

# Using Line Features for 3D Face Registration

## BACHELOR THESIS PRESENTATION

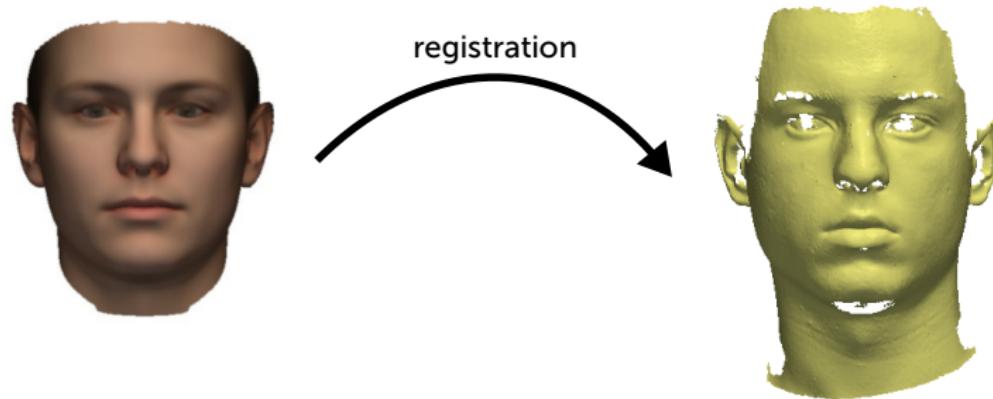
Fabian Brix

Department of Mathematics and Computer Science  
**UNIVERSITÄT BASEL**

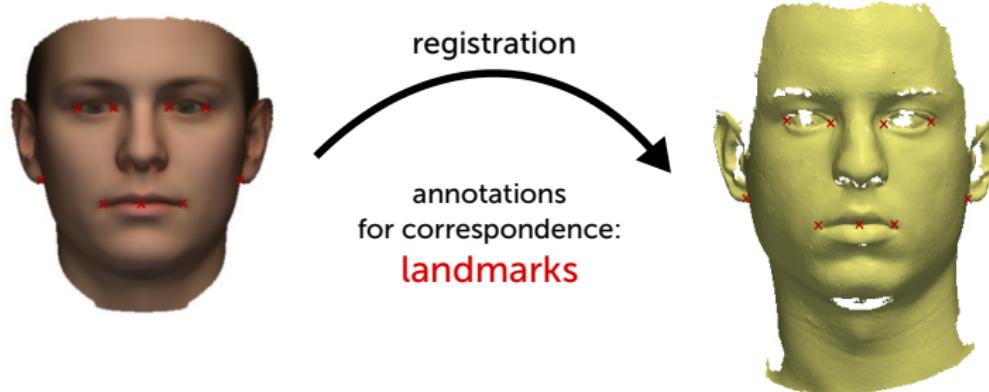
July 30, 2013



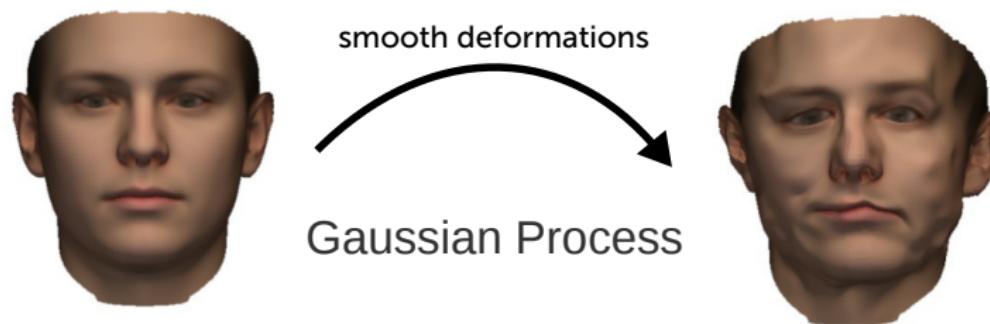
# REGISTRATION OVERVIEW



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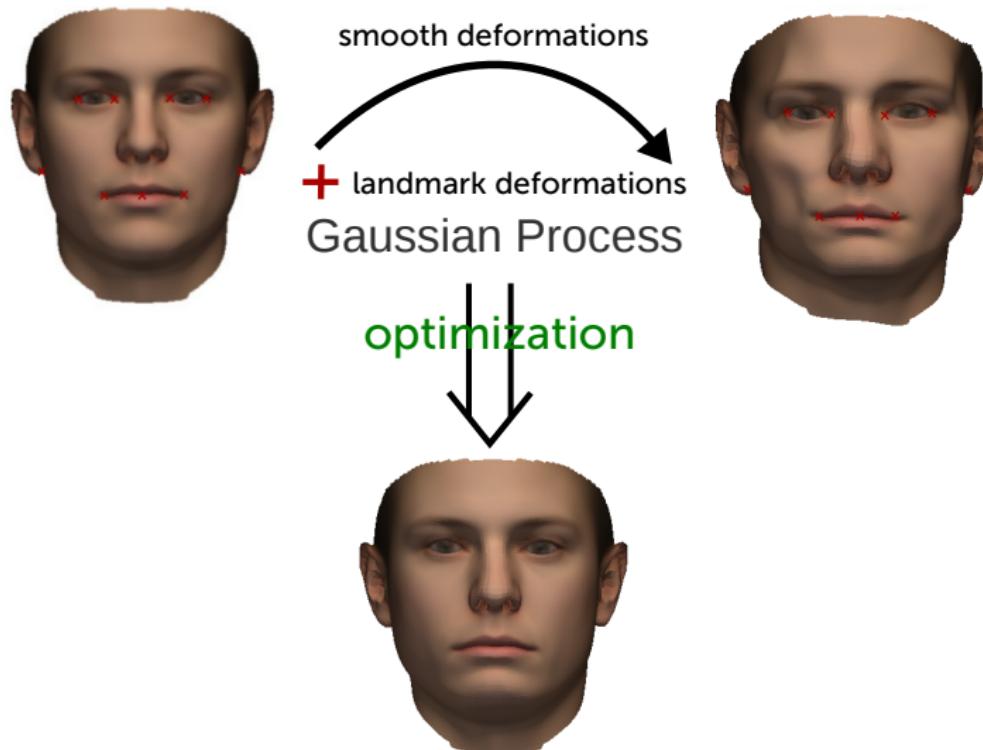
