Exercise 08 for MA-INF 2201 Computer Vision WS24/25
15.12.2024
Submission on 5.01.2025

1. **Procrustres Analysis:** We are given *hands_orig_train.txt.new* which contains 56 landmark points on hand contours from 39 different subjects. The underlying structure of the given data is further explained in the *readme* file. The goal of this task is to align the data. The rough outline of the analysis is as follows:

   - Compute the mean shape (μ_s). (Use affine transformation as shown in slides)
   - Align each shape to μ_s.
   - Compute the RMS error between aligned shapes and the new mean shape.
   - Repeat above steps until convergence (either small error or max number of steps).

   Display the shapes and the mean shape before and after the alignment to verify your results.

   (8 Points)

2. **Statistical Shape Modeling:**

   - Build a PPCA based statistical shape model $\mathcal{M}$ using the data in *hands_align_train.txt.new*. The data is a set of 56 corresponding landmark points on hand-contours from 39 instances that have already been aligned using Procrustres Analysis. Refer to the *readme* file for details about data organization. Choose the number of basis functions N to be the minimum number of principal components preserving 90% of the energy. Visualize μ and the effect of varying positive and negative weights of each ϕ_k.
   - When does the computation of the eigenvalue decomposition for matrix WW^T become computationally prohibitive? What can you do in this case?

   Restriction: Implement PPCA by yourself. You can utilize *np.linalg.eig* or *np.lingalg.svd* for this task.

   (8 Points)

3. **Inference:** Express the test shape in *hands_align_test.txt* in terms of the generated model $\mathcal{M}$. Display the values of h_{ik}. Also, reconstruct the test shape as $\hat{w}_{test}$, visualize the original and the reconstructed shapes and calculate the RMS error between both shapes.

   (4 Points)