Biometric Application using a 3D Face Model

Workshop on 3D and 2D Face Analysis and Recognition

Jan. 28, 2011

Stéphane Gentric, Ph.D.

Research Unit Manager – Biometrics

Morpho Senior Expert

SAFRAN
Morpho

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

SAFRAN
Morpho

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

➢   => limited illumination issues

➢   => expression issues

Weak Passenger cooperation

➢   => Pose issues

Face on the Fly Product

SAFRAN
Morpho

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 ?**

SAFRAN
Morpho

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**

SAFRAN

Morpho
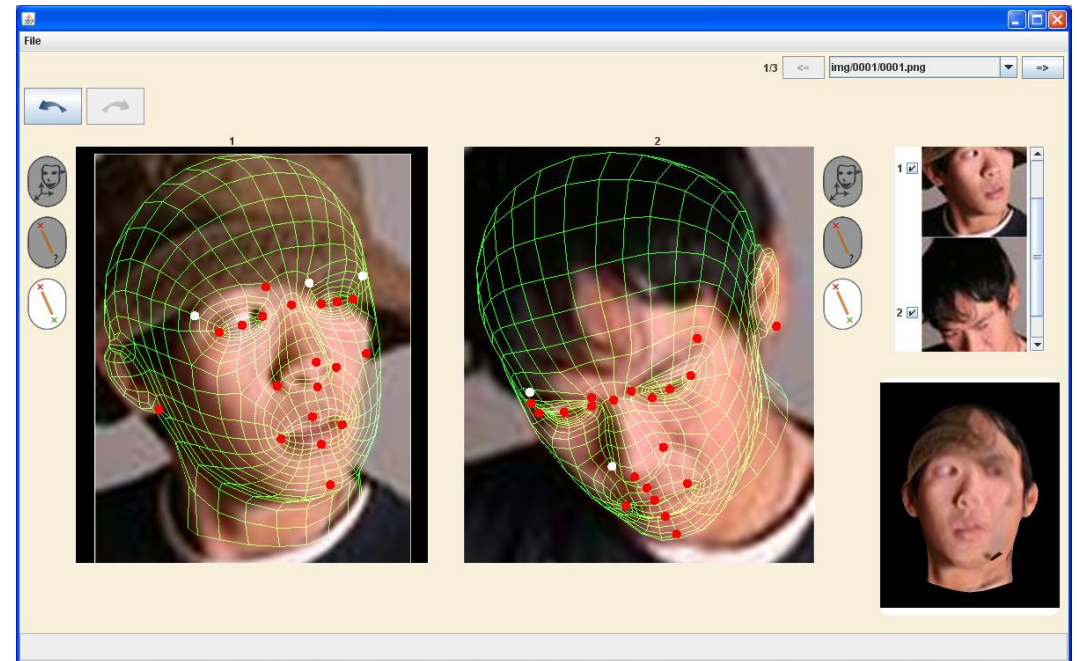
Impact on performance

- **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.
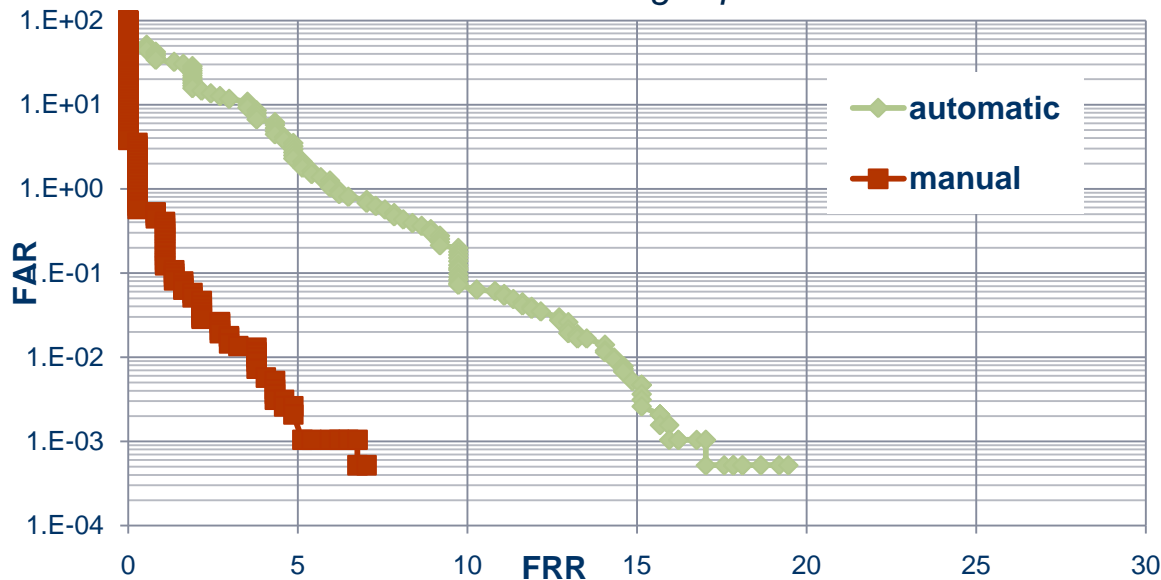
FRR	@FAR = 1.0%	@FAR = 0.1%
Automatic	6.0%	9.7%
Manual	0.3%	1.3%

