

From Deformations to Parts: Motion-based Segmentation of 3D Objects

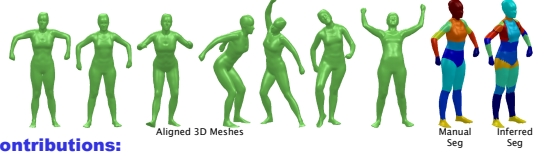
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Segmentation of Articulated 3D Objects

Goal: To discover distinctly moving parts of an articulated object from aligned 3D meshes capturing various object poses.

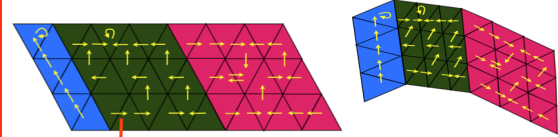


Contributions:

- **Modeling:** We propose a model that,
 - ✦ Discovers a potentially unbounded number of parts,
 - ✦ Guarantees spatially connected segmentation,
 - ✦ Seamlessly deals with object instances having varying 3D shapes,
 - ✦ Is robust to moderate alignment noise.
- **Results:** State-of-the-art prediction of 3D body deformations.

Distributions over Mesh Partitions

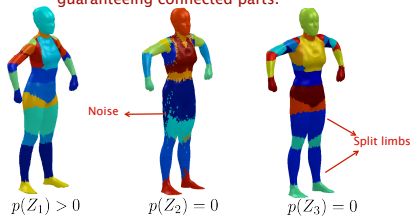
Distance dependent Chinese restaurant process



$$p(c_m = n \mid D, f, \alpha) \propto \begin{cases} f(d_{mn}) & m \neq n, \\ \alpha & m = n. \end{cases}$$

$f(d) = 1[d \leq 1]$ A "window" decay function of width 1 restricts mesh faces to link to immediately adjacent faces, guaranteeing connected parts.

Unlike a standard CRP prior, only partitions with contiguous parts have non-zero prior probability.



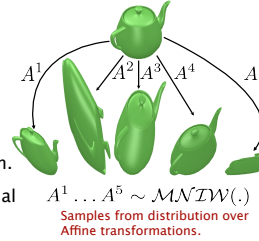
Distributions over Affine Transformations

$$\Sigma \sim \mathcal{IW}(n_0, S_0)$$

$$A \mid \Sigma \sim \mathcal{MN}(M, \Sigma, K)$$

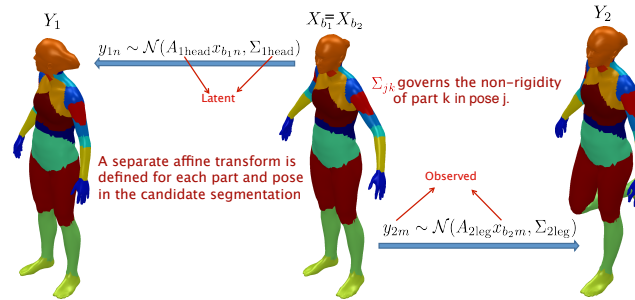
where $A \in \mathbb{R}^{3 \times 4}$ is an **affine** transformation.

- A matrix normal distribution with an inverse Wishart prior over the covariance.
- The mean is set to the identity transformation.
- S_0 is set to match the scale of the translational parameters with that of the mesh coordinates.



Model and Inference

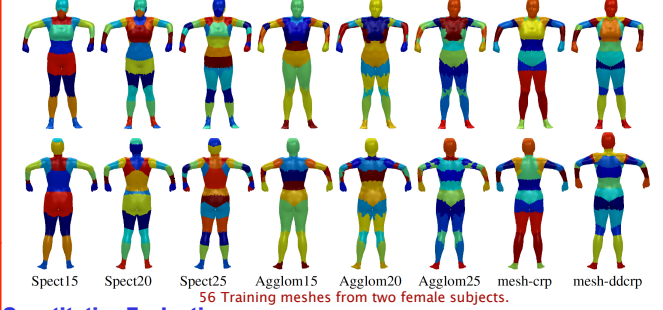
- For each mesh face n , sample an associated link $c_n \sim \text{ddCRP}(\alpha, f, D)$
- For each pose j and each part k , sample an affine transformation A_{jk} and residual noise covariance Σ_{jk} from the MNW distribution.
- Sample the observed location of each pose triangle relative to its corresponding reference triangle, $y_{jn} \sim \mathcal{N}(A_{j c_n} x_{b_j n}, \Sigma_{j c_n})$



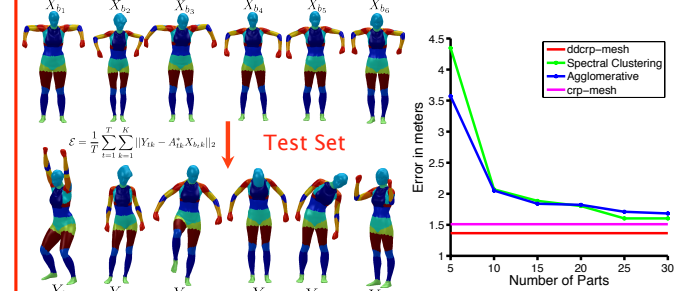
Inference

- Collapsed Gibbs sampler that analytically marginalizes latent affine transformations and noise variables.
- Likelihood evaluation independently marginalizes affine and noise variables for each pose: computation scales linearly with number of poses, parallelizable.
- Large moves in the space of candidate partitions through split and merge.

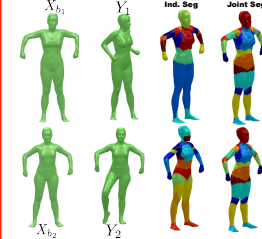
Results: Segmentation of Human Bodies



Quantitative Evaluations:



Shared Segmentation:



Segmentation of Synthetic Meshes:

