



# Population-based Fitting of Medial Shape Models with Correspondence Optimization

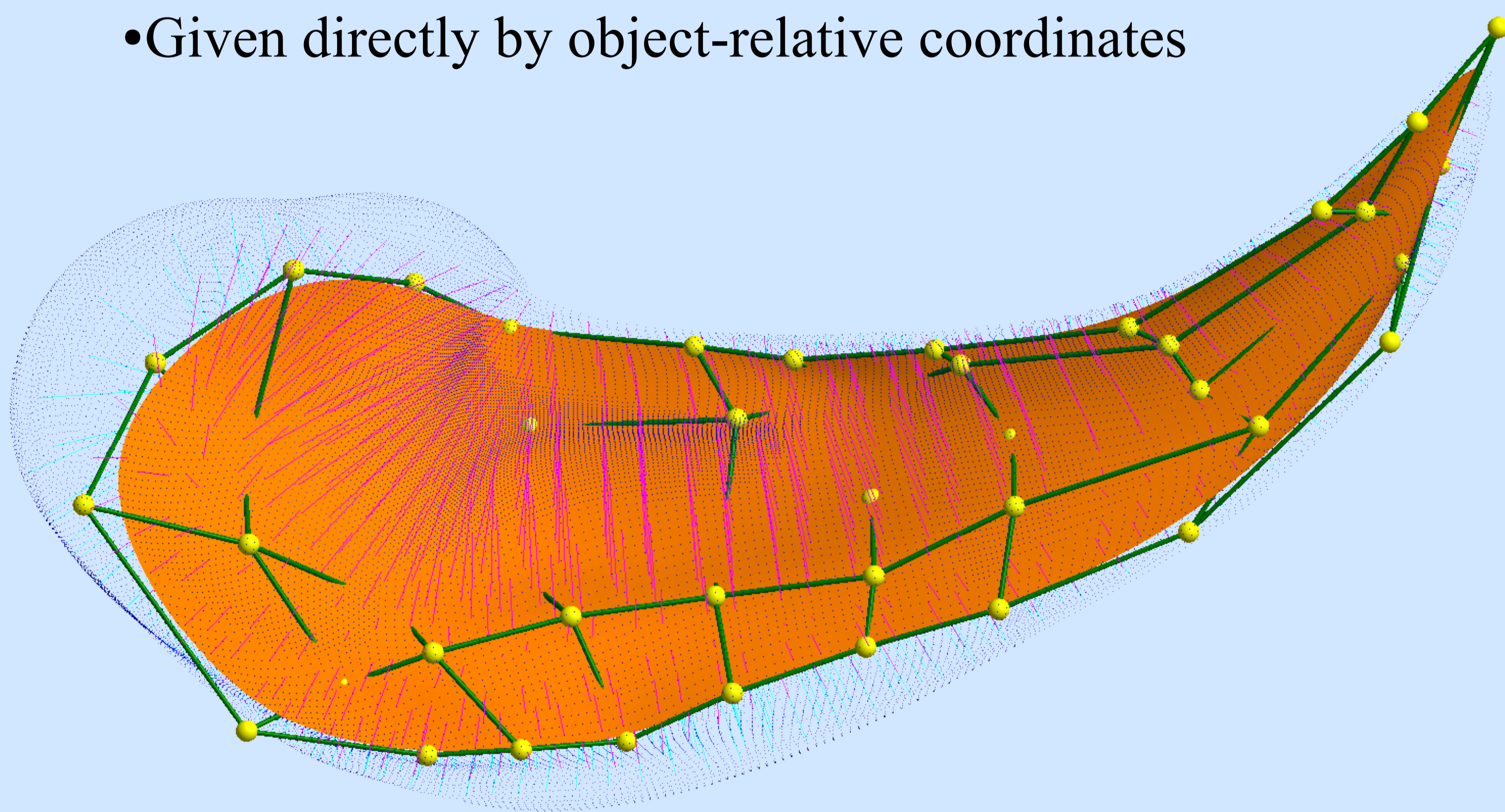
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**Goal:** Construct medially-described shape models of a population using correspondence information derived from the object boundaries

