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2D Convolutional Networks for Automatic Segmentation of Knee Cartilage in 3D MRI

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Abstract : Accurate segmentation of knee cartilage in 3-D magnetic resonance (MR) images for quantitative assessment of volume is crucial for studying and diagnosing osteoarthritis (OA) of the knee, one of the major causes of disability in elderly people. Radiologists generally perform this task in slice-by-slice manner taking 15-20 minutes per 3D image, and lead to high inter and intra observer variability. Hence automatic methods for knee cartilage segmentation are desirable and are an active field of research. This paper presents design and experimental evaluation of 2D convolutional neural networks based fully automated methods for knee cartilage segmentation in 3D MRI. The architectures are validated based on 40 test images and 60 training images from SKI10 dataset. The proposed methods segment 2D slices one by one, which are then combined to give segmentation for whole 3D images. Proposed methods are modified versions of U-net and dilated convolutions, consisting of a single step that segments the given image to 5 labels: background, femoral cartilage, tibia cartilage, femoral bone and tibia bone; cartilages being the primary components of interest. U-net consists of a contracting path and an expanding path, to capture context and localization respectively. Dilated convolutions lead to an exponential expansion of receptive field with only a linear increase in a number of parameters. A combination of modified U-net and dilated convolutions has also been explored. These architectures segment one 3D image in 8 – 10 seconds giving average volumetric Dice Score Coefficients (DSC) of 0.950 - 0.962 for femoral cartilage and 0.951 - 0.966 for tibia cartilage, reference being the manual segmentation.

Keywords : convolutional neural networks, dilated convolutions, 3 dimensional, fully automated, knee cartilage, MRI, segmentation, U-net
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