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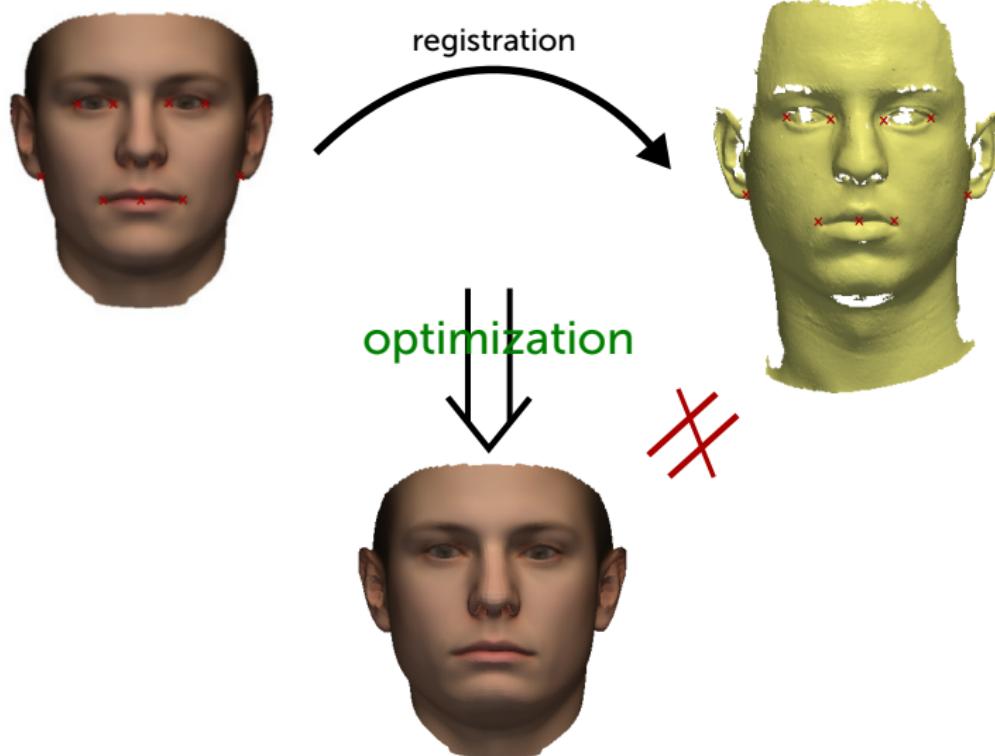
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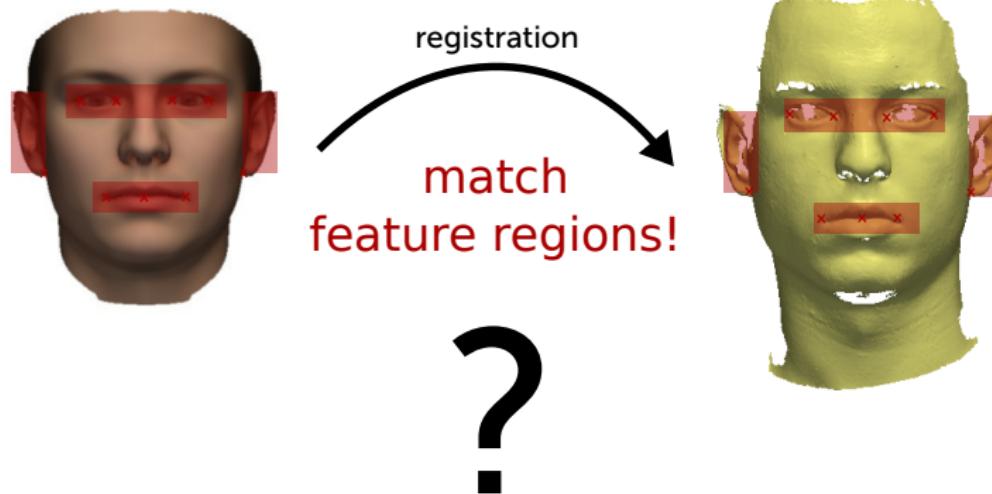
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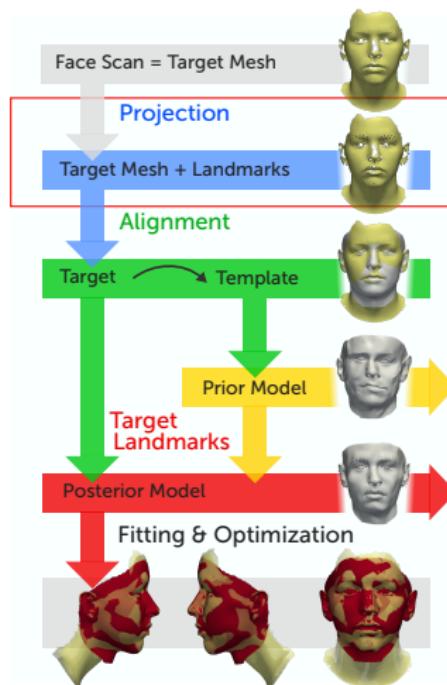
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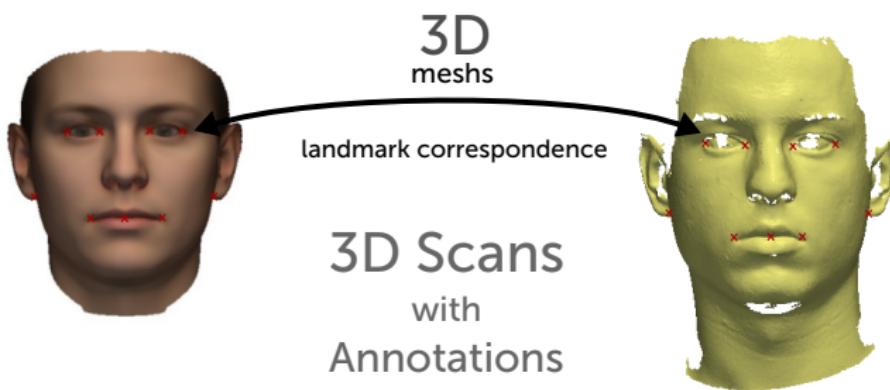
# REGISTRATION OVERVIEW



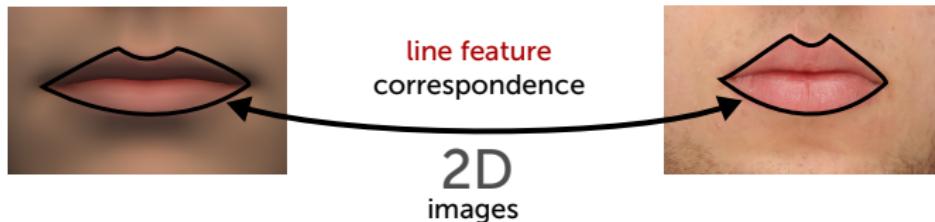
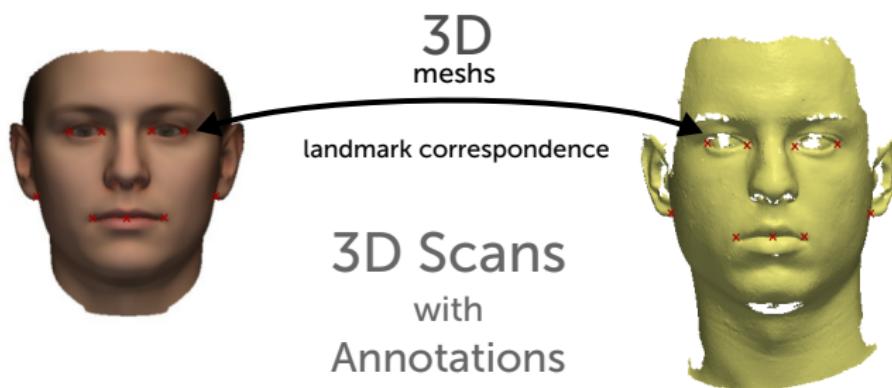
# PIPELINE



