Landmark Labelling for 3D Faces

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Motivation

- Non-cooperative Recognition at a distance
- Modality
- Difficult Cases
- Review
- Assumptions
Non-cooperative Recognition at a distance

Application:
- Surveillance
- Human-Machine Interaction
Motivation

- Non-cooperative Recognition at a distance

Problem

- Application:
  - Surveillance
  - Human-Machine Interaction

- Problems:
  - Pose
  - Occlusion
  - Speed

Solution

Results

Conclusion
Motivation

- Non-cooperative Recognition at a distance

Modality

- Non-Cooperative ⊇ Anti-cooperative
- Proved possible for big database

From [Proenca, 2008]
From [Yan and Bowyer, 2007]
From [Phillips et al., 2005]
From [Havasi et al., 2007]
Motivation

- Non-cooperative Recognition at a distance

Modality

- Non-Cooperative ⊃ Anti-cooperative

Difficult Cases

- Review

Assumptions

Problem

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Modality

- Non-Cooperative ⊃ Anti-cooperative

Proved possible for big database

2D or 3D?

From Proença, 2008
From Yan and Bowyer, 2007
From Phillips et al., 2005
From Havasi et al., 2007

From Liu et al., 2007
Difficult Cases

Recall:  
- Holistic method $\rightarrow$ Need for good Registration  
- Feature based method $\rightarrow$ Need for good Feature Localisation
Difficult Cases

- **Recognition:**
  - Holistic method → Need for good Registration
  - Feature based method → Need for good Feature Localisation

- Will often fail at preprocessing
  - Naive methods for feature detection
  - Strong assumptions
Difficult Cases

- Recognition:
  - Holistic method → Need for good Registration
  - Feature based method → Need for good Feature Localisation

- Will often fail at preprocessing
  - Naive methods for feature detection
  - Strong assumptions

- Recquire better feature detection
Review

- Almost all papers expect non-occluded frontal face
- A few that don’t:
  - Some orientation change:
    - [Colbry et al., 2005]: Curvature + ICP + Relaxation
    - [Lu and Jain, 2006]: Directional Maximum
    - [Faltemier et al., 2008]: Rotated Profile Signature

- Almost all papers expect the nose will be present
- Most papers require two well-defined inner corners of the eyes
Assumptions

- The ones we needed to make:
  - At least half of the face is visible
  - There exist features repeatable across individual

- The ones we did not make:
  - All landmark are present and will match there descriptor
  - Candidates for one landmark descriptor are rare

- The ones we made (only in post-processing)
  - The face is roughly convex
  - Faces are not too flexible (≠ hand)
  - Only 1 face per scene
Problem
The landmark Detection Problem

- Landmark = Position + Label
- Two Approaches:
  - Select One Label + Find Corresponding Position
  - Find All Positions + Find Corresponding Labels
The landmark Detection Problem

■ Landmark = Position + Label

■ Two Approaches:
  - Select One Label + Find Corresponding Position
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The landmark Detection Problem

- Landmark = Position + Label
- Two Approaches:
  - Select One Label + Find Corresponding Position
  - Find All Positions + Find Corresponding Labels
Input Generation

Mesh → Automatic Points → Hand-Placed Points → Input Points

- The landmark Detection Problem
- Input Generation

Clément Creusot, October 25th, 2010
Solution
Our Strategy

- Multi-attribute seeding
- Relaxation by elimination

- Threshold on scores
- Unit-Quaternion clustering
Graph Generation

Graph Properties:
- Complete Graph (for now)
- 5 attributes per Node
- 7 attributes per Edge

Mesh \[\rightarrow\] Neighbourhood \[\rightarrow\] Scalars & Vectors

Input Points \[\rightarrow\] Node Attributes \[\rightarrow\] Edge Attributes \[\rightarrow\] Graphs

- Mesh
- Neighbourhood
- Scalars & Vectors
- Graph Properties:
  - Complete Graph (for now)
  - 5 attributes per Node
  - 7 attributes per Edge
Graph Matching

- Structure
  - list of candidates
  - Associated scores
Graph Matching

Structure
- list of candidates
- Associated scores

Objective:
- Reduce correspondence Nb
Graph Matching

- Structure
  - list of candidates
  - Associated scores

- Objective:
  - Reduce correspondence Nb

- Seeding
  - Partial scores $LDA \rightarrow$ Score
Graph Matching

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- Objective:
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- Seeding
  - Partial scores $LDA \rightarrow$ Score

- Relaxation on hyperedges ($\neq$ Christmas et al., 1995)
Elimination
Elimination
Elimination

QUERY

MODEL
Motivation

Problem

Solution
- Our Strategy
- Graph Generation
- Graph Matching
- Elimination
- Post-Processing

Results

Conclusion

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Elimination

QUERY

MODEL

0.5

0.75

0.8

0.55
Elimination

\[ \text{Support} = 0.75 \]
\[ \text{Score} = 0.7 \]

\[ \text{Thres}_1 \]
\[ \text{Thres}_2 \]
Elimination

<table>
<thead>
<tr>
<th>Nb of Node Correspondences</th>
<th>June</th>
<th>Sept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Seeding</td>
<td>14.0</td>
<td>58.0</td>
</tr>
<tr>
<td>GM</td>
<td>151.0</td>
<td>539.0</td>
</tr>
<tr>
<td>Final</td>
<td>222.0</td>
<td>812.0</td>
</tr>
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Post-Processing

Transformation Matrix 4x4:

\[
\begin{pmatrix}
R' & \vec{t} \\
0 & 1
\end{pmatrix}
\rightarrow
\begin{pmatrix}
\dot{q} \\
\dot{t} \\
\end{pmatrix}
\]

Unit Quaternion
Translation
Scale
Post-Processing

- Clustering
- Mean Transformation
- Final Correspondence
Results
Databases

- **FRGC v2**
  - 4950 faces from 557 people
  - 200 in train set
  - 4750 in test set (3108 Neutral, 1642 Expression)
  - cropped

- **Bosphorus**
  - 4666 faces from 105 people
  - Occlusion, Expression, Rotation
  - 99 in train set (20 for profile)
Results

- For now:
  - 6.3% bad final registration
- If automatic landmarks only:
  - 10.4% bad final registration
- The system doesn’t collapse when dealing with occlusion or pose variation
Conclusion
Conclusion

- Good
  - Very few assumptions on the input data
  - Graphs are very versatile

- Bad
  - Non optimised (preliminary results)
  - Naive post-processing

- Future Work
  - Try different graph topologies
  - Improve robustness to missing points
  - Deal with non-cropped faces
  - Try higher order hyperedges
Conclusion

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Thank you!
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Bibliography


