

Group 1

Assignment 6

Clemens Bachmann
Franz Knobel
Isaak Hanimann
Nicolas Wicki
Pascal Chang

TABLE OF CONTENTS

01

Preprocessing

02

Landmarks

03

Registration

04

PCA

05

Bonus Task 2

View

Viewer

Preprocessing

Landmark Selection

Face Registration

PCA Computation

Bonus Task 2

Trackball Camera Type

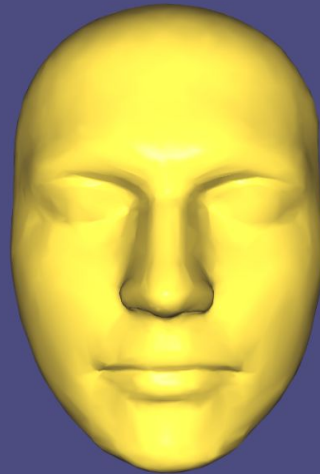
☐ Orthographic view

▼ Draw Options

☐ Face-based☐ Show texture☒ Invert normals☒ Show overlay☒ Show overlay depth☐ Background☐ Line color

35,000 Shininess

▼ Overlays

☐ Wireframe☒ Fill☐ Show vertex labels☐ Show faces labels

Preprocessing

► Viewer

Clean connected components

Show signed distance

Smooth scalar field

Remesh & cut along isoline

5.000000 iso value

Preprocess face

Save mesh

- alain_normal
- alain_smile
- alex_neutral
- alex_smile
- alex_wacky
- ali_neutral_corrected
- ali_smile_corrected
- arda_neutral_corrected
- arda_smile_corrected
- bjarni_neutral
- bjarni_smile
- chrisk_neutral
- chrisk_neutral2
- chrisk_smile
- chriss_glasses
- chriss_neutral
- chriss_smile
- christian_neutral_corrected
- christian_smile_corrected
- daniel_normal
- daniel_smile
- dingguang_normal
- dingguang_smile

Preprocess all

Landmark Selection

► Viewer

Enable Selection

Remove Last Landmark

Remove Landmarks

Save Current Landmarks to File

Load Landmarks from File

Choose folder

../data/face_template/

- headtemplate
- headtemplate_large
- headtemplate_noneck
- headtemplate_noneck_lesshead_4
- template_rigid_aligned_scaled

Face registration

► Viewer

Center & Scale face

Center & Scale template

Align Rigid

Align Non-Rigid

Register

Save registered face

1.000 lambda

0.010 epsilon

Template Face

headtemplate_noneck_lesshead_4

Face to register

- alain_normal_preprocessed
- alain_smile_preprocessed
- alex_neutral_preprocessed
- alex_smile_preprocessed
- alex_wacky_preprocessed
- ali_neutral_corrected_preprocessed
- ali_smile_corrected_preprocessed
- arda_neutral_corrected_preprocessed
- arda_smile_corrected_preprocessed
- bjarni_neutral_preprocessed
- bjarni_smile_preprocessed
- chrisk_neutral2_preprocessed
- chrisk_neutral_preprocessed
- chrisk_smile_preprocessed
- chriss_glasses_preprocessed
- chriss_neutral_preprocessed
- chriss_smile_preprocessed

Register all

PCA Computation

► Viewer

Choose dataset

Show average face

0 - + Face index

Show face

10 - + #Eigen faces

Eigen face index	Value
Eigen face 0	0.000
Eigen face 1	0.000
Eigen face 2	0.000
Eigen face 3	0.000
Eigen face 4	0.000
Eigen face 5	0.000
Eigen face 6	0.000
Eigen face 7	0.000
Eigen face 8	0.000
Eigen face 9	0.000

