SEGNET ARCHITECTURE BASED MODEL FOR CAROTID ARTERY SEGMENTATION

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Abstract:

In this paper, convolutional neural network model based on the SegNet architecture is proposed to achieve segmentation of carotid artery in two-dimensional ultrasound (US) images. Even though ultrasound examination is one of the most used and safest methods for organ and tissue imaging, segmentation of these images is inherently difficult due to low image quality, contrast issues and incorporated multiplicative noise. Carotid artery segmentation consists of lumen and outer wall region segmentation done by two different models. Models are trained on over 260 ultrasound images containing transverse section of various parts carotid artery (CCA, BCA and ECA) with corresponding masks for lumen and outer wall region. Low number of images, variation of carotid artery geometry between different parts of the vessel and low image quality are main issues in automatic image segmentation. SegNet based model in this paper achieved significant results in carotid artery segmentation in ultrasound images and vastly outperforms conventional Convolutional Neural Networks (CNNs) in terms of both segmentation accuracy and training speed.

Key words: carotid artery, convolutional neural network, SegNet, ultrasound imaging

1. Introduction

Medical image segmentation is a vital step in the detection and treatment of many diseases. In particular, ultrasound imaging method is one of the most used clinical imaging methods due to lack of exposure to ionizing radiation for patients and relative low cost of maintenance [1]. Most commonly used mode in ultrasound imaging is two-dimensional B-mode imaging or brightness-mode. In these images, highly reflective structures such as organ boundaries (e.g. vessel wall) are producing brighter echoes and structures that scatter less ultrasound (e.g. blood) are dark. Analysis of carotid artery ultrasound images is crucial in detecting anomalies in carotid artery geometry that indicate the accumulation of plaque in artery wall. Untreated accumulation of plaque leads to narrowing of the arteries, which can go unnoticed for a long period of time until stroke occurs [2]. However, working with this kind of images is very challenging due to image quality degradation and using conventional CNNs produces unsatisfying results. The models presented in this paper are based on SegNet architecture, deep encoder-decoder network for semantic pixel segmentation [3]. Models based on SegNet architecture have found great success in segmentation of biomedical images. In [4] authors applied a model based on SegNet architecture for detecting brain tumor in MRI images and achieved 73.4% IoU score. Dayandaya et al. [5] applied SegNet model for brain regions (white matter, grey matter and cerebrospinal

fluid) segmentation in MRI images and achieved average of 87% Dice Similarity Coefficient for all brain regions.

In this paper, SegNet based model is applied on two-dimensional B-mode ultrasound images containing transverse section of carotid artery.

2. Materials and Methods

Dataset used in this model was acquired during TAXINOMISIS project [6]. The whole dataset contains over 900 images, but the models in this paper are trained on 261 images containing transverse section of the vessel. Each image contains two separate text files with manual segmentation done by expert represented as coordinates of the lumen and wall contour. Masks for model training are generated using information from text files by setting all the pixels inside of the shape to 1 (vessel) and out of it to 0 (background). Images containing atypical carotid artery shapes, images with poor contrast and images with significant amount of noise were manually removed from the training dataset. Two models are created separately for wall and lumen region segmentation, so that they can be individually modified for best segmentation of each region. Modifications such as adding and removing layers and blocks were made on top of original SegNet architecture, and every modification was validated on images from the dataset using Intersection over Union (IoU) and Dice Similarity Coefficient (DSC) metrics.

3. Results

The models were trained to identify the contours of both the media adventitia boundary as well as the lumen intima boundary separately. Thus the segmentation performance was quantified individually for these two boundaries and reported in this section. SegNet based model successfully segmented both lumen and wall region and achieved good results after modifications. The models have achieved high training and validation accuracies.

4. Conclusions

Detailed and precise analysis of clinical data is of great importance for diagnosis of cardiovascular pathologies. Atherosclerosis is one of the leading causes of stroke that can lead to disability and death. Early detection of narrowing of the arteries and plaque components is crucial in preventing these tragic events. Detection of this state in high risk patients allows necessary precaution to be applied in form of medical treatment or surgery.

The aim of this paper is to create segmentation model based on SegNet architecture that can extract region of interest (ROI) which can be used for further and improved analysis or as an input to another automated system.

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