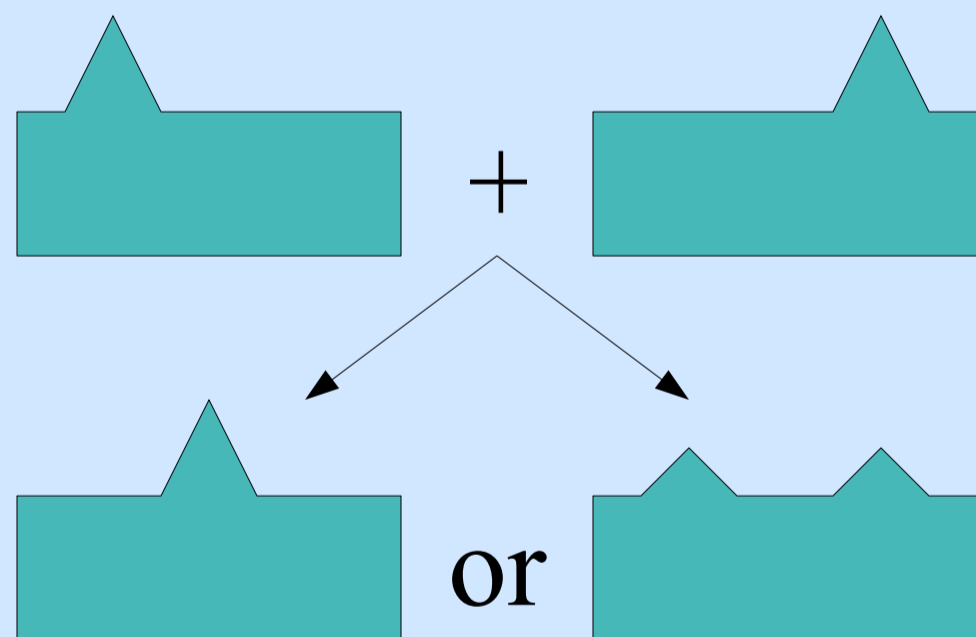
## 1. Problem Description

- Medial shape models (m-reps) focus on the object interior
  - Give significant dimensionality reduction
  - Provide intuitive features (bending, twisting, tapering, etc.)
  - Correspondence between models is *intrinsic*
    - Given directly by object-relative coordinates



**Fig. 1:** A dense sampling of a medial model of a left caudate defined continuously using subdivision surfaces

- Want to match this intrinsic correspondence with the *extrinsic* correspondence driven by the underlying (unknown) anatomy
  - Problem-domain specific
  - Many existing methods, based on:
    - Image intensities
    - Geometry (curvature, etc.)
    - Population statistics (MDL, etc.)
  - Most of the information needed lies on the boundary
  - Described at finer scales than typical m-rep sampling
- Existing m-rep methods enforce regularity and minimize deformation from a template using optimization penalties



## 2. Continuous M-reps

- Provide a unique, differentiable link between the medial axis and the boundary
- Can be finely sampled to incorporate information from smaller scales
- *Medial integrals* summarize this information at higher scales
- We use a representation based on subdivision surfaces (Terriberry and Gerig, MFCA 2006)