Approximate face with Eigen faces

Set weight approximated face

Show face with current weights

Toggle error to face index

0 - + Morph face index

Morphing face with current weights and morph face index: 0

0.000 Morph rate

Show morphed face

Save mesh

Bonus Task 2

► Viewer

../data/vae_faces/eval/

0 - + Face index

Feature index	Value
Feature 0	-0.639
Feature 1	-0.680
Feature 2	-1.000
Feature 3	-0.825
Feature 4	0.371
Feature 5	-0.105
Feature 6	-0.076
Feature 7	-0.242
Feature 8	0.006
Feature 9	-0.492
Feature 10	-0.026
Feature 11	-0.596
Feature 12	-0.109
Feature 13	-0.036
Feature 14	-1.000
Feature 15	-0.566

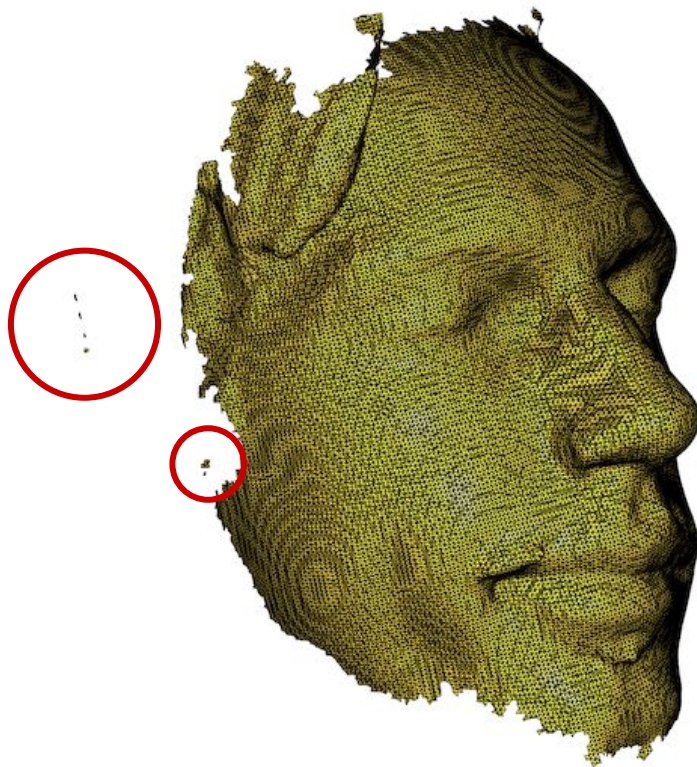
Show original face

Show reconstructed face

Show error to face index

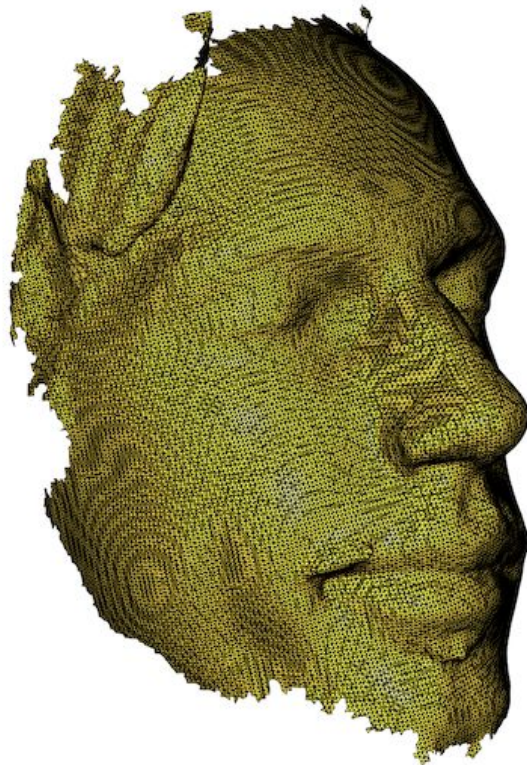
