# Face Recognition with Yale Faces B dataset

Your job is to perform an SVD analysis of these data sets. Please start with the cropped images and perform the following analysis.

1.  Do an SVD analysis of the images (where each image is reshaped into a column vector and each column is a new image).
    **Answer:**
    See codes for the SVD analysis details. (https://github.com/Xiangyu-Gao/Face-recognition-with-SVD-and-PCA)

2.  What is the interpretation of the U, Σ and V matrices? (Plot the first few reshaped columns of U)
    **Answer:**
    The interpretation of matrix U: columns of U are the image basis; we show the first 9 columns of U by reshaping them to $192 \times 168$ size images.

    The interpretation of matrix Σ: The diagonals' singular values represent the contribution of image basis for reconstructing the images.

    The interpretation of matrix V: rows of V* (i.e., columns of V) can be interpreted as the projection from the reconstructed image to the input truth image. From the lecture, V can also be illustrated as the rotation matrix.

    

3.  What does the singular value spectrum look like and how many modes are necessary for good image reconstructions using the PCA basis? (i.e. what is the rank r of the face space?)
    **Answer:**
    We plot the spectrum for the first 500 singular values. We think 50 PCA basis for image reconstruction is enough because they cover most of the "variance" according to the spectrum. We also compare the reconstruction images with 50 PCA basis with the original image.
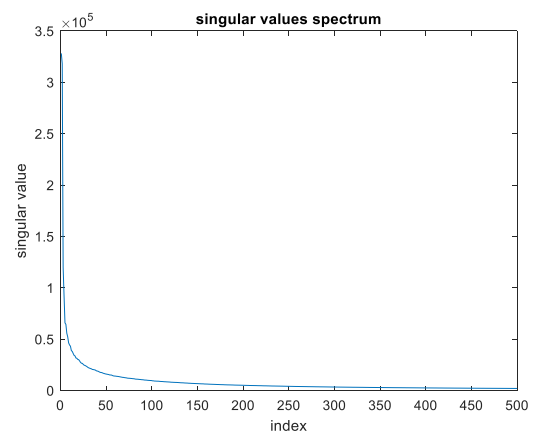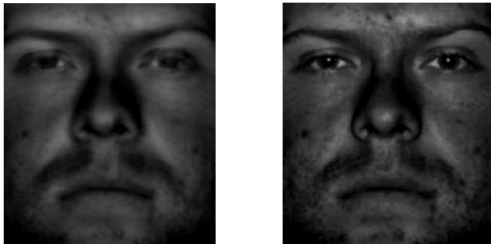
    Reconstruction first image with 50 basis **VS** origin first image

    

    

If we choose less, say 10 basis, the reconstruction first image is blurred:



If we choose more, say 100 basis, the reconstruction first image is clearer:



4. compare the difference between the cropped (and aligned) versus uncropped images in terms of singular value decay and reconstruction capabilities.
   **Answer:**
   We plot the singular value spectrum of the uncropped images below. To compare the singular value decay, we normalize the singular spectrum with maximum 1. From below comparison, the cropped images have faster singular value decay.

   • singular value spectrum of uncropped images **VS** singular value spectrum of cropped images
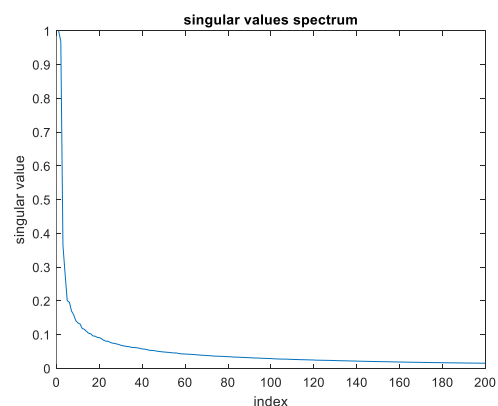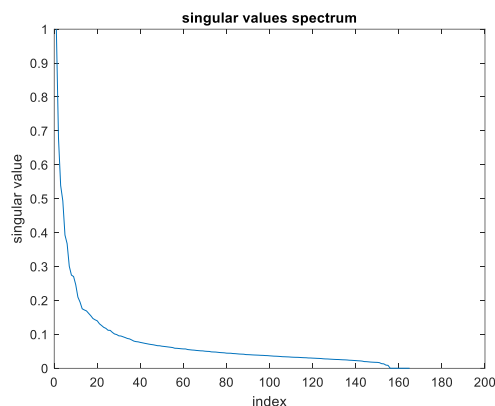


To compare the reconstruction capability, we reconstruction first image of uncropped dataset and cropped dataset with 50 bases. The reconstruction image and original image are shown below. From comparison, we conclude that cropped images have better reconstruction capability (i.e., the reconstruction image is much clearer).

- Reconstruction of uncropped image **VS** Reconstruction of cropped image