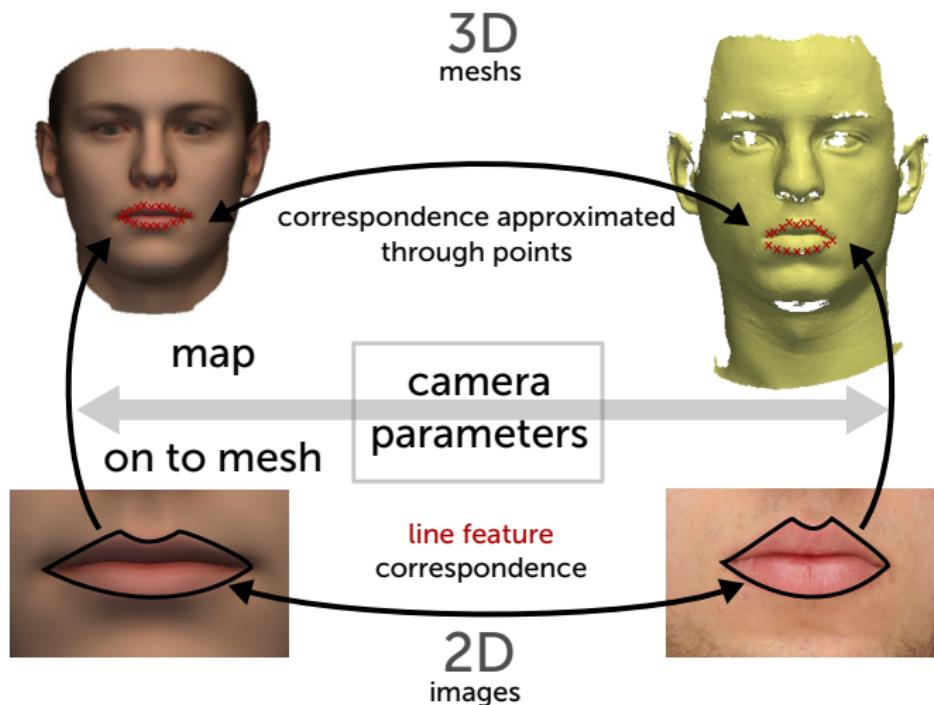
# DATA AND CORRESPONDENCE



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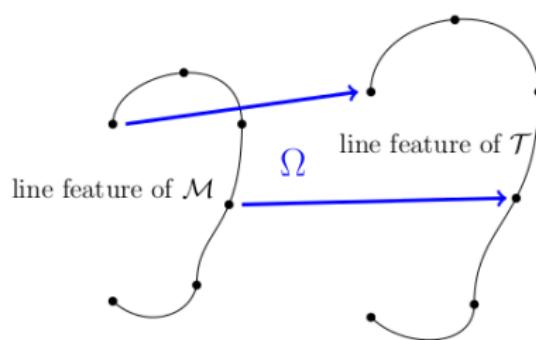


# DATA AND CORRESPONDENCE



## MAPPING LINE FEATURES

Idea: Sample points from the line features and use them as additional landmarks

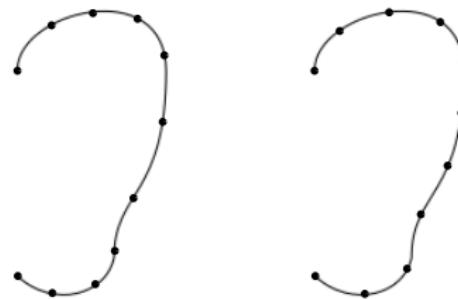


*What about correspondence?*



# EQUIDISTANT SAMPLING

Approximate correspondance by sampling line features in equidistant intervals

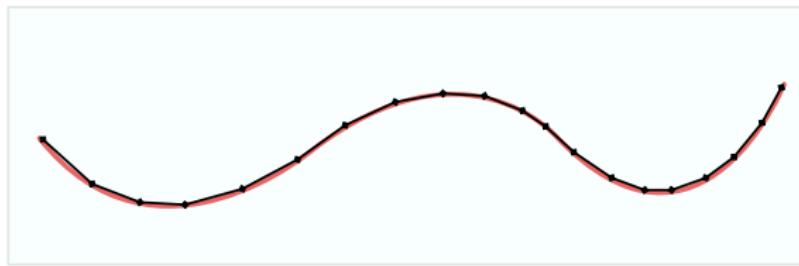




BÉZIER CURVES

Line features consist of Bézier curve segments  
→ underlying parameter is not linear

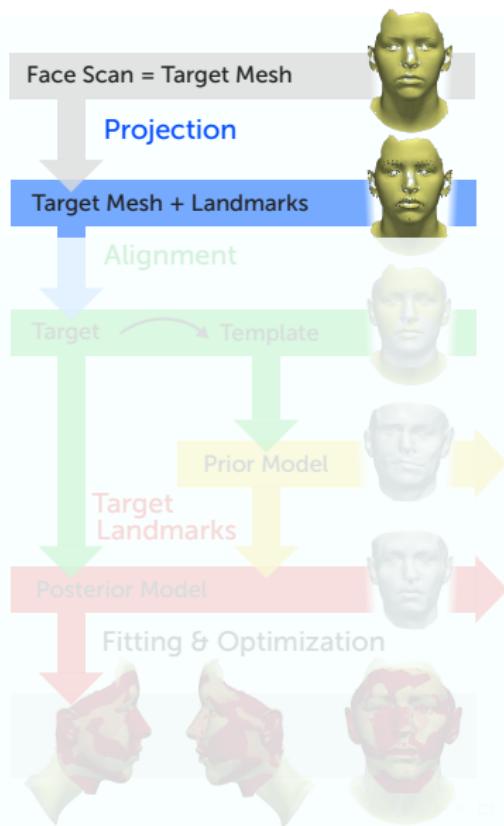
Approximate arc-length of curve through euclidean distance of sampled points



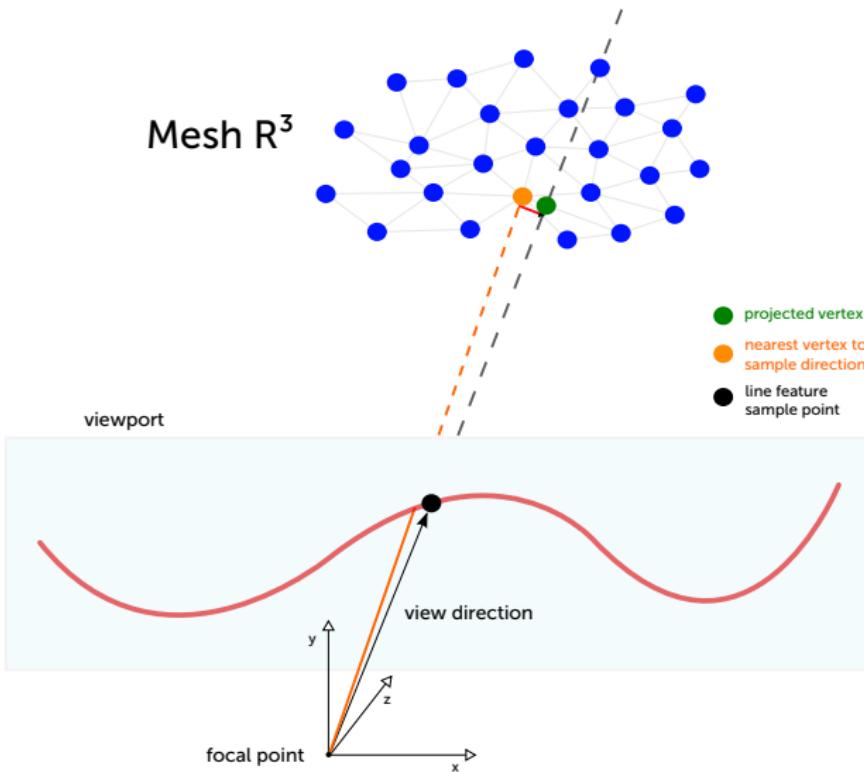
⇒ map point coordinates to approximated fractional length of curve



