

Using Line Features for 3D Face Registration

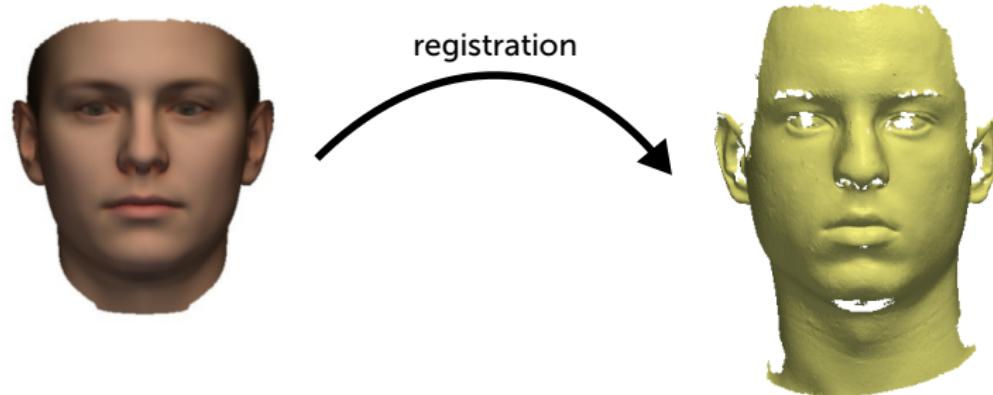
BACHELOR THESIS PRESENTATION

Fabian Brix

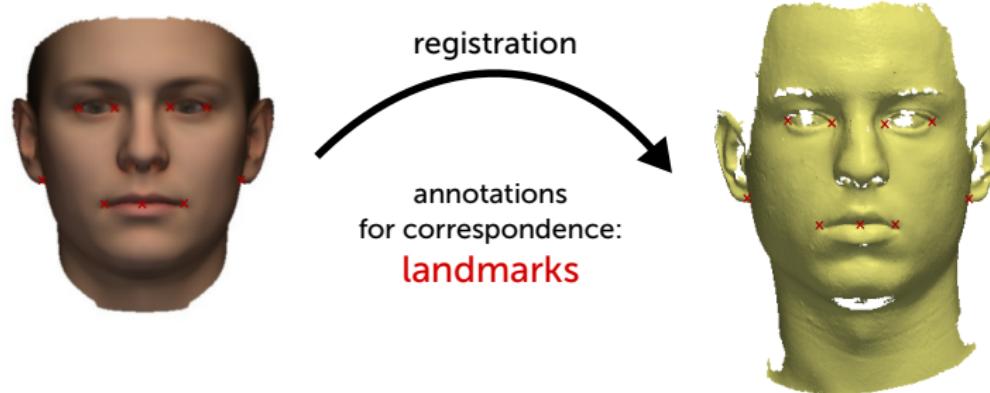
Department of Mathematics and Computer Science
UNIVERSITÄT BASEL

July 29, 2013

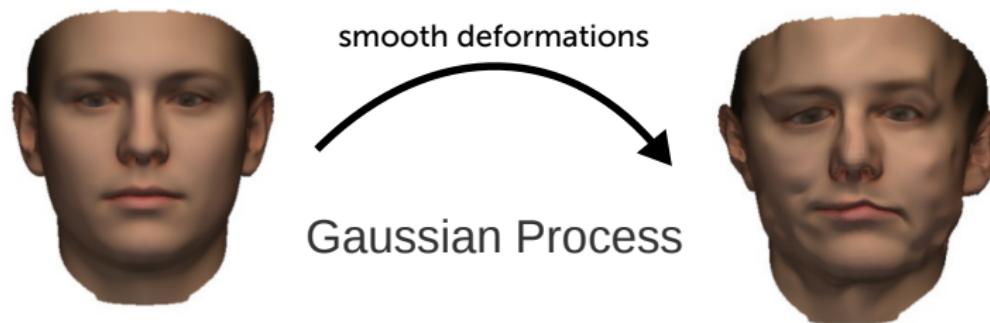
REGISTRATION OVERVIEW



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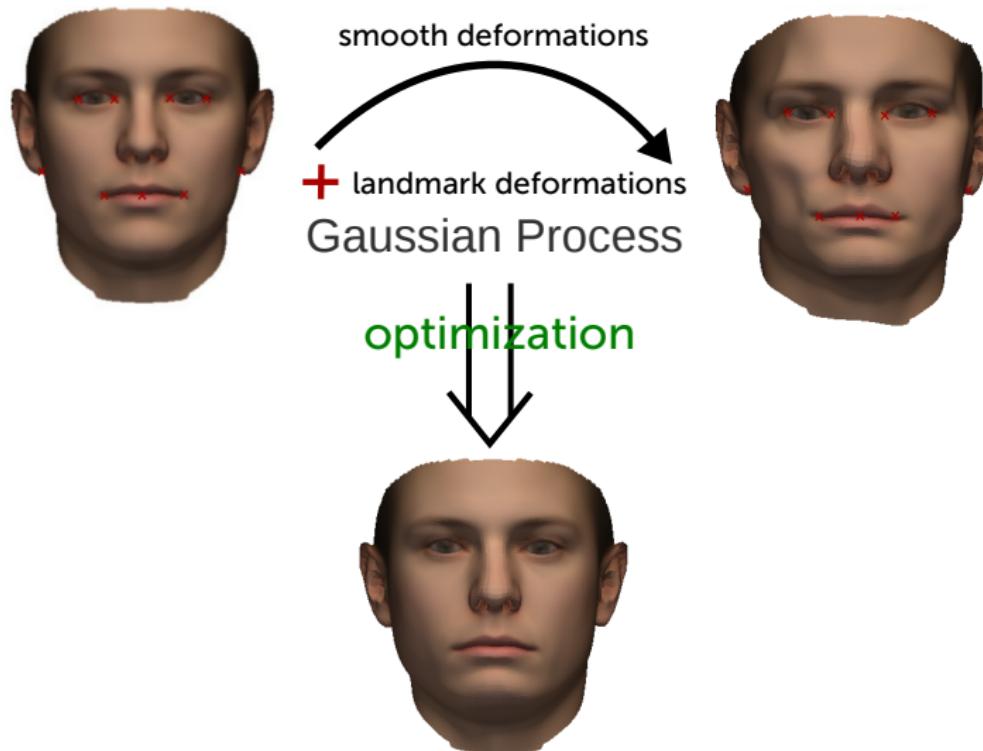
REGISTRATION OVERVIEW



