graphics and vision gravis University of Basel

Face Image Analysis Applications

Probabilistic Morphable Model Fitting
Basel2018

Thomas Vetter
University of Basel

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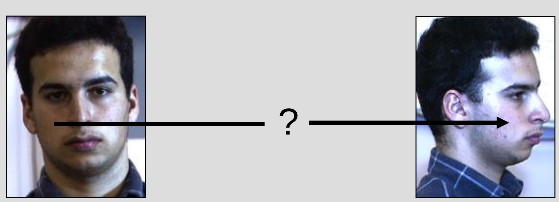
Face Identification by Image Comparison

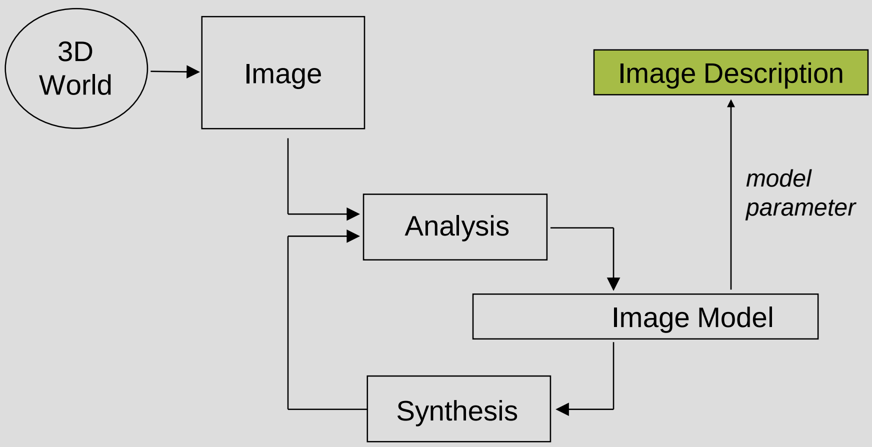
… done by pixel analysis



But which pixel to compare with which ?

Shape information tells us which pixel to compare

Analysis by Synthesis



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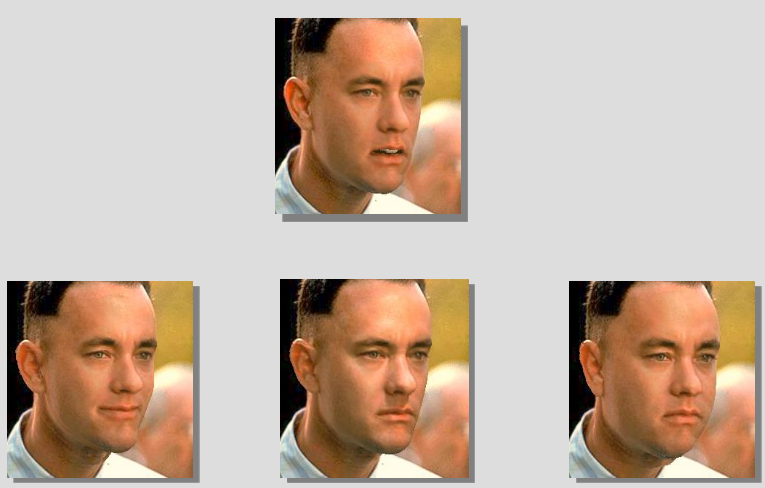
Change Your Image ...



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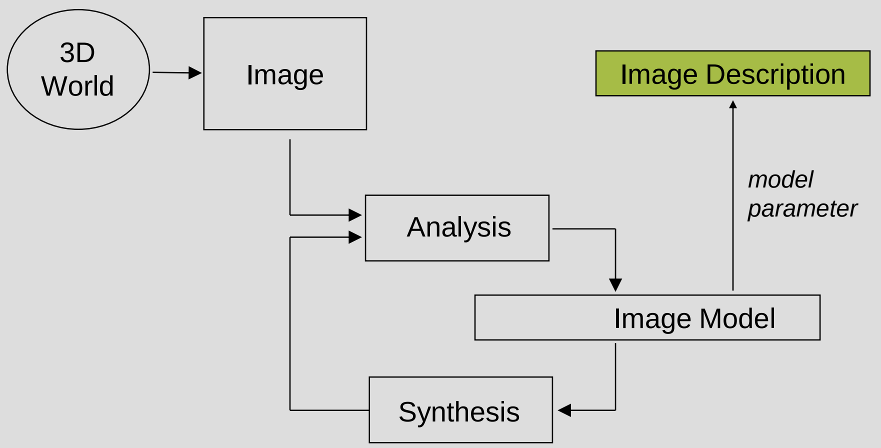
Analysis by Synthesis



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THE BIG QUESTION:

`How is this Image Model structured?`

Is it:

2D, an image based rendering model?

or

3D, a full 3D computer graphics model?

or ….

Possibly, there is no final answer!

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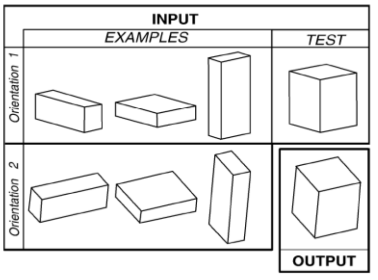
Linear Object Class Idea



Linear Object Classes and Image Synthesis from a Single Example Image.
Thomas Vetter and Tomaso Poggio *IEEE PAMI 1997, 19(7), 733-742.*

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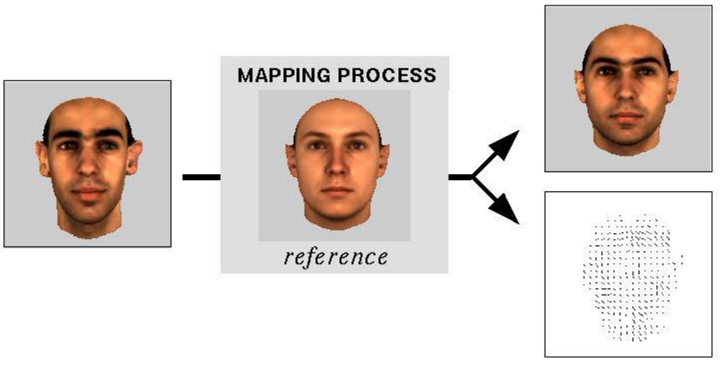
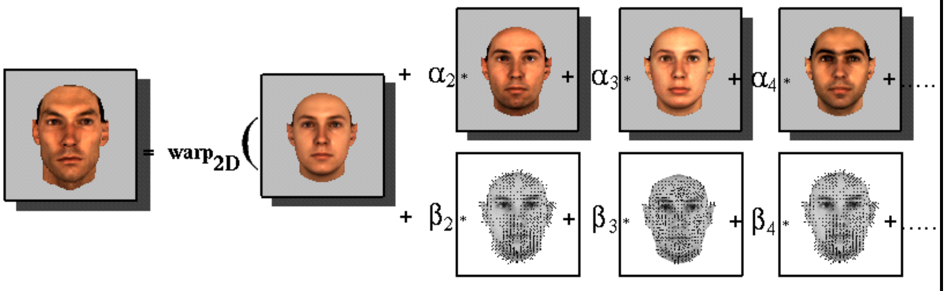
Separating shape and texture in 2D images



