Landmark Labelling for 3D Faces

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Motivation

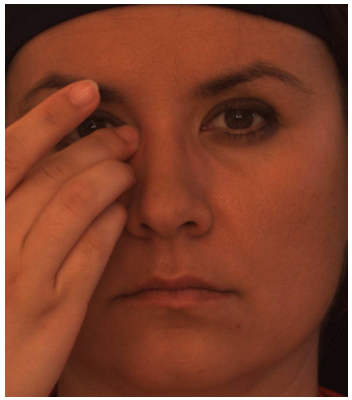
Non-cooperative Recognition at a distance

- Application:
  - Surveillance
  - Human-Machine Interaction

Non-cooperative Recognition at a distance

- Application:
  - Surveillance
  - Human-Machine Interaction
- Problems:
  - Pose
  - Occlusion
  - Speed

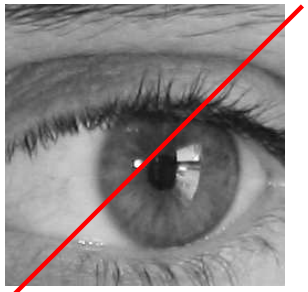
From [Savran et al., 2008]



From [Savran et al., 2008]

Modality

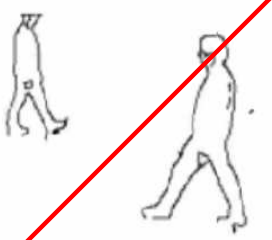
- Non-Cooperative ⊃ Anti-cooperative
- Proved possible for big database



From [Proenca, 2008]

From [Yan and Bowyer, 2007]

From [Phillips et al., 2005]



From [Havasi et al., 2007]

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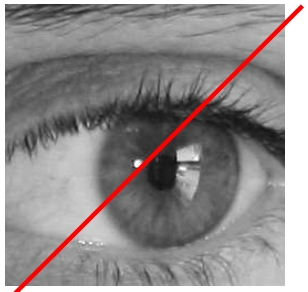

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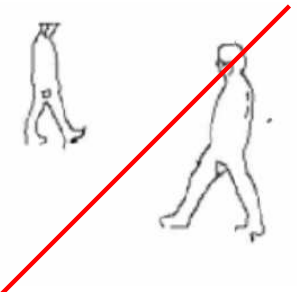
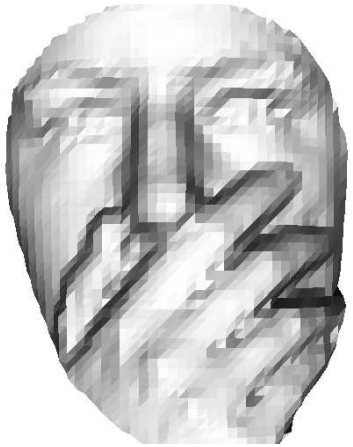
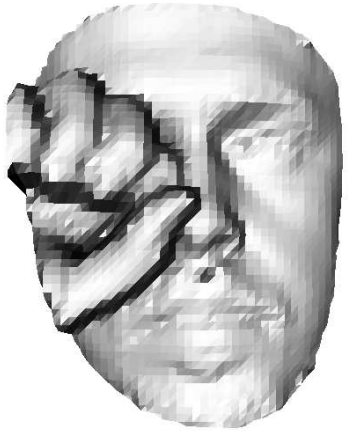
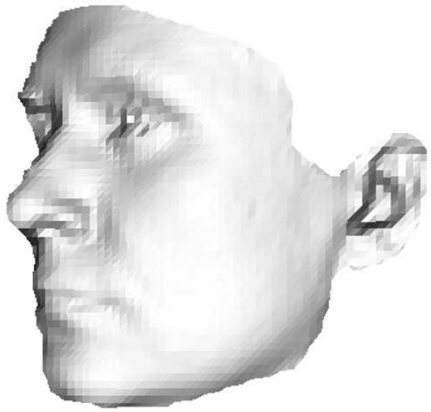


From [Havasi et al., 2007]

- 2D or 3D ?

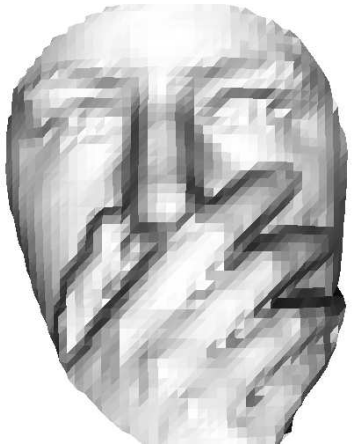
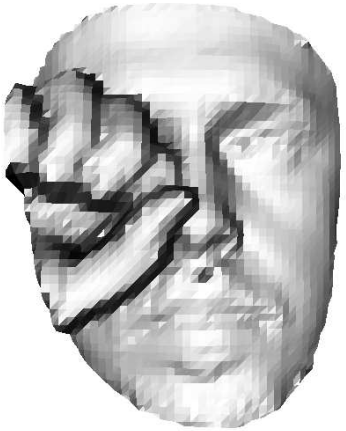
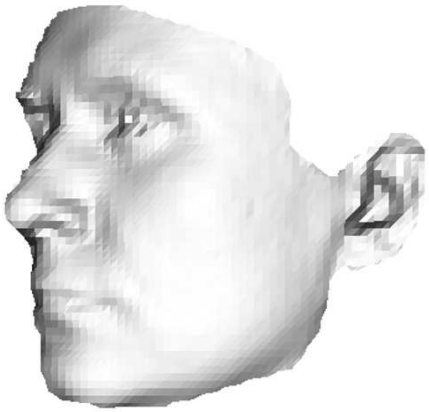
From [Liu et al., 2007]

Difficult Cases

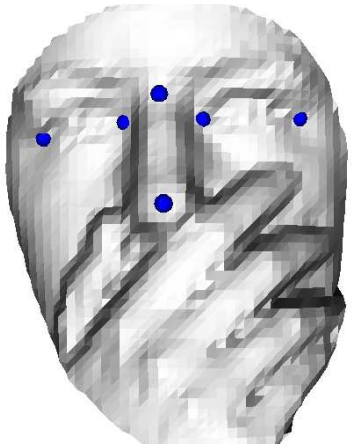
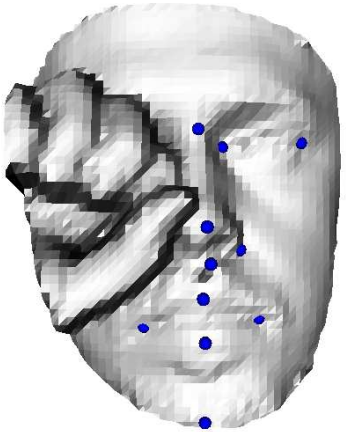
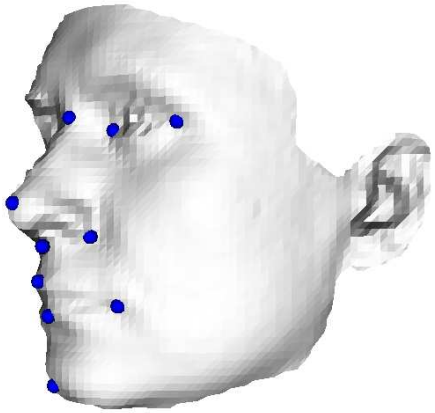
- Recognition:
  - Holistic method $\rightarrow$ Need for good Registration
  - Feature based method $\rightarrow$ Need for good Feature Localisation

Difficult Cases

- Recognition:
  - Holistic method $\rightarrow$ Need for good Registration
  - Feature based method $\rightarrow$ Need for good Feature Localisation
- Will often fail at preprocessing
  - Naive methods for feature detection
  - Strong assumptions

