A Facial Aging Approach to Identification of Identical Twins

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Overview

- Introduction
- Motivation
- Prior Work
- Our Approach
- Experimental Results
- Conclusions & Future Work
Monozygotic (MZ) or identical twins occur when a single egg is fertilized to form one zygote (hence, "monozygotic"), which then divides into two separate embryos.
Motivation

Differences in **lifestyle** and factors such as stress, exposure to the sun, smoking, body weight, etc., have an effect on **how the face ages**
In older people, **aging signs** are more obviously manifested by wrinkles, which are **not clearly visible** in the faces of **young people**.
Motivation (contd.)

Facial aging regions

- Brow furrows
- Crows feet
- Laugh lines
## Prior Work

<table>
<thead>
<tr>
<th>Paper</th>
<th>Focus</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jain et al. [1]</td>
<td>Fingerprint</td>
<td>Similarity of fingerprints was highest in the case of identical twins, followed by siblings, parents and their children, and finally, unrelated people</td>
</tr>
<tr>
<td>Srihari et al. [2]</td>
<td>Fingerprint</td>
<td>Similarity of fingerprints between both fraternal twins and identical twins is the same</td>
</tr>
<tr>
<td>Kong et al. [3]</td>
<td>Palmprint</td>
<td>Identical twins can be distinguished by their palmprints (experimented on 1028 palmprints from 53 pairs)</td>
</tr>
<tr>
<td>Daugman et al. [4]</td>
<td>Iris</td>
<td>Iris patterns of genetically identical eyes are as uncorrelated as the patterns of unrelated eyes. Thus, the textural detail of the iris is sufficiently to distinguish identical twins</td>
</tr>
</tbody>
</table>
## Prior Work (contd.)

<table>
<thead>
<tr>
<th>Paper</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Sun et al. [5]</td>
<td>Iris, Face Fingerprint</td>
<td>There is no significant difference in the performance of a biometric system for the identical twin data and for the general data, so the iris can be used to distinguish identical twins, as much as it can be used to distinguish any unrelated individuals.</td>
</tr>
<tr>
<td>Kodate et al. [6]</td>
<td>Face Recognition</td>
<td>An optical recognition principle can be successful in distinguishing between identical twins for a small database.</td>
</tr>
<tr>
<td>Phillips et al. [7]</td>
<td>Face Recognition</td>
<td>The best performance is obtained when all images of a pair of identical twins are taken on the same day and in the same studio environments.</td>
</tr>
<tr>
<td>Srinivas et al. [8]</td>
<td>Facial Marks</td>
<td>Researched where the potential to enrich facial characterizations used in automatic systems lay and possible improvements that could be made to improve matching performance when dealing with twins.</td>
</tr>
</tbody>
</table>
Our Approach

Flowchart of our process to distinguish identical twins
Our Approach (contd.)

Module 1: Twins Group Classification

Fisher Discriminant Analysis (FDA)

\[
S_w = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} A_{i,j}^w (x_i - x_j)(x_i - x_j)^T
\]

\[
S_b = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} A_{i,j}^b (x_i - x_j)(x_i - x_j)^T
\]

\[
A_{i,j}^w = \begin{cases} 
1/n_c & \text{if } (y_i = y_j = c) \\
0 & \text{if } (y_i \neq y_j)
\end{cases}
\]

\[
A_{i,j}^b = \begin{cases} 
1/n - 1/n_c & \text{if } (y_i = y_j = c) \\
1/n & \text{if } (y_i \neq y_j)
\end{cases}
\]

Local Fisher Discriminant Analysis (LFDA)

\[
\tilde{S}_w = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{A}_{i,j}^w (x_i - x_j)(x_i - x_j)^T
\]

\[
\tilde{S}_b = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{A}_{i,j}^b (x_i - x_j)(x_i - x_j)^T
\]

\[
\tilde{A}_{i,j}^w = \begin{cases} 
A_{i,j}^l/n_c & \text{if } (y_i = y_j = c) \\
0 & \text{if } (y_i \neq y_j)
\end{cases}
\]

\[
\tilde{A}_{i,j}^b = \begin{cases} 
A_{i,j}^l(1/n - 1/n_c) & \text{if } (y_i = y_j = c) \\
1/n & \text{if } (y_i \neq y_j)
\end{cases}
\]
Our Approach (contd.)

Module 2: Twins Discrimination

Landmarking scheme used by MASM [9]

Aging Regions
Our Approach (contd.)

Module 2: Twins Discrimination

Real part of the spatial impulse response of a set of Gabor filters constructed using different frequencies, orientations and sizes of interest

Spatial impulse response of a set of Gabor filters
Experimental Results

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Gallery</th>
<th>Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral, without glasses</td>
<td>588</td>
<td>168</td>
</tr>
<tr>
<td>Smiling, without glasses</td>
<td></td>
<td>164</td>
</tr>
<tr>
<td>Neutral, with glasses</td>
<td></td>
<td>118</td>
</tr>
<tr>
<td>Smiling, with glasses</td>
<td></td>
<td>122</td>
</tr>
</tbody>
</table>

Setup and distribution of probe and gallery images from the ND-Twins database

ROC curves obtained by the two algorithms under the four different test cases.
# Experimental Results

<table>
<thead>
<tr>
<th>Test Case</th>
<th>LFDA Only (%)</th>
<th>LFDA + Aging Features (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral, without glasses</td>
<td>76.3</td>
<td>89.6</td>
</tr>
<tr>
<td>Smiling, without glasses</td>
<td>79.6</td>
<td>90.5</td>
</tr>
<tr>
<td>Neutral, with glasses</td>
<td>77.3</td>
<td>87.7</td>
</tr>
<tr>
<td>Smiling, with glasses</td>
<td>76.1</td>
<td>88.1</td>
</tr>
</tbody>
</table>

ID rates obtained by two algorithms on images from the ND-Twins database

<table>
<thead>
<tr>
<th>Test Case</th>
<th>LFDA Only (%)</th>
<th>LFDA + Aging Features (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral, without glasses</td>
<td>24.11</td>
<td>37.80</td>
</tr>
<tr>
<td>Smiling, without glasses</td>
<td>25.46</td>
<td>42.07</td>
</tr>
<tr>
<td>Neutral, with glasses</td>
<td>21.29</td>
<td>35.59</td>
</tr>
<tr>
<td>Smiling, with glasses</td>
<td>20.90</td>
<td>33.61</td>
</tr>
</tbody>
</table>

Verification rates at 0.1% FAR obtained by two algorithms on four test cases
Conclusions, Future Work

- Aging features are useful in distinguishing identical twins
- Our approach shows good generalization ability and outperforms conventional face recognition algorithms
- Approach performs best when expressions are present

- Investigation of more aging features
- Experiments involving more facial expressions
- Tests on larger databases
- Real life scenarios of face reocognition
References


