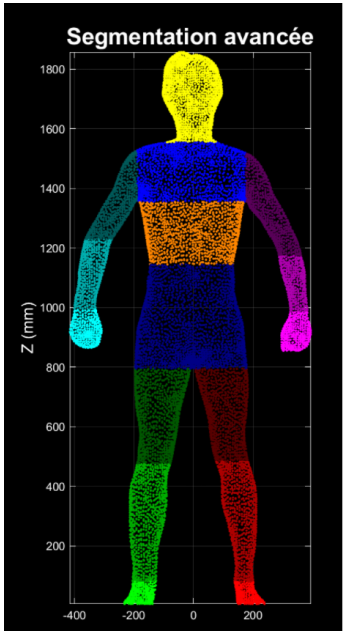
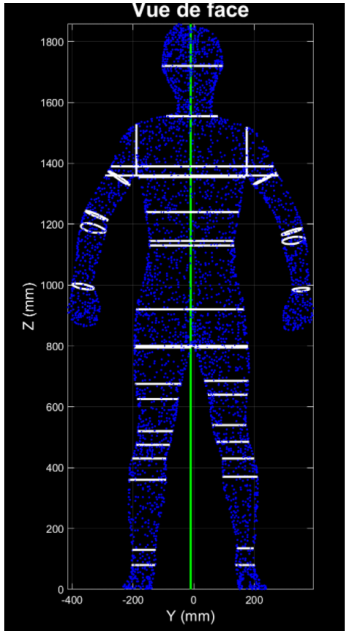
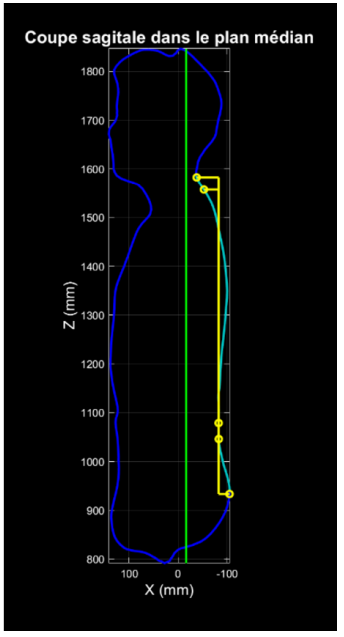
Youdome 3D avatar reconstruction and measurement software For pro sport and health care diagnosis







YOUDOME

Nicolas Douillet, R&D engineer in body scanning
2018 - 2019

ICCUS
ATHLETES. FIRST

Outline

Overall goal : automate, improve and accelerate tape measure for body limb girths. Compute athlete's biometric profile

- (1) : Point set processing
- (2) : Mesh processing
- (3) : Body measurements on mesh and results
- (4) : Video demos
- (5) : Data management and computation optimization
- (6) : Customers, collaborations and partnerships

The dome

- Geodesic dome (truncated v-2-0 geoid)

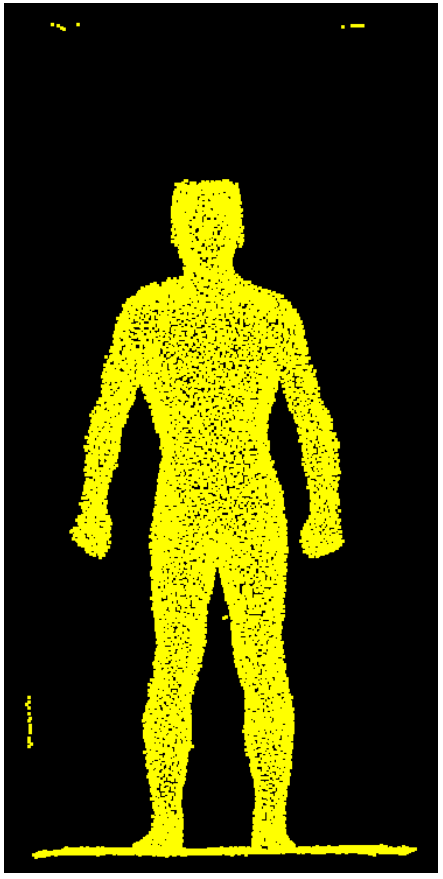
- Acquisition system and computer inside.

- 20 IR sensors.

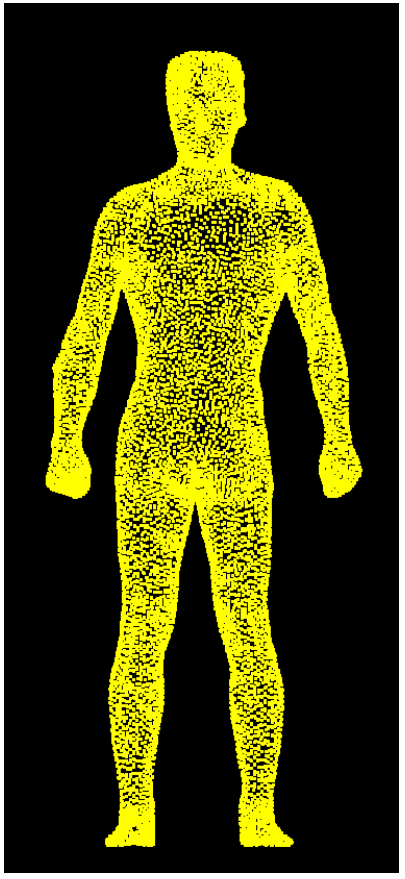
Point set processing steps

- (1) : Realignement + bounding box thresholding
- (2) : Outlier removal
- (3) : Smoothing
- (4) : Grid simplification / random decimation
- (5) : Vertex normals computation

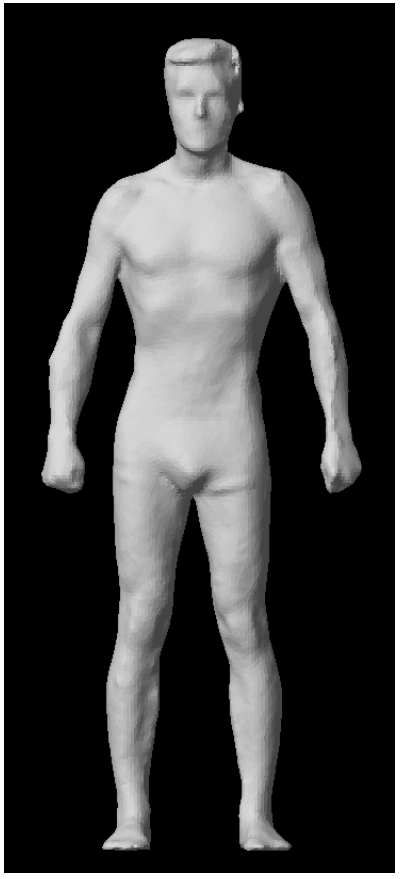
Point set processing



Raw noisy point set
With artefacts



Processed point set



Reconstructed surface
(triangular mesh)

