Active Shape Models

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Summary

- Passive
  - Moment invariants
  - Fourier descriptors
  - Active shape models (passive mode!)
  - Appearance models
  - Medial axis transforms
  - Spherical harmonics (3D)
- Active(segmentation)
  - Generalized Hough transform
  - Deformable models (Snakes)

  Active shape models (Active mode!)

Snake Cons

- Unbounded deformation
- Parameters to be determined
- Initial shape

Improvements

- Statistical shape model
- Constraints on shape deformation
- Modeling grey level appearance (profile)

- Statistical shape model (PDM)
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- Segmentation by shape deformation

Point Distribution Model

$$\boldsymbol{x}_i = (x_{i0},\ y_{i0},\ x_{i1},\ y_{i1},\ \ldots,\ x_{ik},\ y_{ik},\ \ldots,\ x_{in-1},\ y_{in-1})^T$$

$$\bar{\boldsymbol{x}} = \frac{1}{N}\sum_{i=1}^{N}\boldsymbol{x}_i \qquad d\boldsymbol{x}_i = \boldsymbol{x}_i - \bar{\boldsymbol{x}}$$

$$\boldsymbol{S} = \frac{1}{N}\sum_{i=1}^{N} d\boldsymbol{x}_i d\boldsymbol{x}_i^T \qquad \boldsymbol{S}\boldsymbol{p}_k = \lambda_k \boldsymbol{p}_k$$

Point Distribution Model

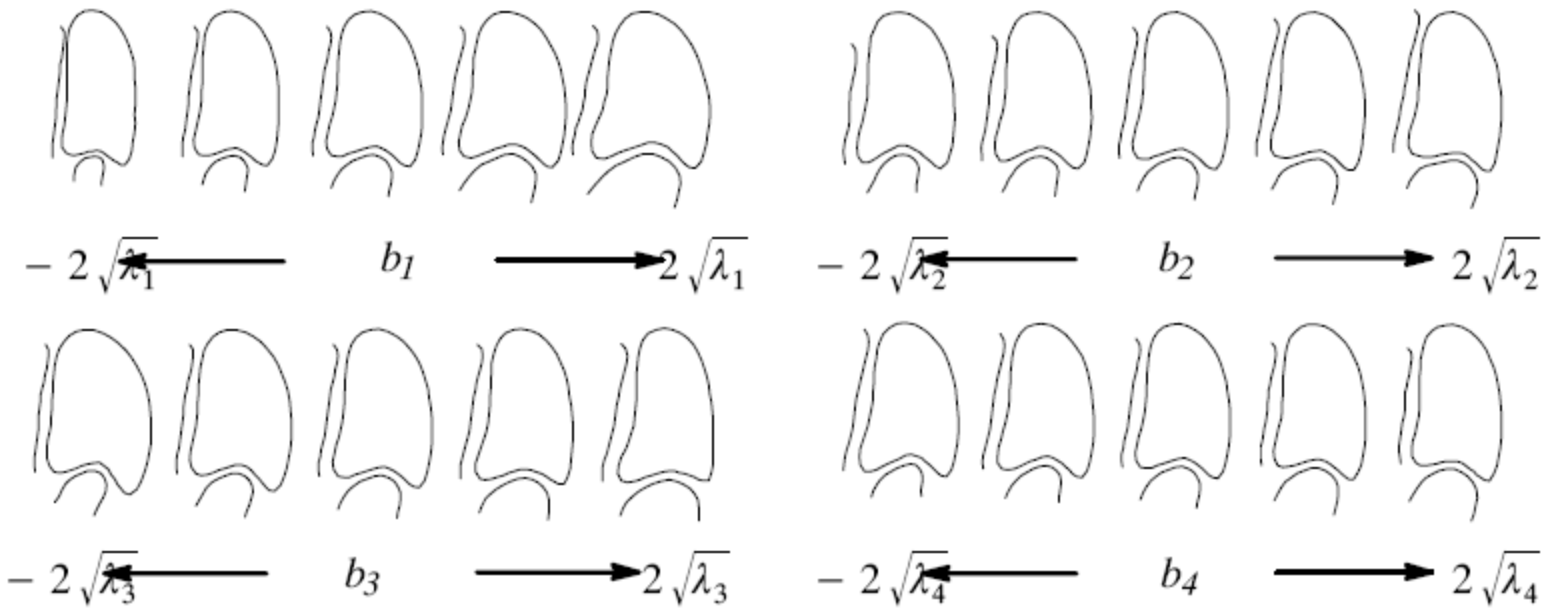
$$\boldsymbol{x} = \bar{\boldsymbol{x}} + \boldsymbol{P}\boldsymbol{b}$$