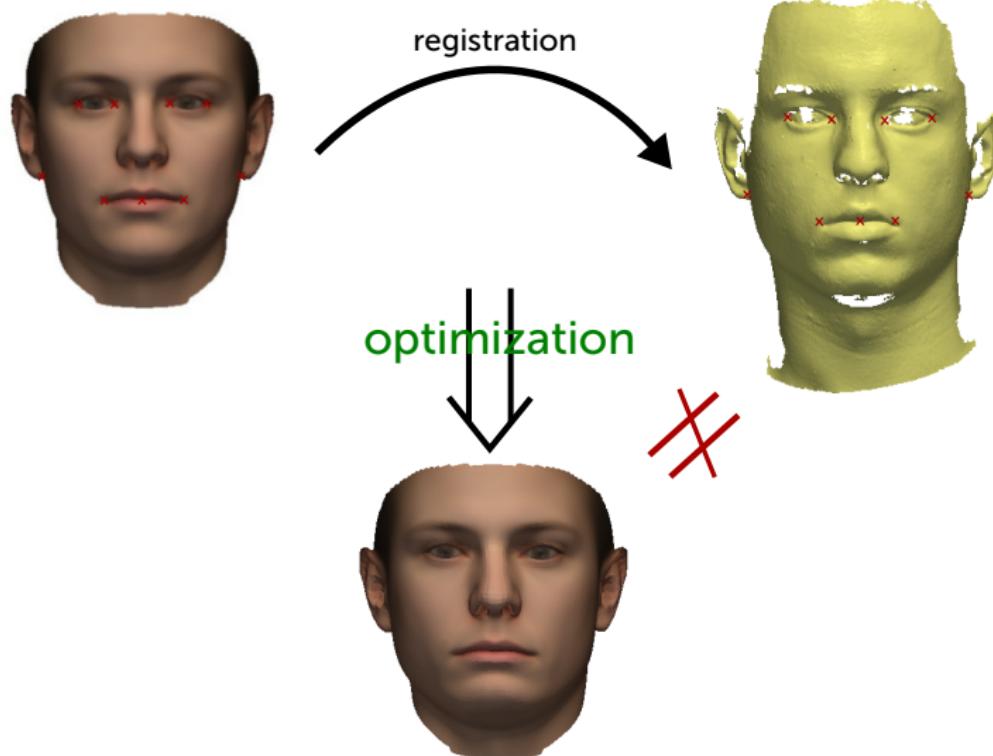
REGISTRATION OVERVIEW



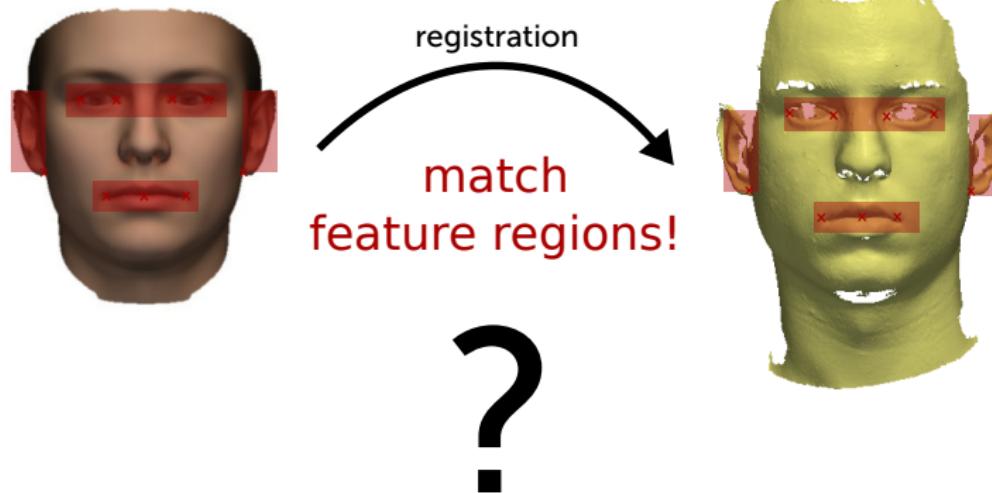
REGISTRATION OVERVIEW



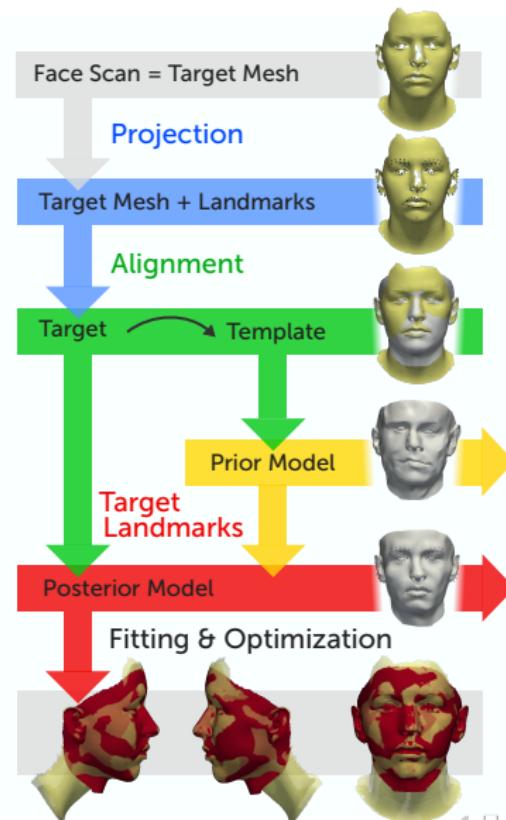
REGISTRATION OVERVIEW



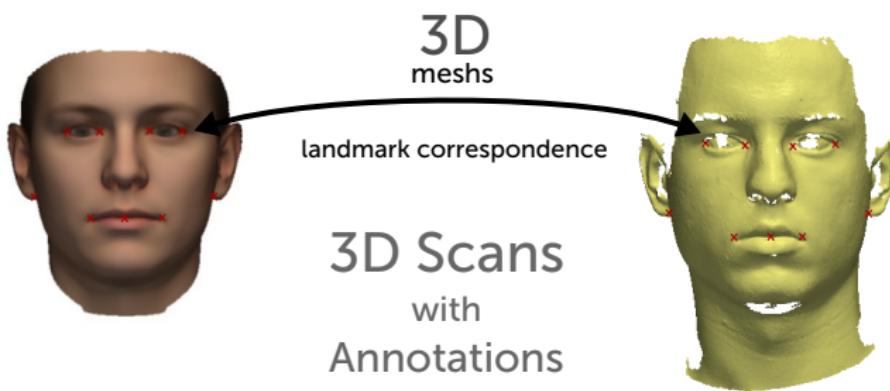
REGISTRATION OVERVIEW



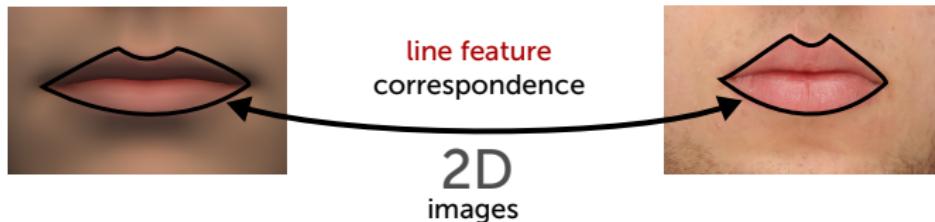
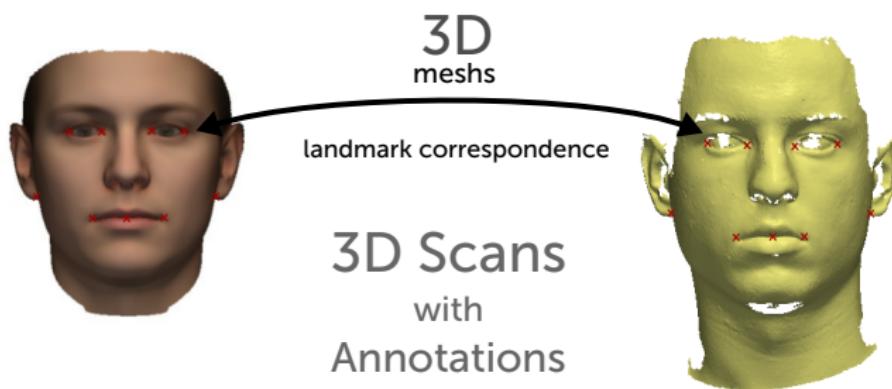