Mesh processing steps

- (1) : Holes and boundary detection, simplification, smoothing, hole filling

- (2) : Mesh subselection and substripe selection

- (3) : Isotropic **mesh slicing** algorithm

- (4) : Avatar **slicing video**

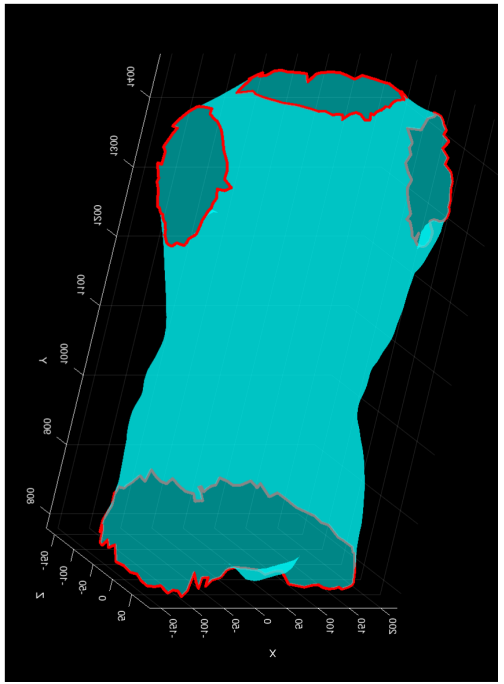
- (5) : Avatar **stick skeleton**

- (6) : Avatar **advanced segmentation** and labelling

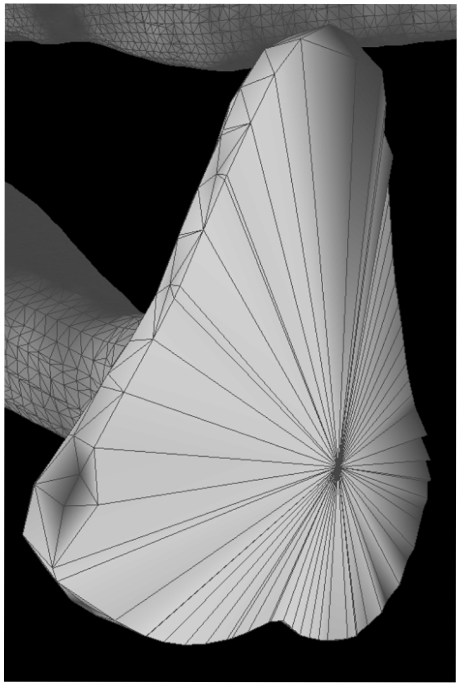
- (7) : Vectorized / oriented slicing

Hole and boundary detection, hole filling

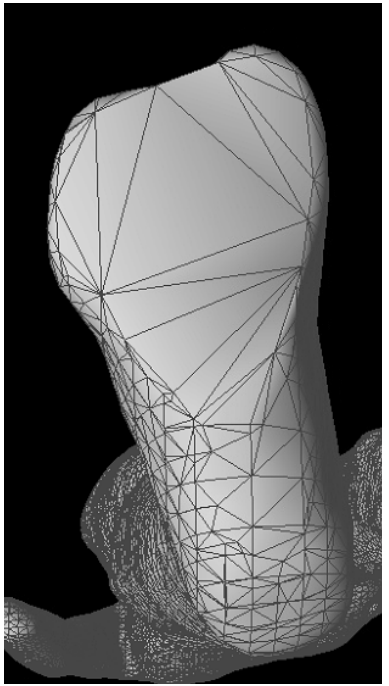
→ Need to cut the mesh above the ground (~zero level altitude thresholding) to correct Poisson mesh bulky reconstructed feet.



