SMAI Assignment 2 Report

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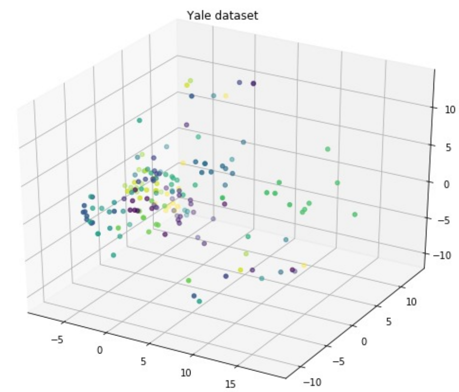
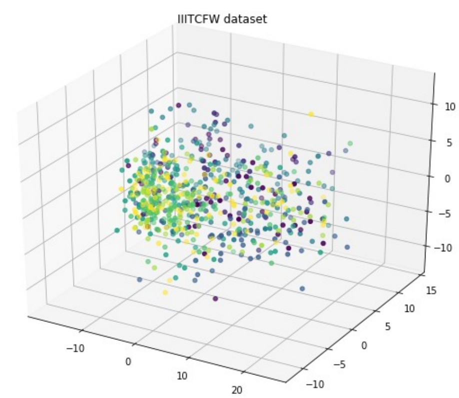
November 3, 2019

1 Question-1



1.1 Eigenfaces

Eigenfaces refer to the eigenvectors of the covariance matrix of the dataset of images.These are used to create a new feature space representation of images which is then used for face recognition or general pattern recognition.



1.2 Number of Eigenfaces required

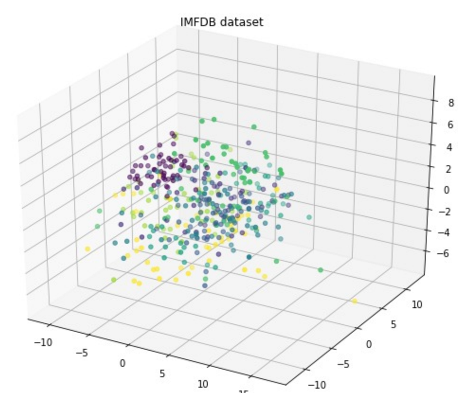
The number of eigenfaces required to satisfactorily represent the images in each of the datasets is as follows:-

