Assignment 2

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SMAI-M-19

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Problem 1.

a) What are eigen faces?
The eigenvectors which we derive from the covariance matrix of faces, and then those eigenvectors are called as eigenfaces. And any face is then some linear combination of those eigen faces. Eigen faces are blurry depiction of faces, each one highlighting certain type of features.

b) How many eigen vec-tors/faces are required to "satisfactorily" reconstruct a person in these three datasets?
Based on the eigen spectrum, if we need about 80-85 % variance in the data, For the yale dataset we need about 10 Eigen Faces, as it is Grayscale image. For IMFDB dataset, we need about 25 EigenFaces, as it is RGB. For IIIT-CFW, its RGB image, plus there is lot of different pattern in data, its really hard to learn from it. so we would need about 40-50 eigenfaces minimum.

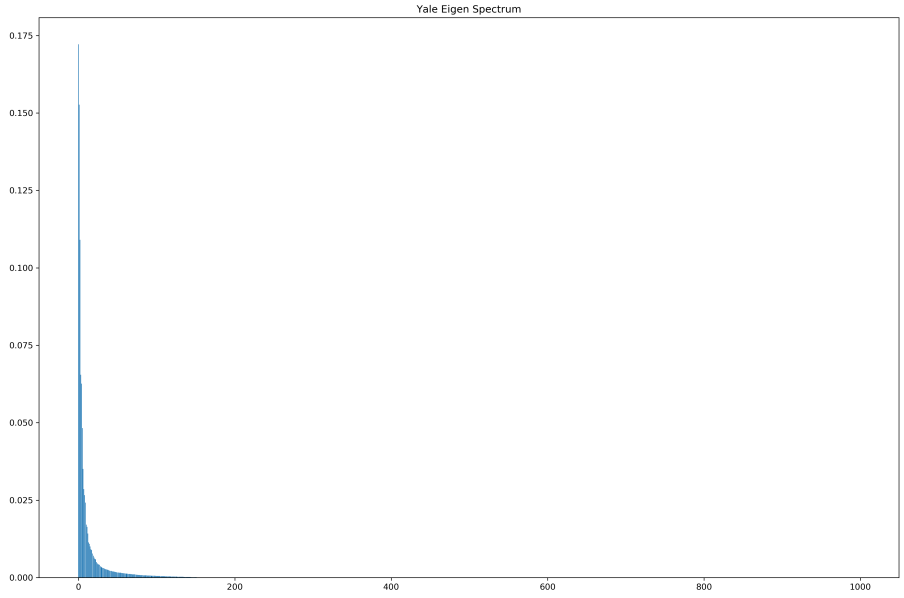

Figure 1: Yale Eigen Spectrum

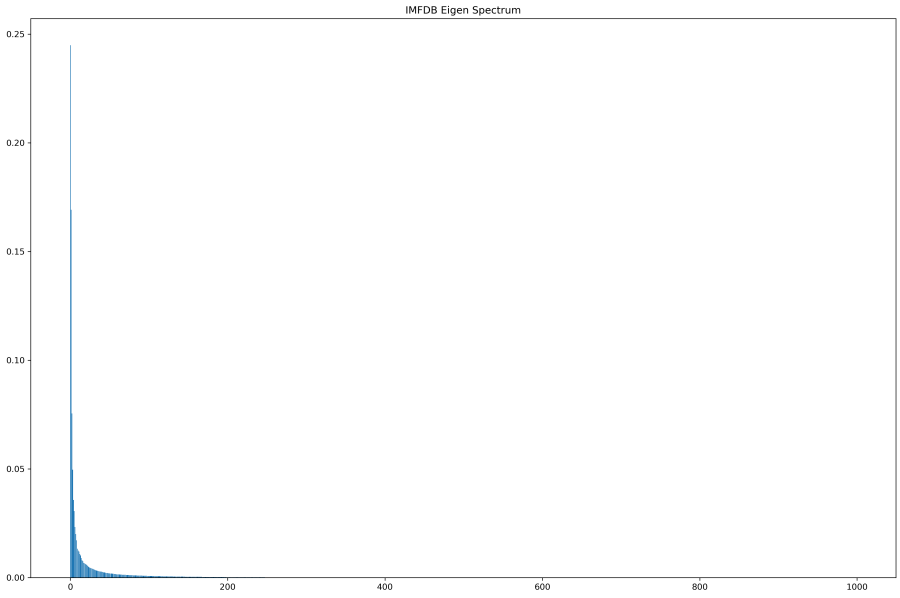

Figure 2: IMFDB Eigen Spectrum

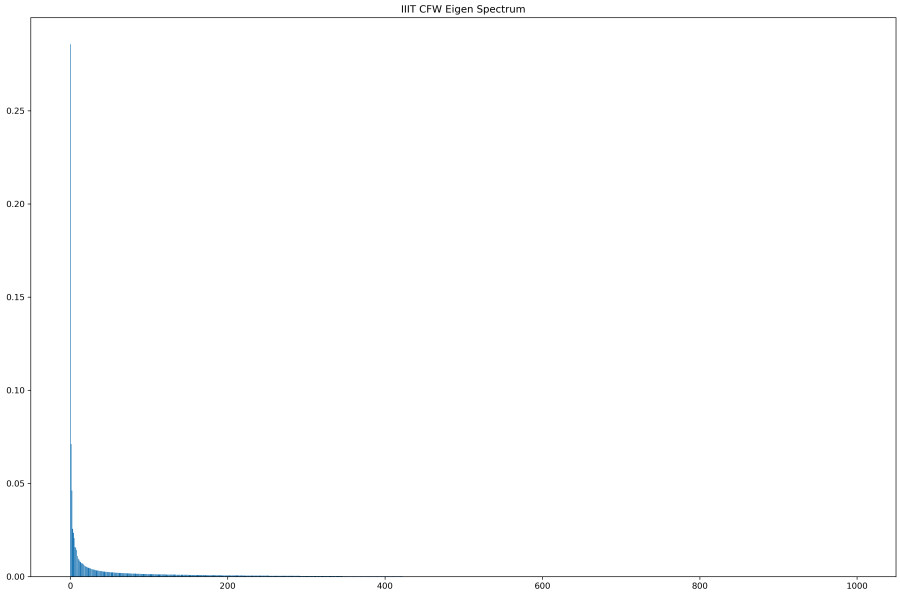

Figure 3: IIIT CFW Eigen Spectrum

c) Reconstruct the image back for each case Plotting randomly taken 6 faces for each dataset.

