ASSIGNMENT-2 REPORT

QUESTION-1

a) What are eigenfaces?

Eigen-faces are a set of eigen-vectors of the covariance matrix of the face-image dataset. They are used in face detection and verification. It can be understood as, a face image is a combination of a set of eigen faces.

b) How many eigenvectors/faces are required to "satisfactorily" reconstruct a person in these three datasets?

Number of eigen-vectors for satisfactory reconstruction is obtained by taking the cumulative sum of the first "n" sorted eigen values and the value of n is kept increasing. The value of "n" at which the cumulative sum is more than 0.95 times the total sum of eigen values is the number of eigen vectors needed.

By using this method, the number of eigenvectors/faces for each dataset for satisfactory reconstruction:

IMFDB dataset : 124
IIIT-CFW dataset : 309.
Yale_face_database dataset : 62

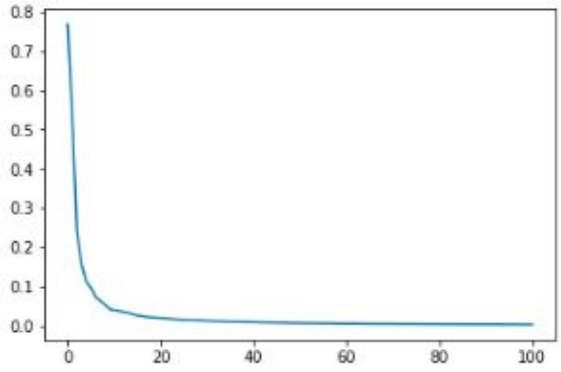
c) Reconstruction errors for the three datasets:

IMFDB dataset: 0.03859199955538973
IIIT-CFW dataset: 0.0681275313485114.
Yale_face_database dataset: 0.05376200551834503

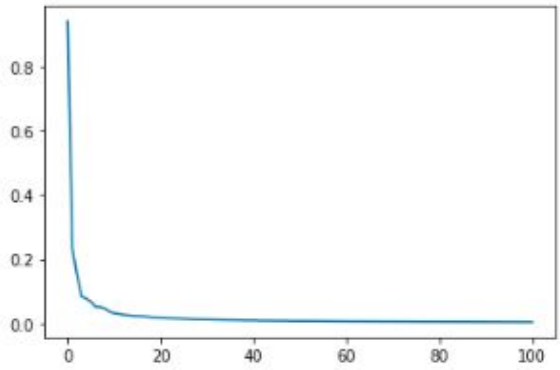
d)

AkshayKumar has the highest reconstruction error in IMFDB
AamirKhan has the highest reconstruction error in IIIT-CFW
Class- 0 has the highest reconstruction error in YALE

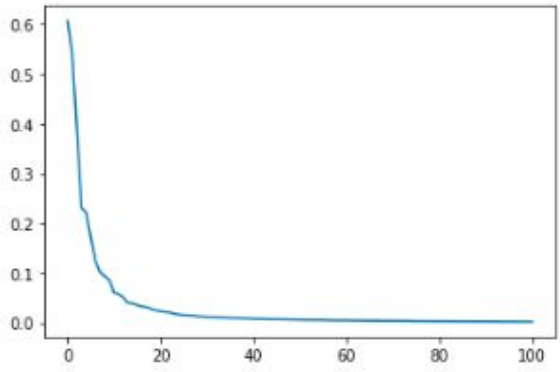
IMFDB DATASET:



RANK: 399
Number of eigen faces req. to get 95%(Sastisfactory) of total eigen values in IMFDB: 124
IIIT-CFW DATASET:



RANK: 671
Number of eigen faces req. to get 95%(Sastisfactory) of total eigen values in IIIT-CFW: 309
YALE DATASET:



RANK: 160
Number of eigen faces req. to get 95%(Sastisfactory) of total eigen values in YALE: 62

QUESTION-2

Comparative study of different selected methods based on their validation accuracy, precision, recall and f1-score values table is presented below.