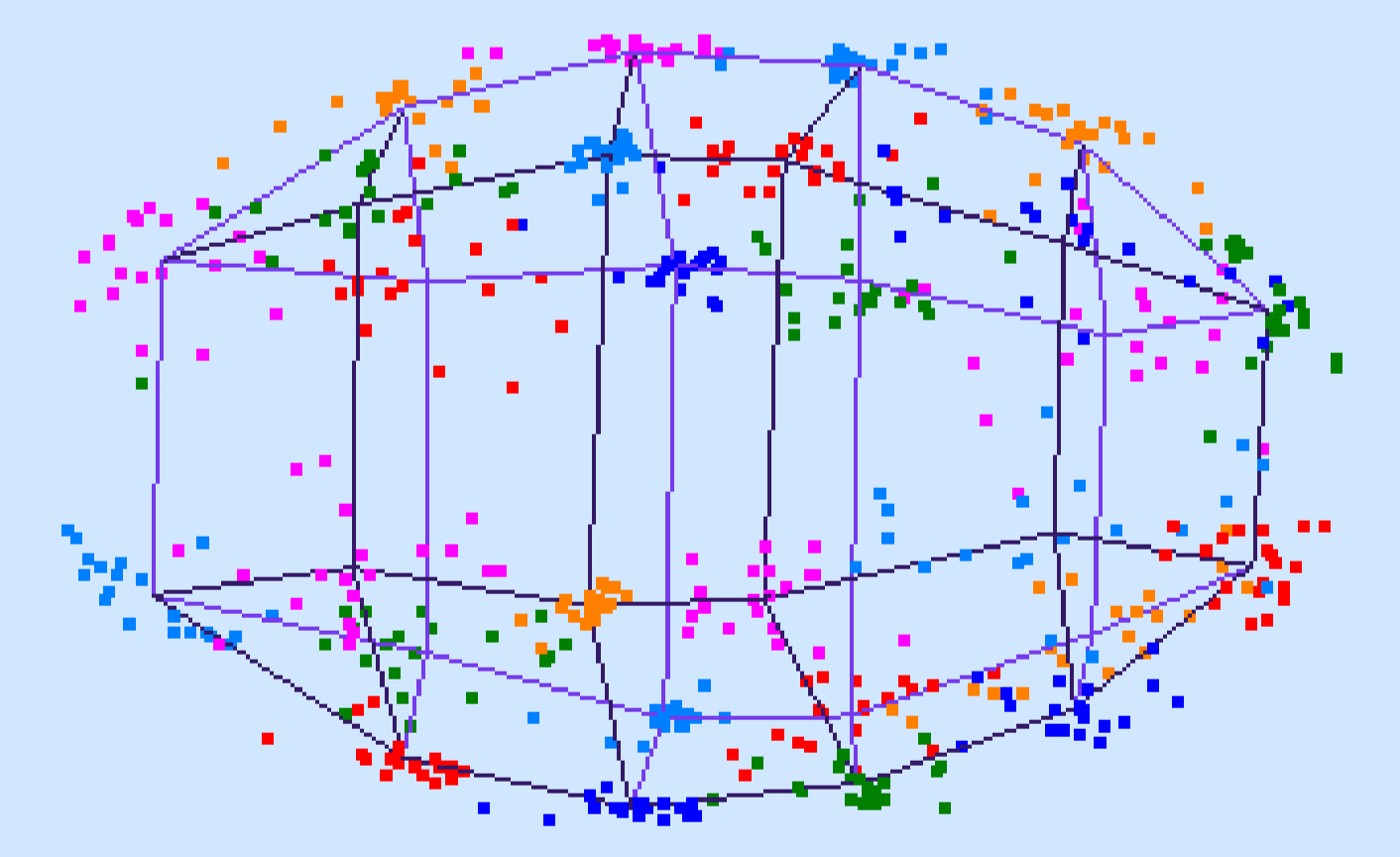
