TFCE for TBSS

controls > schizophrenics
p<0.05 corrected for multiple comparisons across space, using randomise

cluster-based: cluster-forming threshold = 2 or 3

TFCE
eddy and topup - tools for processing of diffusion data

\[ \nu^+ \]
\[ \nu^- \]

Data point

Prediction

\( y \)-component of diffusion gradient

\( z \)-component

\( x \)-component of diffusion gradient
Separate estimation of susceptibility- and eddy current-fields

So, what we need to estimate is:

- One of these per subject
- One of these per volume

FSL-tools: topup eddy
Outline of the talk

• What is the problem with diffusion data?
• Off-resonance field
  • How does it cause distortions?
  • Where does it come from?
• Registering diffusion data
  • How topup works
  • How eddy works
• Practicalities
• Some results
• Quality control
• “Advanced” eddy features
How topup works (very briefly)

\[ p = [0 \quad 1 \quad 0] \]

\[ p = [0 \quad -1 \quad 0] \]

Given two images acquired with different phase-encoding
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

And we know what the off-resonance field is.
How topup works (very briefly)

$\mathbf{p} = [0 \ 1 \ 0]$

We can combine this with the PE information to get displacement maps
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

And use that to correct the distortions
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

BUT we don’t know the field. That is what we want topup to calculate.
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

topup “guesses” a field...
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

...calculates the displacement maps...
How topup works (very briefly)

\[ \mathbf{p} = [0 \ 1 \ 0] \]

\[ \mathbf{p} = [0 \ -1 \ 0] \]

..."corrects" the images...
How topup works (very briefly)

$p = [0 \ 1 \ 0]$ 

$p = [0 \ -1 \ 0]$ 

...and evaluates the results... 
And **this** is the crucial bit.

BAD!
How topup works (very briefly)

$p = [0 \ 1 \ 0]$

$\begin{array}{c}
\text{Because topup can then "guess" another field}
\end{array}$
How topup works (very briefly)

\[ p = [0 \ 1 \ 0] \]

\[ p = [0 \ -1 \ 0] \]

...and another...until it is happy, and then it "knows" the field
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Worlds shortest course on image registration

Maximising/minimising an objective/cost-function
But it is not easy to register diffusion weighted images

- Each image has different distortions -> non-linear registration
- What is the reference image?
Zoltar -- The prediction maker

Given some data in, Zoltar will make a prediction what the data “should” be.

I know this sounds crazy, but please trust me on this. (Zoltar is actually a Gaussian Process)
How eddy works: Loading step

Pick the first dwi

Use current estimates of Susc EC MP

To correct image

And load into prediction maker
How eddy works: Loading step

then the 2nd dwi

Use current estimates of Susc EC MP

To correct 2nd image

And load into prediction maker

Until we have loaded all dwis
How eddy works: Estimation step

Draw a prediction for first dwi

Use current estimates of Susc, EC, MP

To get prediction in “observation space”

Invert

And compare to actual observation
How eddy works: Estimation step

Draw a prediction for 2nd dwi

Use current estimates of Susc, EC, MP

And then we repeat the procedure for the next dwi ...
How eddy works

1. For all scans

\[
\begin{pmatrix}
1 & 0 & 0 \\
0.6 & -0.4 & -0.7 \\
0.8 & 0.6 & 0 \\
-0.4 & 0.9 & 0
\end{pmatrix}
\]

... 

Use susceptibility field and current estimate of EC and movement to “unwarp” scan

Load into prediction maker

2. For all scans

Get prediction

Invert current transform

Use difference to update EC and mp

Get prediction in scan space

Compare to scan
The signal is “modelled” in a data-driven fashion assuming that points close together on the unit sphere have similar signal.
Under the hood of Zoltar

The GP can model voxels with complicated anatomy while still being computationally convenient.

Multi-shell predictions

Shells with strong signal can help inform predictions in shells with poor signal