Dive into Digital Image Processing

Assignment 2

June 2023

1. PCA and Hyperplane Fitting

Use the given template code *Q1.py*. Read comments from code *Q1.py*. Datasets has been kept in the folder *data* and stored as *points2D_Set1.mat* and *points2D_Set2.mat*.

a) Consider the observed set of points of the form $(x, y) \in \mathbb{R}^2$ in the file *points2D_Set1.mat*. Show a scatter plot of the points. Overlay on the scatter plot, the graph of a line showing the linear relationship between Y and X.

b) Repeat the same analysis for the set of points in *points2D_Set2.mat*. Show a scatter plot of the points. Overlay on the scatter plot, the graph of a line showing the linear relationship between Y and X.

c) Compared to the result on the first set of points, justify the quality of the approximation resulting in second question using logical arguments. (Just express your thoughts, part c in ungraded but compulsory)

Submission format: For part *a* and *b* include plots in report. For part *c* just description of your thoughts is enough in 2-3 lines.

2. PCA on MNIST dataset

Use the given template code *Q2.py*. Read comments from code *Q2.py*.
Read all instructions before you start.
Dataset comprising images of handwritten digits has been kept in the folder *data* and stored as *mnist.mat*. Use the entire training set of 60000 examples.
Each image is stored as a matrix (28 × 28) of numbers. For the following computations, make sure to convert (cast) the integer data type to a floating-point type. For every digit, from 0 to 9, compute:

a) the mean μ.

b) the covariance matrix C.

c) the principal mode of variation determined by the eigenvector v_1 and the corresponding eigenvalue λ_1 (where λ_1 is the largest of all eigenvalues) of the covariance matrix C.

The covariance matrix will be of size $28^2 \times 28^2$.

- For each digit, sort the 28^2 eigenvalues of the covariance matrix and plot them as a graph. Comment and justify what you observe. How many "principal" / significant modes of variation (i.e., number of "large" eigenvalues) do you find, for each digit ? Are the significant modes of variation equal to 28^2 or far less ? Why ?

- For each digit, show the 3 images side by side:

  a) $\mu - \sqrt{\lambda_1 v_1}$

  b) μ

  c) $\mu + \sqrt{\lambda_1 v_1}$

  to show the principal mode of variation of the digits around their mean. Comment and justify what you observe. For a certain digit, say 1, what does the principal mode of variation tell you about how people write that digit ?

Submission format: For each part write appropriate answer/ images in the report.