Difficult Cases

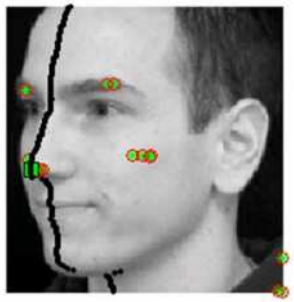




- Recognition:
  - Holistic method $\rightarrow$ Need for good Registration
  - Feature based method $\rightarrow$ Need for good Feature Localisation
- Will often fail at preprocessing
  - Naive methods for feature detection
  - Strong assumptions
- Recquire better feature detection

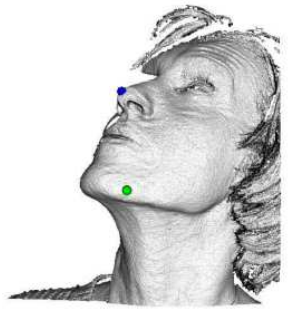
Review

- Almost all paper 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

[Colbry et al., 2005]



[Lu and Jain, 2006]



[Faltemier et al., 2008]

- Almost all papers expect the nose will be present
- Most papers recquire 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 ($\neq$ hand)
  - Only 1 face per scene

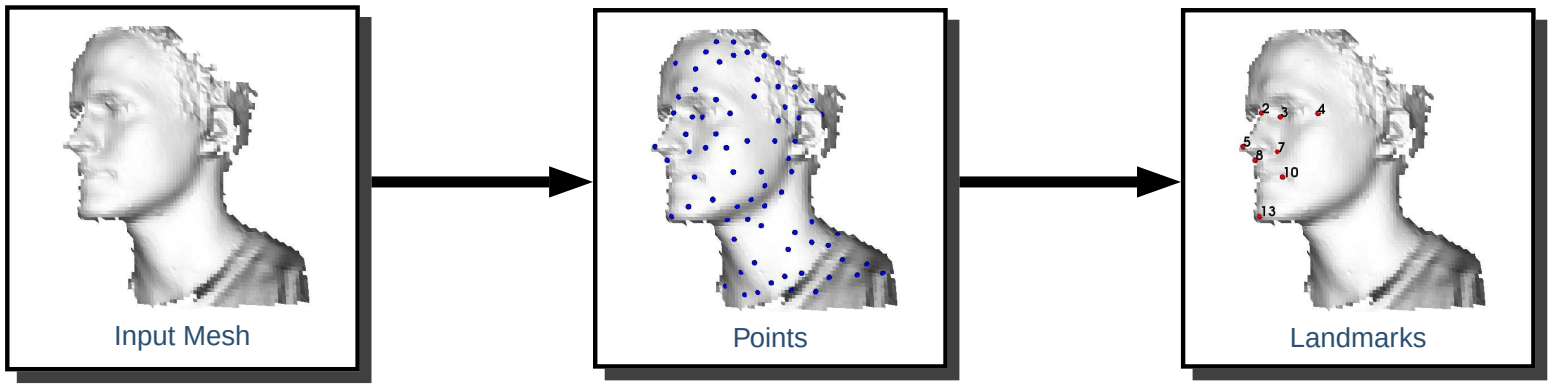
Problem

The landmark Detection Problem

Landmarking

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

The landmark Detection Problem



Repeatable Point Detection **Labelling**

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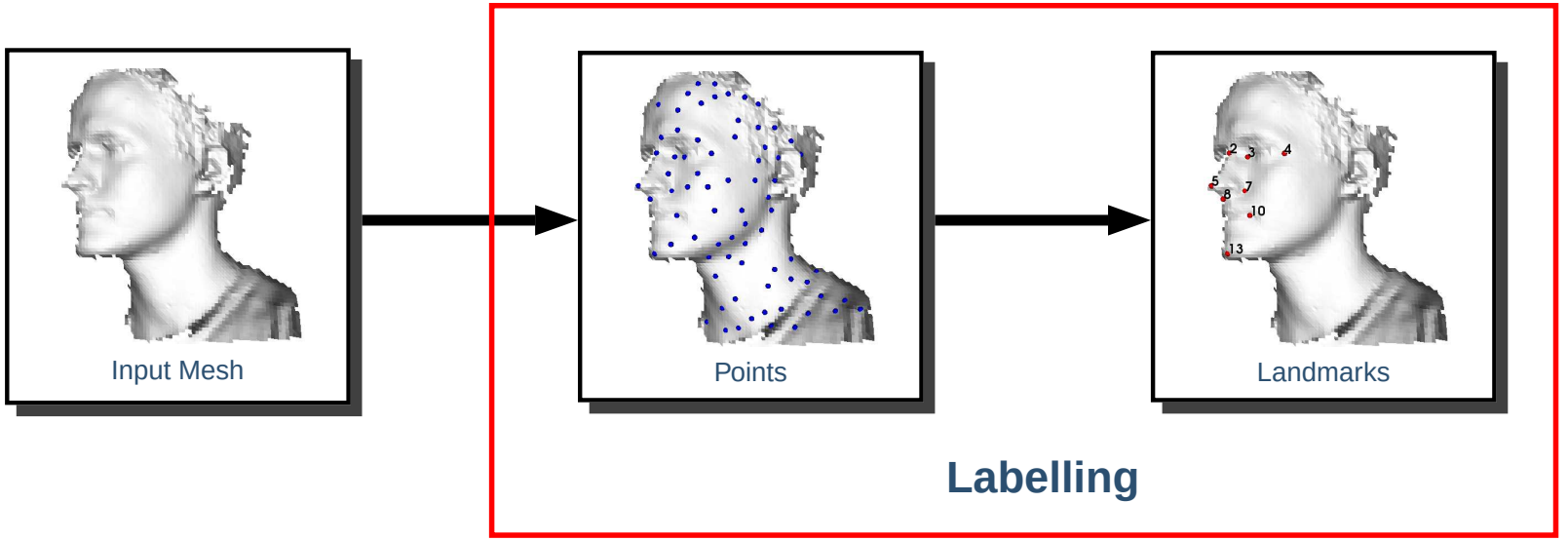
The landmark Detection Problem



