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Identity Solutions

Systematic Analysis of Facial Recognition Improvements in Multiple FRGC Challenges

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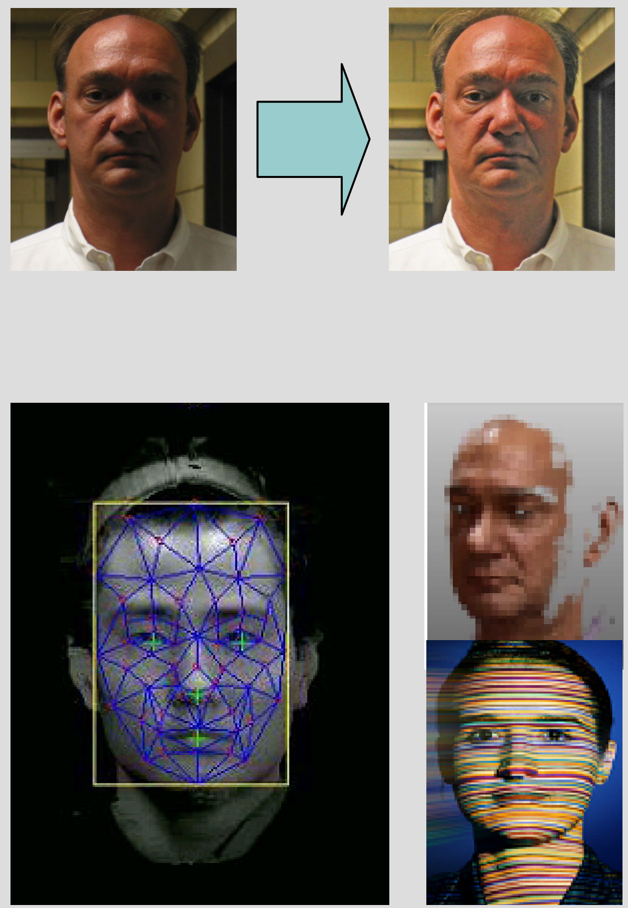
Outline

- **Scanner Characteristics & Illumination Correction**
- **3D Face Recognition**
- **High Resolution Data**
- **Overview to all Challenges**
- **Conclusions & Outlook**
- **References**



→ Scanner Characteristics & Illumination Correction

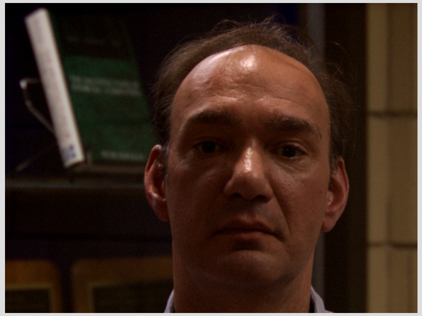
Image Preprocessing
Color Conversation (Minolta Scanner)

Observations

- R, G, B, and 3D scan not recorded at same time resulting in motion artifacts (e.g. pose correction)
- G, B rather dark

Corrective Actions

- Modification of standard RGB to grey conversion, i.e. only use of R channel
- Application of illumination correction algorithms
- Mixed dataset experiments (Exp. 5 & 6) must be handled separately



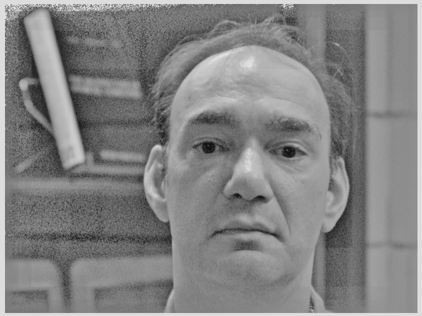


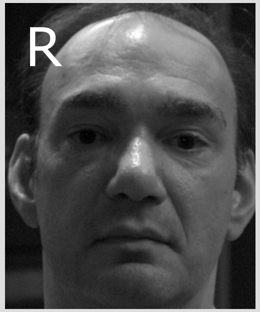
Image Preprocessing - Results

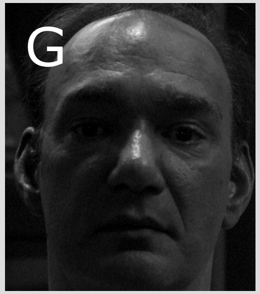
Results

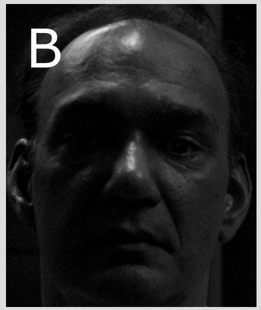
- Exp. 3t: Accuracy on single channels – R>G>B
- Exp. 5: Some overexposure on red channel of **controlled** dataset, R only is worse than RGB to grey conversion [(2R+7G+1B)/10]
- Exp. 6: Underexposure in all channels of **uncontrolled** dataset, R better than RGB to grey conversion [(2R+7G+1B)/10]

	(2R+7G+1B)/10	**R**	**G**
Experiment 3	-	1.2% / 96.7%	2.7% / 92.4%
Experiment 5	4.2% / 79.3%	4.1% / 76.5%	-

