

# Segmentation of Neuron Bundles from Diffusion MRI

SLT Course Project 2016

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30. May 2016

# Presentation Outline

## Overview

- ▶ Model Extensions
- ▶ Implementation
- ▶ Results

# Model Extensions I

**Basis Model:** Data Clustering Using a Model Granular Magnet, Blatt et al. [1]

**Neighbourhood Definition:** No fixed  $k$ -nearest neighbourhood  
 $\implies$  automatically select  $k$  *suitable* neighbours:

1. Search for  $k^*$ -nearest neighbours of voxel  $v_i$
2. Select the  $k$  neighbours ( $k < k^*$ ) with the most similar diffusion profile w.r.t to voxel  $v_i$

We used  $k^* = 26$  and  $k = 6$  which empirically turned out to be suitable.

## Model Extensions II

**Similarity Matrix:** *Pairwise diffusion profiles similarities instead of pairwise voxel distances*

$$D_{ij} = \begin{cases} \|s_i - s_j\| & \text{if } v_i \text{ and } v_j \text{ are mutual neighbours} \\ 0 & \text{otherwise} \end{cases}$$

**Use of Inner Products:** Further we looked at inner products  $\langle s_i, s_j \rangle$  between the diffusion profiles  $\implies$  allows to extend the model by applying a kernel.

$$D_{ij} = \begin{cases} \langle s_i, s_j \rangle & \text{if } v_i \text{ and } v_j \text{ are mutual neighbours} \\ 0 & \text{otherwise} \end{cases}$$

# Implementation

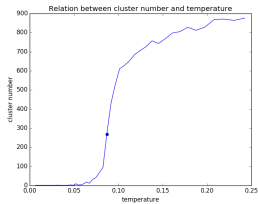
**Language:** Python / numpy

CPU driven, single threaded implementation. Lots of nested loops and room to improve it.

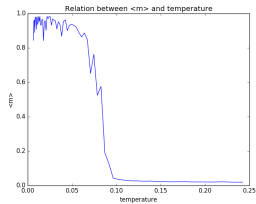
**Attempted Approach:** First implement it correctly, then optimize  $\implies$  We had hard times (even debugging with a small grid was very slow)

Unfortunately, no time left for optimizations like threads, GPU etc.

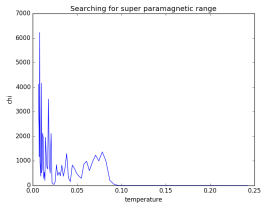
# Results I



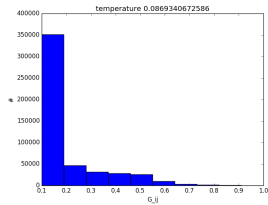
#Clusters



$\langle m \rangle$

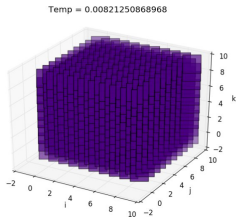


$\chi$

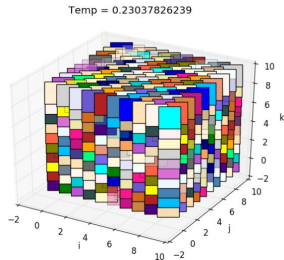


Distribution of  $G$

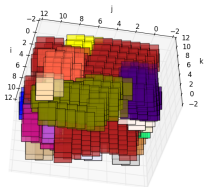
# Results II



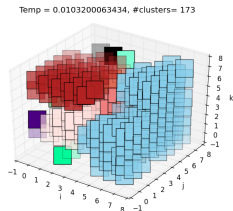
Low Temperature



High Temperature



Super-paramagnetic Regime



Super-paramagnetic Regime

### **Video of Temperature Search / Phase Transitions**



# References

- [1] Marcelo Blatt, Shai Wiseman, and Eytan Domany. “Data clustering using a model granular magnet”. In: *Neural Computation* 9.8 (1997), pp. 1805–1842.