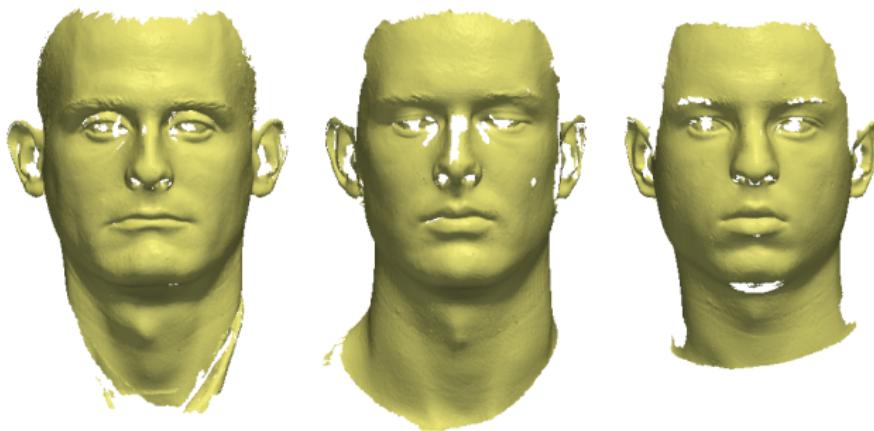
## PIPELINE: PROJECTION



## PROJECTION: 2D TO 3D

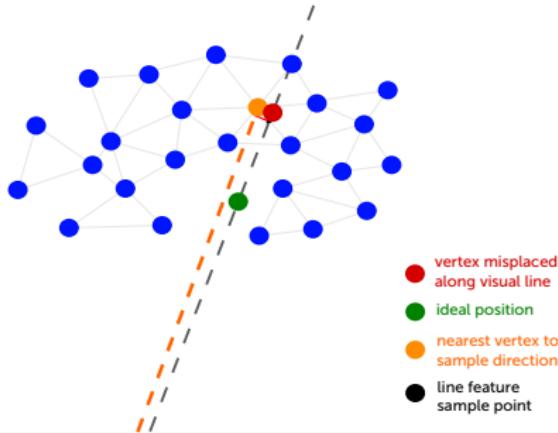


# TARGET MESH HOLES

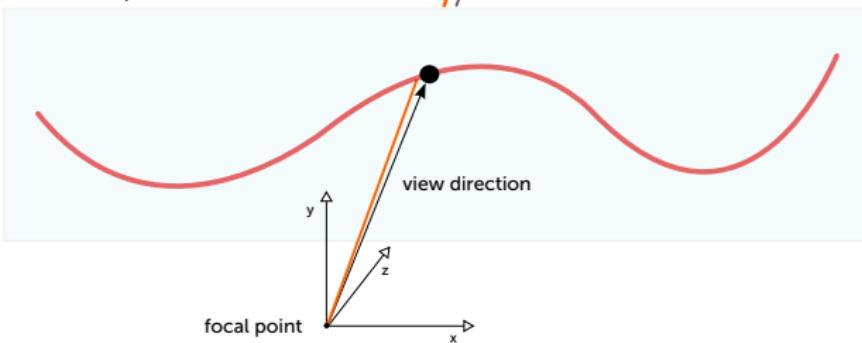


## PROJECTION: HOLES

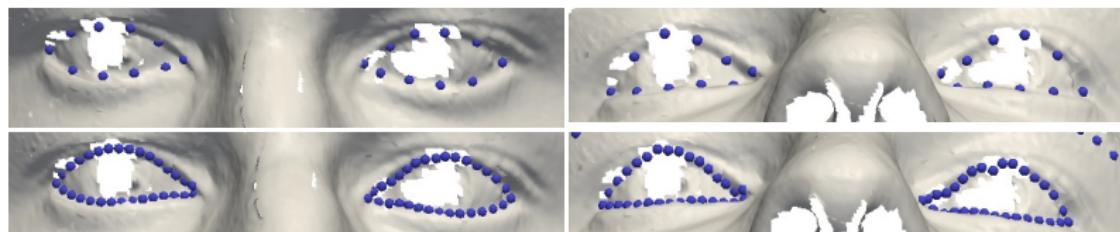
## Mesh $\mathbb{R}^3$



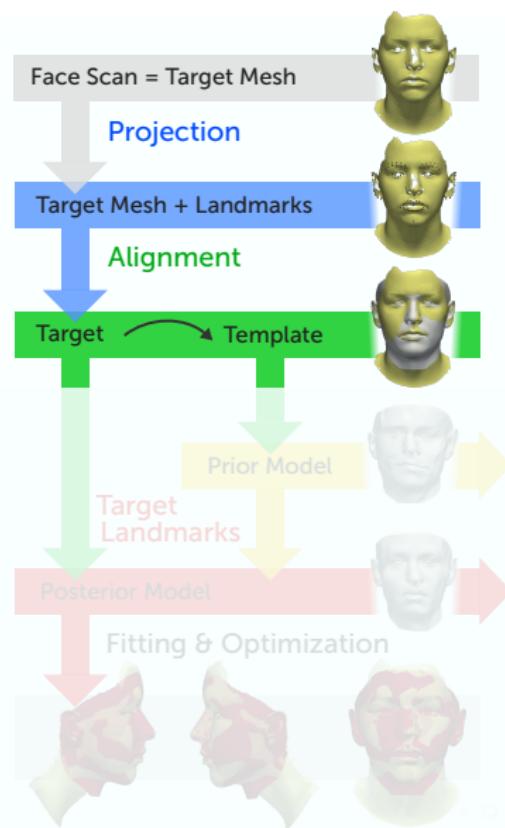
## viewport



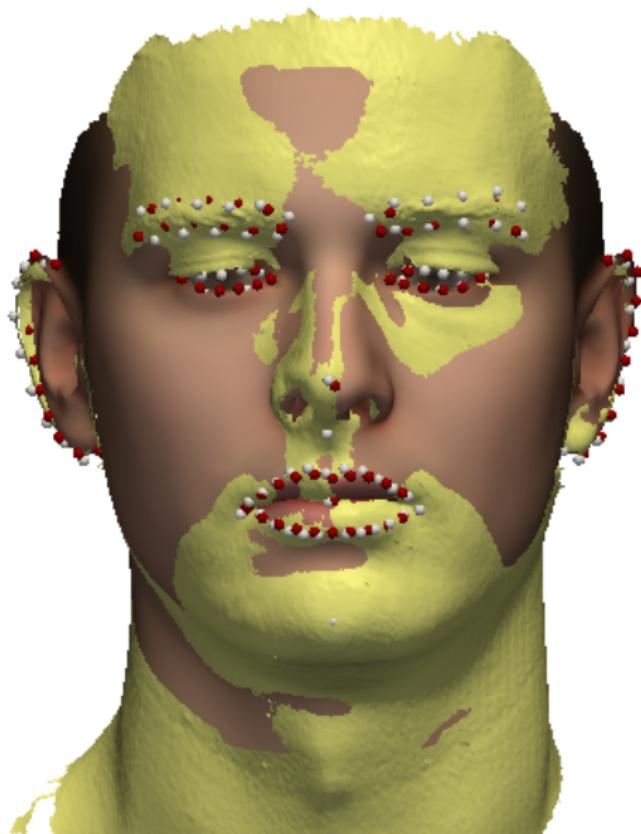
# 3D REPRESENTATION



# TEMPLATE/TARGET ALIGNMENT



# TEMPLATE/TARGET ALIGNMENT



# GAUSSIAN PROCESS

intuitive: a generalization of the normal distribution to functions

a stochastic process where each random variable represents possible function values at a specific input point

