Assignment-2: Face Classification/Verification

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November 2, 2019

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1 Questions

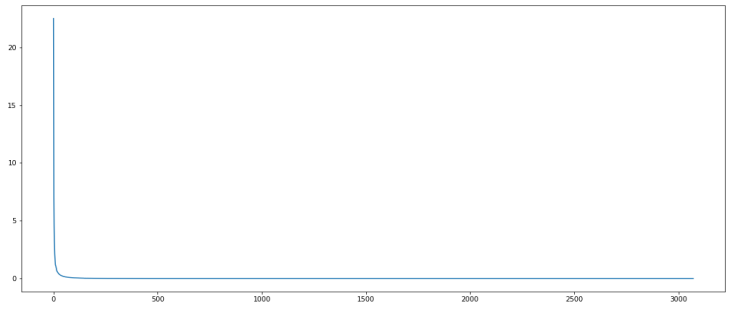
1.1 Problem-1

1. What are "Eigen Faces"?

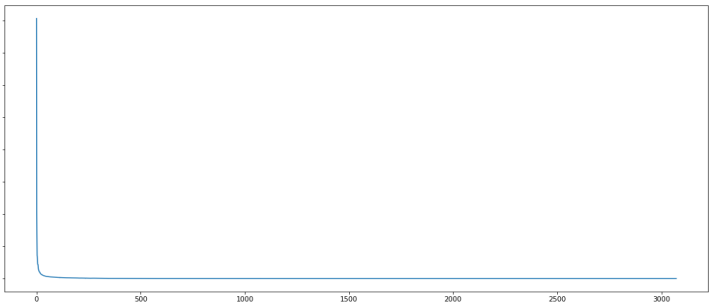
   Eigen Faces are the set of eigen-vectors of the covariance-matrix of face images that are used in the problem of human face recognition. Basically, they are the faces that are reconstruced after applying dimentionality reduction techniques like **PCA** on a given dataset

2. How many eigen vectors/faces are required to reconstruct a person in the three datasets?

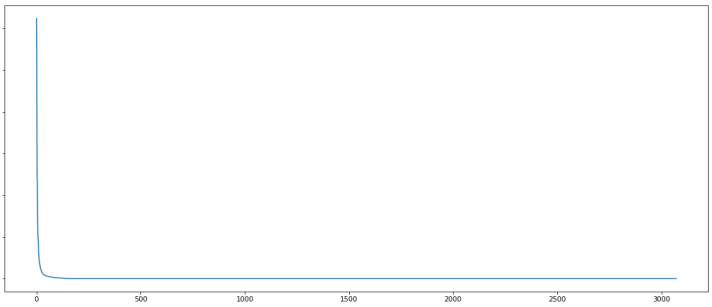
   By seeing the below given eigen-value spectrum, we can say that $k = 50$ to 60 is a satisfactory value for dimentionality reduction for all 3 given datasets.
   IMFDB



   IIIT-CFW

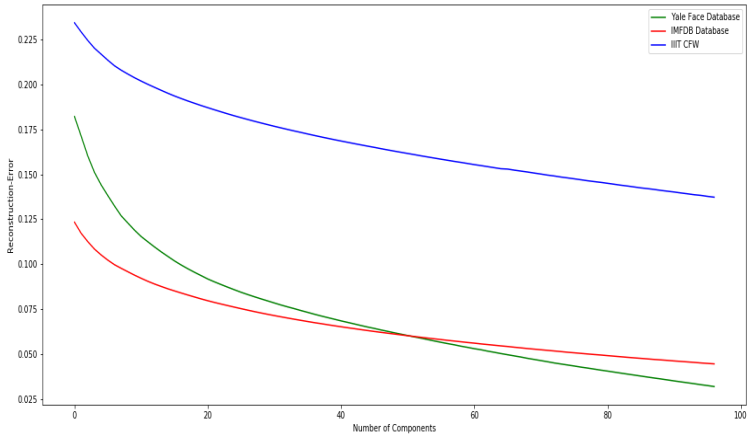


Yale Face Database



Also the scatter plots of each of the database is attached in the jupyter notebook.

3. Which dataset is difficult to represent compactly with fewer eigen-vectors? Why is that? Explain with your empirical observations and intuitive answers?



From the above graph, we notice that faces in the IIIT-CFW Database are difficult to reconstruct with fewer eigen-vectors. This, may be due the great details present in the IIIT-CFW cartoon images that few eigen-vectors are not able to reconstruct the cartoon completely or satisfactorily.

4. Which person/identity is difficult to represent compactly with fewer eigen-vectors?

   The class that is most difficult to represent using fewer eigen-vectors depends on the number of components k chosen. For $k = 10$, the classes are $3, 4, 10$ for IMFDB,IIIT-CFW and Yale-Face Dataset respectively.For $k = 55$, the classes are $3, 5, 4$.