Yale Dataset : 61

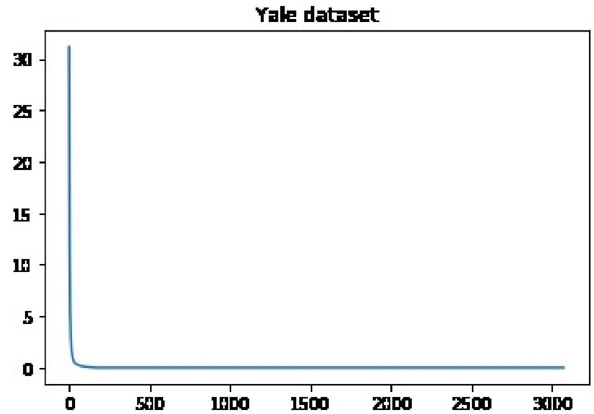
IIIT-CFW Dataset : 308

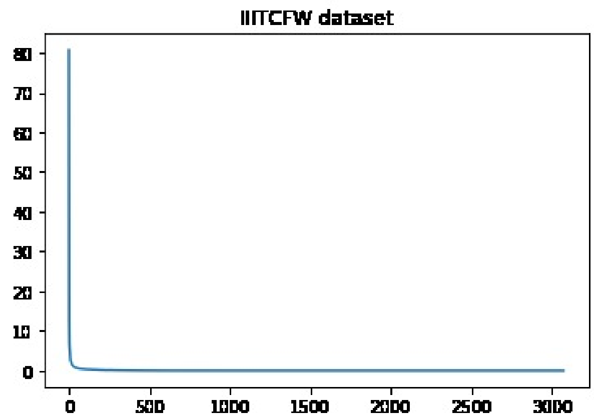
IMFDB Dataset : 123

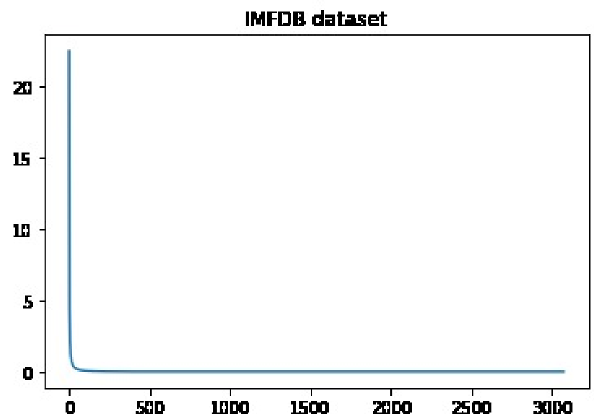
These figures are arrived at by using the assumption we need 95% of the variance of data for good reconstuction. For **satisfactory** reconstuction we need about 50-70 eigenvectors which can be seen from eigen spectrum of the datasets and observing at which points the eigen values tend to 0.



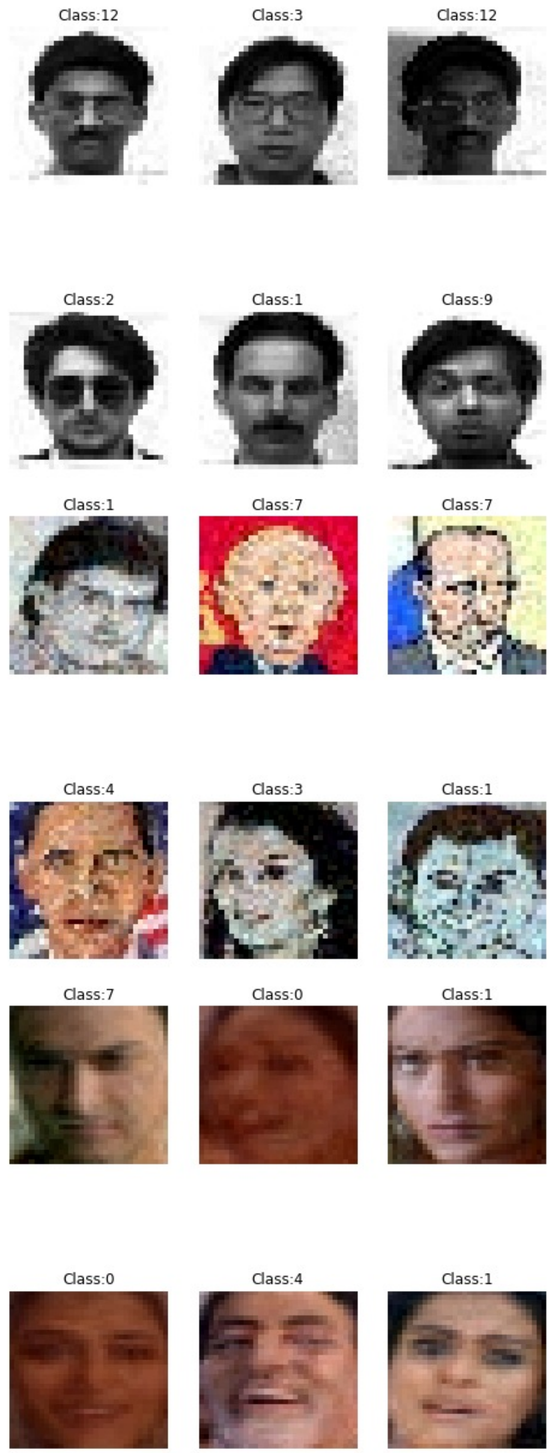
The eigen value spectrum is as shown. Here we see that around 50 the spectrum tends to zero.