*** EER / Verification@FAR 0.1%**



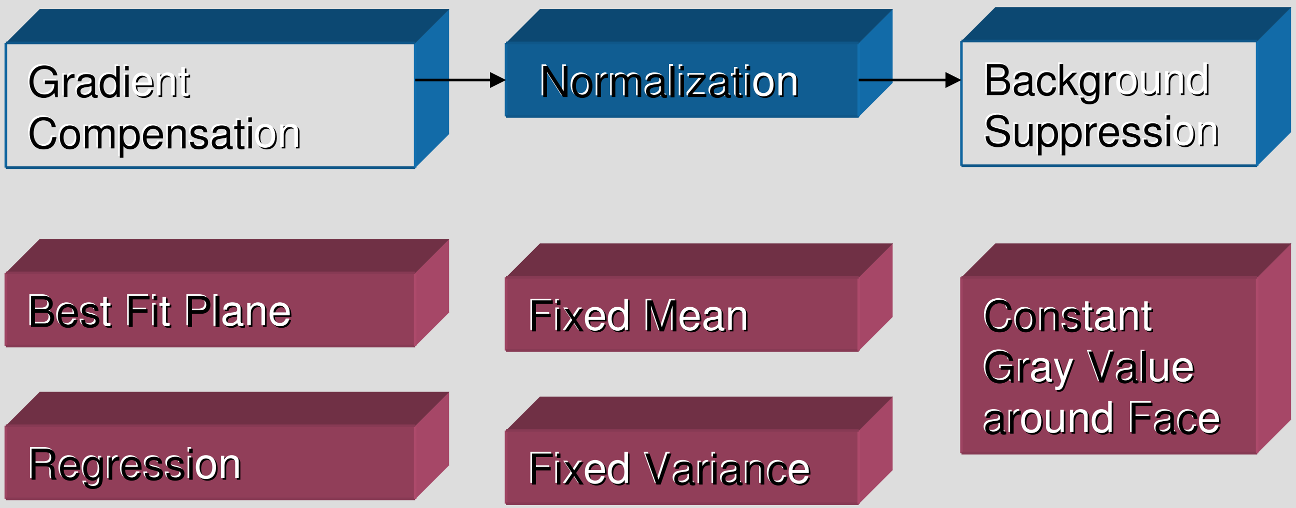




Illumination Correction (I)

Regression Over Grey Level Values in Facial Area

- Symmetry assumption, compensates for the slant of the regression plane
- Standardized image to fixed mean value and fixed variance



Illumination Correction (II)

Neighborhood Dependent Approaches

- Cooperation with Prof. Vijayan Asari, Old Dominion University
- Two approaches evaluated and optimized
  - HPSRR [Asari, Seow, 2004]
  - INDANE [Tao, Asari, 2004]

Experimental Setup

- Subset of FRGC Experiment 4
  - Gallery: 466 controlled images
  - Probe: 958 uncontrolled images
  - Training: 400 controlled, 400 uncontrolled images

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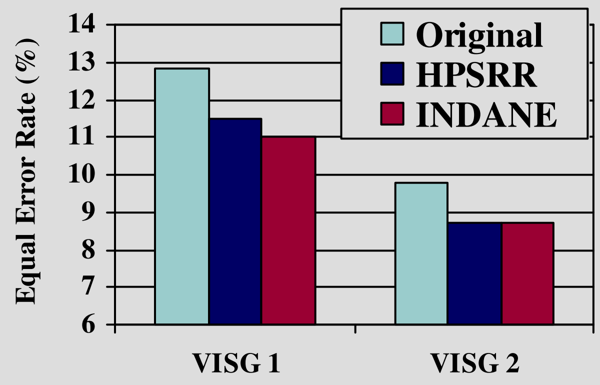
Experiments & Results

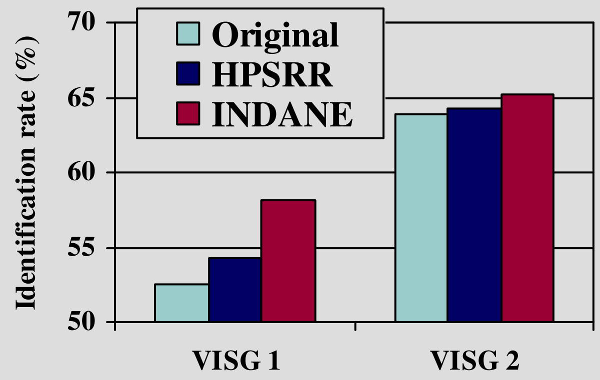
Evaluation Methods

- Two different recognition engines
- VISG 1: FaceTOOLS 3.2 (2004)
- VISG 2: Viisage's Lab engine (2004)
- Enhanced images are used as input to recognition engine
- Verification and identification scenario

Results

- Both illumination correction methods improves Viisage's FR accuracy
- INDANE better than HPSRR (HPSRR annihilates small features)
- Improvement higher with VISG1 (VISG2 already contains regression based illumination correction)





