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3D Meshes of Facial Expression

Ecole Polytechnique Fédérale de Lausanne

A Network Tour of Data Science – Project Presentation

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Introduction

- 3D Geometry Investigation
  - Properties: Expression, Ethnies
  - Deformation

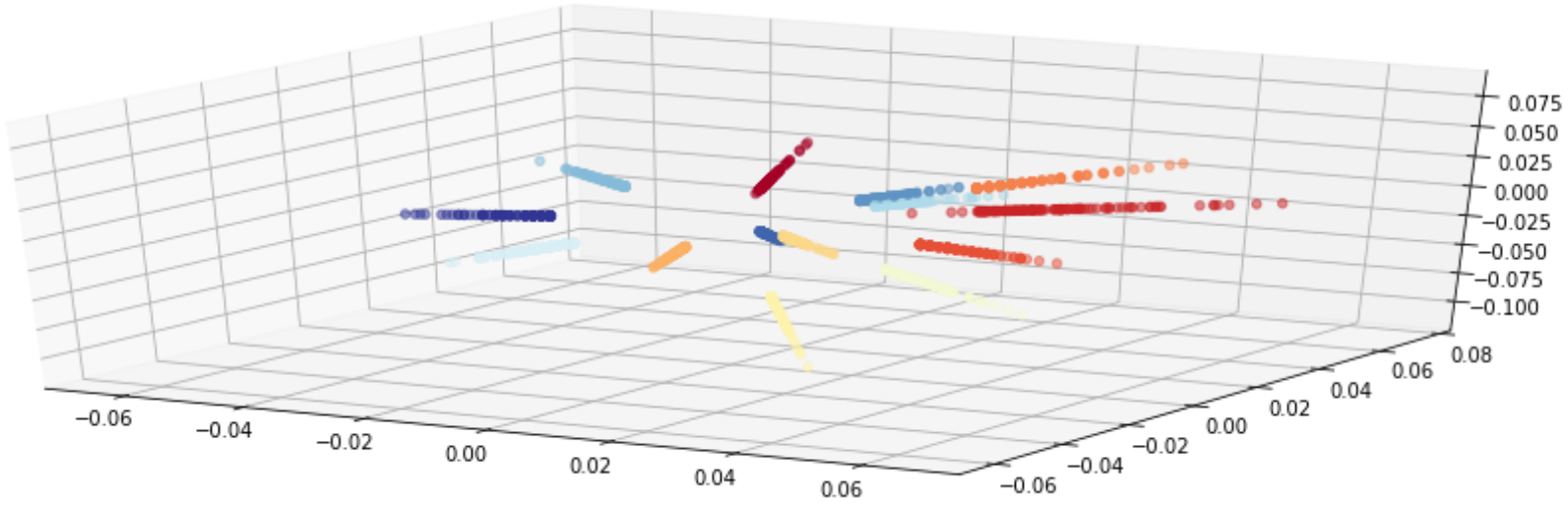
- Work split into two parts
  - Clustering :
    - Is it possible to define clusters that categorize facial expressions as well as ethnicity ?
  - Deformation Transfer
    - Can facial expression (i.e. Mouth open, raised eyebrows, …) be reproduced ?

Data Acquisition / Cleaning

- Database :
  - FaceWarehouse : 150 people, 47 expressions, mainly asian people
  - EPFL : 120 people, mainly caucasian people
  - Meshes are densely registered