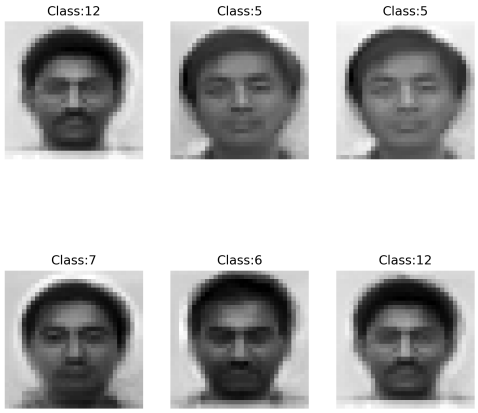

Figure 4: Reconstruction For Yale Face Database

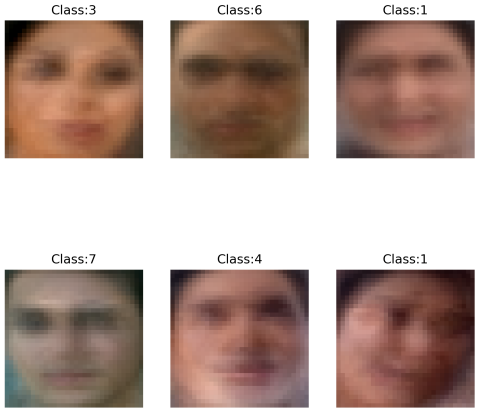

Figure 5: Reconstruction For IMFDB Database

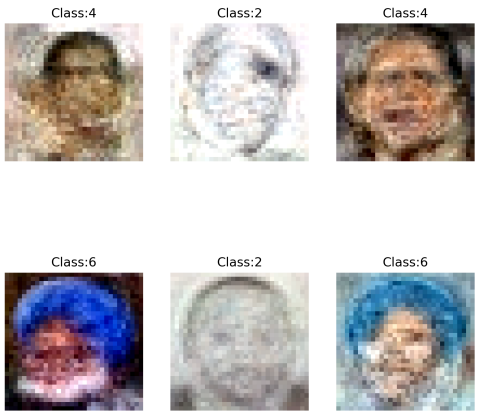

Figure 6: Reconstruction For IIIT - CFW Database

d) Which person/identity is difficult to represent com-pactly with fewer eigen vectors? Why is that? Explain with your empirical observations and intuitive answers

Problem 2. Use an MLP classifier and find the classification accuracy. Which method works well? Do a comparitive study.
From the emperical results, for each dataset, LDA, Kernel LDA and Resnet features are doing much better. And in comparision, LDA and Kernel LDA are doing the most dimensional reduction and giving much higher accuracy. Even on the tough dataset like IIIT - CFW.

	Combination of feature used	reduced dimension space	classification error	accuracy	f1-score
0	Eigen Face & MLP	10	0.21428571428571433	0.7857142857142857	0.7857142857142857
1	Kernel PCA & MLP	10	0.16666666666666663	0.8333333333333334	0.8333333333333334
2	Fisher Face & MLP	5	0.023809523809523836	0.9761904761904762	0.9761904761904762
3	Kernel LDA & MLP	5	0.023809523809523836	0.9761904761904762	0.9761904761904762
4	VGG & MLP	4096	0.45238095238095233	0.5476190476190477	0.5476190476190477
5	resnet & MLP	2048	0.0	1.0	1.0

Figure 7: Yale Face Classification - Feature Comparision

	Combination of feature used	reduced dimension space	classification error	accuracy	f1-score
0	Eigen Face & MLP	25	0.18000000000000005	0.82	0.82
1	Kernel PCA & MLP	25	0.22999999999999998	0.77	0.7699999999999999
2	Fisher Face & MLP	10	0.040000000000000036	0.96	0.96
3	Kernel LDA & MLP	10	0.040000000000000036	0.96	0.96
4	VGG & MLP	4096	0.09999999999999998	0.9	0.9
5	resnet & MLP	2048	0.040000000000000036	0.96	0.96

Figure 8: IMFDB Face Classification - Feature Comparision

	Combination of feature used	reduced dimension space	classification error	accuracy	f1-score
0	Eigen Face & MLP	40	0.44047619047619047	0.5595238095238095	0.5595238095238095
1	Kernel PCA & MLP	40	0.4821428571428571	0.5178571428571429	0.5178571428571429
2	Fisher Face & MLP	20	0.04166666666666663	0.9583333333333334	0.9583333333333334
3	Kernel LDA & MLP	20	0.04166666666666663	0.9583333333333334	0.9583333333333334
4	VGG & MLP	4096	0.3392857142857143	0.6607142857142857	0.6607142857142857
5	resnet & MLP	2048	0.011904761904761862	0.9880952380952381	0.9880952380952381

Figure 9: IIIT-CFW Face Classification - Feature Comparision

Problem 3. Use t-SNE based visilization of faces? Does it make sense? Do you see similar people coming together? or something else? Can you do visualization dataset wise and combined?
It doesn't show a nice classification like we get in PCA or LDA with 2 or 3 dimensions. Everything looks mixed