2D Morphable Face Image Model



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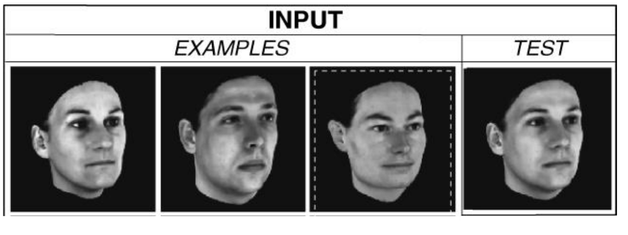
Linear Object Class Idea



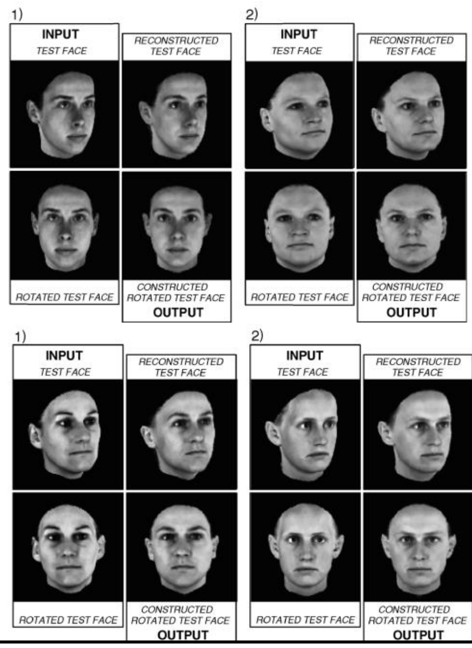


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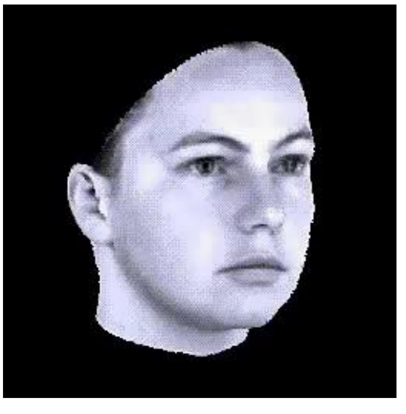
Image based rendering



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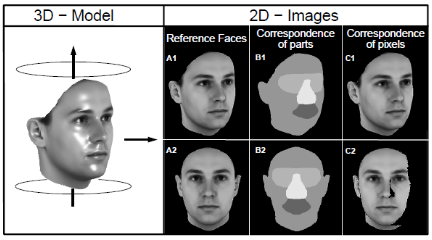

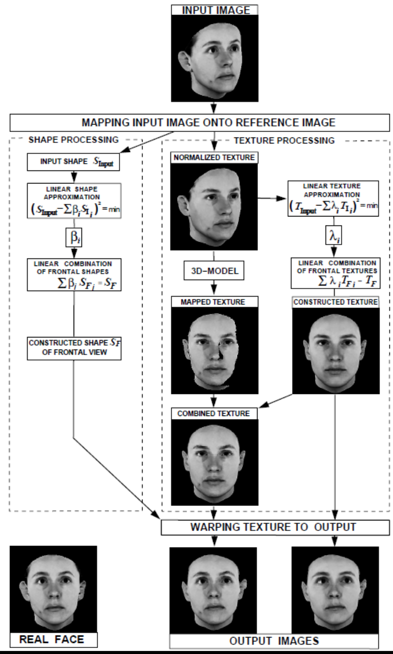

Synthesis of novel views from a single face image.
Thomas Vetter, *IJCV 1998, 28(2), 103-116.*

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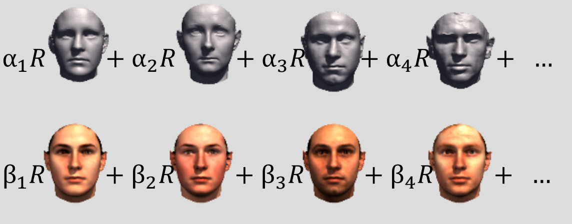
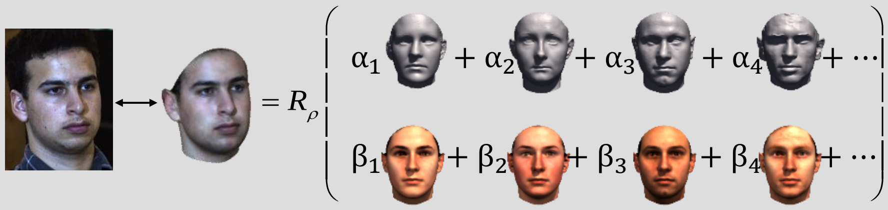
Morphable 2D Face Model

=



Morphable 3D Face Model



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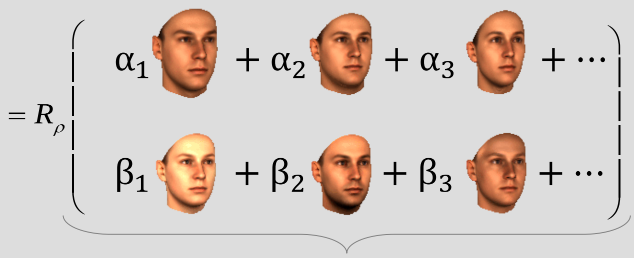
Morphable Models for Image Registration



Output

$\boldsymbol{R}$ = Rendering Function
ρ = Parameters for Pose, Illumination, ...

Optimization Problem: Find optimal α, β, ρ !

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Face Recognition

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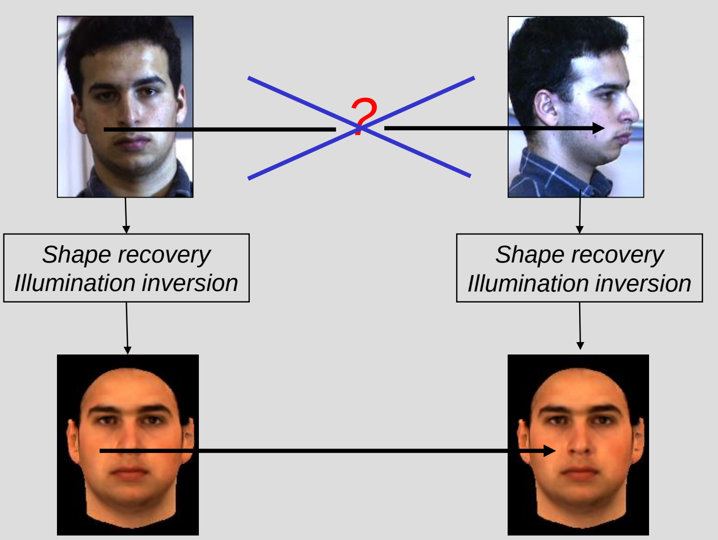
Normalizing for pose, illumination and …



