

Active Appearance Model Based Segmentation Cardiac MR and Transthoracic Echo Images and Image Sequences

Milan Sonka

The University of Iowa, Iowa City IA, USA milan-sonka@uiowa.edu



Í

Active Appearance Model Based Segmentation

• Goals:

- Development of a robust segmentation technique based on shape and appearance
- Single approach to variety of medical image analysis problems via machine learning
- Native analysis in 2D, 2D+time, 3D, 4D
- Validation in large groups of subjects
- Application to cardiac MR, cardiac echo, liver tumor resection surgery planning, ...
- Direct computer-aided diagnosis of disease status













• Modes of covariance matrix variation can be determined via eigen-decomposition of the covariance matrix.

$$S\mathbf{p}_{i} = \lambda_{i}\mathbf{p}_{i}$$

$$P = (\mathbf{p}^{1}\mathbf{p}^{2}\mathbf{p}^{3}\dots\mathbf{p}^{2N})$$

Principal Component Analysis creates a more compact basis function from a multi-dimensional set of data where the mean is at the origin.

The result is a PDM model of shapes

Calgary 10

 $x \approx \bar{x} + P\mathbf{b}$

Í

<section-header><section-header><list-item><list-item><list-item><list-item><list-item><list-item>

















- Conventional AAM better suited for appearance matching than for accurate border detection - local structures and boundary information are not specifically considered
- Local border properties are considered in Active Shape Models

Hybrid ASM/AAM matching

Calgary 19

*





Fully Automated Segmentation

- Hough Transform determines LV centers
- AAM matching till convergence
- ASM/AAM matching till convergence (typically 3-5 iterations)
- AAM matching initialized with mean appearance and most recent shape
- Several initial orientations used to achieve sufficiently good match.





Complete Hybrid ASM/AAM Segmentation

fir





Validation Indices

- fir
- Border positioning errors (signed average, RMS, max)
- Area measurements (LV, RV, EPI)
- Computer-determined results compared with observer-defined independent standard
- Regression analysis used for area measurements
- Bland-Altman statistic used to compare area measures



























Three-dimensional AAM

Í

- In general it is an extension of 2D + time
- Point correspondence remains a problem
- Model construction:
 - Instead of Delaney triangulation, LV is explicitly defined by hand as a set of tetrahedrons – doing it once for training set
 - Quaternion representation used for 3D objects (common in computer graphics)
 - 3D warping implemented using Barycentric coordinates (center of gravity of triangles)











3D-AAM ... unsolved problems

É

- Model lacks resolution in the z-direction affecting the ability of the model to extend to the apex and base in many segmentations
- Point correspondence still a difficult problem in developing new models.
- The model is dependent on the set of samples.

































- 1) shape features distinguish normal/infarct/hypertrophic heart in 2D cardiac MR
- 2) motion features in 2D+T echo



Cardiomyopathy



• Promising results for distinguishing hypertrophic cardiomyopathy





 Early detection of irreversible changes of RV function in congenital heart disease – project ongoing
 Calgary 66



Conclusion

- fir
- AAM is a powerful technique with a wide application field to medical image data
- Hybrid ASM/AAM further improves segmentation performance
- New applications can be designed almost automatically by supplying new sets of manually-traced examples