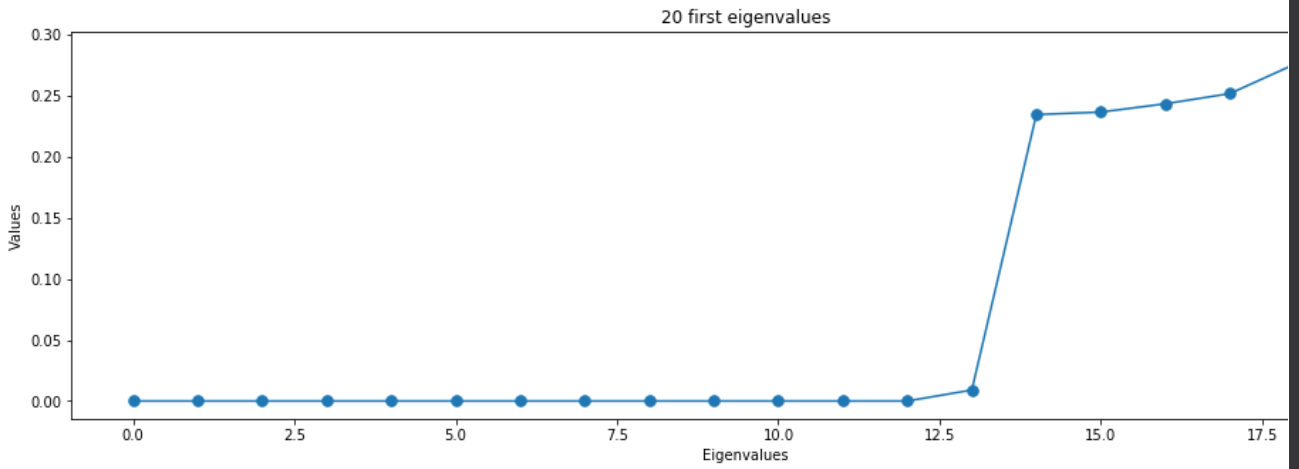
Classification – Person Dependent - Faces

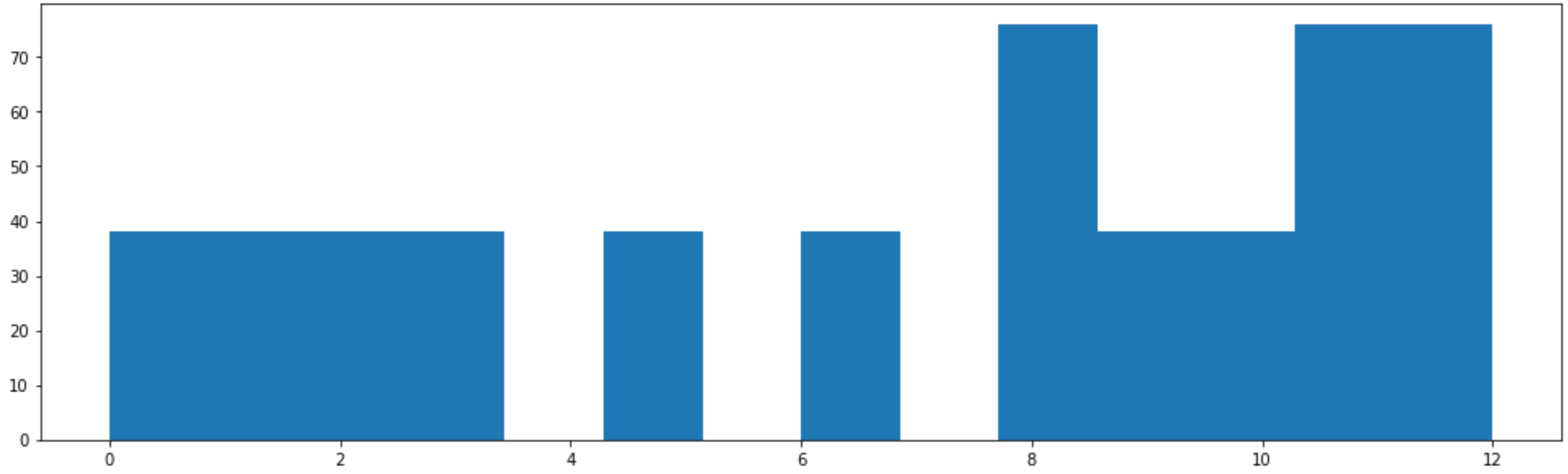
- Features
  - Remove user specifc neutral
- Laplacian embedding
- Classification with kNN
  - None misclassified test samples



