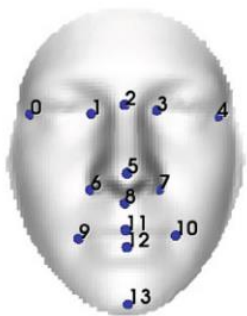




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# A Machine-Learning Approach to Keypoint Detection and Landmarking on 3D Meshes

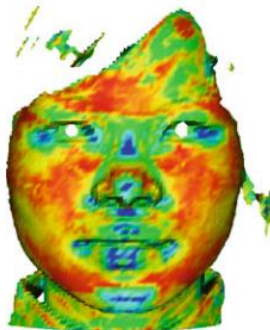
Analyse d'article scientifique



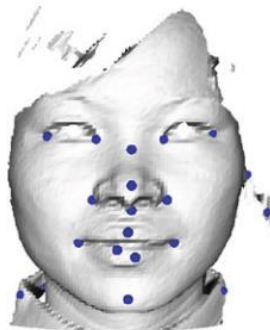
Landmarks in model  $\mathcal{L}$



Input Mesh



Keypoint Score Map

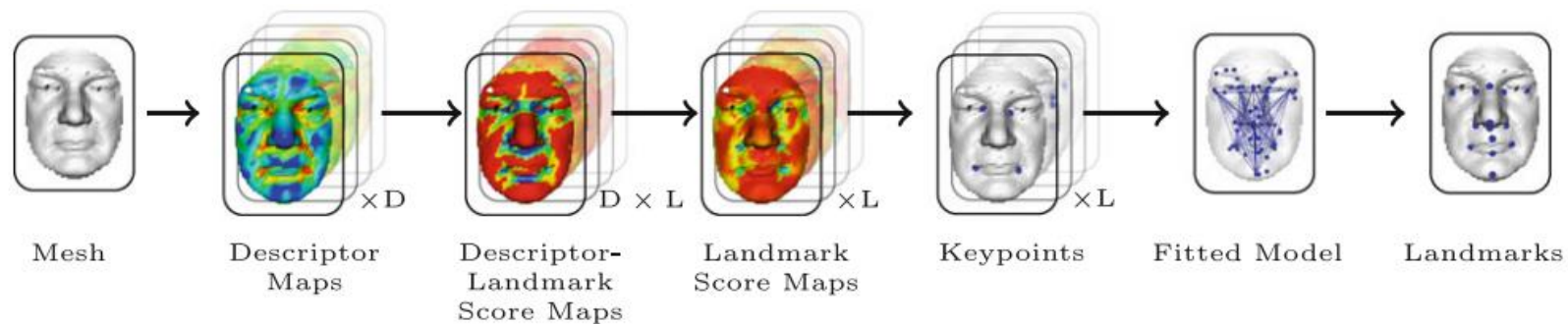


Detected Keypoints

Guénon Marie  
Favreau Jean-Dominique  
Tanguy Arnaud

# Introduction

- ▶ Extraction de keypoints sur mesh 3D
- ▶ Application au landmarking

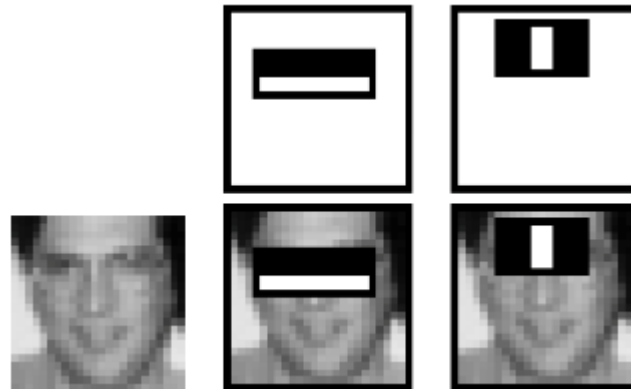


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  - ▶ L'algorithme
2. Détails techniques
  - ▶ Keypoints
  - ▶ Landmarks
3. Résultats
  - ▶ Keypoints
  - ▶ Landmarks
  - ▶ Temps de calcul

# Principe général

- Détection de visage en 2D



## 1. Principe général

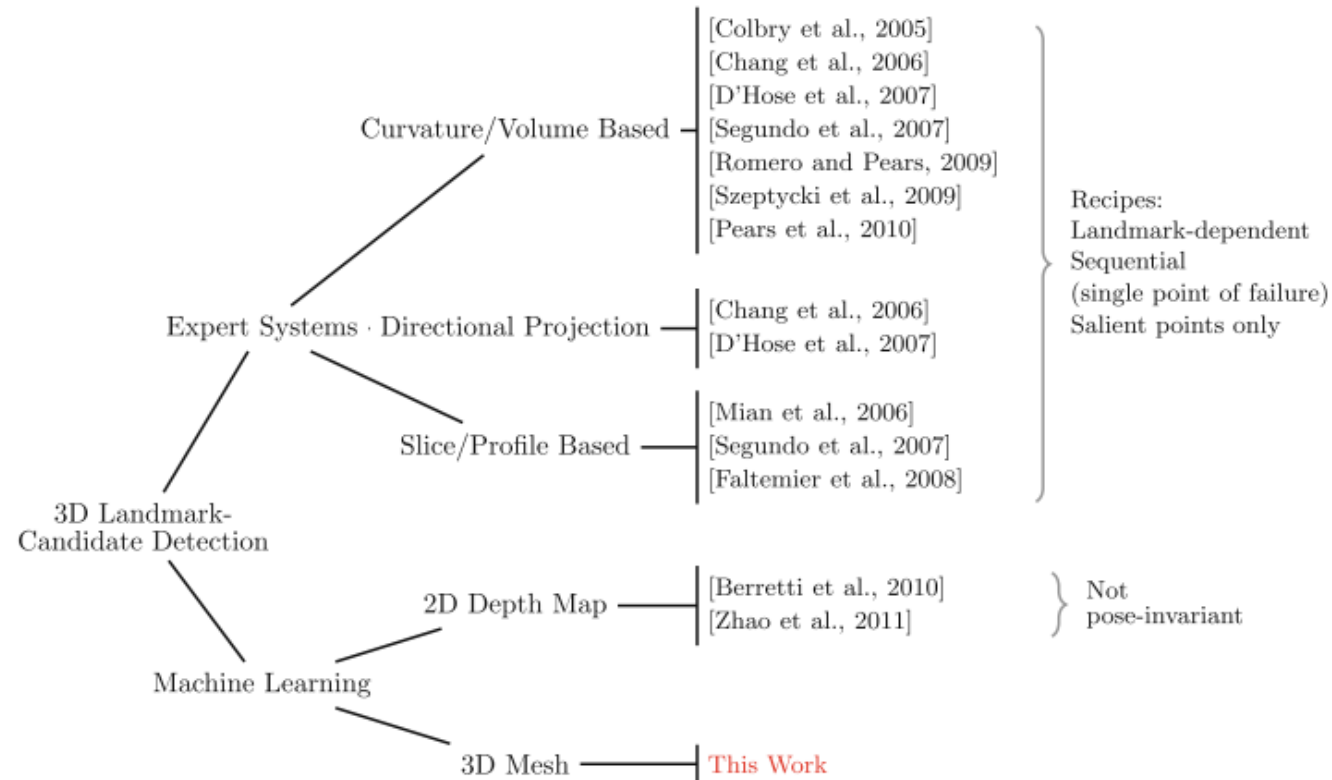
- État de l'art
- L'algorithme

## 2. Détails techniques

## 3. Résultats

# Principe général

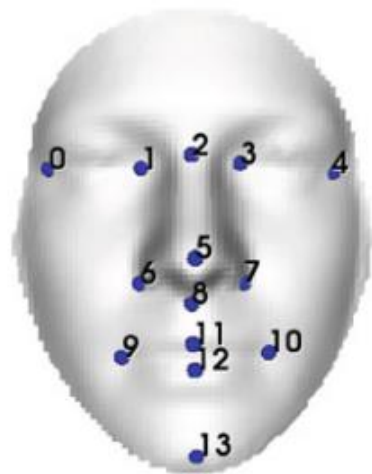
## ► État de l'art 3D



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# Principe général

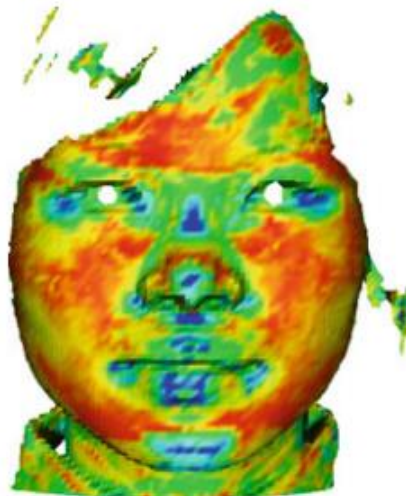
## ► L'algorithme



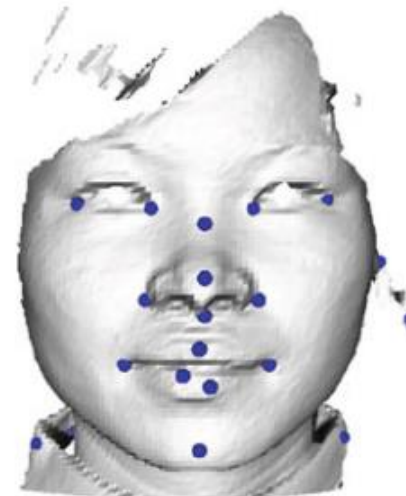
Landmarks in model  $\mathcal{L}$



Input Mesh



Keypoint Score Map



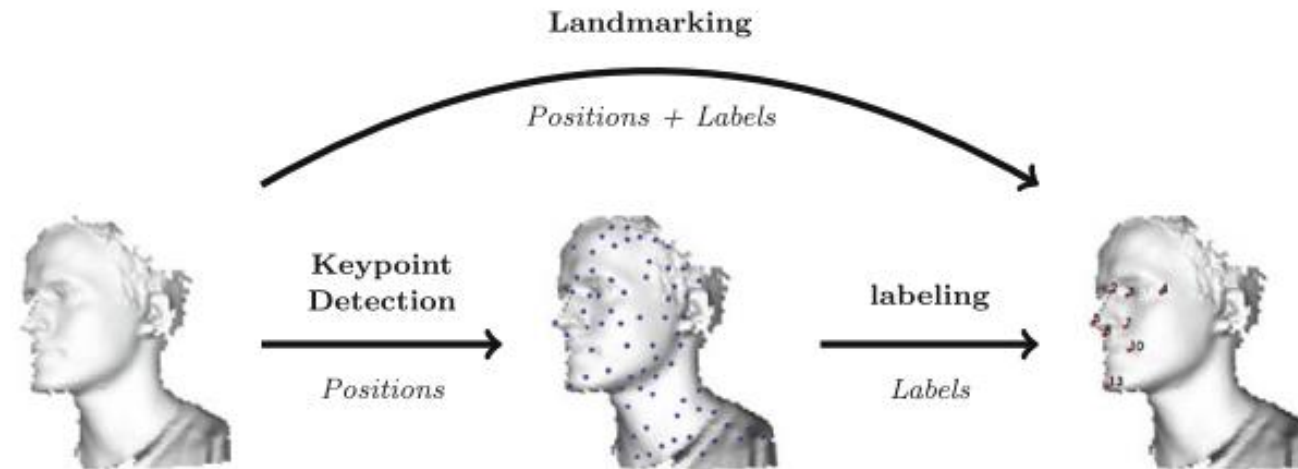
Detected Keypoints

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# Principe général

## ► L'algorithme

**Fig. 2** Problem breakdown. The landmarking problem is split into two sub-problems that are solved independently: keypoint detection and labeling. Although this paper mainly focuses on solving the keypoint detection problem, we also apply our technique in a landmarking problem

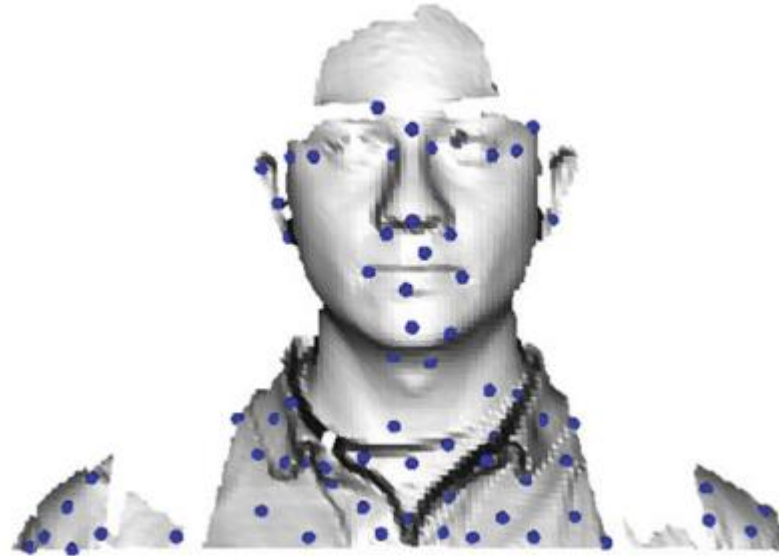


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# Détails techniques

- ▶ Keypoints

- ▶ Offline
- ▶ Online

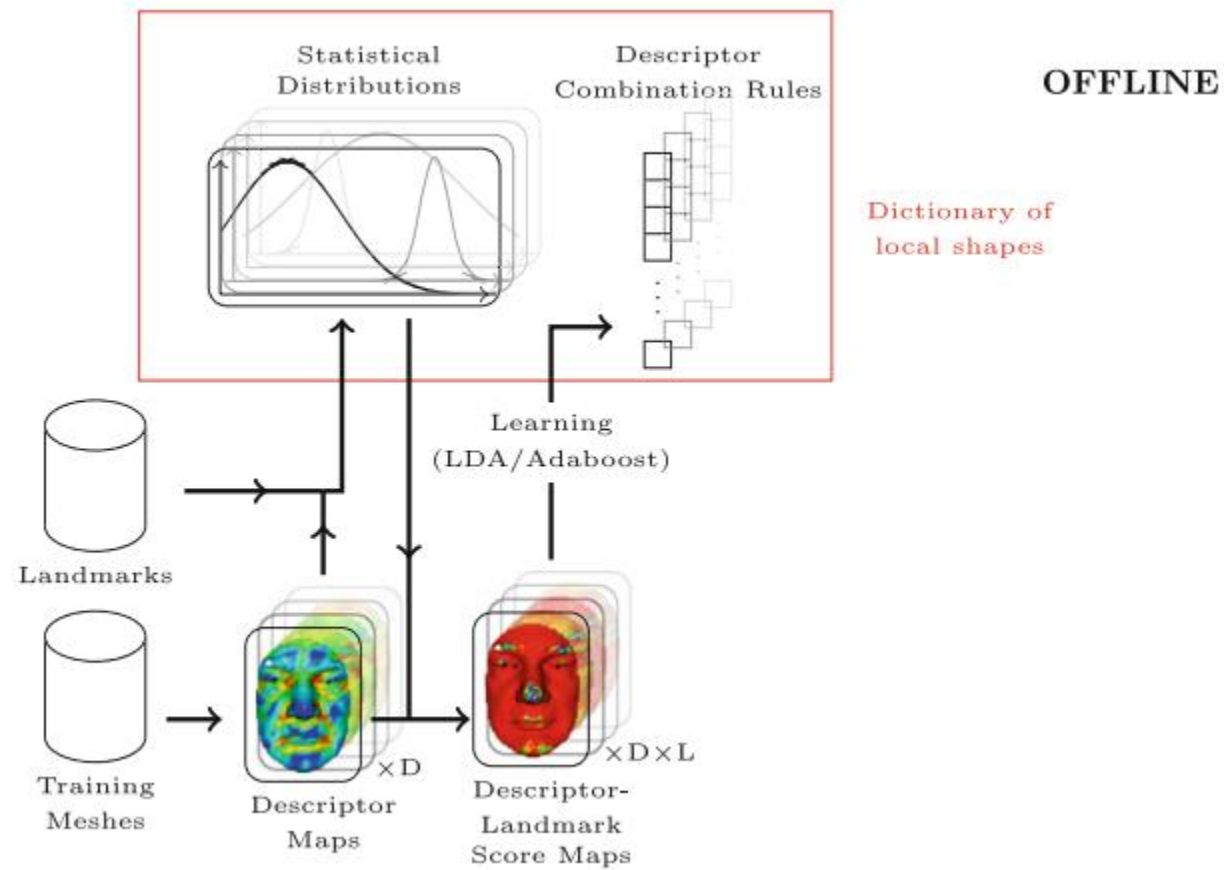


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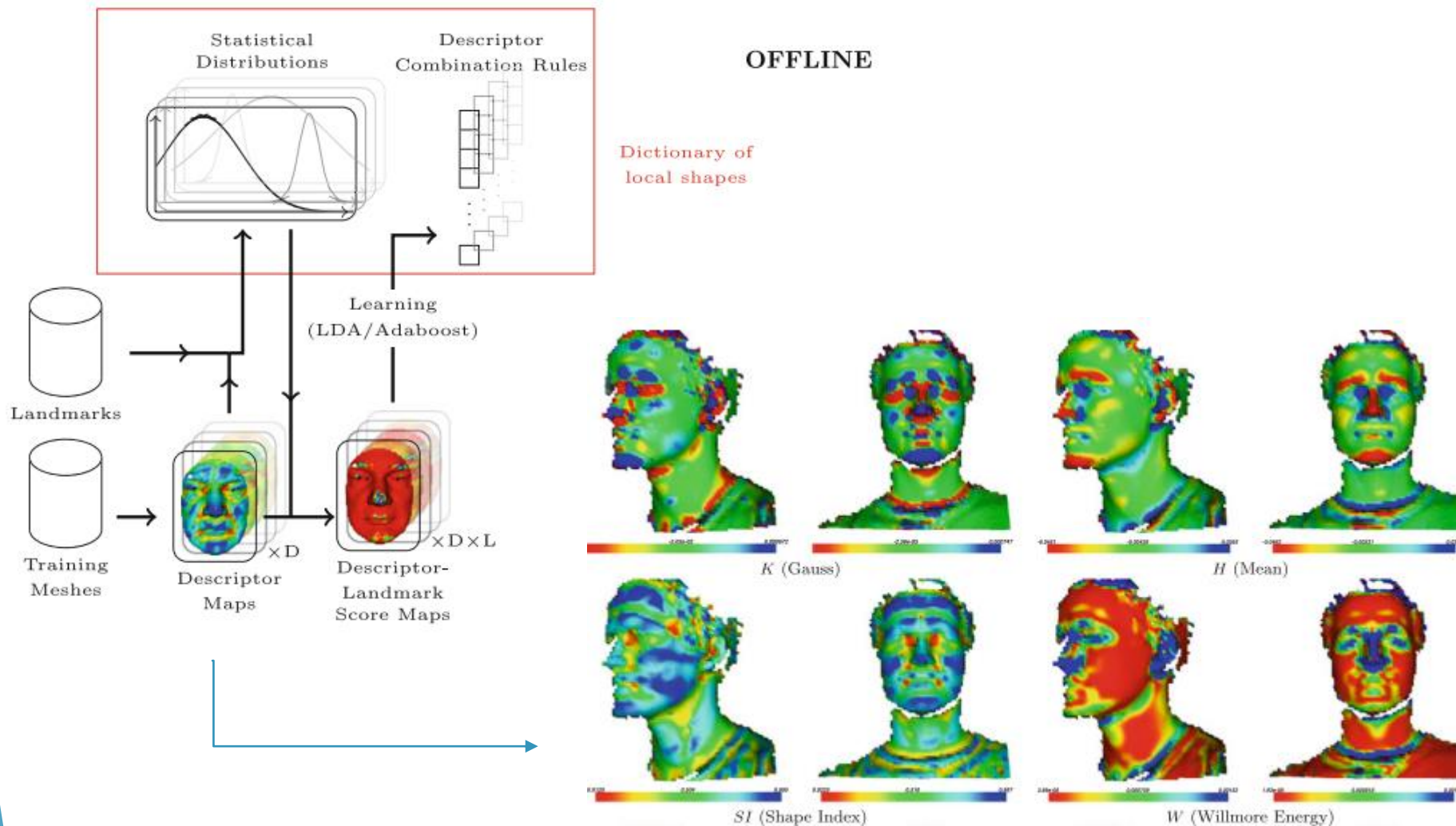
# Détails techniques

## ► Keypoints



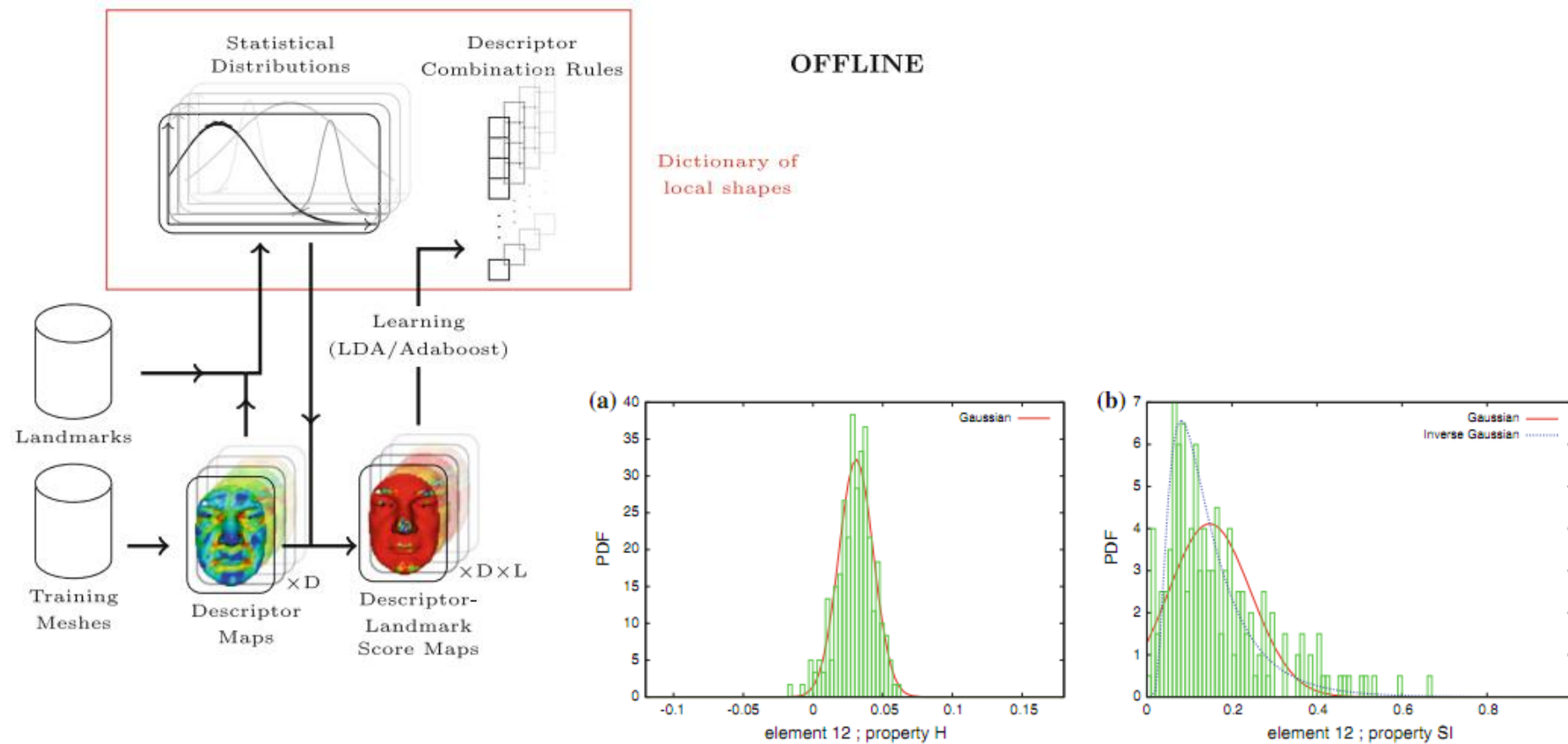
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# Détails techniques



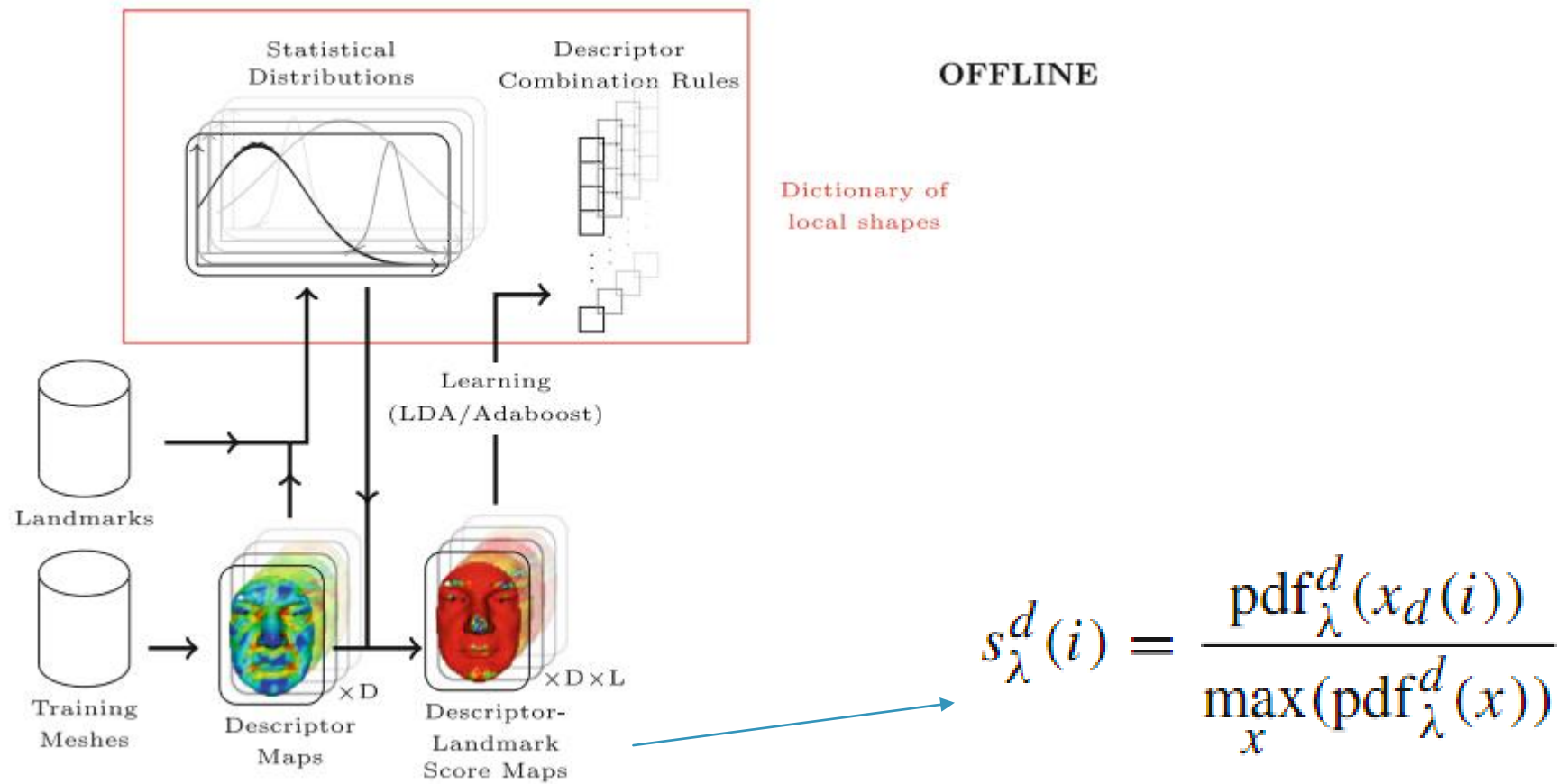
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# Détails techniques



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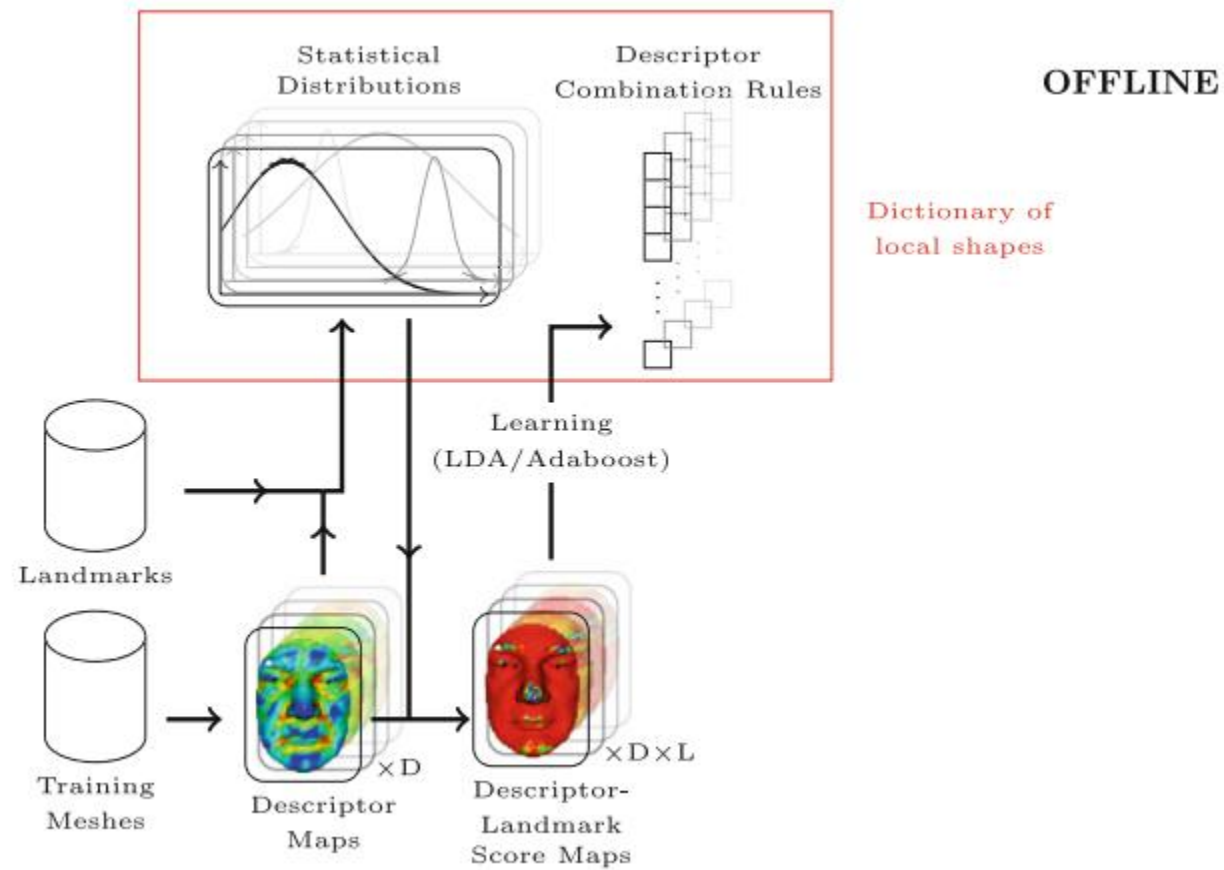
# Détails techniques



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# Détails techniques

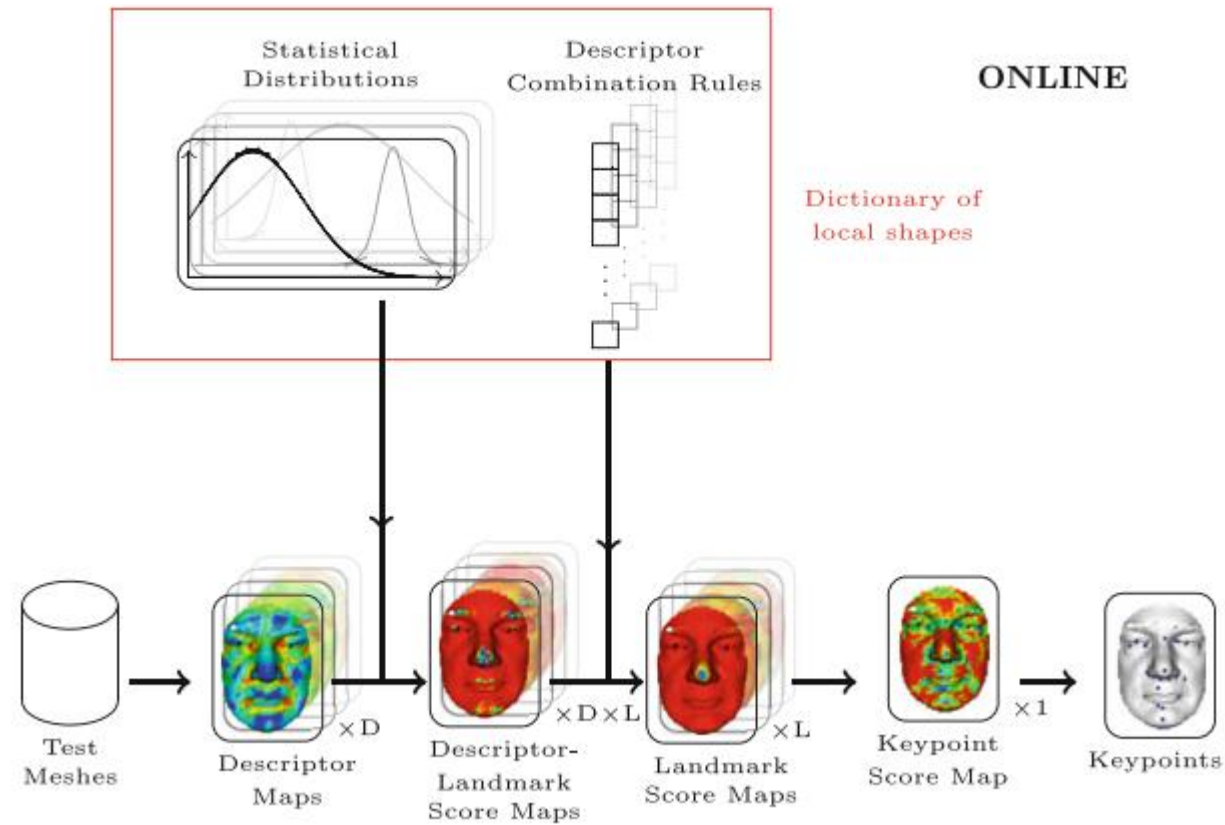
## ► Keypoints



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# Détails techniques

## ► Keypoints

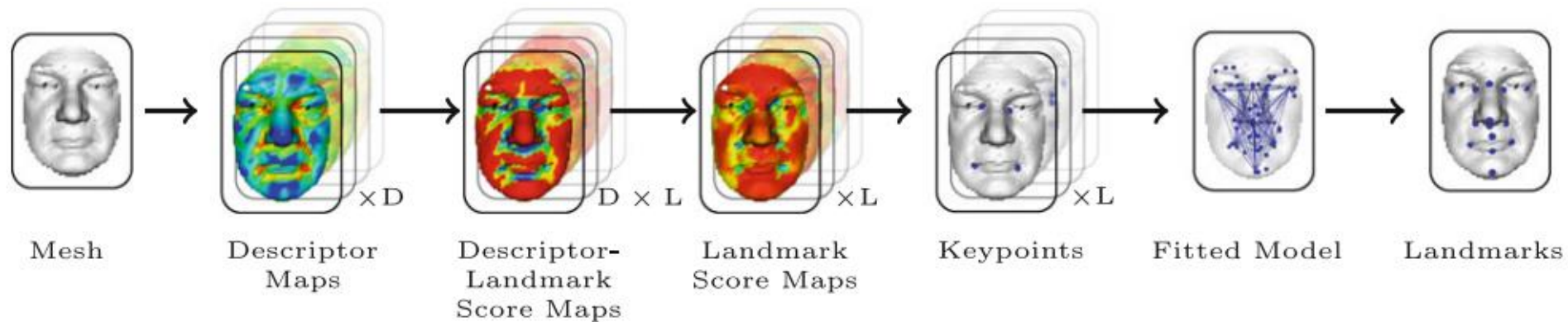


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# Détails techniques

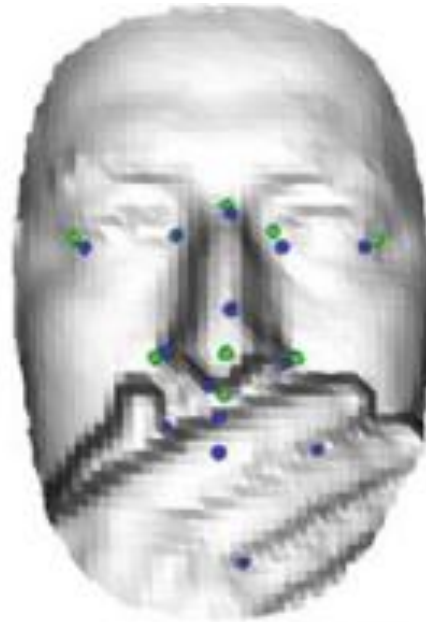
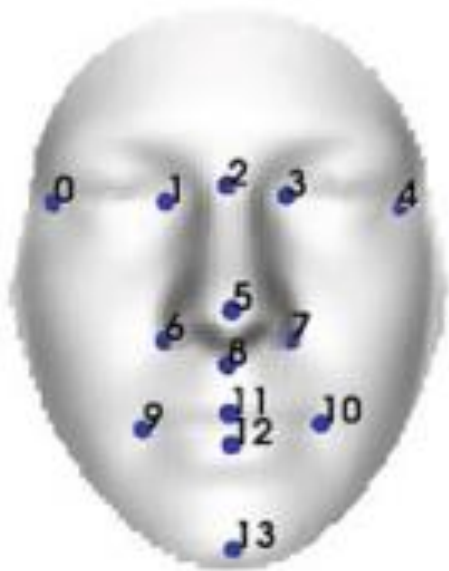
## ► Landmarks



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# Détails techniques

## ► Landmarks



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# Résultats

## ► Keypoints

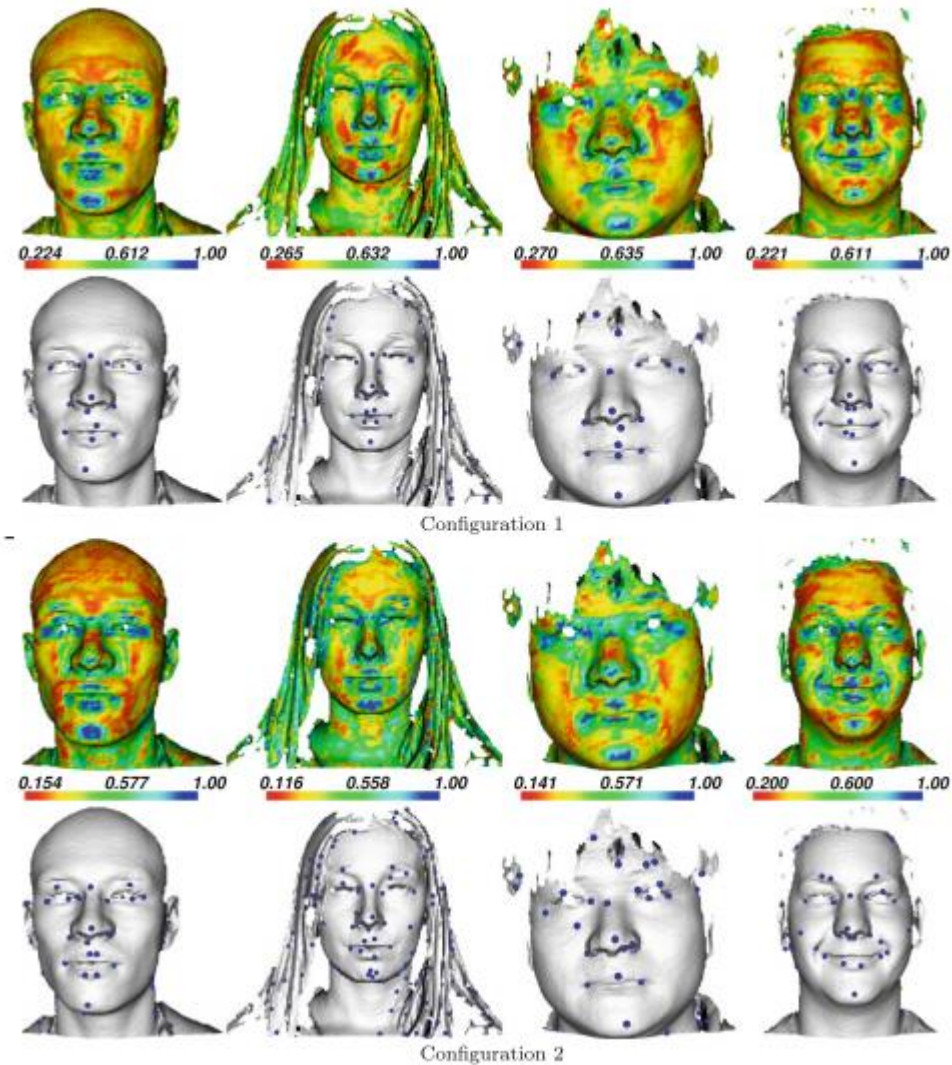
### ► 10 descripteurs :

- First principal curvature ( $k_1$ )
- Second principal curvature ( $k_2$ )
- Gaussian curvature ( $K$ )
- Mean curvature ( $H$ )
- Shape Index ( $SI$ )
- Log Curvedness ( $LC$ )
- Distance to Local Plane ( $DLP$ )
- Local Volume ( $VOL$ )
- Spin Image Histogram ( $SIH$ )
- Spherical Histogram ( $SH$ )

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# Résultats

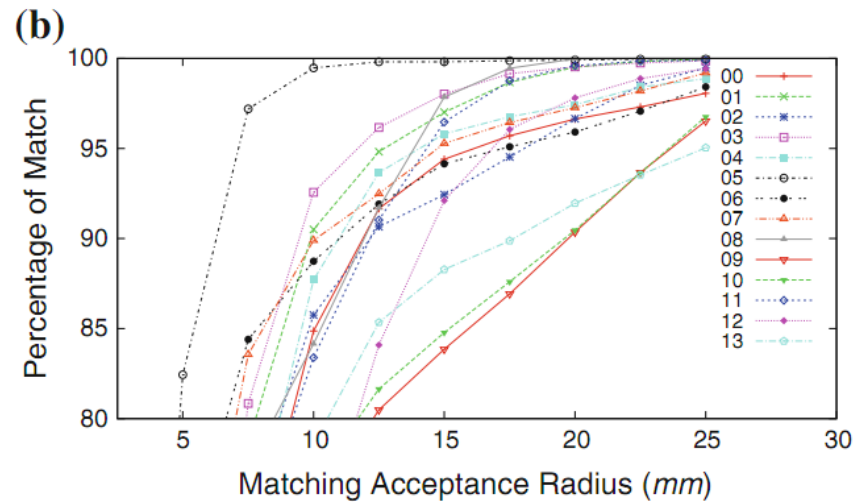
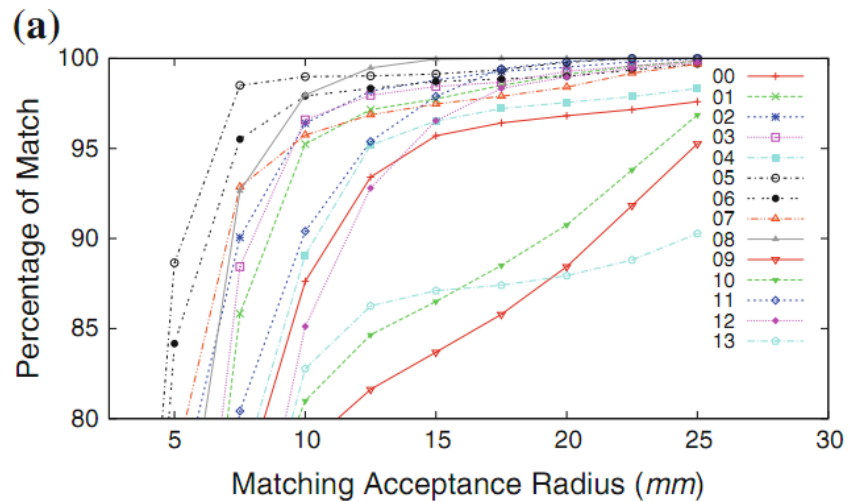
- Keypoints
  - Multi-scale
  - Single-scale



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# Résultats

## ► keypoints

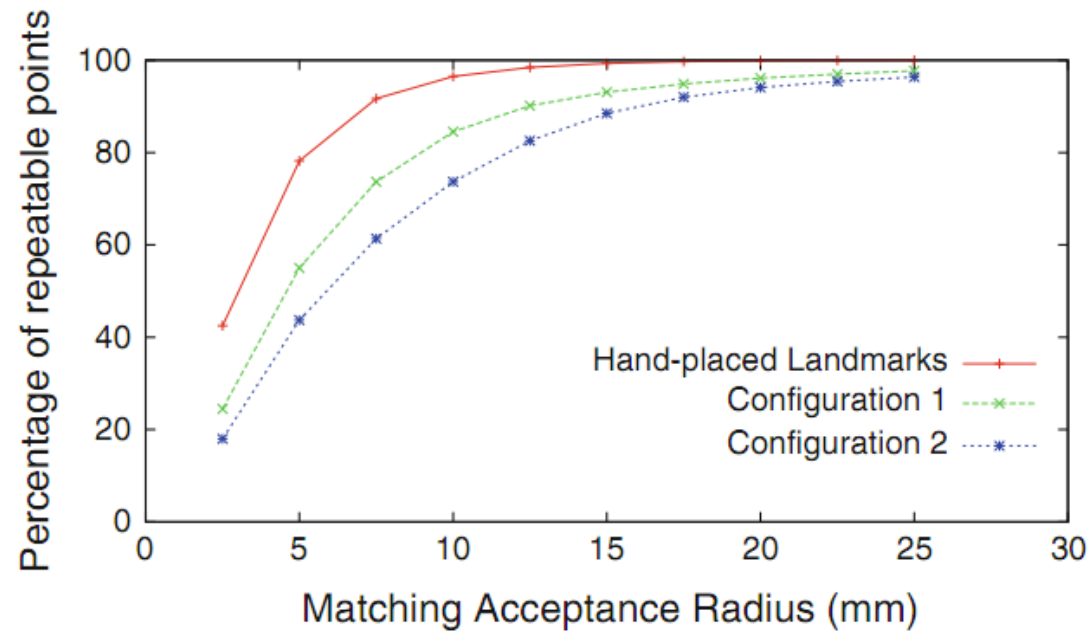


**Fig. 18** Matching percentage per landmark (0–13) with an increasing matching acceptance radius on the FRGC v2 test set. (a) using all descriptors (Configuration 1), (b) using a subset of descriptors (Configuration 2)

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# Résultats

## ► keypoints



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# Résultats

## ► Landmarks

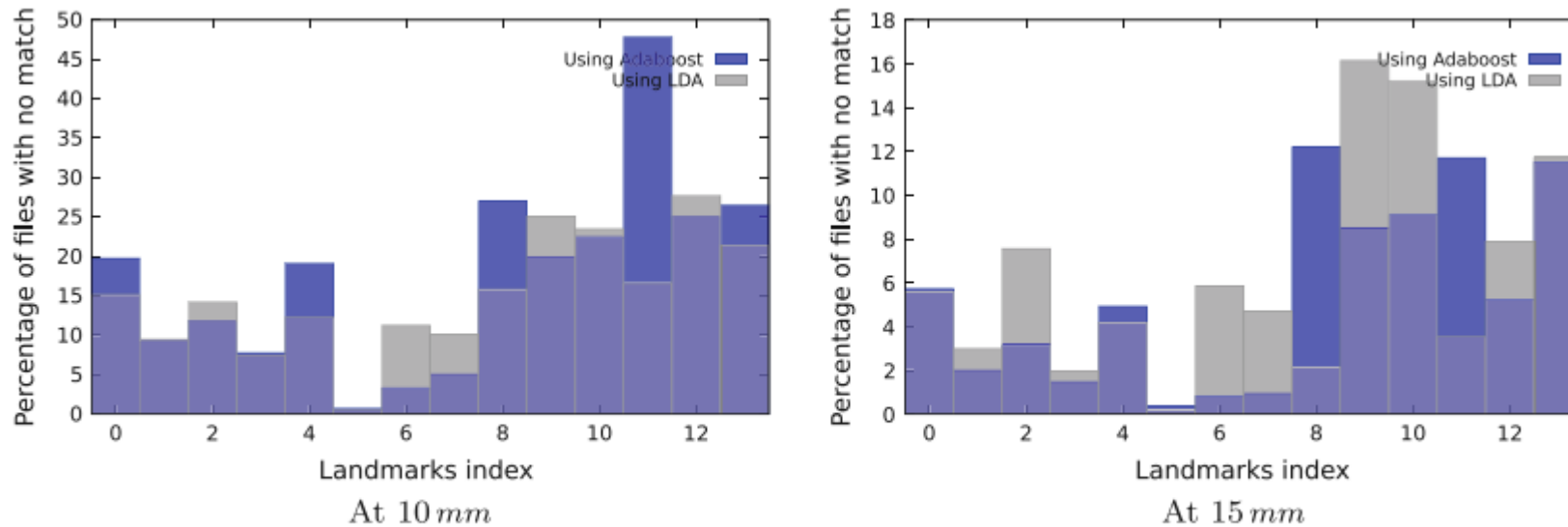


Fig. 26 Retrieval error rate for the LDA and AdaBoost DL-score combination methods for the 14 landmarks

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**Table 1** 3D face landmarking systems that are tested on more than 4000 models from the FRGC v2 dataset

Authors	[Chang et al., 2006]	[Mian et al., 2006]	[Segundo et al., 2007]	[Romero and Pears, 2009]	[Alyuz et al., 2010]			[Segundo et al., 2010]		This Work, 2011			
#Landmarks	3	1	6	3	5			5		14			
Acceptance Radius	<?	<?	<?	< 12	< 10	< 12	< 20	< 10	< 15	< 10	< 12	< 15	< 20
Nose (05)	99.40	98.3	99.95	99.77	99.62	99.80	99.87	99.95	99.95	99.01	99.81	100.0	100.0
Eye Inner Corners (01,03)	—	—	99.83	96.82	96.59	98.54	99.54	99.02	99.64	98.73	99.71	99.96	100.0
Nose Corners (06,07)	—	—	99.76	—	98.60	99.29	99.87	99.35	99.95	99.36	99.87	99.98	99.98
Subnasale (08)	—	—	99.98	—	—	—	—	—	—	99.68	99.98	100.0	100.0
Mouth Corners (09,10)	—	—	—	—	—	—	—	—	—	91.33	95.63	98.34	99.73
Eye Outer Corners (00,04)	—	—	—	—	—	—	—	—	—	89.84	95.92	99.01	99.84
Nasion (02)	—	—	—	—	—	—	—	—	—	97.26	99.07	99.81	100.0
Upper Lip (11)	—	—	—	—	—	—	—	—	—	96.21	98.21	99.73	99.96
Lower Lip (12)	—	—	—	—	—	—	—	—	—	92.04	96.00	98.38	99.05
Chin (13)	—	—	—	—	—	—	—	—	—	84.94	91.96	96.60	98.72
Candidate Selection	ES	ES	ES	ES	ES			ES		ML			
Independence	no	n/a	no	yes	no			no		yes			
Test Size	4,485	4,950	4,007	4,013	4,007			4,007		4,750			
Train Size	—	—	—	—	—			—		200			
Pre-processing	S,C <sup>1</sup>	∅	H,C	S,H	S,H,C			S,H,C		∅			
Pre-processing Time	—	—	1.1s	—	—			1.0s		0s			
Processing Time	—	—	0.4s	—	—			0.3s		1.18s			

ES: Expert System, ML: Machine Learning, C: Cropped/Segmented, H: Hole Filling, S: Spike Removal

<sup>1</sup> In [Chang et al., 2006] the mesh were cropped using 2D texture (skin colour).

Results using the same metric are colored the same. When a comparison is possible, results in bold font highlight the best system score for the given metric

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# Résultats

**Fig. 29** Examples of landmarking in cases with missing nose where expert systems usually fail (model 04814d22 and 04505d222 of the FRGC). Our system doesn't need the nose tip to be correctly detected in order to find the other landmarks (landmark independence). *Blue* points represents our results. *Green* points represent the ground truth (Color figure online)



**Fig. 30** Examples of localizations on rotated meshes. Our system only uses relative vertex positions and normals and is therefore translation and rotation invariant (pose invariant)

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# Résultats

## ► Temps de calcul

Authors	[Chang et al., 2006]	[Mian et al., 2006]	[Segundo et al., 2007]	[Romero and Pears, 2009]	[Alyuz et al., 2010]	[Segundo et al., 2010]	<b>This Work, 2011</b>
Pre-processing	S,C <sup>1</sup>	∅	H,C	S,H	S,H,C	S,H,C	∅
Pre-processing Time	–	–	1.1s	–	–	1.0s	0s
Processing Time	–	–	0.4s	–	–	0.3s	1.18s

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# Conclusion

- ▶ Pas aussi précis sur des petits rayons
- ▶ Plus robuste aux occlusions et aux rotations
- ▶ Relativement rapide et facilement parallélisable
- ▶ Algorithme généralisable à n'importe quel type de forme fixe

# Bibliographie

- ▶ **A Machine-Learning Approach to Keypoint Detection and Landmarking on 3D Meshes**; Clement Creusot, Nick Pears, Jim Austin
- ▶ [http://docs.opencv.org/trunk/doc/py\\_tutorials/py\\_objdetect/py\\_face\\_detection/py\\_face\\_detection.html](http://docs.opencv.org/trunk/doc/py_tutorials/py_objdetect/py_face_detection/py_face_detection.html)

# Merci de votre attention, avez-vous des questions ?

