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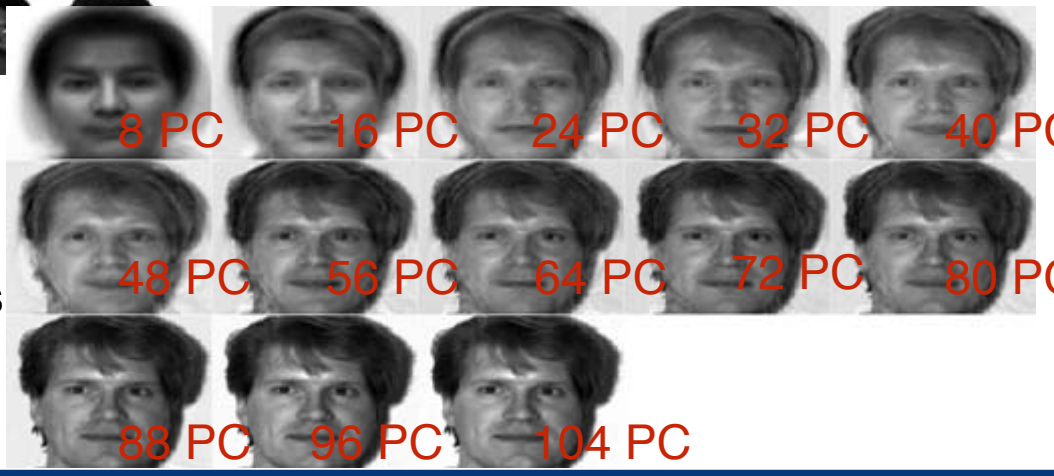
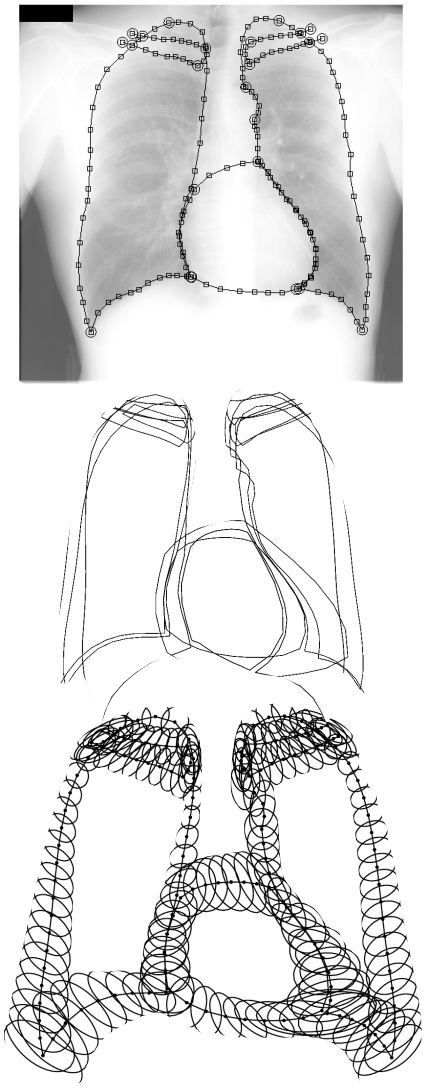


80X80 aligned patches depicting faces. We organise them as column vectors having 6400d rows

And what about medical image analysis

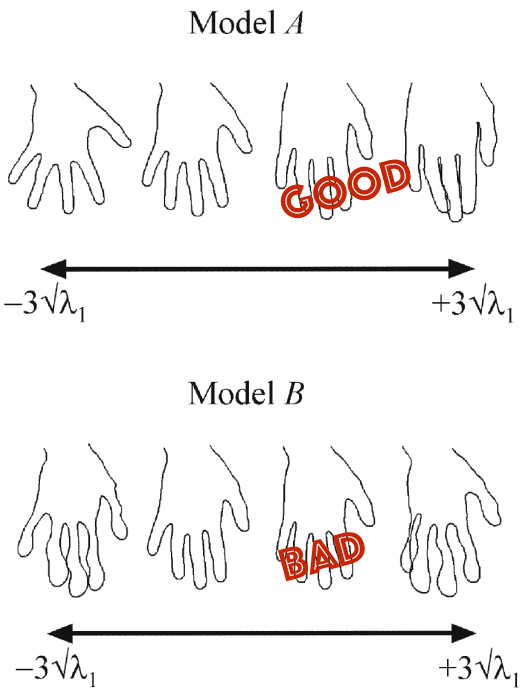
- Shapes can be captured by PCA
  - Shapes can be represented as Point Distribution Models PDM
  - Described by a fixed number of landmarks
  - Registered together
  - All the instances of each landmark across the dataset form a point cloud
  - We stack the coordinates of the landmarks in feature vectors
  - Instead of independent PCA for each point cloud, perform a PCA on whole-shape vectors!



