Face Collections

15-463: Rendering and Image Processing
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Nov. 2: Election Day!

Your choice!
Figure-centric averages

Averages: Hundreds of images containing a person are averaged to reveal regularities in the intensity patterns across all the images.

Cambridge, MA by Antonio Torralba
More by Jason Salavon


“100 Special Moments” by Jason Salavon

Why blurry?

Little Leaguer

Kids with Santa

The Graduate

Newlyweds
Face Averaging by Morphing

Point Distribution Model

Average faces

Manipulating Facial Appearance through Shape and Color

Duncan A. Rowland and David I. Perrett

St Andrews University

IEEE CG&A, September 1995
Face Modeling

Compute *average* faces (color and shape)

Compute *deviations* between male and female (vector and color differences)

Changing gender

Deform shape and/or color of an input face in the direction of "more female"
Enhancing gender

more same original androgynous more opposite

Changing age

Face becomes “rounder” and “more textured” and “grayer”

original

color

both
**Change of Basis (PCA)**

From $k$ original variables: $x_1, x_2, \ldots, x_k$:

Produce $k$ new variables: $y_1, y_2, \ldots, y_k$:

\[
\begin{align*}
    y_1 &= a_{11}x_1 + a_{12}x_2 + \ldots + a_{1k}x_k \\
    y_2 &= a_{21}x_1 + a_{22}x_2 + \ldots + a_{2k}x_k \\
    \vdots \\
    y_k &= a_{k1}x_1 + a_{k2}x_2 + \ldots + a_{kk}x_k
\end{align*}
\]

such that:

$y_k$'s are uncorrelated (orthogonal)

$y_1$ explains as much as possible of original variance in data set

$y_2$ explains as much as possible of remaining variance

etc.

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**Subspace Methods**

How can we find more efficient representations for the ensemble of views, and more efficient methods for matching?

- **Idea:** images are not random… especially images of the same object that have similar appearance

E.g., let images be represented as points in a high-dimensional space (e.g., one dimension per pixel)
Linear Dimension Reduction

Given that differences are structured, we can use ‘basis images’ to transform images into other images in the same space.

What linear transformations of the images can be used to define a lower-dimensional subspace that captures most of the structure in the image ensemble?
Principal Component Analysis

Given a point set \( \{ \mathbf{f}_j \}_j = 1 \ldots P \), in an \( M \)-dim space, PCA finds a basis such that

- coefficients of the point set in that basis are uncorrelated
- first \( r < M \) basis vectors provide an approximate basis that minimizes the mean-squared-error (MSE) in the approximation (over all bases with dimension \( r \))

Remark:

- If the data is multi-dimensional Gaussian, then its marginals are Gaussian, and the PCA coefficients are statistically independent
- If the marginal PCA coefficients are Gaussian, then
  - the maximum entropy joint distribution is multi-dim Gaussian
  - but the true joint distribution may NOT be Gaussian
EigenFaces

First popular use of PCA for object recognition was for the detection and recognition of faces [Turk and Pentland, 1991]

- Collect a face ensemble
- Normalize for contrast, scale, & orientation.
- Remove backgrounds
- Apply PCA & choose the first $N$ eigen-images that account for most of the variance of the data.

Blinz & Vetter, 1999

show SIGGRAPH video