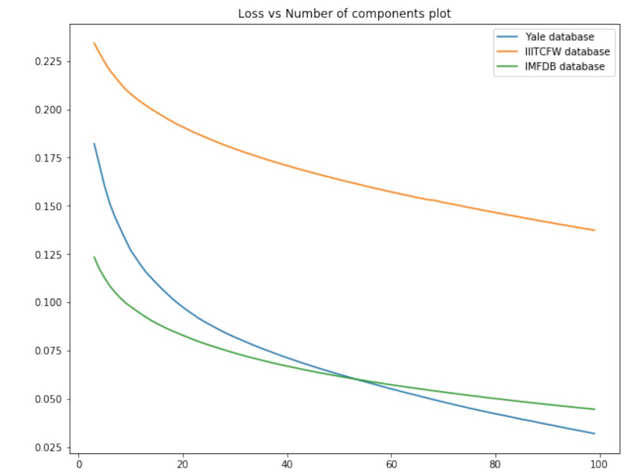




1.3 Reconstruction and Problems



The most difficult database to represent, from empirical observations, is the **IIITCFW dataset**. This is because the database has a higher spread in the eigenvalue spectrum, so, to account for more of the total spread, we need to take more eigenvalues. we can see the graph below that clearly depicts that reconstruction error is more in IIITCFW.



For reconstruction with 10 components we get:

In **Yale**, the most difficult person to represent is with class 10, in **IIITCFW**, it is Barack Obama, and in **IMFDB** it is Shilpa Shetty. This was determined empirically, by calculating reconstruction error for each class separately.Intuitively it may be due large variations or noise in the samples of the above classes

2 Question 2

2.1 Classification Results

Yale Dataset

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Yale
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	Feature Used	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	MLP classifier with PCA feature	75	0.176471	0.823529	0.823529
1	SVM classifier with PCA feature	75	0.000000	1.000000	1.000000
2	Logistic Regression classifier with PCA feature	75	0.000000	1.000000	1.000000
3	MLP classifier with KPCA feature	75	0.352941	0.647059	0.647059
4	SVM classifier with KPCA feature	75	0.647059	0.352941	0.352941
5	Logistic Regression classifier with KPCA feature	75	0.294118	0.705882	0.705882
6	MLP classifier with LDA feature	14	0.235294	0.764706	0.764706
7	SVM classifier with LDA feature	14	0.000000	1.000000	1.000000
8	Logistic Regression classifier with LDA feature	14	0.000000	1.000000	1.000000
9	MLP classifier with KLDA feature	14	0.000000	1.000000	1.000000
10	SVM classifier with KLDA feature	14	0.000000	1.000000	1.000000
11	Logistic Regression classifier with KLDA feature	14	0.000000	1.000000	1.000000
12	MLP classifier with VGG feature	4096	0.352941	0.647059	0.647059
13	SVM classifier with VGG feature	4096	0.647059	0.352941	0.352941
14	Logistic Regression classifier with VGG feature	4096	0.235294	0.764706	0.764706
15	MLP classifier with Resnet feature	2048	0.000000	1.000000	1.000000
16	SVM classifier with Resnet feature	2048	0.000000	1.000000	1.000000
17	Logistic Regression classifier with Resnet fea...	2048	0.000000	1.000000	1.000000

IIITCFW Dataset

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IIITCFW
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	Feature Used	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	MLP classifier with PCA feature	75	0.470588	0.529412	0.529412
1	SVM classifier with PCA feature	75	0.455882	0.544118	0.544118
2	Logistic Regression classifier with PCA feature	75	0.485294	0.514706	0.514706
3	MLP classifier with KPCA feature	75	0.500000	0.500000	0.500000
4	SVM classifier with KPCA feature	75	0.602941	0.397059	0.397059
5	Logistic Regression classifier with KPCA feature	75	0.470588	0.529412	0.529412
6	MLP classifier with LDA feature	7	0.588235	0.411765	0.411765
7	SVM classifier with LDA feature	7	0.617647	0.382353	0.382353
8	Logistic Regression classifier with LDA feature	7	0.544118	0.455882	0.455882
9	MLP classifier with KLDA feature	7	0.602941	0.397059	0.397059
10	SVM classifier with KLDA feature	7	0.617647	0.382353	0.382353
11	Logistic Regression classifier with KLDA feature	7	0.544118	0.455882	0.455882
12	MLP classifier with VGG feature	4096	0.308824	0.691176	0.691176
13	SVM classifier with VGG feature	4096	0.279412	0.720588	0.720588
14	Logistic Regression classifier with VGG feature	4096	0.308824	0.691176	0.691176
15	MLP classifier with Resnet feature	2048	0.000000	1.000000	1.000000
16	SVM classifier with Resnet feature	2048	0.000000	1.000000	1.000000
17	Logistic Regression classifier with Resnet fea...	2048	0.000000	1.000000	1.000000