Clustering – Person Dependent - Faces

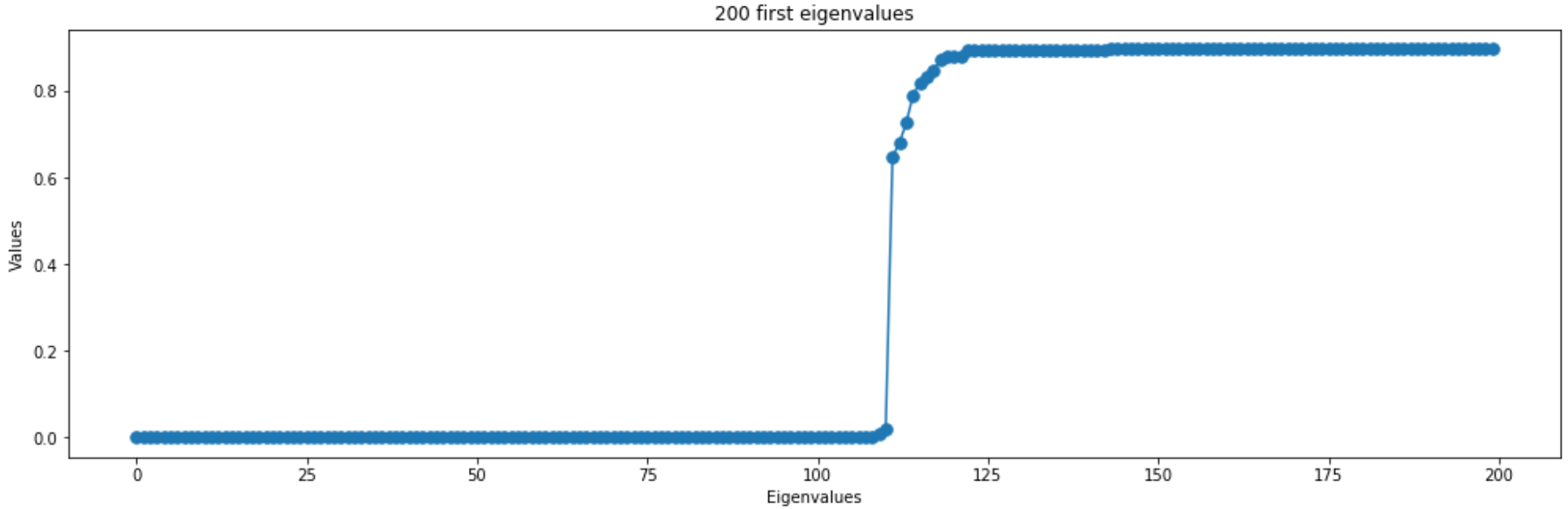
- Features
  - Remove user specific neutral
- Laplacian's decomposition
- Clustering with K-Means
  - Selection using zero eigenvalue