Boundary detection



Feet cut hole filling I
Contour isobarycentre

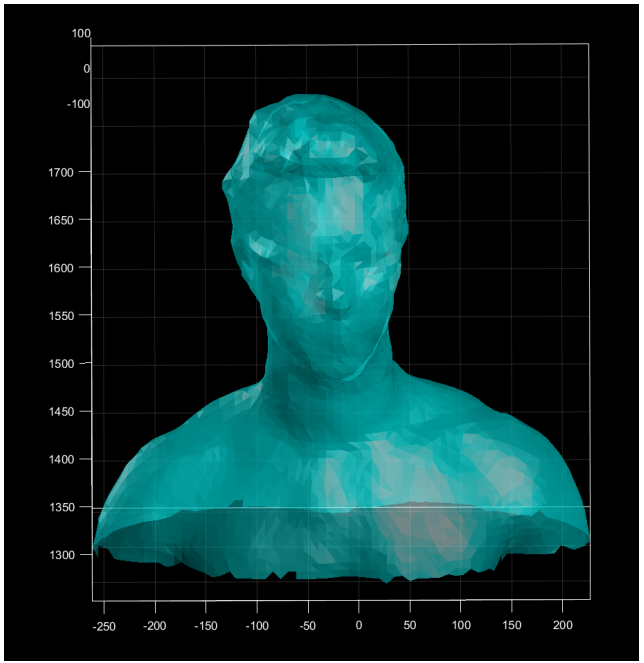


Feet cut hole filling II
Ensure curvature continuity

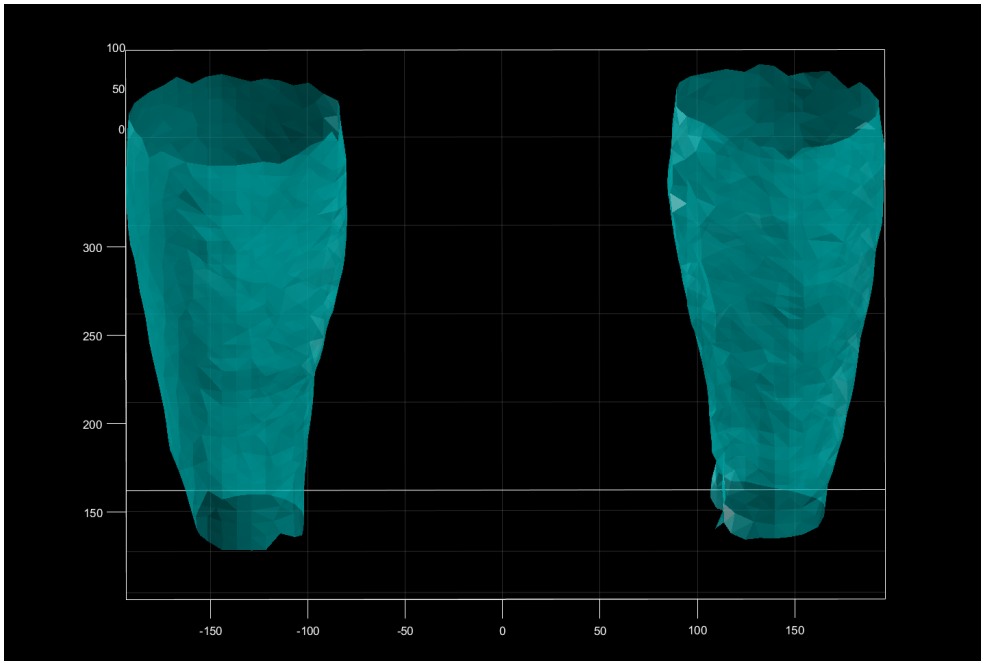
Mesh subselections

- Vectorized bounding boxes basic principle (point set then mesh)
- Usefull for segmentation and for CPU performances improvement

→ Avoid to process all the mesh and allows instead to select only the area of interest.