→ 3D Facial Recognition

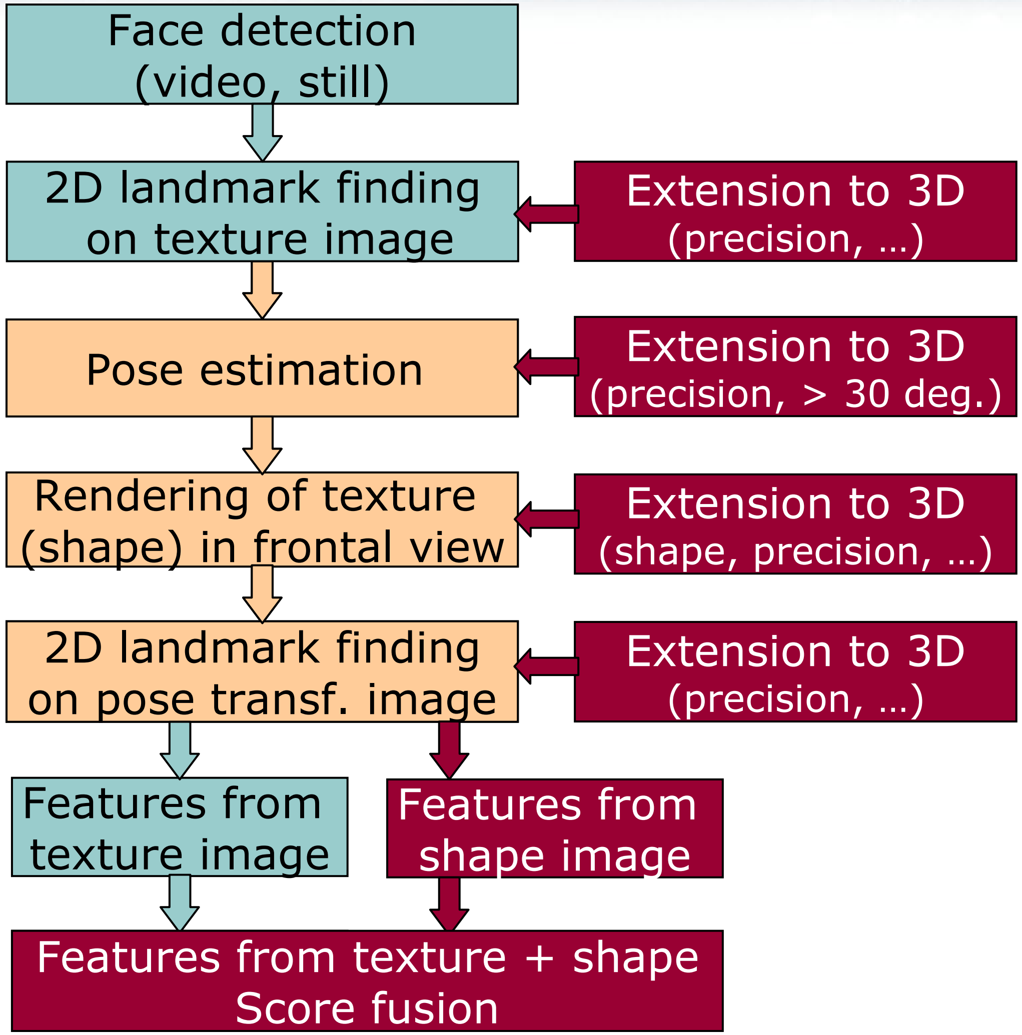
Fusion Strategies for 2D/3D Algorithms

Fusion on algorithmic level

- Landmark finding (2D, 3D)
- Pose estimation (2D, 3D)
- Pose correction (2D, 3D)
- …

Fusion on score level

- Shape and texture yield independent scores and quality (confidence)
- Fusion of scores



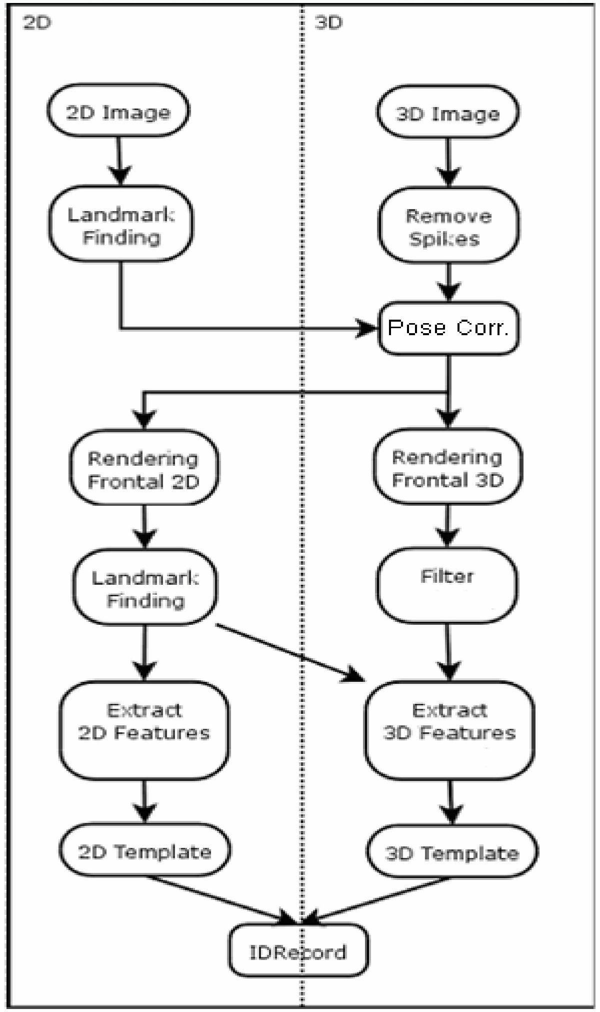
Viisage's 3D Approach (DICAR)

