Learning-Based Hepatic Lesion Segmentation for a User Guidance System to Support Embolization Treatments

Master's thesis introductory talk

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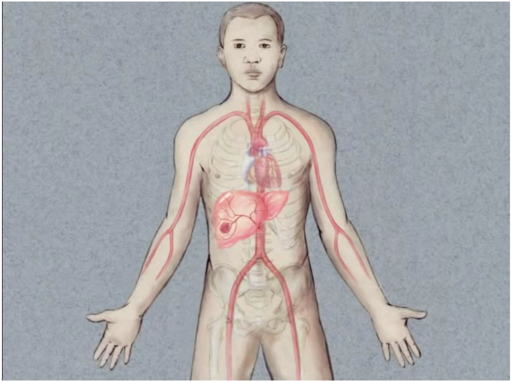
Transcatheter Arterial Chemoembolization (TACE)



https://www.youtube.com/watch?v=2Ny4vvD81XM

The TACE Procedure

1. C-arm CT imaging and 3-D reconstruction during intervention
2. accurate and fast lesion segmentation
3. computation of path for catheter to tumor

Environmental Context

Figure: mobile device in interventional environment

Accurate and Fast Lesion Segmentation

Accuracy

- only vessels supporting the tumor should be targeted
- all of them have to be treated

$\Longrightarrow$ most recent scan data is needed

Outline

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Accurate and Fast Segmentation

Fully manual segmentation

$\Rightarrow$ labeling by hand takes a lot of user time

Fully automated segmentation

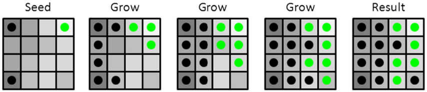
$\Rightarrow$ takes a lot of computation time due to lack of world knowledge

Semi-automatic segmentation

$\Rightarrow$ user guided seed based segmentation potentially faster than both

Current System

GrowCut



- simple algorithm for segmentation
- iterative method
- no training data needed

Client-server model

- mobile device for input and output
- server for computation

Goals and Possible Improvements

Current system

- only 25 labeled ROIs for evaluation (about 120^3 voxels each)
- does not learn from data
- is dependent on strong server for computation (for 3-D data)

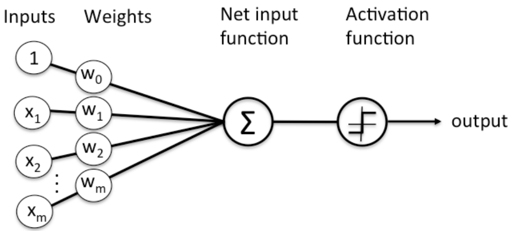
Proposed learning-based system

- accurate segmentation
- makes use of collected data
- server or offline system only used for training
- supporting interactive segmentation
- minimal user input needed

Artificial Neural Networks (ANN)

Base unit

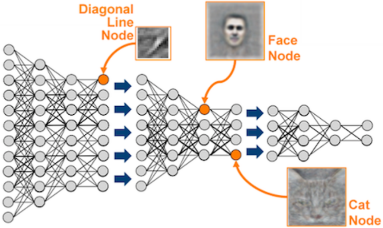
- loosely modeled after biological neuron
- weighted sum of inputs propagated to activation function
- output of one layer of units is input of the next layer



Deep Learning Networks

Deep network

- has several layers
- feature hierarchy



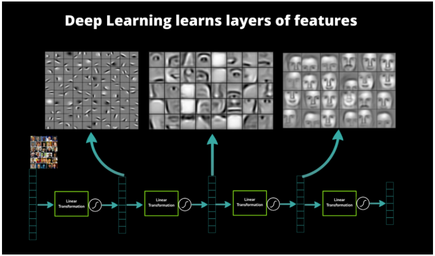


Figure: each layer learns more complex structures from its predecessor

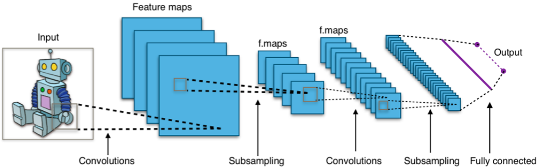
Convolutional Neural Networks (CNN)

Convolutional layer

- kernel weights are learned
- searching for structures in the input data

Subsampling layer

- reduces overfitting
- makes features shift invariant



U-Net – the First Step

MICCAI 2015 paper by Ronneberger et al. [1]

Architecture

- contracting path to capture context
- symmetric expanding path enables precise localization
- data augmentation by random deformation

Evaluation

- warping error
- rand error
- pixel error

U-Net – the First Step

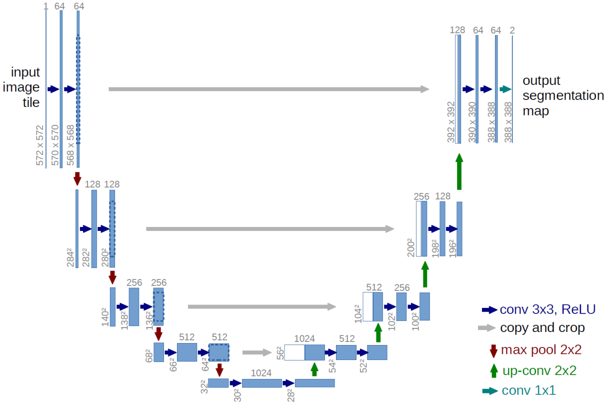


Figure: U-Net - Convolutional Networks for Biomedical Image Segmentation

Artificial Neural Networks

Learning the weights is computationally expensive

can be parallelized efficiently on a GPU

Computation

Given the weights **W**, computation can be efficiently performed by matrix vector multiplication

Learning Procedure

Let $\mathbf{t} = t_1, t_2..., t_n$ be the ground truth

n the number of training samples

o_i the produced output

the error E is given by:

$$E = \frac{1}{2} \sum_{0}^{n} (t_i - o_i)^2 \quad (1)$$

resulting optimisation problem is solved via gradient descent

Advantages of Neural Networks

- expert knowledge for feature crafting not needed
- supports offline learning on GPU
- learned weights transmitted to mobile device
- no server is necessary for on-the-fly segmentation
- training does not require large amounts of data

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Problem

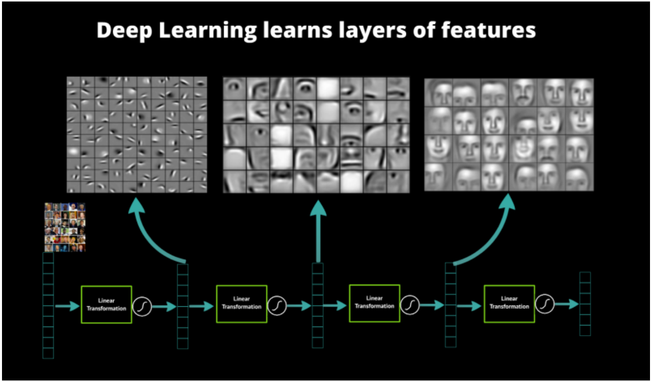
Find a fast and accurate method for hepatic lesion segmentation on mobile devices

First Approach

- deep learning based approach for segmentation
- training of CNN using ground truth data
- use of U-Net structure and augmentation to compensate few available data

Thank You for Your Attention

Are there any questions?



Bibliography I

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Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015.