Preprocessing

1. Keep largest component
2. Compute distance field
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up



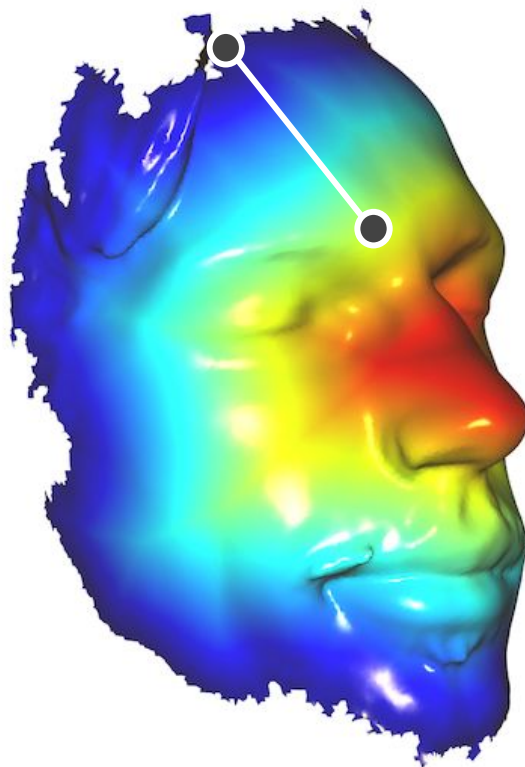
Preprocessing

1. **Keep largest component**
2. Compute distance field
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up



Preprocessing

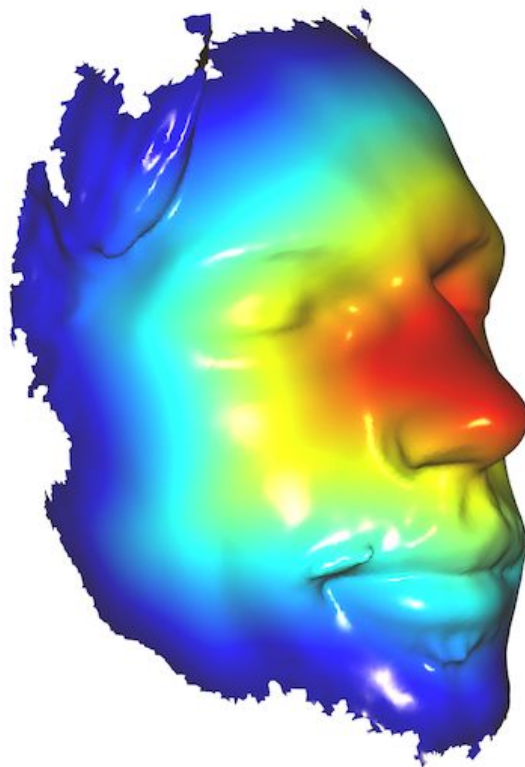
1. **Keep largest component**
2. **Compute distance field**
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up



Preprocessing

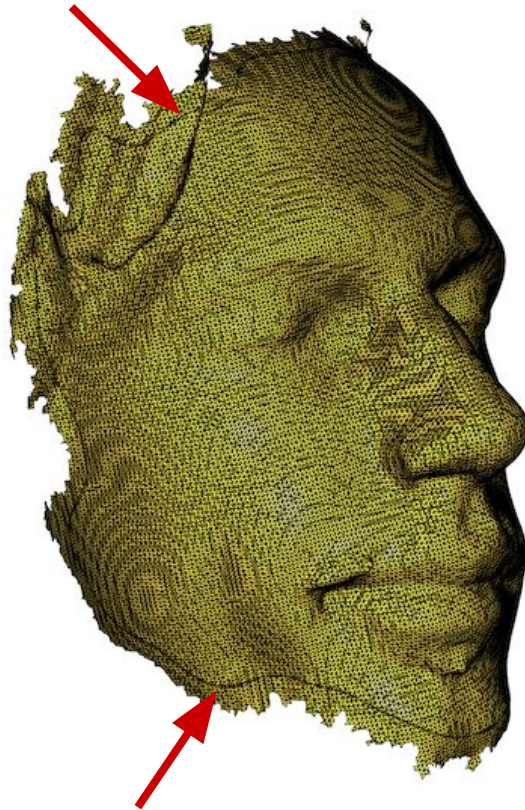
1. Keep largest component
2. Compute distance field
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up

$$\min_{\tilde{s}} \sum_{i=1}^n A_i \left(\|L\tilde{s}_i\|^2 + w \|\tilde{s}_i - s_i\|^2 \right)$$