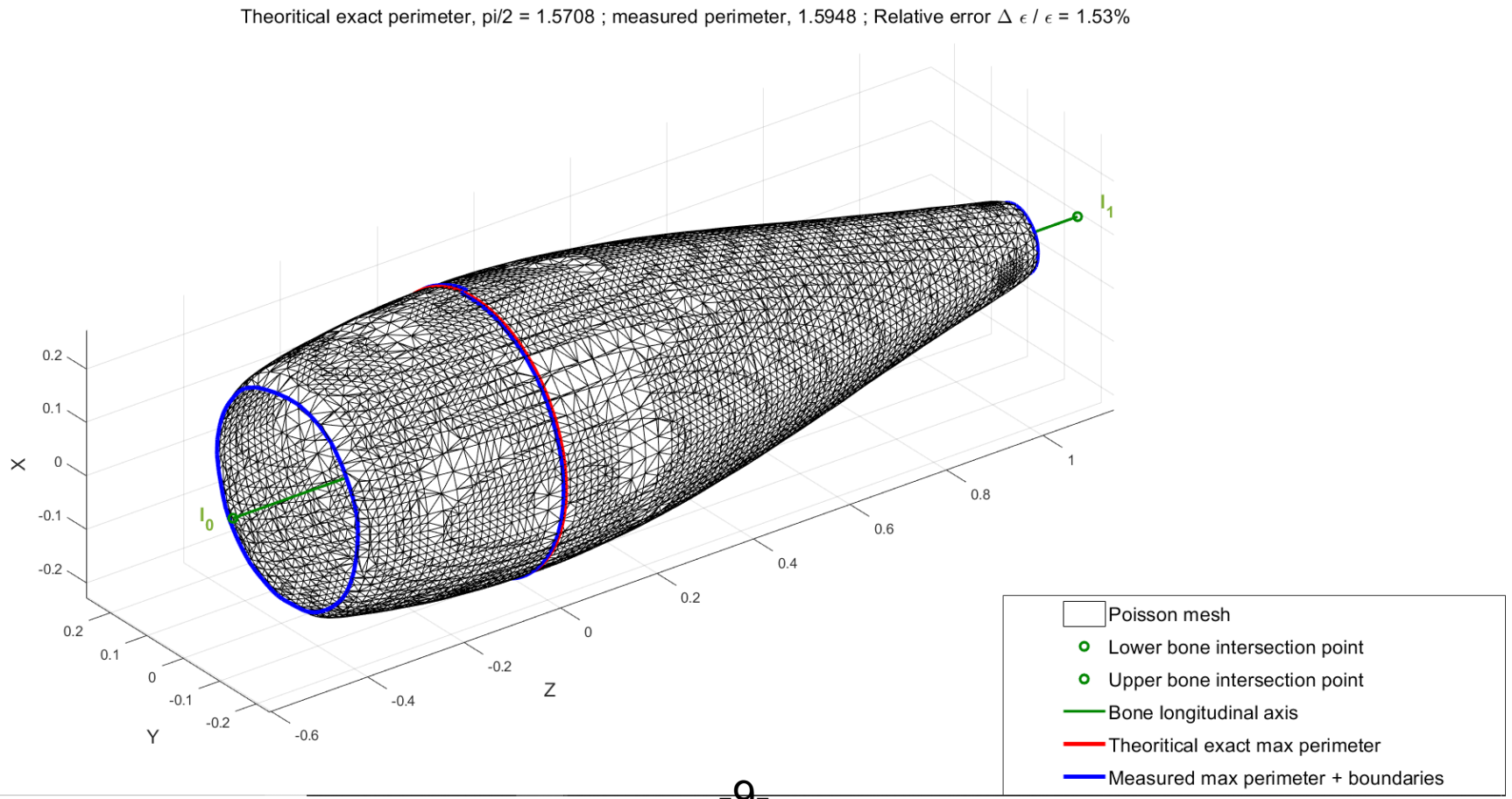
Bust



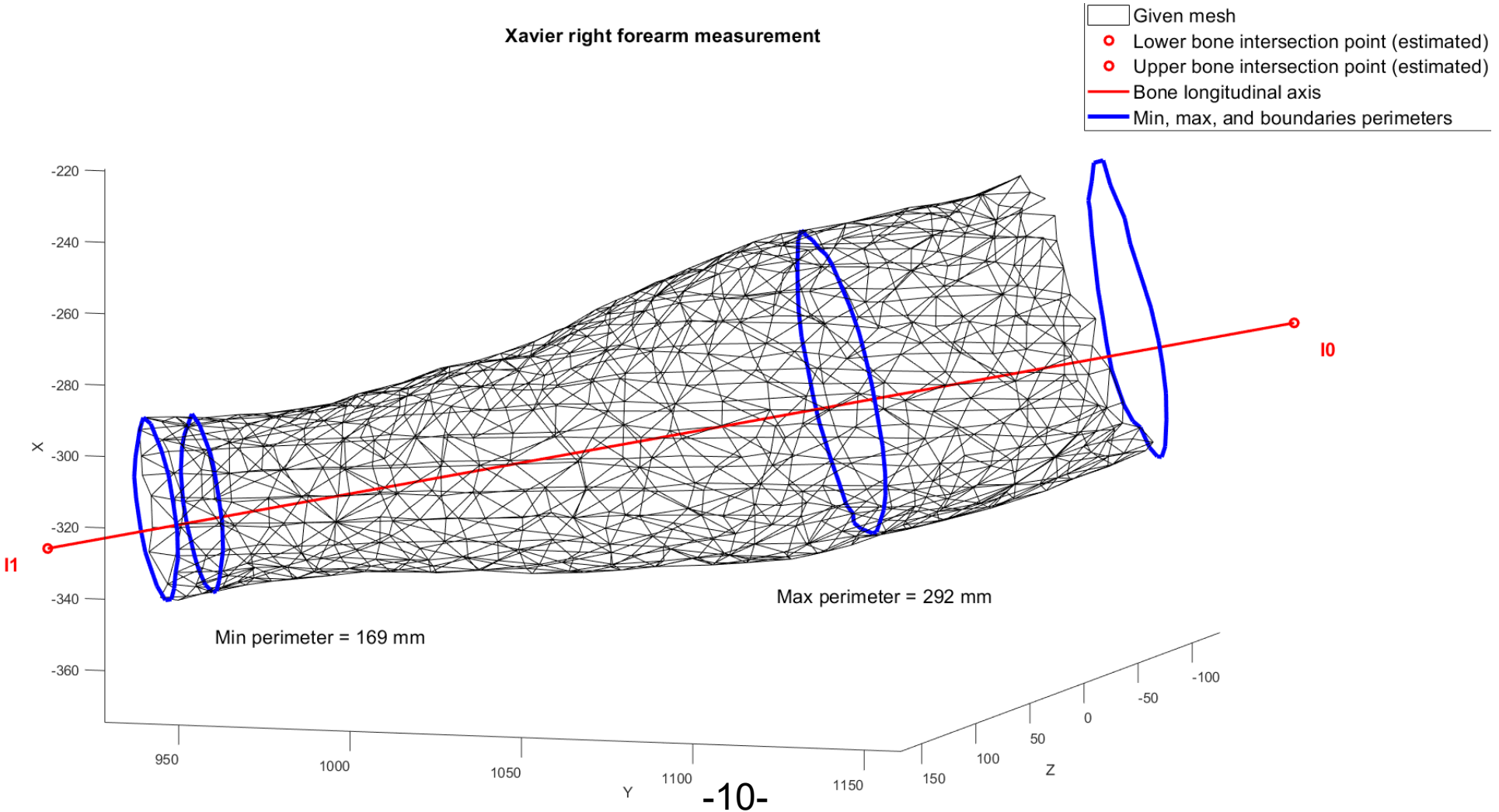
Calves

Mesh slicing beginings 1 : simulation data

Muscle modelization (point set + mesh) and measure its transversal slice perimeter

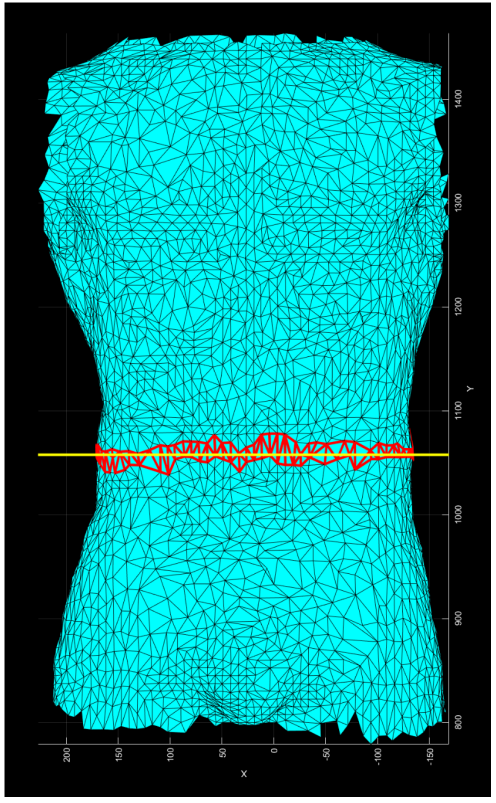


Mesh slicing beginings 2 : real data

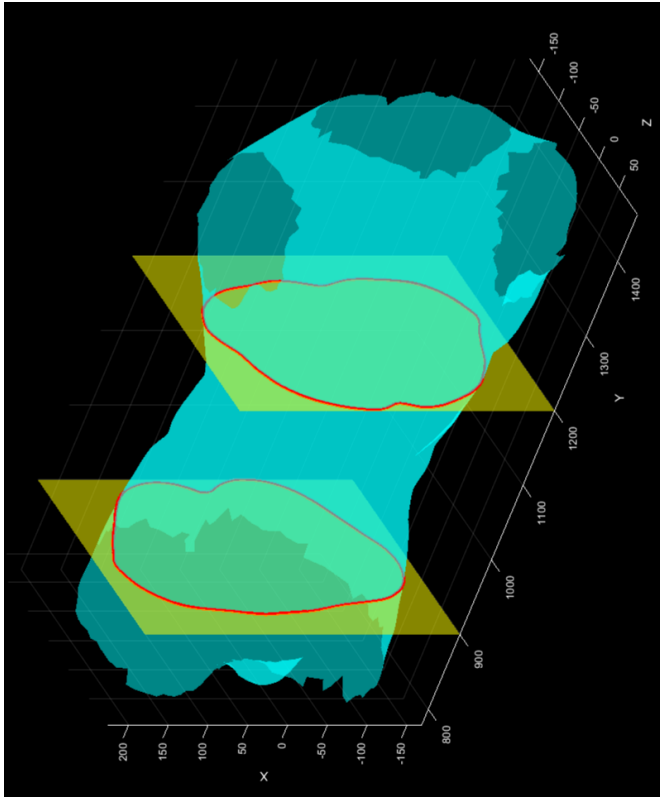


Mesh slicing

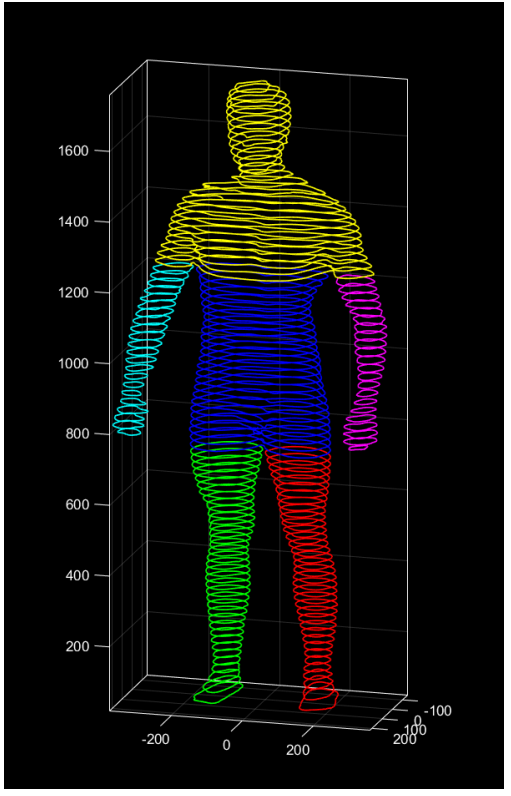
- Exact and robust slices
- Compute new points (intersections)



