

# Biometric Application using a 3D Face Model

## Workshop on 3D and 2D Face Analysis and Recognition

**Jan. 28, 2011**

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# Biometric Market

## Identity Solution

- Secure Deliverance of a unique right (Vote, ID document)
- Statistically good Quality images ... but very large population

## Forensic Application

- Solving Crime : every hit counts
- Heterogeneous image quality
- Police officer may spend time on a single case

## Border Control Application

- Increase workflow & Maintain Security level
- Passenger cooperation ?

### UIDAI

- Unique ID for India
- 10 fingers + 2 Irises
- 1+ billion citizens

### FBI

- central US system for latent fingerprints and tenprints

### SmartGate

- Australian Airports
- 40+ Gates - facial
- 2+ millions crossing

# Face Recognition in Biometric Market

## ■ Identity Solution

- Huge systems => 10e7 images and 10e14 comparisons.
- Trade-Off between accuracy and system cost
  - Cost : matching speed (CPU) and template size (RAM)

## ■ Forensic Applications

- Compare images from various origins
  - resolution + illumination + expression + Pose issues
- Face localization and pose adjustment may be done manually.

Face Image  
Enhancement  
Product

## ■ Border Control Applications

- Real time process
- Custom acquisition system => resolution issues
- Weak Passenger cooperation => limited illumination issues
- Weak Passenger cooperation => expression issues
- Weak Passenger cooperation => Pose issues

Face on the Fly  
Product

# Face Image Enhancement Need

## ■ Context

- What is the accuracy of Facial Recognition Systems ?
- It depends !

## ■ MBGC '08 – Portal challenge

- High Resolution, high quality, cooperative subject
- EER = 0% => perfect accuracy

## ■ MBGC '08 - Video challenge

- Very low resolution, non-frontal face ...
- EER = 49% => nearly random

- When the image quality is too bad for automatic processing, is there a way to interact with an operator, in order to improve biometric performance ?

# Face Image Enhancement

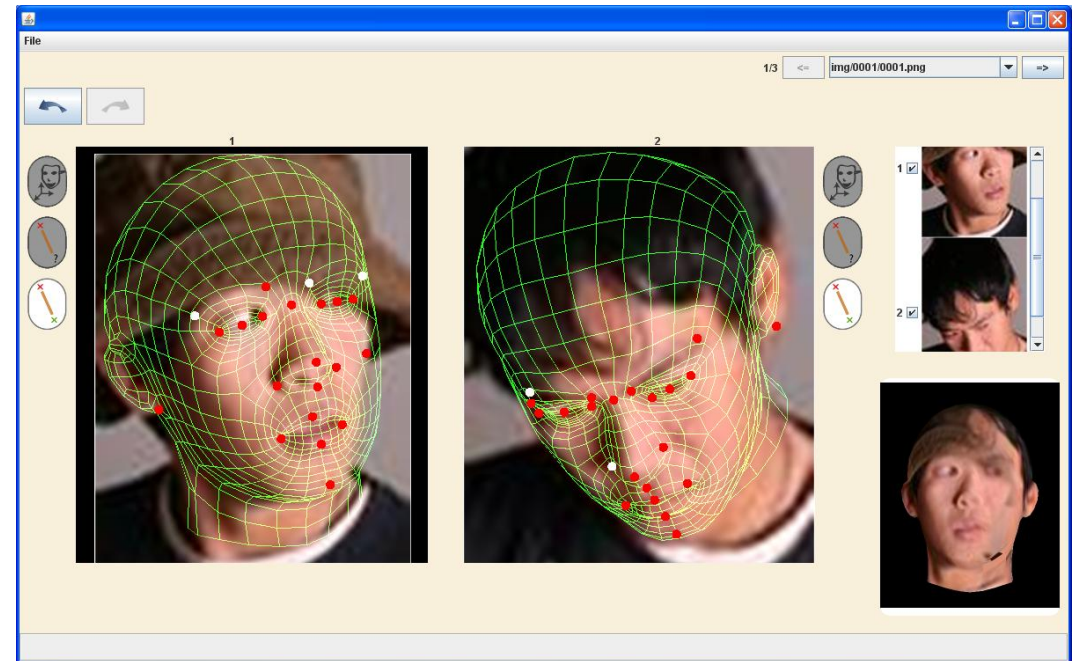
- In order to cope with non-frontal pose face images, we have proposed a tool that enables an operator to drive the fitting of a 3D face model on multiple 2D face images.