IMFDB Dataset

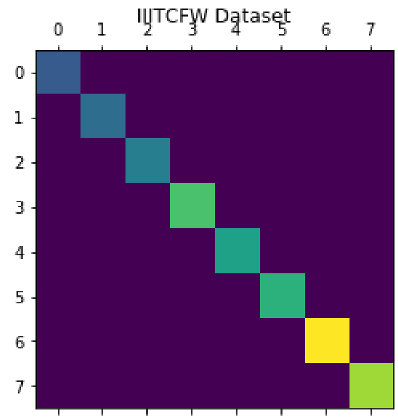
IMFDB

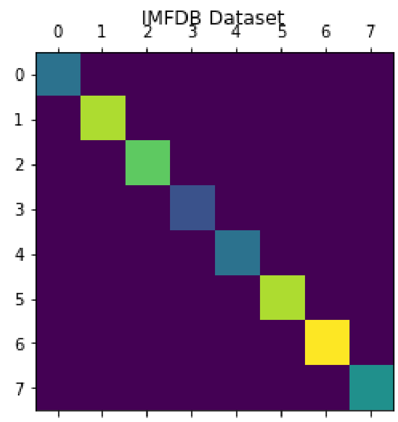
	Feature Used	Reduced Dimension Space	Classification Error	Accuracy	F1-Score
0	MLP classifier with PCA feature	75	0.075	0.925	0.925
1	SVM classifier with PCA feature	75	0.150	0.850	0.850
2	Logistic Regression classifier with PCA feature	75	0.075	0.925	0.925
3	MLP classifier with KPCA feature	75	0.375	0.625	0.625
4	SVM classifier with KPCA feature	75	0.675	0.325	0.325
5	Logistic Regression classifier with KPCA feature	75	0.550	0.450	0.450
6	MLP classifier with LDA feature	7	0.225	0.775	0.775
7	SVM classifier with LDA feature	7	0.250	0.750	0.750
8	Logistic Regression classifier with LDA feature	7	0.175	0.825	0.825
9	MLP classifier with KLDA feature	7	0.150	0.850	0.850
10	SVM classifier with KLDA feature	7	0.250	0.750	0.750
11	Logistic Regression classifier with KLDA feature	7	0.175	0.825	0.825
12	MLP classifier with VGG feature	4096	0.075	0.925	0.925
13	SVM classifier with VGG feature	4096	0.000	1.000	1.000
14	Logistic Regression classifier with VGG feature	4096	0.125	0.875	0.875
15	MLP classifier with Resnet feature	2048	0.050	0.950	0.950
16	SVM classifier with Resnet feature	2048	0.025	0.975	0.975
17	Logistic Regression classifier with Resnet fea...	2048	0.125	0.875	0.875

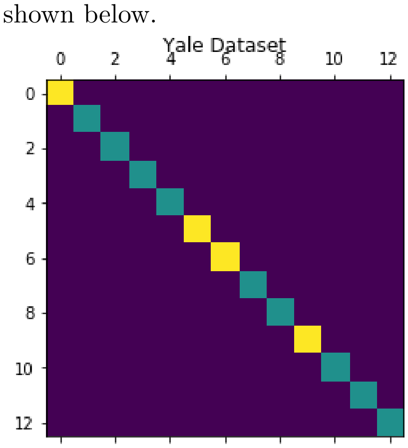
It was observed that **ResNet with MLP**, performed the best. Kernel methods do not seem to work very well for the classification.

