gravis

University of Basel

Face Image Analysis Applications

Probabilistic Morphable Models

Summer School, June 2017

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University Basel

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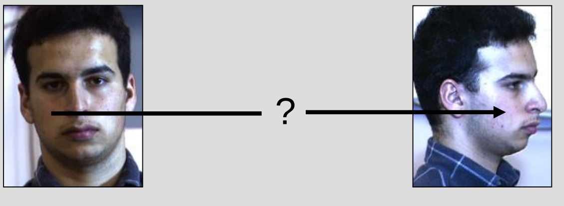
Face Identification by Image Comparison

… done by pixel analysis



But which pixel to compare with which ?

Shape information tells us which pixel to compare

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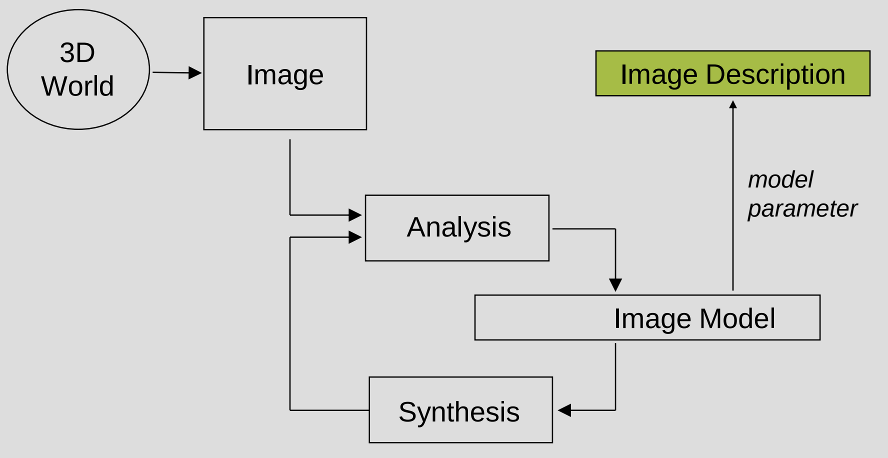
Analysis by Synthesis



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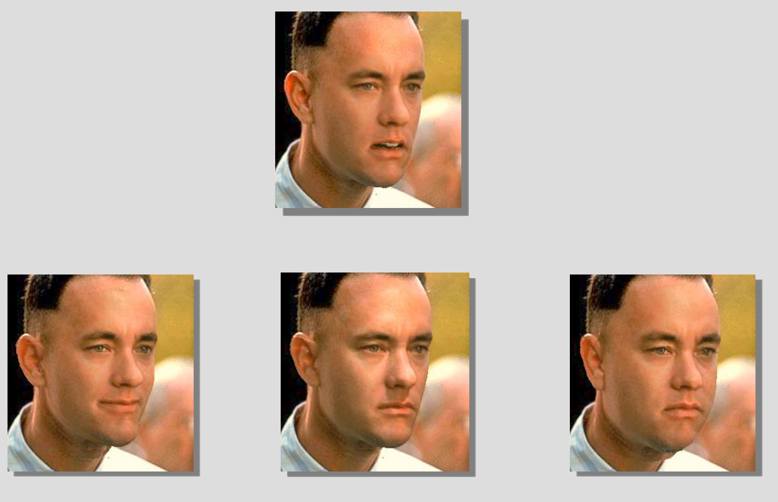
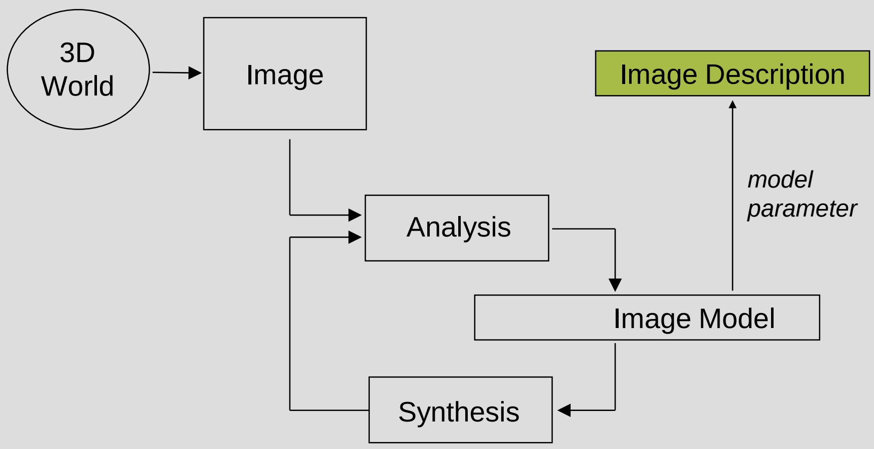
Change Your Image ...



Analysis by Synthesis



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THE BIG QUESTION:

`How is this Image Model structured?`

Is it:

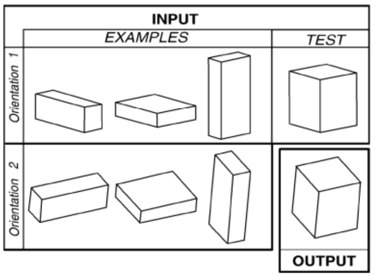
2D, an image based rendering model?

Or

3D, a full 3D computer graphics model?

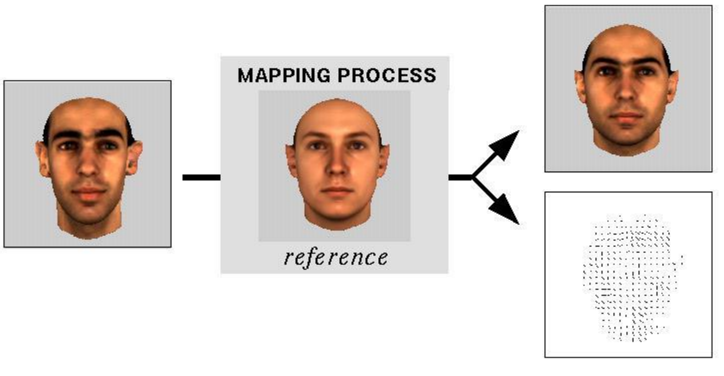
Possibly, there is no final answer!

Linear Object Class Idea

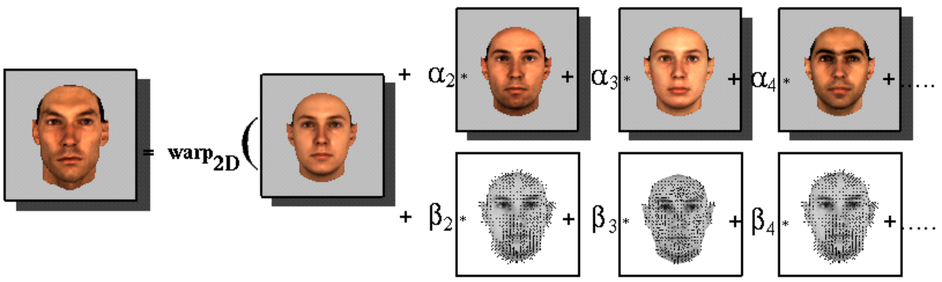


Linear Object Classes and Image Synthesis from a Single Example Image.
Thomas Vetter and Tomaso Poggio *IEEE PAMI 1997, 19(7), 733-742.*

