

# Learning from Images

## Autoencoder (8 Points)

WiSe 2024/25

The aim of this exercise is to compare dimensionality reduction methods such as PCA as a linear embedding with linear and non-linear Auto-encoder Neural Networks.

### Exercise 1: PCA on Face images (5 Points)

For this task you need to implement Dimensionality Reduction on a given face dataset (See Principal Components Analysis (PCA) as discussed in the lecture). The file *pca.py* contains more details to implement it on your own (without scikit-learn) using a Singular Value Decomposition (SVD). Figure 1 shows an example of a reconstruction from that encoded basis with different number of dimensions used. The mean reconstruction error for the test images should be around (a) 10 dimensions  $\sim 16.18$ , (b) 75 mean error  $\sim 10.48$  and (c) 150 dim, mean error  $\sim 9.36$ .

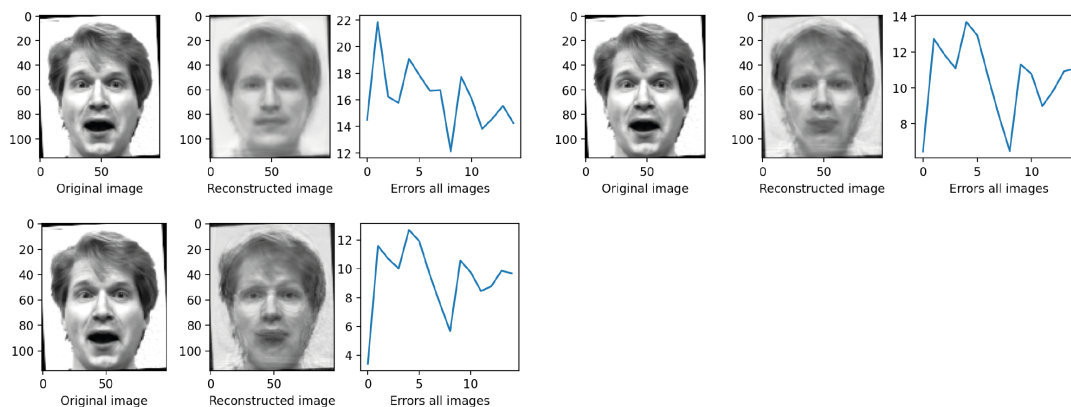


Figure 1: Example original and reconstructed image of the test data using a standard PCA. The plot shows the reconstruction error for all 10 test images. (a) used 10 dimensions for reconstruction (b) 75 dimensions for reconstruction used (c) 150 basis functions used for reconstruction.

### Exercise 2: Linear Autoencoder (3 Points)

The file *auto-encode.py* contains instructions for your linear pytorch autoencoder implementation using a very simple fully-connected neural network. **Note:** Both methods should achieve roughly the same reconstruction results. Figure 2 (next page) shows the results of the approach - a trained neural network that uses only a linear mapping and works as an Autoencoder network with an encoder and decoder path.

**Due:** Please hand in the resulting plots and your mean reconstruction error over all test images in a text file.

This is Exercise 4/4. The tasks are designed to be solvable in 2 weeks. **Information on due date and a link to upload your solution as a .zip file is given in the Moodle system.** Please submit only one single .zip file with the sources of your solution. **Please insert all necessary images so that each task is directly executable. Otherwise I reserve point deductions..** Submission after due date will be deducted with 3 points for each delayed week.

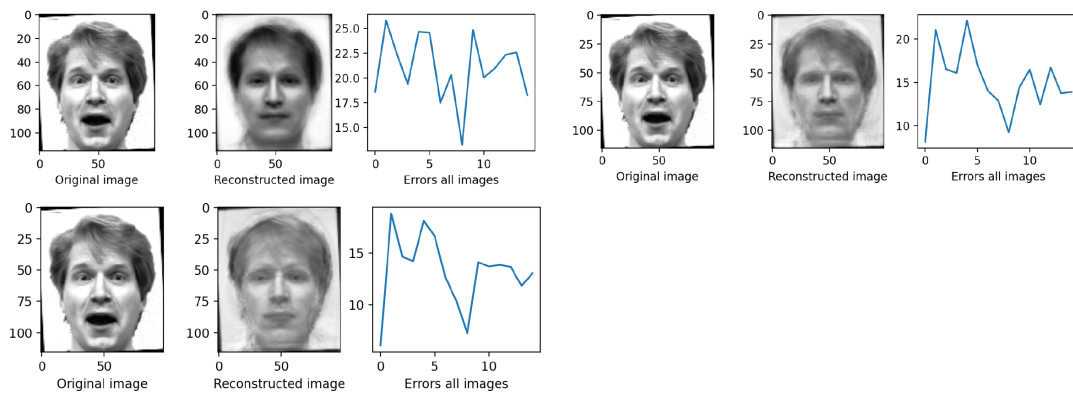


Figure 2: Example original and reconstructed image of the test data using a simple linear autoencoder. The plot shows the reconstruction error for all 10 test images. (a) used 10 output values in the encoder for reconstruction (mean error  $\sim 21.04$ ) (b) 75 output values are used for reconstruction (mean error  $\sim 14.87$ ) (c) 150 encoder output dimensions used for reconstruction (mean error  $\sim 13.25$ ).