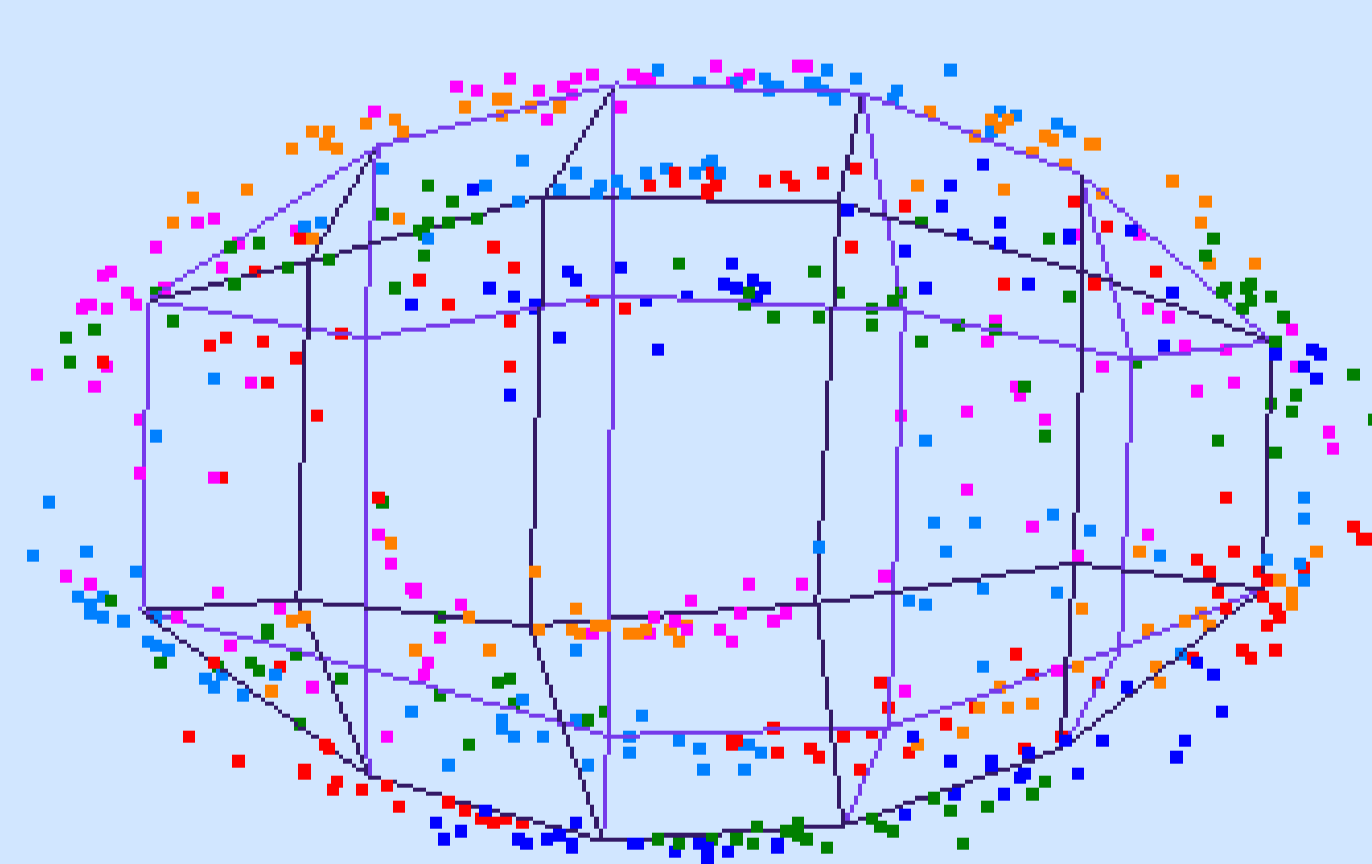
## 3. Correspondence Optimization