Separating shape and texture in 2D images



2D Morphable Face Image Model



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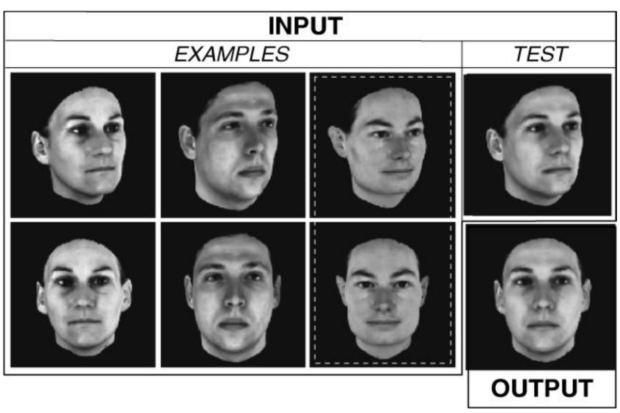
Linear Object Class Idea



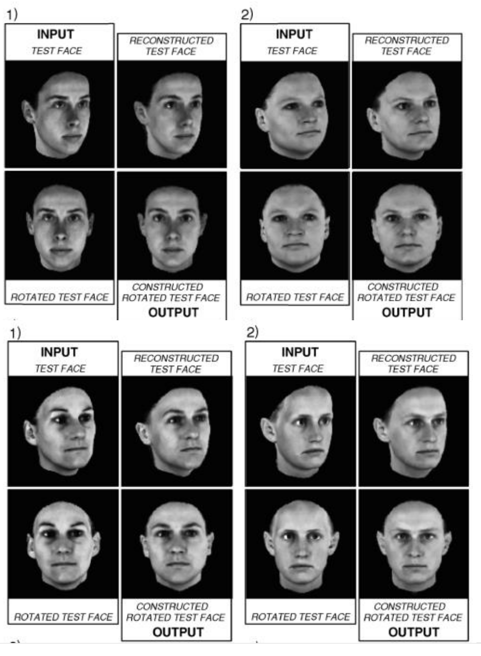
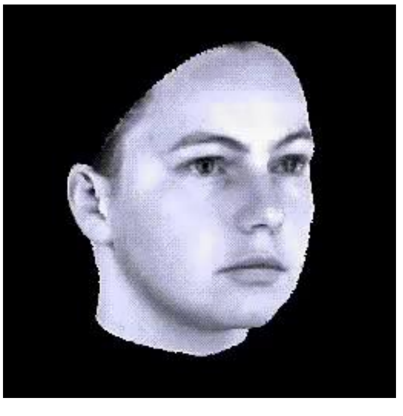
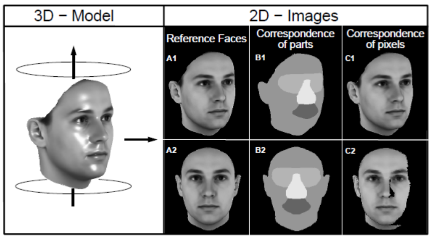
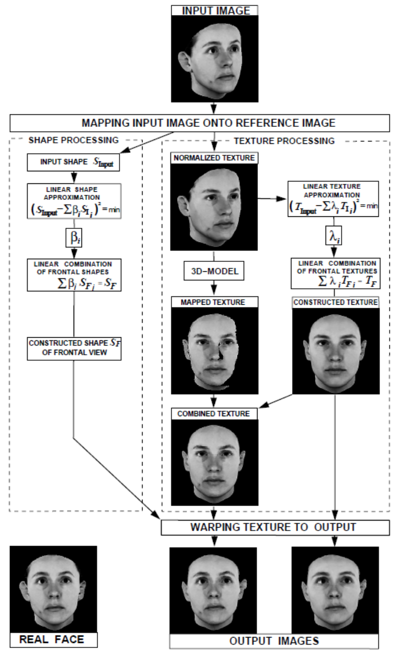


Image based rendering







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

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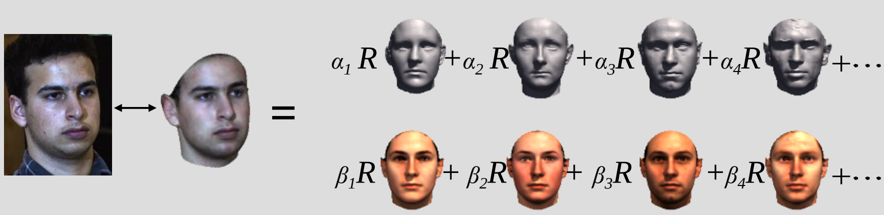
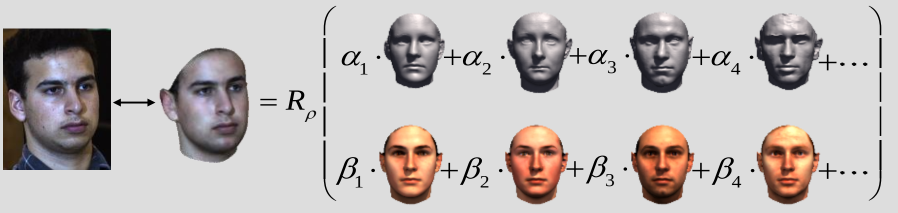
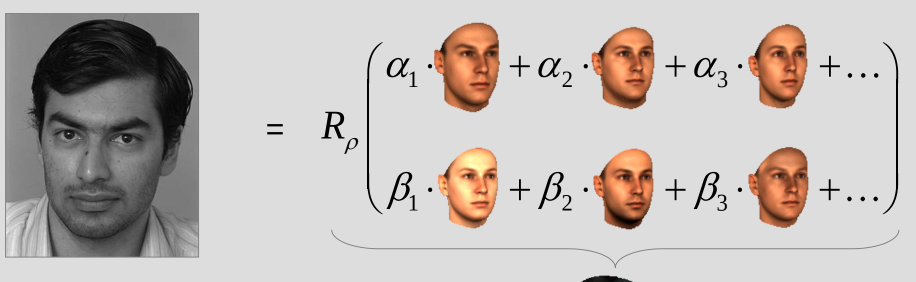
Morphable 2D Face Model



Morphable 3D Face Model



Morphable Models for Image Registration



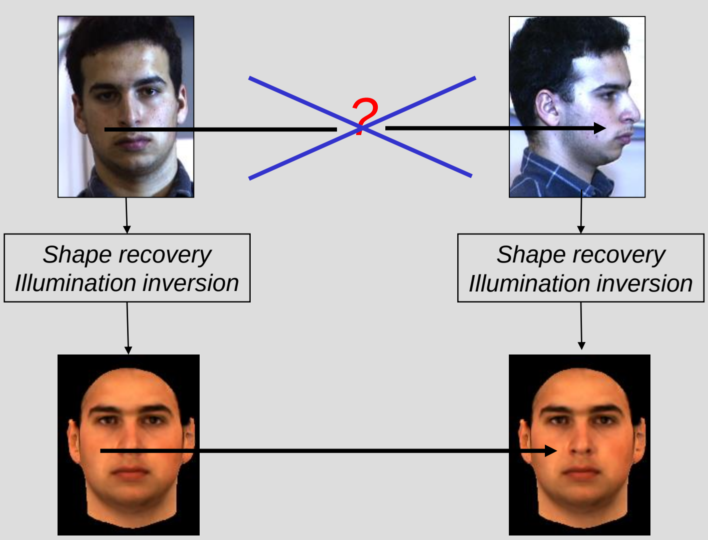
$\boldsymbol{R}$ = Rendering Function
ρ = Parameters for Pose, Illumination, ...

Optimization Problem: Find optimal α, β, ρ !