Triangles belt selection

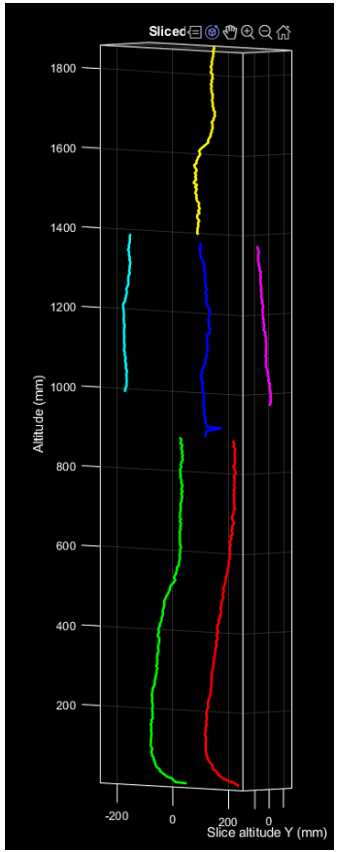


Avatar slices

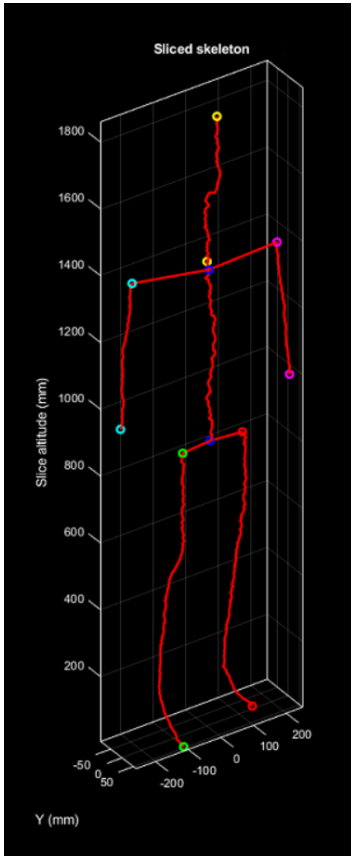


Sliced rebuilt avatar

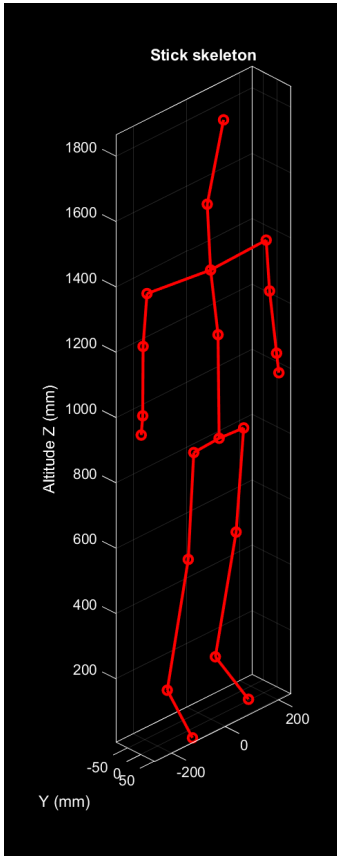
Stick skeleton computational steps



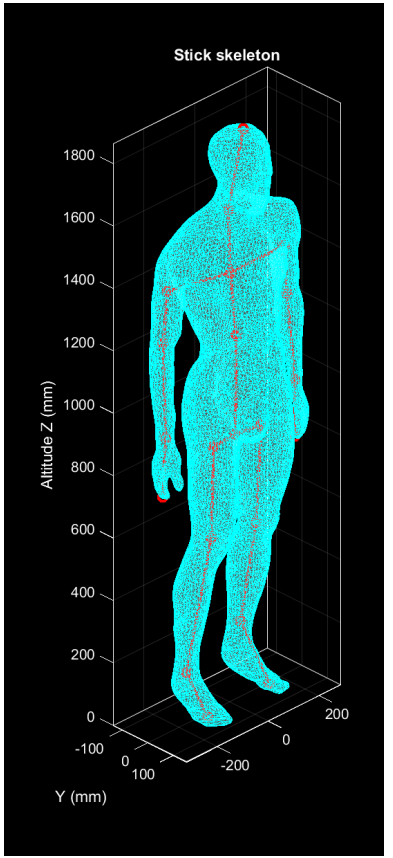
Sliced skeleton

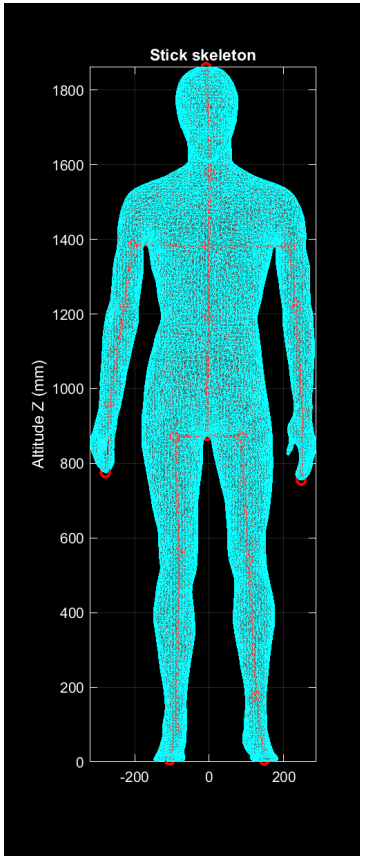


+ extremities
& junctions



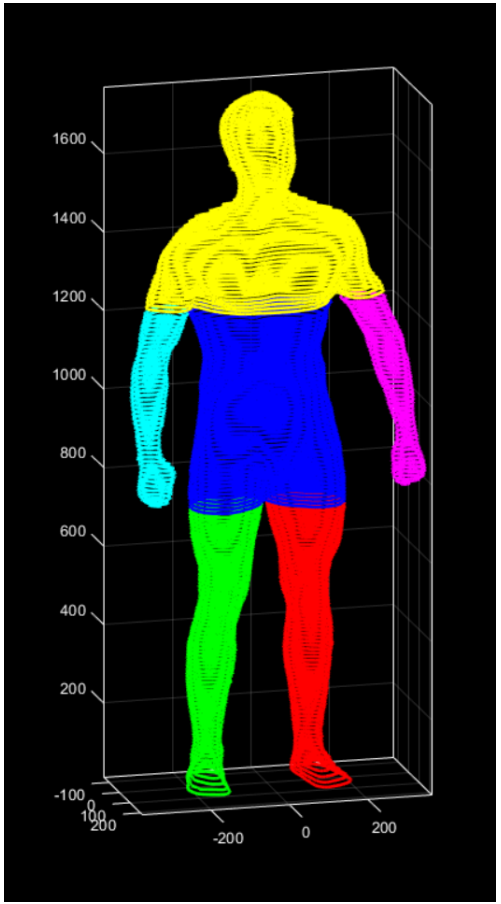
+ landmarks





→ Avatar advanced segmentation

Segmentations steps

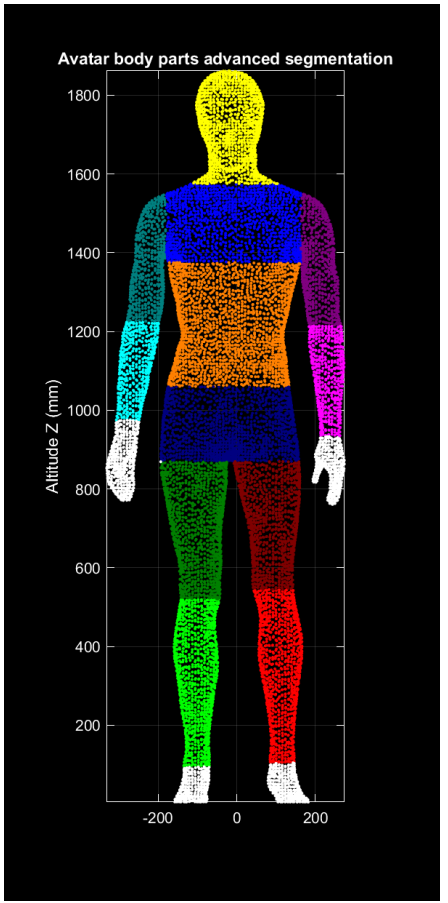


Avatar 1st rough segmentation

- 4 limbs + trunk
  + bust

- based on evolution of contours number

- Robust, but lacks of accuracy for further measurements