2.2 Confusion Matrices

The Confusion matrices for the best models are shown below.

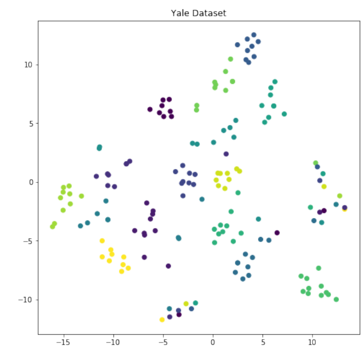


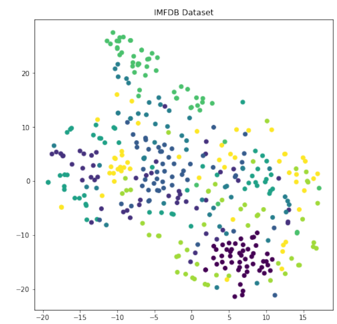


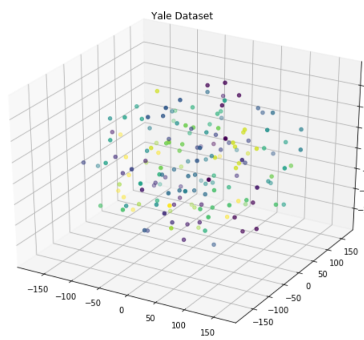


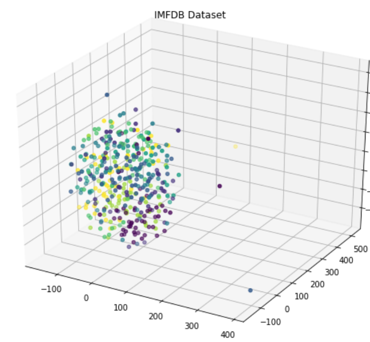
3 Question 3

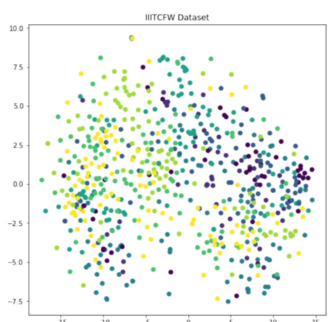
Yes t-SNE makes sense as we observe that with the exception of a few outliers, the data points with the same classes are closer and are clustered compactly in the t-SNE.When we combine the data we observe that images belonging to same classes are closer.

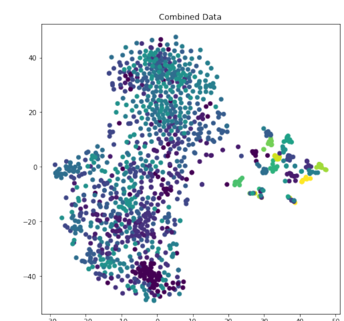

Yale Dataset

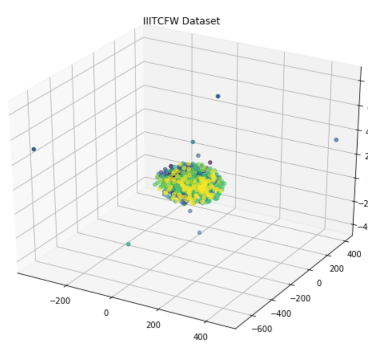

IMFDB Dataset

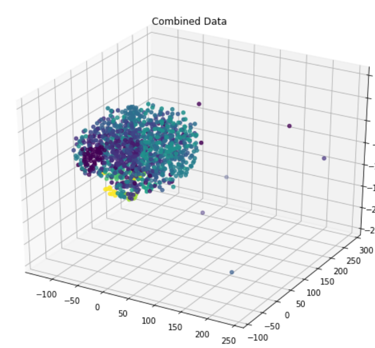

Yale Dataset


IMFDB Dataset


IIITCFW Dataset


Combined Data


IIITCFW Dataset


Combined Data

4 Question 4

4.1 Formulation

To verify with a given class id we can train a KNN classifier using traindata and trainlabels and find the most similar k images to the input image and then based on majority voting predict the class of the image.If it matches with true class Id we return True else return False.
The metrics like accuracy or precision are suitable for this purpose.