Table for Dataset-1 IMFDB:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	67	71.25	28.75	0.718546
1	KPCA+MLP	67	78.75	21.25	0.772119
2	LDA+MLP	7	97.50	2.50	0.976496
3	KLDA+MLP	7	90.00	10.00	0.889093
4	VGG+MLP	4096	86.25	13.75	0.839177
5	RESNET+MLP	2048	95.00	5.00	0.949704

Table for Dataset-2 IIIT-CFW:
Dataset shape: (672, 32, 32, 3)

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	309	27.407407	72.592593	0.238728
1	KPCA+MLP	309	34.814815	65.185185	0.370308
2	LDA+MLP	7	96.296296	3.703704	0.960840
3	KLDA+MLP	7	99.259259	0.740741	0.994315
4	VGG+MLP	4096	68.148148	31.851852	0.661961
5	RESNET+MLP	2048	98.518519	1.481481	0.980208

Table for Dataset-3 Yale:
Dataset shape: (165, 32, 32, 3)

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	62	81.818182	18.181818	0.773016
1	KPCA+MLP	62	87.878788	12.121212	0.857778
2	LDA+MLP	14	100.000000	0.000000	1.000000
3	KLDA+MLP	14	100.000000	0.000000	1.000000
4	VGG+MLP	4096	60.606061	39.393939	0.596032
5	RESNET+MLP	2048	100.000000	0.000000	1.000000

Following are the confusion matrices obtained for the best models:

```
Confusion matrix of the best model in IMFDB Dataset: LDA
[[12  2  0  0  0  0  0  0]
 [ 0  8  0  0  0  0  0  0]
 [ 0  0  7  0  0  0  0  0]
 [ 0  0  0 12  0  0  0  0]
 [ 0  0  0  0  9  0  0  0]
 [ 0  0  0  0  0 11  0  0]
 [ 0  0  0  0  0  0 10  0]
 [ 0  0  0  0  0  0  0  9]]
Confusion matrix of the best model in IIIT-CFW Dataset: k-LDA
[[ 6  0  0  0  0  0  0  0]
 [ 0  6  0  0  0  0  0  0]
 [ 0  0 18  0  0  0  0  0]
 [ 0  0  0 17  0  0  0  0]
 [ 0  0  0  0 21  0  0  0]
 [ 0  0  0  0  0 22  0  0]
 [ 0  0  0  0  0  0 23  0]
 [ 0  0  0  0  0  1  0 21]]
Confusion matrix of the best model in Yale Dataset: RESNET
[[3 0 0 0 0 0 0 0 0 0 0 0 0 0]
 [0 2 0 0 0 0 0 0 0 0 0 0 0 0]
 [0 0 2 0 0 0 0 0 0 0 0 0 0 0]
 [0 0 0 3 0 0 0 0 0 0 0 0 0 0]
 [0 0 0 0 2 0 0 0 0 0 0 0 0 0]
 [0 0 0 0 0 2 0 0 0 0 0 0 0 0]
 [0 0 0 0 0 0 2 0 0 0 0 0 0 0]
 [0 0 0 0 0 0 0 5 0 0 0 0 0 0]
 [0 0 0 0 0 0 0 0 1 0 0 0 0 0]
 [0 0 0 0 0 0 0 0 0 3 0 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 1 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 3 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 0 2 0]
 [0 0 0 0 0 0 0 0 0 0 0 0 0 2]]
```

IMFDB Dataset: LDA+MLP, RESNET+MLP, KLDA+MLP work best.

IIIT-CFW Dataset: LDA+MLP, RESNET+MLP, KLDA+MLP work best.