PIPELINE



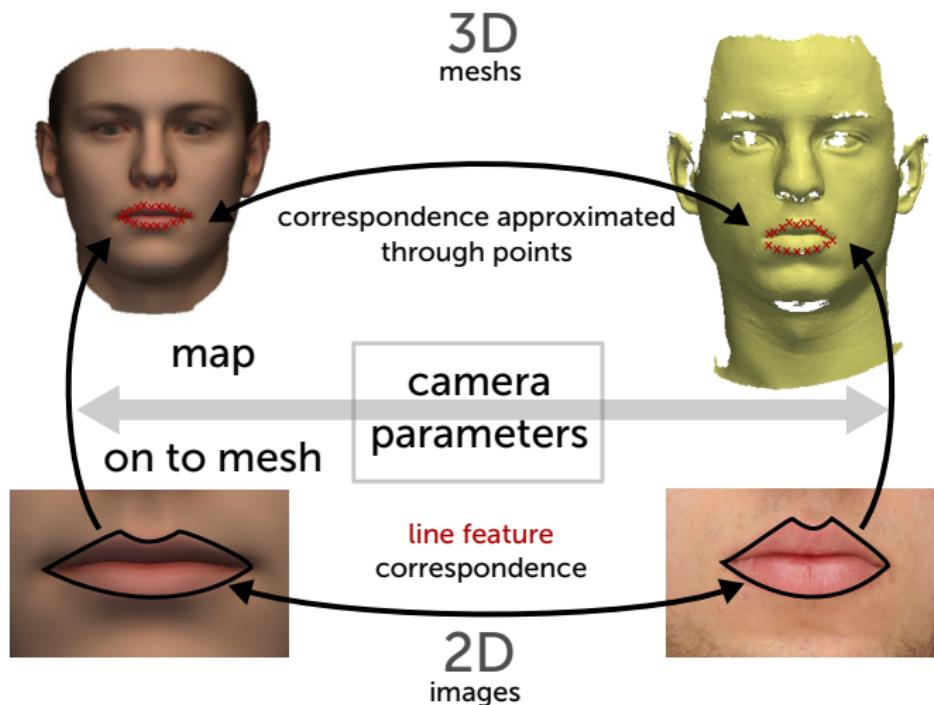
DATA AND CORRESPONDENCE



DATA AND CORRESPONDENCE

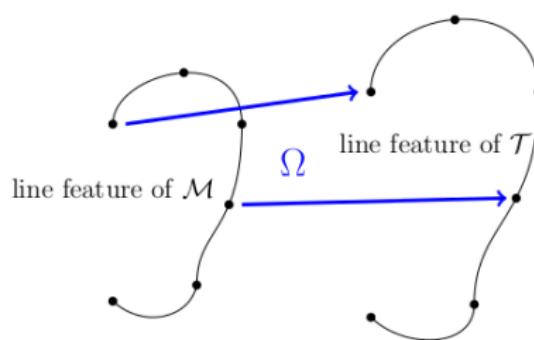


DATA AND CORRESPONDENCE



MAPPING LINE FEATURES

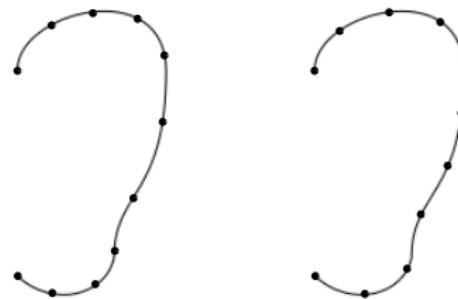
Idea: Sample points from the line features and use them as additional landmarks



What about correspondence?