Yale

	Feature Used	Reduced Dimension Space	Verification Error	Accuracy	Precision
0	Feature PCA and kvalue 3	75	0.176471	0.823529	0.823529
1	Feature PCA and kvalue 5	75	0.117647	0.882353	0.882353
2	Feature PCA and kvalue 7	75	0.235294	0.764706	0.764706
3	Feature KPCA and kvalue 3	75	0.176471	0.823529	0.823529
4	Feature KPCA and kvalue 5	75	0.117647	0.882353	0.882353
5	Feature KPCA and kvalue 7	75	0.235294	0.764706	0.764706
6	Feature LDA and kvalue 3	14	0.000000	1.000000	1.000000
7	Feature LDA and kvalue 5	14	0.000000	1.000000	1.000000
8	Feature LDA and kvalue 7	14	0.000000	1.000000	1.000000
9	Feature KLDA and kvalue 3	14	0.000000	1.000000	1.000000
10	Feature KLDA and kvalue 5	14	0.000000	1.000000	1.000000
11	Feature KLDA and kvalue 7	14	0.000000	1.000000	1.000000
12	Feature VGG and kvalue 3	4096	0.529412	0.470588	0.470588
13	Feature VGG and kvalue 5	4096	0.647059	0.352941	0.352941
14	Feature VGG and kvalue 7	4096	0.529412	0.470588	0.470588
15	Feature Resnet and kvalue 3	2048	0.000000	1.000000	1.000000
16	Feature Resnet and kvalue 5	2048	0.000000	1.000000	1.000000
17	Feature Resnet and kvalue 7	2048	0.000000	1.000000	1.000000

IIITCFW

	Feature Used	Reduced Dimension Space	Verification Error	Accuracy	Precision
0	Feature PCA and kvalue 3	75	0.617647	0.382353	0.382353
1	Feature PCA and kvalue 5	75	0.544118	0.455882	0.455882
2	Feature PCA and kvalue 7	75	0.588235	0.411765	0.411765
3	Feature KPCA and kvalue 3	75	0.632353	0.367647	0.367647
4	Feature KPCA and kvalue 5	75	0.544118	0.455882	0.455882
5	Feature KPCA and kvalue 7	75	0.558824	0.441176	0.441176
6	Feature LDA and kvalue 3	7	0.588235	0.411765	0.411765
7	Feature LDA and kvalue 5	7	0.573529	0.426471	0.426471
8	Feature LDA and kvalue 7	7	0.573529	0.426471	0.426471
9	Feature KLDA and kvalue 3	7	0.588235	0.411765	0.411765
10	Feature KLDA and kvalue 5	7	0.573529	0.426471	0.426471
11	Feature KLDA and kvalue 7	7	0.573529	0.426471	0.426471
12	Feature VGG and kvalue 3	4096	0.367647	0.632353	0.632353
13	Feature VGG and kvalue 5	4096	0.294118	0.705882	0.705882
14	Feature VGG and kvalue 7	4096	0.279412	0.720588	0.720588
15	Feature Resnet and kvalue 3	2048	0.044118	0.955882	0.955882
16	Feature Resnet and kvalue 5	2048	0.029412	0.970588	0.970588
17	Feature Resnet and kvalue 7	2048	0.000000	1.000000	1.000000