$$\boldsymbol{P} = (\boldsymbol{p}_1 \;\; \boldsymbol{p}_2 \;\; \ldots \;\; \boldsymbol{p}_t)$$

$$\boldsymbol{b} = (b_1 \;\; b_2 \;\; \ldots \;\; b_t)^T$$

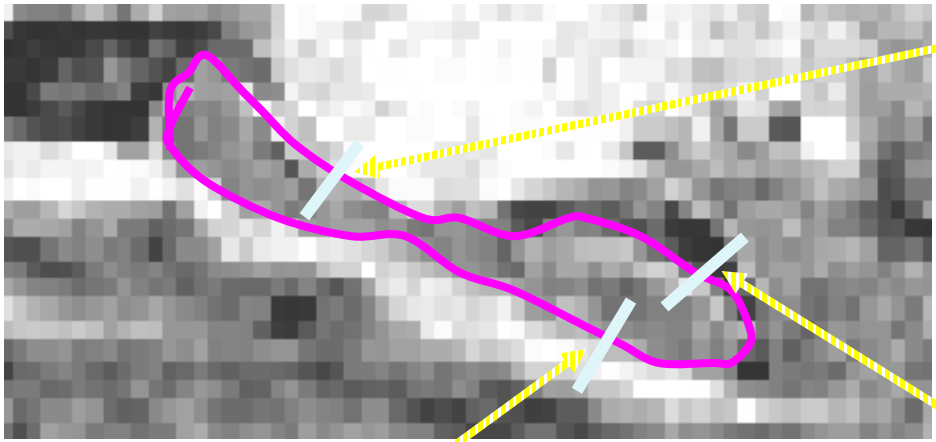
$$D_m^2 = \sum_{k=1}^{t} \left(\frac{b_k^2}{\lambda_k} \right) \leq D_{\max}^2$$

