Face Classification and Verification

Kanaparthy SV Samhita

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0.1 Assignment

Given three different datasets *Yale Face Database*, *Indian Movie Face Database*, *IIIT Cartoon Face Dataset* with face images of human. we need to perform experiments on these images to get familiarize with problems of classification and verification.

0.2 Image Features

- The features used are:
  - PCA / Eigen face
  - KernelPCA
  - LDA / Fisher face
  - Kernel Fisher Face
  - VGG Face
  - Resnet features
- we get the eigen faces of the images after applying the above features.
- **what is Eigen face?**
  It is the set of eigen vectors extracted from the dataset of images of faces by performing feature extraction algorithms. The images in the dataset can be reconstructed from this orthogonal basis set.
- We need some minimum no.of eigen vectors to satisfactorily reconstruct the images.
- **To find required no.of eigen vectors:** we choose no.of eigen vectors(k) such that the lost information $\frac{\sum_{i=k+1}^{d} \lambda_i}{\sum_{i=1}^{d} \lambda_i}$ is less than 5%.
- According to above we get **124**, **309**, **62** eigen vectors required for the data sets *IMFDB*, *IIIT-CFW*, *Yale* respectively.
- **Reconstruction of images:** The reconstruction errors for three databases using PCA:
  - IMFDB: 0.033
  - IIIT-CFW : 0.065
  - Yale: 0.041
- **Person difficult to represent compactly** can be observed by checking which identity has maximum error when reconstructed. It is *AmirKhan* in IMFDB, *ManmohanSingh* in IIIT-CFW, *Person7* in Yale dataset.

0.3 Classifiers

- We had used MLP, Logistic regression, SVM, Decision Trees classifiers.
- Performed training and validation on the few models and compared their performance based on Reduced Dimensional Space, Classification error, Accuracy, F1-score for all the three databases.
- From Fig.1 we can see that (PCA+LDA)+LR has reasonably good accuracy on all the datasets. The Resnet and VGG features work well compared to other features as they takes features directly from the data. So, Overall Resnet+SVM model has high accuracy among all the models.
- Yale dataset is relatively smaller. So all the models perform good on this dataset.

.....IMFDB Table.....

	feature	Reduced Dim	Clssn error	Accuracy	F1_score
0	(PCA+LDA)+LR	7	22.50	77.50	0.8000
1	KPCA+MLP	124	50.00	50.00	0.7250
2	Resnet+SVM	2048	2.50	97.50	0.9500
3	VGG+SVM	4096	2.50	97.50	0.9000
4	LDA+DesicionTree	7	16.25	83.75	0.6625
5	VGG+MLP	4096	13.75	86.25	0.8625

.....CFW Table.....

	feature	Reduced Dim	Clssn error	Accuracy	F1_score
0	(PCA+LDA)+LR	7	55.555556	44.444444	0.437037
1	KPCA+MLP	135	63.703704	36.296296	0.555556
2	Resnet+SVM	2048	2.222222	97.777778	0.970370
3	VGG+SVM	4096	26.666667	73.333333	0.644444
4	LDA+DesicionTree	7	59.259259	40.740741	0.296296
5	VGG+MLP	4096	37.037037	62.962963	0.629630

.....Yale Table.....

	feature	Reduced Dim	Clssn error	Accuracy	F1_score
0	(PCA+LDA)+LR	14	3.030303	96.969697	1.000000
1	KPCA+MLP	60	24.242424	75.757576	0.939394
2	Resnet+SVM	2048	0.000000	100.000000	1.000000
3	VGG+SVM	4096	42.424242	57.575758	0.393939
4	LDA+DesicionTree	14	3.030303	96.969697	0.727273
5	VGG+MLP	4096	54.545455	45.454545	0.454545

Figure 1: Classification Models performance

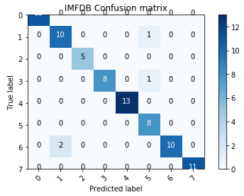

Figure 2: IMFDB Resnet+SVM model

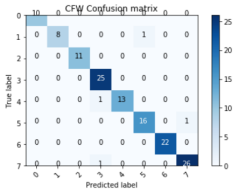

Figure 3: CFW Resnet+SVM model

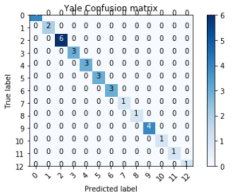

Figure 4: Yale (PCA+LDA)+LR model

- **TSNE based visualization of faces:** TSNE is a nonlinear dimensionality reduction technique well-suited for embedding high dimensional data for visualization in a low dimensional space of two or three dimensions.

