TBSS: Tract-Based Spatial Statistics

Robust “voxelwise” cross-subject stats on diffusion-derived measures
Tensor-derived parameters: Fractional Anisotropy

- FA encodes how strongly directional diffusion is
  - (derived from diffusion tensor eigenvalues)
- Hence good marker for WM integrity
  - i.e., good marker for disease, development, etc.

\[
FA = \sqrt{\frac{3}{2}} \left( \frac{(\lambda_1 - \bar{\lambda})^2 + (\lambda_2 - \bar{\lambda})^2 + (\lambda_3 - \bar{\lambda})^2}{\lambda_1^2 + \lambda_2^2 + \lambda_3^2} \right)
\]

FA=0          FA=0.8
VBM-style Analysis of FA

- VBM [Ashburner 2000, Good 2001]
- Align all subjects’ data to standard space
- Segment -> grey matter segmentation
- Smooth GM
- Do voxelwise stats (e.g. controls-patients)

- Like VBM but no segmentation needed
VBM-style Analysis of FA

**Strengths**
- Fully automated & quick
- Investigates whole brain

- Alignment difficult; smallest systematic shifts between groups can be incorrectly interpreted as FA change
- Needs smoothing to help with registration problems
- No objective way to choose smoothing extent
TBSS : Tract-Based Spatial Statistics

- Need: robust “voxelwise” cross-subject stats on DTI
- Problem: alignment issues confound valid local stats
- TBSS: solve alignment using alignment-invariant features:
  - Compare FA taken from tract centres (via skeletonisation)
2. “Skeletonise” Mean FA
3. Threshold Mean FA Skeleton

giving “objective” tract map
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giving “objective” tract map
4. For each subject’s warped FA, fill each point on the mean-space skeleton with nearest maximum FA value (i.e., from the centre of the subject’s nearby tract)
5. Do cross-subject voxelwise stats on skeleton-projected FA and Threshold, (e.g., permutation testing, including multiple comparison correction)
Schizophrenia (Mackay)

TBSS & VBM show reduced FA in corpus callosum & fornix
VBM shows spurious result in thalamus due to increased ventricles in schiz.
Multiple Sclerosis (Cader, Johansen-Berg & Matthews)

A. CC area
B. Lesions
C. EDSS

FA

Ax

Ra
TBSS - Conclusions

• Attempting to solve correspondence/smoothing problems
• Less ambiguity of interpretation/spurious results than VBM
• Easier to test whole brain than ROI/tractography