Active Appearance Models

Theory and Applications

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Why AAM?

- ASM is relatively fast
- ASM too simplistic; not robust when new images are introduced
- May not converge to good solution
- Key insight: ASM does not incorporate all gray-level information in parameters

Active Appearance Models

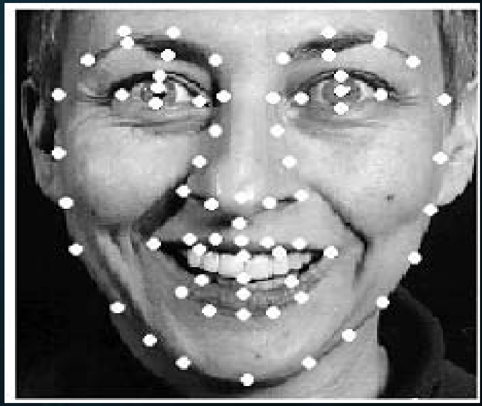
- Combine shape and gray-level variation in single statistical appearance model
- Goals:
  - Model has better representational power
  - Model inherits appearance models benefits
  - Model has comparable performance

How to generate AAM

- Label training set with landmark points representing positions of key features
- Represent these landmarks as a vector x
- Perform PCA on these landmark vectors

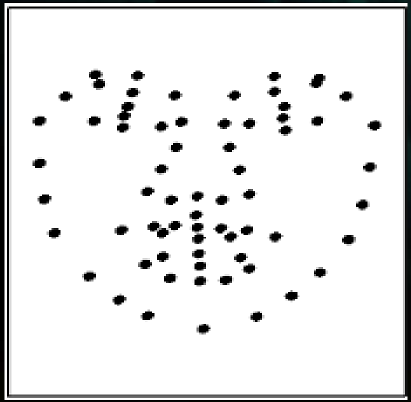
Appearance Models

Combined Model



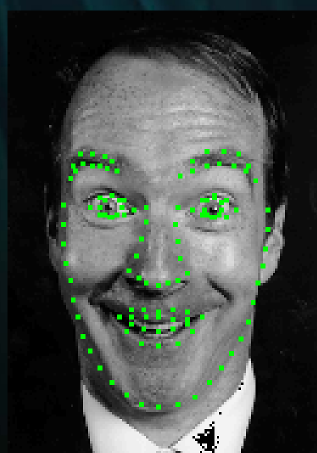
“Shape”

“texture”



Building an Appearance Models

- For each example



Shape: $\mathbf{x} = (x_1, y_1, \ldots, x_n, y_n)^T$

Warp to mean shape

Raster Scan

Texture: **g**

$$g = (g_{im} - \beta 1) / \alpha$$

$$\alpha = g_{im}\bar{g}, \beta = (g_{im} 1) / n$$

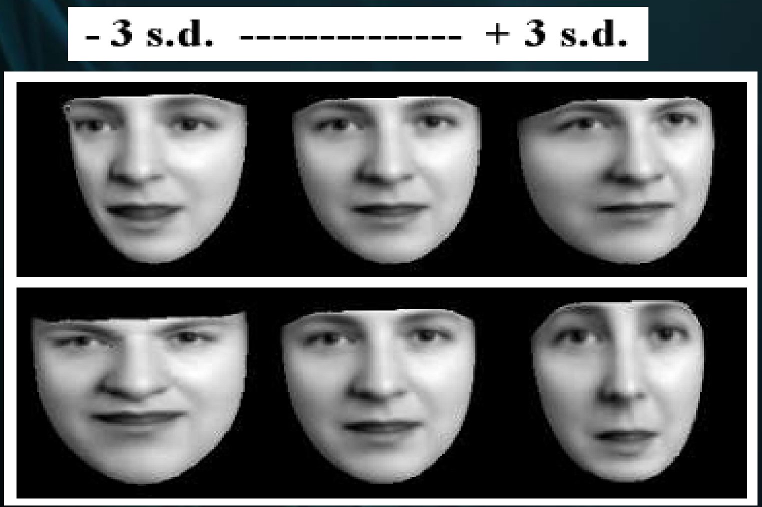
Building an Appearance Models

- Principal component analysis
  - shape model: $\mathbf{x} = \overline{\mathbf{x}} + \mathbf{P}_s \mathbf{b}_s$
  - texture model: $\mathbf{g} = \overline{\mathbf{g}} + \mathbf{P}_g \mathbf{b}_g$
- Columns of $\mathbf{P}_r$ form shape and texture bases
- Parameters $\mathbf{b}_r$ control modes of variation