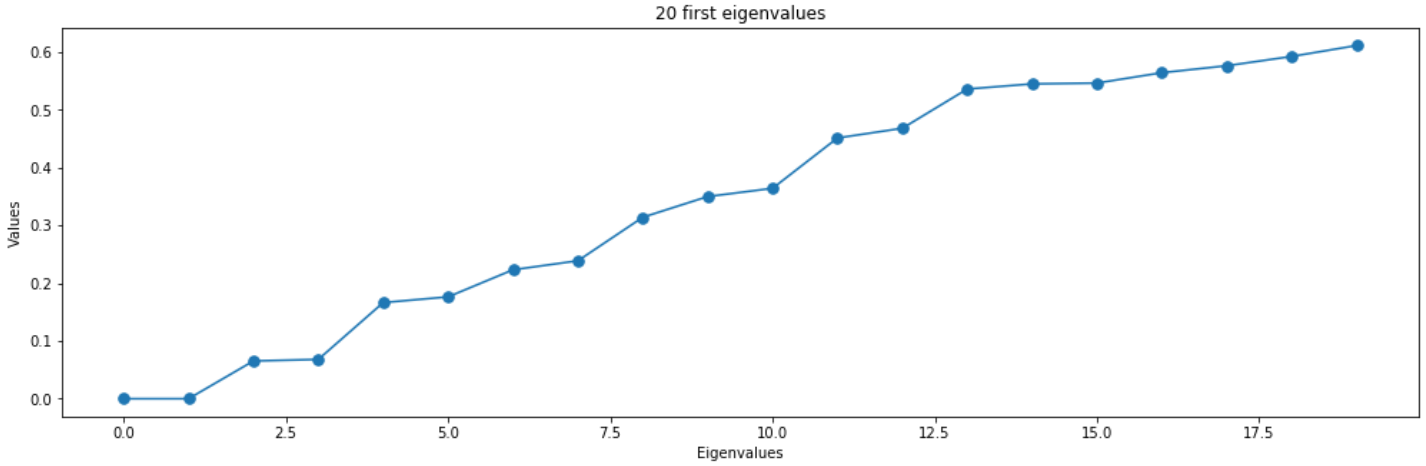


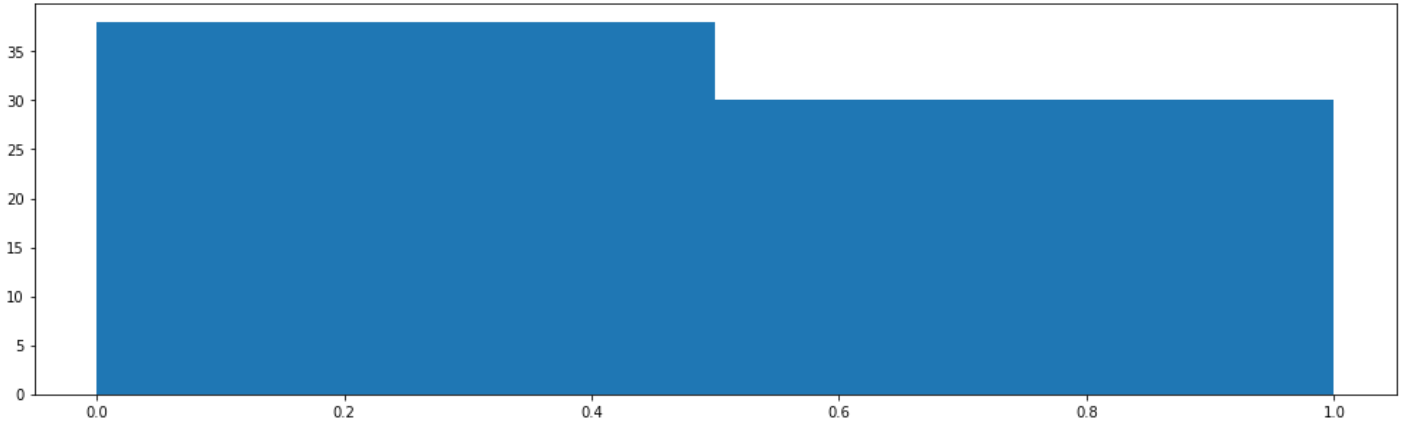
Clustering – Person Independent

- Features
  - Remove average identity
  - Remove vertices with no displacement
- Laplacian's decomposition
  - Zero eigenvalues match identity and not expressions