# GP PRIOR

sample functions from the space of possible inputs  
these functions are defined by the covariance of the input points

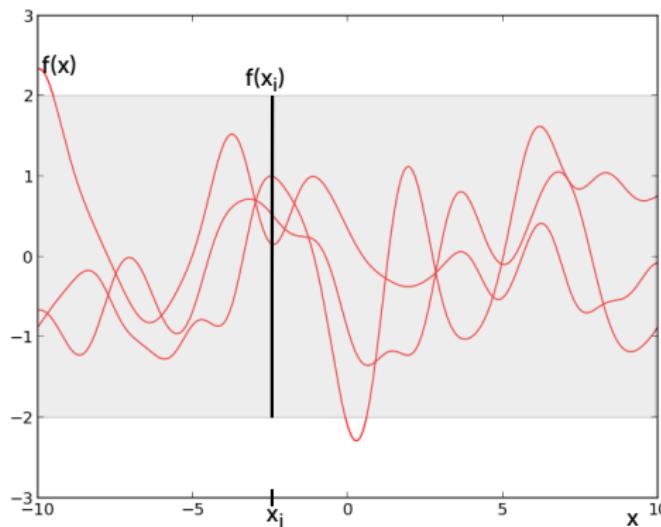


Figure: normal distribution over 1000 input points

## GP POSTERIOR DISTRIBUTION

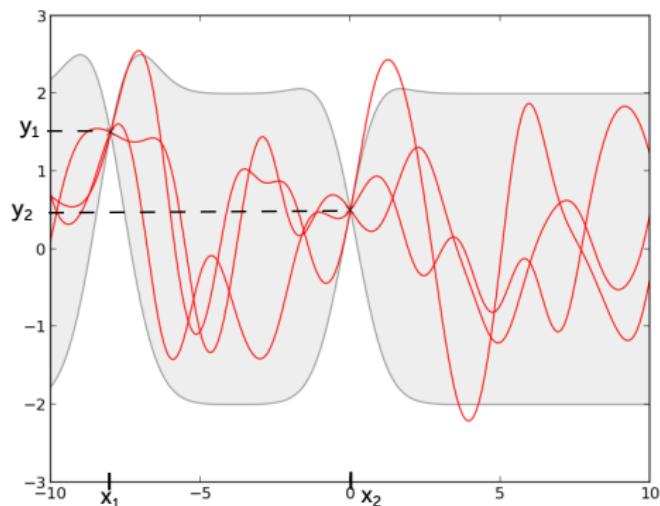


Figure: posterior distribution fixed at 2 input points



# GP POSTERIOR DISTRIBUTION

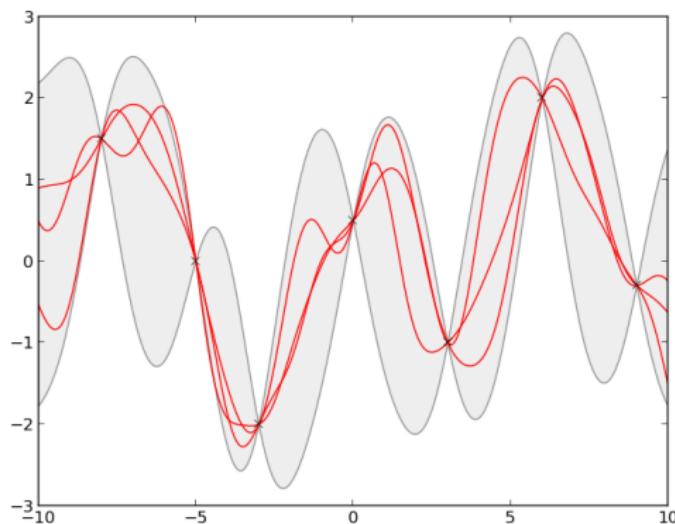


Figure: posterior distribution fixed at 7 input points

# GPR IN 3D FACE REGISTRATION

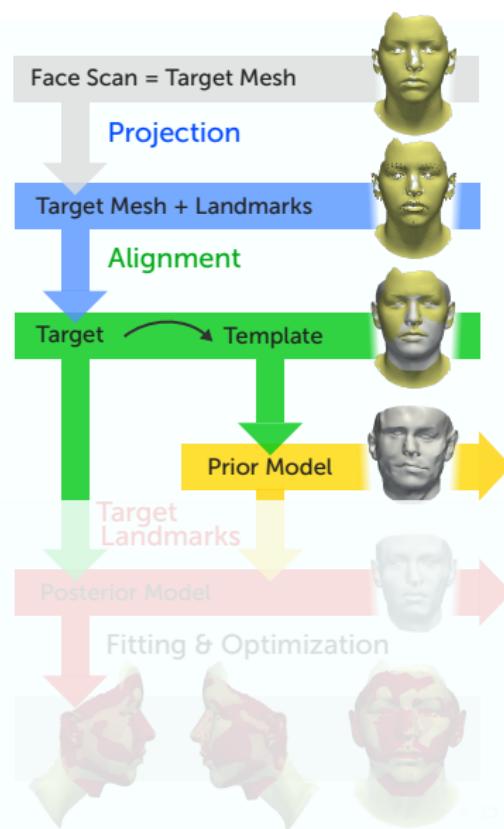
definition of Vector-valued GP

$$\mu : \mathcal{M} \rightarrow \mathbb{R}$$

$$k : \mathcal{M} \times \mathcal{M} \rightarrow \mathbb{R}^3 \times \mathbb{R}^3$$