1.2 Problem-2

1. Use an MLP classifier and find the classification accuracy? Which method works well?

   In order to do a comparitive study, I tried all combinations of feature extraction and classifiers.The results are as follows:

   IMFDB

	Feature	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	PCA with MLP	55	0.100	0.900	0.900
1	PCA with SVM	55	0.150	0.850	0.850
2	PCA with LOGISTIC	55	0.150	0.850	0.850
3	KPCA with MLP	55	0.525	0.475	0.475
4	KPCA with SVM	55	0.700	0.300	0.300
5	KPCA with LOGISTIC	55	0.500	0.500	0.500
6	LDA with MLP	7	0.225	0.775	0.775
7	LDA with SVM	7	0.175	0.825	0.825
8	LDA with LOGISTIC	7	0.175	0.825	0.825
9	KLDA with MLP	7	0.250	0.750	0.750
10	KLDA with SVM	7	0.175	0.825	0.825
11	KLDA with LOGISTIC	7	0.175	0.825	0.825
12	VGG with MLP	4096	0.100	0.900	0.900
13	VGG with SVM	4096	0.100	0.900	0.900
14	VGG with LOGISTIC	4096	0.100	0.900	0.900
15	RESNET with MLP	2048	0.025	0.975	0.975
16	RESNET with SVM	2048	0.050	0.950	0.950
17	RESNET with LOGISTIC	2048	0.025	0.975	0.975

   IIIT-CFW

	Feature	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	PCA with MLP	55	0.485294	0.514706	0.514706
1	PCA with SVM	55	0.455882	0.544118	0.544118
2	PCA with LOGISTIC	55	0.411765	0.588235	0.588235
3	KPCA with MLP	55	0.573529	0.426471	0.426471
4	KPCA with SVM	55	0.573529	0.426471	0.426471
5	KPCA with LOGISTIC	55	0.544118	0.455882	0.455882
6	LDA with MLP	7	0.676471	0.323529	0.323529
7	LDA with SVM	7	0.602941	0.397059	0.397059
8	LDA with LOGISTIC	7	0.617647	0.382353	0.382353
9	KLDA with MLP	7	0.661765	0.338235	0.338235
10	KLDA with SVM	7	0.602941	0.397059	0.397059
11	KLDA with LOGISTIC	7	0.617647	0.382353	0.382353
12	VGG with MLP	4096	0.382353	0.617647	0.617647
13	VGG with SVM	4096	0.323529	0.676471	0.676471
14	VGG with LOGISTIC	4096	0.323529	0.676471	0.676471
15	RESNET with MLP	2048	0.014706	0.985294	0.985294
16	RESNET with SVM	2048	0.014706	0.985294	0.985294
17	RESNET with LOGISTIC	2048	0.014706	0.985294	0.985294

Yale-Face Database

	Feature	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	PCA with MLP	55	0.058824	0.941176	0.941176
1	PCA with SVM	55	0.117647	0.882353	0.882353
2	PCA with LOGISTIC	55	0.058824	0.941176	0.941176
3	KPCA with MLP	55	0.823529	0.176471	0.176471
4	KPCA with SVM	55	0.764706	0.235294	0.235294
5	KPCA with LOGISTIC	55	0.470588	0.529412	0.529412
6	LDA with MLP	14	0.176471	0.823529	0.823529
7	LDA with SVM	14	0.058824	0.941176	0.941176
8	LDA with LOGISTIC	14	0.058824	0.941176	0.941176
9	KLDA with MLP	14	0.117647	0.882353	0.882353
10	KLDA with SVM	14	0.058824	0.941176	0.941176
11	KLDA with LOGISTIC	14	0.058824	0.941176	0.941176
12	VGG with MLP	4096	0.647059	0.352941	0.352941
13	VGG with SVM	4096	0.588235	0.411765	0.411765
14	VGG with LOGISTIC	4096	0.529412	0.470588	0.470588
15	RESNET with MLP	2048	0.117647	0.882353	0.882353
16	RESNET with SVM	2048	0.058824	0.941176	0.941176
17	RESNET with LOGISTIC	2048	0.000000	1.000000	1.000000