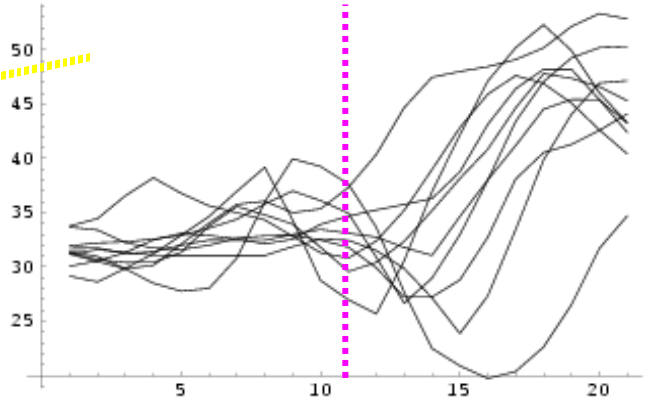
Point Distribution Model

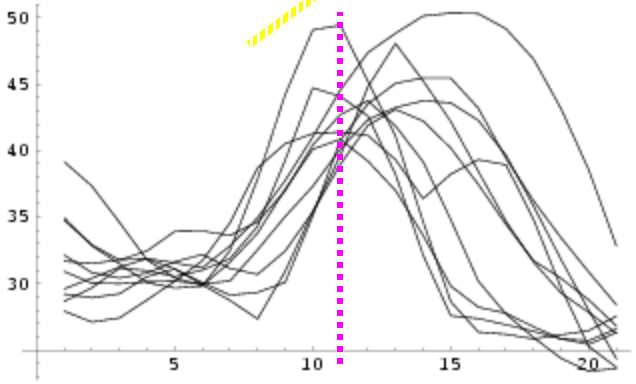


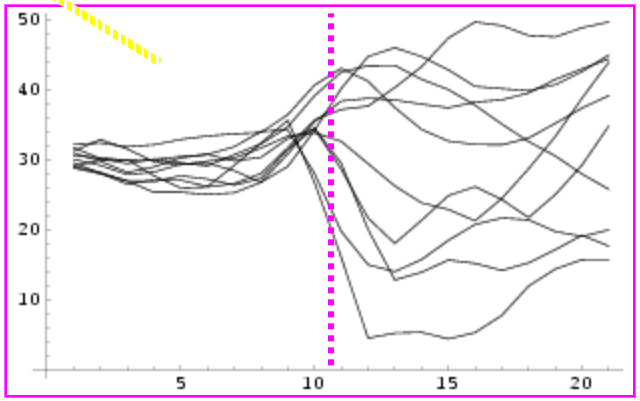
- Statistical shape model (PDM)
- Modeling grey level appearance (profile)
- Segmentation by shape deformation