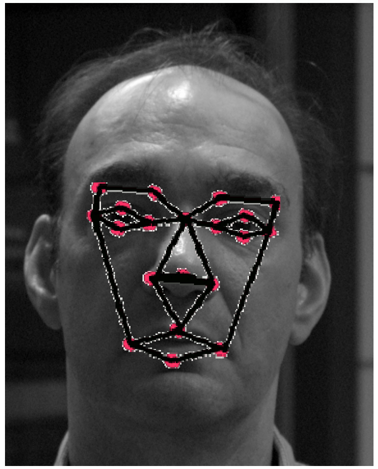
Foundation – HGM

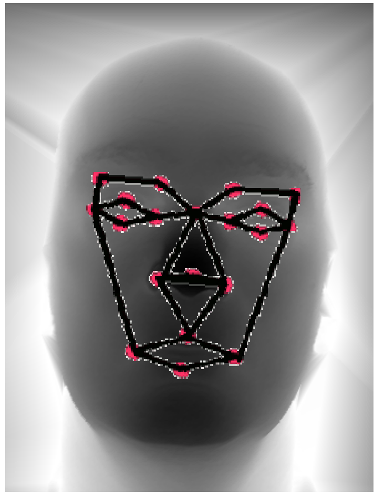
- Graph is automatically located to landmarks
- Optimized features are extracted at the landmark positions -> facial template
- Correlation in feature space determines the similarity between faces

Extension to 3D

- Extension from texture to depth images
- Additional feature extraction on surface data
- Fusion of texture and shape results on score level







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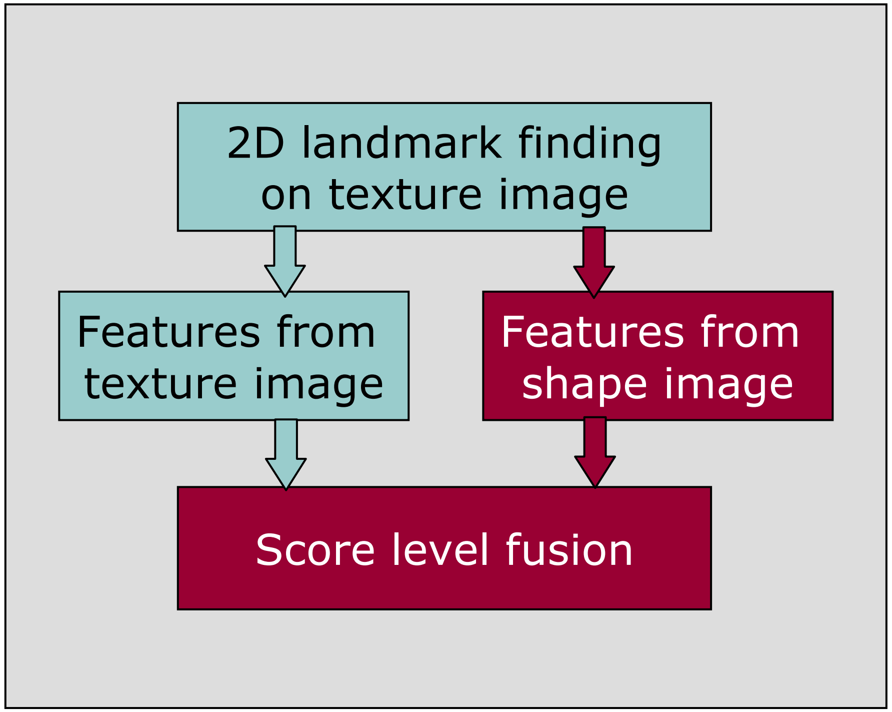
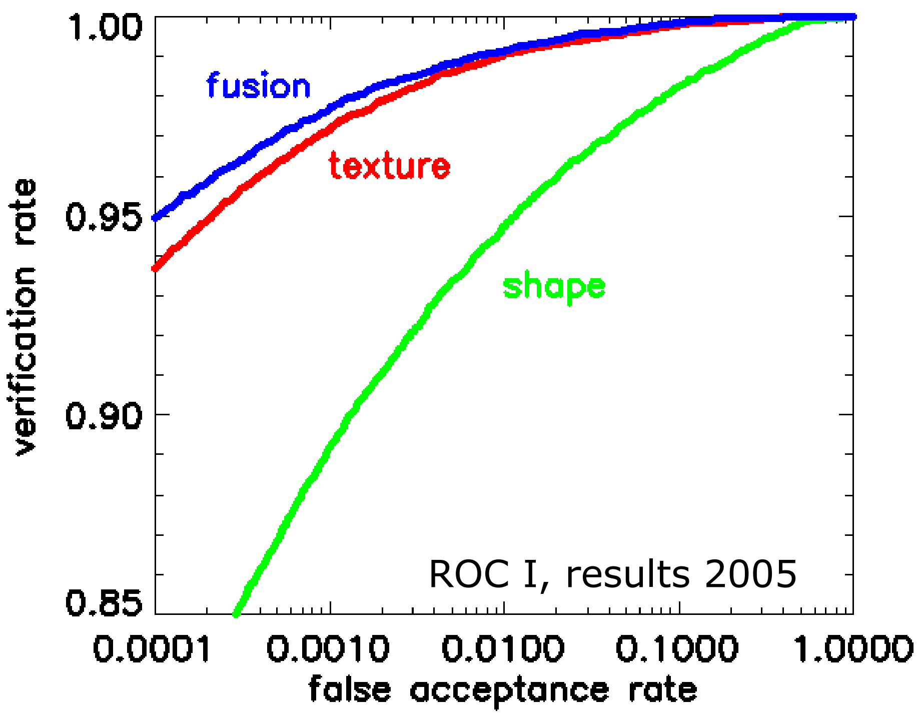
Results of Score Fusion