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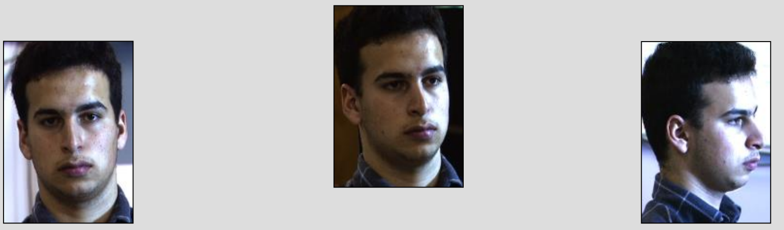
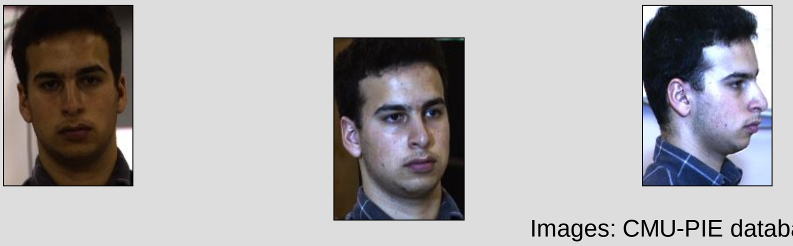
Face recognition



Complex Changes in Appearance



Images: CMU-PIE database. (2002)

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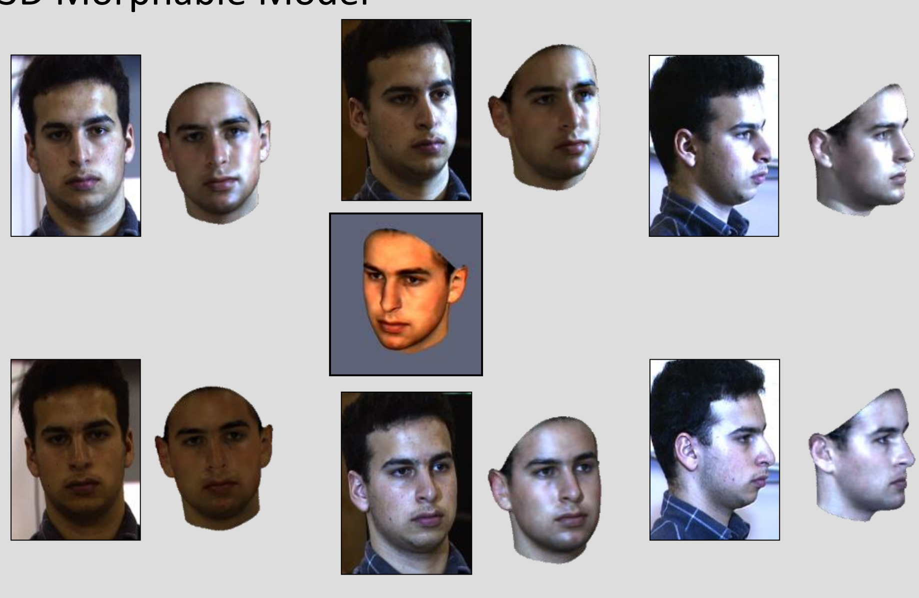
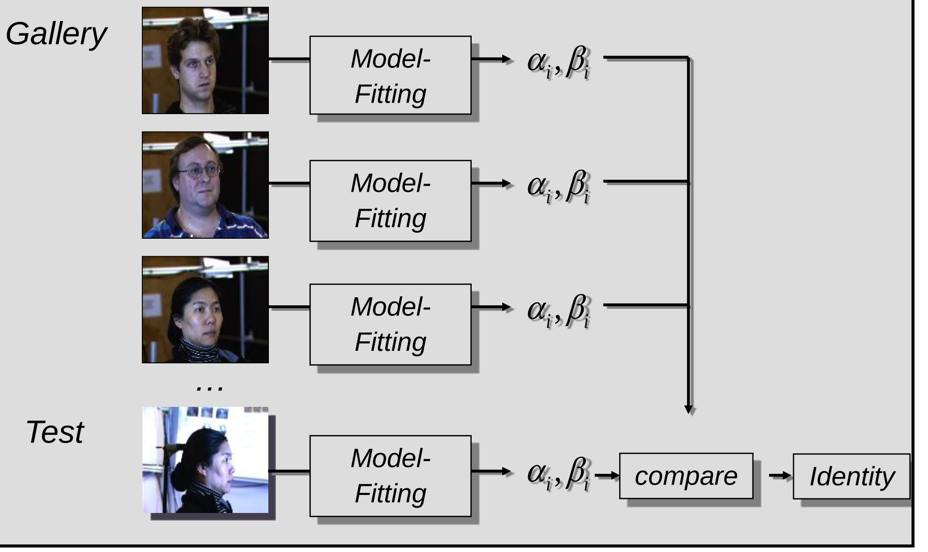
3D Morphable Model



Identification by shape and texture coefficients only



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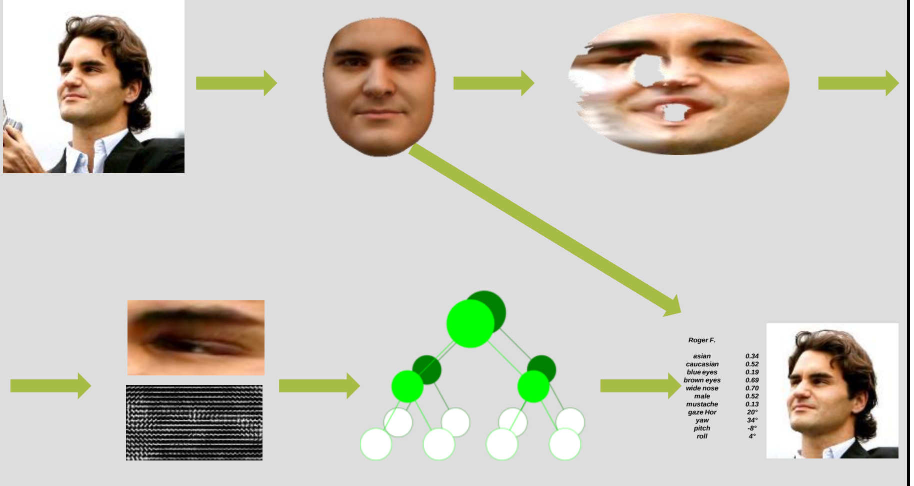
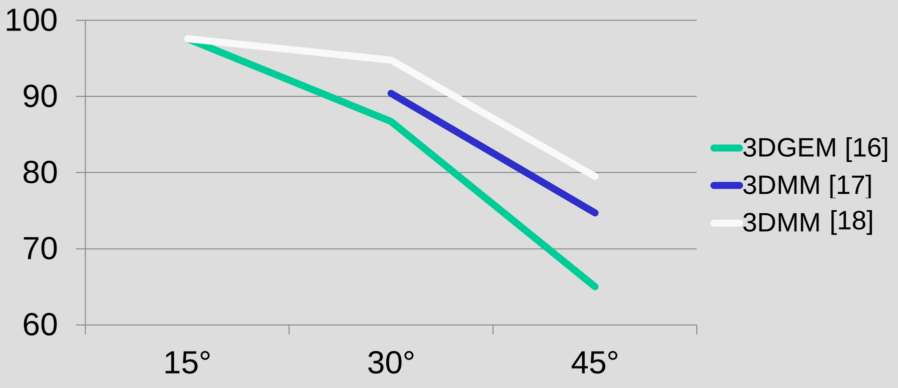
Face analysis