Avatar 2nd full segmentation

- 8 half limbs
  + 4 extremities
  + head
  + 3 parts trunk

- Uses landmarks Information in addition and relative position location a priori.

- Best accuracy

Body measurements on mesh and results

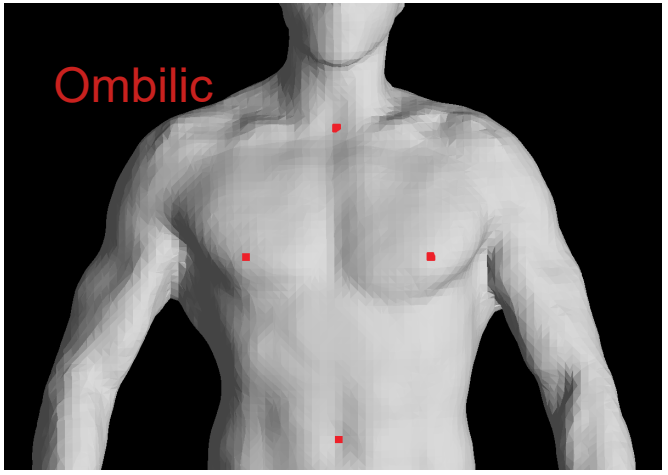
- (1) : **Landmarks** level / altitude detection

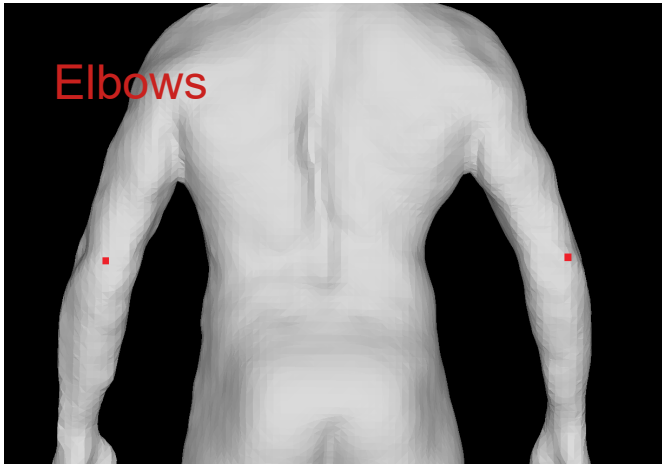
- (2) : **Limb girths** and body perimeter curves

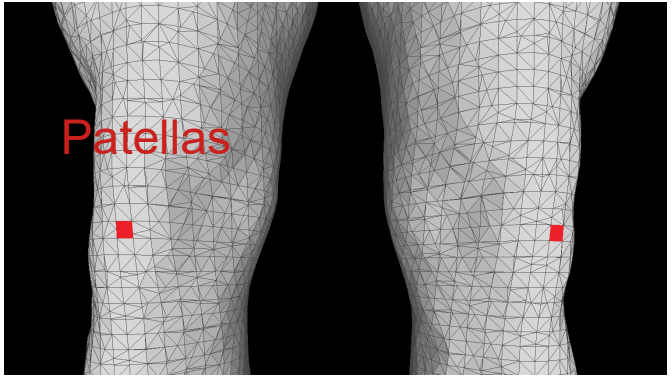
- (3) : **Lumbar profile** extraction and bending values estimation

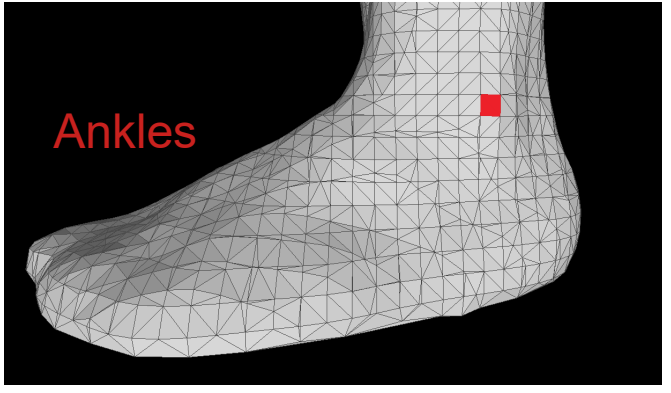
- (4) : 2D Convex hull in 3D option for slices girth