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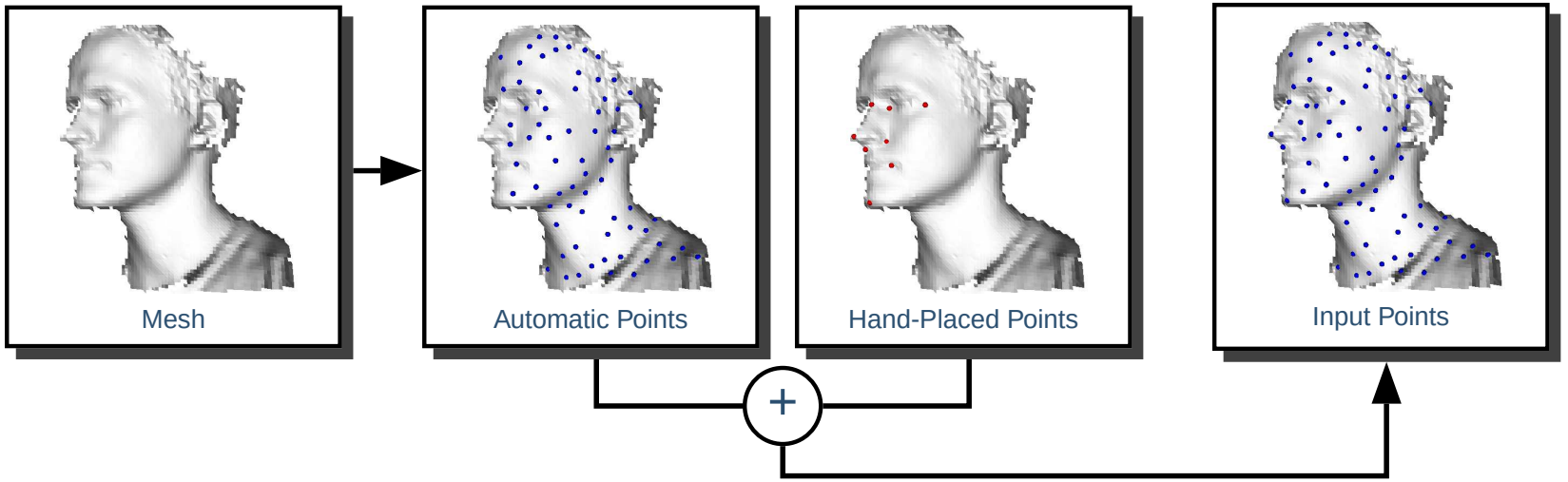
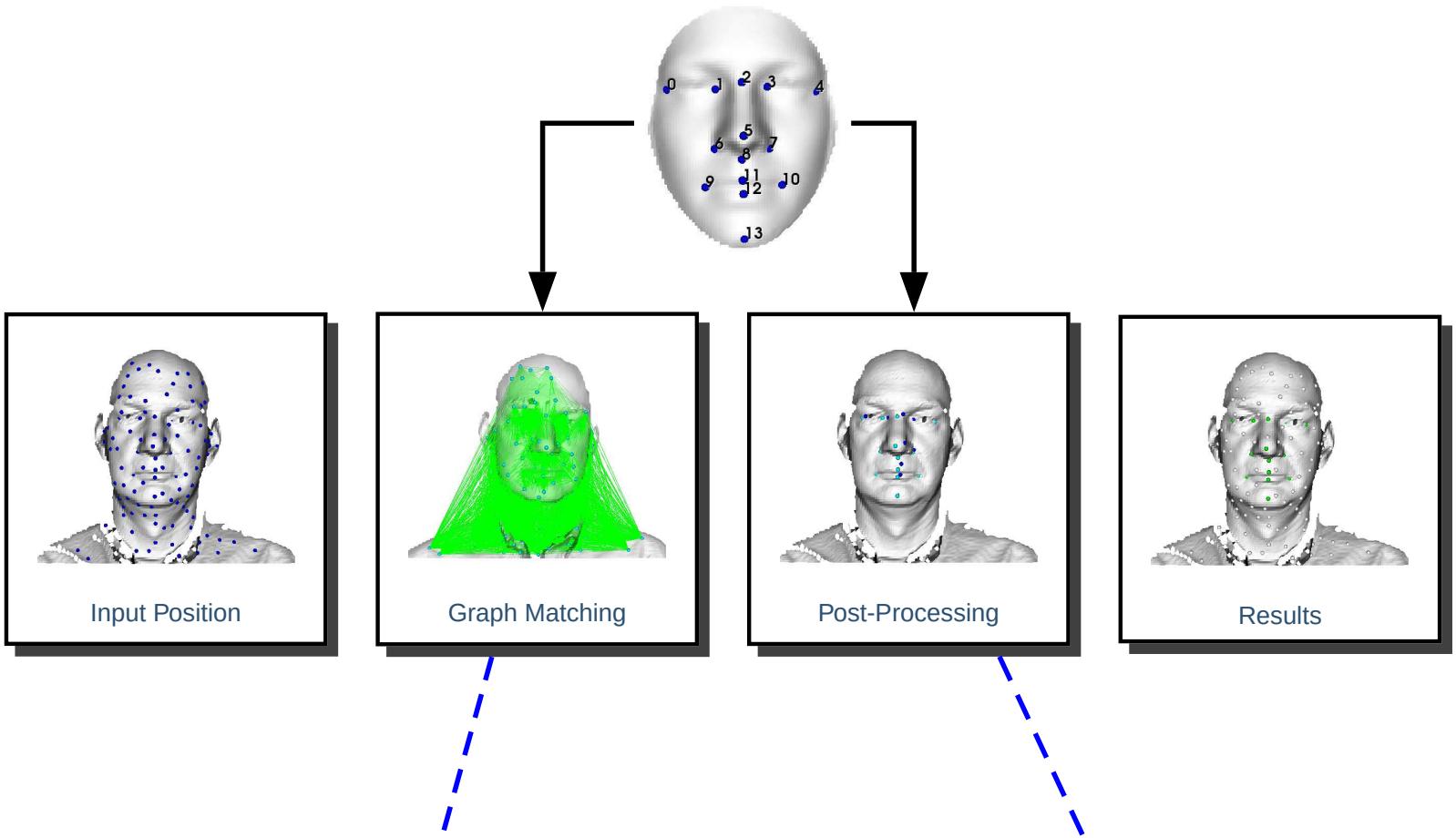
Input Generation