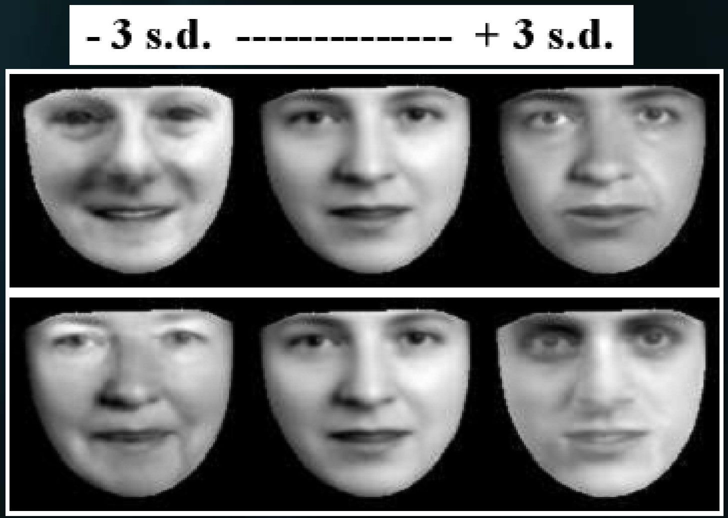
Combined Appearance Models

- Shape and texture may be correlated
- Concatenate shape and gray-level parameters (from PCA)
- Apply a further PCA to the concatenated vectors
  - PCA of $\begin{pmatrix} \mathbf{b}_s \\ \mathbf{b}_g \end{pmatrix} \Rightarrow \begin{pmatrix} \mathbf{x} \\ \mathbf{g} \end{pmatrix} = \begin{pmatrix} \overline{\mathbf{x}} \\ \overline{\mathbf{g}} \end{pmatrix} + \begin{pmatrix} \mathbf{Q}_\mathbf{x} \\ \mathbf{Q}_\mathbf{g} \end{pmatrix} \mathbf{c}$

