and 28/30 for tibial plateaux and femoral condyles respectively.

Although these results are promising, further work is needed to eliminate the few cases with gross errors and improve accuracy. An accurate segmentation of tibial plateaux and femoral condyles makes possible computation of various measures characterising joint space. Segmentation of both posterior and anterior contours provides 3D pose information currently absent from estimation of joint space in plane radiographs. This should enable measures more strongly correlated with the actual volume of cartilage than the commonly used minimum joint space width to be obtained. The segmentation method will also be extended to enable automated detection and characterisation of osteophytes and to constrain analysis of sclerosis and cysts.

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