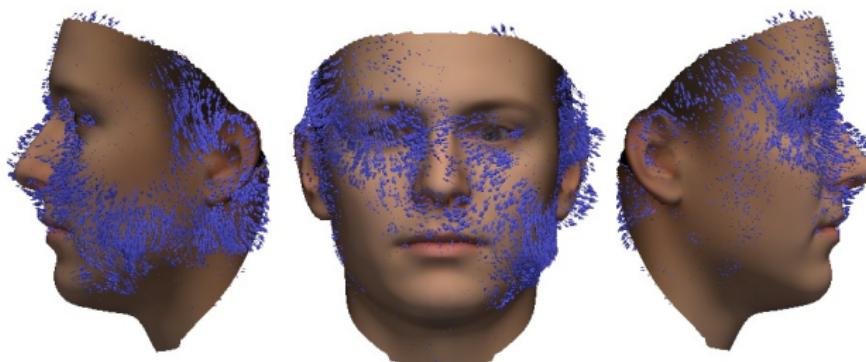
# PIPELINE: DEFORMATION PRIOR



# DEFORMATION PRIOR

build GP Prior from template mesh vertices

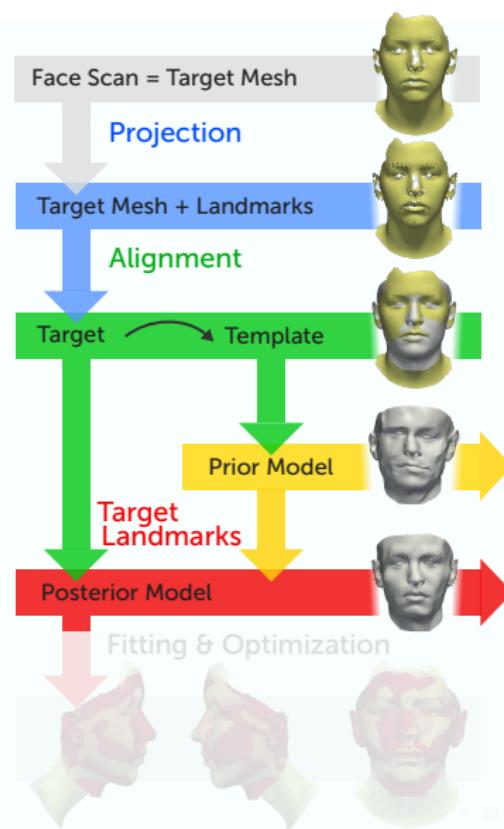
⇒ GP defines a distribution of possible deformations of the template mesh



# PRIOR FACES



# PIPELINE: DEFORMATION POSTERIOR

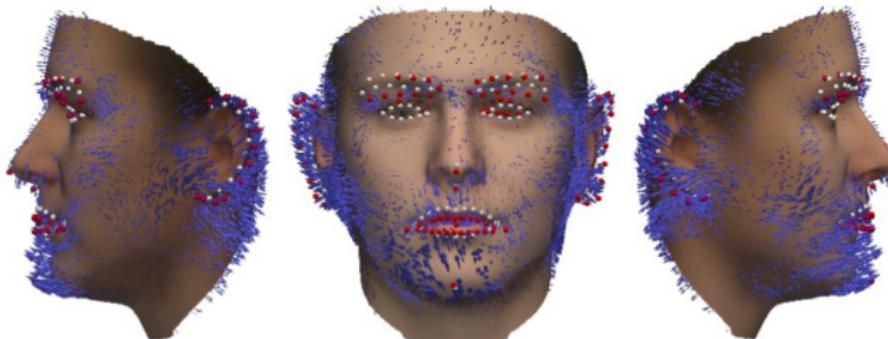


# 3D GP POSTERIOR

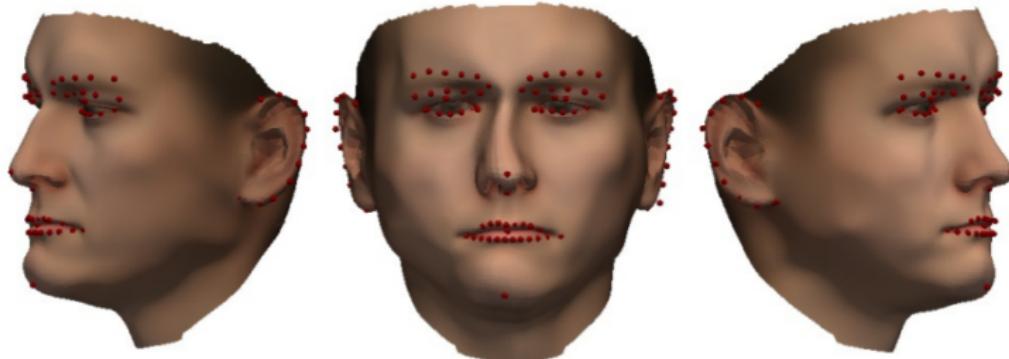
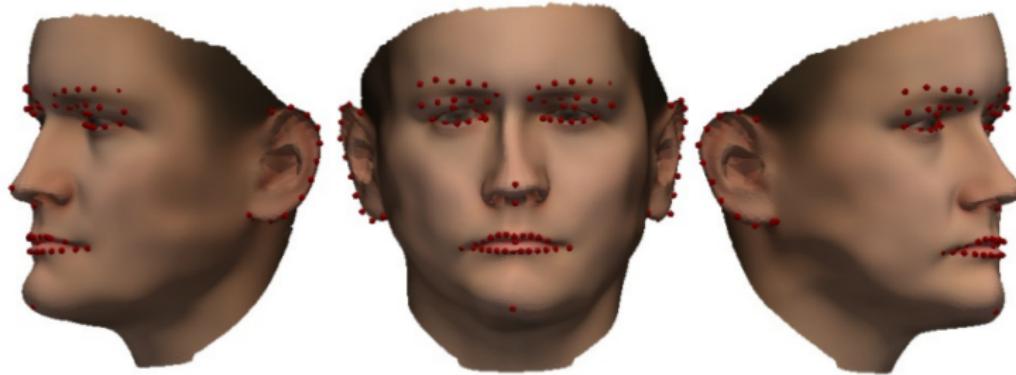
inference in the space of possible template surface deformations

training data: residuals of the line feature sample coordinates:

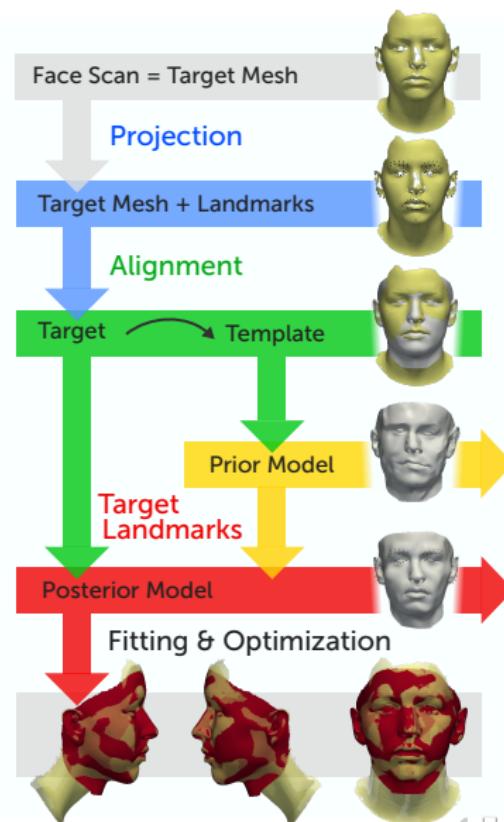
$$R = \{t - m | t \in L_T, m \in L_M\}$$



## POSTERIOR FACES



# FITTING & OPTIMIZATION



# PARAMETRIC MODEL

GP Posterior distribution of admissible deformations

How to optimize deformation samples?