Output

Face Recognition

Normalizing for pose, illumination and …

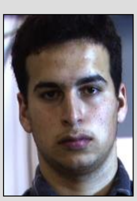


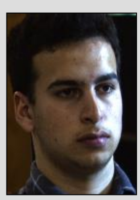
Multi-Features Fitting Algorithm

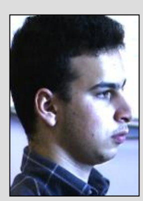
1 2 3 4 5

anchor	x				
edge	x	x		x	x
pixel int.			x	x	x
spec. highl.					x
tex. const.				x	x
prior		x	x	x	x

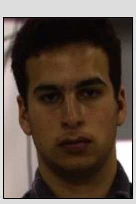
Face recognition

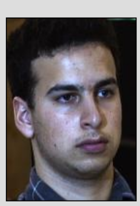






Complex Changes in Appearance





Images: CMU-PIE database. (2002)

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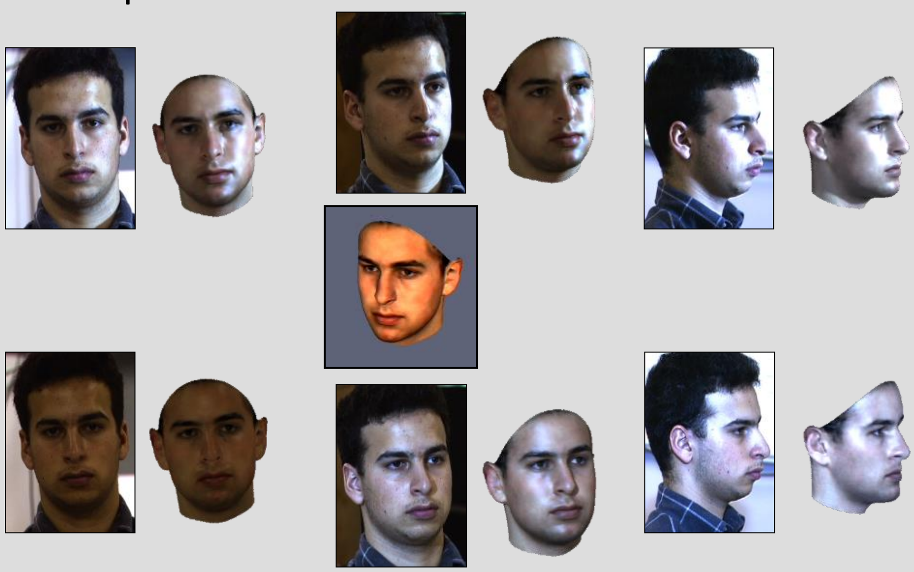
3D Morphable Model



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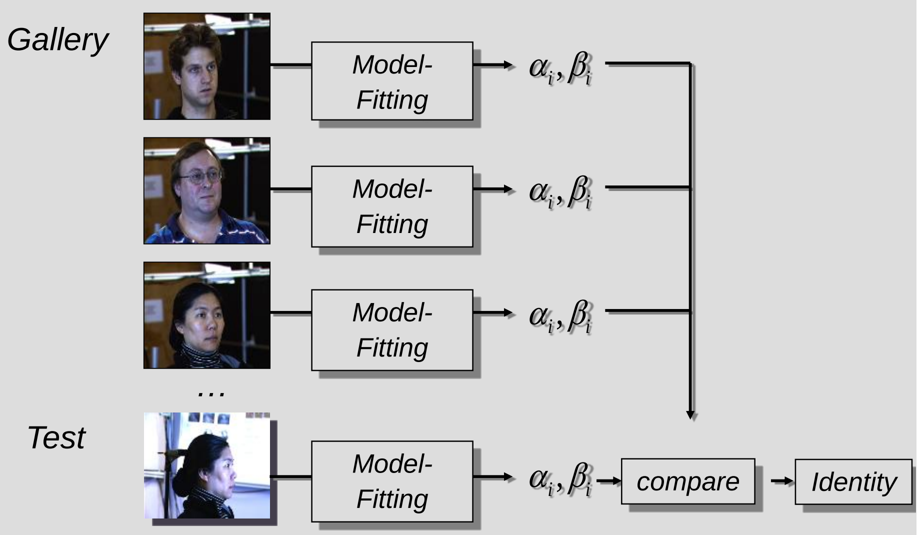
Identification by shape and texture coefficients only



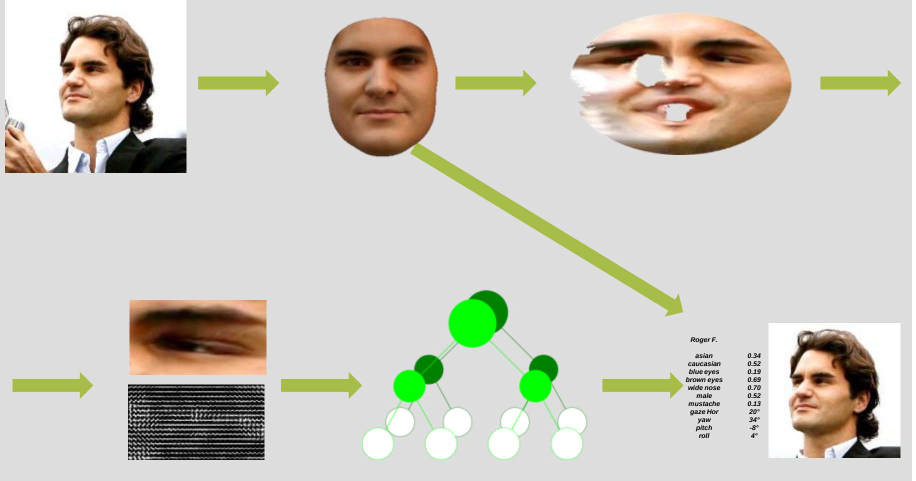
Correct Identification "1 out of 68" (%)

		gallery		
		front	side	profile
probe	front	99.8	99.5	83.0
	side	97.8	99.9	86.2
	profile	79.5	85.7	98.3
	total	92.3	95.0	89.0

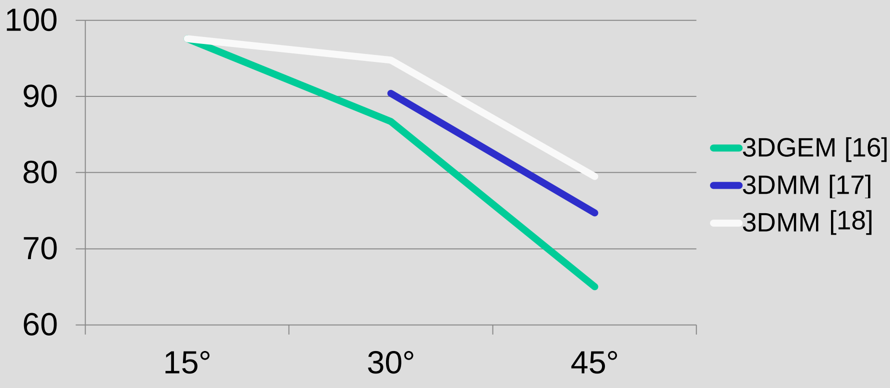
CMU-PIE database: 4488 images of 68 individuals