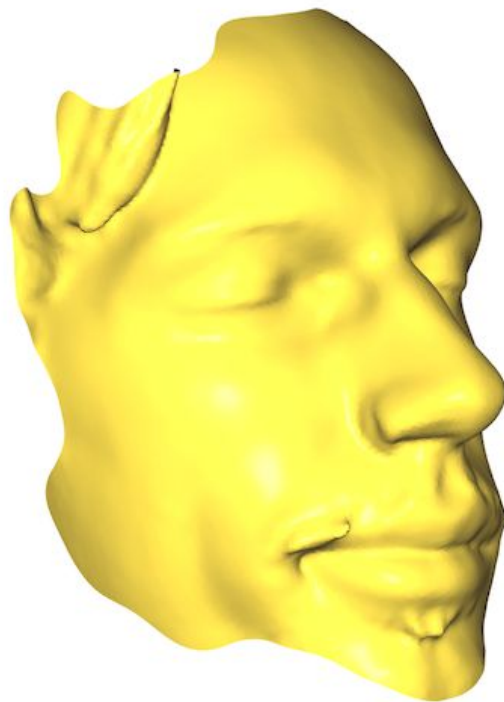
Preprocessing

1. Keep largest component
2. Compute distance field
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up



Preprocessing

1. Keep largest component
2. Compute distance field
3. Smooth distance field
4. Remesh along isoline
5. Cut mesh & clean up



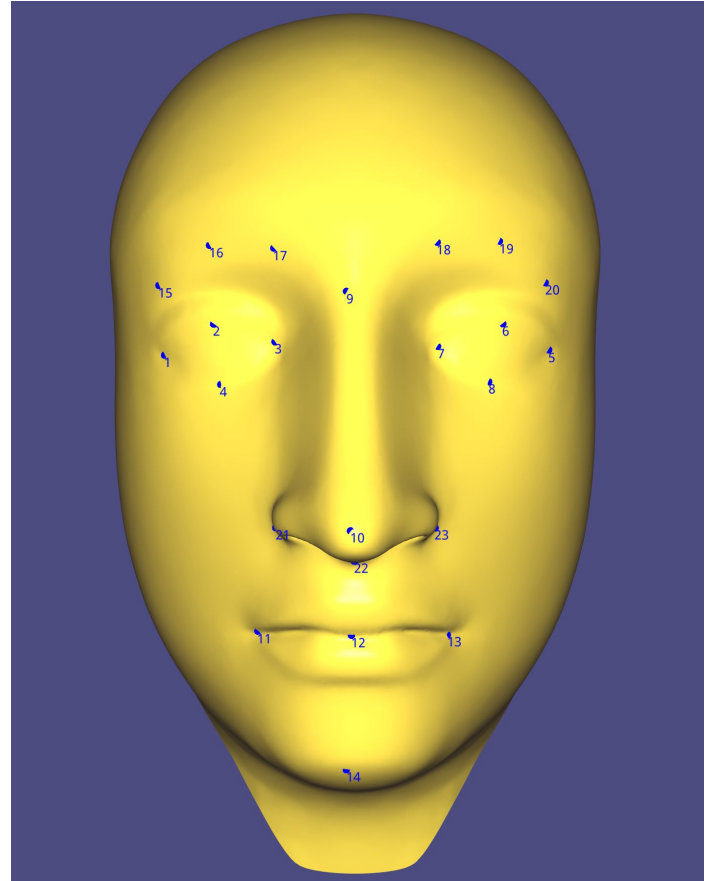
Landmarks

23 Landmarks

Landmark:

- index of face (triangle) of the intersection
- barycenter coordinates of the point within face

