Segmentation of Neuron Bundles from Diffusion MRI

SLT Course Project 2016

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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 $\Longrightarrow$ 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 profile 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 $\Longrightarrow$ 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

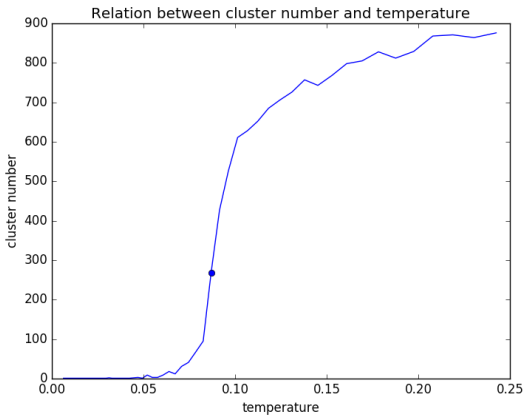
Language: Python / numpy

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

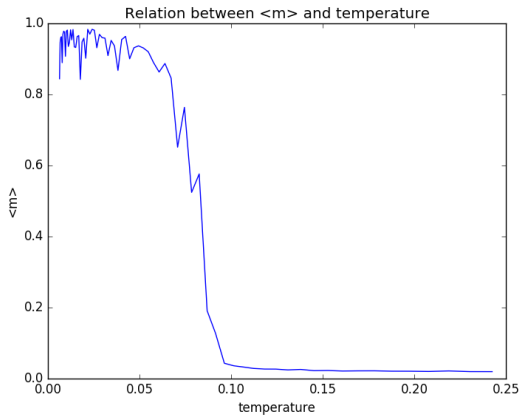
Attempted Approach: First implement it correctly, then optimize $\Longrightarrow$ We had hard times (even debugging with a small grid was very slow)

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

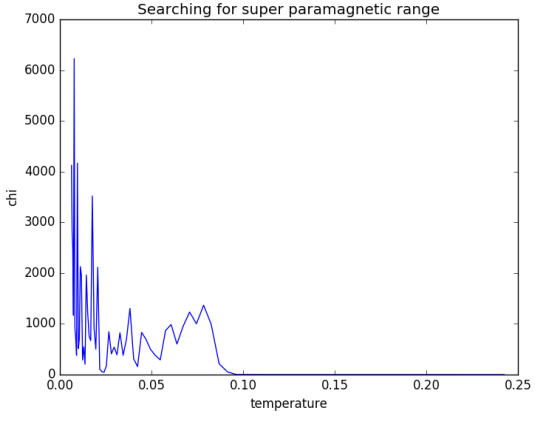
Results I



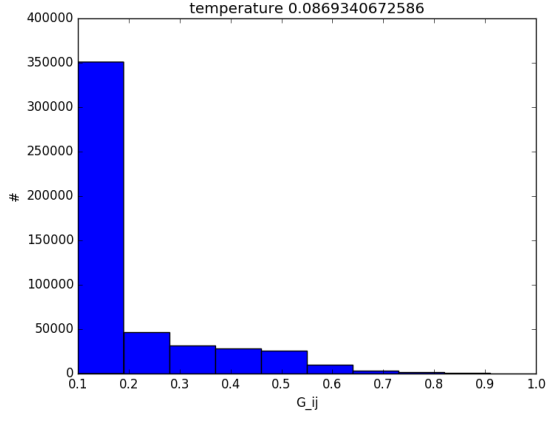
#Clusters



$\langle m \rangle$

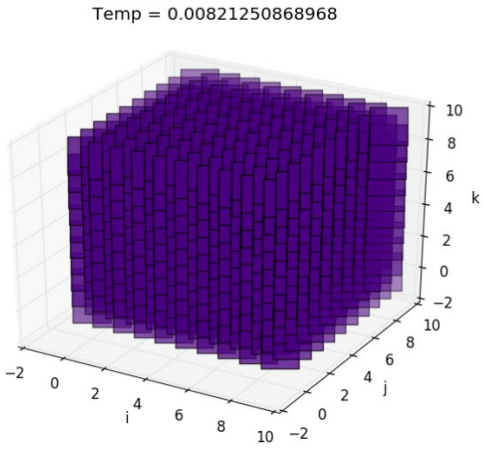


χ

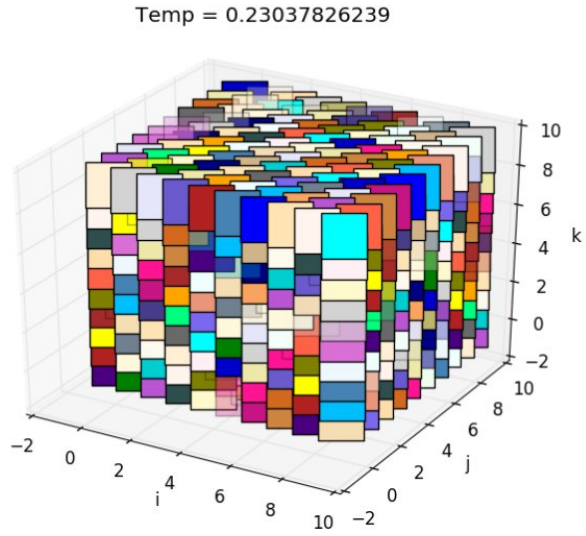


Distribution of G

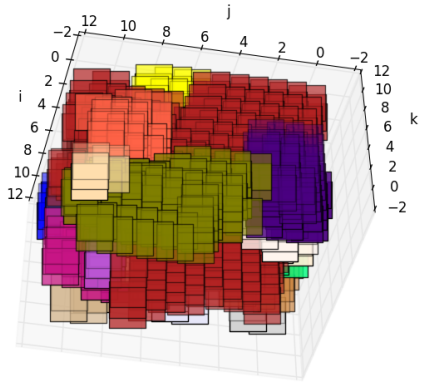
Results II



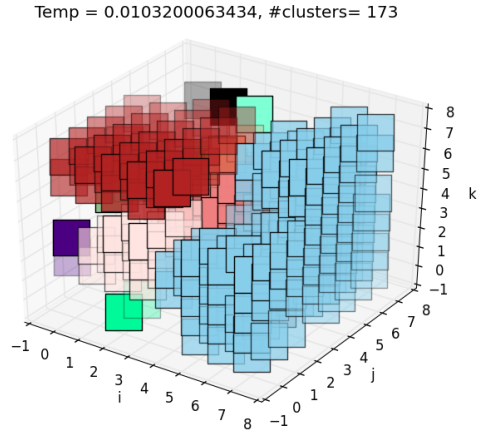
Low Temperature



High Temperature



Super-paramagnetic Regime



Super-paramagnetic Regime

Results III

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.