- Texture strongly outperforms shape, even in spite of unbalanced illumination
- Score level fusion yields the best results

Fusion of Algorithms and Scores

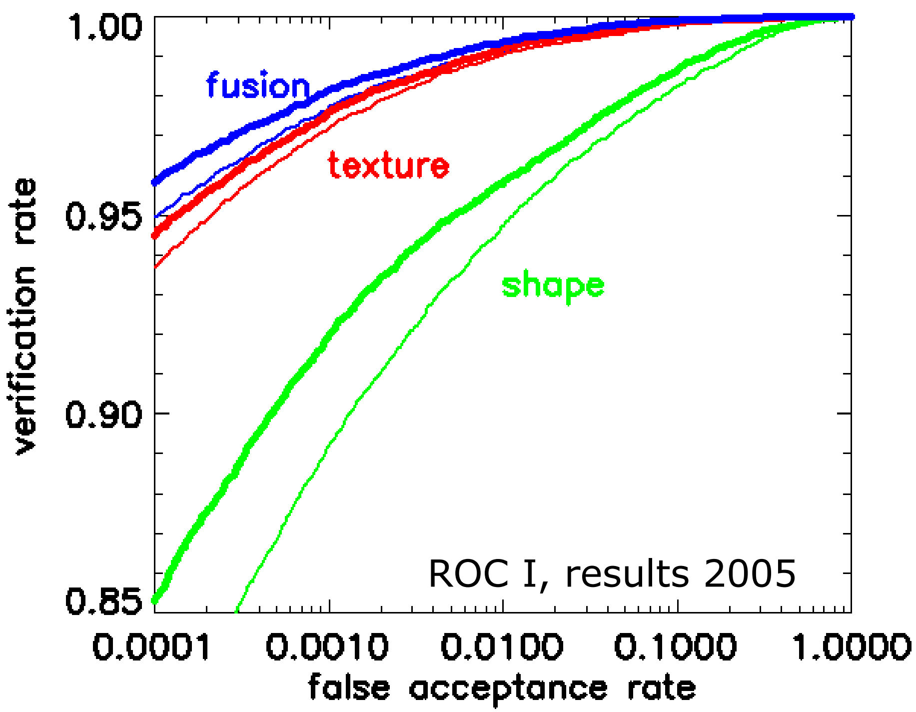
Pose correction based on texture and shape