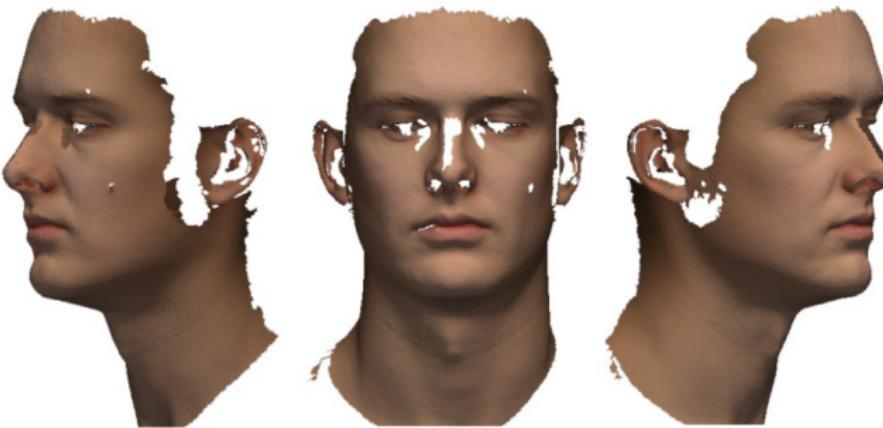
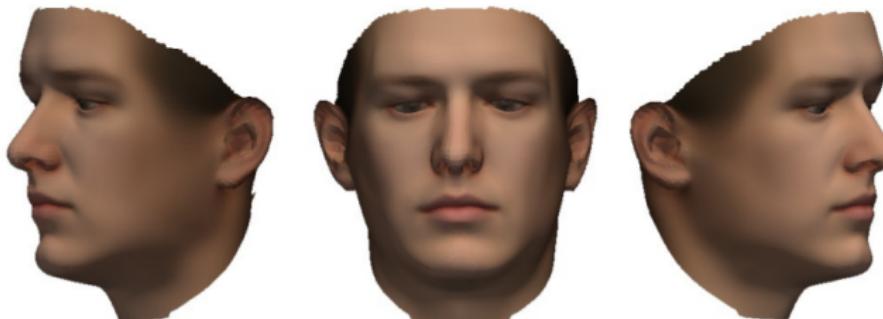
Mercer's theorem: distribution → parametric model

⇒ optimize model parameters  
verify with loss function

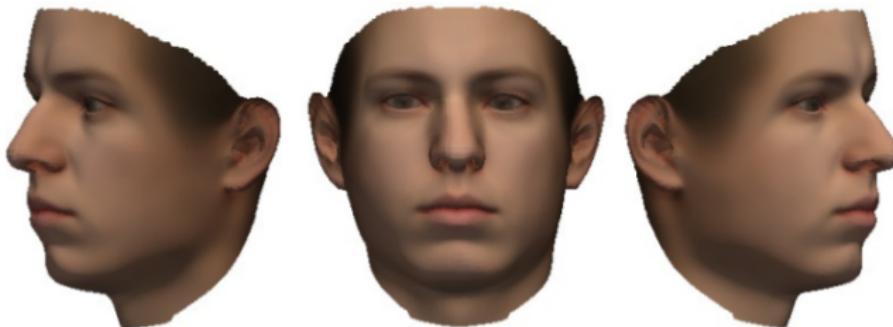
# MEAN SQUARED ERROR



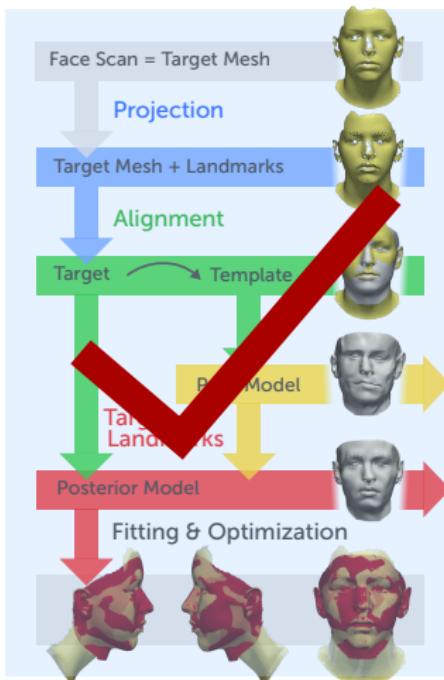
# ROBUST ESTIMATOR



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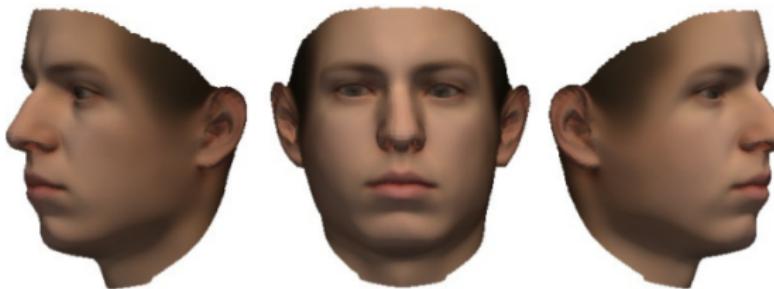
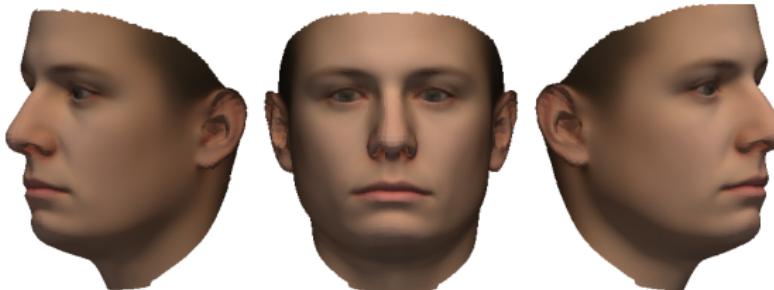
# PIPELINE: CHECK



