



## General Geometric Morphometric Workflows

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### TPS series programs

<https://www.sbmorphometrics.org/>

1. Collect landmarks into a \*.tps format file using TpsUTIL and TpsDIG (see Collecting Landmarks handout)
2. Open file in TpsRELW
3. Click through the Compute workflow: Consensus, Partial Warps, Relative Warps
4. PCA plot is found under the Display button “Relative Warps” (Relative warps is essentially a synonym for PCA as long as you do not reweight the partial warps in the Options tab)
5. To visualize shapes within the PCA morphospace, use the Camera tool and click on a point to visualize

For a video that shows the basic moves, see: <https://vimeo.com/106153106>

### PAST (Paleontological Statistics)

<https://www.nhm.uio.no/english/research/resources/past/>

1. Collect landmarks in tps format using the ImageJ or another method of your choice (see Collecting Landmarks handout)
2. Open the TPS file in PAST using the Edit > Open sequence
3. Select all of the data by clicking in the upper left corner of the data table
4. Perform Procrustes superimposition under Transform > Landmarks > Procrustes (2D + 3D) (use default options or choose 3D) [do not ever use the Keep Size option unless you have scaled your landmarks to mm or some other unit]
5. Produce a PCA plot in one of two ways:
  - a. Geometry > Landmarks > PCA (relative warps)
    - i. This is the easy option
    - ii. view the thin-plate spline deformations by clicking on the Deformations tab and then adjusting the Score to an appropriate value based on the axes in the PCA plot

- b. Using the standard multivariate analysis workflow:
  - i. Transform > subtract mean
  - ii. Multivariate > Ordination > PCA (make sure to retain the default Variance-covariance method on the Summary screen)
  - iii. Scatter plot, scores, and loadings should be identical to the Landmarks method, except you don't have the option to visualize thin-plate splines this way

### ***geomorph***

<https://cran.r-project.org/web/packages/geomorph/index.html>

Refer to the Quick Guide to Geomorph manual by Emma Sherratt for more details about the following workflow. See also the R Markdown tutorial by Katrina Jones.

1. Collect landmarks in tps format using method of your choice (see Collecting Landmarks handout)
2. Load the geomorph package
3. Import the landmarks into *geomorph* using the *readland.tps()* function
4. Do Procrustes superimposition using the *gpagen()* function
5. Perform PCA using the *plotTangentSpace()* function

### ***MorphoJ***

[https://morphometrics.uk/MorphoJ\\_page.html](https://morphometrics.uk/MorphoJ_page.html)

1. Collect landmarks in tps format using method of your choice (see Collecting Landmarks handout)
2. Start MorphoJ and choose New Project from the file menu
3. Give the project a name on the first line and give your data set a name (e.g., Osteostraci landmarks).
4. Choose the TPS file type and choose your file.
5. Do Procrustes analysis: Preliminaries -> New Procrustes Fit  
Choose the option "Align by principal axes"  
Push the button "Perform Procrustes Fit"

You will see a graphic showing the aligned specimens. The mean value of each landmark is numbered and the tiny dots represent the scatter of individual specimens

6. Create a covariance matrix for your data. This is a necessary step for doing a Principal Components plot: Preliminaries -> Generate Covariance Matrix  
Select Procrustes coordinates under data types  
Click the Execute button  
You won't see any visible sign that anything happened
7. Perform a principal components analysis : Variation -> Principal Components Analysis. Click the PC scores button on the graphics window that pops up. Right click in the background and choose "Label Data Points".
8. To produce a thin-plate spline visualization of a position in shape space, return to the PC shape changes frame  
Right click in background and "Change type of graph" to "Transformation Grid"

IanDworkin has produced a series of video tutorials at  
<https://www.youtube.com/playlist?list=PLgwACOW1w4Ed9ME880KF0ZP6QrZz9RzLe>

## **Mathematica**

<https://github.com/pdpolly/Morphometrics-for-Mathematica>

1. Collect landmarks in tps format using method of your choice (see Collecting Landmarks handout)
2. Load the *Morphometrics for Mathematica* package
3. Import landmarks using the *tpsImport[]* function
4. Do Procrustes superimposition with the Procrustes function on the imported landmarks (columns 2 onward)
5. Produce PCA plot and splines using the *PrincipalComponentsOfShape[]* function, which takes as its arguments the Procrustes coordinates from Step 4, a list of two PCs (usually {1,2}) and a vector of labels (column 1 of the imported landmarks)