2D landmark finding on pose transf. image

Features from texture image

Features from shape image

Score level fusion



- Pose correction yields further improvement in both modalities and after fusion

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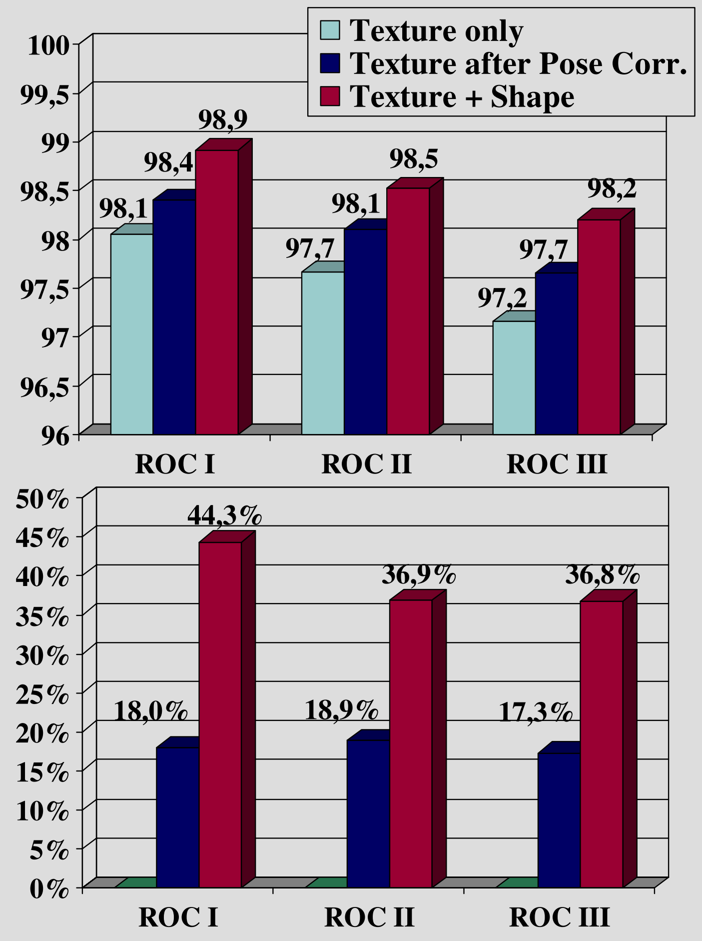
3D Results on Actual Engine

Results of 2005 are confirmed

- 2D HGM engine only performs at level of 97–98% correct verification rate @ FAR of 0.1%
- Pose correction using 3D shape improves verification rate by approx. 18 % in comparison to 2D engine
- Combined pose correction, HGM on shape and score fusion of shape and texture improves verification rate by 37-44% in comparison to 2D engine
- Absolute differences are less than 1% in verification rate



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→ High Resolution Data

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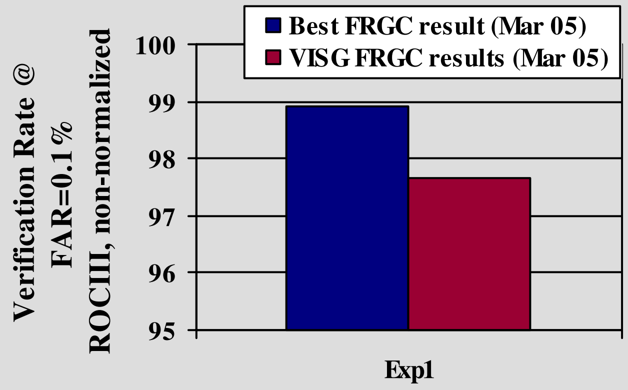
High Resolution Data

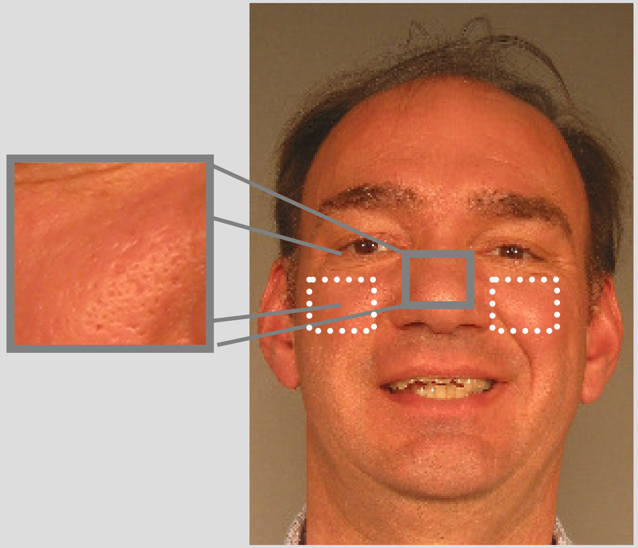
Motivation

- Analysis of FRGC results (2005)

Solution

- Correlation based method to exploit additional information in high resolution images
- Selection of appropriate areas, where facial micro features are invariant to pose, illumination and expression
- Fully integrated into Viisage’s core FR engine
  - Landmark/region finding
  - Score fusion HGM/Facial Micro Features





