ShapeLME: Longitudinal statistical analysis tutorial

The estimation of subject specific shape models also lets us re-evaluate shapes at known time-points. These generated shapes are represented by mesh points which are setup to be in longitudinal correspondence. This is particularly useful to compute longitudinal statistical analysis, which we do next.

We implement linear mixed-effects models for shape correspondences in the package **ShapeLME**

Installation

- Create and cd into a **build** directory in the **shape-lme** package part of the tutorial.
- Run **ccmake ../**
- Once compiled and built: **cd deformetrica/tutorial/scripts/**

We are now ready to do some statistical analysis.

From shape meshes to point correspondences

Each observation of each subject are estimated and stored in vtk format with information about mesh points, polygonal connectivity surface normals, and every shape observation is evaluated in correspondence with every other shape. We extract just the point correspondence positions alone and store it in another directory in lpts format.

From vtk to lpts

- **data-path**: path to **regressed observed shape meshes** - our naming: reg_at_obs_time_pts
- **output-data-path**: path to output point correspondence files - our naming: shape_lpts_for_stats

Run the script:

- **python write_vtk_to_lpts_script.py**

Estimating longitudinal trajectories

Now that we have shape data in longitudinal correspondences, we estimate longitudinal shape trajectories using a mixed-effects model. The mixed-effects model can take in multiple covariates such as eisk of onset group membership (CTRL, LOW, MED, HIGH), sex, among

other information and estimate an associated model. For the tutorial, the data used is CTRL and HIGH risk HD females. Once the script is run, the output directory for each structure will have fixed and random effects estimates along with the design file used.

Estimating mixed-effects

- **input-data-path**: the lpts directory path obtained as output above - shape_lpts_for_stats
- **output-data-path**: path to fixed and random effects files for each structure - mixed_effects_results

Run the script:

- **python estimate_mixed_effects_script.py**

Visualizing shapes and trajectories

The baseline shapes along with the respective group evolutions of each category can be visualized in Paraview. To do this, we convert the respective point and velocity files back to vtk format keeping the original neighborhood and connectivity information of the input mesh data. Once thats done, we then load the respective vtk files into Paraview and compare the visualizations there.

- **input-path**: the mixed effects results directory
- **output-data-path**: output vtk shape sequences path for each structure - our naming: output_shape_seq_vtk

Run the script:

- **python create_shape_sequences_script.py**

Hypothesis testing

We finally test the hypothesis for significant differences between CTRL and HIGH risk groups by a non-parametric permutation test using the Hotelling t^2 statistic. The input to this are the point correspondence files, and the output is a p-value.

- **input-data-path**: the lpts directory path obtained as output above - shape_lpts_for_stats
- **output-data-path**: text file listing hypothesis results - we store it in mixed_effects_results

Run the script:

- **python group_hypothesis_testing_script.py**