Landmarks detection : examples



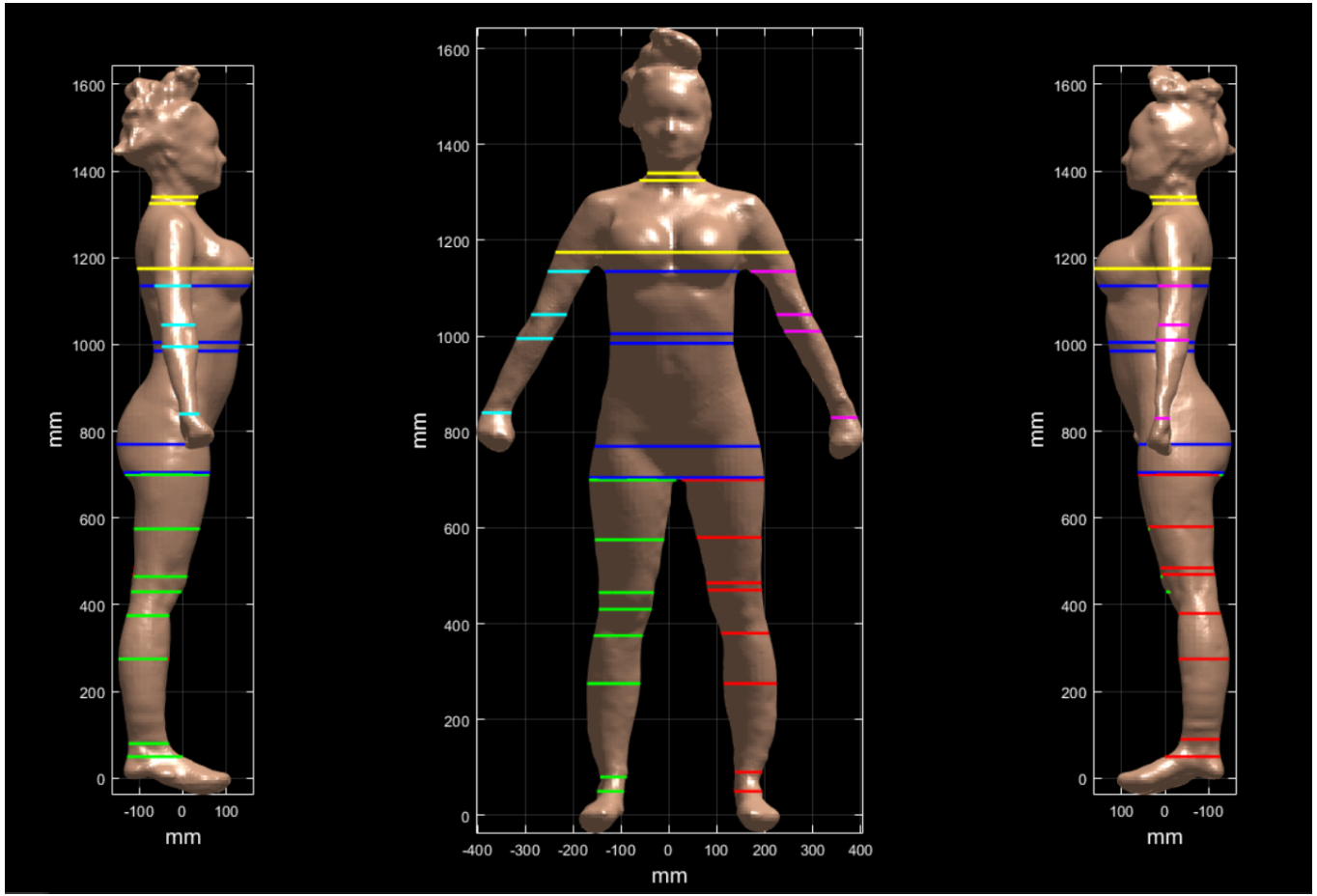






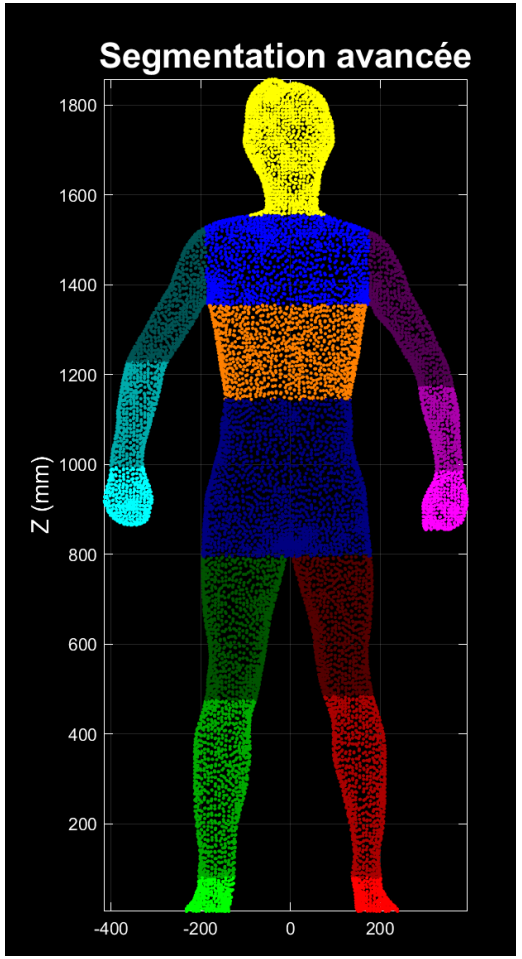
Required precision on landmarks location : ~5 cents coin diameter