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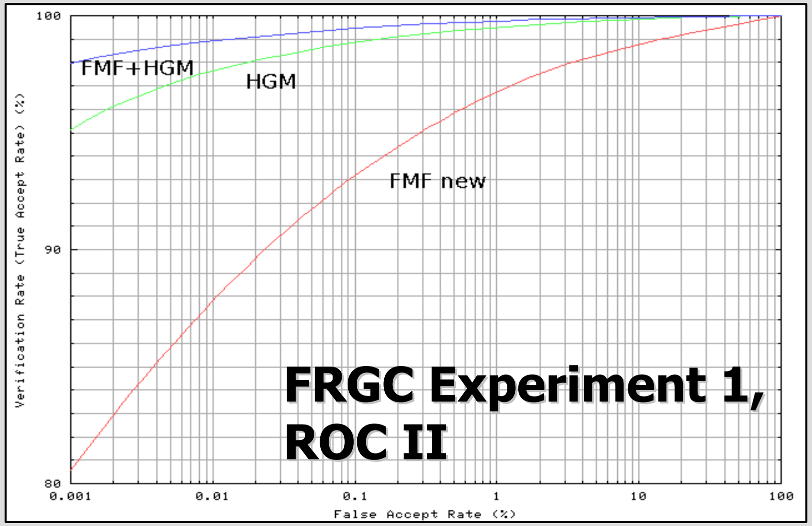
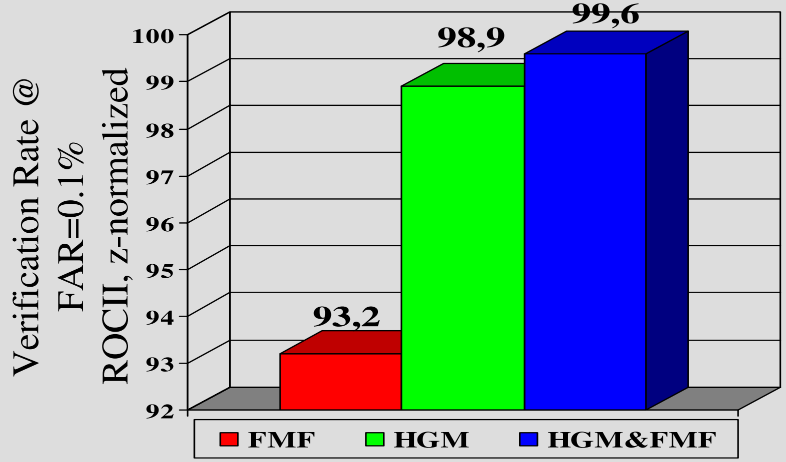
Facial Micro Features (FMF)

Results

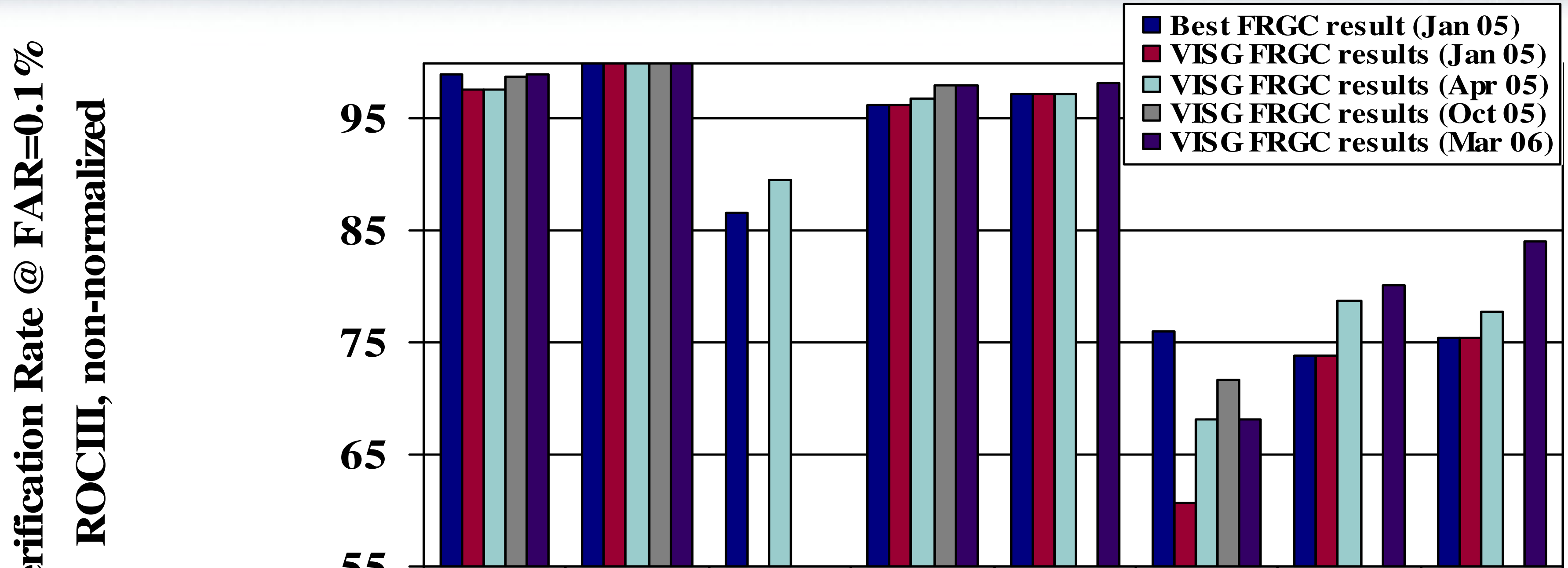
- Successfully tested on multiple data sets (e.g., FRGC, FERET)
- Significant improvement of accuracy on high resolution images (FRGC experiment #1)
- Unchanged accuracy on insufficient images
- Low matching speed for large scale tests -> hierarchical matching implemented
- Small additional template size (~3kB)