IMFDB

	Feature Used	Reduced Dimension Space	Verification Error	Accuracy	Precision
0	Feature PCA and kvalue 3	75	0.400	0.600	0.600
1	Feature PCA and kvalue 5	75	0.425	0.575	0.575
2	Feature PCA and kvalue 7	75	0.300	0.700	0.700
3	Feature KPCA and kvalue 3	75	0.400	0.600	0.600
4	Feature KPCA and kvalue 5	75	0.400	0.600	0.600
5	Feature KPCA and kvalue 7	75	0.275	0.725	0.725
6	Feature LDA and kvalue 3	7	0.150	0.850	0.850
7	Feature LDA and kvalue 5	7	0.150	0.850	0.850
8	Feature LDA and kvalue 7	7	0.125	0.875	0.875
9	Feature KLDA and kvalue 3	7	0.150	0.850	0.850
10	Feature KLDA and kvalue 5	7	0.150	0.850	0.850
11	Feature KLDA and kvalue 7	7	0.125	0.875	0.875
12	Feature VGG and kvalue 3	4096	0.025	0.975	0.975
13	Feature VGG and kvalue 5	4096	0.075	0.925	0.925
14	Feature VGG and kvalue 7	4096	0.100	0.900	0.900
15	Feature Resnet and kvalue 3	2048	0.125	0.875	0.875
16	Feature Resnet and kvalue 5	2048	0.050	0.950	0.950
17	Feature Resnet and kvalue 7	2048	0.025	0.975	0.975

4.2 Observations

Here we observe that the suitable number of neighbours or k parameter for KNN changes with the type of features we use and the dataset.
For **Yale data** we get that LDA and Resnet are very good features and 5 is suitable value for K.
For **IIITCFW data** we get that Resnet is a good feature and 7 is suitable value for K.
For **IMFDB data** we get that VGG,Resnet are good features and 7 is suitable value for K.

5 Question 5

5.1 Problem Statement

I have chosen the problem of predicting whether a image is cartoon like or real. The problem is evidently not trivial - given a photo,it is difficult to identify the features that may help us predict whether it is real or cartoonish.

5.2 Applications

If we are able to build a system that can tell whether a particular image is real or cartoonish then it may help in the following areas.

- Media/Information :- For the print media we usually require real images of a person to print some information .Nowdays tools have been developed to automate generation of news articles.So we can use our system to accurately allow only real images related to news article.

- Identification :- The image of a person is used in various official id cards.Thus for online application of such ID cards we can use our system to filter out images which are cartoonish or graphically generated.

5.3 Model Pipeline

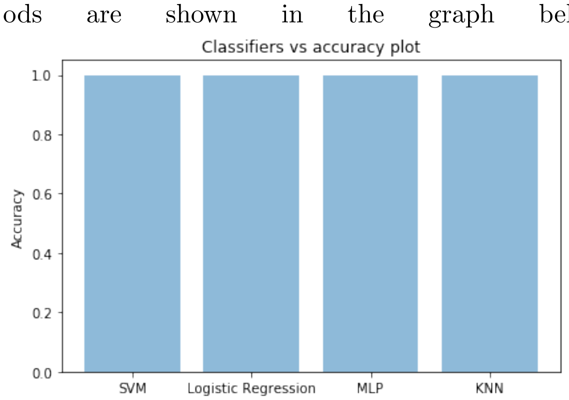
- We first take the IIIT-CFW,IMFDB,Yale datasets and change their labels so that the label is 0 for cartoons(IIITCFW) and 1 for real images(Yale,IMFDB). We concatenate the three datasets to form a single dataset.

- We then use the Resnet features for the dataset as they give the best representation in all the datasets.