Solution

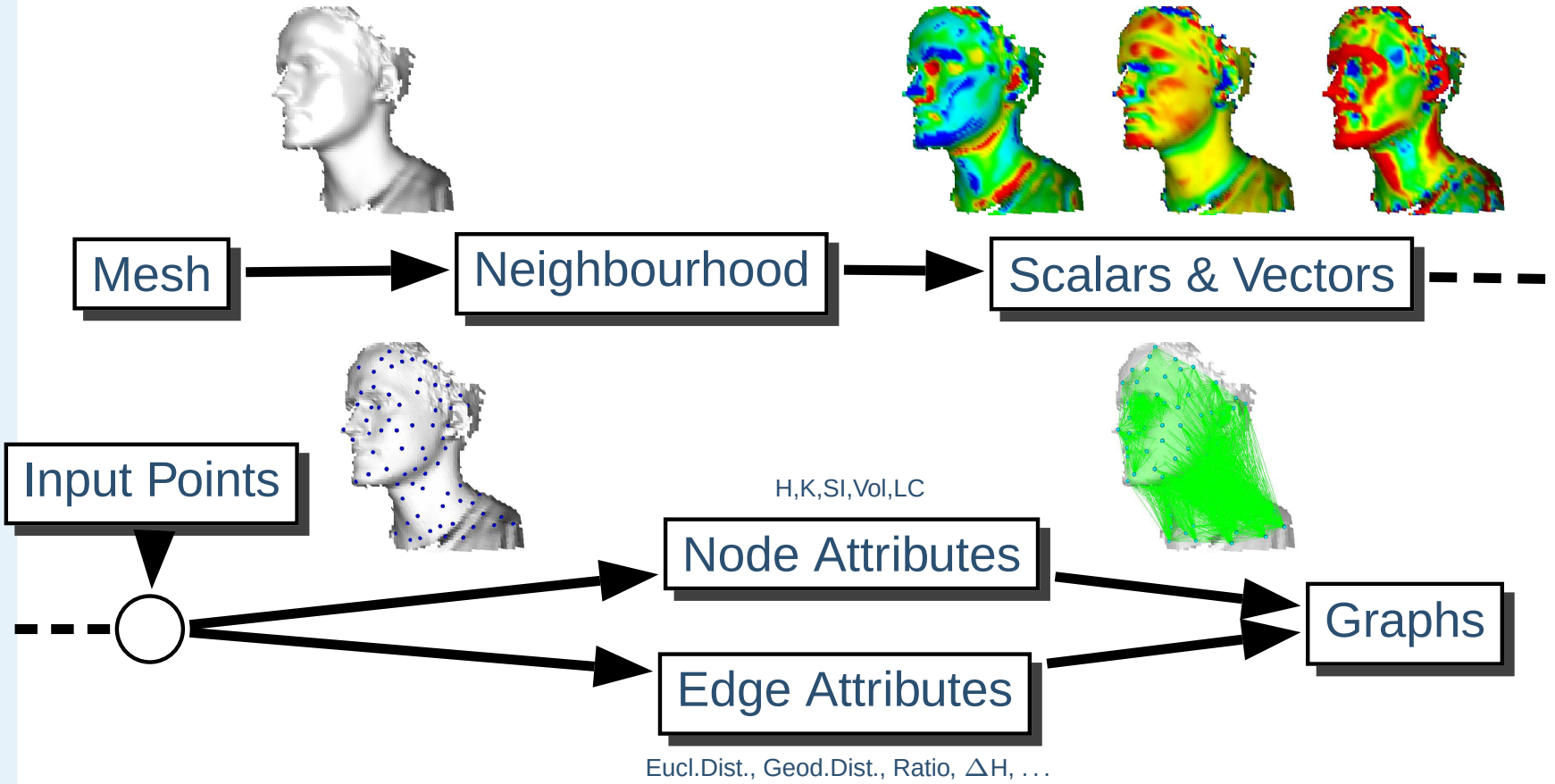
Our Strategy



- Multi-attribute seeding
- Relaxation by elimination

- Threshold on scores
- Unit-Quaternion clustering

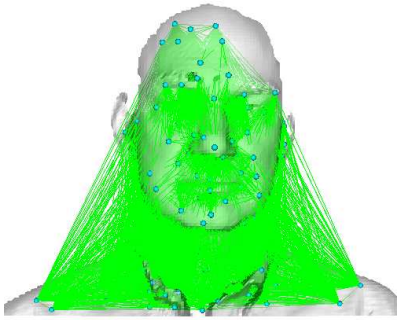
Graph Generation

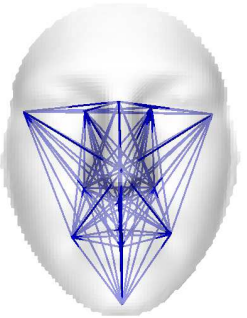


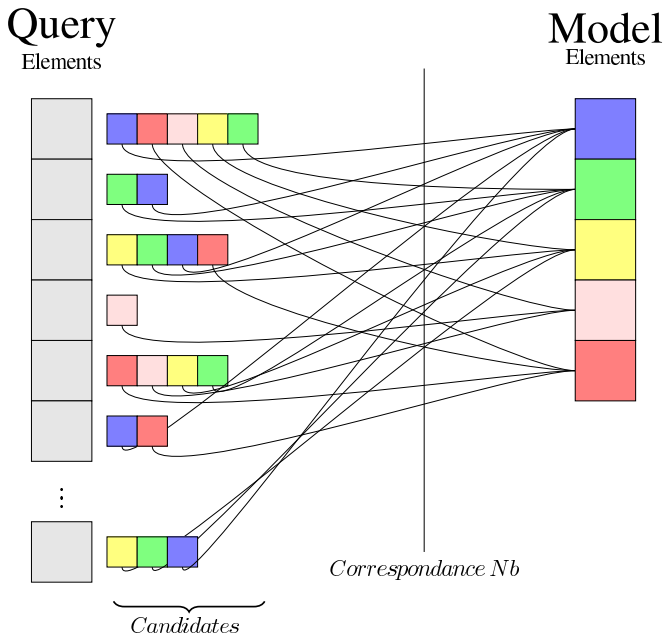
- Graph Properties:
  - Complete Graph (for now)
  - 5 attributes per Node
  - 7 attributes per Edge

Graph Matching

- Structure
  - list of candidates
  - Associated scores

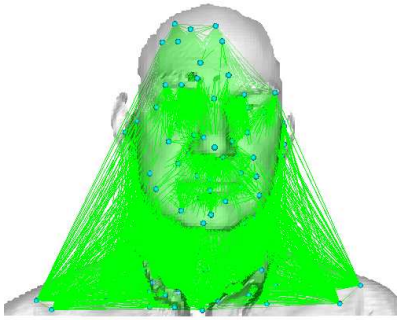


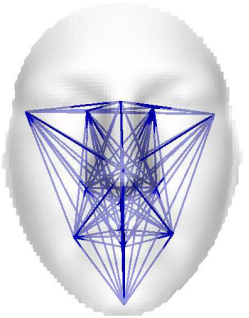


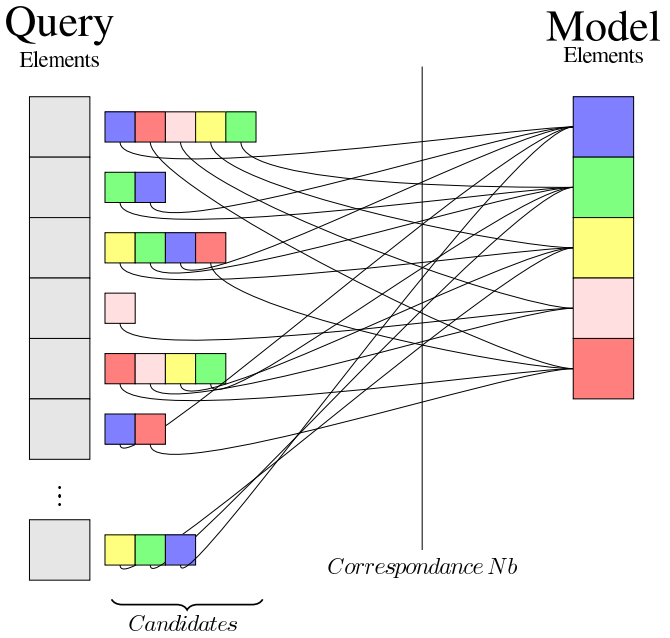


Graph Matching

- Structure
  - list of candidates
  - Associated scores
- Objective:
  - Reduce correspondence Nb







Graph Matching

- Structure
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- Objective:
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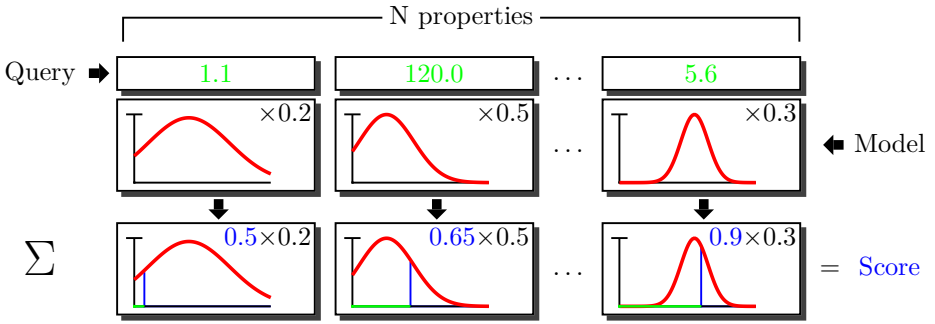
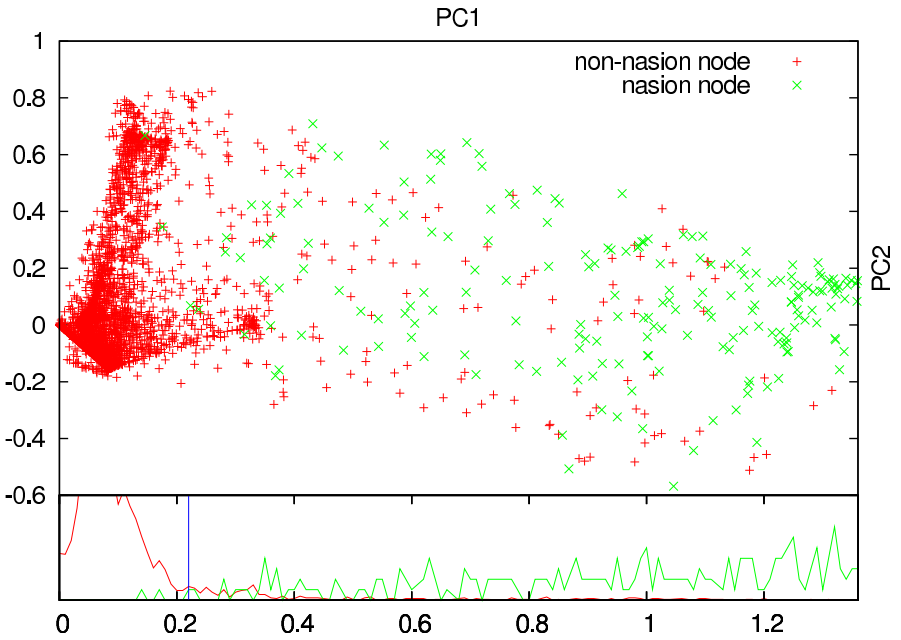
- Seeding
  - Partial scores $\overset{LDA}{\rightarrow}$ Score

