Question 1: (30 total points) Image data analysis with PCA

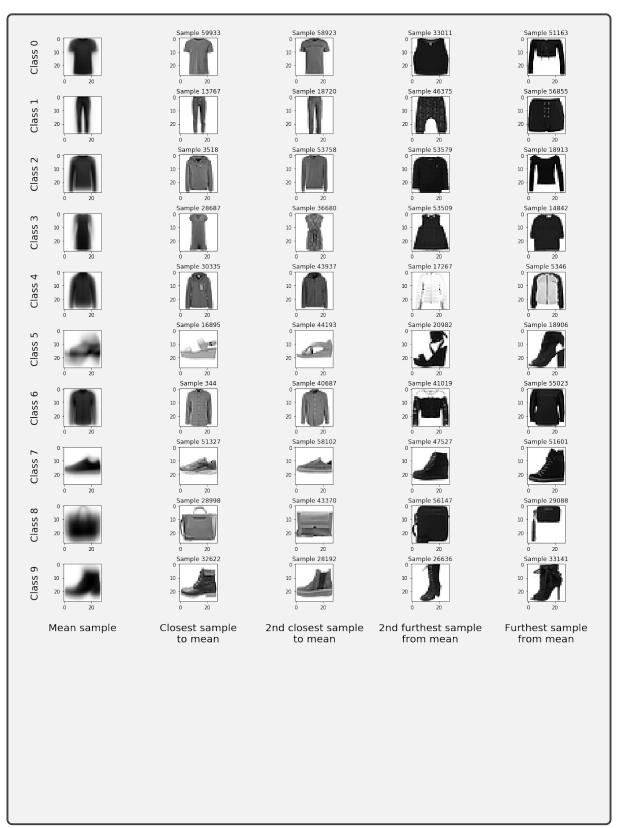
In this question we employ PCA to analyse image data

1.1 (3 points) Once you have applied the normalisation from Step 1 to Step 4 above, report the values of the first 4 elements for the first training sample in Xtrn_nm, i.e. Xtrn_nm[0,:] and the last training sample, i.e. Xtrn_nm[-1,:].

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First 4 elements of the first training sample in Xtrn_nm:
[-3.13725490e-06 -2.26797386e-05 -1.17973856e-04 -4.07058824e-04]

First 4 elements of the last training sample in Xtrn_nm:
[-3.13725490e-06 -2.26797386e-05 -1.17973856e-04 -4.07058824e-04]
```

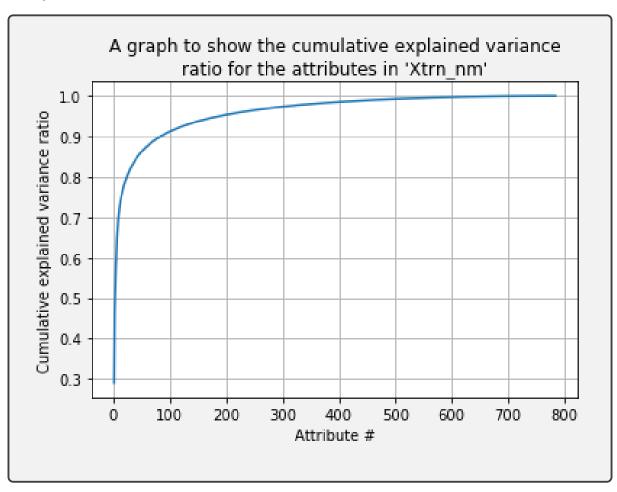
1.2 (4 points) Using Xtrn and Euclidean distance measure, for each class, find the two closest samples and two furthest samples of that class to the mean vector of the class.



1.3 (3 points) Apply Principal Component Analysis (PCA) to the data of Xtrn_nm using sklearn.decomposition.PCA, and find the cumulative explained variance.

The explained variances for the first 5 principal components: [19.80980567 12.11221047 4.10615661 3.38182839 2.62477022]

1.4 (3 points) Plot a graph of the cumulative explained variance ratio. Discuss the result briefly.



1.5 (4 points) Display the images of the first 10 principal components in a 2-by-5 grid, putting the image of 1st principal component on the top left corner, followed by the one of 2nd component to the right. Discuss your findings briefly.



1.6 (5 points) Using Xtrn_nm, for each class and for each number of principal components K=5,20,50,200, apply dimensionality reduction with PCA to the first sample in the class, reconstruct the sample from the dimensionality-reduced sample, and report the Root Mean Square Error (RMSE) between the original sample in Xtrn_nm and reconstructed one.

Your Answer Here		

K = 5	5, 20, 50, 200.			
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1.7 (4 points) Display the image for each of the reconstructed samples in a 10-by-4 grid, where each row corresponds to a class and each row column corresponds to a value of

Your Answer Here		

Question 2: (25 total points) Logistic regression and SVM

In this question we will explore classification of image data with logistic regression and support vector machines (SVM) and visualisation of decision regions.

2.1 (3 points) Carry out a classification experiment with multinomial logistic regression, and report the classification accuracy and confusion matrix (in numbers rather than in graphical representation such as heatmap) for the test set.

Your Answer Here	

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2.5 (6 points) We used default parameters for the SVM in Question 2.2. We now want to
tune the parameters by using cross-validation. To reduce the time for experiments, you
pick up the first 1000 training samples from each class to create Xsmall, so that Xsmall
contains 10,000 samples in total. Accordingly, you create labels, Ysmall.

Your Answer Here	

value of C you found in Question 2.5.			-
Your Answer Here			

2.6 (3 points) Train the SVM classifier on the whole training set by using the optimal

Question 3: (20 total points) Clustering and Gaussian Mixture Models

In this question we will explore K-means clustering, hierarchical clustering, and GMMs.

3.1 (3 points) Apply k-means clustering on Xtrn for k=22, where we use sklearn.cluster.KMeans with the parameters n_clusters=22 and random_state=1. Report the sum of squared distances of samples to their closest cluster centre, and the number of samples for each cluster.

Your Answer Here	

3.2 (3 points) Using the training set only, calculate the mean vector for each language
and plot the mean vectors of all the 22 languages on a 2D-PCA plane, where you apply
PCA on the set of 22 mean vectors without applying standardisation. On the same figure
plot the cluster centres obtained in Question 3.1.

Your Answer Here					

ar	are any structures in the spoken languages.						
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3.3 (3 points) We now apply hierarchical clustering on the training data set to see if there

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i.e.,						
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3.5 (6 points) We now consider Gaussian mixture model (GMM), whose probability distribution function (pdf) is given as a linear combination of Gaussian or normal distributions,