k-Means and Graph Cuts Clustering of Diffusion MRI in rat STN

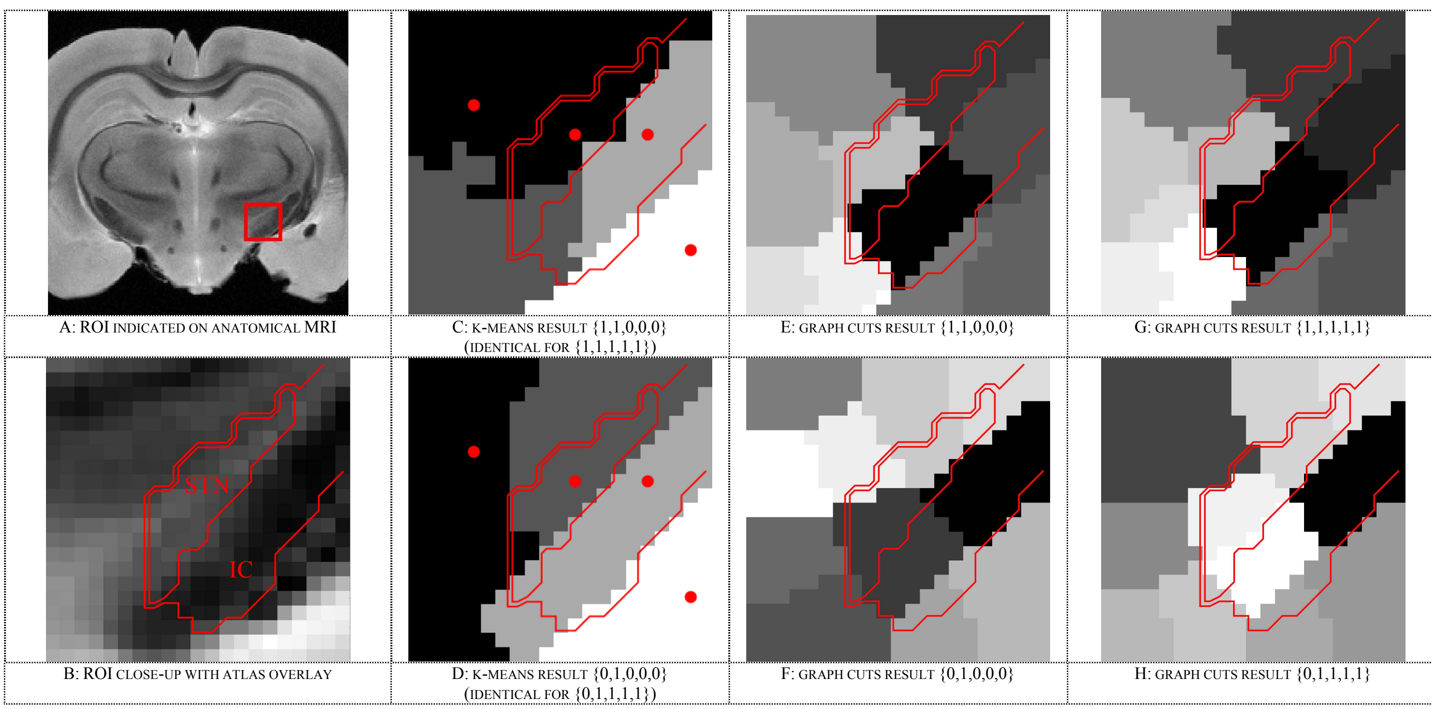
E. BRUNENBERG[1], E. PELGRIM[1], B. TER HAAR ROMENY[1], AND B. PLATEL[2]
[1]BIOMEDICAL ENGINEERING, EINDHOVEN UNIVERSITY OF TECHNOLOGY, EINDHOVEN, NETHERLANDS, [2]BIOMEDICAL ENGINEERING, MAASTRICHT UNIVERSITY MEDICAL CENTER, MAASTRICHT, NETHERLANDS

INTRODUCTION - Deep Brain Stimulation (DBS) of the subthalamic nucleus (STN) for Parkinson's Disease alleviates motor symptoms, but often causes cognitive or emotional side effects due to stimulation of STN parts other than the motor part [1]. In this abstract, we present the results of different clustering algorithms in order to separate the STN motor and cognitive/emotional parts.

METHODS – We used anatomical (RARE, 67-µm pixel, 500-µm slice) and HARDI data (b-value 3000 s/mm^2, 132 directions, 100-µm pixel) of a fixed rat brain measured at 9.4T [2]. The ROI (21 by 21 pixels) for clustering was determined from a digitized rat brain atlas [3,4]. Registration was performed using a T2-weighted MRI template [5] and the non-linear registration FSL tool FNIRT [6]. Clustering was done using two algorithms that have proven useful for classifying diffusion MRI data of the thalamus, namely k-means [7,8] and spectral clustering involving graph cuts [9]. For rat STN we already showed that HARDI results in more heterogeneous diffusion glyphs than DTI [2]. Therefore, clusters were calculated using the L_2 norm on the spherical harmonics coefficients (using even orders up to 8th: 45 coefficients) of each diffusion profile [10]. To investigate the influence of different orders, we experimented with several weightings denoted in a vector. The vector {1,1,0,0,0} means that the distance measure contains no information of 4th, 6th, and 8th order, but is the result of the L_2 norm on 0th and 2nd order coefficients. Parameters for k-means are four seed points (one in internal capsule (IC), one in STN, two in surrounding structures), while graph cuts was performed in 10 steps, yielding 11 clusters.

RESULTS – The context of the STN ROI can be seen in Figure 1 A. In Figure 1 B, the registered atlas is overlaid and the STN and IC are indicated. Clustering results of the k-means and graph cuts algorithms for different weighting vectors are given in Figure 1 C-H. The k-means clustering finds one IC cluster, the best result being generated without 0th order information (Figure 1 D). However, this technique is apparently unable to distinguish the STN from surrounding structures. In three cases of graph cuts results, the medial STN is separated (Figure 1 E-G-H). This might correspond to the cognitive/emotional part of the rat STN. The STN motor part would still be connected to the environment.

DISCUSSION – For k-means, the use of 2nd order information is important, while the 0th order can be excluded. The seed point selection is a disadvantage; the k-means algorithm needs manual or atlas-based points and will find clusters around these points by definition. The graph cuts method does not have this bias. This technique shows a medial STN cluster for several weightings, all including 2nd order information. However, using only this order does not give satisfactory results. The IC is split, probably because too much spatial information is embedded in the affinity matrix. To improve the promising results of this study, we could investigate other possible distance measures for HARDI in future research. Furthermore, fiber tracking projections from the STN could be used as input for clustering instead of or in addition to STN voxels.



A: ROI INDICATED ON ANATOMICAL MRI; C: K-MEANS RESULT {1,1,0,0,0} (IDENTICAL FOR {1,1,1,1,1}); E: GRAPH CUTS RESULT {1,1,0,0,0}; G: GRAPH CUTS RESULT {1,1,1,1,1}

B: ROI CLOSE-UP WITH ATLAS OVERLAY; D: K-MEANS RESULT {0,1,0,0,0} (IDENTICAL FOR {0,1,1,1,1}); F: GRAPH CUTS RESULT {0,1,0,0,0}; H: GRAPH CUTS RESULT {0,1,1,1,1}

Figure 1: The STN ROI and the clustering results for this ROI.

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