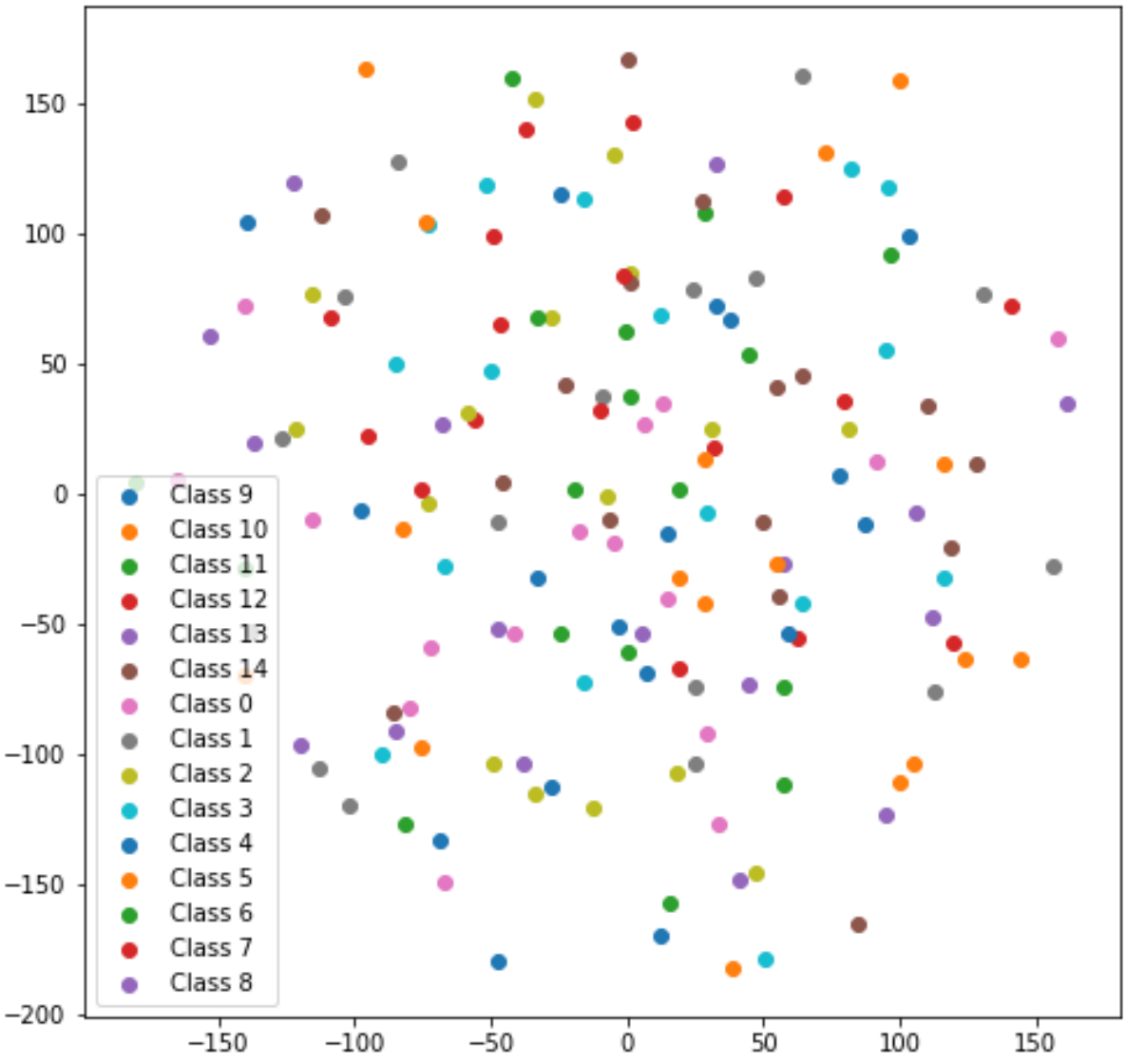

Figure 10: Yale Database with 2 Components

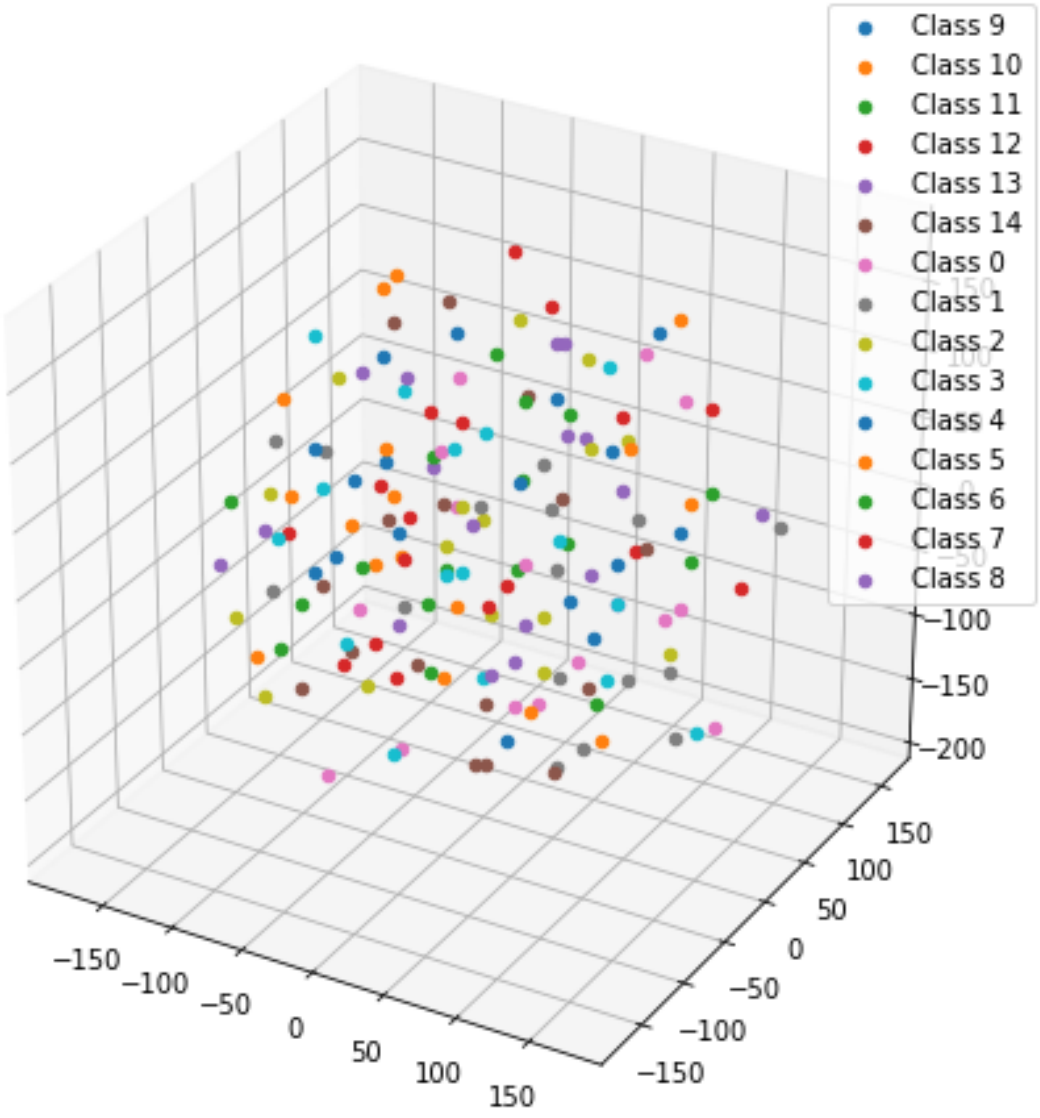

Figure 11: Yale Database with 3 Components

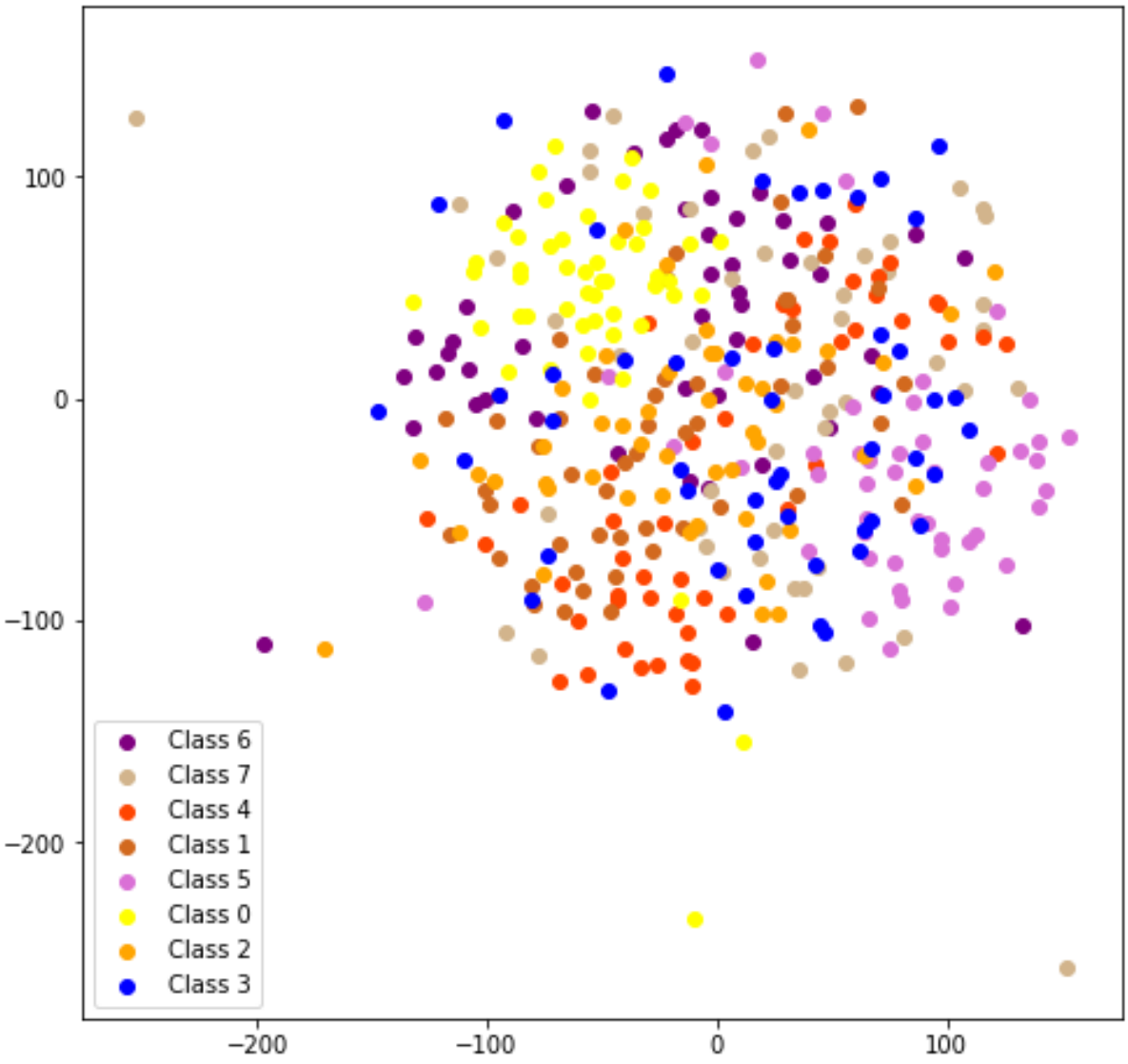

Figure 12: IMFDB Database with 2 Components