EQUIDISTANT SAMPLING

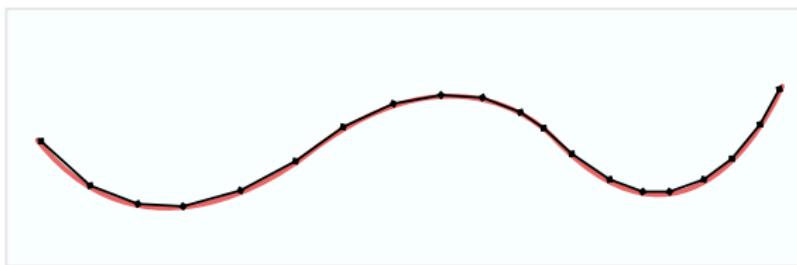
Approximate correspondance by sampling line features in equidistant intervals



BÉZIER CURVES

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

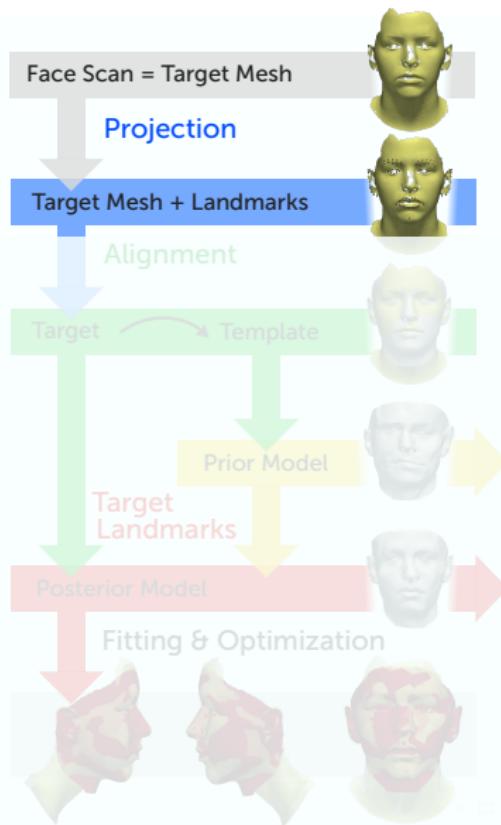
Approximate arc-length of curve through euclidean distance of sampled points



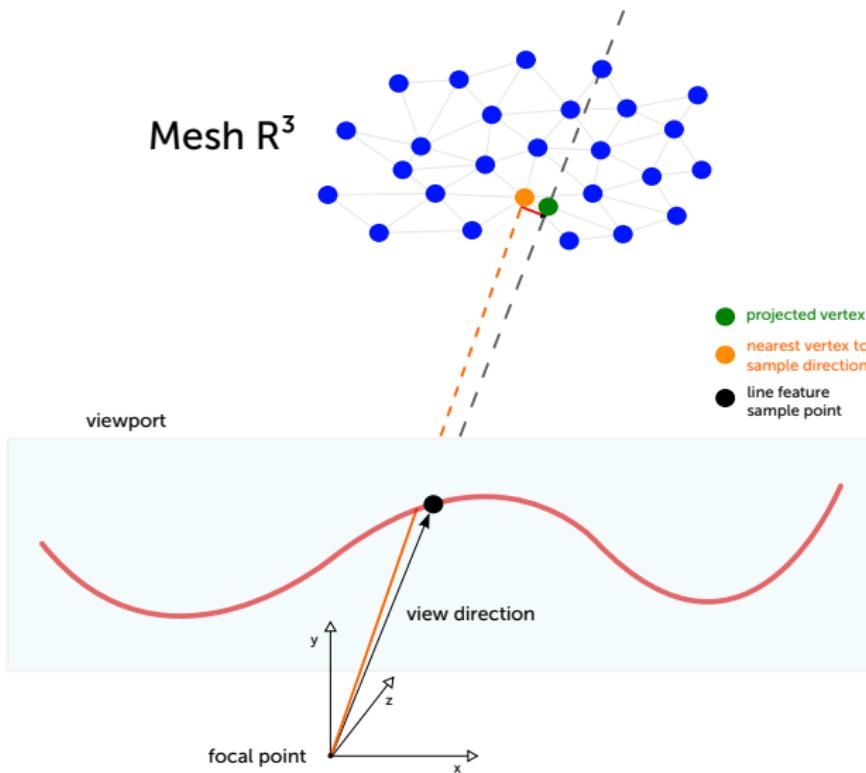
Rightarrow map point coordinates to approximated fractional length of curve



