

# Non-Local Robust Detection of DTI White Matter Differences With Small Databases

Inserm

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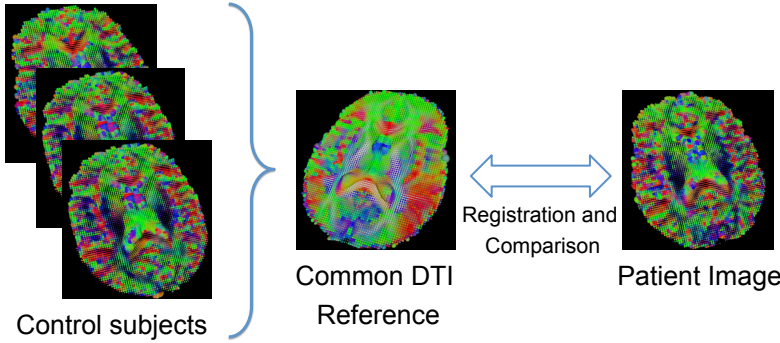


## Purpose

New approach towards detection of DTI white matter differences

- Utilize more samples by considering neighboring voxels
- More robust detection when utilizing small control databases

## Material and Methods



Overall non-local comparison algorithm at point  $x$

- Search for control patches  $B_m(x_j)$  similar to the patient patch  $B(x)$  in a local neighborhood
- Associate a weight  $w_{mj}$  to each control patch  $B_m(x_j)$
- Keep the center voxel value  $D_{mj}$  of each control patch
- Utilize the weighted samples to perform the comparison

### Selection of patches

- Preselection: test on average value and covariance
- Similarity based weight (squared differences)

$$w_{mj} = e^{-\frac{1}{2\beta|B(x)|} \sum_{i \in B(x)} \Delta_i^T \hat{\Sigma}^{-1}(x) \Delta_i}$$

### Differences detection test

- Computation of weighted mean and covariance matrix

$$\mu_x = \frac{1}{\sum_{i,j} w_{ij}} \sum_{i,j} w_{ij} D_{ij}$$

$$\Sigma_x = \frac{\sum_{i,j} w_{ij} (D_{ij} - \mu)(D_{ij} - \mu)^T}{\left(\sum_{i,j} w_{ij}\right)^2 - \sum_{i,j} w_{ij}^2}$$

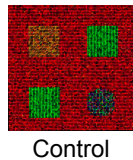
- Evaluate Mahalanobis distance  $Z^2(D_x, \mu_x, \Sigma_x)$  between patient DTI value and controls distribution
- Derive p-value assuming  $Z^2$  follows a  $\chi_d^2$  distribution

$$p_x = 1 - F_{\chi_d^2} [Z^2(D_x, \mu_x, \Sigma_x)]$$

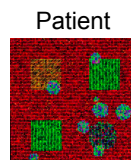
## Experiments

### Simulated Data Experiment

- Influence of control database size ?
- Noisy simulated tensor images
- 90 control images, 1 patient image
- Comparison of detection results
- Database size from 15 to 90



Control

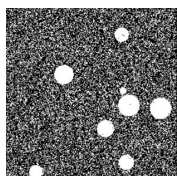


Patient

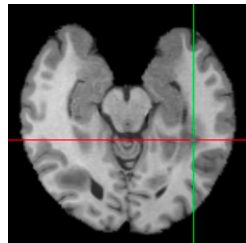
### Multiple Sclerosis data experiment

- Detect differences due to MS lesions or diffuse disease
- 10 MS patients, 160 control DTI images
- Detection of differences with different permutations of controls
- Database size from 20 to 80 controls
- Evaluate reproducibility of results

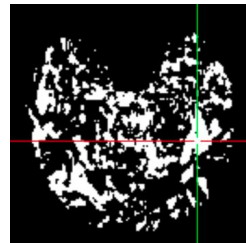
## Results



Detections without NLM (N=15)

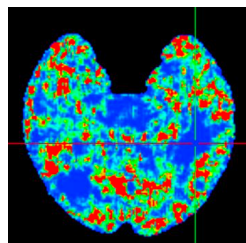
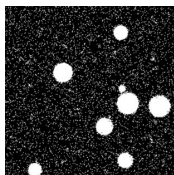


Patient T1 Image

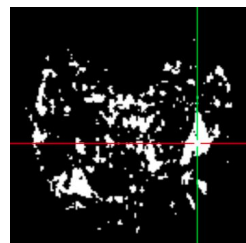


Differences detected without NLM

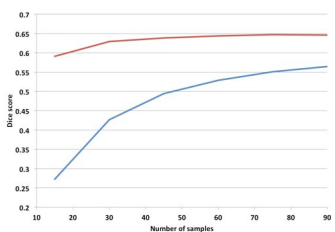
Detections with NLM (N=15)



Number of samples in NLM (red = high)



Differences detected with NLM



## Conclusion

- New non-local approach to DTI comparison
- Search in a neighborhood of similar patches
- Adapted test for weighted samples
- Main findings
  - Quantitative improvement of detection rate (less false positives)
  - Allows for robust comparison even against small databases
  - Improved reproducibility with different control databases
- Future works
  - Extension to higher order diffusion models (e.g. multi-tensors, ODF)
  - Adaptation to robust population comparison
  - Accounting for spatial correlation of patches

[1] O. Commowick et al. Detection of DTI white matter abnormalities in multiple sclerosis patients. MICCAI '08, pp 975-982. 2008.

[2] V. Arsigny et al. Log-Euclidean metrics for fast and simple calculus on diffusion tensors. Magnetic Resonance in Medicine, 56(2):411-421. 2006.