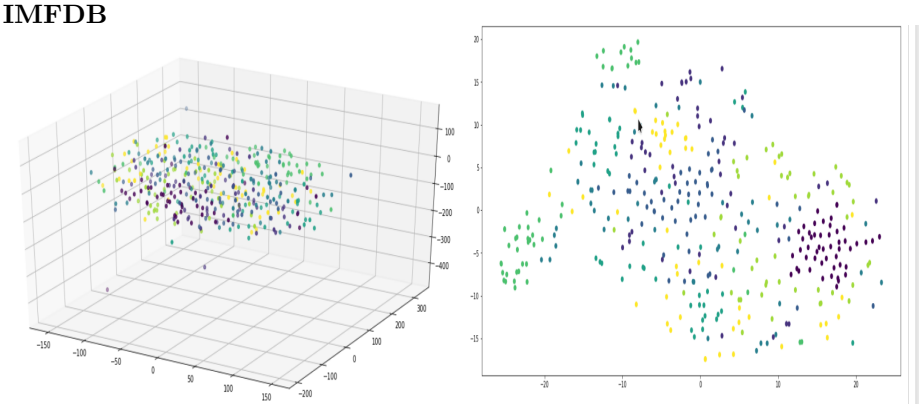
From the above tables, we see that we get high accuracies when we apply RESNET With Logistic Regression

1.3 Problem-3

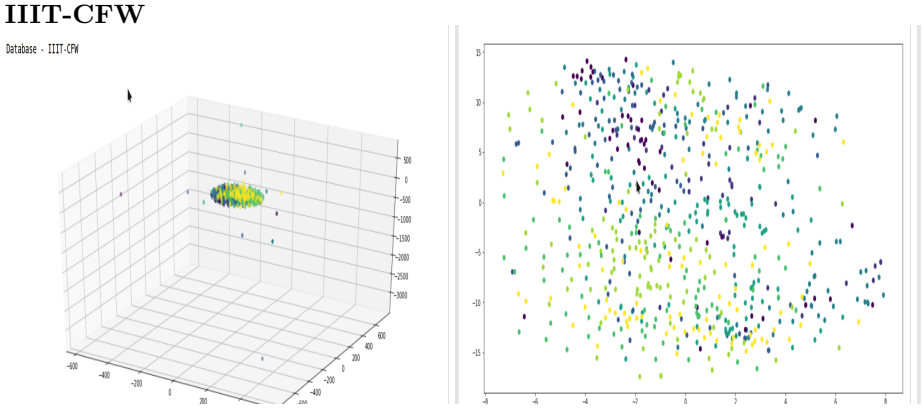
1. Use t-SNE based vizualization of faces? Does it make sense? Do you see similar people coming together? Can you do vizualization datawise and combined?

   From the plots given below and present in the jupyter notebook, we see that after t-SNE, the faces with similar classes tend to come closer.Also, if we plot the faces in all datasets, we see the formation of clusters of similar classes.

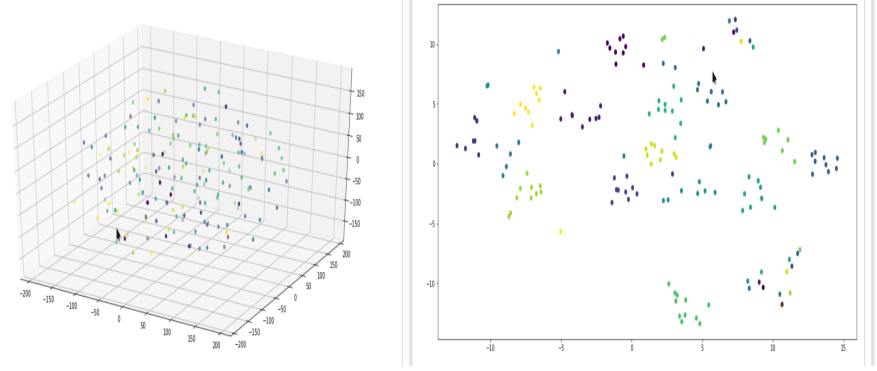
   IMFDB



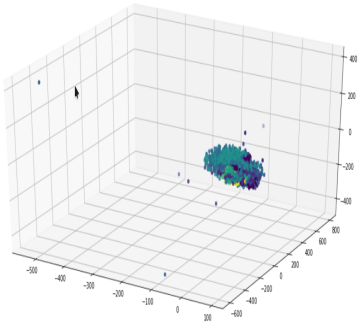
   IIIT-CFW

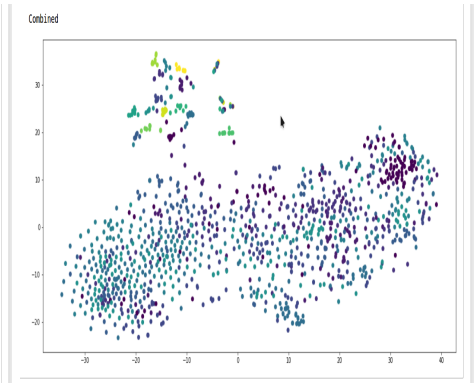


   Yale



Combined





1.4 Problem-4

1. How do we formulate the problem using KNN? How do we analyze the performance?

   We can see the problem as assigning a label to a point which is occurs maximum times in the labels of its k-nearest neighbours.The results with various feature extraction-techniques is as follows:

