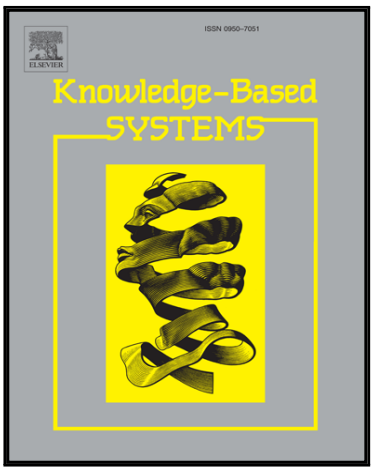

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Symmetric Convolutional Neural Network for Mandible Segmentation

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Abstract

Mandible segmentation is an essential step in craniomaxillofacial surgery planning, which aims to segment mandible from multi-slice computed tomography (MSCT) images. One main disadvantage of most existing mandible segmentation methods is that they require numerous expert knowledge for semi-automatic segmentation. However, the high-quality expert knowledge is hard to achieve in practice due to the scarcity of experienced doctors and experts. To solve this problem, we propose an end-to-end trainable deep learning based method, which performs segmentation in an automatic, accurate and efficient manner. Different from the popular convolutional neural network (CNN), our proposed symmetric convolutional neural network (SCNN) enforces convolution and deconvolution computation to be symmetric as to achieve a good segmentation performance. Furthermore, benefiting from the manner of end-to-end, SCNN could automatically perform mandible segmentation from raw image data. Such advantages remarkably reduce the human effort and achieve competitive performance. To verify the effectiveness of our method, we build a multi-slice computer tomography mandible dataset which includes 93 cases. The experimental results show that the proposed SCNN is superior to several popular baselines in terms of the dice similarity coefficient (DSC).

Keywords: Automatic mandible segmentation, Symmetric convolutional neural network, End-to-end medical image segmentation.

1. Introduction

Multi-slice computed tomography (MSCT) images consist of a series of cross-sectional images scanned from different angles with a specific interval. Mandible segmentation aims to segment the mandible from MSCT images, which is widely used in the areas of computer-aided diagnosis including but not limited to mandible fracture treatment, fracture location, fracture classification, forensic sex identification, and computer-assisted surgery planning [1]. A highly accurate mandible segmentation is a key step in preoperative planning in craniomaxillofacial surgeries, which provides evidence towards the final decision of surgeon. In practice, there are some challenges in mandible segmentation from MSCT images as follows.

First, complex mandible stereo shapes and non-standard scan posts make mandible segmentation challenging and difficult. The mandibular condyle is quite different from the mandibular body on the transverse plane, where the former will generate different views of the mandible in transverse plane slices. Moreover, low contrast and resolution of MSCT images further increase the difficulty to MSCT image segmentation. What is more challenging is that transverse slices include various mandible deformations caused by lack of uniform pose criterion during scanning MSCT images.

Second, it is difficult to build an MSCT mandible dataset. Mandible MSCT images are different from cancer, brain, and lung images which have been well-established in a large number of works [2]. Although hospitals have collected many mandible MSCT data, most of the data contain unusable fracture cases since some patients receive MSCT scanning at the last minute. In other words, the data in the transition stage is missing. Furthermore, it is a daunting task to manually annotate the mandible mask from each transverse slice at the pixel level.

Finally, some intrinsic properties of mandible make it difficult to be segmented from MSCT images. More specifically, some parts of the mandible are remarkably smaller than the mandible body, for example, mandibular condyle area only takes around 14% area of

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