3 poses x 22 illuminations = 66 images per individua

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

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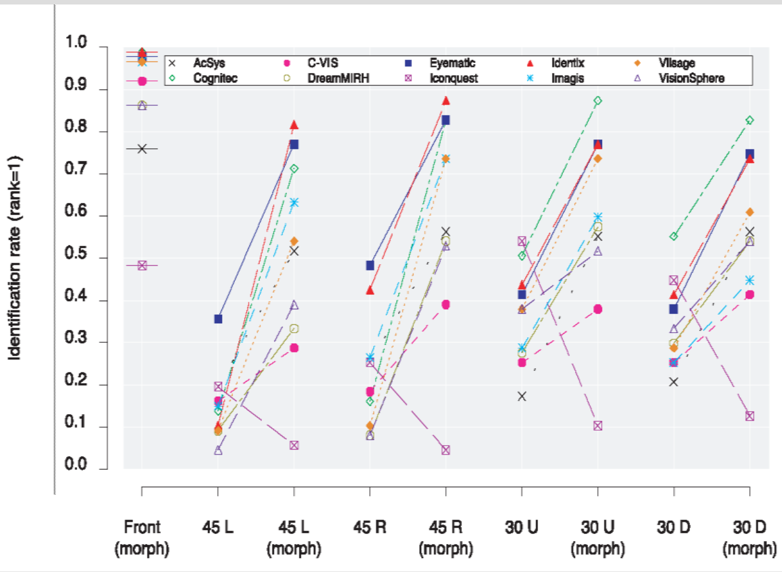
Image Preprocessing for FRVT 2002

Image Preprocessing for FRVT 2002



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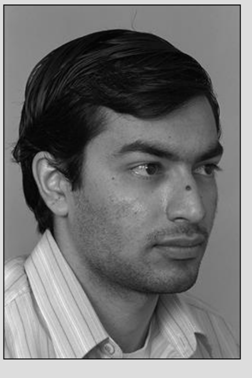
Skin Detail Analysis for Face Recognition



Skin Detail Analysis for Face Recognition

Jean Sebastian Pierrard , Thomas Vetter   CVPR 2007

Overview

Characterizing moles

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

Recognition

- Reference Systsem → Morphable Model

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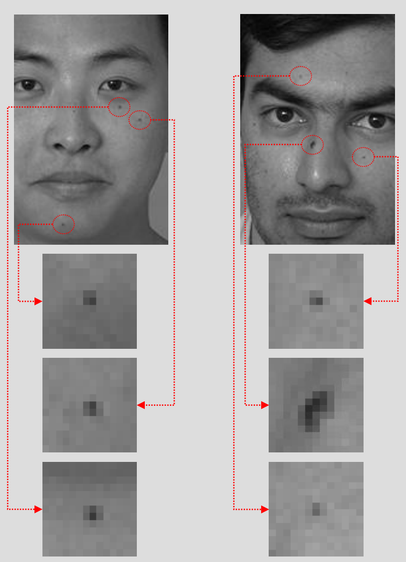
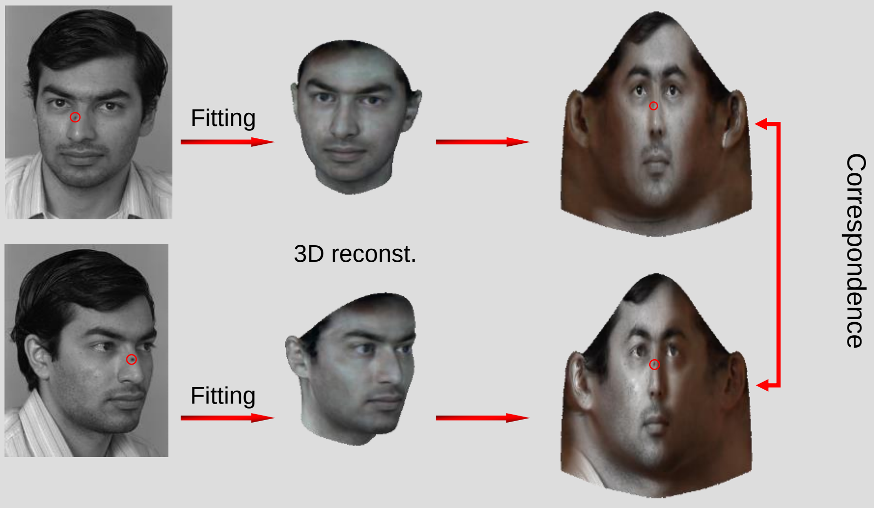
Data used

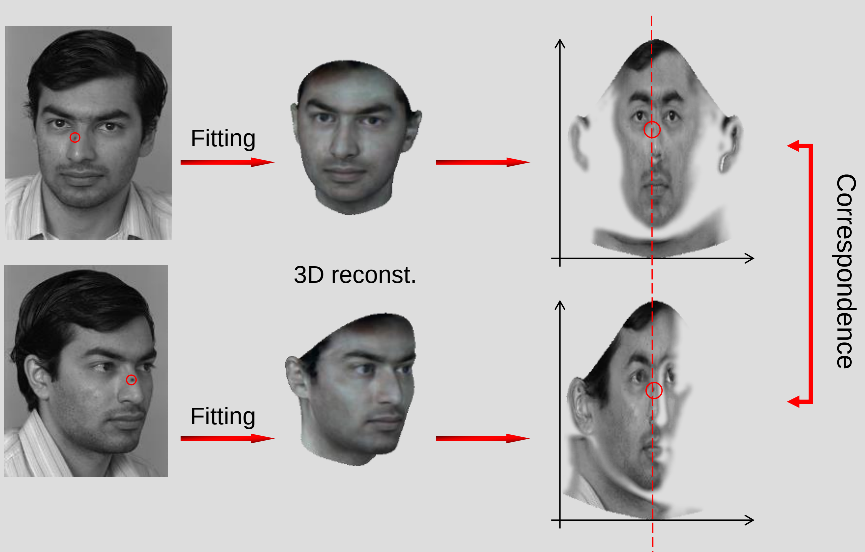
- Results based on subset of FERET-data base
  - Gray scale
  - Medium resolution (10-20k pixels face area)
  - Mole sizes: 2-20 pixels