Multi-PIE: Face recognition



[16] Prabhu et al., **“Unconstrained Pose-Invariant Face Recognition using 3D Generic Elastic Models”,** PAMI 2011
[17] Schönborn et al., **“A Monte Carlo Strategy to Integrate Detection and Model-Based Face Analysis”,** GCPR 2013
[18] Egger et al., **“Pose Normalization for Eye Gaze Estimation and Facial Attribute Description ”,** GCPR 2014

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Try a new hairstyle!

3D Geomety
and Texture

3D Pose, Position
Illumination,
Foreground,
Background

Try a new hairstyle!

3D Geomety

and Texture

3D Pose, Position

Illumination,

Foreground,

Background

Image Preprocessing for FRVT 2002

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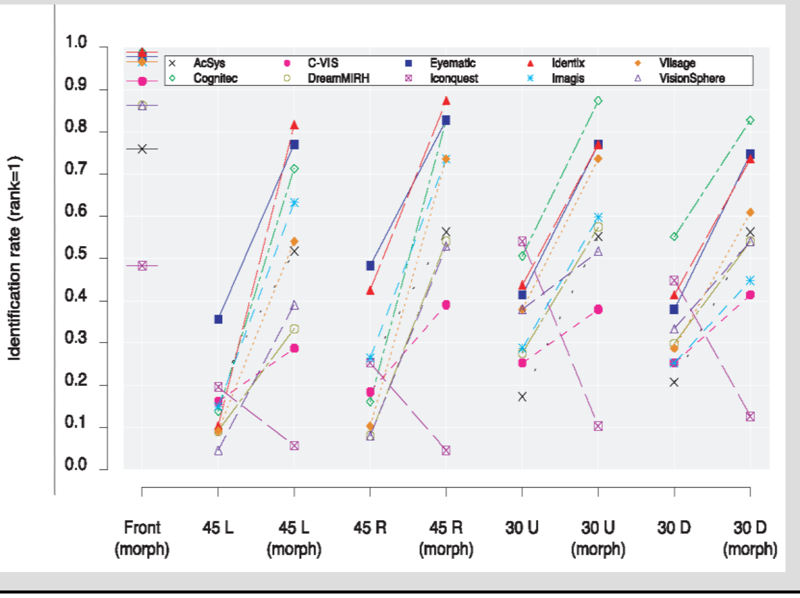
Image Preprocessing for FRVT 2002



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Skin Detail Analysis for Face Recognition

Skin Detail Analysis for Face Recognition

Jean Sebastian Pierrard , Thomas Vetter CVPR 2007

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Overview

Characterizing moles

- Appearance → Blob detection
- Location → Skin segmentation
- Importance → Saliency measure

Recognition

- Reference Systsem → Morphable Model

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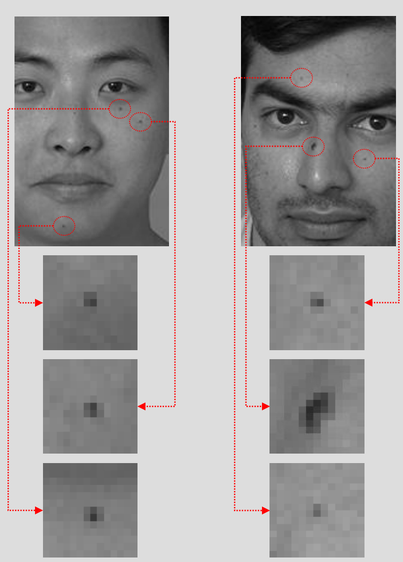
Data used

- Results based on subset of FERET-data base
  - Gray scale
  - Medium resolution (10-20k pixels face area)
  - Mole sizes: 2-20 pixels



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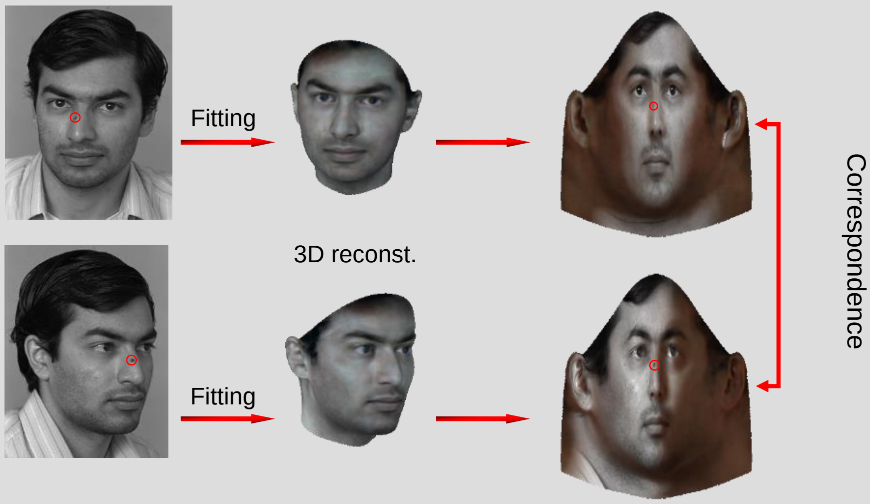
Morphable Model for Correspondence



