HAI Assignment 1 Report

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Code : https://github.com/ekansh09/IIITH-HAI-Assignment-1

Overleaf : https://www.overleaf.com/read/gvsgchnhwbqx

1. EIGENFACES

Eigenfaces is a method used for face recognition and detection by determining the variance of faces in a collection of face images and use those variances to encode and decode a face in a machine learning way without the full information reducing computation and space complexity [1].

1.1. Eigenfaces needed to satisfactorily reconstruct the image

Top eigenvectors whose corresponding eigenvalues have 95% sum of total eigenvalues were taken to preserve 95% variance of data (Figure 1).
Table 1 represents the number of eigenvectors selected while maintaining 95% data variance and reconstruction error for each dataset.

Dataset	No. of Eigenvectors	Reconstruction Error
IMFDB	81	0.036
IIIT-CFW	174	0.059
Yale	38	0.050

Table 1. PCA performance

1.2. Observations from Eigenvectors

The classification of each identity has done on the basis of respective class number assigned to it. Also, same number of eigenvectors (Table 1) for 95% variance are used for each dataset.
The class with highest reconstruction error can be easily distinguished in Figure 2.

Dataset	Highest Reconstruction Error
IMFDB	class: 3
IIIT-CFW	class: 5
Yale	class: 7

Table 2. Class having highest reconstruction error

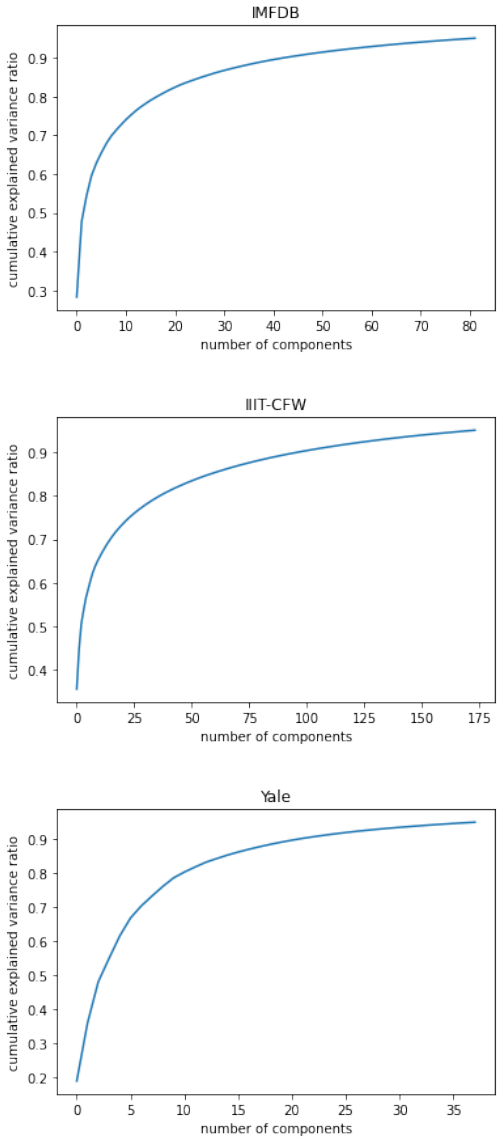

Figure 1. Cumulative Variance Ratio vs Number of Components

2. MLP Classifier

14 combinations of features extraction algorithms were used with MLP Classifier having 2 layers (1000 size each), activation as Relu , solver as adam for 350 iterations. Performace has been observed by using testing accuracy.