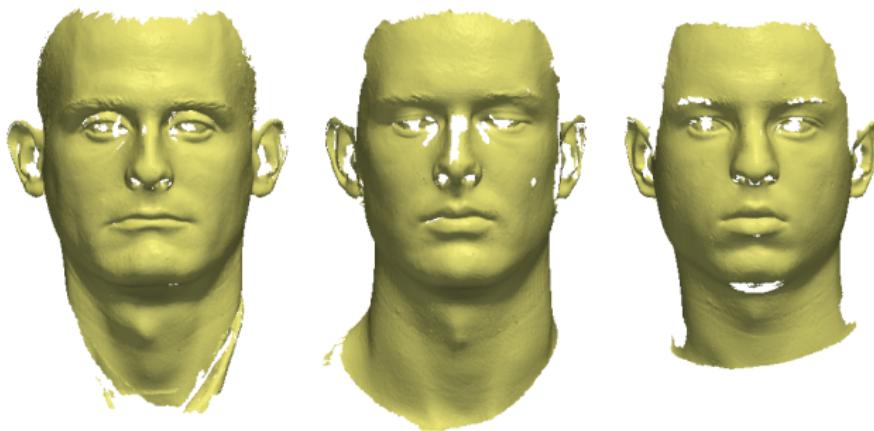
PIPELINE: PROJECTION



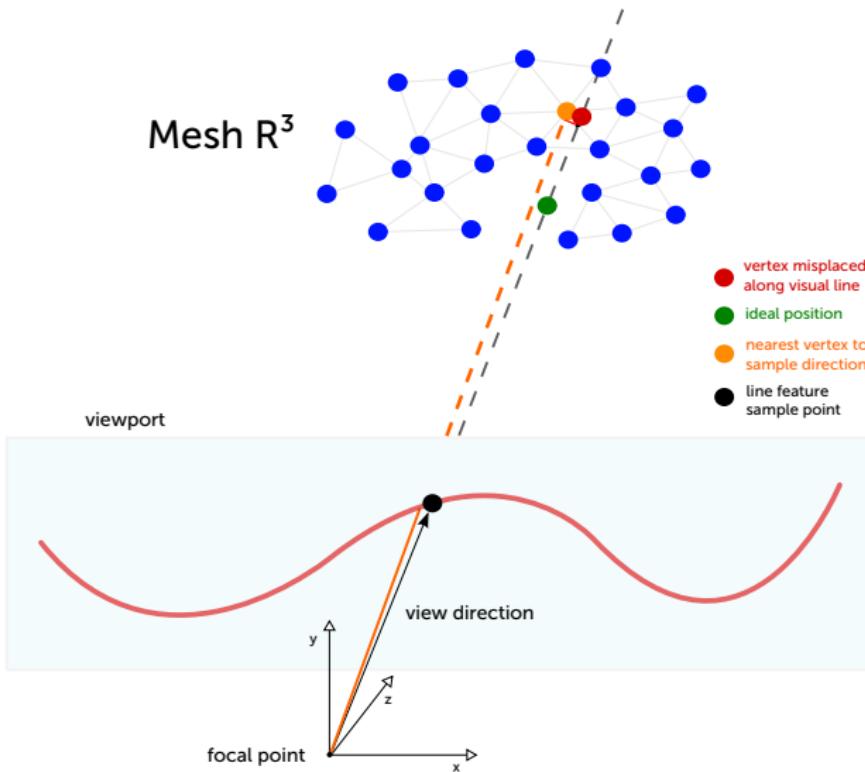
PROJECTION: 2D TO 3D



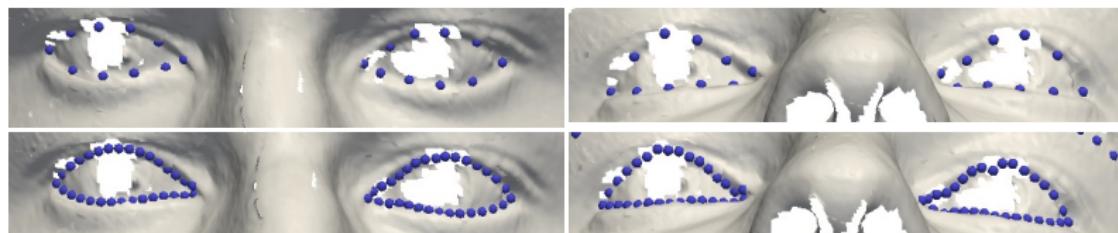
TARGET MESH HOLES



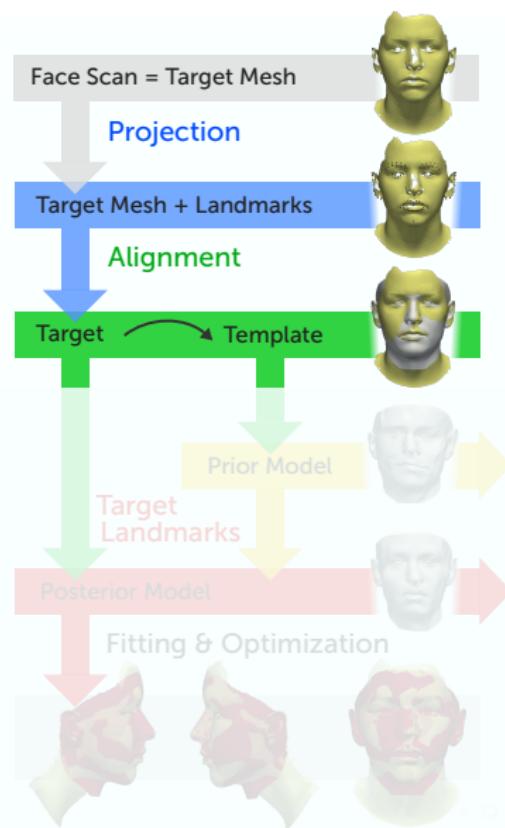
PROJECTION: HOLES



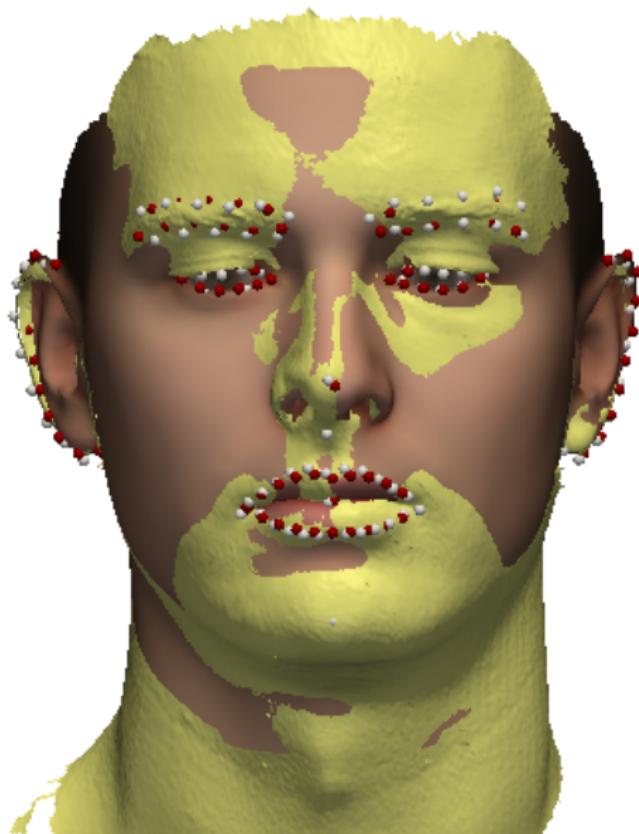
3D REPRESENTATION



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

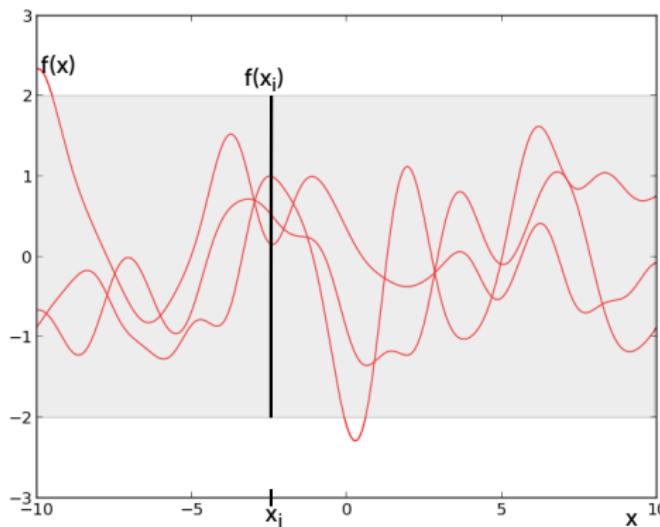


Figure: normal distribution over 1000 input points

GP POSTERIOR DISTRIBUTION

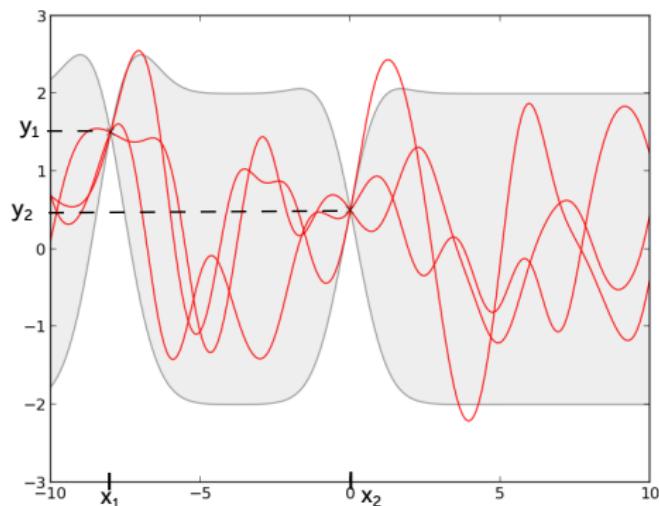