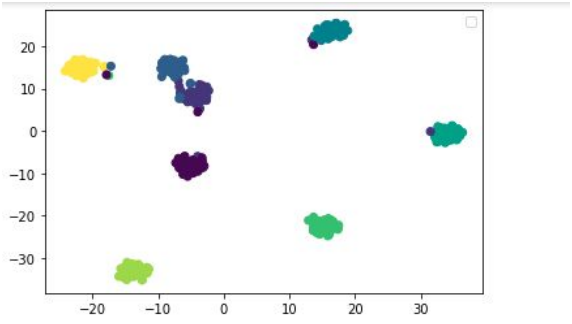
YALE Dataset: LDA+MLP, RESNET+MLP, KLDA+MLP work best.

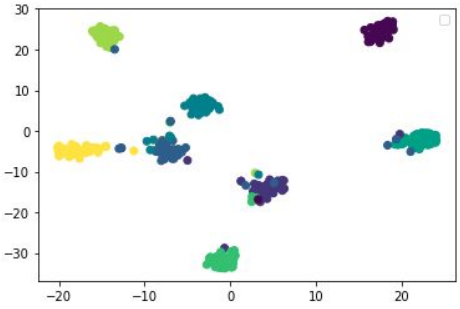
QUESTION-3

Use t-SNE based visualization of faces? Does it make sense? Do you see similar people coming together?or something else? Can you do visualization dataset-wise and combined?

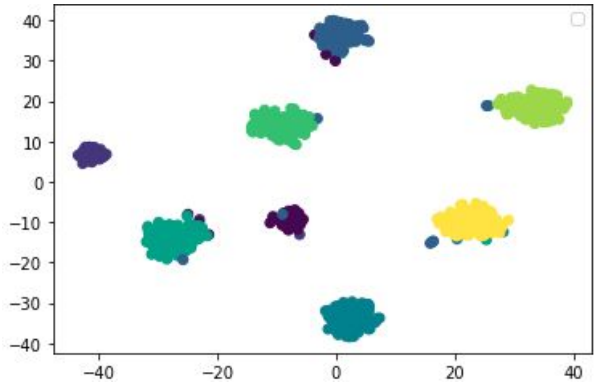
Yes, it makes sense as t-SNE clusters far better than PCA. It can be observed that similar people/classes do come together when see tsne plots with sifferent features like lda,pca,klda etc.,

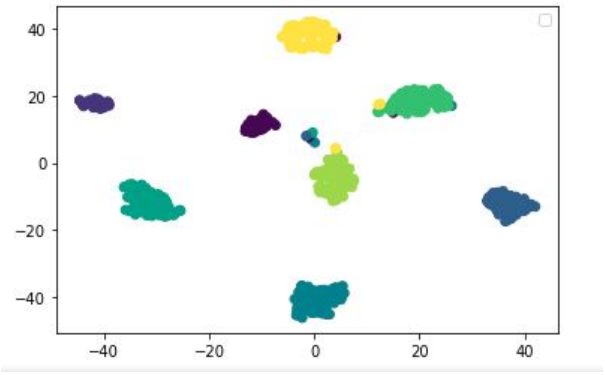
Plots of t-sne on lda and k-lda for the IMFDB:



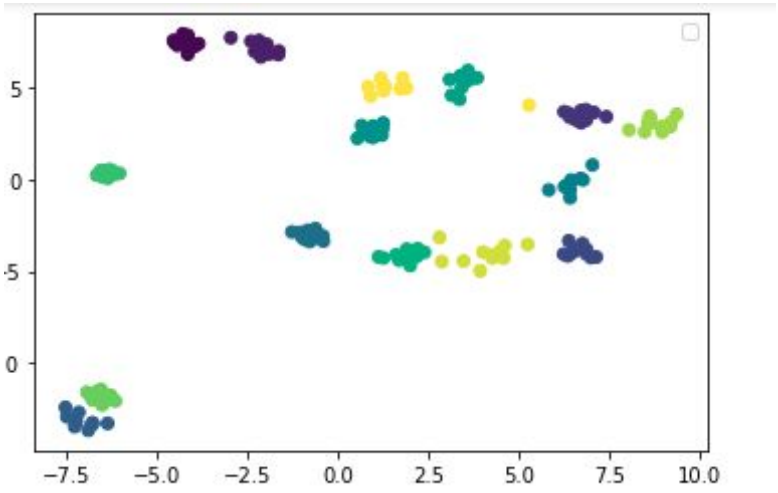


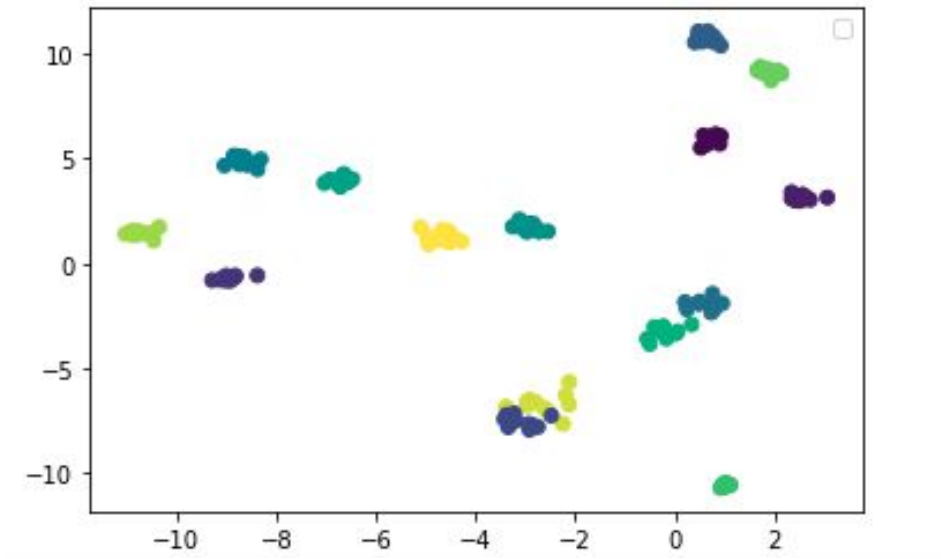
Plots of t-sne on lda and k-lda for the IIIT-cfw:





Plots of t-sne on lda and k-lda for the Yale:





QUESTION-4

a) For given face samples, we extract the features like pca,kpca,lda,klda,resnet and vggnet and label it as “yes” or ”no” by passing it through our trained k nearest neighbours model. Higher k values are preferred as more neighbours are taken into account.

b) Performance analysis can be done using metrics like precision,accuracy and f1 scores.As it can be used in critical situations related to security we need to avoid

false negatives . So,Precision is preferred as punishes false positives but not false negatives.

Emperical Results for k=7:

Table for Dataset-1 IMFDB:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	67	30.00	70.00	0.256258
1	KPCA+MLP	67	46.25	53.75	0.435903
2	LDA+MLP	5	98.75	1.25	0.988421
3	KLDA+MLP	5	96.25	3.75	0.960066
4	VGG+MLP	4096	93.75	6.25	0.930625
5	RESNET+MLP	2048	96.25	3.75	0.958759

Table for Dataset-2 IIIT-CFW:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	309	15.555556	84.444444	0.054668
1	KPCA+MLP	309	18.518519	81.481481	0.095853
2	LDA+MLP	5	97.037037	2.962963	0.954645
3	KLDA+MLP	5	97.777778	2.222222	0.974947
4	VGG+MLP	4096	69.629630	30.370370	0.675416
5	RESNET+MLP	2048	96.296296	3.703704	0.961239

Table for Dataset-3 Yale:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	62	39.393939	60.606061	0.328153
1	KPCA+MLP	62	60.606061	39.393939	0.570238
2	LDA+MLP	5	93.939394	6.060606	0.892857
3	KLDA+MLP	5	100.000000	0.000000	1.000000
4	VGG+MLP	4096	48.484848	51.515152	0.442222
5	RESNET+MLP	2048	96.969697	3.030303	0.961905

