Introduction

- **Goal**: non-supervised object recognition, image classification
- **Method**: compute a mean object and characteristic modes of variation
- **Basic Tool**: non-supervised diffeomorphic image matching
- **Advantages**: non-supervised, non-specific to a particular dataset
- **Example**: Yale face image dataset
- **Classification Application**: face expression recognition task

Diffeomorphic Image Matching

- **Initial Image**: A
- **Target Image**: B
- **Method**: search for a diffeomorphism \( h \) such that \( A \circ h \simeq B \)

Image Similarity Criterion: Local Cross-Correlation (LCC)

\[
LCC(A, B) = \int_{\Omega} v_A(y)^T v_B(y) \, dy
\]

with \( v_A(y) \) local variance of image \( A \) in a gaussian neighborhood of point \( y \), and \( v_A(y) \) the local covariance

- **Smoothing Term**: for example \( R(h) = ||h - Id||_P \)
- **Image Matching**: multiscale gradient descent with respect to warping field \( h \) of \( E(A, B, h) = R(h) - LCC(A \circ h, B) \)

Computation of the Mean Image

- **Data**: set of \( n \) images \( I_i \)
- **Goal**: computation of a mean image \( M \)
- **Problem**: gradient descent involving \( M \) intensity leads to local minima
- **Solution**: use diffeomorphisms

\[
M = \frac{1}{n} \sum_{i=1}^{n} I_i \circ h_i
\]

Classiﬁcation Task: Face Expression Recognition

- **Goal**: associate, to any new face, its expression (among 5 given expressions)
- **Data**: a training set, a new face with and without expression
- **Method**: compare the warping field between the 2 new images to known labeled fields (after alignment to the mean face). Result: 53/65. Incorrect labels are marked.

Modes of Shape Variation

- **Data**: \( n \) images \( I_i, n \) warping fields \( h_i \)
- **Method**: warping ﬁeld statistics
- **Correlation between 2 ﬁelds**: \( (h_i[h_j]) = \int h_i(y) \cdot h_j(y) \, dy \)
- **Modes**: diagonalization of correlation matrix, extraction of eigenmodes \( F_k \) and their eigenvalues \( \sigma_k \)
- **Example**: application of the modes to the mean image \( M \) with different amplitudes

Modes of Shape and Intensity Variation

- **Intensity Variations**: \( v_i \)
- **Intensity Variation Correlation**: \( (v_i[v_j]) = \int v_i(y) \cdot v_j(y) \, dy \)
- **Combined Shape-Intensity Correlation**: \( (h_i, v_i[v_j]) = (h_i[h_j]) + (v_i[v_j]) \)
- **New Modes**: with 2 parts (deformation ﬁeld and intensity modiﬁcation ﬁeld)

Algorithm Comparison: SVM on images leads to 17 errors instead of 12

Without Normal Face: use warping ﬁeld from the mean face to the new face. Result: 41/65 (SVM on images: 38).