   Dataset = IMFDB

	Feature	Reduced Dimension Space	Classification Error	Accuracy	Precision
0	PCA with KNN	55	0.350	0.650	0.650
1	KPCA with KNN	55	0.350	0.650	0.650
2	LDA with KNN	7	0.125	0.875	0.875
3	KLDA with KNN	7	0.125	0.875	0.875
4	VGG with KNN	4096	0.125	0.875	0.875
5	RESNET with KNN	2048	0.075	0.925	0.925

   Dataset = IIIT-CFW

	Feature	Reduced Dimension Space	Classification Error	Accuracy	Precision
0	PCA with KNN	55	0.558824	0.441176	0.441176
1	KPCA with KNN	55	0.514706	0.485294	0.485294
2	LDA with KNN	7	0.735294	0.264706	0.264706
3	KLDA with KNN	7	0.735294	0.264706	0.264706
4	VGG with KNN	4096	0.441176	0.558824	0.558824
5	RESNET with KNN	2048	0.000000	1.000000	1.000000

   Dataset = Yale

	Feature	Reduced Dimension Space	Classification Error	Accuracy	Precision
0	PCA with KNN	55	0.294118	0.705882	0.705882
1	KPCA with KNN	55	0.294118	0.705882	0.705882
2	LDA with KNN	14	0.058824	0.941176	0.941176
3	KLDA with KNN	14	0.058824	0.941176	0.941176
4	VGG with KNN	4096	0.588235	0.411765	0.411765
5	RESNET with KNN	2048	0.000000	1.000000	1.000000

The various metrics to analyze performance are accuracy,precision,classification-error,f1-score etc

1.5 Problem-5

1. Take a combination of IIIT-CFW and IMFDB datasets and try to classify the face as male/female.Basically, the problems is a binary classification problem of Gender Determination.
2. **Real Life Applications of Solution-**
   (a) In the age of digital media, we have a lot of data of people's faces in different orientations and environments.
   (b) If we are able to develop a model, that can predict a person's gender with a satisfactory accuracy, then we can easily track movement of people.
   (c) It will be very helpful in improving security at airports and offices where people may try to forge their gender to avail benefits.
3. **Pipeline-**
   (a) Load both the datasets and combine them using vstack.
   (b) Create a new label set with 0 as Female and 1 as Male.
   (c) Try all the feature extraction techniques along with the various classifiers.
   (d) Evaluate the above methods based on accuracy,precision,f1-score etc.
4. **Metrics Used-**
   (a) Accuracy,Precision,F1-Score.

We see that RESNET+KNN OR RESNET+LOGISTIC perform the best

Some Examples of correct and Wrong predictions are given at end of the jupyter notebook

	Feature	Reduced Dimension Space	Classification Error	Accuracy	F1-Score	Precision
0	PCA with MLP	55	0.148148	0.851852	0.851852	0.851852
1	PCA with SVM	55	0.231481	0.768519	0.768519	0.768519
2	PCA with LOGISTIC	55	0.185185	0.814815	0.814815	0.814815
3	PCA with KNN	55	0.194444	0.805556	0.805556	0.805556
4	KPCA with MLP	55	0.148148	0.851852	0.851852	0.851852
5	KPCA with SVM	55	0.268519	0.731481	0.731481	0.731481
6	KPCA with LOGISTIC	55	0.175926	0.824074	0.824074	0.824074
7	KPCA with KNN	55	0.194444	0.805556	0.805556	0.805556
8	LDA with MLP	1	0.379630	0.620370	0.620370	0.620370
9	LDA with SVM	1	0.370370	0.629630	0.629630	0.629630
10	LDA with LOGISTIC	1	0.370370	0.629630	0.629630	0.629630
11	LDA with KNN	1	0.370370	0.629630	0.629630	0.629630
12	KLDA with MLP	1	0.398148	0.601852	0.601852	0.601852
13	KLDA with SVM	1	0.370370	0.629630	0.629630	0.629630
14	KLDA with LOGISTIC	1	0.370370	0.629630	0.629630	0.629630
15	KLDA with KNN	1	0.370370	0.629630	0.629630	0.629630
16	VGG with MLP	4096	0.027778	0.972222	0.972222	0.972222
17	VGG with SVM	4096	0.064815	0.935185	0.935185	0.935185
18	VGG with LOGISTIC	4096	0.037037	0.962963	0.962963	0.962963
19	VGG with KNN	4096	0.037037	0.962963	0.962963	0.962963
20	RESNET with MLP	2048	0.009259	0.990741	0.990741	0.990741
21	RESNET with SVM	2048	0.009259	0.990741	0.990741	0.990741
22	RESNET with LOGISTIC	2048	0.000000	1.000000	1.000000	1.000000
23	RESNET with KNN	2048	0.000000	1.000000	1.000000	1.000000