# RESULTS

- ▶ COMPARISON: WITH  $\Leftrightarrow$  WITHOUT LINE FEATURES
  
- ▶ CARICATURES

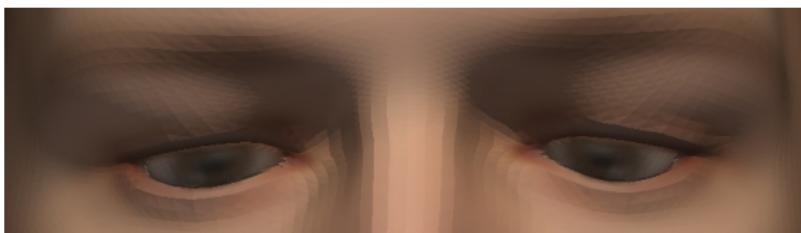
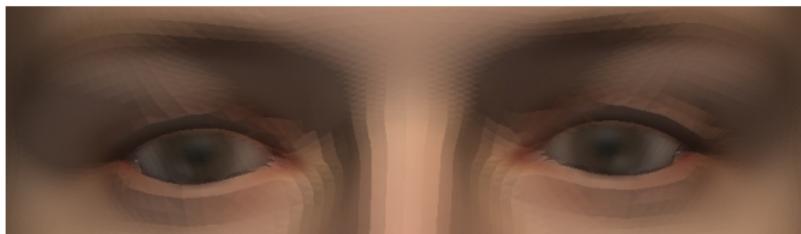
# COMPARISON



# COMPARISON - MOUTH



## COMPARISON - EYES



## COMPARISON - EARS

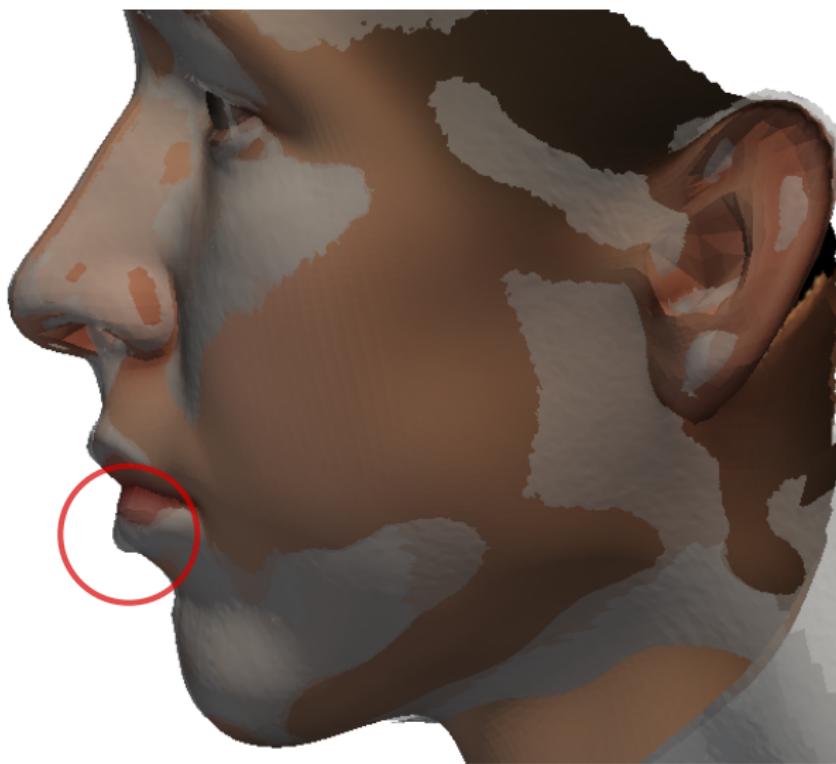


# CARICATURES

video



# EXPRESSIVENESS



# CONCLUSION

- ▶ Incorporation of line features rendered good registration results
- ▶ Optimization process has to be further adapted for more expressiveness

# FUTURE WORK

detect template regions corresponding to **holes** in target

detect template regions **missing** in target

by registering target on to template

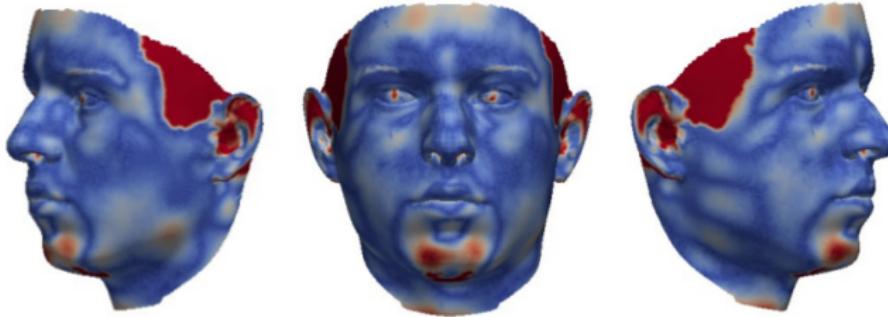
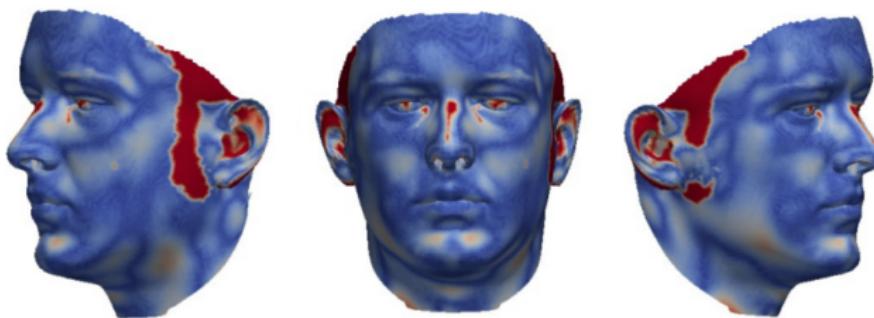
⇒ use Mean Squared Error to perform optimization without artifacts

# THANK YOU FOR LISTENING!

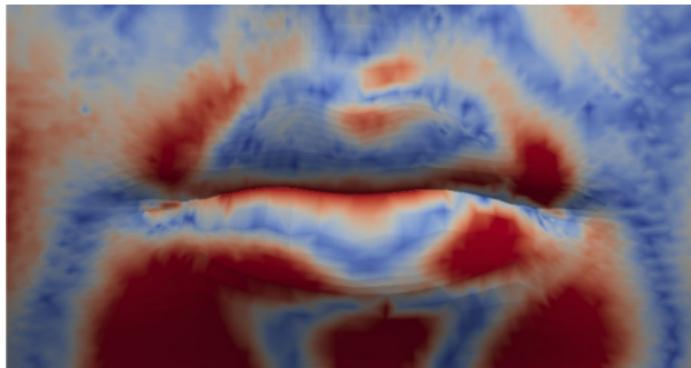
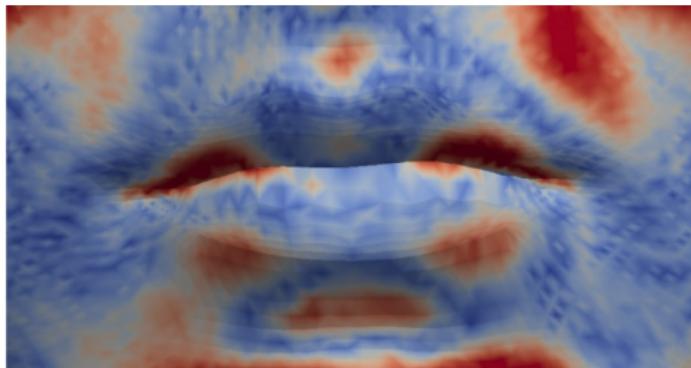
Any questions?



## DISTANCE MEASURE



# DISTANCE MEASURES - MOUTH



# DISTANCE MEASURES - EYES

