Programming Assignment 9

Click this link to download the PCA MNIST notebook and then complete problems 1-4.

Problem 1

1/1 point (graded)

Let the function $F_k\ (x)$ denote the operation of taking a handwritten digit image $x \in \mathbb{R}^{784}$, projecting it to k dimensions using PCA, and then reconstructing an image in $\mathbb{R}^{784}$ from the projection alone. Which of the following alternatives best describes the function $F_k\ (x)$?

- It is a nonlinear function that combines a linear operation (projection) with a nonlinear operation (reconstruction).
- It is a nonlinear function that combines a nonlinear operation (projection) with another nonlinear operation (reconstruction).
- **It is a linear function that can be represented by a single matrix.**
- It is the product of k nonlinear functions.

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Problem 2

2/2 points (graded)

In the notebook, we defined a function `show_digit` that takes a 784-dimensional vector and then

- clips all entries in the vector to lie in the range $[0, 255]$,
- converts the vector into a 28×28 array, and
- displays the image represented by this array of grayscale values.

To explain why the first step---clipping the entries---is needed, say whether each of the following statements is `true` or `false`.

a) The original MNIST images occasionally have pixel values that do not lie in the range $[0, 255]$.

- ○ True
- ◉ False

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b) The reconstructed images $F_k\ (x)$ may have pixel values that do not lie in the range $[0, 255]$.

- ◉ True
- ○ False

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Problem 3

1/1 point (graded)

In the notebook, for any desired dimension k, we determined the PCA projection to k dimensions using the entire data set, and then used this one projection for all images. Instead, we could determine the PCA projection (to k dimensions) for each individual digit, and we could then project each image using the projection for the corresponding digit. What is a potential benefit of the latter scheme?

- It is potentially more space-efficient.
- **It potentially preserves more information about each image.**
- The projection operation is potentially faster.
- None of the above.

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Problem 4

1/1 point (graded)

In assessing which dimension to project to, why is it useful to look at examples of reconstructed digits rather than simply looking at the fraction of residual variance (which can be computed directly from the eigenvalues)?

- It is more precise than looking at the fraction of residual variance.
- **It is hard to interpret what a particular fraction of residual variance means, in terms of what kind of information has been lost.**
- The residual variance only tells us how much information has been lost in the projection, not in the reconstruction.

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