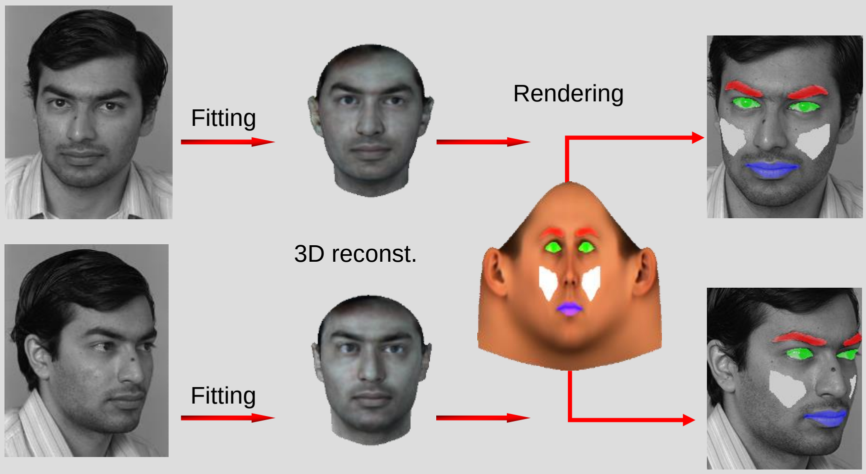
Morphable Model for Correspondence



3DMM maps visible region on a common reference

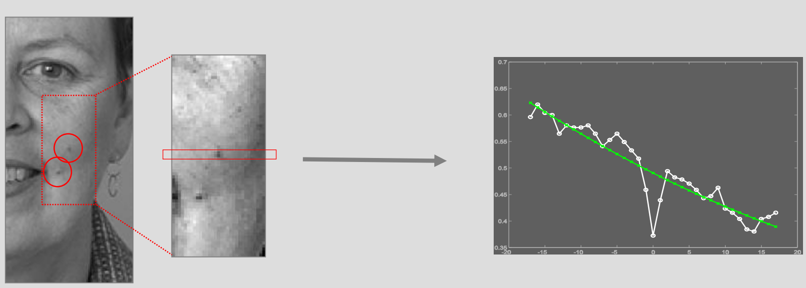


Morphable Model for Correspondence II

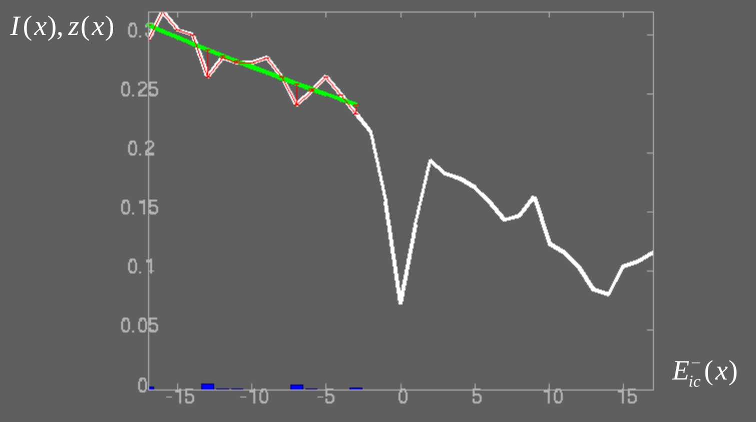


Mole Detection: Shading Problem

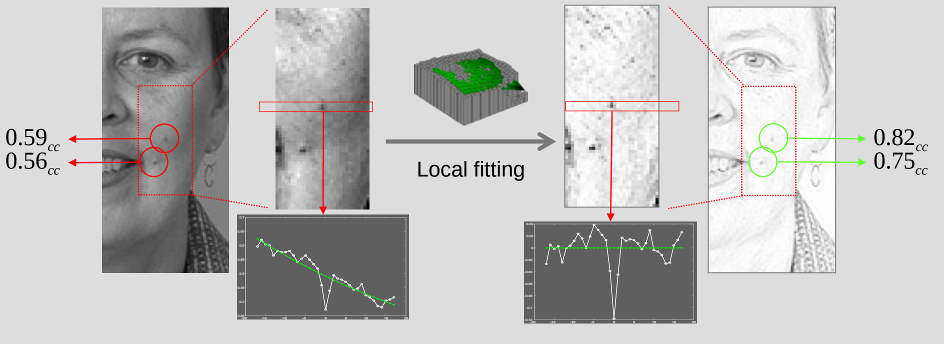
- Template matching is sensitive to intensity gradients !



Illumination Compensation

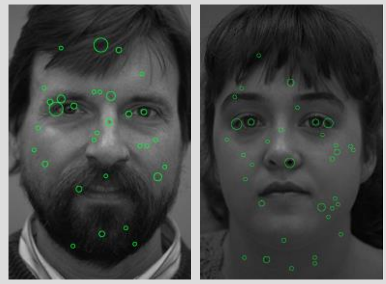


Mole Detection: Shading Problem



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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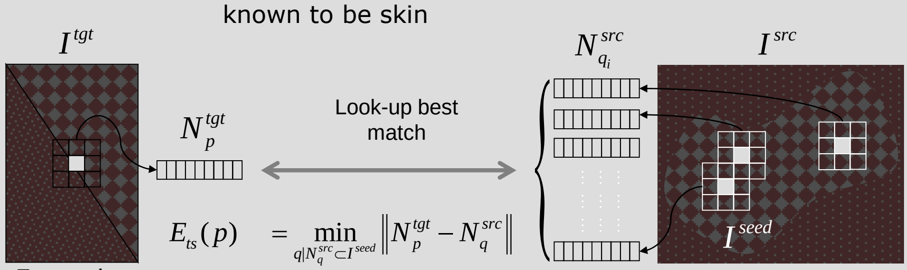
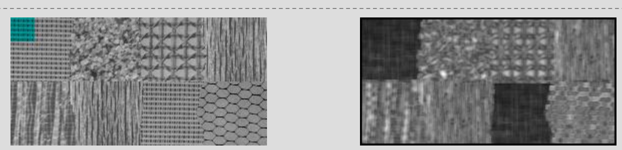
(Skin) Texture Similarity

<u>Basic idea:</u> Compare image texture with samples that are known to be skin

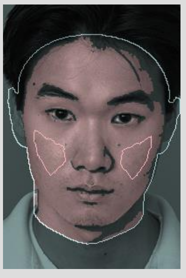


Example



Skin Segmentation

- Texture similarity facilitates simple segmentation-by-thresholding method
- Get threshold from seed region: in $I^{skin}(p) = \begin{cases} 1 & \text{if } E_{ts}(p) \leq \max\limits_{q \in I^{seed}} E_{ts}(q) \\ 0 & \text{otherwise} \end{cases}$



- Result still affected by shading

$I^{seed} = \text{"cheeks"}$

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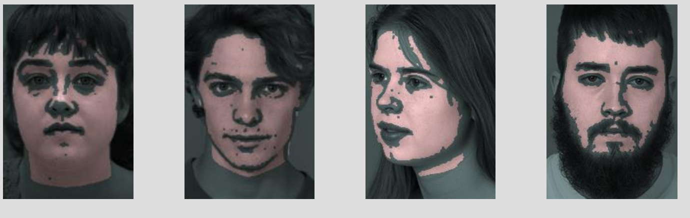
Segmentation Results

Thresholding

GrabCut



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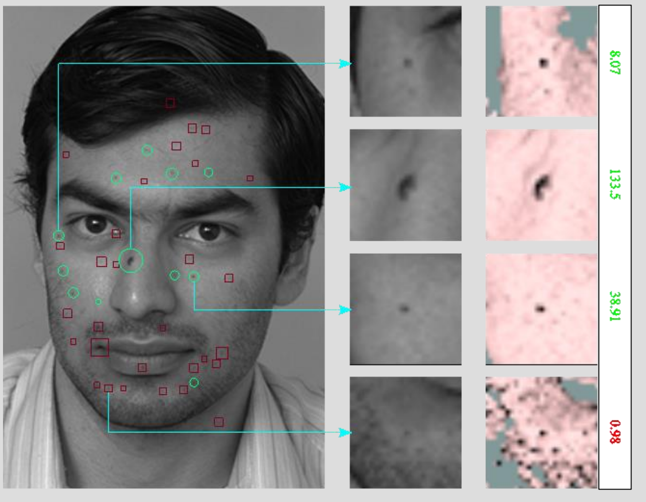
Selection by Saliency



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Recognition

- Find matching pairs of moles in reference frame

- Identification score:
  weighted sum of saliencies from matched points

Face Recognition

- Based <u>only</u> 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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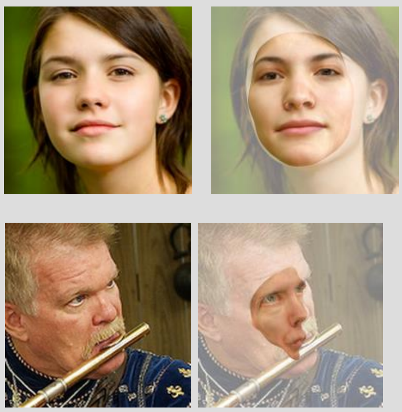
Occlusion-aware 3D Morphable Face Models

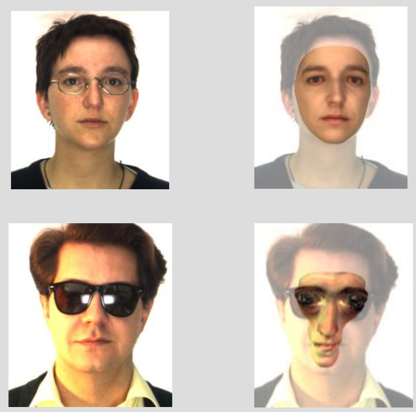
Bernhard Egger, Andreas Schneider, Clemens Blumer, Andreas Morel-Forster, Sandro Schönborn, Thomas Vetter

