Active Appearance Models
Theory and Applications

Yanfei Mao
University of Utah
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: \( \mathbf{x} = (x_1, y_1, \ldots, x_n, y_n)^T \)

Texture: \( \mathbf{g} \)

\[
\alpha = g_{im} \bar{g}, \quad \beta = (g_{im1}) / n
\]
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

\[ \text{PCA of } \begin{pmatrix} b_s \\ b_g \end{pmatrix} \rightarrow \begin{pmatrix} x \\ g \end{pmatrix} = \begin{pmatrix} \bar{x} \\ \bar{g} \end{pmatrix} + \begin{pmatrix} Q_x \\ Q_g \end{pmatrix} c \]
Combined Appearance Models

First two modes of shape variation

First two modes of gray-level variation

First four modes of appearance variation
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
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

- Note: shape and gray-level variations are correlated
Interpreting Images

Place model in image → Measure Difference → Update Model

Iterate
Interpreting Images

- Model generates image $I_m(p)$
  - parameters $p = \{c, x_c, y_c, s, \theta\}$

- Minimise $|I_{target} - I_m(p)|^2$
  - residual error $\delta I = I_{target} - I_m(p)$
  - predict correction $\delta p = R \delta I$
  - $p \Rightarrow \delta p$

- repeat to convergence

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

Initial                                2 its                       Converged(11 its)
Thank you!