Figure: posterior distribution fixed at 2 input points



GP POSTERIOR DISTRIBUTION

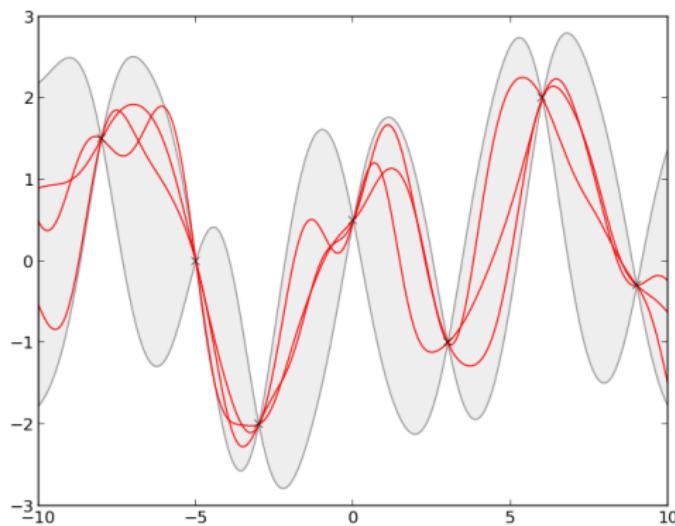


Figure: posterior distribution fixed at 7 input points

GPR IN 3D FACE REGISTRATION

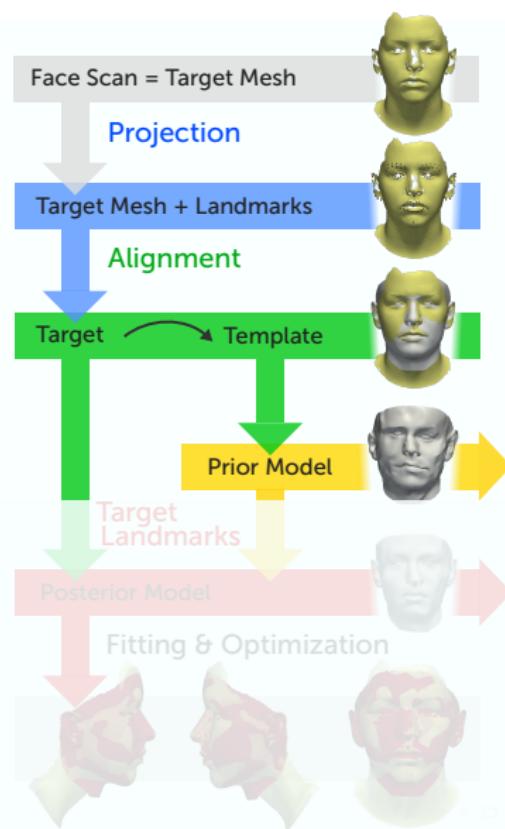
definition of Vector-valued GP

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

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

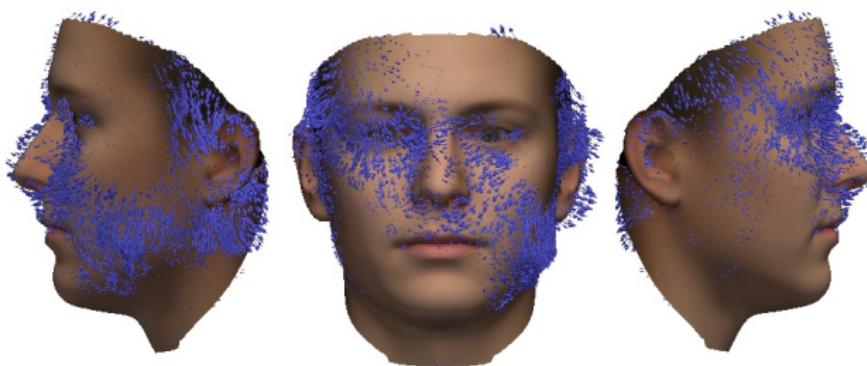


PIPELINE: DEFORMATION PRIOR



DEFORMATION PRIOR

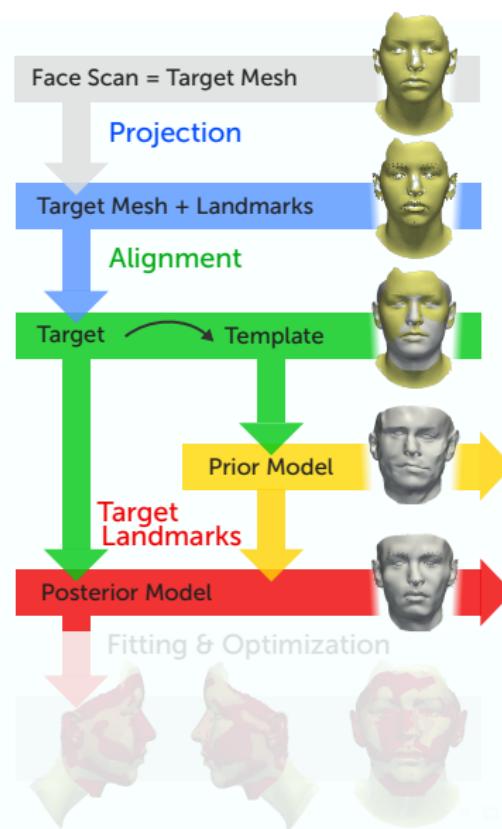
