Face Recognition with PCA, LDA and Spectral Clustering

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Motivation

• **Our Project Goal:**
  • To explore the influence of **new feature spaces** that can provide higher discriminative power for the face recognition problem
  • New feature spaces were generated through PCA, LDA and Spectral Clustering algorithms.

<table>
<thead>
<tr>
<th>Data Set</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features</strong></td>
<td>All pixels in an image</td>
</tr>
<tr>
<td><strong># instances</strong></td>
<td>1288</td>
</tr>
</tbody>
</table>
# Dataset

<table>
<thead>
<tr>
<th>Person</th>
<th>Class</th>
<th># instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariel Sharon</td>
<td>0</td>
<td>77</td>
</tr>
<tr>
<td>Colin Powell</td>
<td>1</td>
<td>236</td>
</tr>
<tr>
<td>Donald Rumsfeld</td>
<td>2</td>
<td>121</td>
</tr>
<tr>
<td>George W Bush</td>
<td>3</td>
<td>530</td>
</tr>
<tr>
<td>Gerhard Schroeder</td>
<td>4</td>
<td>109</td>
</tr>
<tr>
<td>Hugo Chavez</td>
<td>5</td>
<td>71</td>
</tr>
<tr>
<td>Tony Blair</td>
<td>6</td>
<td>144</td>
</tr>
</tbody>
</table>

Total number of instances: 1288
Approach: PCA and LDA

75% Train

25% Test

Feature Vector

Projection

SVM Classifier trained

Prediction

New Feature Vector

… Feature Vector

Projection

• PCA
• LDA
Approach: LDA

Maximize distance between classes

Minimize variation in all classes
Approach: Spectral Clustering

[Diagram showing the process flow for Spectral Clustering, including steps like "Feature Vector," "New Feature Vector," "Spectral Clustering," and "Prediction." Each step is labeled with percentages (100%, 75%, 25%).]
Approach: Spectral Clustering

- Created a graph with all the images considering a k-nn graph (KNNG) and a Fully Connected graph (FCG).
  - Each image is represented as a feature vector as described above.
  - Each feature vector is *scaled* with zero mean and one unit variance.
  - Two images are compared using its feature vectors with an Euclidean distance.

- It was employed an implementation from scikit-learn [3] python that considers the Normalized Graph Laplacian Sym [2].
Experiments - Tuning

- LDA generates number of components = \#_of_classes – 1 (6)
Experiments - Tuning

Spectral Clustering - KNNG

Comparison
Discussion

- PCA and Spectral Clustering need at least 50 and 40 components to achieve an accuracy near 0.7, while LDA got higher accuracies with only 6 components. Let’s see the projections!!
Discussion

Spectral Clustering Projection
Discussion

LDA Projection
Discussion

PCA eigenvalues are plotted and we can appreciate which pixels are more important (white color) to help in increase the variance of the features. Let’s See!!

LDA Projections

Not possible to see a structure of a face.

- This is due that it does not work directly on the eigenvectors of the covariance matrix of the data.
- Instead, it tries to project instances of the same class as close as possible, while the projected means per class as farther as possible
• Related to spectral Clustering, FCG achieved a better performance than KNNG. Let’s See!!
  • One intuition of this result is that the FCG assigns a weight for all the possible edges considering lower weights for similar instances and higher for different ones.
  • In contrast KNNG only assigns a weight 1 for its k-nearest neighbors and sometimes the graph could be disconnected and generate more connected components than the number of classes that we have.
  • Notice that connected components of a same class if they are projected in different regions, they can damage the learning instead of improving it.
Conclusion

• In this project, we have applied a machine learning design cycle to the Face Recognition Problem considering PCA, LDA and Spectral Clustering approaches.

• The main contribution of our work is that we have explored, tuned and discussed different ways of modeling a face recognition problem achieving similar results in this three scenarios.

Future Work

• Consider other spectral methods (e.g. other graphs) in conjunction with different distances measures (e.g. cosine)

• Train with the complete LFW dataset.
Questions
References