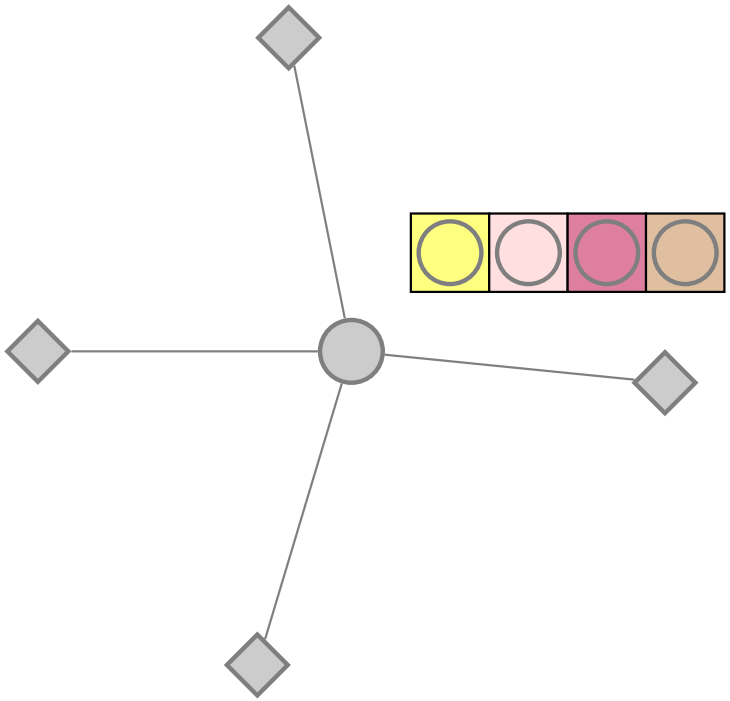




Graph Matching

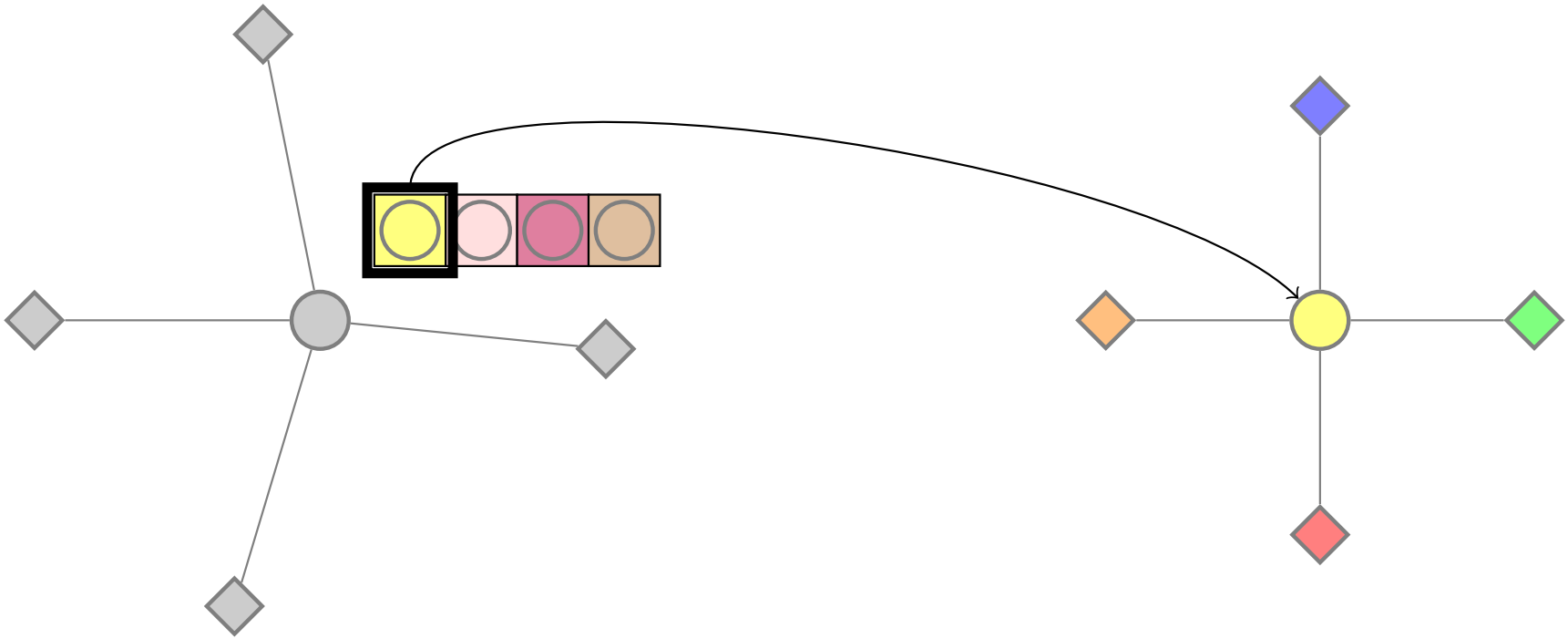
- Structure
  - list of candidates
  - Associated scores
- Objective:
  - Reduce correspondence Nb
- Seeding
  - Partial scores $\overset{LDA}{\rightarrow}$ Score
- Relaxation on hyperedges ($\neq$ [Christmas et al., 1995])

Elimination



QUERY

Elimination



QUERY

MODEL

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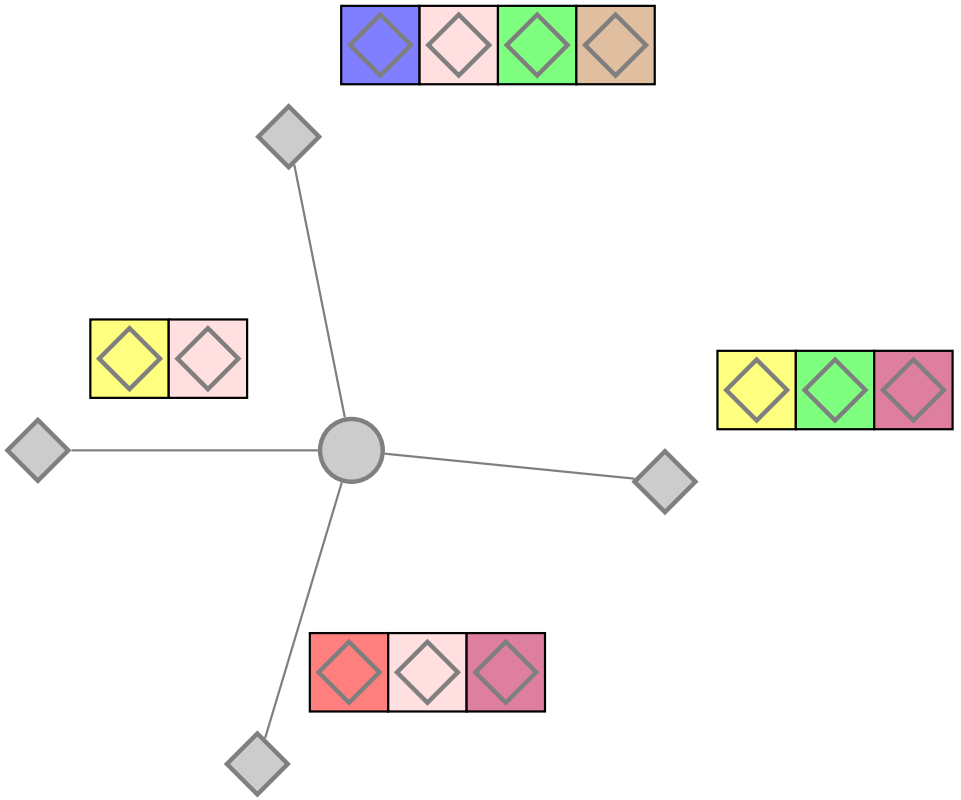