Saved/Loaded from Textfile



Registration

Rigid alignment: center meshes and find optimal rotation using SVD

Non-rigid alignment:

$$\underbrace{\begin{bmatrix} L_{\text{cot}} \\ \lambda C_b \\ \lambda C_l \\ \lambda C_d \end{bmatrix}}_A \mathbf{x}' = \underbrace{\begin{bmatrix} L_{\text{cot}} \mathbf{x} \\ \lambda C_{wb} \\ \lambda C_{wl} \\ \lambda C_{wd} \end{bmatrix}}_b$$

$$A\mathbf{x}' = b \implies A^\top A\mathbf{x}' = A^\top b$$

View

Face registration

Viewer

Center & Scale face

Center & Scale template

Align Rigid

Align Non-Rigid

Register

Save registered face

1.000 lambda

0.010 epsilon

Template Face

headtemplate_large

Face to register

alain_normal_preprocessed

alain_smile_preprocessed

alex_neutral_preprocessed

alex_smile_preprocessed

alex_wacky_preprocessed

ali_neutral_corrected_preprocess

ali_smile_corrected_preprocess

arda_neutral_corrected_preprocess

arda_smile_corrected_preprocess

bjarni_neutral_preprocessed

bjarni_smile_preprocessed

chris_neutral2_preprocessed

chris_neutral_preprocessed

chris_smile_preprocessed

chris_glasses_preprocessed

chris_neutral_preprocessed

chris_smile_preprocessed

Register all

21.7 FPS



Registration Demo

PCA

- Face reconstruction with Eigen vectors
- Morph two faces

Performance

- Small covariance matrix
- Reconstruct Eigen faces
- Significant speedup

#Eigen faces

- Vary the number of Eigen faces
- Error visualization

Eigen space

- Restricted
- Min to max
- Reasonable

PCA

- Face reconstruction with Eigen vectors
- Morph two faces

Performance

$$C = \frac{1}{M} \sum_{n=1}^M \Phi_n \Phi_n^T \quad (3)$$

$$= AA^T$$

$$\mathbf{u}_l = \sum_{k=1}^M \mathbf{v}_{lk} \Phi_k, \quad l = 1, \dots, M \quad (6)$$

#Eigen faces

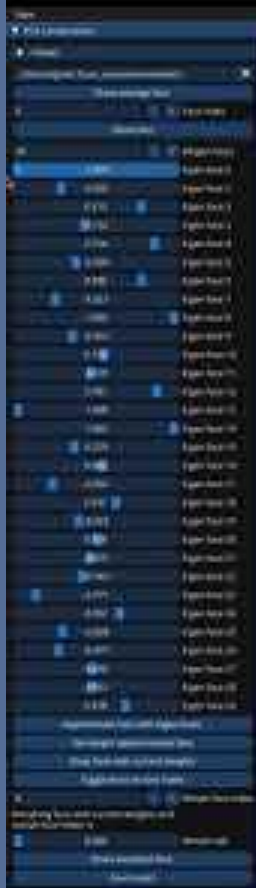
- Vary the number of Eigen faces
- Error visualization