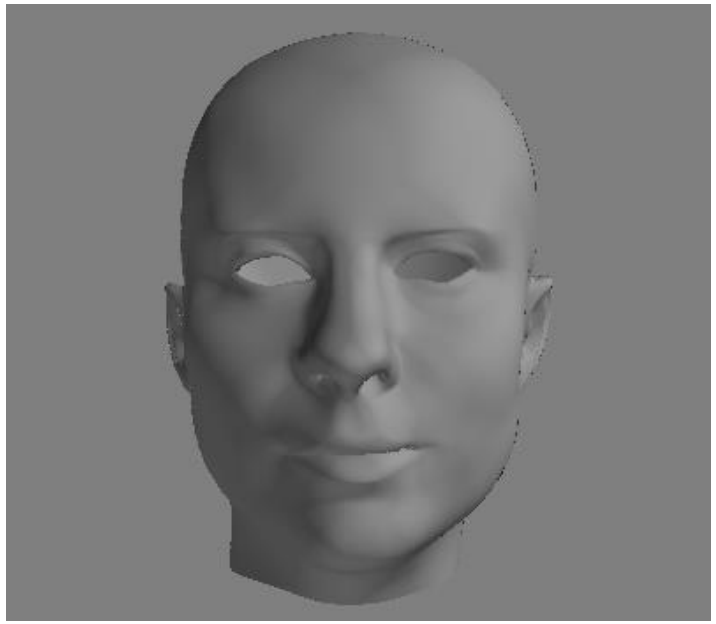
Clustering – Person Dependent - Ethnies

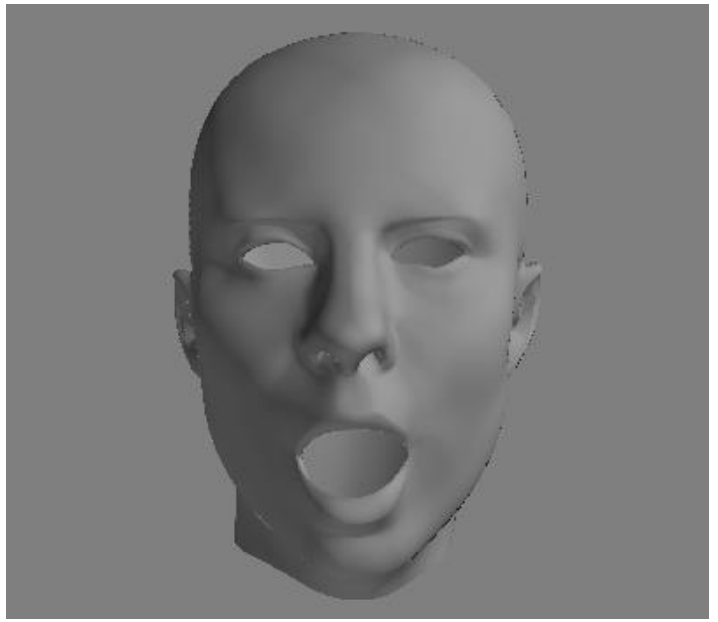




Deformation Transfer

- Estimate transformation between expressions
- Graph-based approach





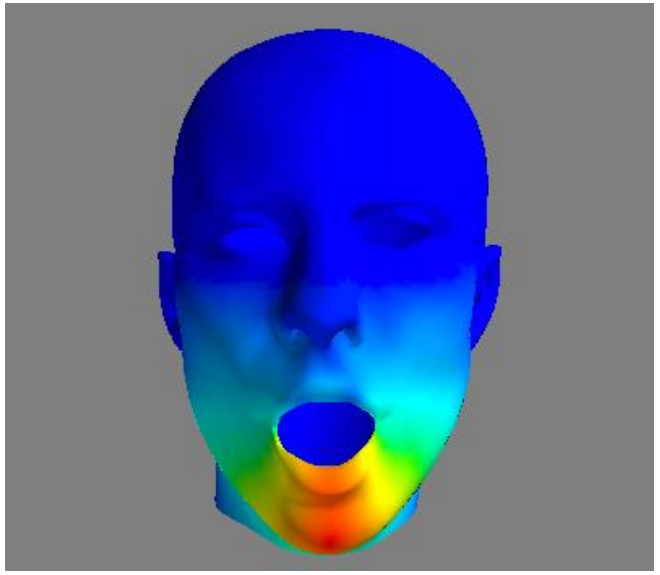
Deformation Field

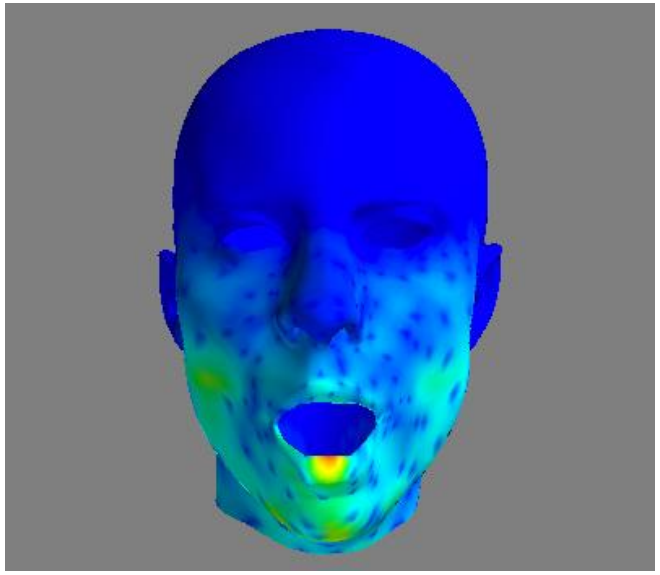
- Estimate the deformation field only using a sparse subset of *K* target's vertices
- Deformation learning using graph-based tool :

