Homework 11, due April 3rd, 11:59pm

March 27, 2024

1. Download from Canvas the image `bird.png`, containing a bird shape and the file `horses.zip`, containing 327 horse shapes of size 128×128 pixels each. Load all images and divide their values by 255 if necessary, so that the largest value is 1.

   a) Perform Principal Component Analysis on the horse images using SVD. Discard the two largest singular values and plot the graph of the remaining singular values sorted in decreasing order. (1 point)

   b) Plot a graph of the coordinates of the horses projected to the 2D plane generated by the first and second principal component. (1 point)

   c) On the same graph, display the coordinates of the projections from b) using one color (black) and the projection of the bird image on the same two principal components (PCs) using a red "x". Be sure to subtract the mean of the horses and project to the PCs of the horses. (1 point)

   d) Using the model from a), display the image `horse060.png` and its binary reconstruction obtained after thresholding the PCA reconstruction using 20 PCs with the value 0.5.. (1 point)

   e) Using the model from a), display the bird image and its binary reconstruction using 20 PCs obtained the same way as in e) above. (2 points)

   f) Compute the distances of the horses and the bird to the plane generated by the 32 largest PCs. On the same graph, plot the computed distances (on the y-axis) vs the coordinates of the projections on the second PC (on the x-axis) for the horses (black) and bird (red "x"). (2 points)

   g) Plot the histogram of the distances obtained at f) for the horses. (1 point)