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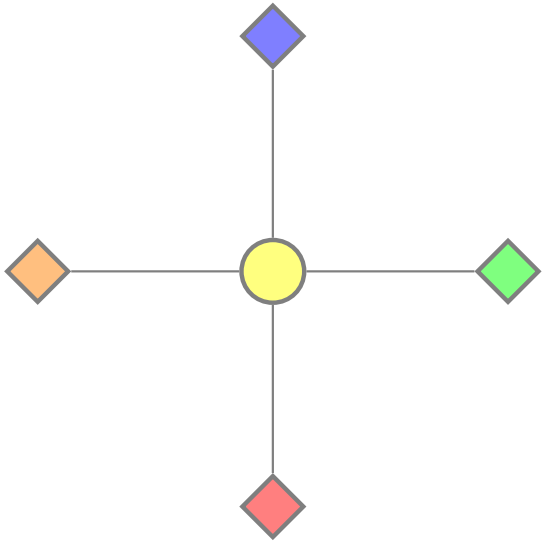

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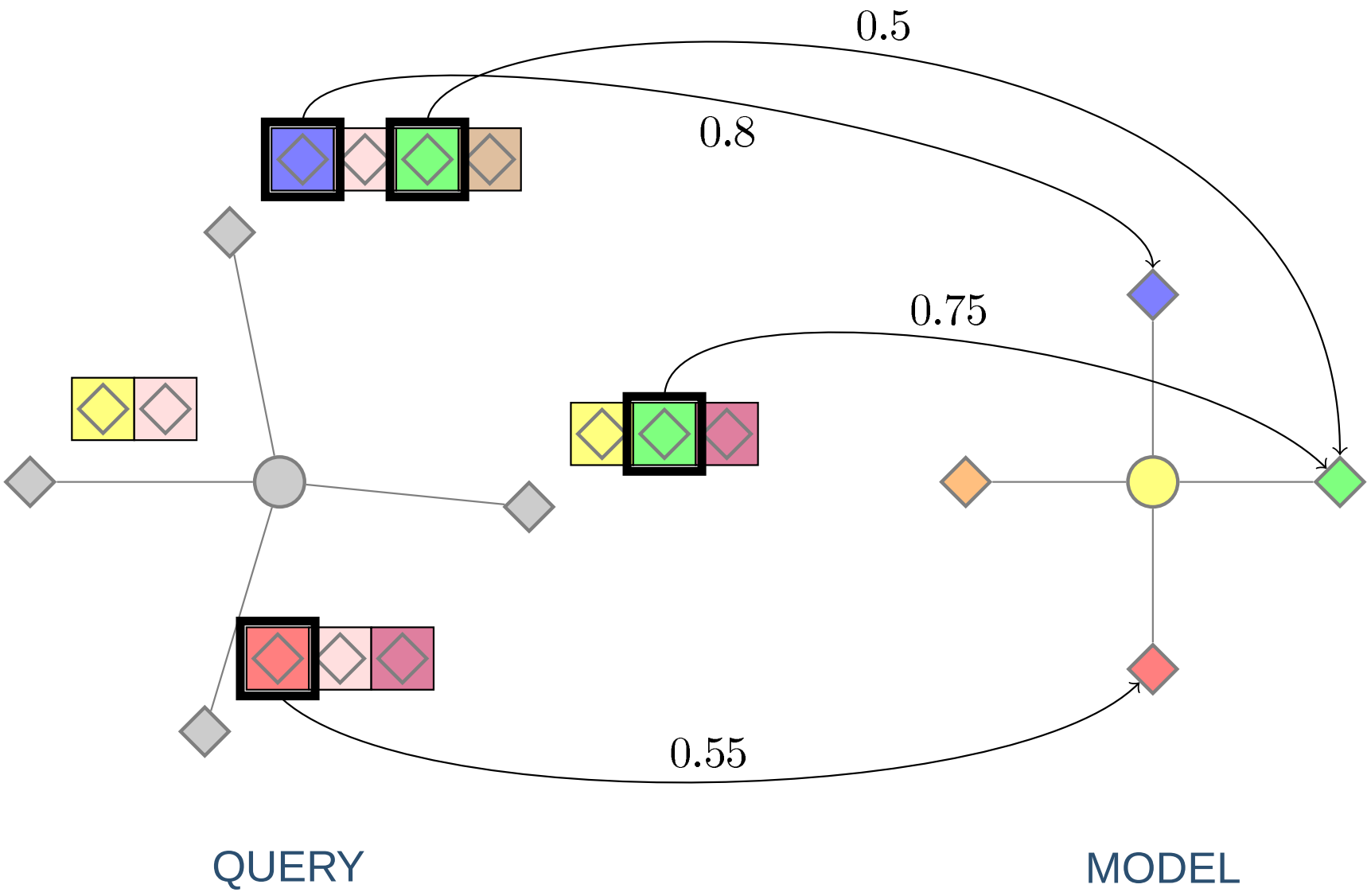

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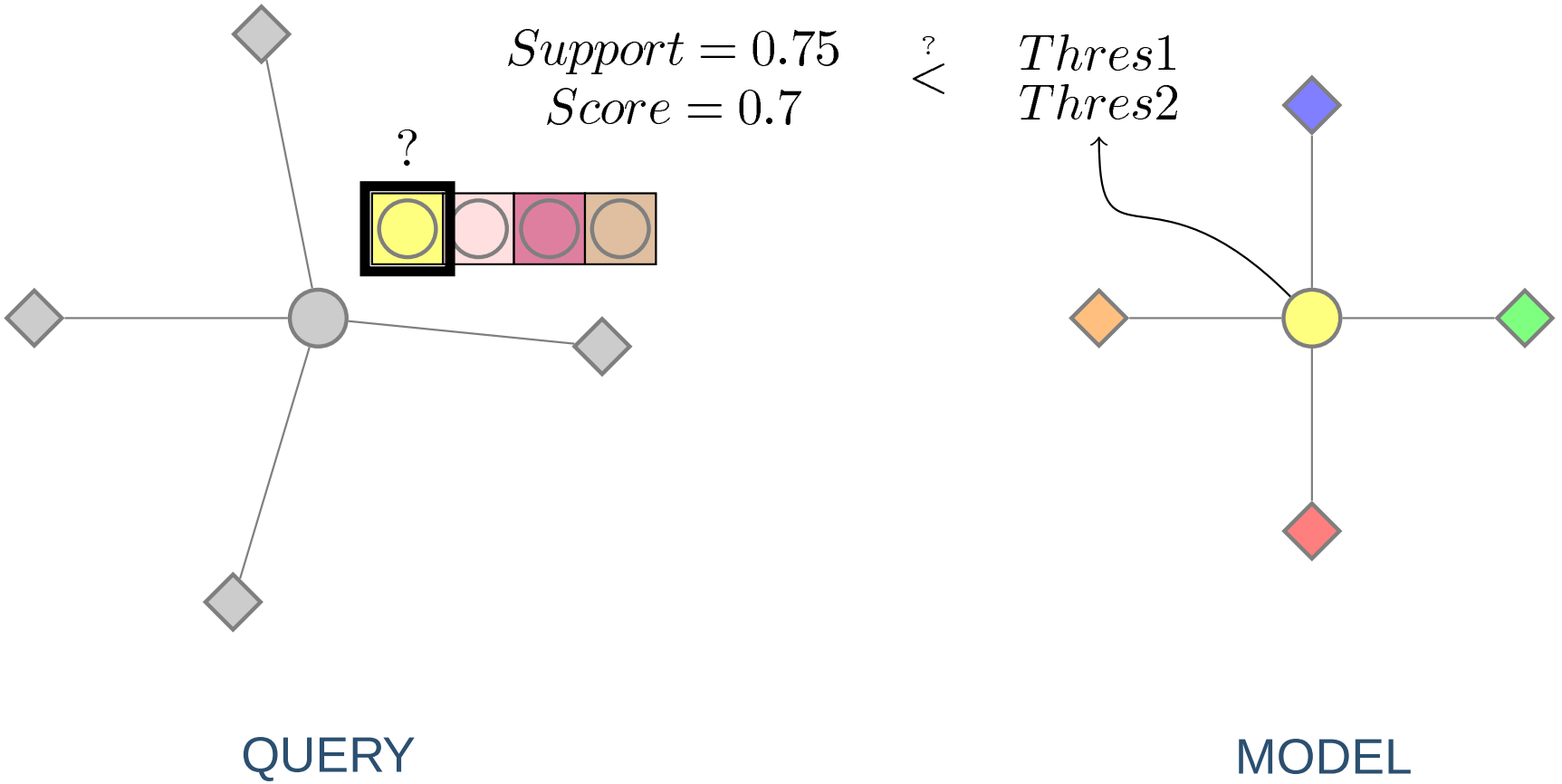