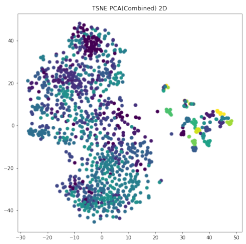

Figure 5: TSNE for Combined data after PCA

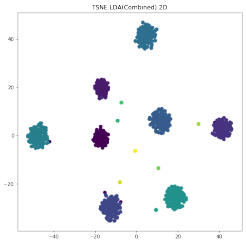

Figure 6: TSNE for Combined data after LDA

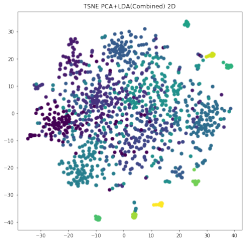

Figure 7: TSNE for Combined data after PCA+LDA

0.4 KNN Classifier

- Performance of KNN classifier was observed by varying feature extraction methods and k values.

- From Fig.8, we see the following are the best models: Resnet + KNN7, PCA+LDA + KNN9, VGG + KNN3.

.....IMFDB Table.....

	feature	Reduced Dim	Verifn error	Accuracy	Precision
0	(PCA+LDA)+KNN9	7	22.50	77.50	0.8000
1	KPCA+KNN7	124	50.00	50.00	0.7250
2	Resnet+KNN7	2048	2.50	97.50	0.9500
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Figure 8: KNN models performance

0.5 Application (Gender Prediction)

Database: IIIT-CFW + IMFDB
Classification: Male / Female
Problem: Given an image, we need to classify it as Male(Y=0) or Female(Y=1).

- The classification is done using different models and their performance is shown in the below table:

	feature	Accuracy
0	PCA+LR	82.325581
1	PCA+SVM	92.558140
2	PCA+MLP	88.837209
3	PCA+DecisionTree	74.883721
4	LDA+LR	72.093023
5	LDA+SVM	56.279070
6	LDA+MLP	52.093023
7	LDA+DecisionTree	70.232558
8	(PCA+LDA)+LR	78.604651
9	(PCA+LDA)+SVM	79.069767
10	(PCA+LDA)+MLP	79.069767
11	(PCA+LDA)+DecisionTree	77.209302

Figure 9: Accuracy Analysis for different Models

- *K-Fold Validation* the variances observed are:
  - PCA+LR : 17.148
  - LDA+LR : 0.528
  - PCA+LDA+LR : 19.15
- The data is visualised in 2D using TSNE, PCA, Isomap. we can observe TSNE does better clusterring of classes.
- Using Logistic Regression as classifier, the Fig.13 shows few cases where the images of the dataset are correctly and wrongly classified images.

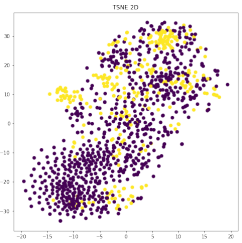

Figure 10: TSNE

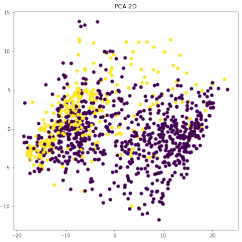

Figure 11: PCA

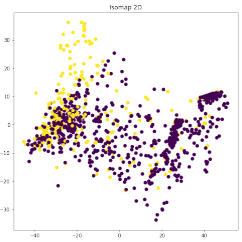

Figure 12: Isomap

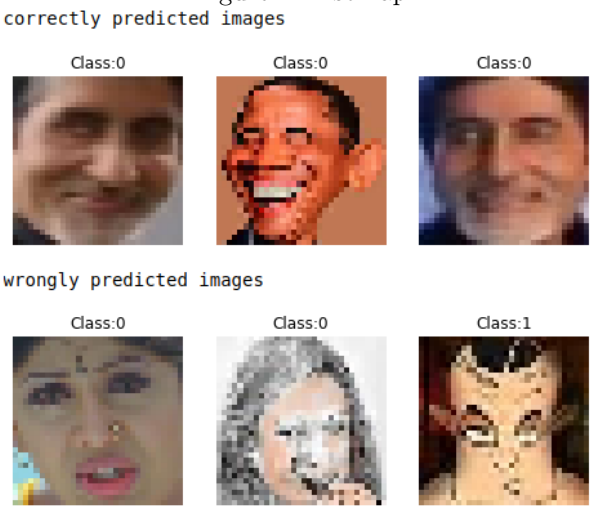

Figure 13: examples