Grey Level Appearance

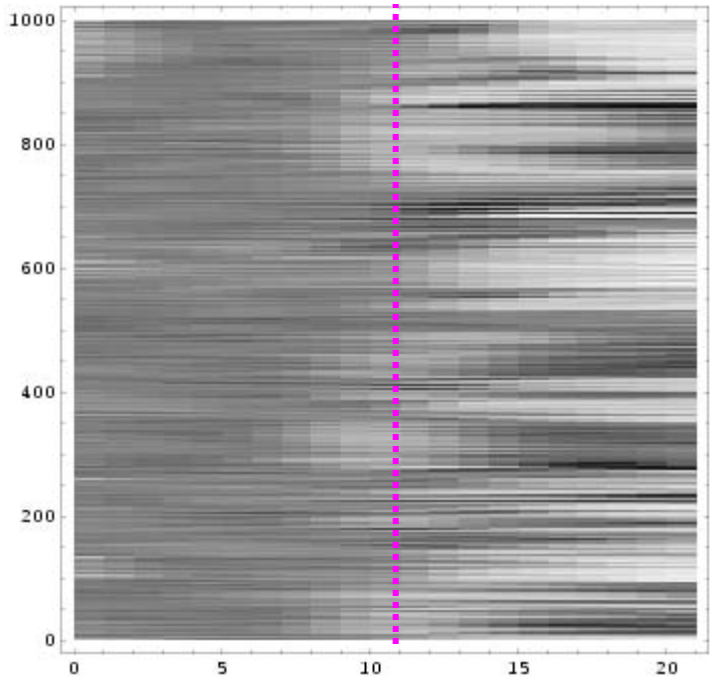




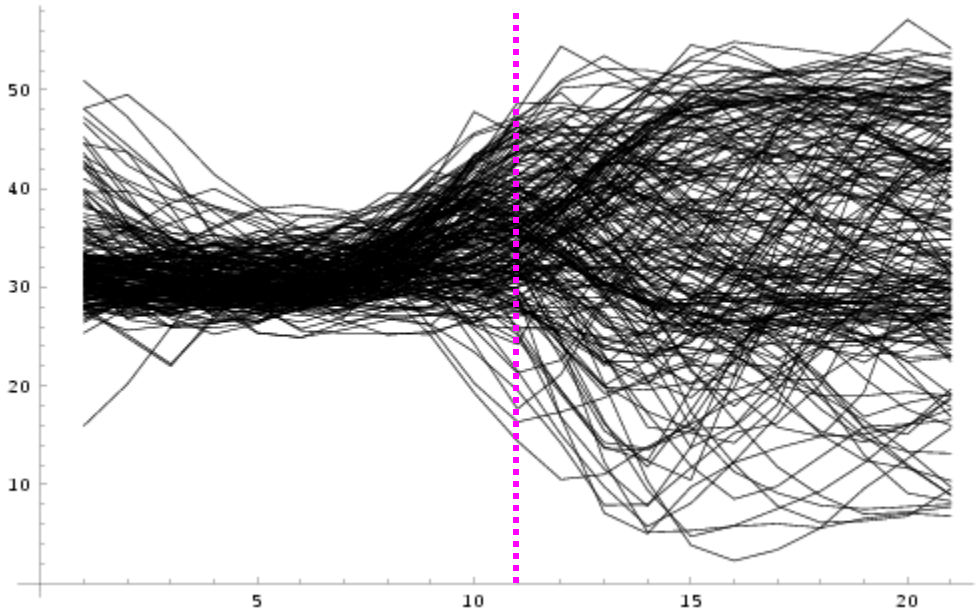




Grey Level Appearance



Inside Outside

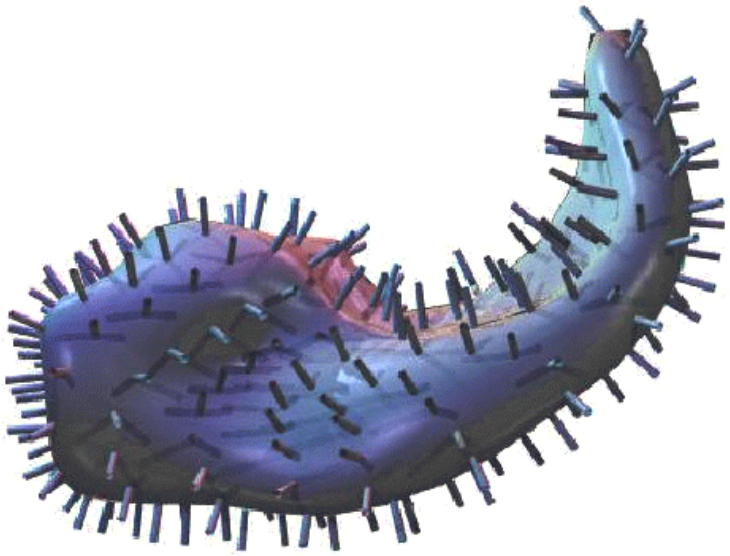


Inside Outside

hippocampus

Grey Level Appearance

- Extending to 3D



Grey Level Appearance

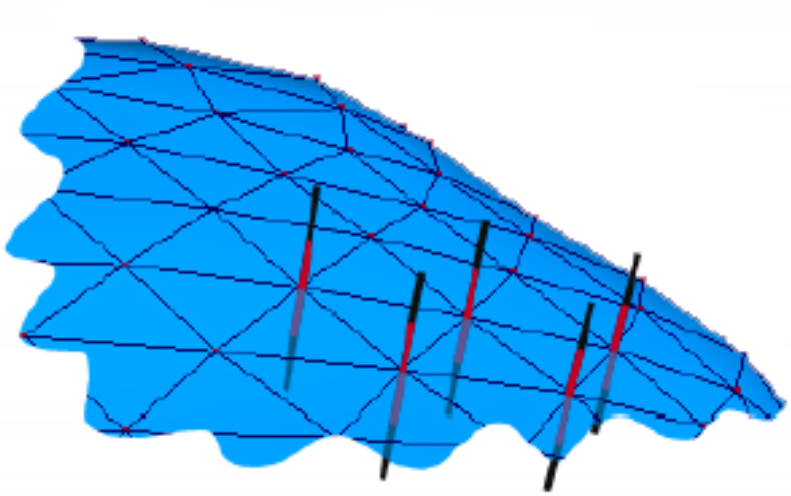
- Compute derivative over profiles to make it invariant to uniform scaling and addition of a constant
- Normalize over pixels in profile
- Calculate average over all shapes
- Calculate covariance matrix for these profiles