- **Simply Drag & Drop**

3D points on 2D images



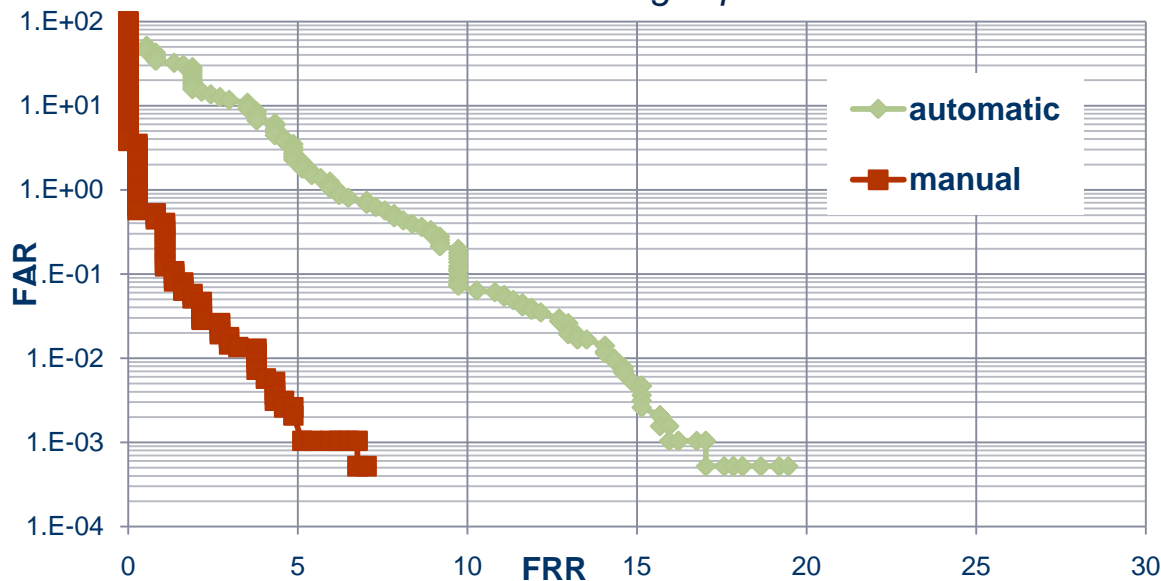
- **Automatic pose adjustment on each image**
- **Automatic deformation of a 3D morphable model.**
- **Synthesis of a frontal view with texture coming from multiple images**



# Impact on performance

- Evaluation on a small database (370 face images) processed by 40 operators.
- We compare frontal reference images with frontal views synthesized after :
  - Automatic fitting of the 3D model
  - or
  - Manual fitting by an operator.

*DET curves. Manual fitting improvement.*



<i>FRR</i>	@ <i>FAR</i> = 1.0%	@ <i>FAR</i> = 0.1%
Automatic	6.0%	9.7%
Manual	0.3%	1.3%

# Face Image Enhancement

- Even if the benefit of such a tools decreases with the improvement of automatic processing, there will always be a need for processing more difficult images

- Every Hit Count !

- Some of the current challenges are :

- Can we allow more degrees of freedom to our 3D model ?

- How can an operator drive that process ?*

- Can we automatically remove non uniform illumination ?

- Can we automatically merge images with different illumination ?

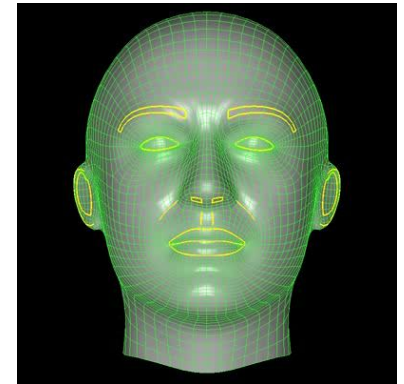
- How can an operator drive that process ?*

- Can we automatically remove non-neutral expression ?

- Can we automatically merge images with different expression ?

- How can an operator drive that process ?*

- This application is useful to test the potential of different algorithms on poor quality images



# Border Control Challenges

- **Current automated Border Control Gates Systems require :**
  - that the passenger stops in front of the camera(s)
  - a minimum level of cooperation from the passenger (look at the camera, don't smile ...)
  
- **As the goals are :**
  - To reduce the border crossing time
  - To maintain or improve security level compared to custom officer
  - To improve Passenger Acceptance
  
- **We have designed a gate that :**
  - Requires no stop from the passenger
  - Improves biometric performance
  - Lowers passenger cooperation level