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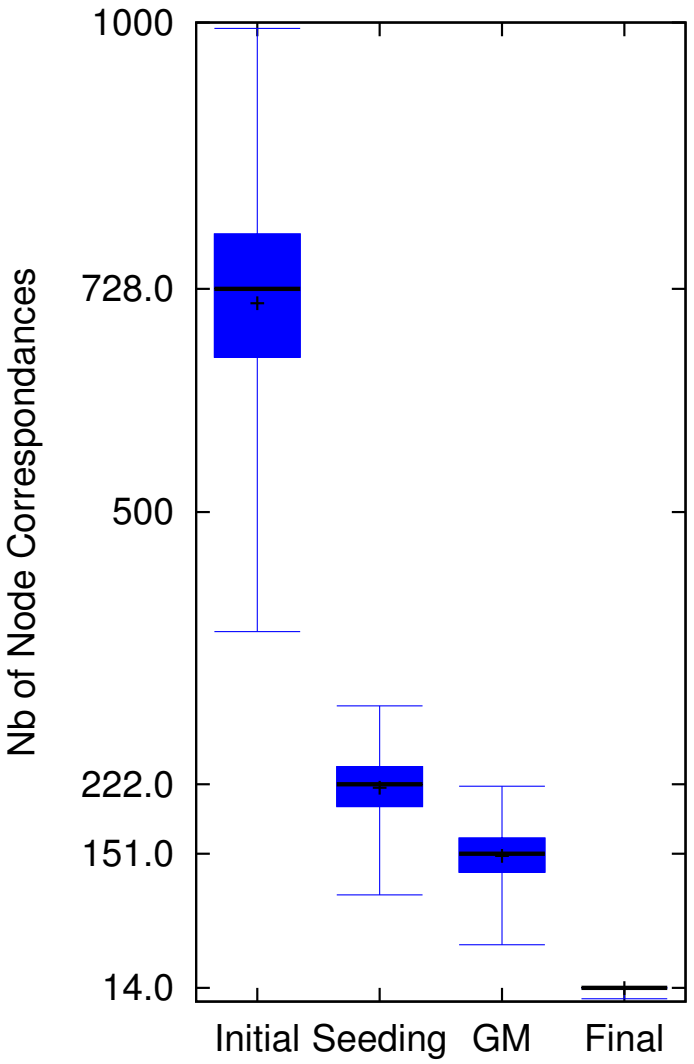

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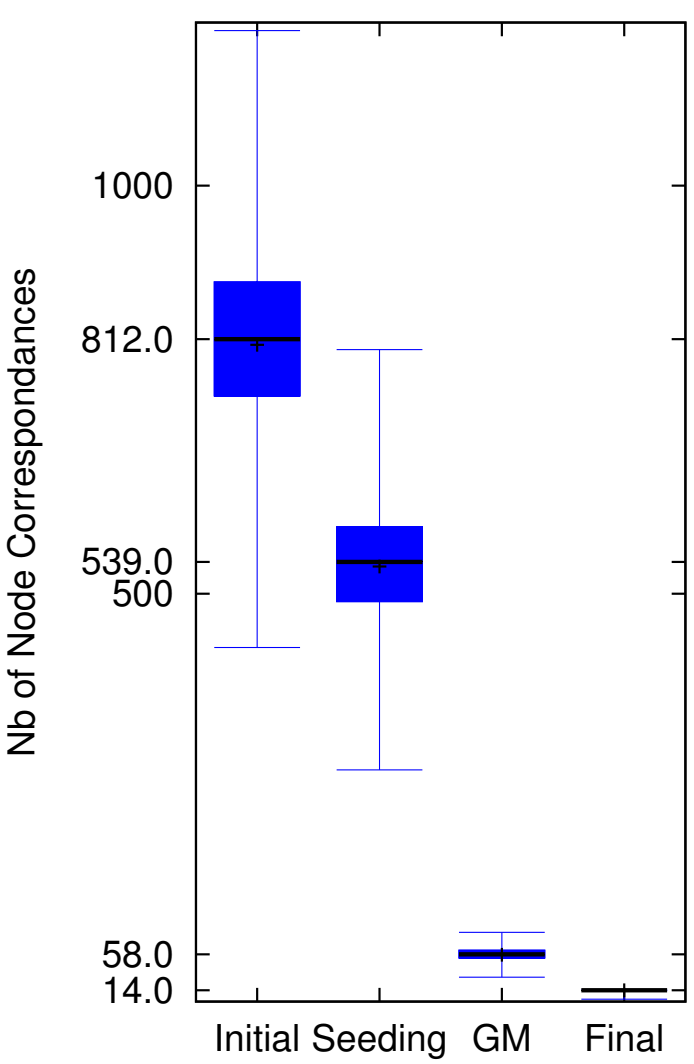
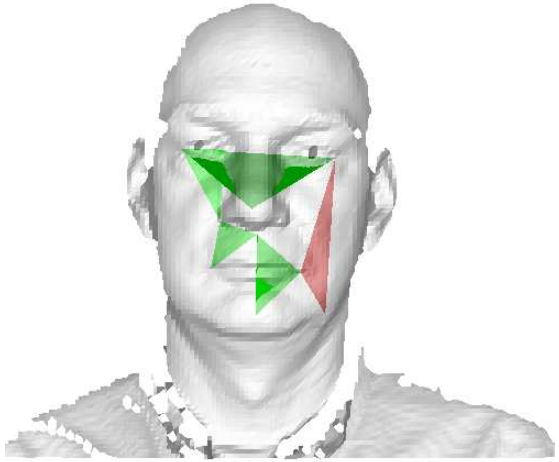
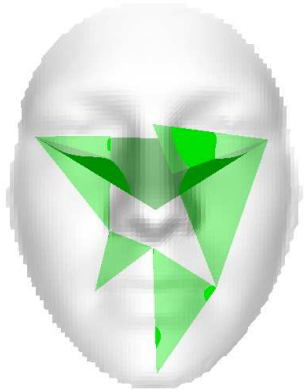


Sept.