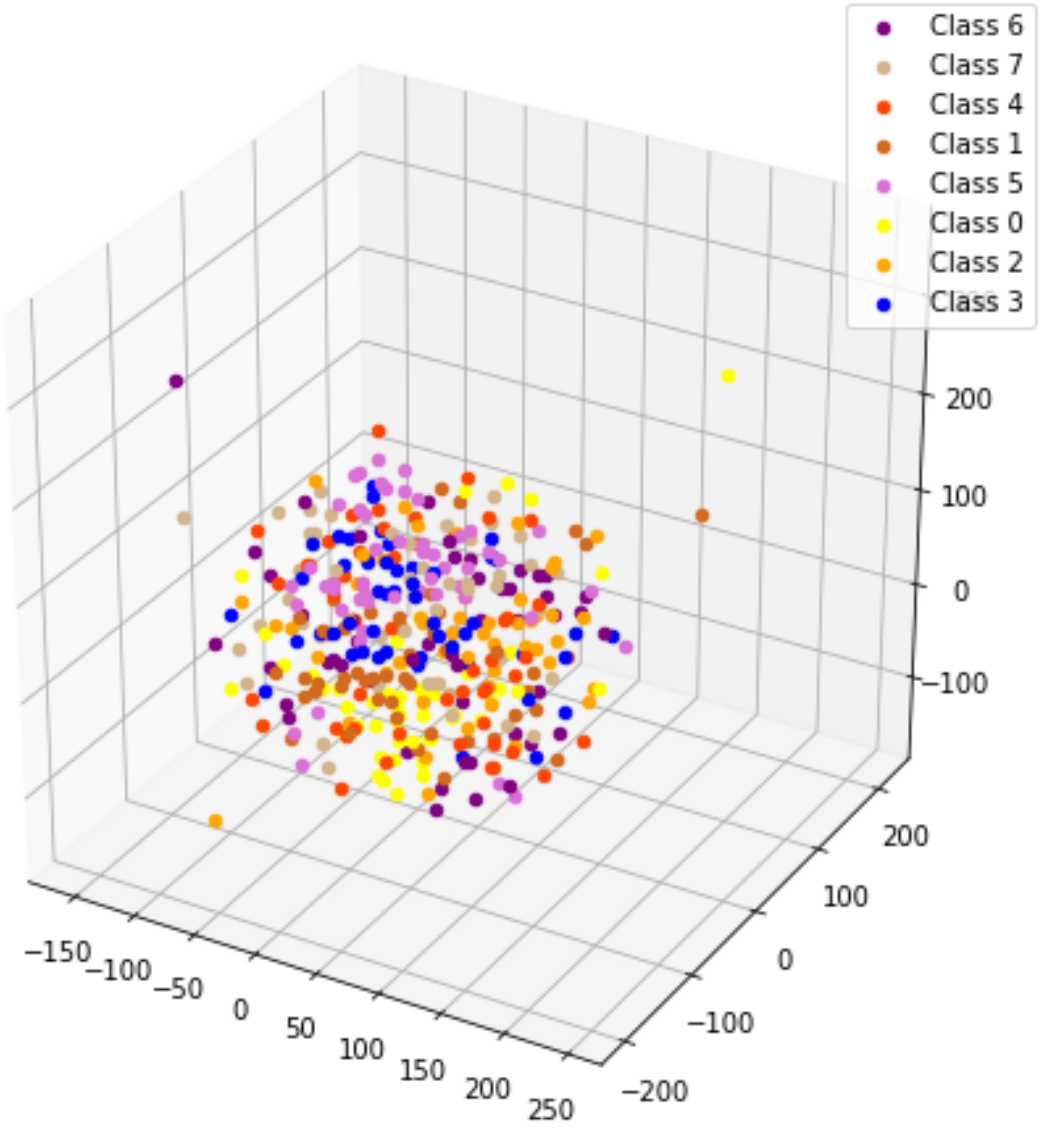

Figure 13: IMFDB Database with 3 Components

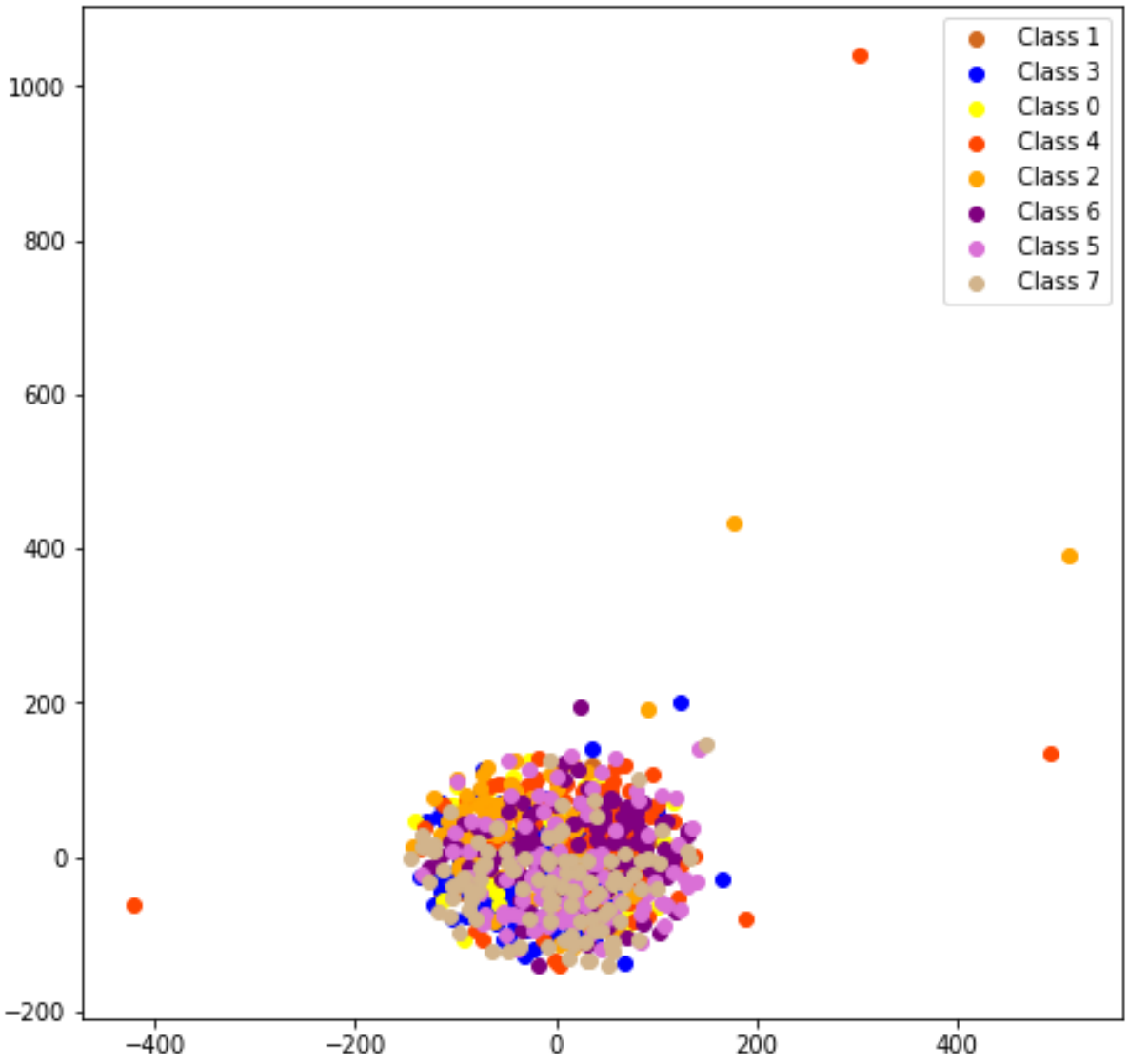

Figure 14: IIIT-CFW Database with 2 Components

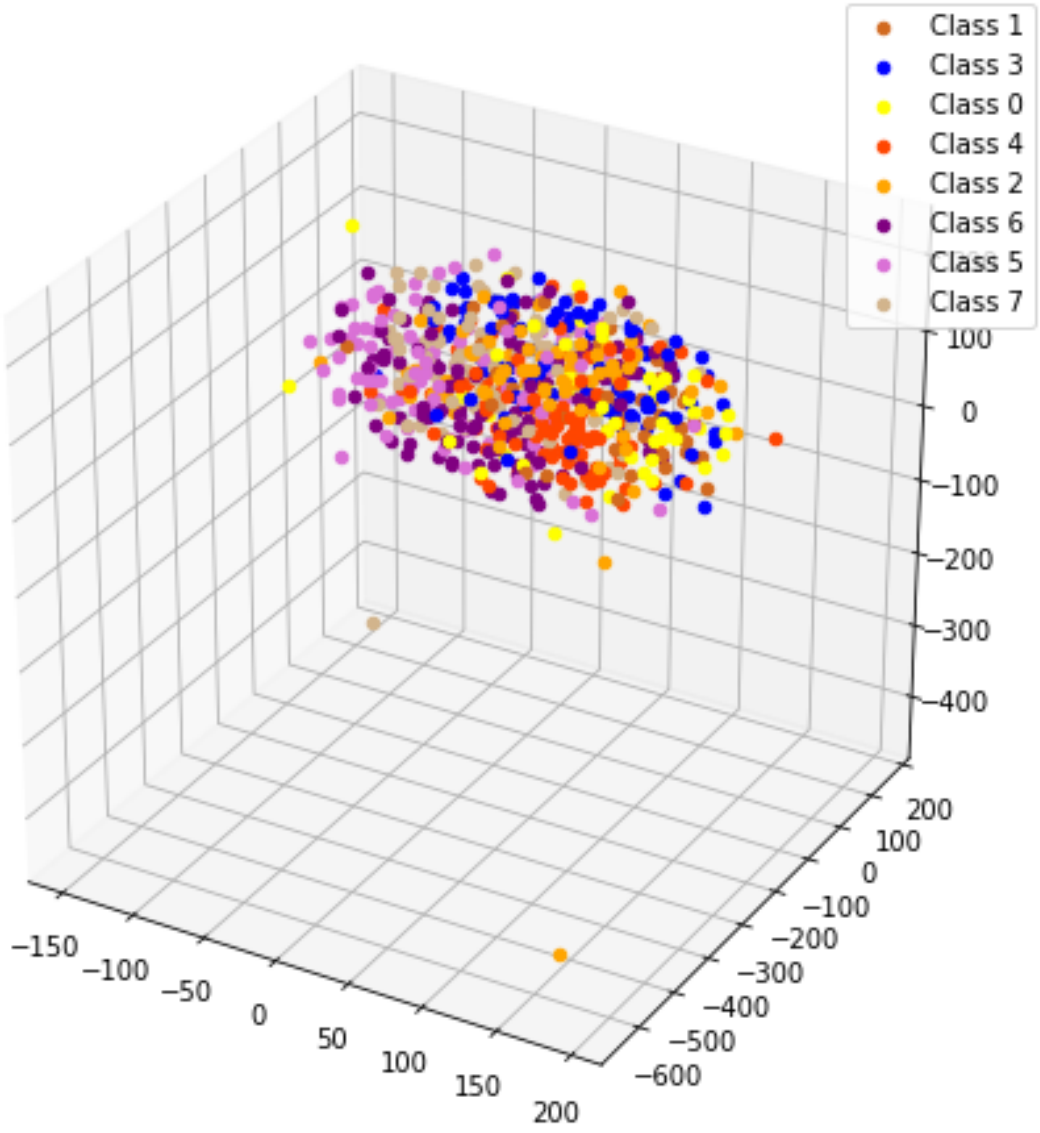

Figure 15: IIIT-CFW Database with 3 Components