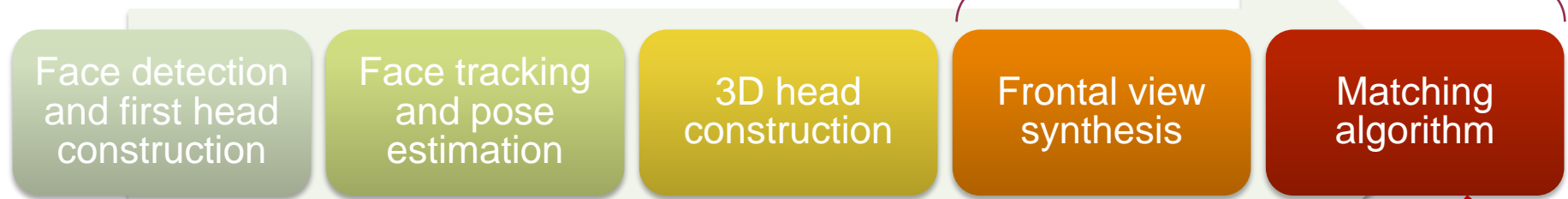
# Face on the Fly

## MorphoWay V on the Fly – Entry kiosk



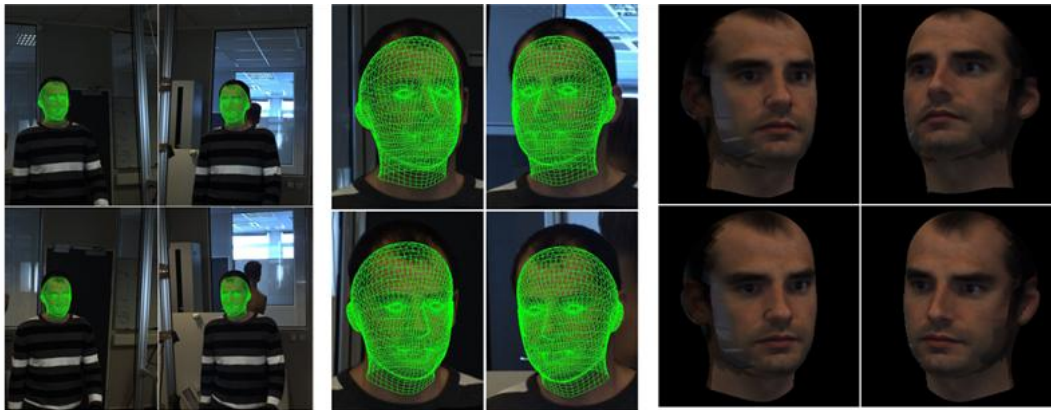
# Face on the Fly

End of sequence



Initialization

Each frame



## ■ Two different approaches have been tested

### ■ Stereo based

- *No limitation on the shape of the face*
- *Local fitting of images help the final texture synthesis*
- *At pixel level => first we align images between themselves, then we fit with model*

### ■ Model Based

- *Shape deformation are limited to a learned space*
- *Global model lead to a better robustness to local errors*
- *Good texture synthesis when only one camera see the texture*
- *At pixel level => independent fitting with model, then texture merging*

## ■ A merged approach implies to compare different kind of information.

- Are those images well aligned ? “Image vs Image” cost
- Does my Head Model well fit with this image ? “Image vs model” cost

# Face on the Fly – Project History

## ■ 2004-2007. First prototype.

- Ph.D. Thesis. with UPMC. William Ivaldi. “Synthèse de vue frontale et modélisation 3D de visages par vision multi-caméras”
- *W. Ivaldi, M. Milgram, S. Gentric, "A hybrid resampling framework for facial shape alignment," icpr, vol. 1, pp.488-491, ICPR, Volume 1, 2006*
- *W. Ivaldi, M. Milgram, S. Gentric: Generic Facial Encoding for Shape Alignment with Active Models. ICIAR (2) 2006: 341-352*

## ■ 2008-2010. Robustness improvement. Product design & Optimization.

- *N. Moënne-Loccoz, B. de Roquemaurel, S. Romdhani et S. Gentric. Reconstruction à la volée de portraits frontaux par modélisation 3D des visages. REFIG, 4(1), 2010*

## ■ 2010+. Next Generation

- Ph.D. Thesis with Telecom ParisTech & UPMC . Catherine Herold. Particle filter for Temporal Face Consolidation.
- *C. Herold, S. Gentric, N. Moënne-Loccoz. Multi-Pass Particle Filter for 3D Head pose Tracking using an Instantiated 3D Head Model. ICIP'11. To be reviewed*

# Face on the Fly - Challenges

## ■ Cost reduction

- Use of non-synchronized, non-calibrated webcams ?
  - *Impact on performance*
  - *Subject : On-line Auto-Calibration of a multi-camera system*
- Can super-resolution algorithms improve final face synthesis ?

## ■ Robustness to Expressions

- How to detect and cope with 3D non-neutral expression ?
- How to acquire a neutral expression while passengers are speaking ?

## ■ Robustness to Illumination

- Can we detect and remove illumination sources in real-time ?
- How to cope with glasses and reflection on glasses ?



# Questions ?