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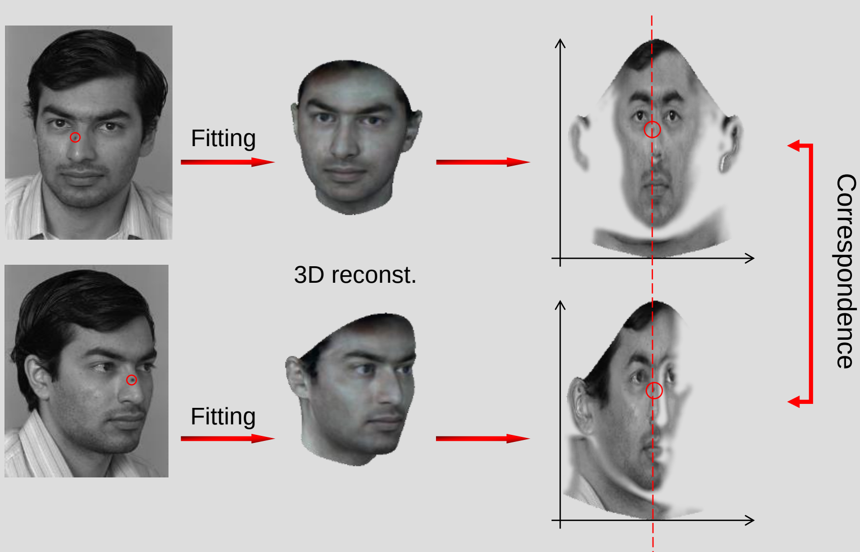
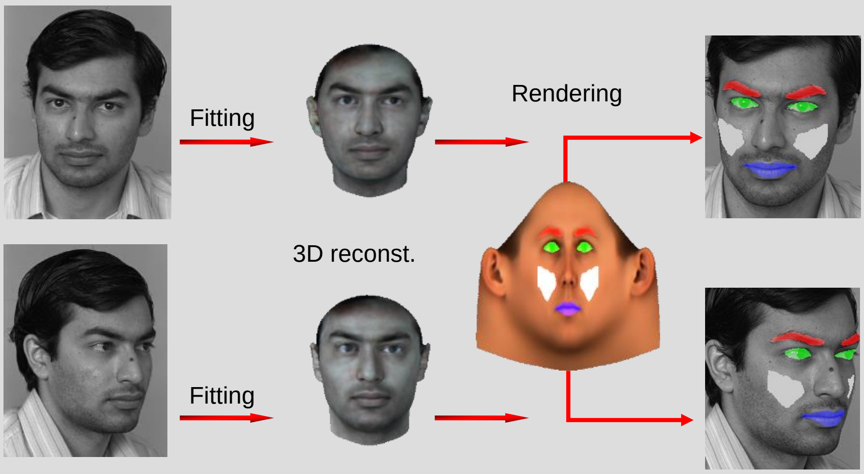
3DMM maps visible region on a common reference

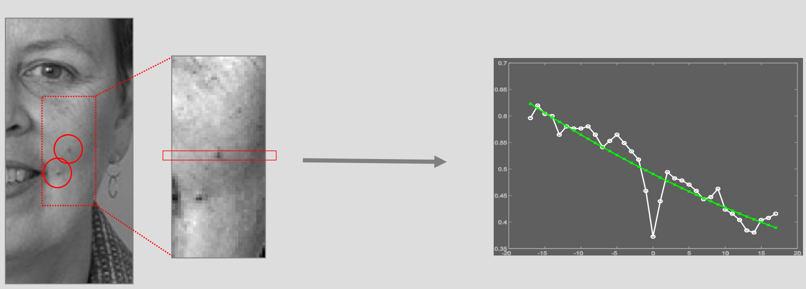


Morphable Model for Correspondence II



Mole Detection: Shading Problem

- Template matching is sensitive to intensity gradients !



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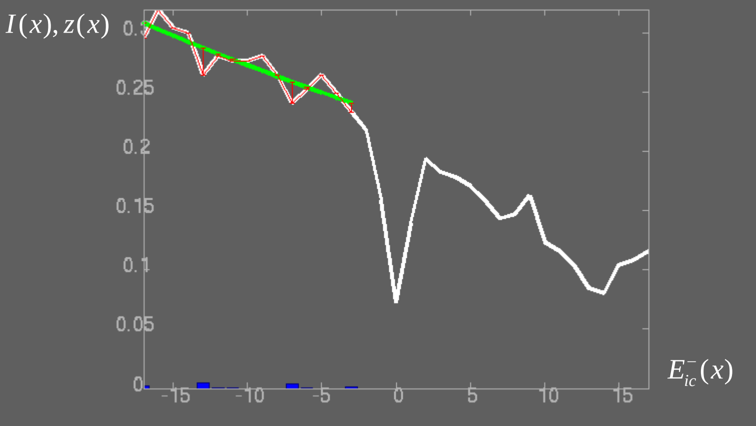
Illumination Compensation



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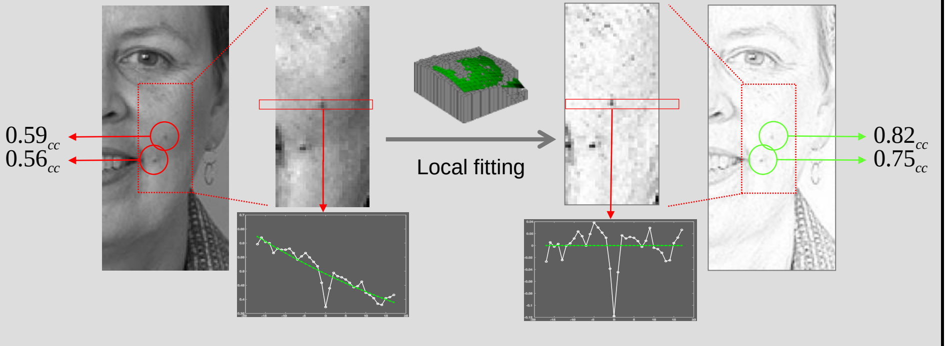
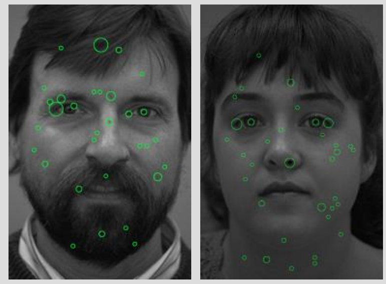
Mole Detection: Shading Problem



False Positives

- Templates also match common facial features
- Sporadic hits due to hairstyle, beard, …



- We need to mask out non-skin regions / outliers
- 3DMM is **not** sufficient

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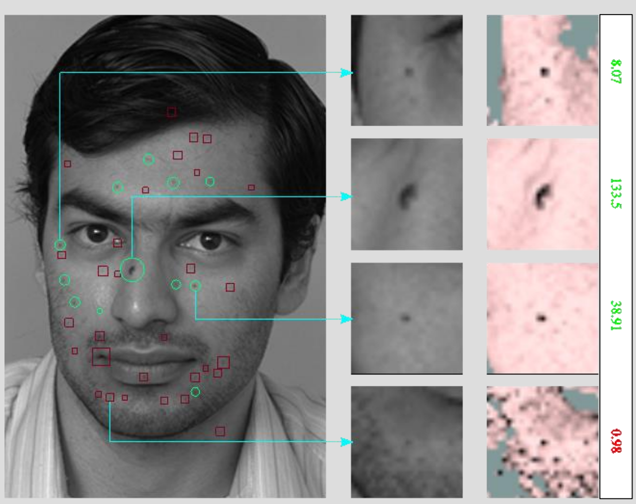
Selection by Saliency



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Recognition

- Find matching pairs of moles in reference frame

- Identification score:
  weighted sum of saliencies from matched points

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Face Recognition

- Based only on mole locations and saliency.