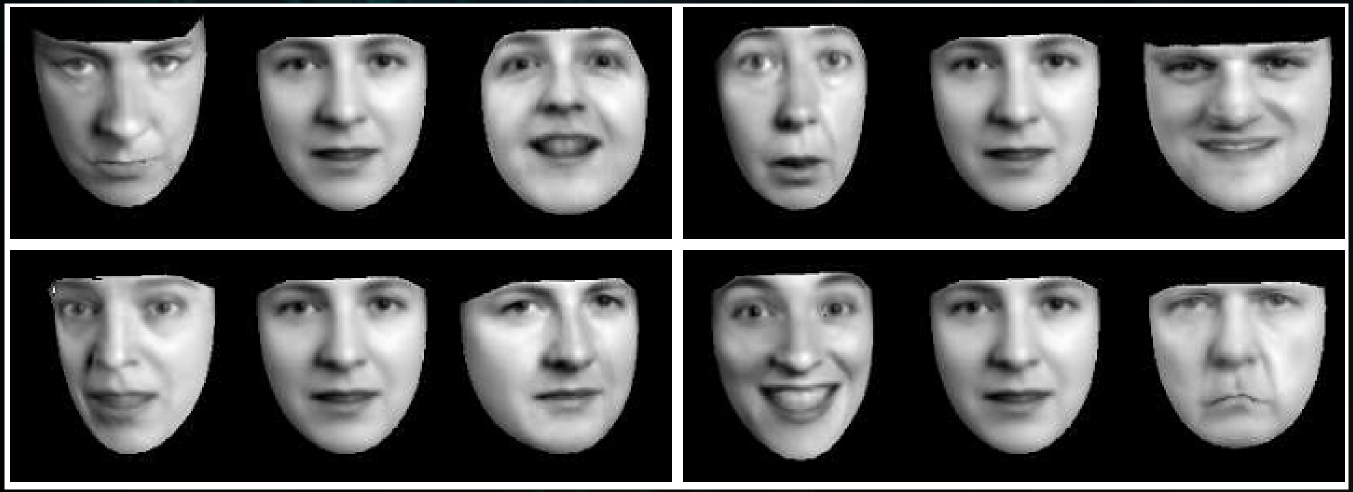
Combined Appearance Models



First two modes of shape variation



First two modes of gray-level variation



First four modes of appearance variation **C**

AAM Properties

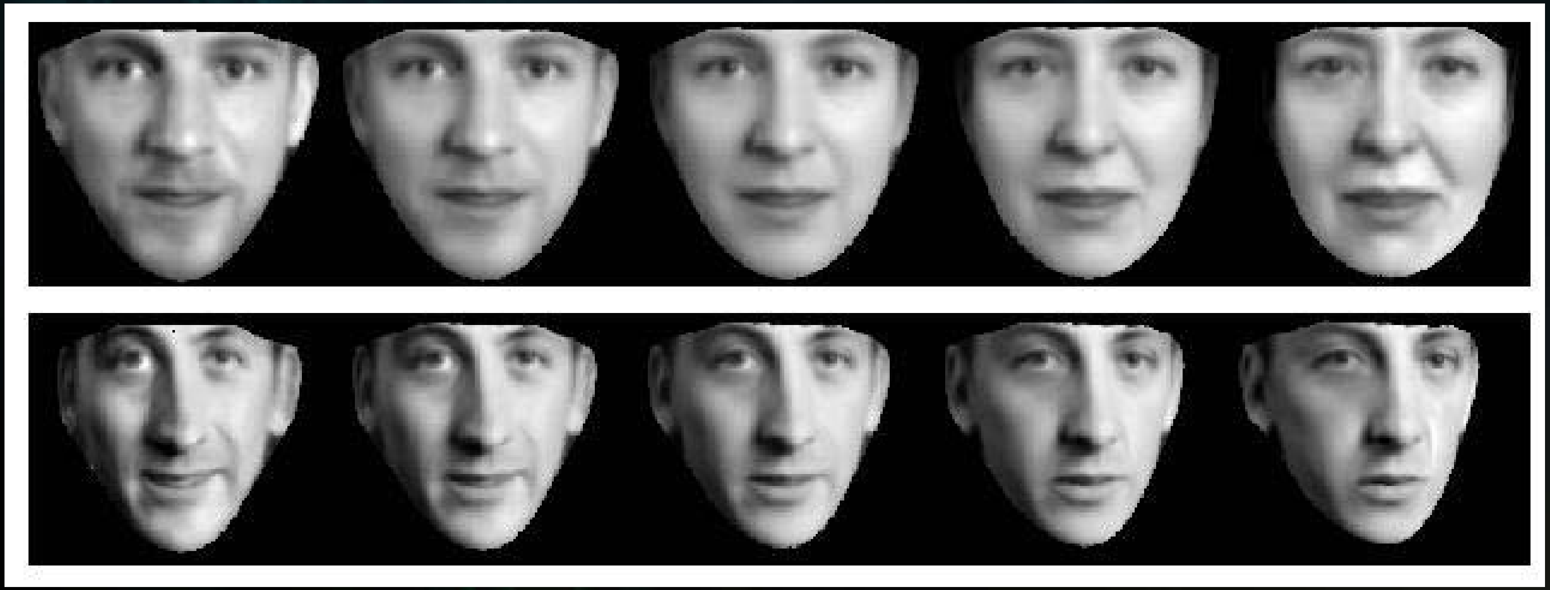
- Combines shape and gray-level variations in one model
  - No need for separate models
- Compared to separate models, in general, needs fewer parameters
- Uses all available information

AAM Properties

- Inherits appearance model benefits
  - Able to represent any face within bounds of the training set
  - Robust interpretation
- Model parameters characterize facial features

