Identity and Expression Recognition on Low Dimensional Manifolds

Pedro Martins ♦ Jorge Batista
Institute of Systems and Robotics
Department of Electrical and Computer Engineering, University of Coimbra, Portugal

Abstract

- Face geometry extracted using Active Appearance Models (AAM).
- Low dimensional manifolds were then derived using Laplacian EigenMaps resulting in two types of manifolds, one for model identity and the other for expression. The recognition is composed by a two step cascade, where first the identity is predicted and then its associated expression model is used to predict the facial expression.
- The identity overall recognition rate was 96.8%. Facial expression results are identity dependent, the most expressive individual achieves 81.2% of overall recognition rate.

Active Appearance Models

- Generative nonlinear parametric models of shape and texture, commonly used to model faces.

Shape and Texture Models

\[ x = \{x_1, \ldots, x_n\}, \quad \theta = \{\theta_1, \ldots, \theta_m\} \]

Simultaneous Inverse Compositional Image Alignment

Warp \( I(x, \theta) \) with \( W(x, \theta) \)

Error Image

\( \sum_{i=1}^{n} \sum_{j=1}^{m} \nabla^{2} u_{i,j}(x, \theta) \)

Fitting Goal

\[ \min_{\theta} \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{m} \nabla^{2} u_{i,j}(x, \theta) \]

Laplacian EigenMaps

- Nonlinear dimension reduction techniques that derive a low dimensional manifold lying in a higher dimensional more complex manifold.
- Given \( k \) feature points, \( \{x_1, \ldots, x_k\} \), a graph with \( k \) nodes is build. The embedding map is found by computing the eigenvectors of the graph Laplacian.

Algorithm

- Build the adjacency graph, each node is connected to the \( k \) nearest neighbors
- Choose the weights for edges in the graph, \( w_{ij} \) is node \( i \) and \( j \) are connected by an edge
- Eigen-decomposition of the graph laplacian, \( \{L \} = \text{eig}(D - \frac{1}{2} \text{sym}(W)) \)
- Form the low-dimensional embedding \( \phi = \{f_1, f_2, \ldots, f_p\} \)

Identity Manifold

- Results for Identity Recognition

<table>
<thead>
<tr>
<th>Person</th>
<th>Person 2</th>
<th>Person 3</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98.75</td>
<td>0.08</td>
<td>1.79</td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
<td>2.05</td>
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</tr>
<tr>
<td>4</td>
<td>1.59</td>
<td>0.13</td>
<td>2.53</td>
</tr>
</tbody>
</table>

| Overall Recognition Rate | 96.8% |

Person-Dependent Expressions Manifolds

Simultaneous Identity and Facial Expression Recognition

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- Low dimensional manifolds were then derived using Laplacian EigenMaps resulting in two types of manifolds, one for model identity and the other for expression.
- The recognition is composed by a two step cascade, where first the identity is predicted and then its associated expression model is used to predict the facial expression.

Fitting Example

Experimental Results

- For evaluation proposes a Facial Dynamics Database was built.
- 4 Individuals / 7 Different Facial Expressions / 4 Folds / 440 x 440 / Total of 6678 Frames

Method 1: HMM Network

Method 2: One-Against-All SVM

Support Vector Machines

Support Vector Machines

Predicted Facial Expression

Predicted Identity

HMM = 81.27%

HMM = 75.95%

HMM = 73.20%

HMM = 81.27%

Overall Recognition Rate: 96.8% (95.4% in training)