	Saliency threshold *(Gallery subset size)*					
	5 *(156)*		**10** *(107)*		**15** *(83)*	
Probe	Fail	Perf.	Fail	Perf.	Fail	Perf.
bc	69	55.77	39	63.55	26	68.67
bd	34	78.20	13	87.85	8	90.36
be	17	89.10	7	**93.45**	4	**95.18**
bf	20	87.18	5	**95.32**	5	**93.97**
bg	47	69.87	24	77.57	17	79.51
bh	68	56.41	30	71.96	21	74.70
bk	42	73.07	22	79.44	13	84.33

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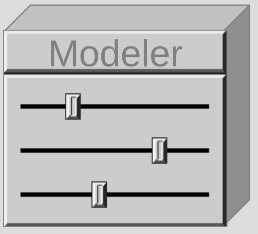
Manipulation of Faces



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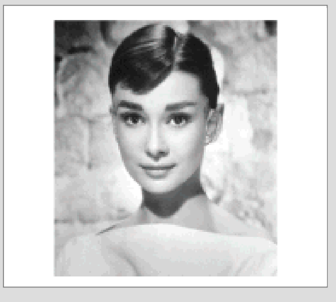
Modeling of 2D Images



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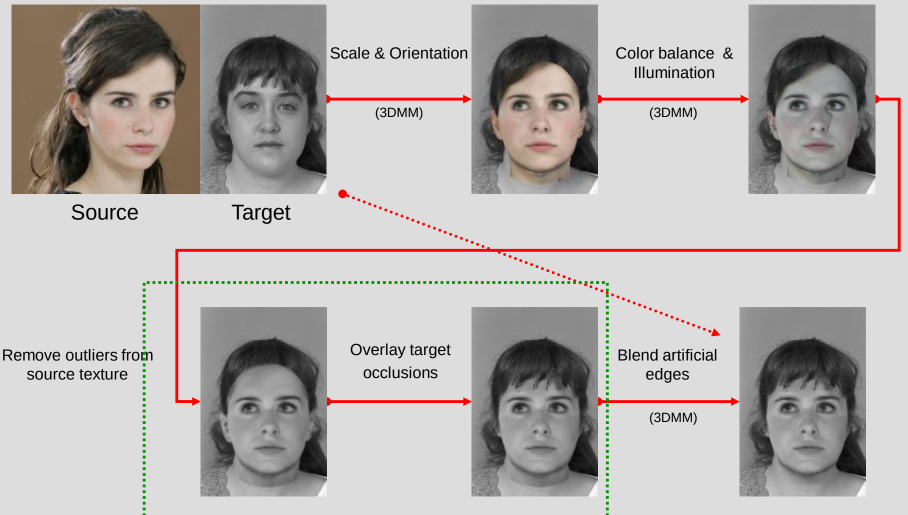
Face Exchange Tasks



Difficult problem, even for humans.
Has never be automated !

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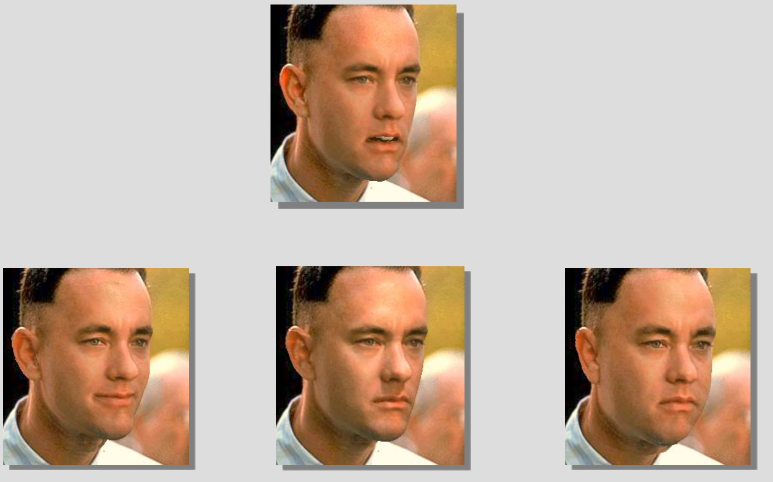
Change Your Image ...



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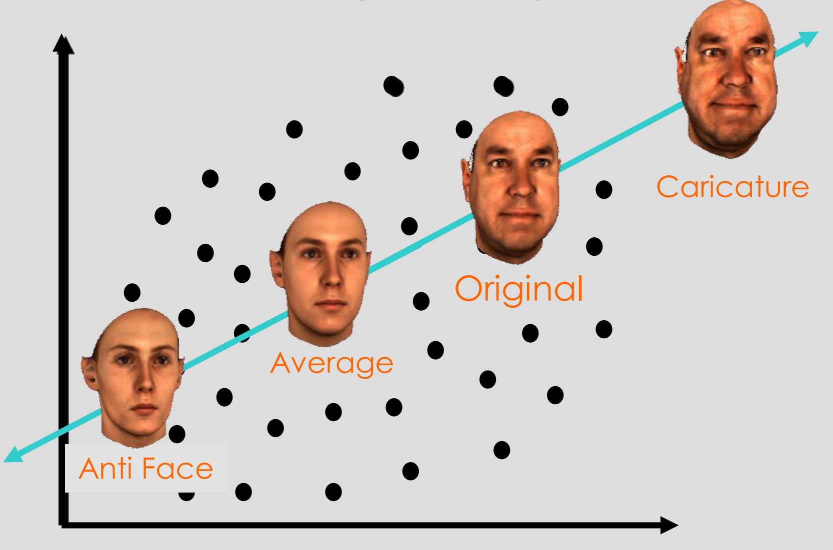
Continuous Modeling in Face Space



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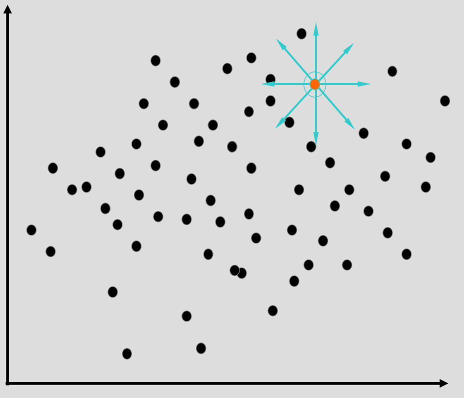
Modeling the Appearance of Faces

- Which directions code for specific attributes ?