Post-Processing



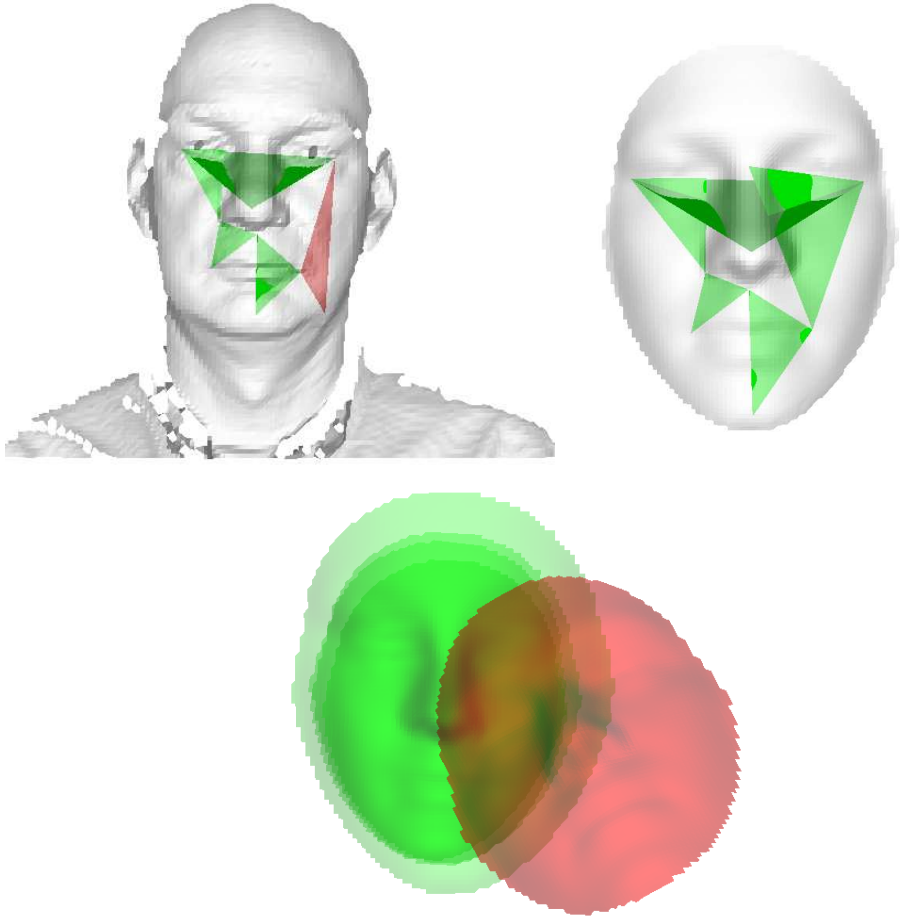


Transformation Matrix 4x4:

$$\left(\begin{array}{c|c} R' & \vec{t} \\ \hline 0 & 1 \end{array}\right) \rightarrow \begin{array}{l} \dot{q} \\ \vec{t} \\ s \end{array}$$

Unit Quaternion
Translation
Scale

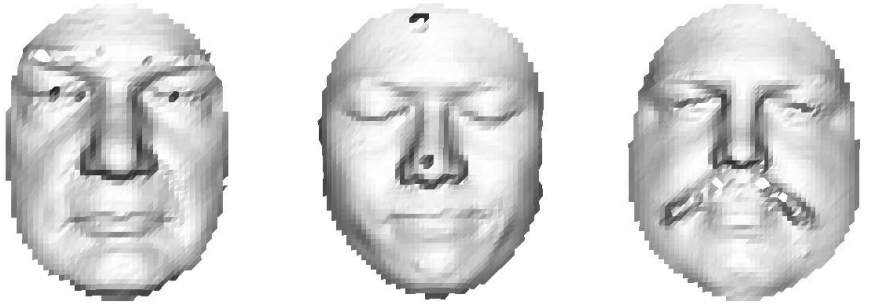
Post-Processing



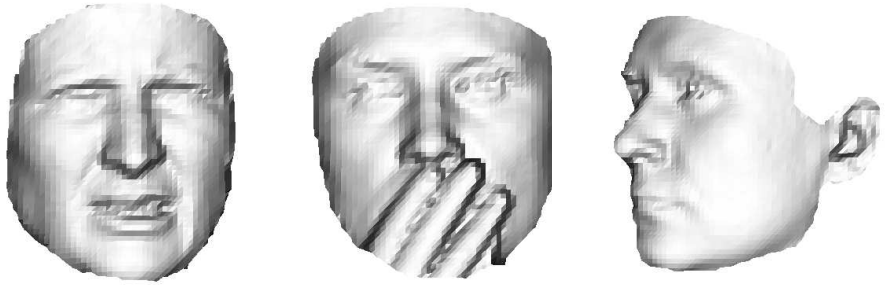
- Clustering
- Mean Transformation
- Final Correspondence

Results

Databases



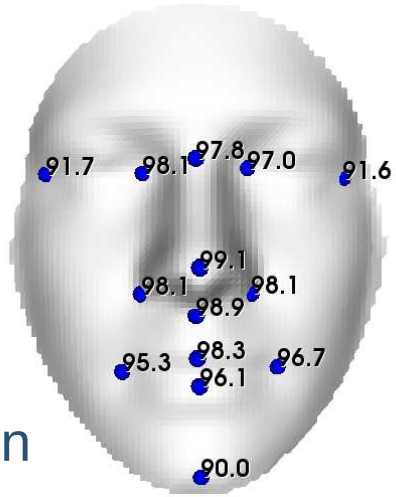
- FRGC v2
  - 4950 faces from 557 people
  - 200 in train set
  - 4750 in test set (3108 Neutral, 1642 Expression)
  - cropped
- Bosphorus
  - 4666 faces from 105 people
  - Occlusion, Expression, Rotation
  - 99 in train set (20 for profile)



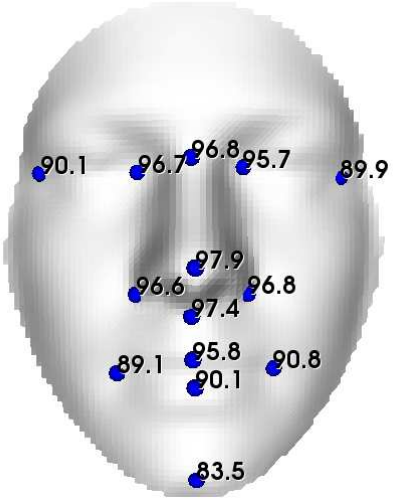
Results

- 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

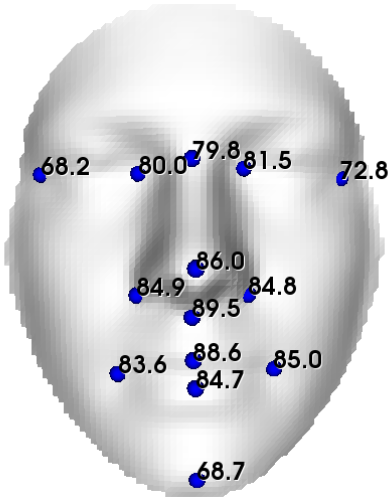
FRGC v2 - Neutral



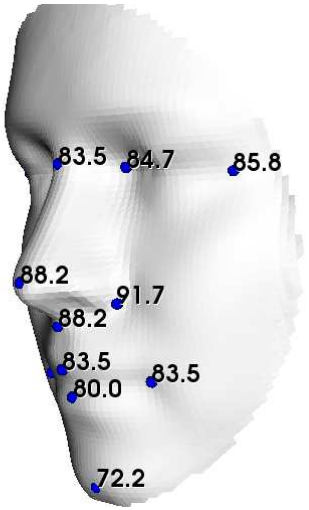
FRGC v2 - All



Bosphorus - Occluded



Bosphorus - Rotation 45



Conclusion

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- 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

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Thank you !

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