

Predicting Survival of Liver Tumor Patients with Machine Learning

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A grayscale MRI scan of a liver. A red arrow points to a bright, irregularly shaped mass in the upper right quadrant of the liver, which is identified as an HCC tumor. The rest of the liver shows a mottled, granular texture.

Analyse HCC tumors

How long will he survive?
What is the best treatment?

PREDICTING PATIENT SURVIVAL IN HEPATOCELLULAR CARCINOMA FROM DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGING DATA USING NEURAL NETWORKS



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Motivation and Problem Statement

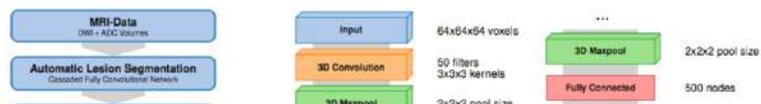
- Liver and liver lesion segmentation is an important step towards deriving quantitative biomarkers for clinical diagnosis and survival prediction
- Until now, no fully automated method exists that automatically segments the liver and its lesion from DW-MRI images with clinical application such as survival prediction
- Gold standard in survival predictions are classical hand-crafted features based on histogram or grey-level-occurrence matrix (GLCM by Haralick et al.)

Contribution

- First application of **Cascaded Fully Convolutional Neural Networks** FCNs [1,2] for DW-MRI liver and liver lesion segmentation
- Proposal of **quantitative biomarkers** based on **3D CNN features** to predict **patient survival**
- Demonstration of **fully automatic** method to predict long/short survival of HCC patients from DW-MRI images

Materials and Methods

- 31 patients with primary diagnosis of HCC liver cancer
- DW-MRI scans to measure apparent diffusion coefficient (ADC) in the tumor
- Automatic segmentation by cascading 2 consequent FCNs to learn more specific features as proposed in [2]
- Feature extraction using classical features based on histogram and texture as the gold standard
- Feature extraction using a 3D Convolutional Neural Network which we call the "SurvivalNet"
- Survival prediction according to shorter or longer survival in comparison to median survival using k-Nearest-Neighbours for classical features and softmax for 3D CNN features



SURVIVALNET: PREDICTING PATIENT SURVIVAL FROM DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGES USING CASCADED FULLY CONVOLUTIONAL AND 3D CONVOLUTIONAL NEURAL NETWORKS

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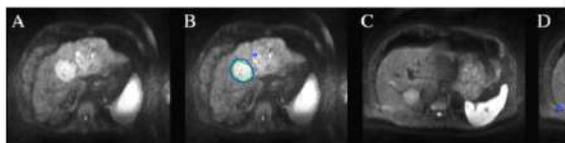
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Experiments and Results

Automatic segmentation of HCC with CFCN on DW-MRI achieves a dice score of 69.1% and precision of 70%.



Results of the automatic HCC tumor segmentation in DW-MRI: Ground truth label of HCC tumor segmentation in blue, automatic segmentation using CFCN in blue.

Approach	Features	ACC [%]	Precision [%]	Sensitivity [%]
Manual Tumor Segmentation	SurvivalNet CNN	68	69	68
	Histogram Features	61	62	61
	Haralick Texture Features	61	65	61
Automatic Tumor Segmentation	SurvivalNet CNN	65	64	65
	Histogram Features	58	59	58
	Haralick Texture Features	61	62	62

Survival prediction results using both manual tumor segmentation and the output of automatic segmentation as inputs for the survival prediction.

ABSTRACT

Automatic non-invasive assessment of hepatocellular carcinoma (HCC) malignancy has the potential to substantially enhance tumor treatment strategies for HCC patients. In this work we present a novel framework to automatically characterize the malignancy of HCC lesions from DWI images.

We predict HCC malignancy in two steps: As a first step we automatically segment HCC tumor lesions using cascaded fully convolutional neural networks (CFCN). A 3D neural network (SurvivalNet) then predicts the HCC lesions' malignancy from the HCC tumor segmentation. We formulate this task as a classification problem with classes being "low risk" and "high risk" represented by longer or shorter survival

and molecularly highly heterogeneous group of cancers that commonly arise in a chronically damaged liver. Importantly, HCC subtypes differ significantly in clinical outcome. The stepwise transformation to HCC is accompanied by major changes in tissue architecture including an increase in cellularity and a switch in vascular supply (i.e. arterialization). These differences provide the basis for the non-invasive detection of HCC [2]. In particular, diffusion weighted-magnetic resonance imaging (DW-MRI) detects differences in random Brownian motion, which is commonly reduced in highly cellular HCC due to an increase in cell membranes and macromolecules. The apparent diffusion coefficient (ADC) parameter value, which can be derived from two DW-MRI

Your Project: Use Machine Learning to Predict Patient Survival

The Dataset:

DWI-Images of ~100 HCC Patients including Tumor ROI

Your Tasks:

Extract Features (Intensity, Shape, Texture, Deep CNN etc) and use them to classify patients according to survival time (long/short survival)

Required prior knowledge:

Python, some statistics

What's in for you:

Possibility of extension with thesis

Co-authorship on any paper your results will be used for

Access to computing resources