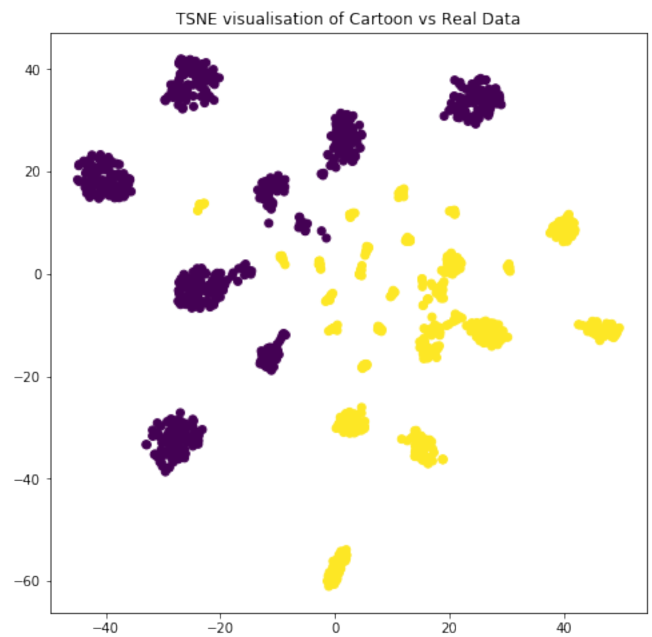
- We perform K fold cross validation on the dataset using four classifiers namely SVM,MLP,Logistic,KNN and report the mismatch and accuracy

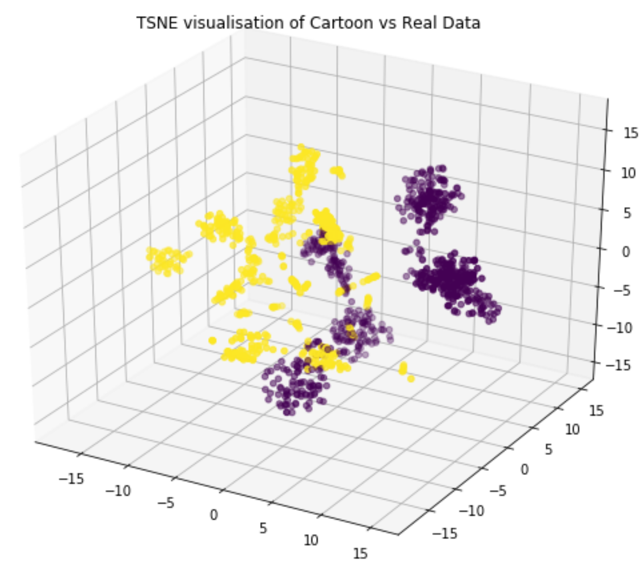
5.4 Qualitative Results

The accuracies for the 3 methods are shown in the graph below.

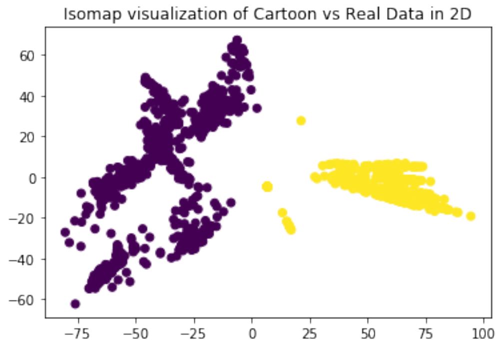


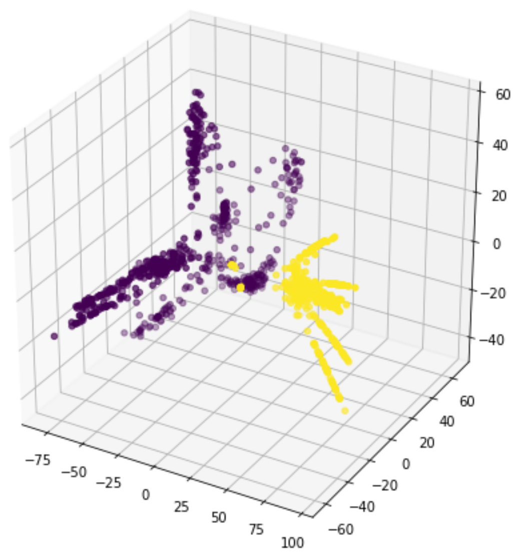
The t-SNE visualization of the Resnet features of data, in 2D and 3D, is as shown below.





The 2D and 3D Resnet features Isomap plots are also given below.





5.5 Quantitative Results

We observe that MLP and KNN correctly classify all the test samples but SVM,Logistic regression fails in few cases.

SVM failed to classify the following image.

Logistic Regression failed to classify the following images.