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Convolutional Neural Networks for Image Segmentation in Clinical Applications

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Statement of Originality

I hereby certify that the work embodied in this thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968.

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Contents

Abstract

The convolutional neural network (CNN) has been remarkably successful in performing automatic image segmentation in a number of clinical applications. It is able to decrease the time taken for the segmentation process as well as minimise the errors with respect to manual segmentation by a human operator. However, most of the developed CNN architectures have redundant components and trainable parameters. These redundancies cause the implementation of a CNN to be expensive in terms of time and memory usage. In this thesis, we study several CNN architectures in terms of their structures, components and number of trainable parameters to gain a deeper insight into the requirements of a CNN to achieve a state-of-the-art performance on a clinical segmentation task. As a result, we developed a CNN with a novel adjacent upsampling method that achieves a state-of-the-art performance for an organ segmentation task while being much smaller in terms of the number of trainable parameters and computation time. We developed a CNN with an optimised architecture that outperforms other state-of-the-art CNNs with similar components on an organ segmentation task. Furthermore, we developed a novel augmented classification structure to improve the performance of a segmentation network for an object detection task. We also demonstrate the implementation of a CNN on a complex digital pathology segmentation problem with the use of multiple considerations. We show that with the appropriate CNN architecture and implementation, an effective and efficient CNN based approach can be developed to assist medical experts in different segmentation problems.