Eigen space

- Restricted
- Min to max
- Reasonable

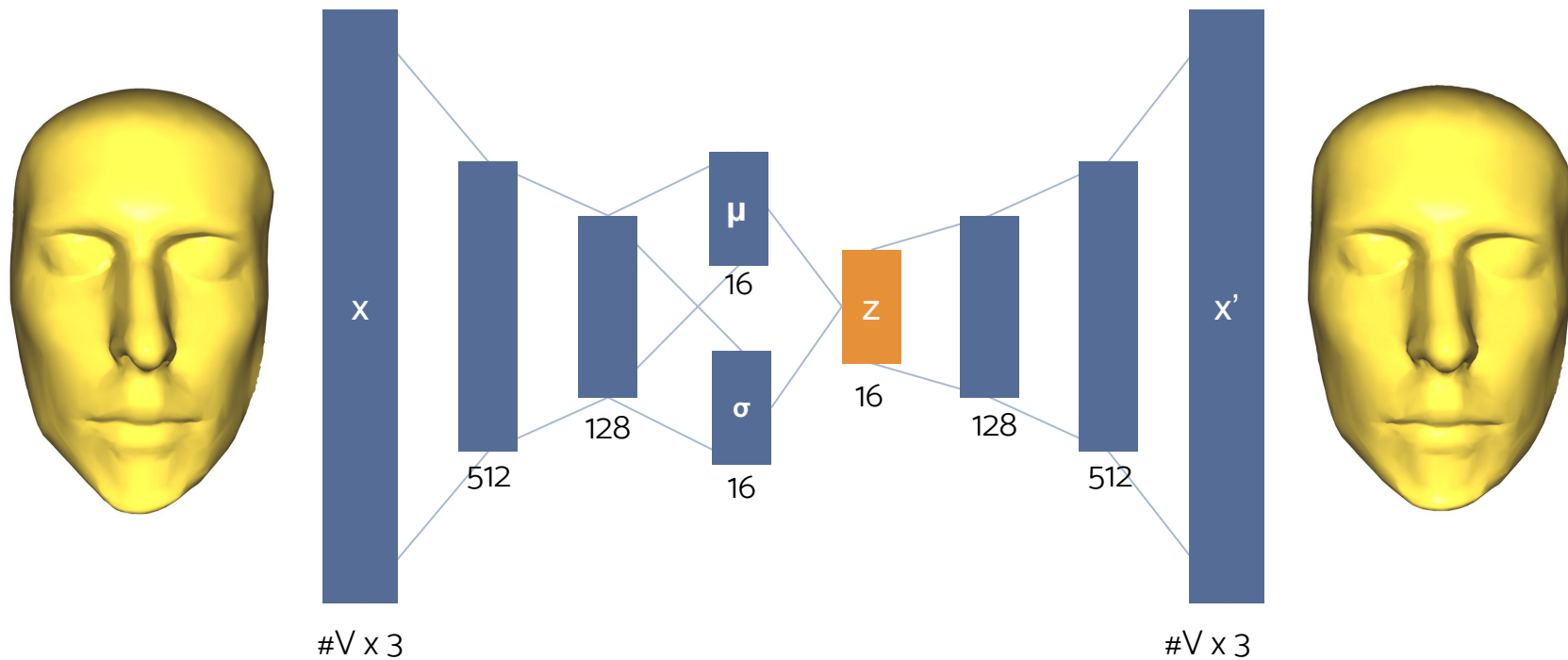
PCA Demo

- Long load time (~12s)
- PCA (183 ms)
- Error variation
- Eigen space variation
- Eigen weights reasonable