SAFRAN
Morpho

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**

SAFRAN
Morpho
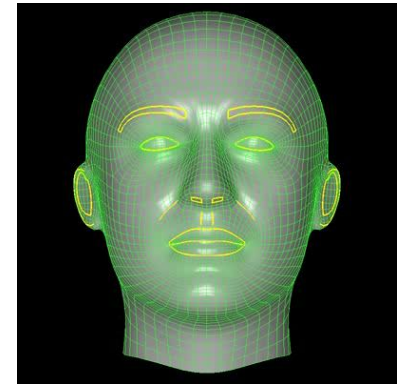
Border Control Challenges

- **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
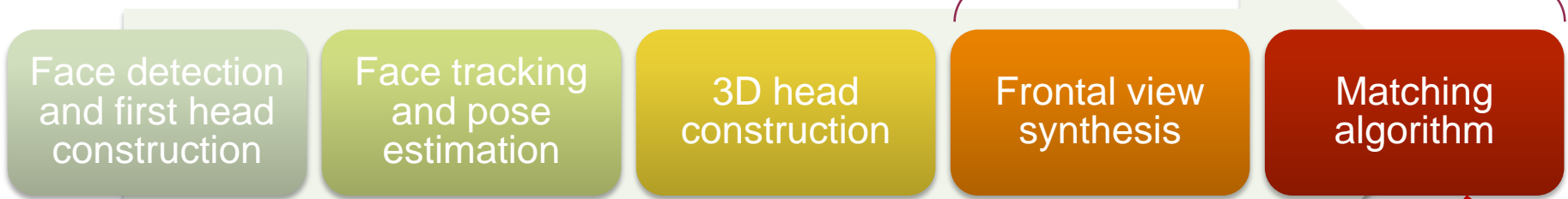 - Lowers passenger cooperation level

SAFRAN
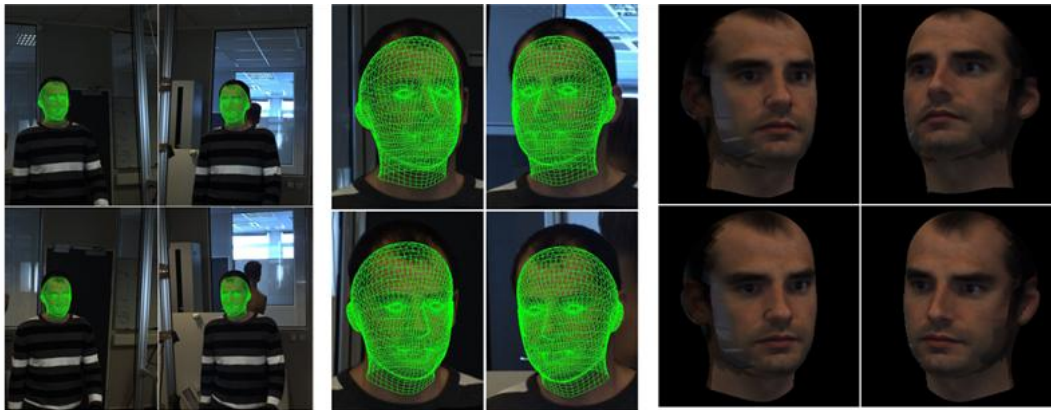Morpho

Face on the Fly

MorphoWay V on the Fly – Entry kiosk

4 calibrated and synchronized cameras

ID scan

SAFRAN
Morpho

Face on the Fly

| Face detection and first head construction | Face tracking and pose estimation | 3D head construction | Frontal view synthesis | Matching algorithm |

Initialization

Each frame

End of sequence

SAFRAN
Morpho

Face on the Fly

- **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

SAFRAN
Morpho

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*

SAFRAN
Morpho

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 ?

SAFRAN

Morpho

Questions ?

SAFRAN

Morpho