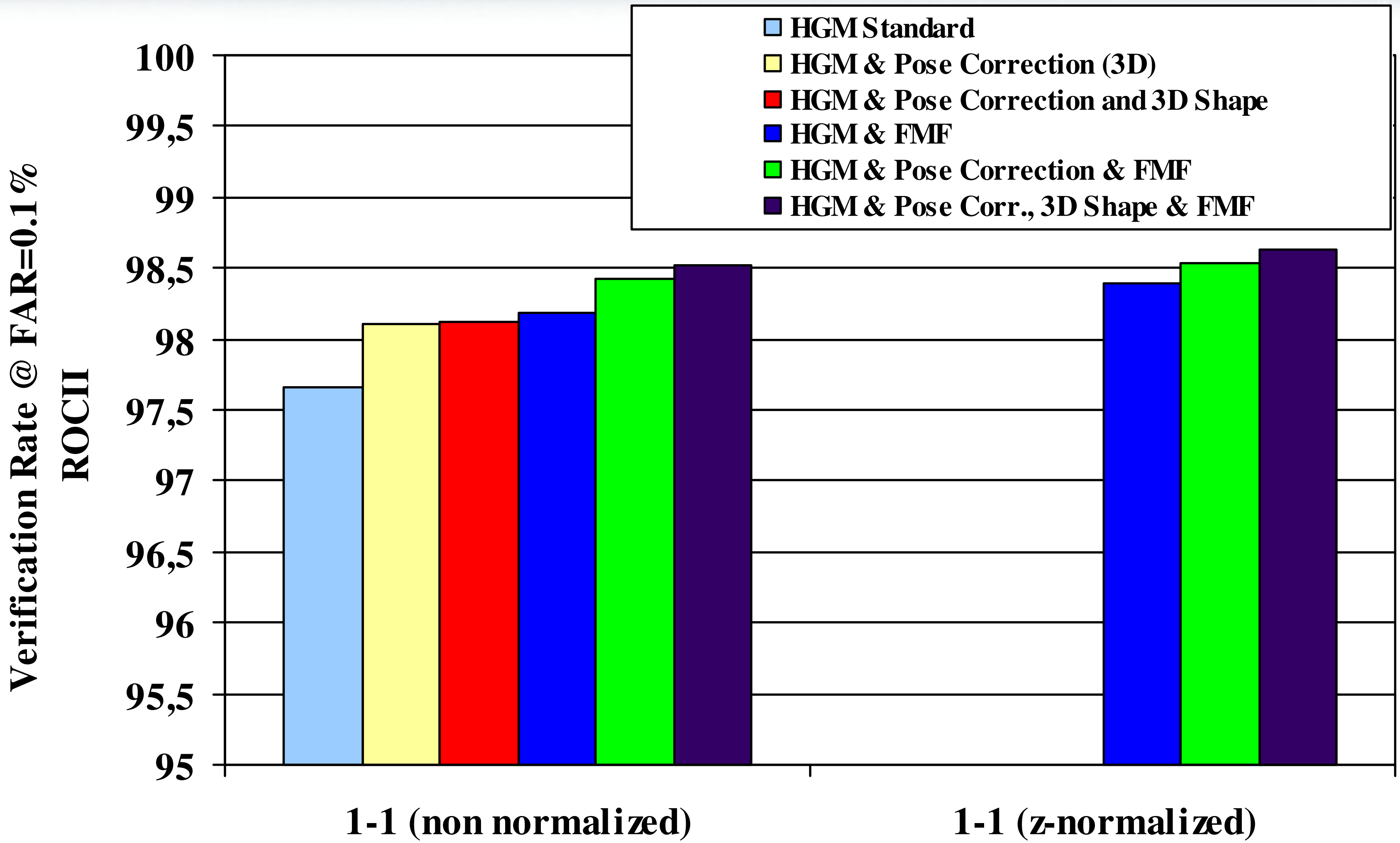
→ Overview to all Challenges

Evolution of FR Performance (FRGC data)



	Exp1	Exp2	Exp 3s	Exp3t	Exp3 (s+t)	Exp4	Exp5	Exp6
Best FRGC result (Jan 05)	98,92	100	86,55	96,22	97,28	76	73,9	75,5
VISG FRGC results (Jan 05)	97,64	99,96	---	96,22	97,28	60,65	73,90	75,50
VISG FRGC results (Apr 05)	97,64	99,96	89,56	96,88	97,28	68,10	78,75	77,72
VISG FRGC results (Oct 05)	98,78	100,00	---	98,11	---	71,75	---	---
VISG FRGC results (Mar 06)	98,98	99,91		98,06	98,21	68,12	80,18	84,06

3D vs. Micro Features on Exp. 3



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→ Conclusions & Outlook

Conclusions and Outlook

Summary

- ✓ Illumination correction greatly improves recognition on uncontrolled images
- ✓ High resolution works well for cooperative scenarios
- ✓ High resolution adds more than 3D
- ✓ We used a general purpose FR system in contrast to prior submissions

Outlook

- ✓ **FRGC** provided a cornerstone to improve FR systematically
- ✓ **FRGC** focused on specific aspects (high resolution, 3D)
- ✓ There are scenarios like low resolution, images with pose , and video processing that have been left untouched
- ✓ **FRGC II** may focus on those
- ✓ Thanks to Jonathon Philips and TSWG
- ✓ **Thanks** to all people, that contributed to the collection of datasets either with their faces or their heads.

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THANK YOU!

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