$$\boldsymbol{d}_i^* = \arg\min \left\| \boldsymbol{M}(\boldsymbol{x}_i^s + \boldsymbol{d}_i) - \boldsymbol{x}_i^t \right\|_2^2 + \alpha \boldsymbol{d}_i^T \boldsymbol{L} \boldsymbol{d}_i$$

- Anchor selection:

$$\boldsymbol{M}_{ij} = \begin{cases} 1 & j \in C \\ 0 & otherwise \end{cases}$$





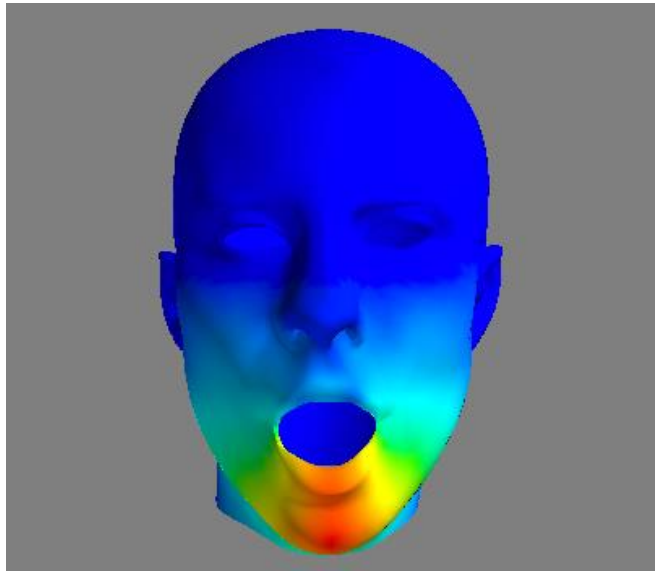
Constrained reconstruction

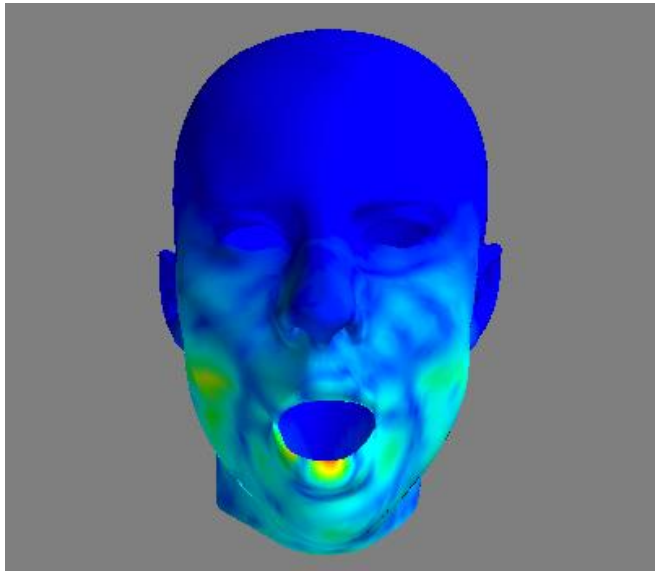
- Estimation of local curvature using Laplacian

$$\Rightarrow \boldsymbol{L}\boldsymbol{x}^t \approx \boldsymbol{L}\boldsymbol{x}^s$$ => No unique solution