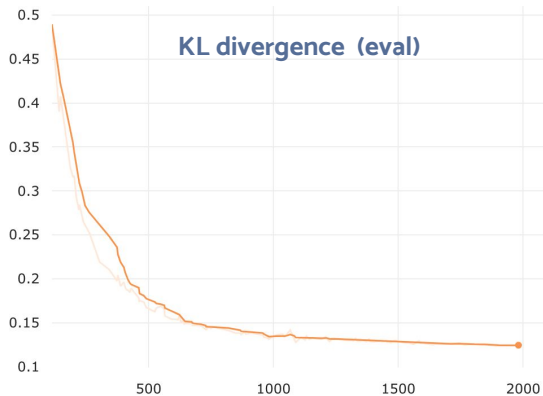
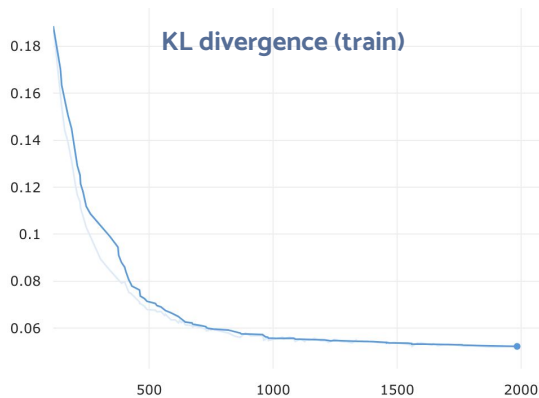
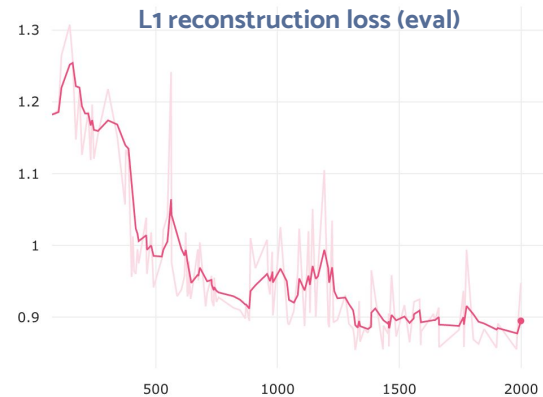
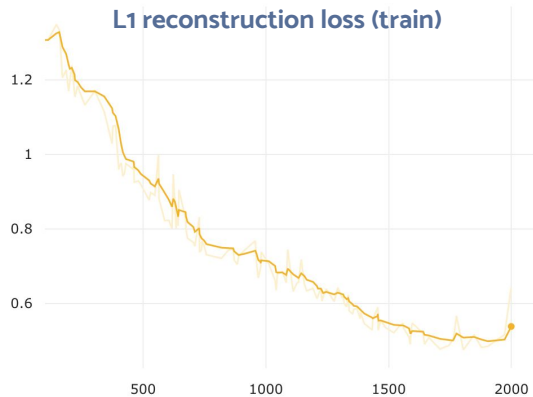
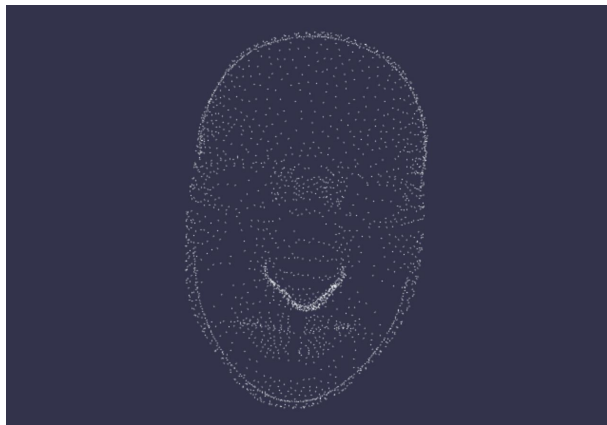
Bonus Task 2