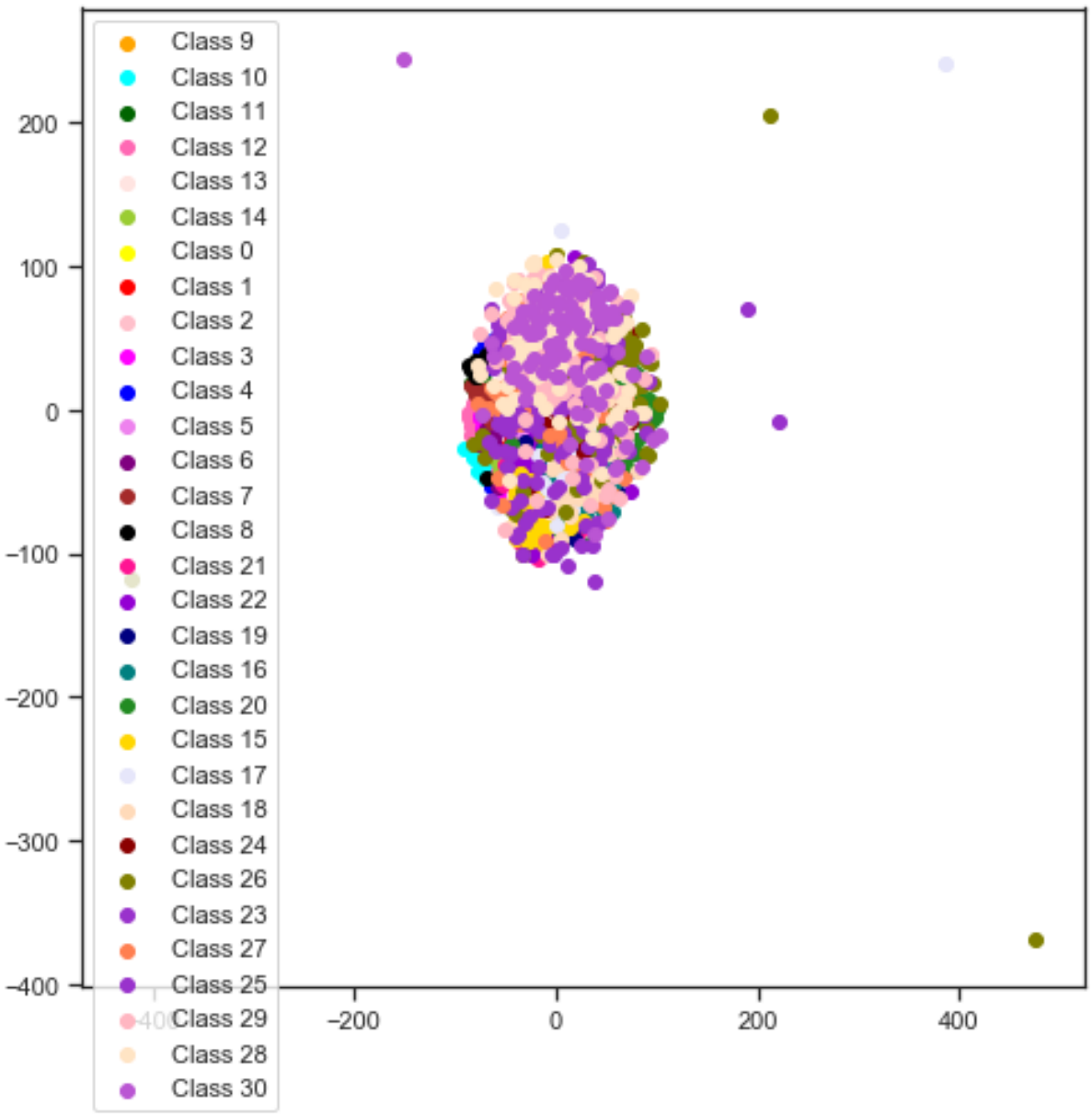

Figure 16: Combined Database with 2 Components

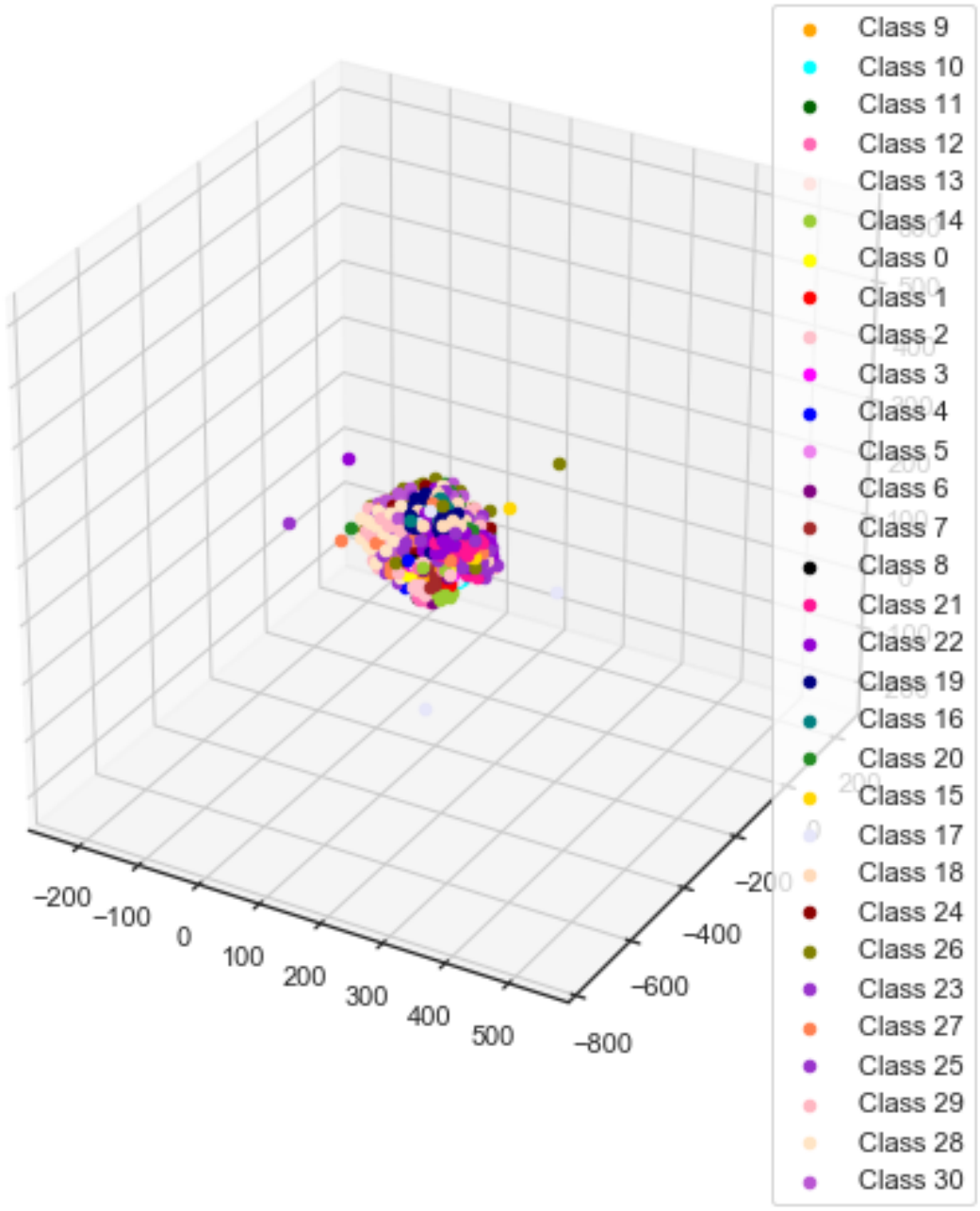

Figure 17: Combined Database with 3 Components

Problem 4. In practice "face" is used for verification. i.e., input is "identity/classID) and the face image" and response is "Yes" or "No". (i) How do we formulate the problem using KNN (ii) How do we analyze the performance ? suggest the metrics (like accuracy) that is appropriate for this task. Show empirical results with all the representations and variations in K