AAM Properties

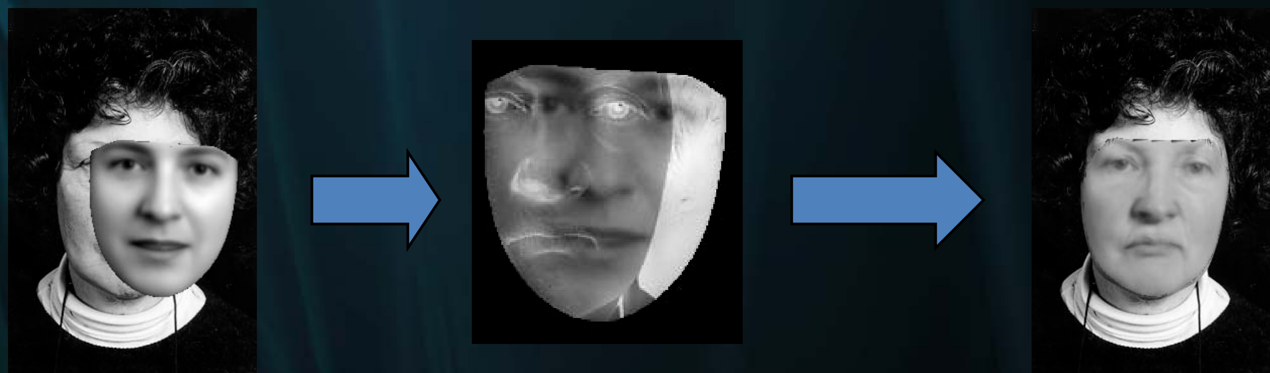
- Obtain parameters for inter and intra class variation (identity and residual parameters) – “explains” face



AAM Properties

- Useful for tracking and identification
  - Refer to: G.J.Edwards, C.J.Taylor, T.F.Cootes. "Learning to Identify and Track Faces in Image Sequences“. Int. Conf. on Face and Gesture Recognition, p. 260-265, 1998.
- Note: shape and gray-level variations are correlated

Interpreting Images



Place model in image

Measure Difference

Update Model

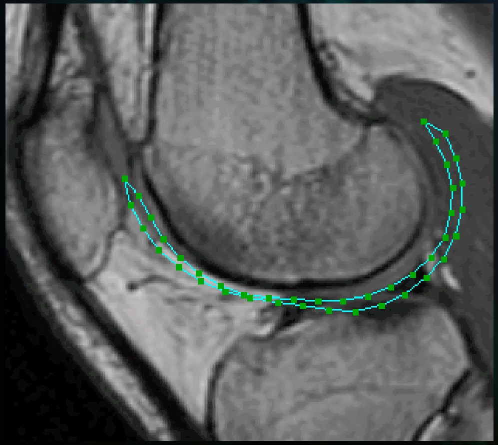
Iterate

Interpreting Images

- Model generates image $\mathbf{I}_m(\mathbf{p})$
  - parameters $\mathbf{p} = \{\, \mathbf{c}, x_c, y_c, s, \theta \,\}$
- Minimise $|\, \mathbf{I}_{target} - \mathbf{I}_m(\mathbf{p}) \,|^2$
  - residual error $\delta\mathbf{I} = \mathbf{I}_{target} - \mathbf{I}_m(\mathbf{p})$
  - predict correction $\delta\mathbf{p} = \mathbf{R}\,\delta\mathbf{I}$
  - $\mathbf{p} \to \mathbf{p} - \delta\mathbf{p}$
  - repeat to convergence

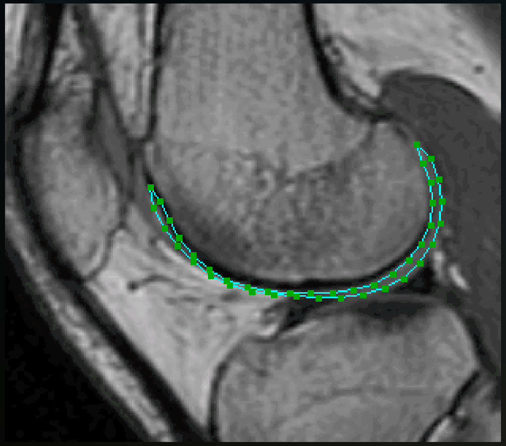
- Difficult optimization problem
  - high-dimensional, local minima, slow

Interpreting Images



Initial

2 its



Converged(11 its)

Thank you!