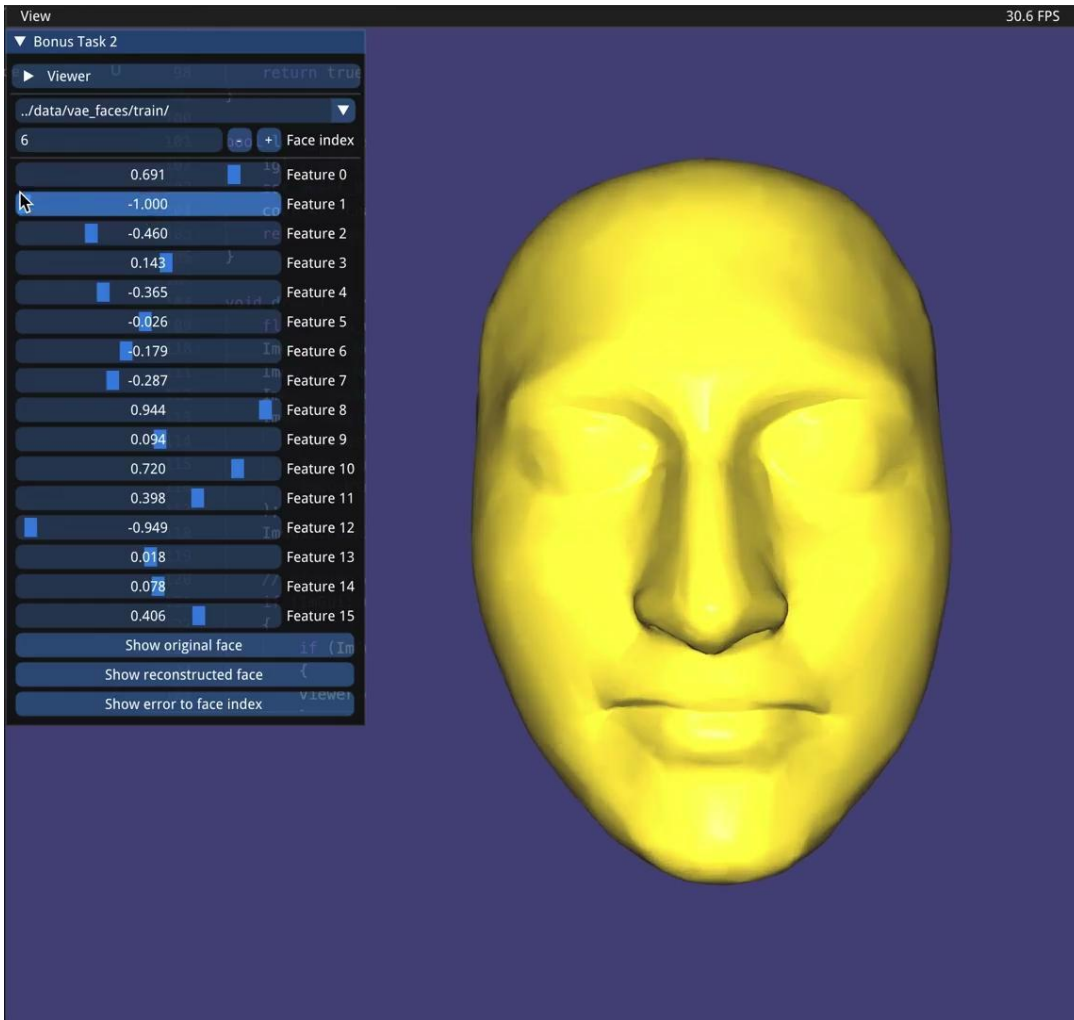
Variational Autoencoder



Variational autoencoder:

- Minimize KL divergence and reconstruction error (L1 loss)
- Training set: 102 faces
- Test set: 10 faces
- Latent space dimension: 16
- Comet.ml for logging metrics





Integrating results in C++:

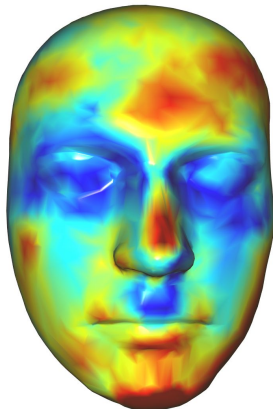
- Export model weights
- Export latent variable
- Implement the decoder in C++



Reference



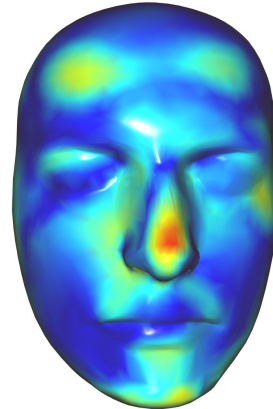
VAE



error ~ 1.98



PCA



error ~ 0.93

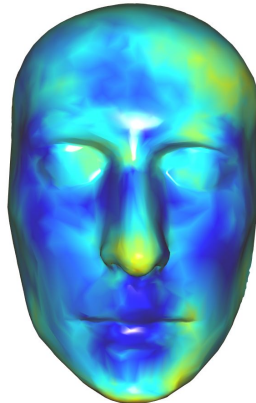
Test set



Reference



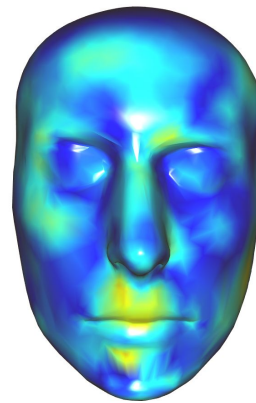
VAE



error ~ 1.33



PCA



error ~ 0.96

Train set

Bonus Task 2

Observations

- VAE not very good for now (need more tuning & regularization)
- VAE latent space seems less “organized” than PCA
- Could test other methods, but have interesting results already!

THANKS

**FOLLOW
WITH Q&A**