27th British Machine Vision Conference, September 2016

Face Image Analysis under Occlusion



Source: AFLW Database



Source: AR Face Database

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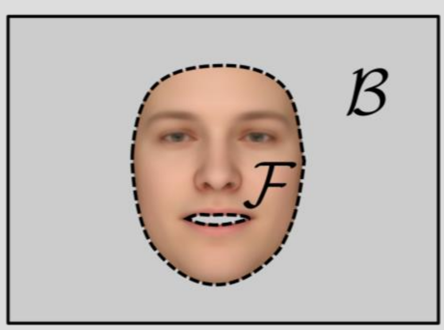
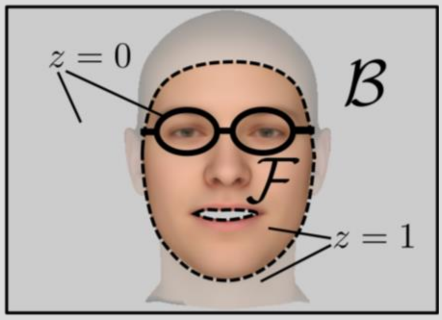
There is nothing like: no background model



$$\ell(\theta; I) = \prod_{x \in I} \ell\big(\theta; I(x)\big) = \prod_{i \in F} l_{face}(\theta; \tilde{I}_i) \prod_{i` \in B} b(\tilde{I}_{i`})$$

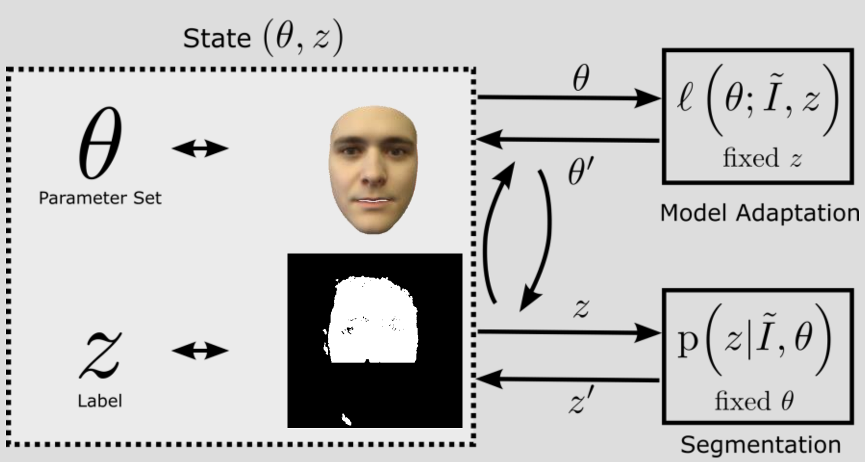
"**Background Modeling for Generative Image Models**"
Sandro Schönborn, Bernhard Egger, Andreas Forster, and Thomas Vetter *Computer Vision and Image Understanding, Vol 113, 2015.*

Occlusion-aware Model



$$l(\theta; \tilde{I}, z) = \prod_i l_{face}(\theta; \tilde{I}_i)^z \cdot l_{non-face}(\theta; \tilde{I}_i)^{1-z}$$

Inference



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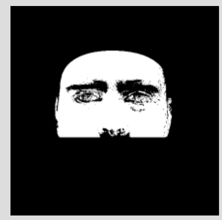
Initialisation: Robust Illumination Estimation

Init z



Init θ_{camera}

Init θ_{light}

54

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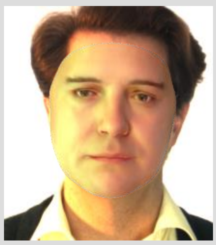
Results: Qualitative

Source: AR Face Database



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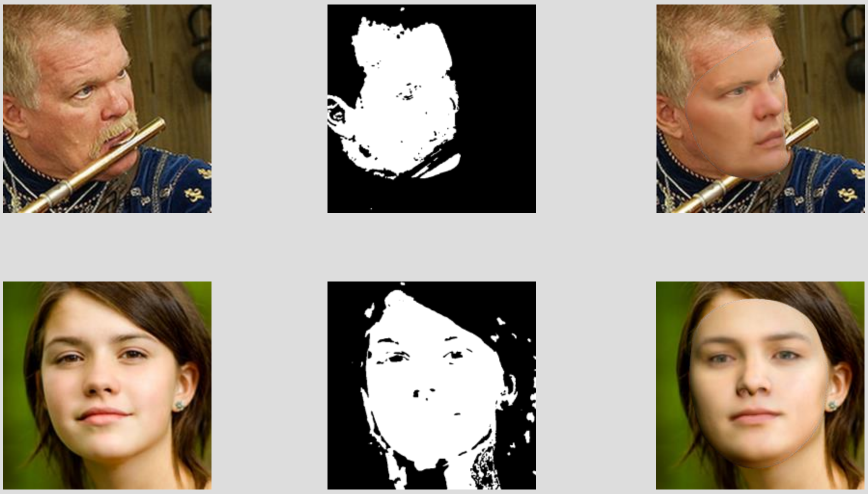
Results: Qualitative

Source: AFLW Database



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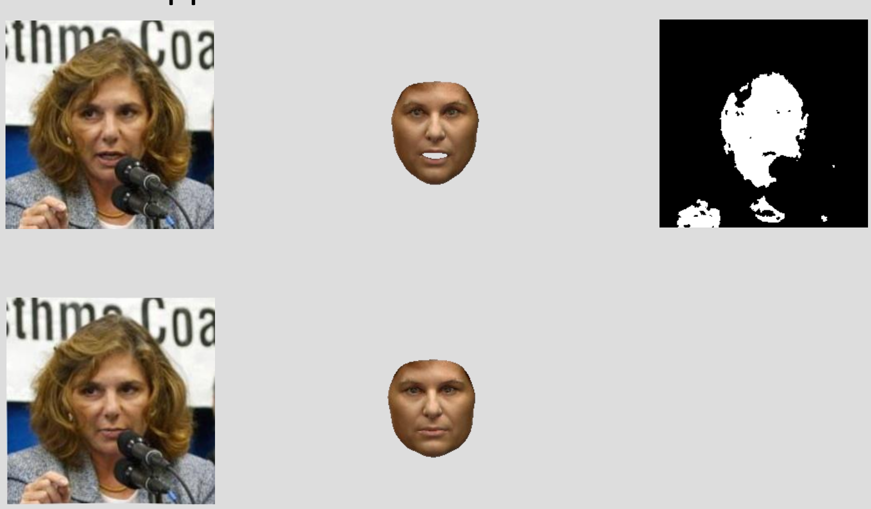
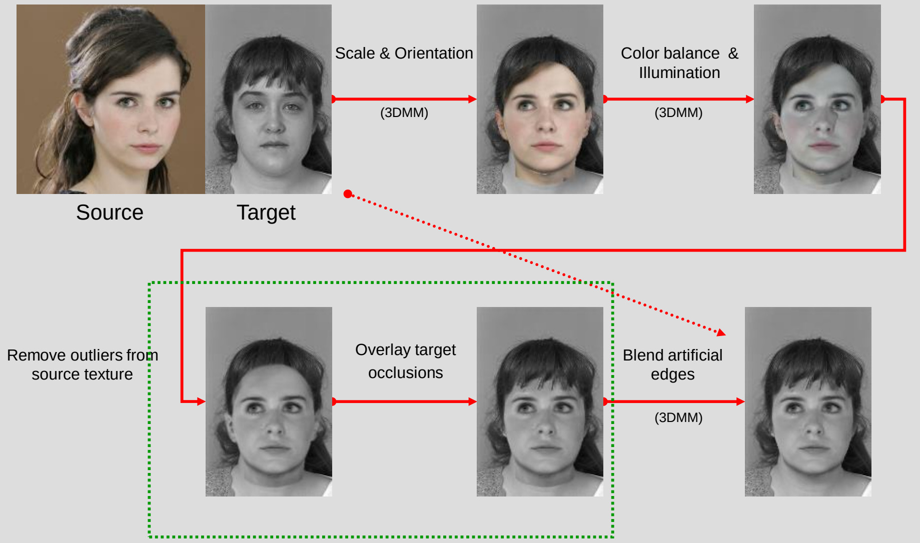
Results: Applications