Emperical Results for k=13:

Table for Dataset-1 IMFDB:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	67	28.75	71.25	0.272469
1	KPCA+MLP	67	48.75	51.25	0.385334
2	LDA+MLP	5	100.00	0.00	1.000000
3	KLDA+MLP	5	92.50	7.50	0.911937
4	VGG+MLP	4096	92.50	7.50	0.923664
5	RESNET+MLP	2048	93.75	6.25	0.935817

Table for Dataset-2 IIIT-CFW:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	309	11.851852	88.148148	0.065051
1	KPCA+MLP	309	11.111111	88.888889	0.048907
2	LDA+MLP	5	97.037037	2.962963	0.973699
3	KLDA+MLP	5	97.777778	2.222222	0.982014
4	VGG+MLP	4096	62.962963	37.037037	0.588135
5	RESNET+MLP	2048	96.296296	3.703704	0.963524

Table for Dataset-3 Yale:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	62	42.424242	57.575758	0.383333
1	KPCA+MLP	62	48.484848	51.515152	0.434444
2	LDA+MLP	5	84.848485	15.151515	0.877551
3	KLDA+MLP	5	84.848485	15.151515	0.880342
4	VGG+MLP	4096	66.666667	33.333333	0.634921
5	RESNET+MLP	2048	100.000000	0.000000	1.000000

Emperical Results for k=17:

Table for Dataset-1 IMFDB:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	67	17.50	82.50	0.128557
1	KPCA+MLP	67	16.25	83.75	0.094775
2	LDA+MLP	5	98.75	1.25	0.987469
3	KLDA+MLP	5	95.00	5.00	0.949515
4	VGG+MLP	4096	95.00	5.00	0.954240
5	RESNET+MLP	2048	97.50	2.50	0.976260

Table for Dataset-2 IIIT-CFW:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	309	12.592593	87.407407	0.053143
1	KPCA+MLP	309	14.074074	85.925926	0.054497
2	LDA+MLP	5	97.037037	2.962963	0.970681
3	KLDA+MLP	5	97.777778	2.222222	0.968213
4	VGG+MLP	4096	74.814815	25.185185	0.714435
5	RESNET+MLP	2048	99.259259	0.740741	0.993434

Table for Dataset-3 Yale:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	62	30.303030	69.696970	0.251190
1	KPCA+MLP	62	33.333333	66.666667	0.240630
2	LDA+MLP	5	81.818182	18.181818	0.844444
3	KLDA+MLP	5	66.666667	33.333333	0.643810
4	VGG+MLP	4096	39.393939	60.606061	0.439626
5	RESNET+MLP	2048	93.939394	6.060606	0.946939

Emperical Results for k=23:

Table for Dataset-1 IMFDB:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	67	20.00	80.00	0.088235
1	KPCA+MLP	67	17.50	82.50	0.132126
2	LDA+MLP	5	98.75	1.25	0.989048
3	KLDA+MLP	5	95.00	5.00	0.957816
4	VGG+MLP	4096	88.75	11.25	0.887451
5	RESNET+MLP	2048	92.50	7.50	0.924811

Table for Dataset-2 IIIT-CFW:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	309	20.000000	80.000000	0.075999
1	KPCA+MLP	309	17.037037	82.962963	0.061355
2	LDA+MLP	5	95.555556	4.444444	0.944678
3	KLDA+MLP	5	100.000000	0.000000	1.000000
4	VGG+MLP	4096	74.074074	25.925926	0.699631
5	RESNET+MLP	2048	96.296296	3.703704	0.963370

Table for Dataset-3 Yale:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA+MLP	62	30.303030	69.696970	0.276998
1	KPCA+MLP	62	18.181818	81.818182	0.203210
2	LDA+MLP	5	63.636364	36.363636	0.658519
3	KLDA+MLP	5	33.333333	66.666667	0.400159
4	VGG+MLP	4096	42.424242	57.575758	0.383810
5	RESNET+MLP	2048	90.909091	9.090909	0.870748

QUESTION-5 : Gender Prediction:

In this problem, I create a dataset which is a combination of IMFDB and IIIT-CFW. IMFDB contains real images of male and female filmstars and CFW contains male and female politicians. Our model must classify these images as male and female.