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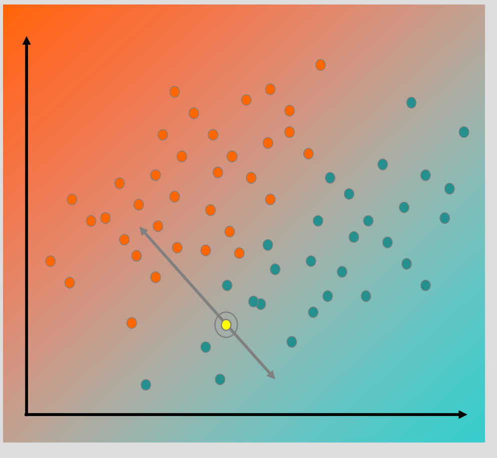
Learning from Examples



Attributes of Faces

Gender

Weight

Original

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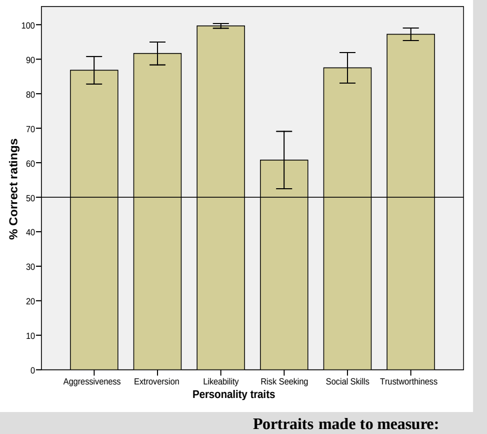
Portraits made to Measure

- Computer can learn to model faces according to „human“ categories.

Aggressive

Trustworthy

Portraits made to Measure



Portraits made to measure:
Mirella Walker and Thomas Vetter
Journal of Vision, 9(11):12, 1-13, 2009
.

Expressions

Original

Simulation of Aging of Human Faces in Images

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Aging model:

model predicts perceived age

Ageing: linear shape model only

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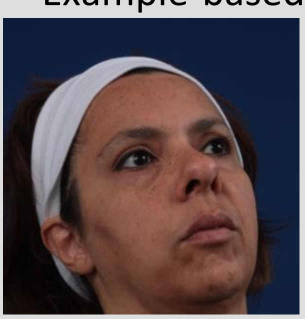
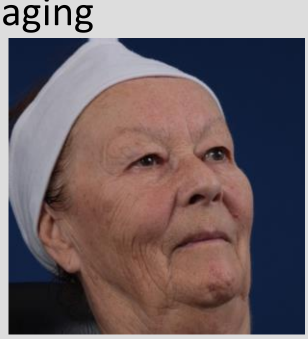
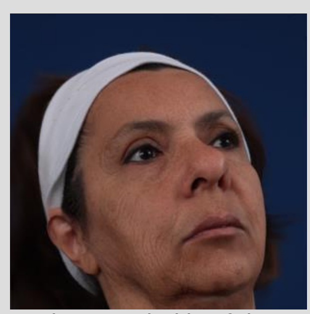
Example-based aging



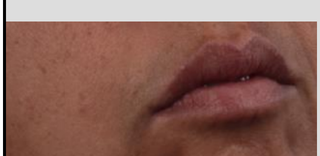
Target Image

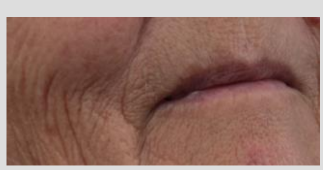


Donor Image

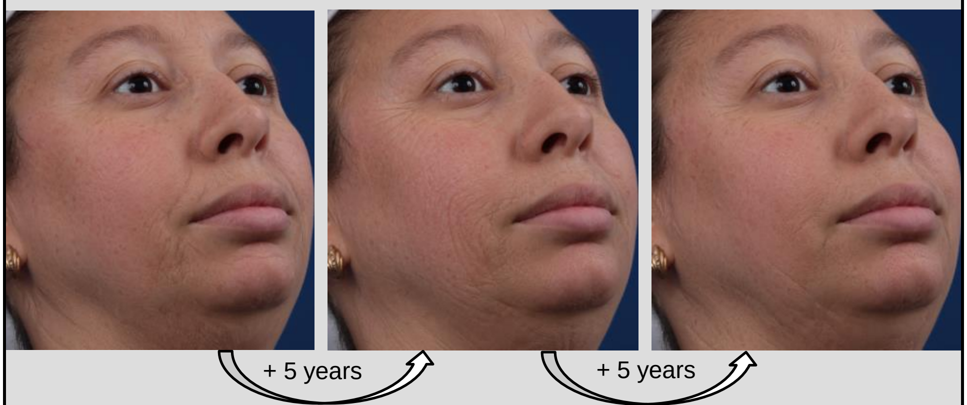


Shape and Skin of donor transferred to target





Example-based Texture: The Problem



Target Image
AGE: 40

Shape and Skin of donor
AGE: 45

Shape and Skin of donor
AGE: 50

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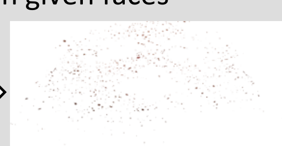
Parametric Pigmentation Model

$$\rho(x, y, \sigma) = \sum_{u,v \in \Omega} \mathcal{N}\left((x-u, y-v)^T, \sigma\right)$$

- σ regulates the spread
- u, v learned freakle position from example data Ω
- The parameters σ, u, v and different freckle shapes are learned by detecting freckles in given faces

Facial texture source



detected freckles

σ, u, v

learned distribution parameters

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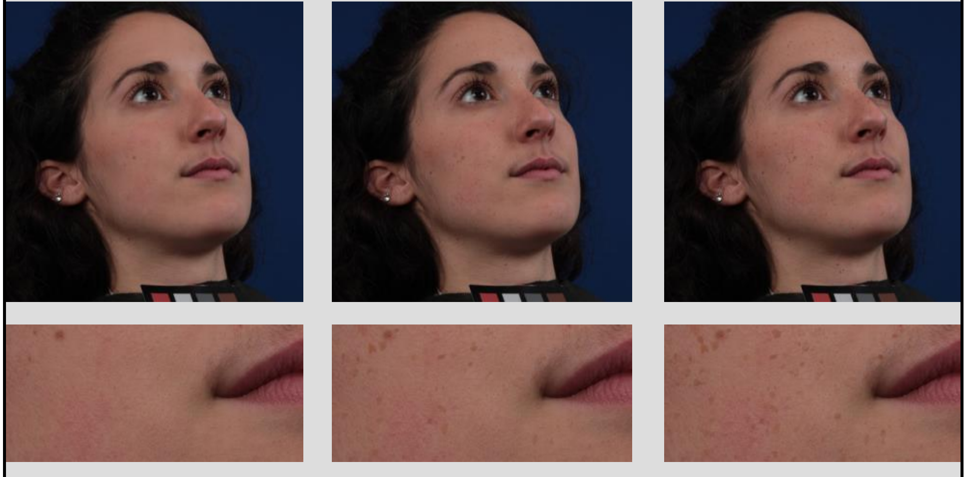
Parametric Pigmentation Model