Source: LFW Database



Face Exchange Tasks



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

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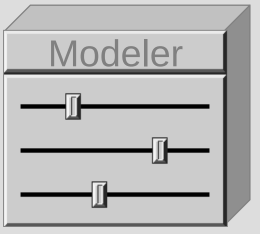
Manipulation of Faces



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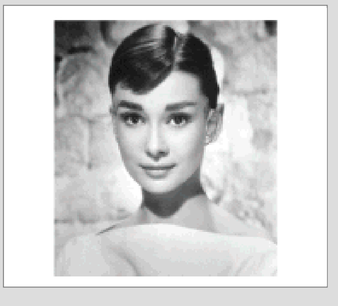
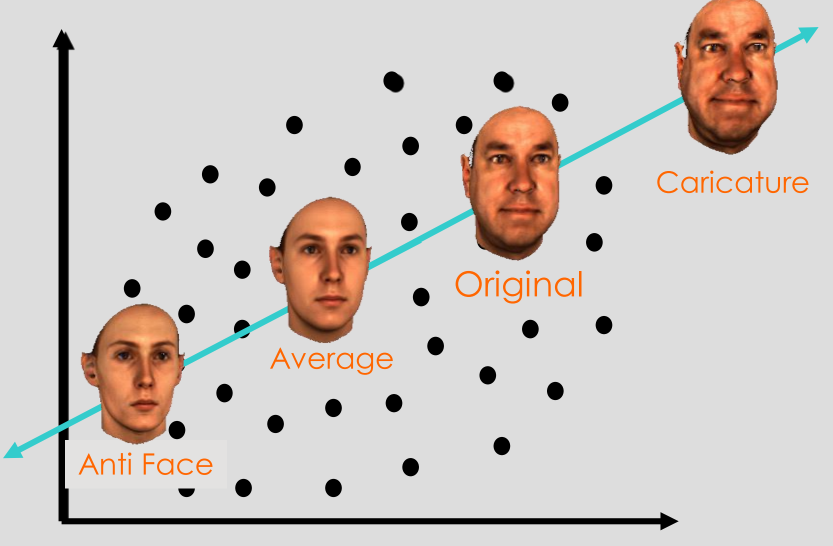
Modeling of 2D Images



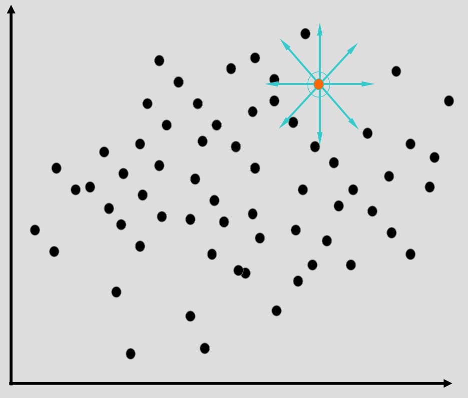
Face Image Manipulation

Continuous Modeling in Face Space

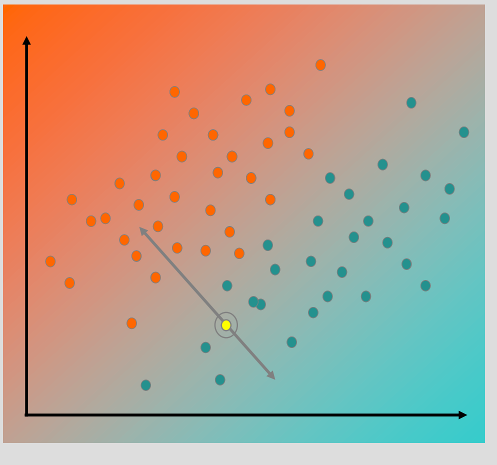


Modeling the Appearance of Faces

- Which directions code for specific attributes ?



Learning from Examples



Attributes of Faces

Gender

Weight

Original

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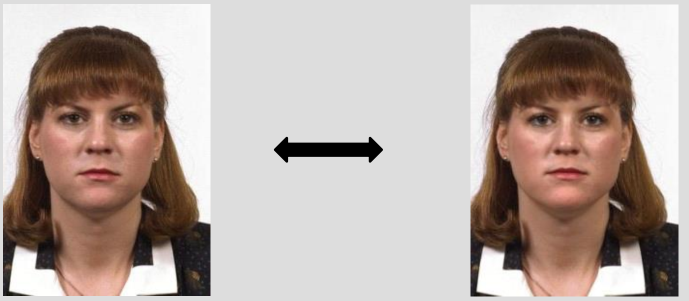
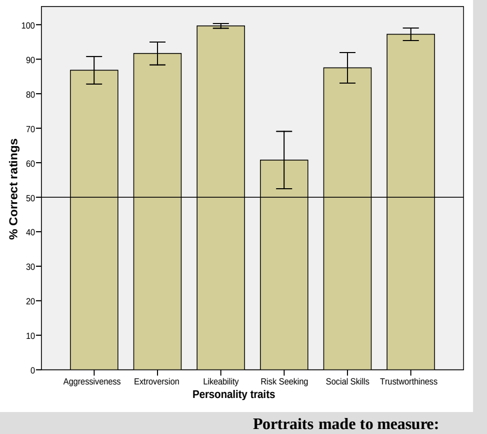
Portraits made to Measure

- 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
.