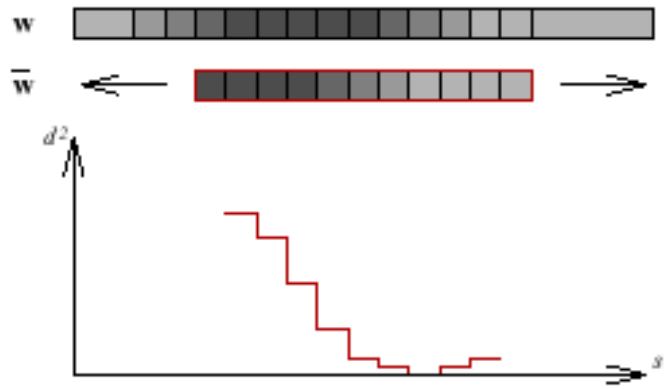
- Statistical shape model (PDM)
- Modeling grey level appearance (profile)
- Segmentation by shape deformation

Segmentation by shape deformation

- Initialization of model
- Iterative optimization driven by local image match
- Deformation constraints using statistical shape model

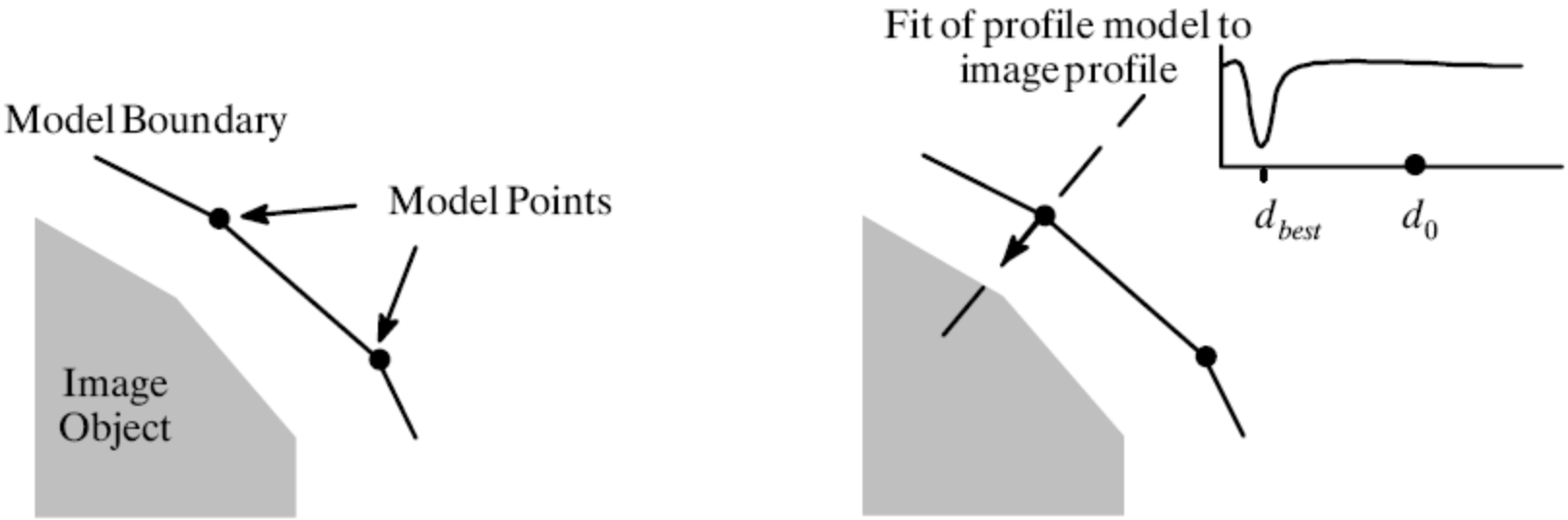
Local image match forces





$$d^2_{Maha}(s) = (\mathbf{w}(s) - \overline{\mathbf{w}})\Sigma_{\mathbf{w}}^{-1}(\mathbf{w}(s) - \overline{\mathbf{w}})$$

Local image match forces



$$f_{prof}(d) = (\boldsymbol{h}(d) - \bar{\boldsymbol{g}})^T \boldsymbol{S}_{\boldsymbol{g}}^{-1}(\boldsymbol{h}(d) - \bar{\boldsymbol{g}})$$

Conclusion

- Using prior knowledge of training set
- Using Grey level appearance model
- Constraint on shape deformation