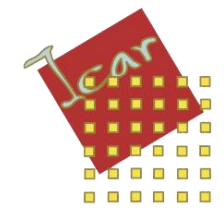


SYMMETRY ANALYSIS OF 3D BACK SURFACE FOR SCOLIOSIS DIAGNOSIS AND FOLLOW-UP

Marion MORAND ^{1,2}, Olivier COMAS ², Christophe FIORIO ¹ and Gérard SUBSOL ¹

1. Research team ICAR, LIRMM, University of Montpellier / CNRS, France
2. DMS Imaging, Mauguio, France
mmorand@dms-imaging.com



ABSTRACT. Symmetry analysis of anatomical structure surfaces offers good promise for diagnosis, follow-up and therapy planning of pathologies causing abnormal deformities. Especially, analysis of back surface asymmetry shows good results for monitoring patients affected by scoliosis, which is characterized by a lateral deviation of the spine with local rotation of vertebrae. Our work addresses the problem of detecting and modelling symmetry of bilateral structures, and more particularly of the back surface of scoliotic patients. We propose a new method to compute a piecewise curved symmetry surface for 3D back surface. The algorithm is based on the computation of a 3D symmetry line, which defines strips by orthogonal slicing and which corresponds to the spinous process line. A set of local symmetry planes forms a piecewise symmetry surface and allows to quantify the back surface rotation, which could be correlated to the local rotation of vertebrae.

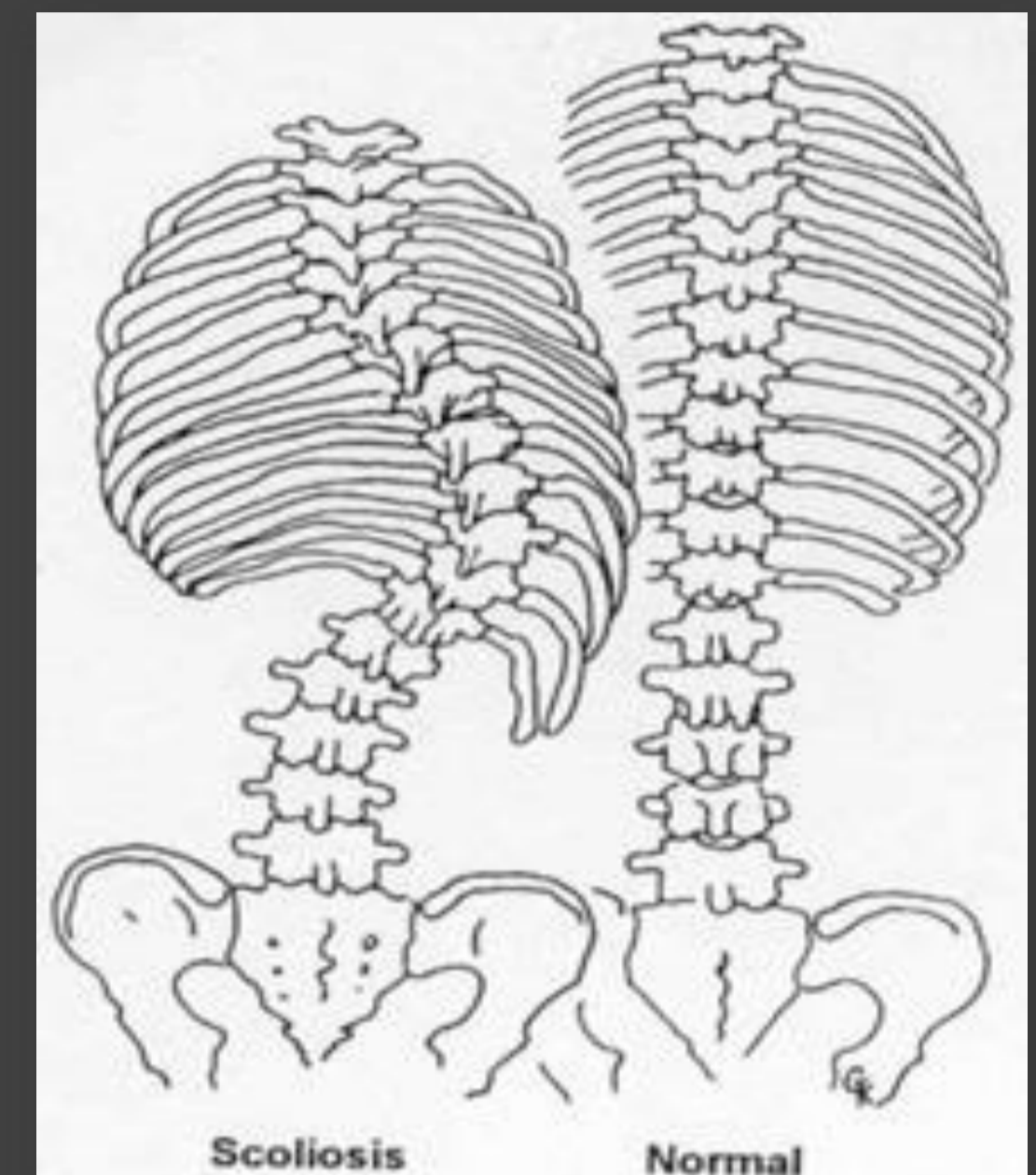
BACKGROUND CONTEXT: Scoliosis

- Permanent and progressive 3D deformation of the spine.
- Detection by clinical examination of 3D back surface alterations. Definitive diagnosis by full spine radiographs.
- X-rays delivered to patients are a major public health concern, especially with children.
- Early detection could reduce radiographs and allow a better therapy planning.



Scoliosis parameters :

- Lateral deviation of the spine
- Vertebrae rotation
- Cobb angle
- Scapular and pelvis imbalance

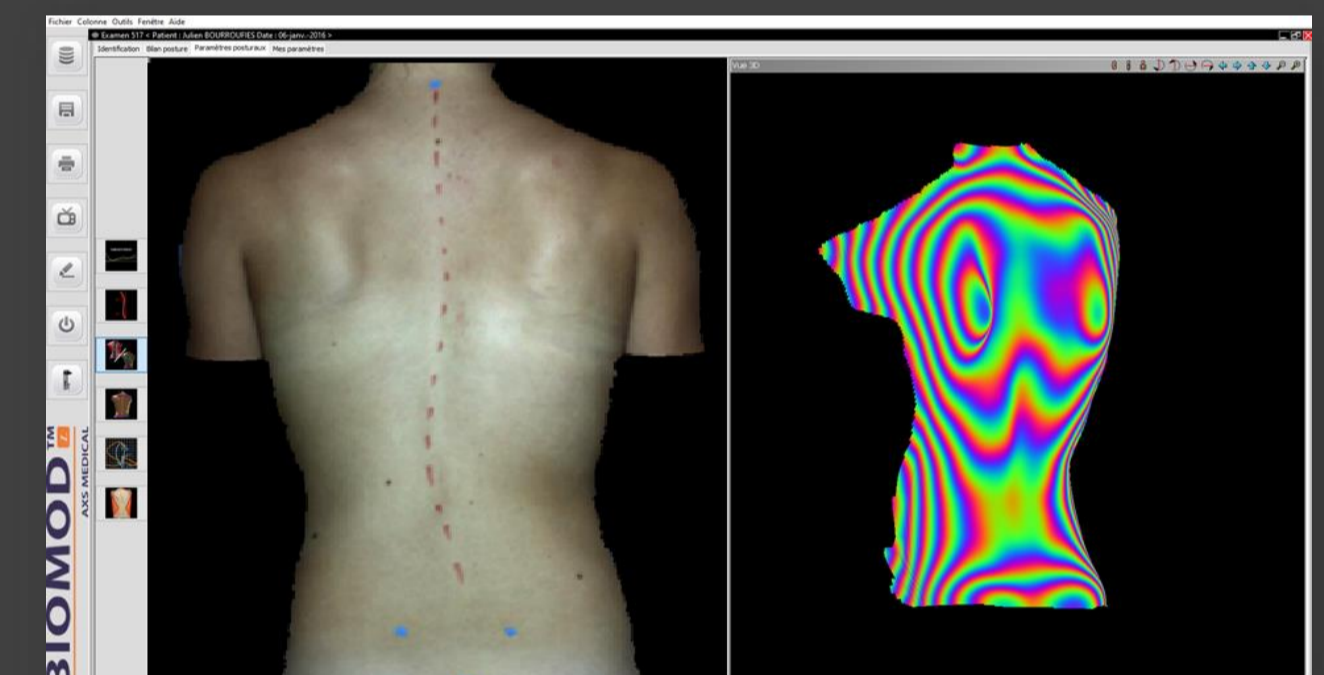
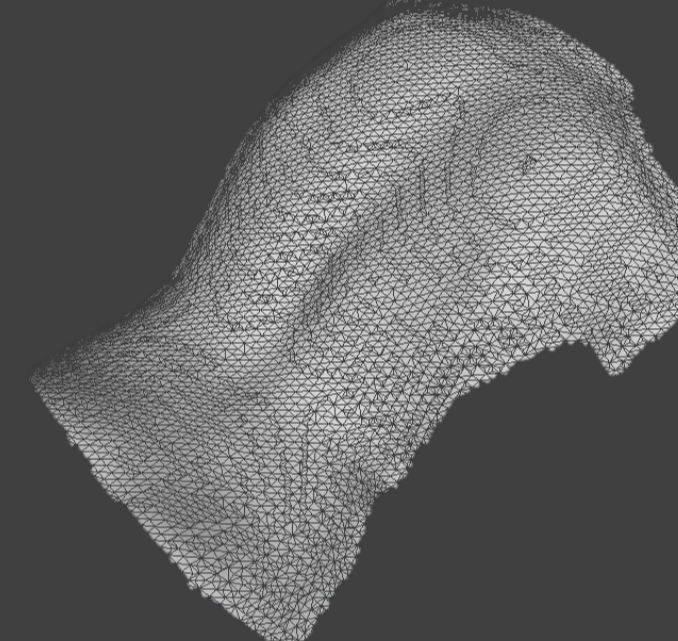


GLOBAL OBJECTIVE: How to characterize scoliosis, using only 3D back surface?

3D ACQUISITION SYSTEM: Optical medical devices

- Noninvasive optical systems give a 3D mesh of the back.
- Work in progress to develop surface measurements of 3D parameters, which allow better quantification of the back surface deformation.

BIOMOD system (DMS Imaging)

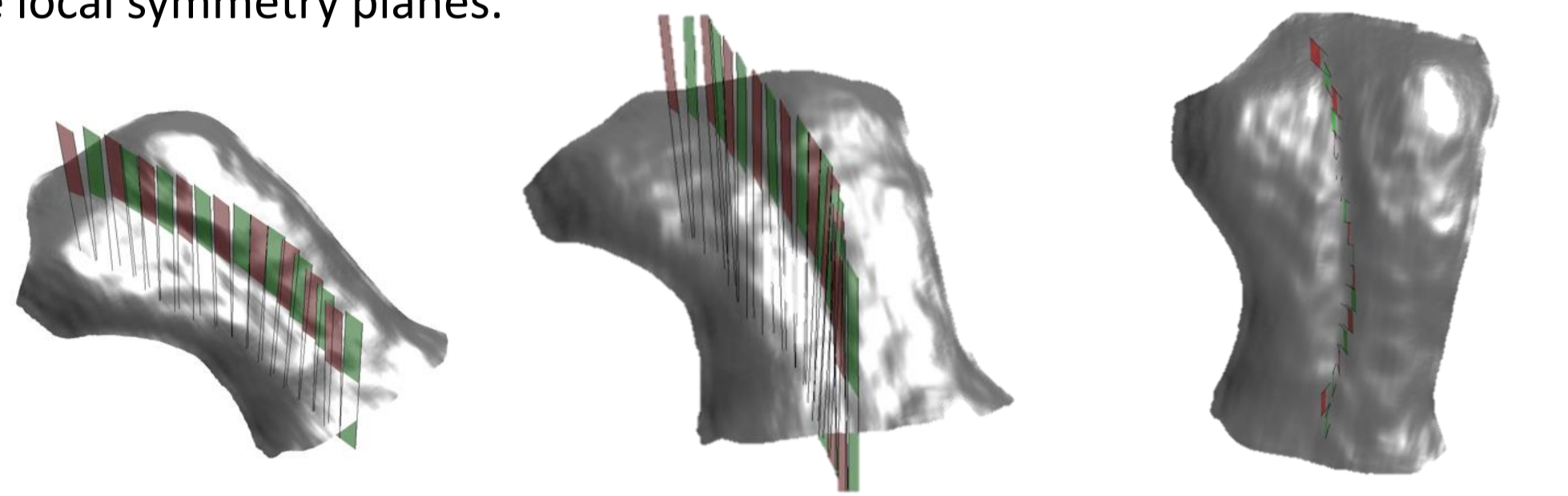


PURPOSE: Automatic extraction of the symmetry surface of the 3D back surface

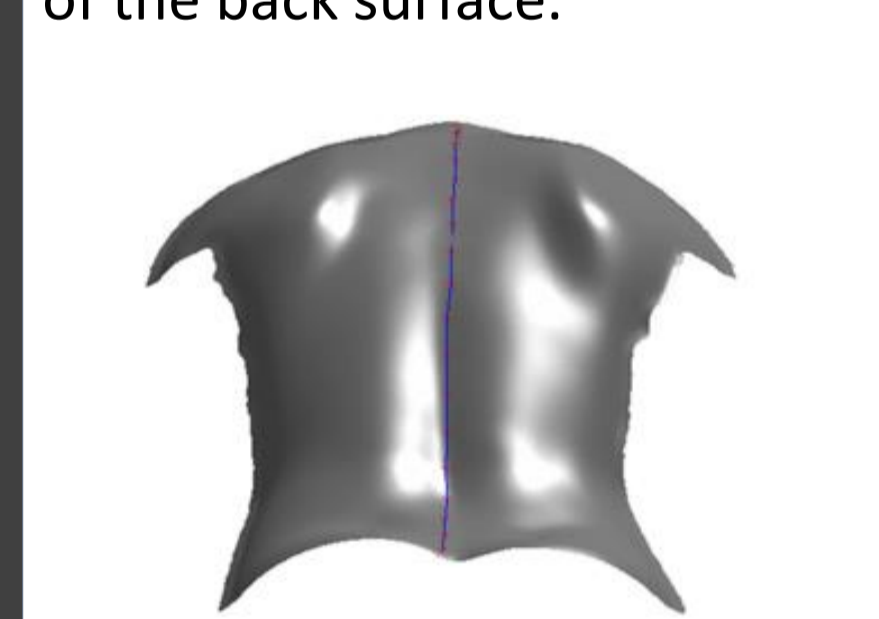
Apply PCA on 3 sub-meshes to define an initial symmetry line and a set of parallel strips.



For each strip, compute a local symmetry plane by a robust ICP-based method [2] and build a 3D piecewise curved symmetry surface by fusing all the local symmetry planes.



Compute symmetry line [3] and quantify the dissymmetry of the back surface.



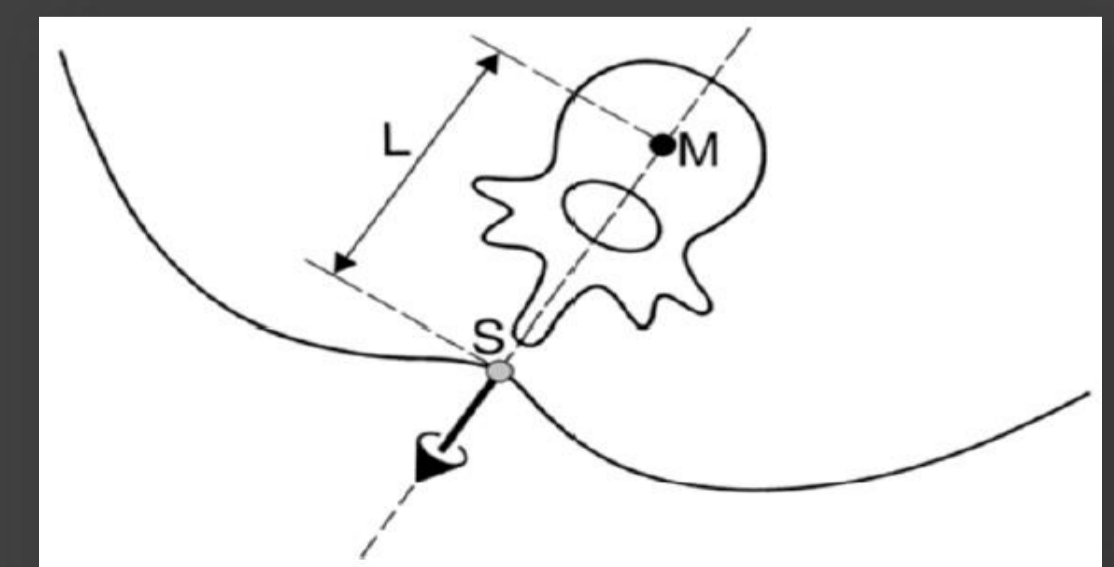
RESULTS: Comparison between our symmetry line and the spinal curve palpated by a clinician.

	Number of patients 112 (100%)	Number of patients / Cobb range			Number of patients / BMI range		
		22 (24,6%) [5° - 15°]	68 (50,8%) [15° - 25°]	22 (24,6%) [25° - 54°]	42 (37,4%) [14 - 17]	58 (51,8%) [17 - 19]	12 (10,8%) [19 - 22]
RMSD _{lat} (mm)	4.82 ±1.81	4.54 ±1.90	4.89 ±1.97	4.91 ±1.08	4.88 ±1.71	4.84 ±1.95	4.45 ±1.36
RMSD _{depth} (mm)	0.69 ±0.34	0.58 ±0.33	0.71 ±0.34	0.73 ±0.34	0.72 ±0.34	0.67 ±0.33	0.74 ±0.36
MDE (mm)	5.8 ±2.28	5.57 ±2.43	5.89 ±2.44	5.84 ±1.47	5.91 ±2.28	5.77 ±2.37	5.59 ±1.77

FUTURE WORK:

- Correlate orientation of the local symmetry planes with orientation of the 3D back surface and axial rotation of the vertebrae [1].
- Test the method for patients in high asymmetric postures (lateral bending...).
- Propose new 3D parameters for scoliosis detection, diagnosis and follow-up.

Construction of intern configuration using back shape [1]



[1] Drerup, B. (2014). Rasterstereographic measurement of scoliotic deformity. *Scoliosis*, 9:22.

[2] Combes, B. and Hennessy, R. and Waddington, J. and Roberts, N. and Prima, S. (2008). Automatic symmetry plane estimation of bilateral objects in point clouds. *IEEE Conf. on Computer Vision and Pattern Recognition*, Anchorage, USA.

[3] Morand, M. and Comas, O. and Fiorio, C. and Subsol, G. (2018). Automatic extraction of the 3D symmetry line of back surface: application on scoliotic adolescents. *IEEE Conf. of the Engineering in Medicine and Biology Society*, Honolulu, USA.