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)
- Modeling grey level appearance (profile)
- Segmentation by shape deformation
Point Distribution Model

\[ x_i = (x_{i0}, y_{i0}, x_{i1}, y_{i1}, \ldots, x_{ik}, y_{ik}, \ldots, x_{in-1}, y_{in-1})^T \]

\[
\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i \quad \text{and} \quad dx_i = x_i - \bar{x}
\]

\[
S = \frac{1}{N} \sum_{i=1}^{N} dx_i dx_i^T \quad \text{and} \quad Sp_k = \lambda_k p_k
\]
Point Distribution Model

\[ x = \bar{x} + Pb \]

\[ P = (p_1 \quad p_2 \quad \ldots \quad p_t) \]

\[ b = (b_1 \quad b_2 \quad \ldots \quad b_t)^T \]

\[ D_m^2 = \sum_{k=1}^{t} \left( \frac{b_k^2}{\lambda_k} \right) \leq D_{\text{max}}^2 \]
Point Distribution Model

\[ -2 \sqrt{\lambda_1} \quad b_1 \quad 2 \sqrt{\lambda_1} \]

\[ -2 \sqrt{\lambda_2} \quad b_2 \quad 2 \sqrt{\lambda_2} \]

\[ -2 \sqrt{\lambda_3} \quad b_3 \quad 2 \sqrt{\lambda_3} \]

\[ -2 \sqrt{\lambda_4} \quad b_4 \quad 2 \sqrt{\lambda_4} \]
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
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

\[
d^2_{Maha}(s) = (w(s) - \bar{w})\Sigma_w^{-1}(w(s) - \bar{w})
\]
Local image match forces

\[ f_{\text{prof}}(d) = (h(d) - \bar{g})^T S_g^{-1}(h(d) - \bar{g}) \]

Model Boundary
Model Points
Image Object

Fit of profile model to image profile

\[ d_{\text{best}} \quad d_0 \]
Conclusion

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