	Combination of feature used	reduced dimension space	verification error	accuracy	f1-score
0	Eigen Face & MLP	10	0.26190476190476186	0.7380952380952381	0.7380952380952381
1	Kernel PCA & MLP	10	0.2857142857142857	0.7142857142857143	0.7142857142857143
2	Fisher Face & MLP	5	0.023809523809523836	0.9761904761904762	0.9761904761904762
3	Kernel LDA & MLP	5	0.023809523809523836	0.9761904761904762	0.9761904761904762
4	VGG & MLP	4096	0.47619047619047616	0.5238095238095238	0.5238095238095238
5	resnet & MLP	2048	0.0	1.0	1.0

Figure 18: Yale Face Verification - Comparision

	Combination of feature used	reduced dimension space	verification error	accuracy	f1-score
0	Eigen Face & MLP	25	0.329999999999999996	0.67	0.67
1	Kernel PCA & MLP	25	0.38	0.62	0.62
2	Fisher Face & MLP	10	0.030000000000000027	0.97	0.97
3	Kernel LDA & MLP	10	0.030000000000000027	0.97	0.97
4	VGG & MLP	4096	0.089999999999999997	0.91	0.91
5	resnet & MLP	2048	0.040000000000000036	0.96	0.96

Figure 19: IMFDB Face Verification - Comparision

	Combination of feature used	reduced dimension space	verification error	accuracy	f1-score
0	Eigen Face & MLP	40	0.47023809523809523	0.5297619047619048	0.5297619047619048
1	Kernel PCA & MLP	40	0.4821428571428571	0.5178571428571429	0.5178571428571429
2	Fisher Face & MLP	20	0.04166666666666663	0.9583333333333334	0.9583333333333334
3	Kernel LDA & MLP	20	0.04166666666666663	0.9583333333333334	0.9583333333333334
4	VGG & MLP	4096	0.3392857142857143	0.6607142857142857	0.6607142857142857
5	resnet & MLP	2048	0.023809523809523836	0.9761904761904762	0.9761904761904762

Figure 20: IIIT-CFW Face Verification - Comparision

Problem 4. Emotion classification Briefly explain the problem. Why the problem is not trivial.Why a solution to this may be of some use. Suggest good applications. Suggest good reasons why solving your problem is. Explain your experimental pipeline, splits, evaluation metrics, quantitative results, qualitative results

Doing emotion classification based on the emotion provided in emotion.txt of IMFDB and Yale Dataset. Emotion classification can be useful for security purpose. People can rarely hide microexpression. So If we have footage of their interogation, we can apply classification, and pick out emotion which as a human we can miss.
Apply MLP on LDA features, gives 90% accuracy. It misclassified 10% Precision Score is

0.9 Recall Score is 0.9 F1 Score is 0.9
Plotted facetgrid for TSNE features, and scatter plot for PCA and LDA

```
Iteration 150, loss = 0.07106854
Iteration 151, loss = 0.04349857
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Stopping.
accuracy 0.9014084507042254
precision score 0.9014084507042254
recall score 0.9014084507042254
F1 Score 0.9014084507042254
```