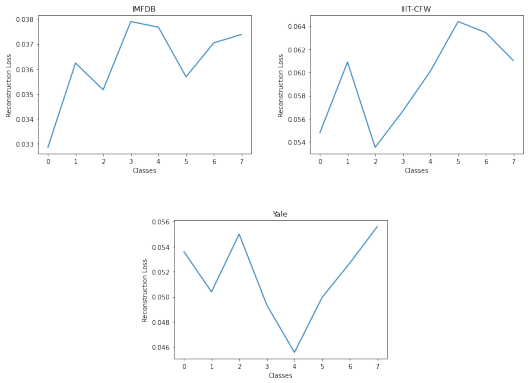

Figure 2. Reconstruction error for each Class in all datasets

Feature Extraction Method	IMFDB	IIIT-CFW	Yale
PCA	74.000000	52.380000	85.710000
LDA	97.000000	96.430000	100.000000
VGG	87.000000	72.020000	50.000000
ResNet	97.000000	97.620000	97.620000
Kernel PCA	74.000000	52.380000	85.710000
Kernel LDA	99.000000	98.810000	100.000000
VGG + PCA	89.000000	66.670000	45.240000
ResNet + PCA	97.000000	96.430000	100.000000
VGG + LDA	100.000000	97.620000	100.000000
ResNet + LDA	100.000000	100.000000	100.000000
VGG + Kernel PCA	89.000000	66.670000	45.240000
ResNet + Kernel PCA	97.000000	96.430000	100.000000
VGG + Kernel LDA	99.000000	96.430000	78.570000
ResNet + Kernel LDA	100.000000	100.000000	100.000000

Figure 3. Performance of MLP using various feature extraction methods on all datasets

It can be observed from Figure 3 that ResNet + Kernel Lda (rbf) outperforms all other methods.

3. t-SNE based visilization of faces

t-Distributed Stochastic Neighbor Embedding (t-SNE) is an unsupervised, non-linear technique primarily used for data exploration and visualizing high-dimensional data [2].

In Figure 4, Images belonging to same class can be observed closer to each other with few outliers in all datasets.

4. k-NN Classifier

Features were extracted using dimensionality reduction algorithms then splitted into train and test set and fitted to k-NN classifier. After testing a few combinations, ResNet + Kernel LDA and ResNet + LDA performed the best among all.

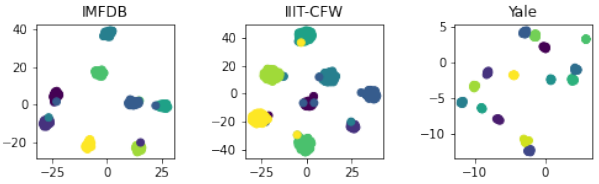

Figure 4. t-SNE (2-D) Visualization

Feature Extraction Method	IMFDB (k=1)	IIIT-CFW (k=10)	Yale (k=3)
PCA	69.000000	42.860000	85.710000
LDA	98.000000	97.020000	100.000000
VGG	90.000000	72.620000	50.000000
ResNet	94.000000	98.210000	100.000000
Kernel PCA	69.000000	42.860000	85.710000
Kernel LDA	98.000000	98.810000	100.000000
VGG + PCA	90.000000	74.400000	52.380000
ResNet + PCA	95.000000	97.620000	100.000000
VGG + LDA	100.000000	98.810000	83.330000
ResNet + LDA	100.000000	100.000000	100.000000
VGG + Kernel PCA	90.000000	74.400000	52.380000
ResNet + Kernel PCA	95.000000	97.620000	100.000000
VGG + Kernel LDA	99.000000	97.620000	85.710000
ResNet + Kernel LDA	100.000000	100.000000	100.000000

Figure 5. Performance of k-NN using various feature extraction methods on all datasets

The performance of k-NN classifier on different datasets using different confinations of dimensionality reduction algorithms is shown in Figure 5.

5. Conclusion

The features of faces present in IIIT-CFW dataset are complex and difficult to classify by MLP and k-NN in comparison to other datasets (IMFDB and Yale Dataset). In the case of ResNet and Kernel LDA together, the accuracy came out to be 100% because these dimensionality reducing algorithms extracted some important features which were then used to classify the identity.

References

[1] M. Galarnyk. Pca using python (scikit-learn), Feb 2021.

[2] L. van der Maaten and G. Hinton. Visualizing data using t-sne. *Journal of Machine Learning Research*, 9(86):2579–2605, 2008.