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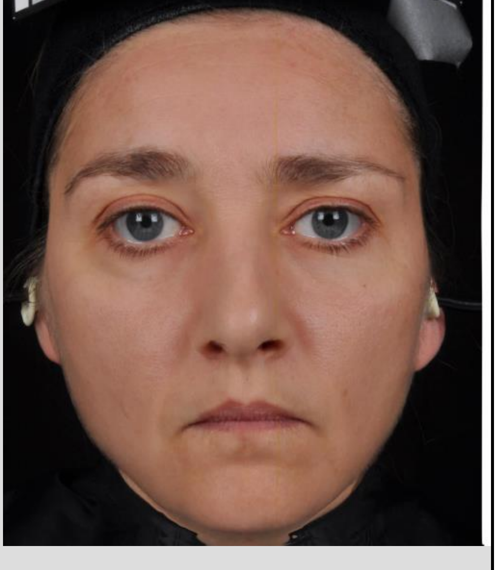
Aging Model

- Shape: continuous
- Pigmentation: stochastic
- Wrinkles: example based



Transfer of Facial Expressions

Original:

 -  = smile

Novel Face:

 + smile = 

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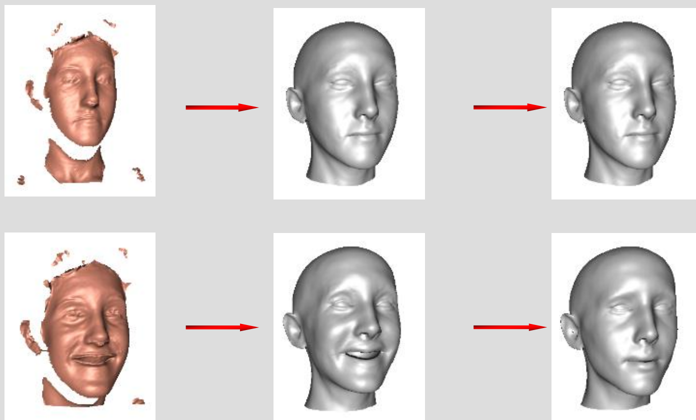
Expression Invariant 3D Face Recognition with a Morphable Model

Brian Amberg, Reinhard Knothe and Thomas Vetter

IN: *IEEE Proceedings FG2008: 8th International Conference Automatic Face and Gesture Recognition, Amsterdam, The Netherlands, 2008.*

Expression Invarant 3D Face Recognition



Input 3D Scans | **Approximation of Input with Morphable Expression Model** | **Expression Normalized**

Expression Invariant 3D Face Recognition with a Morphable Model
Brian Amberg, Reinhard Knothe and Thomas Vetter, *IEEE FG2008*

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Linear Expression Model

- Modeling facial expressions in a separate subspace

$$F(\alpha) = \mu + M\ \alpha$$

$$F(\alpha_n, \alpha_e) = \mu + M_n \alpha_n + M_e \alpha_e$$

- Face Scans differ in Orientation and Translation

$$Data(\alpha) = R(F(\alpha_n, \alpha_e)) + T$$

Expression Transfer

Id

+ Xp

=

Fitting — *Fitting* — *Rendering*

$\alpha_{ID}^1, \alpha_{XP}^1, \beta^1$

$\alpha_{ID}^2, \alpha_{XP}^2, \beta^2 \longrightarrow \alpha_{ID}^1, \alpha_{XP}^2, \beta^1$

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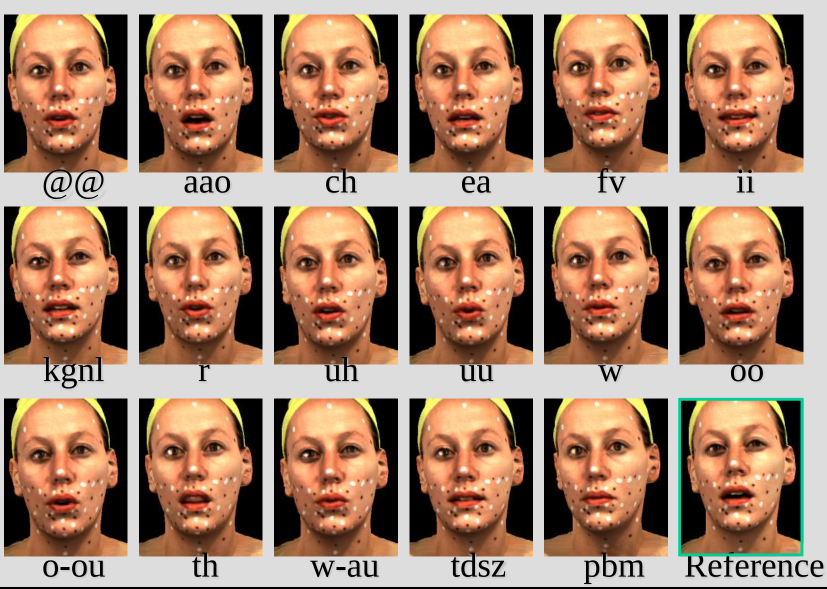
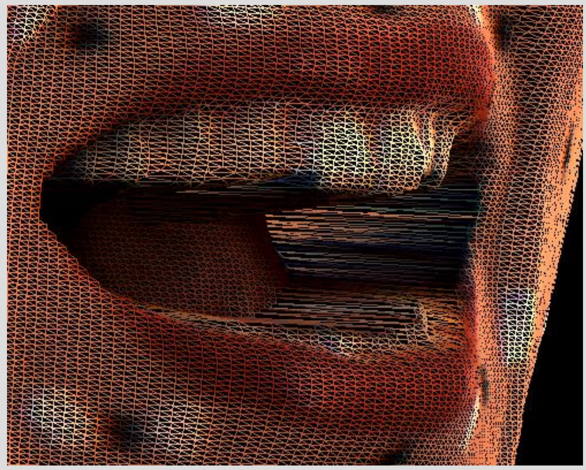
3D Scans of Visemes



Mouth Mesh



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Mouth Modeler

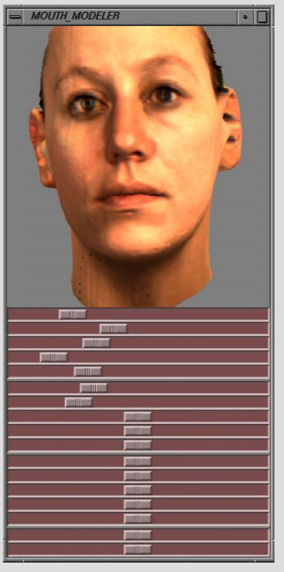
Principal

Components

Mouth Modeler

Principal

Components



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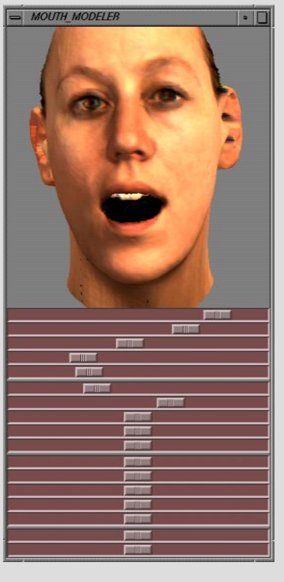
Mouth Modeler

Principal

Components



Speech Animation

Text → Phonemes ← Audio

Phonemes
↓
Visemes
↓
Morph Targets
↓
Video

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Retargeting Face Motions

Animation of Images