build GP Prior from template mesh vertices
→ GP defines a distribution of possible deformations of the template



PRIOR FACES



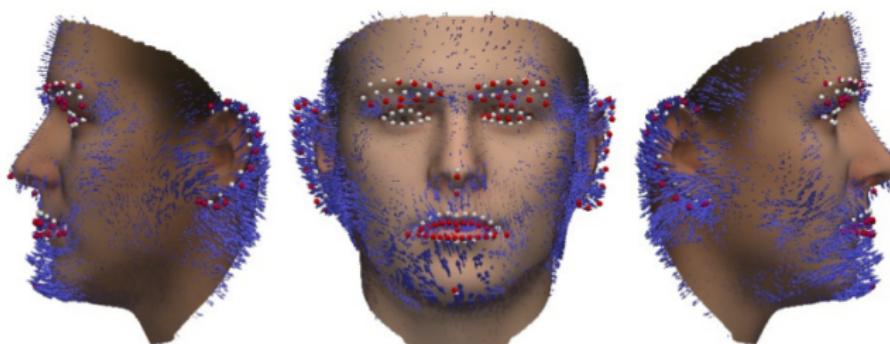
PIPELINE: DEFORMATION POSTERIOR



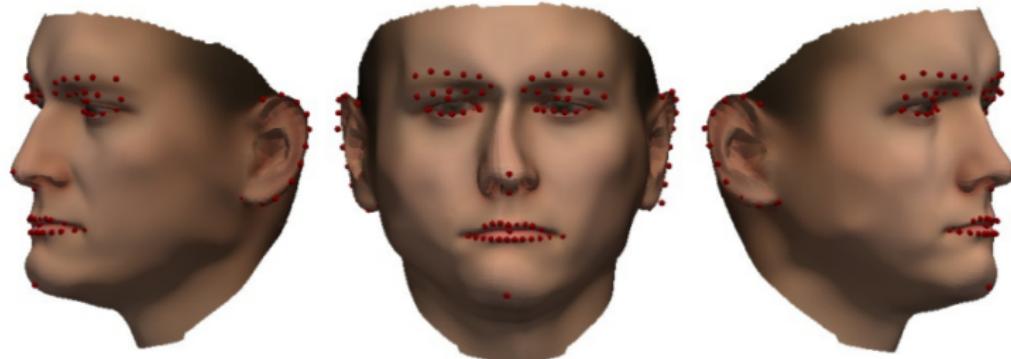
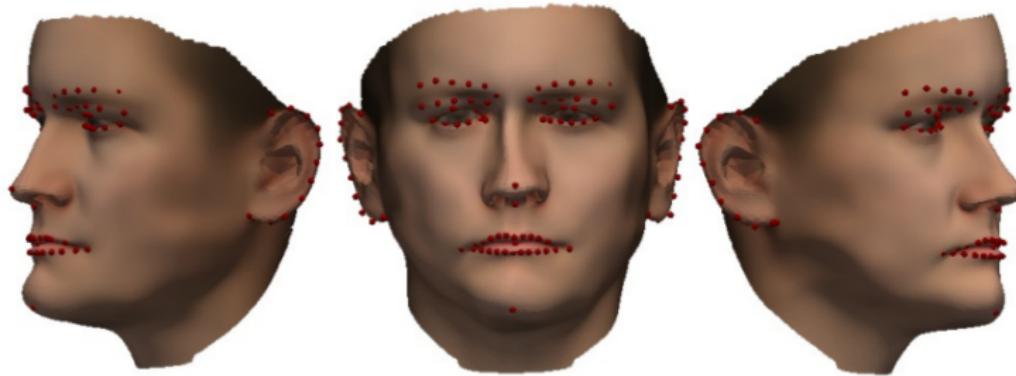
3D GP POSTERIOR

inference in the space of possible template surface deformations
training data: residuals of the line feature sample coordinates:

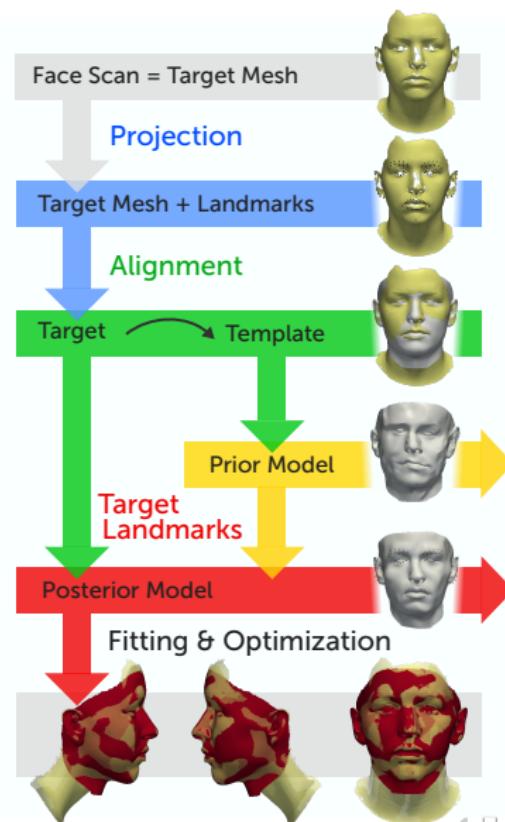
$$R = \{t - m | t \in L_T, l \in L_M\}$$