This problem is non trivial as the images are of low quality, 32x32 and hence the differentiating characteristics like hair, face-shape,expression,and angle of view are not evident and hence it is also difficult to sometimes classify them manually.

Use cases involve permissions to gender seperated workspaces and emergencies.

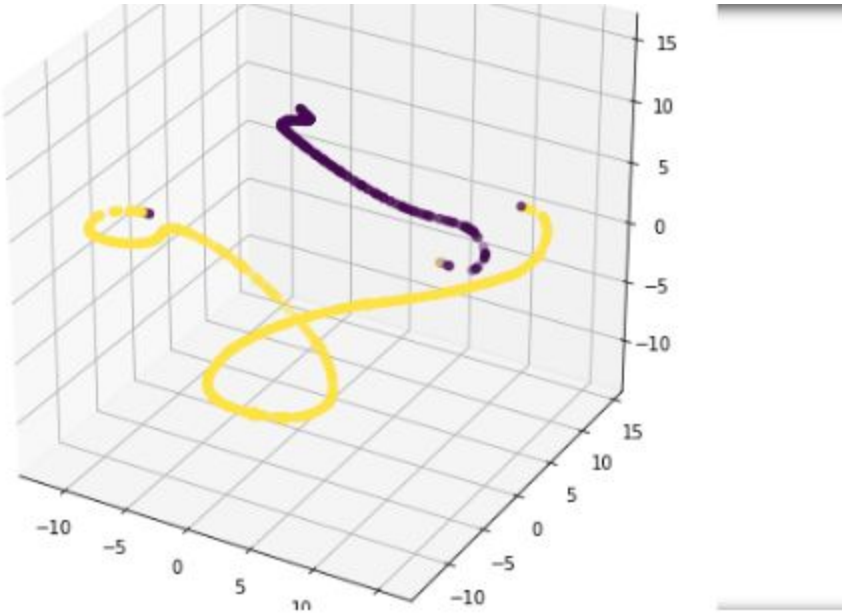
Pipeline:

Feature extraction for dataset(IMFDB + CFW) using PCA, LDA, KLDA, KPCA.
Training and testing will be done using MLP Classifier with LDA
80:20 split will be used on the dataset.

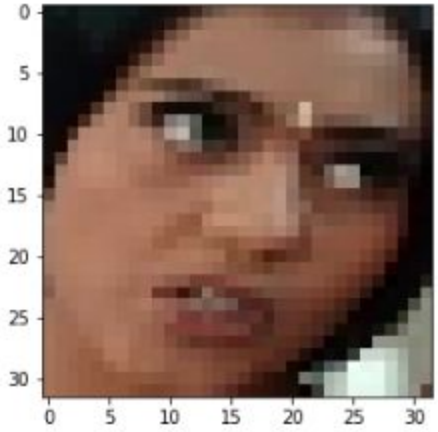
Qualitative Analysis:

	Feature Space	Reduced-Dim-Space	Accuracy	Classification-Error	f1-score
0	PCA	150	86.976744	13.023256	0.830975
1	KPCA	150	88.372093	11.627907	0.840414
2	LDA	5	99.069767	0.930233	0.987317
3	KLDA	5	100.000000	0.000000	1.000000
4	RESNET+PCA	2048	97.209302	2.790698	0.966629

```
Accuracy for k-LDA features: 99.53488372093024
5-fold cross -val mean accuracy: 99.6498028015776
Accuracies of individual folds [1.0, 0.9941860465116279, 1.0, 0.9941520467836257, 0.9941520467836257]
```



Correctly classified image samples:



0 5 10 15 20 25 30

Incorrectly classified image samples: