AUTOMATIC EXTRACTION OF A PIECEWISE SYMMETRY SURFACE OF A 3D MESH
APPLICATION TO SCOLIOSIS

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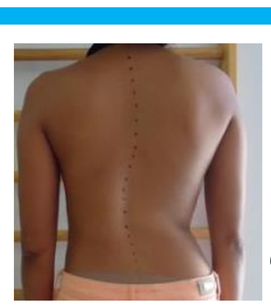
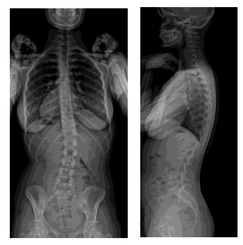
CONTEXT

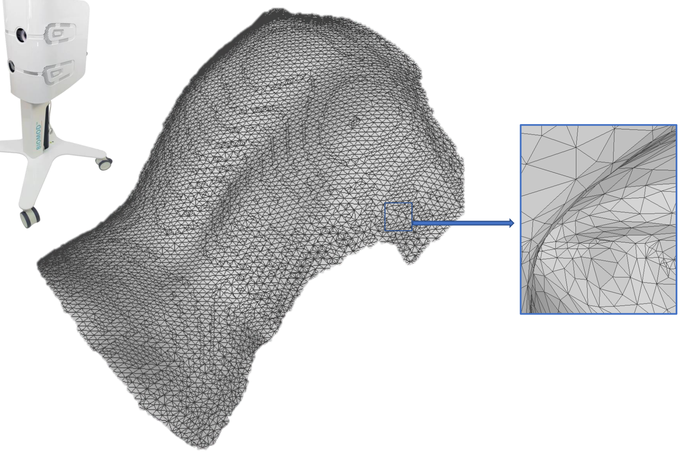
- Scoliosis: permanent and progressive 3D deformation of the spine
- Detection by clinical examination of the 3D back shape
- Definitive diagnosis by full spine radiographs but X-ray dose is a major public health concern, especially with children
- Noninvasive optical systems give a 3D mesh of the back surface
- Define 3D parameters to quantify back surface [1]

Compute a 3D symmetry surface



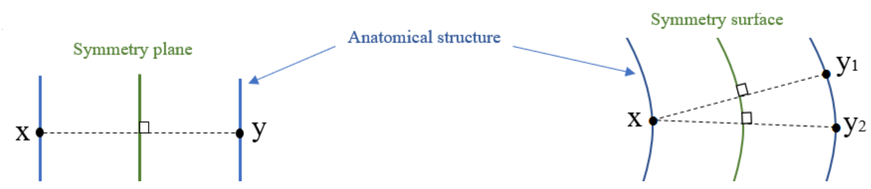


BIOMOD system (DMS Imaging)



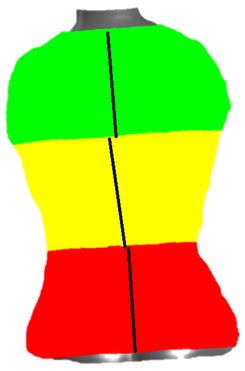
HOW TO COMPUTE A 3D SYMMETRY SURFACE?

- 2D slicing, symmetry line and interpolation [2] → orientation dependent
- Fitting a 3D function [3,4] instead of a plane → limited deformations
- Using anatomical features (in particular, for brain or face shape analysis) →specific to some applications



DESCRIPTION OF OUR METHOD

Initialization of the symmetry line by PCA on 3 regions (thoracic sup and inf, lumbar), orthogonally to the direction defined by the prominent vertebra and the intergluteal fold



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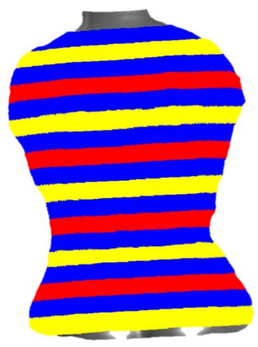
Definition of thick strips, orthogonally to the symmetry line



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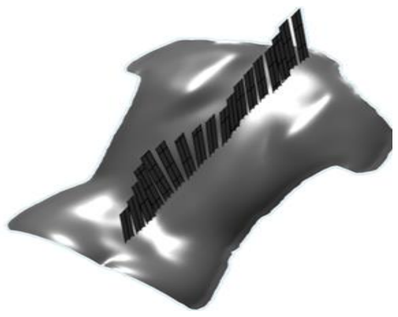
For each strip, compute automatically a local symmetry plane by a robust ICP method (based on [5])



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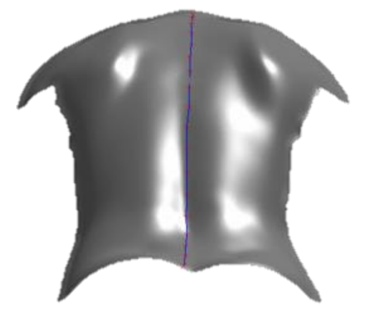
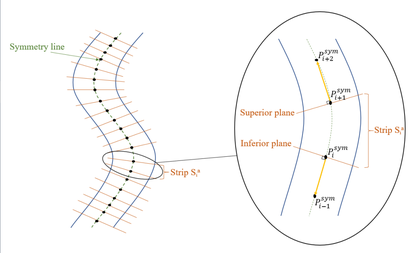
New 3D symmetry line by intersection of the local symmetry planes and the surface



New strips orthogonal to the new 3D symmetry line



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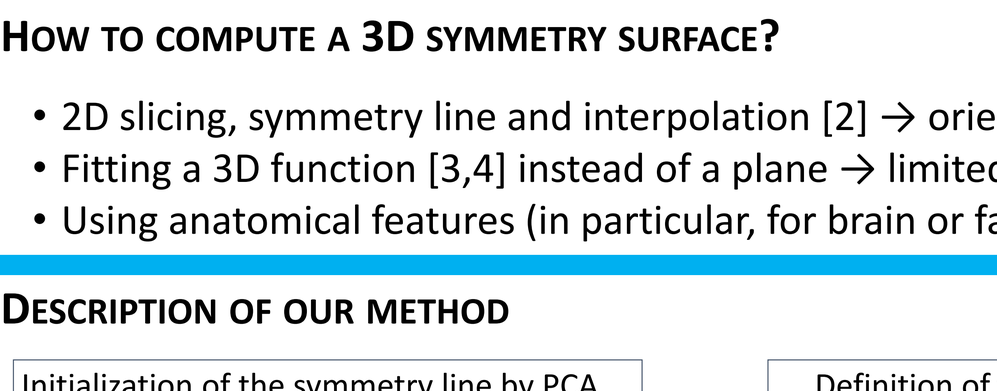
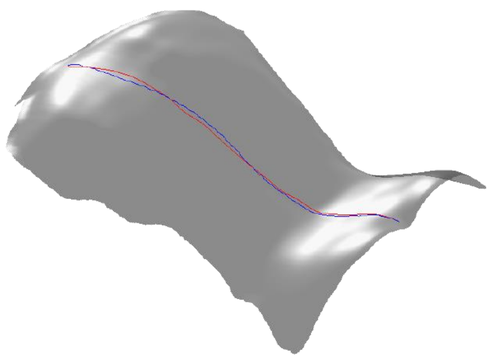
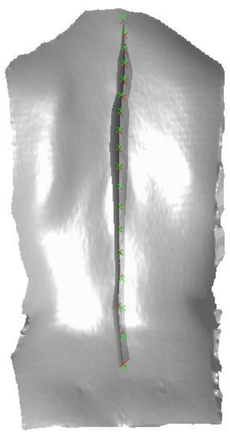


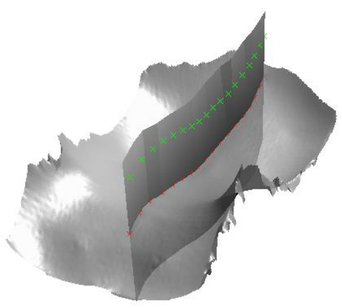
3D piecewise symmetry surface

RESULTS

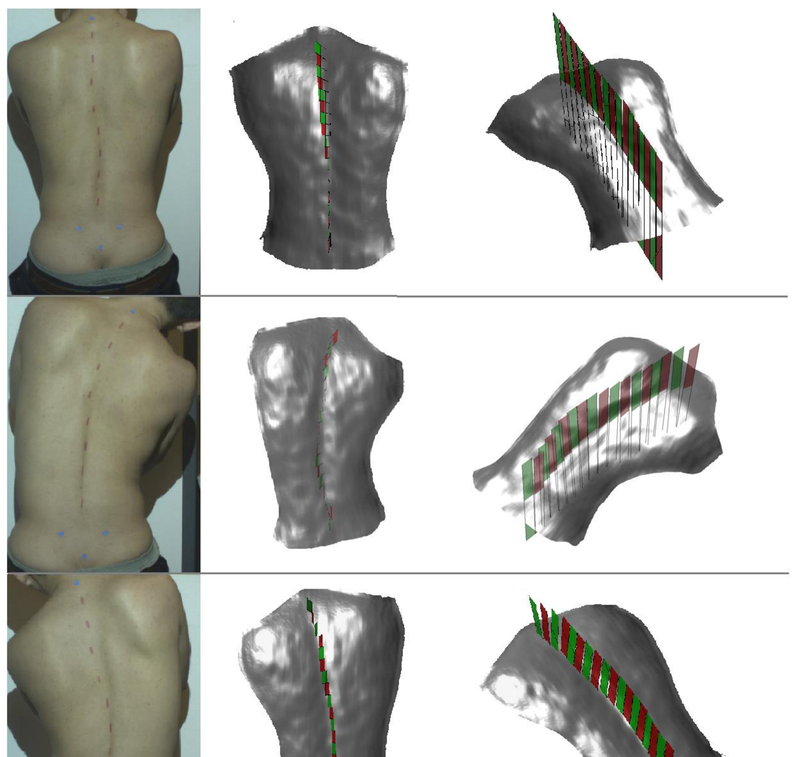


Symmetry line [6]: automatic method (blue) / expert (red)





Estimation of the centre (green points) and the axial rotation of the vertebra



Application to a patient in bending position

FUTURE WORK

- Interpolate the piecewise symmetry surface
- Automatize parameters (i.e. number of regions)
- Application to scoliosis classification
- Extend to other medical applications (i.e. facial deformation)

[1] Drerup (2014). Rasterstereographic measurement of scoliotic deformity. Scoliosis.
[2] Lee & Liu (2012). Curved Glide-Reflection Symmetry Detection. IEEE Trans. Pattern Analysis & Machine Intelligence.
[3] Sato et al. (1996). Detecting Planar and Curved Symmetries of 3D Shapes from a Range Image. Computer Vision & Image Understanding.
[4] Combès (2010). Efficient computational tools for the statistical analysis of shape and asymmetry of 3D point sets. Ph.D. thesis, University of Rennes 1.
[5] Combès et al. (2008). Automatic symmetry plane estimation of bilateral objects in point clouds. IEEE Conf. on Computer Vision and Pattern Recognition, Anchorage, USA.
[6] Morand et al. (2018). Automatic extraction of the 3D symmetry line of back surface: application of scoliotic adolescents, IEEE Conf. Engineering in Medicine and Biology Society, Honolulu (USA).

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