POSTERIOR FACES



FITTING & OPTIMIZATION

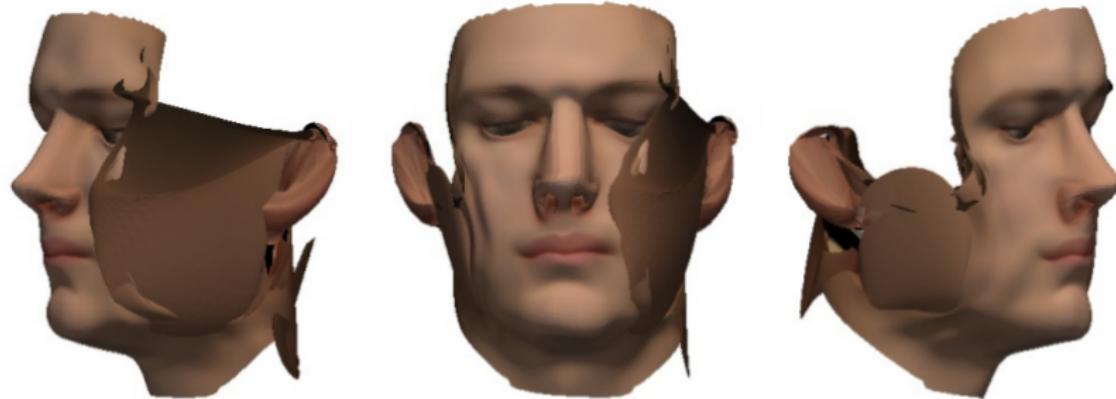


PARAMETRIC MODEL

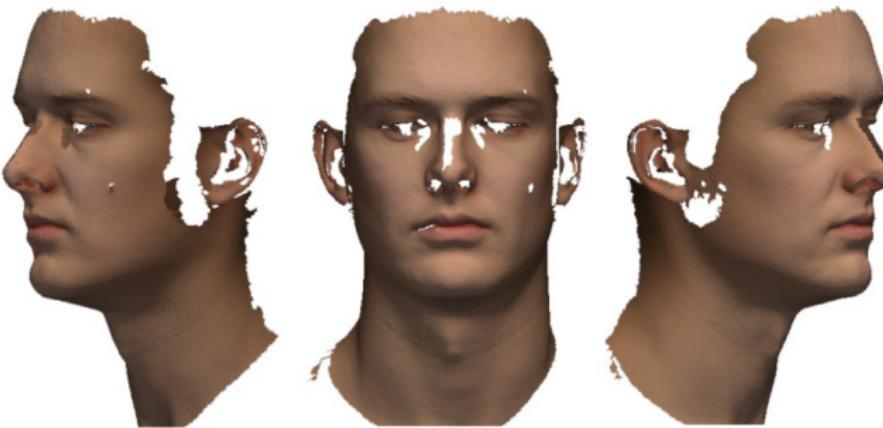
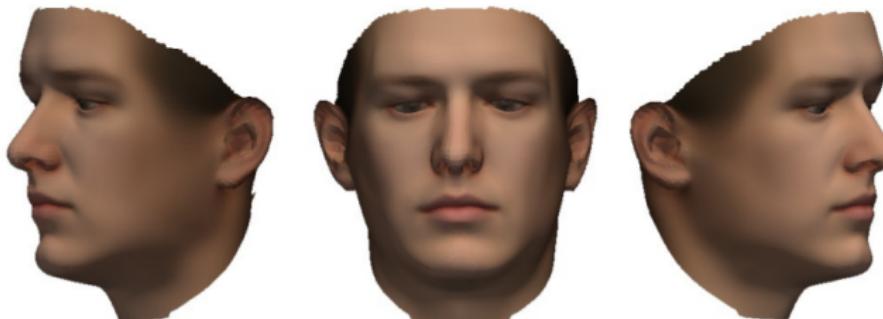
GP Posterior distribution of admissible deformations
How to optimize deformation samples?

Mercer's theorem: distribution → parametric model
⇒ optimize model parameters

MEAN SQUARED ERROR



ROBUST ESTIMATOR



ROBUST ESTIMATOR



RESULTS

COMPARISON: WITH \Leftrightarrow WITHOUT LINE FEATURES

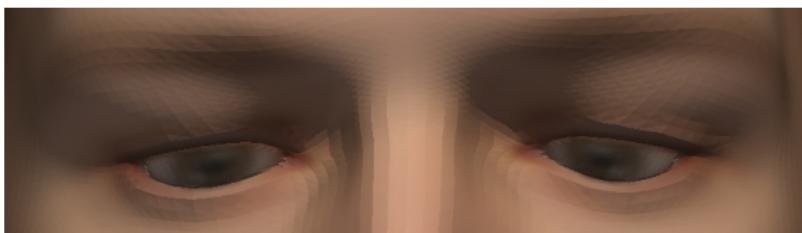
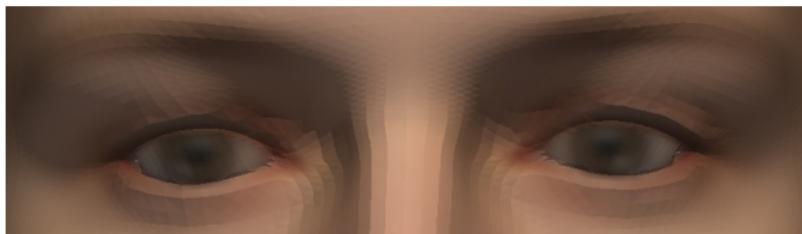
CARICATURES



COMPARISON - MOUTH



COMPARISON - EYES



COMPARISON - EARS



CARICATURES

CONCLUSION

Incorporation of line features rendered good registration results

Optimization process has to be further adapted for more expressiveness

FUTURE WORK

detect “outlier regions” - template regions corresponding to holes in target
by registering template on to target
⇒ use Mean Squared Error to perform optimization without artifacts

THANK YOU FOR LISTENING!

Any questions?