- Do not derive a new method for *extrinsic* correspondence
- Optimize the *intrinsic* correspondence during the model fitting process to match a given, extrinsic correspondence
- For a set of intrinsically corresponding medial points
  - Compute the associated points on the boundary by projecting along the spoke direction
  - Map these to a *common coordinate system* (e.g., the average shape) using the extrinsic correspondence
  - Minimize the cluster size in the common coordinate system:
 
$$F_C^j = \sum_{(m,r,U) \in \mathcal{S}} (\phi_j(m,r,U) - \mu_i)^2 \cdot w_i \quad w_i = |\det(\mathbf{I} - rS_{\text{rad}}) \Delta M|$$
- Incorporate into multi-scale, constrained, non-linear CG opt.
  - Take alternate steps between image match and corr. match
  - Correspondence steps slide points along the medial axis
    - Goal is to reparameterize the axis, not change the shape
  - (Approximately) transverse: two processes do not interfere

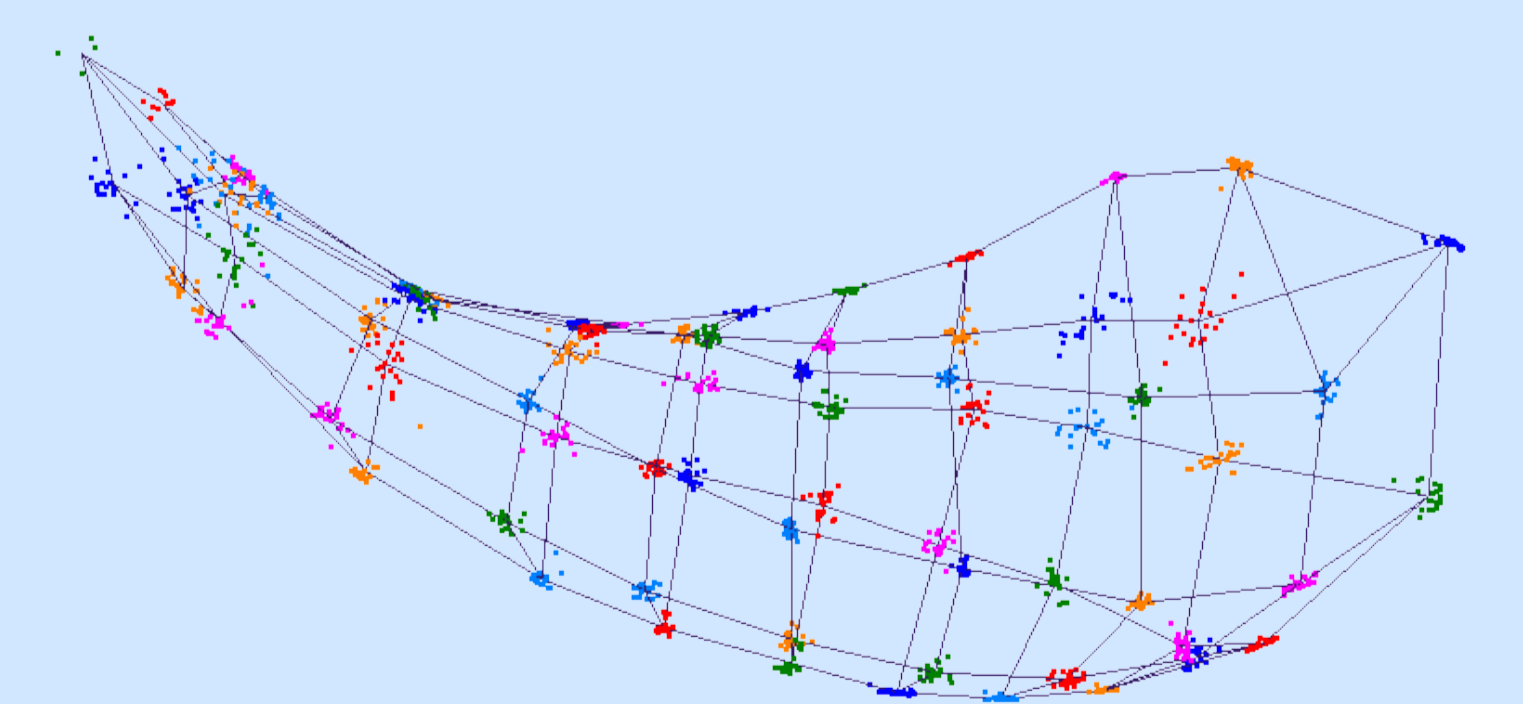
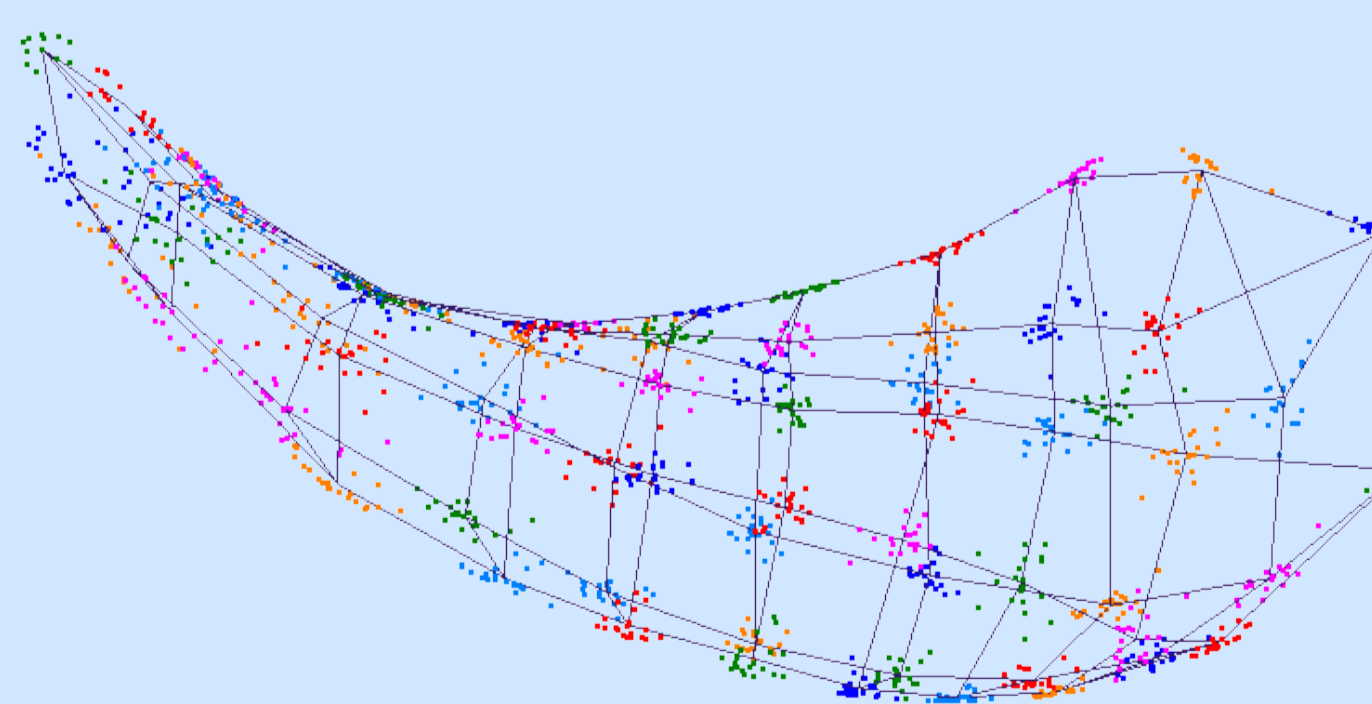
## 4. Results

Without Correspondence Optimization

With Correspondence Optimization



Synthetic deformed ellipsoids



Caudates from a pediatric autism study

**Fig. 2:** Clusters of corresponding points after optimization

- Little change in volume overlap with corr. optimization
  - Ellipsoids' Dice coefficient: 96.88% with (96.72% without)
  - Caudates' Dice coefficient: 91.24% with (91.81% without)