Images from: van Ginneken, B, Stegmann, MB, Loog, M **(2006)**. Segmentation of anatomical structures in chest radiographs using supervised methods: a comparative study on a public database. *Med Image Analisys*, 10, 1:19-40.

Shape analysis

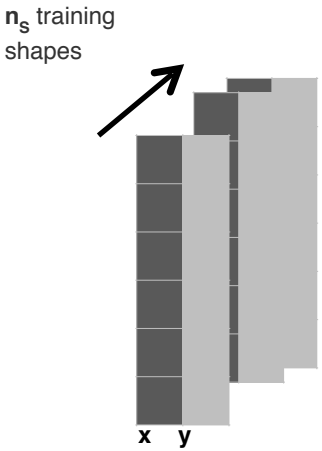
- Simple shapes: align control points manually
- Complex shapes: solving the correspondence problem
  - Manual pixel/voxel segmentation
  - Mesh the segmentation
  - Resample meshes with the same number of points
  - Bring the points into correspondence
    This is a registration problem!
  - Common approach: parameterize the shapes by projection onto a topological shape primitive (e.g. the unit sphere)
  - Solve correspondence by re-parameterization
- Statistical Models of Shape: Optimisation and Evaluation, Rhodri Davies, Carole Twining and Chris Taylor, Springer, 2008



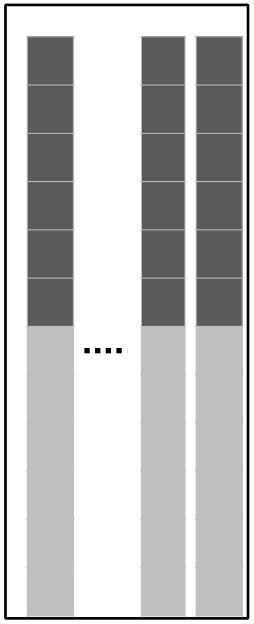
Slide courtesy of Diana Matheus and Ahmad Ahmadi

Shape analysis

- Compute a mean shape S_μ from the PDM $S_\mu = \frac{1}{n_S}\sum_{i=1}^{n_S} S_i$
- Use PCA to calculate an orthogonal basis of shape deformations

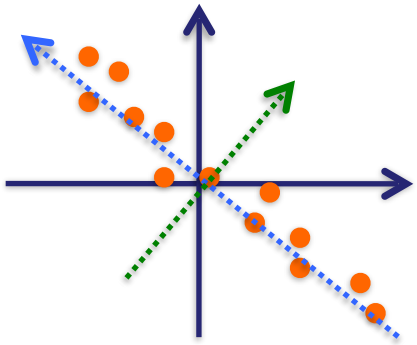


Landmark representation in x/y coordinates

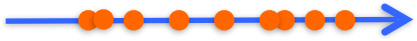


Training data matrix for PCA: Representation as shape vectors

S_i



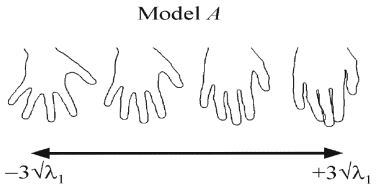
PCA



Slide courtesy of Diana Matheus and Ahmad Ahmadi

PCA as a regularization

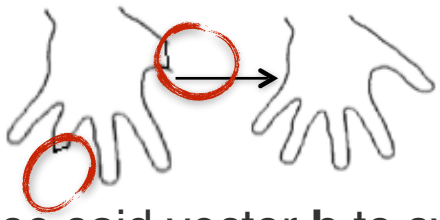
- We can show the modes of variation captured by the model by synthesis of a new shape :
  1. We vary weights associated with eigen-modes to get new data-points that are representative of the learnt modes of variation of the data. In the example below we get new “legal”shape by varying **b**.



$$\mathbf{x} = \bar{\mathbf{x}} + \mathbf{\Phi b}$$

Shape vector for artificial shape — Mean shape vector — PCA basis (eigenvectors) — Weight vector

- We can regularise a data-point (a shape, a patch) using PCA:
  1. We can take a high dimensional data-point that is a noisy version of the data-points seen during training (for example a shape that is not very regular or that ignores part of the object) and we can reduce its dimensionality through PCA getting a vector of weights **b**.



$$\mathbf{b}' = \mathbf{\Phi}^T(\mathbf{x}' - \bar{\mathbf{x}})$$

Weight vector for the nearest plausible shape — PCA basis (eigenvectors) — Shape vector of candidate points — Mean shape vector

  2. We can use said vector **b** to synthesise a new “legal” data-point, for example a “legal” shape.