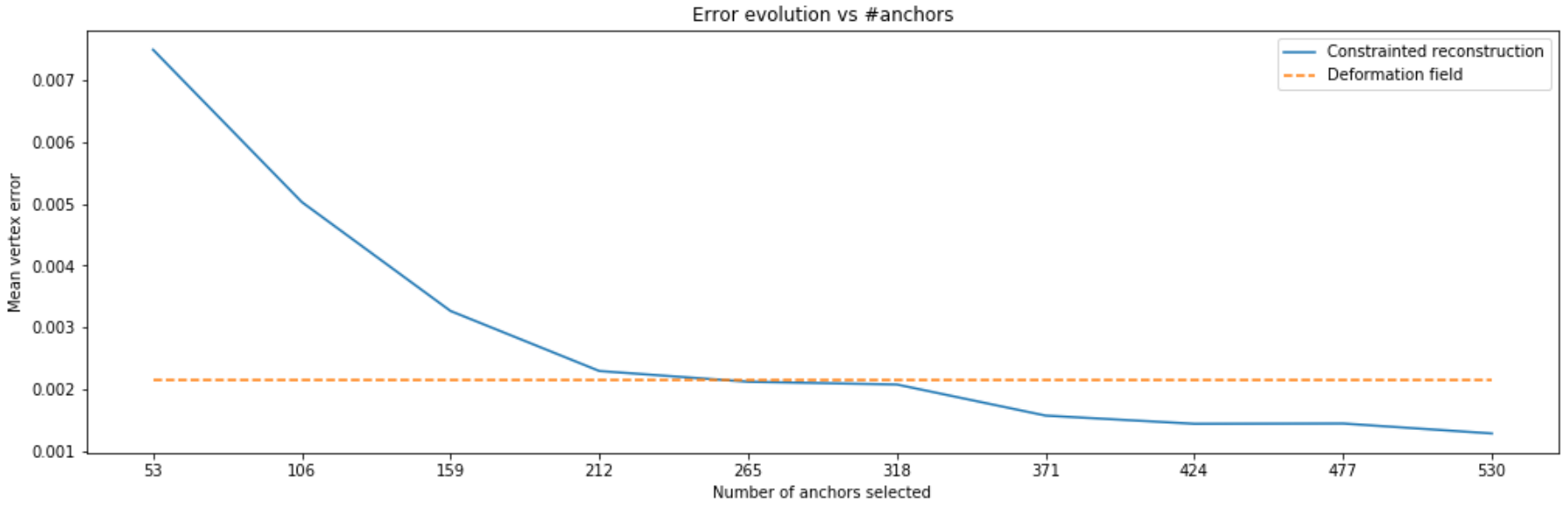
- Augmentation with positional constraints :

$$\begin{bmatrix} \boldsymbol{L} \\ \lambda \boldsymbol{A} \end{bmatrix} \boldsymbol{x}^t = \begin{bmatrix} \boldsymbol{\delta}^s \\ \lambda \boldsymbol{C}^t \end{bmatrix} \quad \text{where} \quad C^t_{(0\ \ldots k)} = \boldsymbol{x}^t_k, k \in C$$





Constrained Reconstruction - Anchors



Conclusion

- Clustering
  - Removing person specific variation helps to discriminate expressions
  - Removing average identity does not helps to be person independent
  - Ethnicity clustering gives good results
- Deformation
  - Deformation Field catch the semantic of expression but fail to give realistic solution
  - Constraints of the curvature provide a more robust and realistic solution.