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Expressions

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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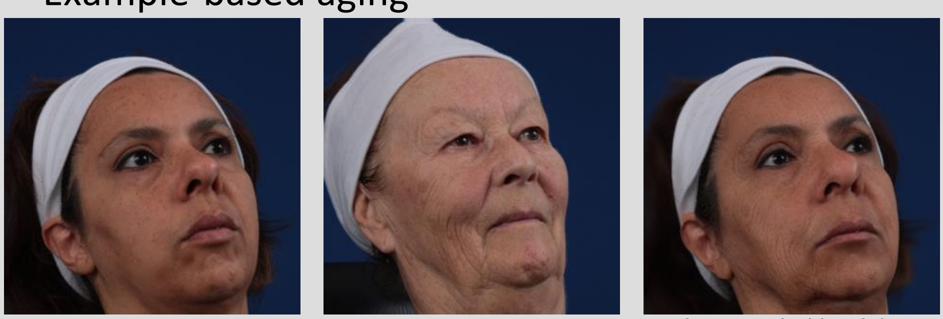
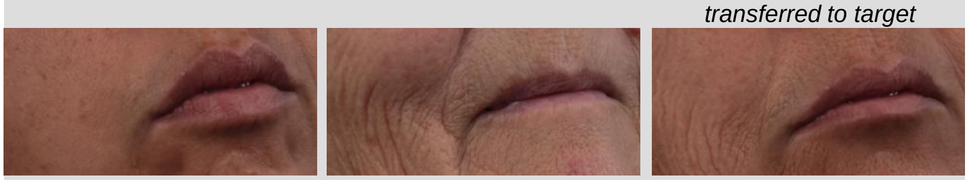
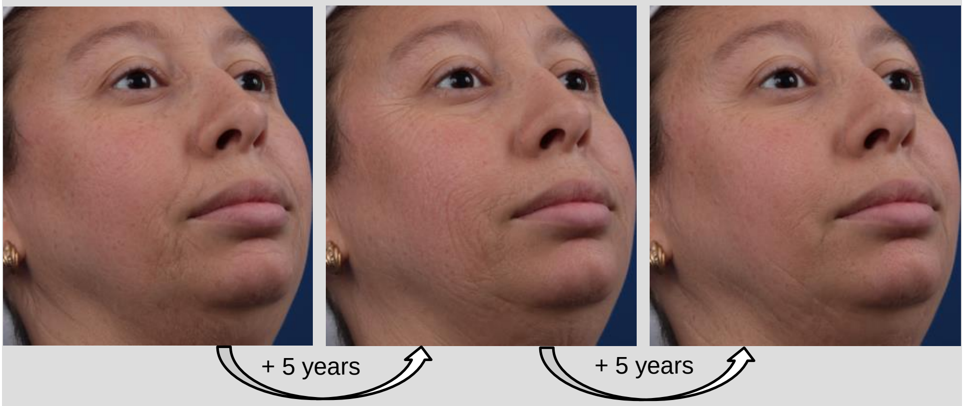
Example-based aging



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

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

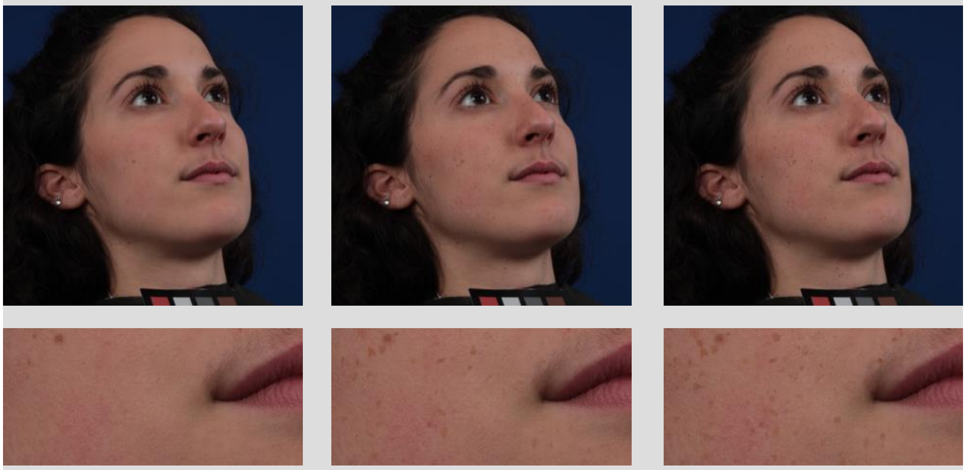
Facial texture source

detected freckles

σ, u, v

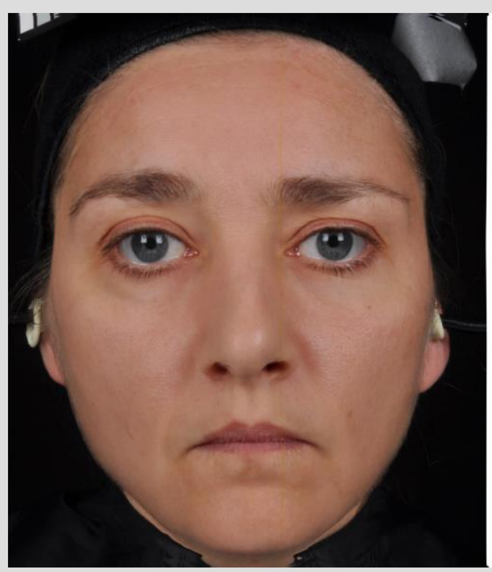
learned distribution parameters

Parametric Pigmentation Model



Aging Model

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



Transfer of Facial Expressions

Original:

 -  = smile

Novel Face:

 + smile = 

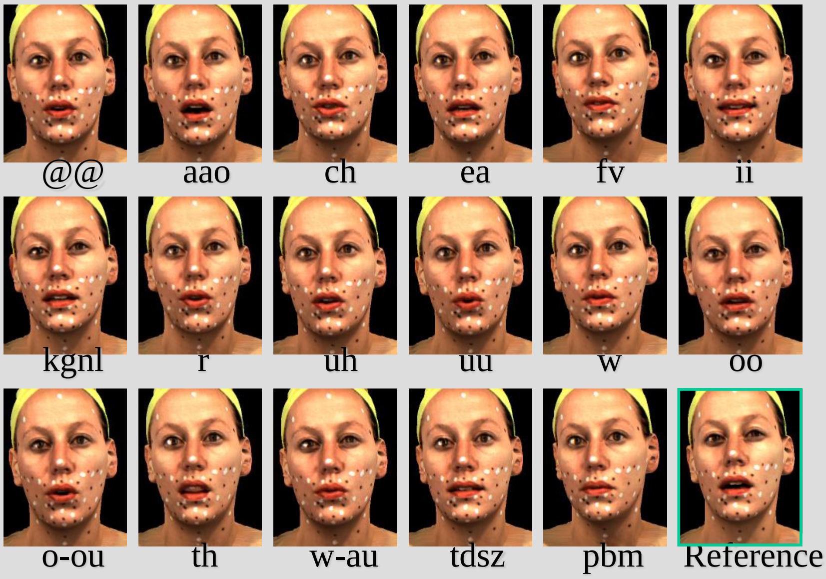
Expression Transfer

Id () + Xp () = 

Fitting *Fitting* *Rendering*

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

3D Scans of Visemes



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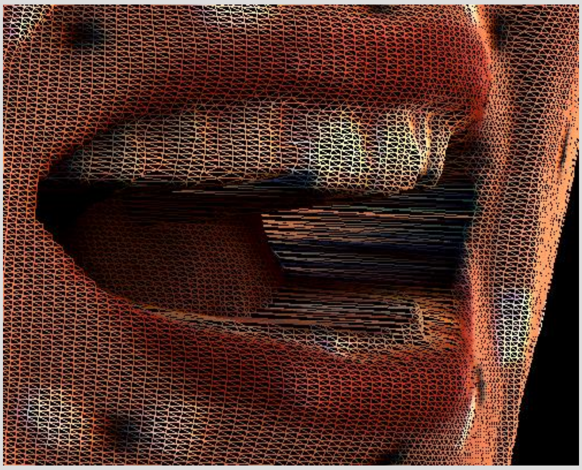
Mouth Mesh



Mouth Modeler

Principal

Components

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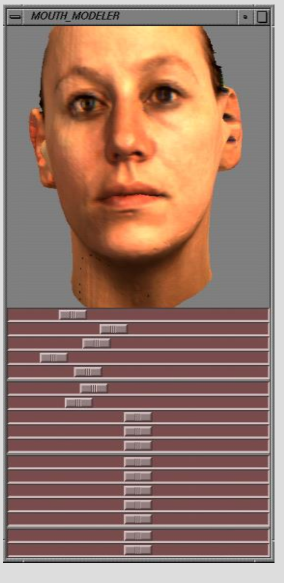
Mouth Modeler



Principal

Components

Mouth Modeler

Principal

Components

Speech Animation

Text ↘ ↙ Audio

Phonemes

↓

Visemes

↓

Morph Targets

↓

Video

Retargeting Face Motions