Figure 21: Metrics of classification

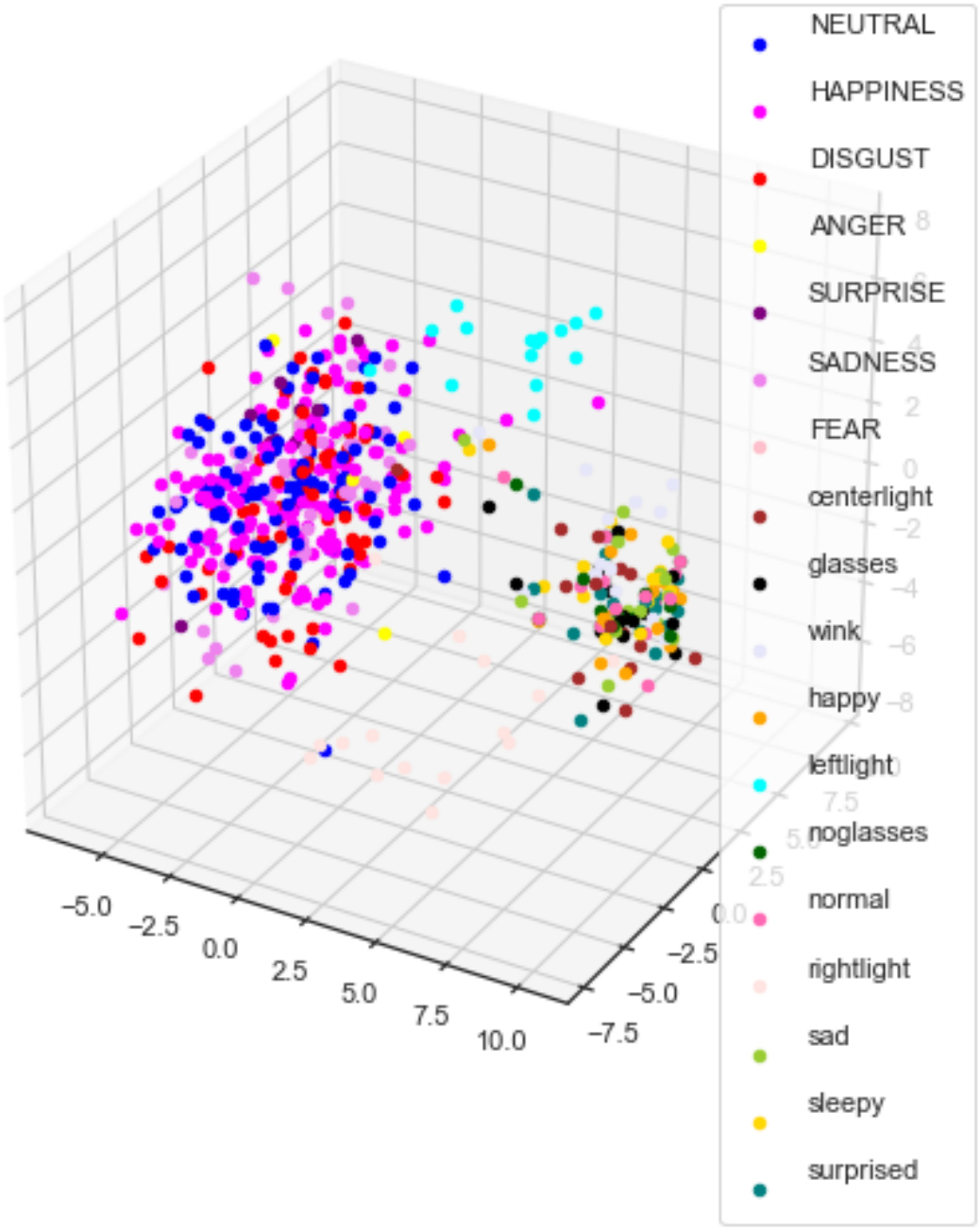

Figure 22: Scatter Plot of PCA Features

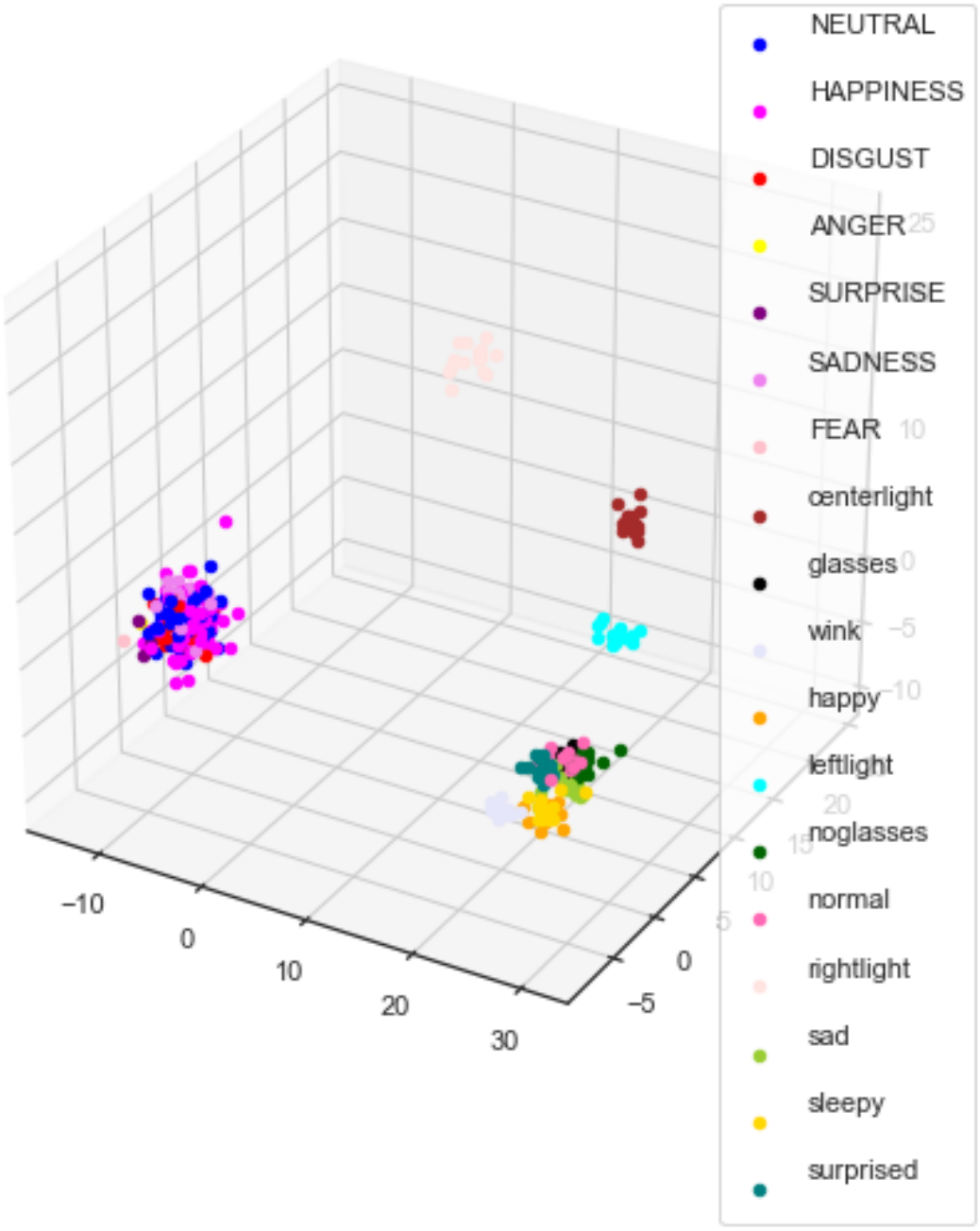

Figure 23: Scatter Plot of LDA Features

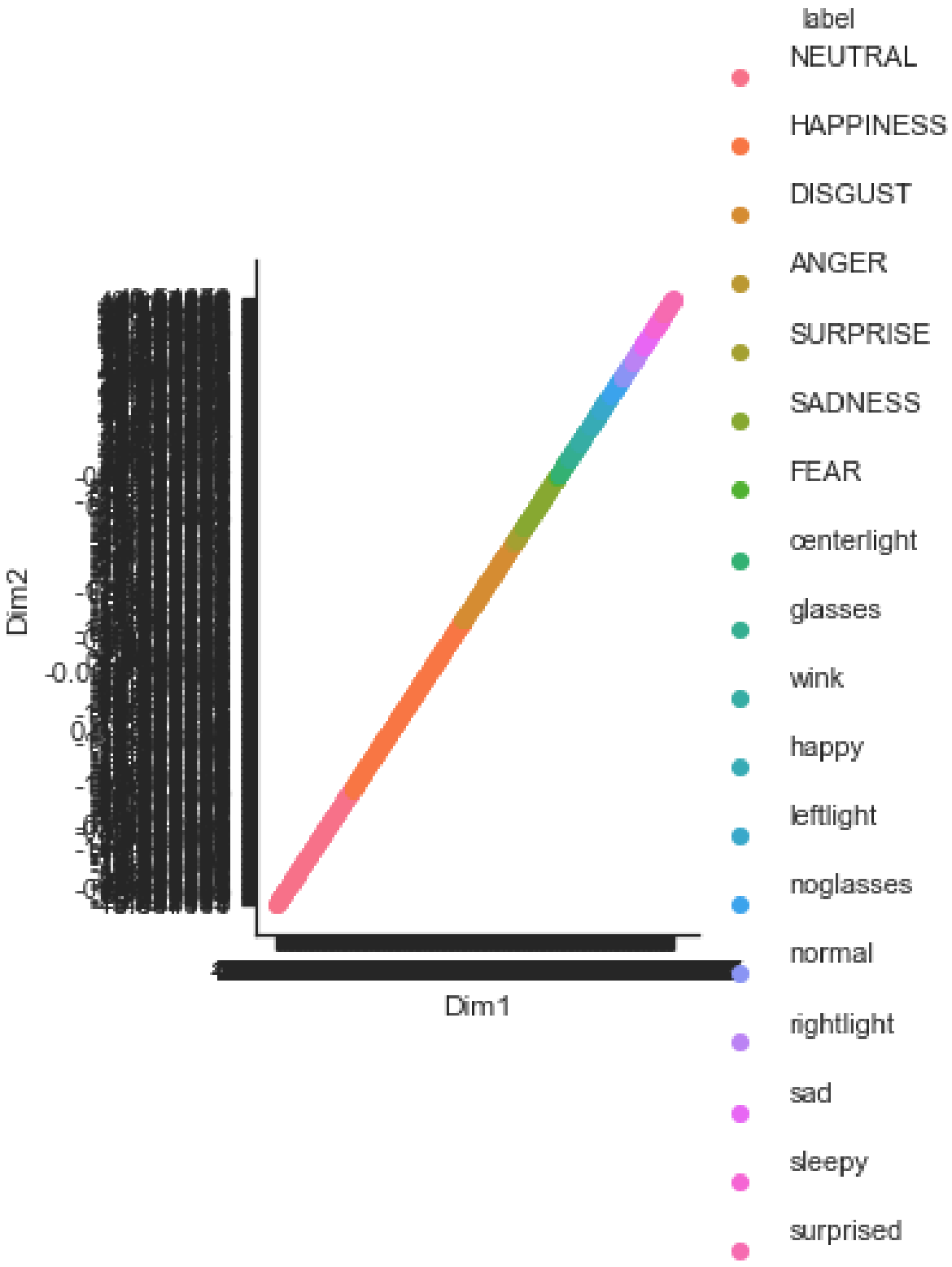

Figure 24: Facetgrid plot TSNE features