Lab: Visualization and Medical Image Analysis
1. Meeting

TractSeg - Fast and accurate white matter tract segmentation

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Note

- I like to prepare slides to provide some structure for our meeting(s) in case that this is my responsibility
- I don’t want to forcibly impose this structure
- Feedback always welcome

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1. Introducing ourselves
2. Organizational matters
3. Clarifying the goal
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Introducing myself (if you want)

- Interests: Visual Computing, Deep Learning, Machine Learning
- Currently: Image Acquisition and Analysis in Neuroscience
- Past semester: Visual Data Analytics
- Previous projects:
  - Extracurricular: Proteomic Analysis of Stress Granules-Associated Proteins
  - Master seminar: Neural Parametric Models for 3D Deformable Shapes
  - Bachelor thesis: Inverse Rendering of Wave Optical BRDFs
  - Bachelor PG: LMB Network for Animal Re-Identification
  - Computer Graphics course project: Development of racing game prototype

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Important Dates

- January 15, 2024: Intermediate presentation
- February 23, 2024: Submission of report draft to Prof. Schultz
- **TBA: Submission of report draft to Johannes**
- **TBA: Test presentation with Johannes**
- March 8, 2024: Submission of final report and code
- March 15, 2024: Final presentation

Organizational matters

- Meetings: Weekly, biweekly, …? Time? Flexible duration?
- Online or in-person?
- Expectations?
- Anything else?

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Clarifying the goal

- Replace the directions input of TractSeg with fODFs

  -> additional information, resolve directional ambiguity

- “Analyzing, evaluating, experimenting with original work” vs. “Actually providing own novel contribution”?
- To what extend should original paper be elaborated on (as in a seminar)?

Plan (as I imagine it right now)

- Understand methods
- Get TractSeg to work
- Setup some example data, create reference results, …
- Identify how inputs (tract directions) in TractSeg code are used
- Insert fODFs using bonndit somehow :)
- Experiment, evaluate, …

Notes for myself: Practical result

- Implementation of a method
- Experiments to demonstrate capabilities and limitations
- Code: correctness, efficiency, readability
- Independent work and own ideas
- Carefully designed, conducted, and interpreted experiments

Notes for myself: Written report

- Describe the overall design of the software, usage, dependencies
- Highlight the steps that took most of your time and effort
- Present and interpret experiments
- Conclude with a clear statement about achievements and future work
- Typical length: 5-10 pages per person

Notes for myself: Oral presentation

- <= 30 minutes per person, followed by discussion
- Understanding of the tools you have been using
- Defend design choices and experimental setups
- Introduction: topic and motivation

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TractSeg - Overview

- Segmentation framework designed to extract white matter tracts from the brain
- Utilizing multiple U-nets and local peak directions as input

Approach

- Input: fODF peaks -> Output: 3D segmentation for each tract

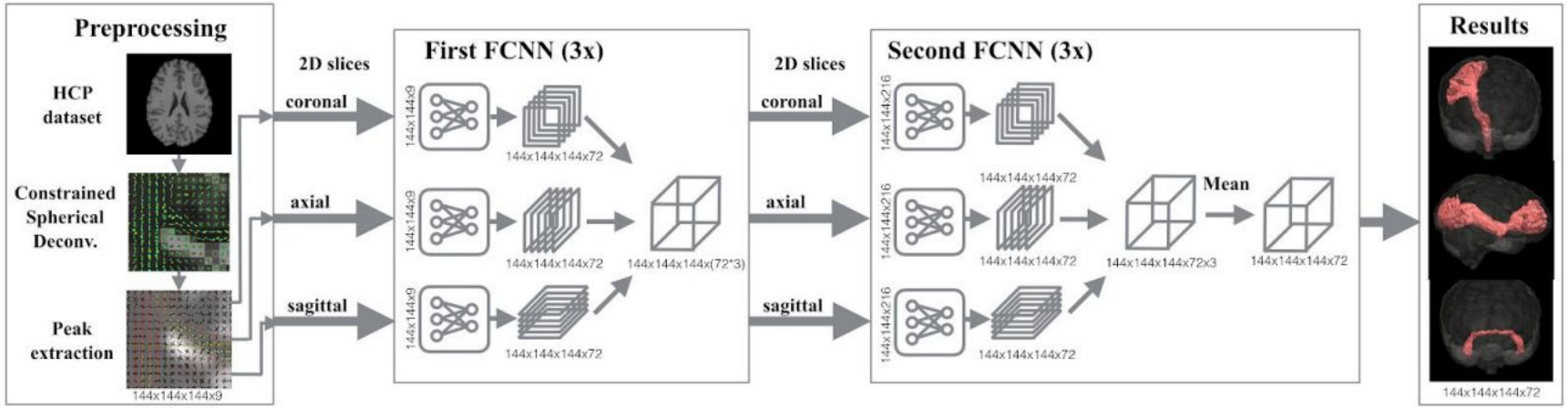

Figure 1: TractSeg segmentation pipeline. Constrained Spherical Deconvolution is used to extract the three dominant diffusion directions in each voxel. A 2D encoder-decoder FCNN then produces one tract probability image for each orientation (coronal, axial, sagittal) and for each tract. The tract probability images from the three orientations are then concatenated in the channel dimension resulting in a 3D image with 216 channels. This is used as input for a second FCNN which again runs three times. The three outputs per tract from the second FCNN are merged using the *Mean* to generate the final segmentation. The final segmentation is a 72-channel image, wherein each channel contains the voxel probabilities for one tract.

fODFs

- From spherical deconvolution
- Per voxel fiber orientation probability density
- Local maxima as indicator of fiber directions

Motivation

- Avoid typical preprocessing (registration, parcellation, tractography, clustering)

  -> Direct segmentation (vs. ROI vs. clustering)

- Applications: characterize brain, identify abnormal morphology in diseased brains, neurosurgical planning, …

Direct segmentation of brain white matter tracts in diffusion MRI

TODO

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Next steps

- Read paper again - multiple times :)
- **TractSeg installation**
- **Get dataset, run TractSeg,** try out parameters, …

Thank you!