Results : limb girths I

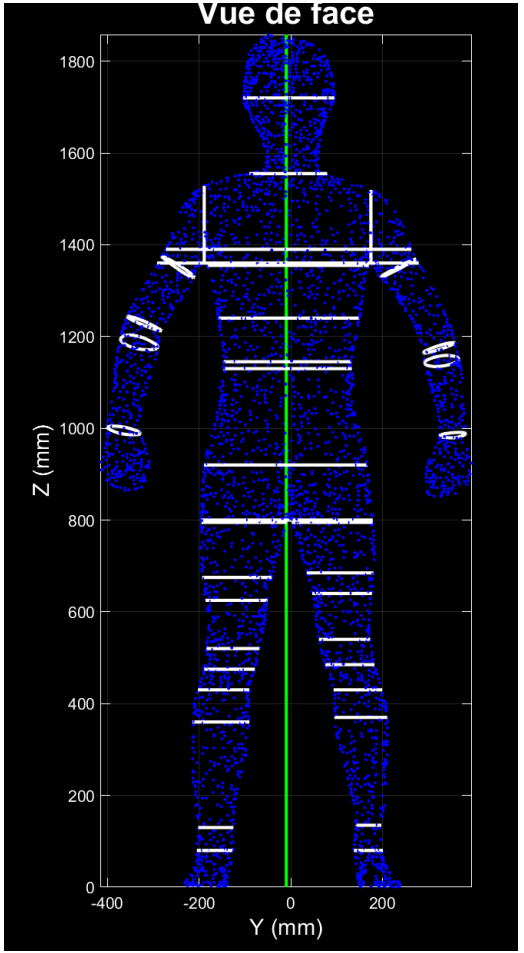


Horizontal 1st slicing

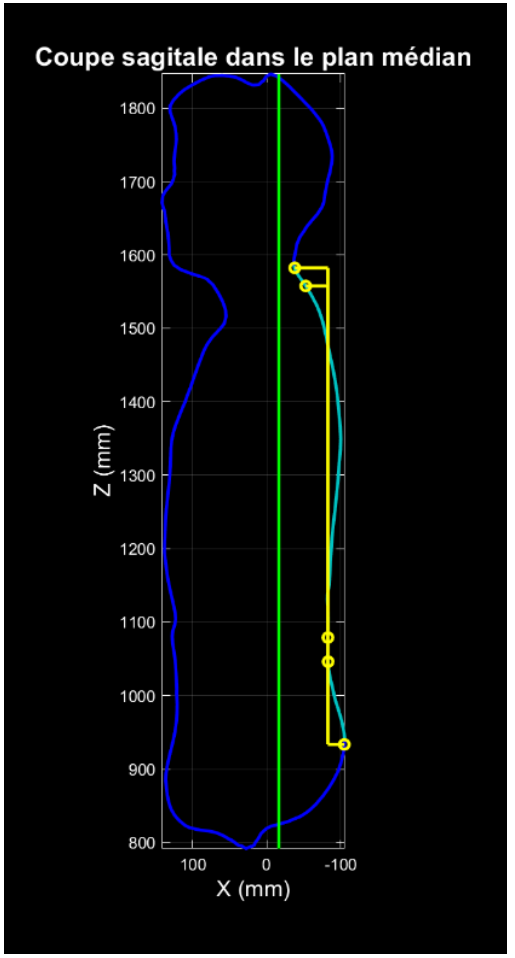
Results : limb girths II



Advanced segmentation

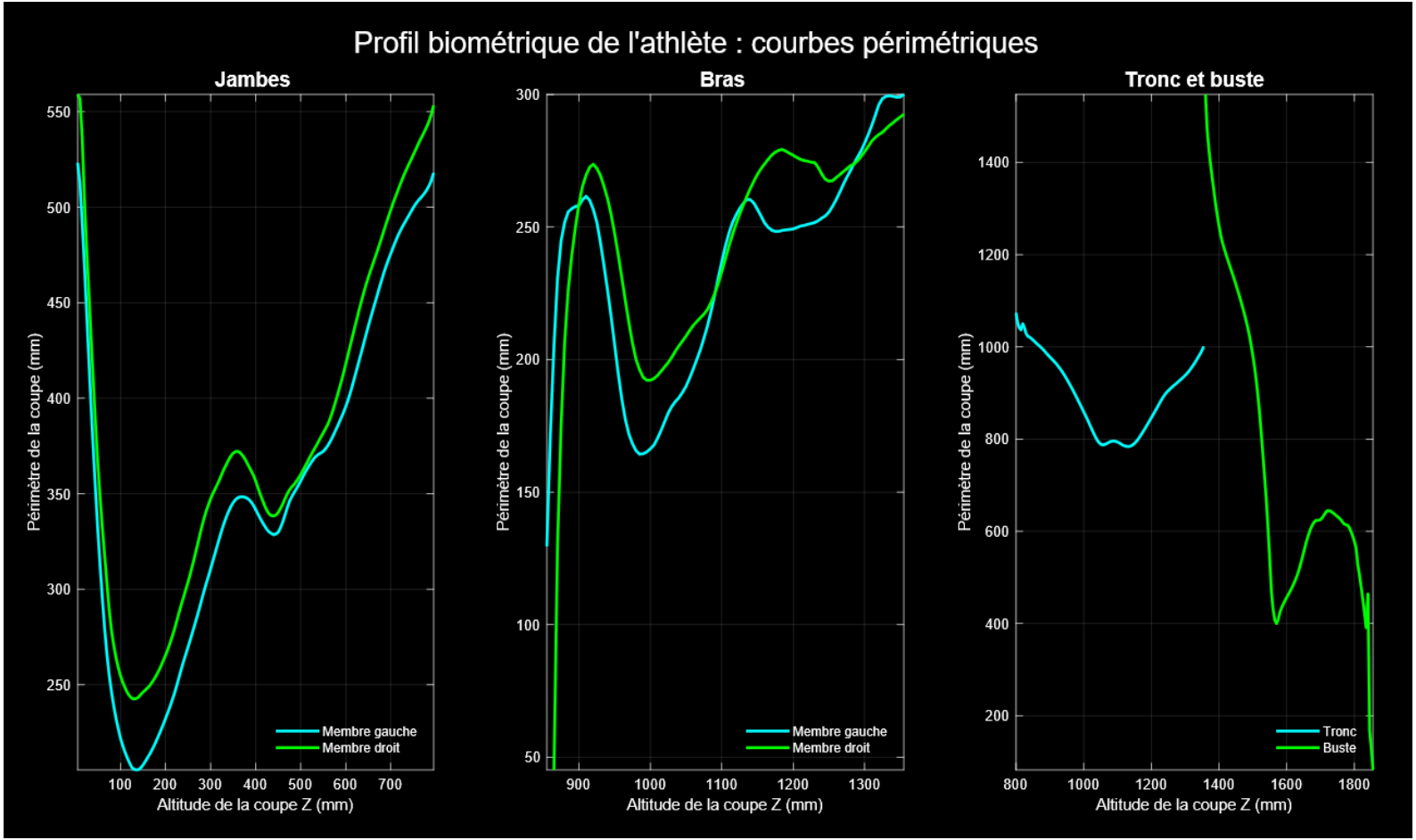


Vectorized slicing

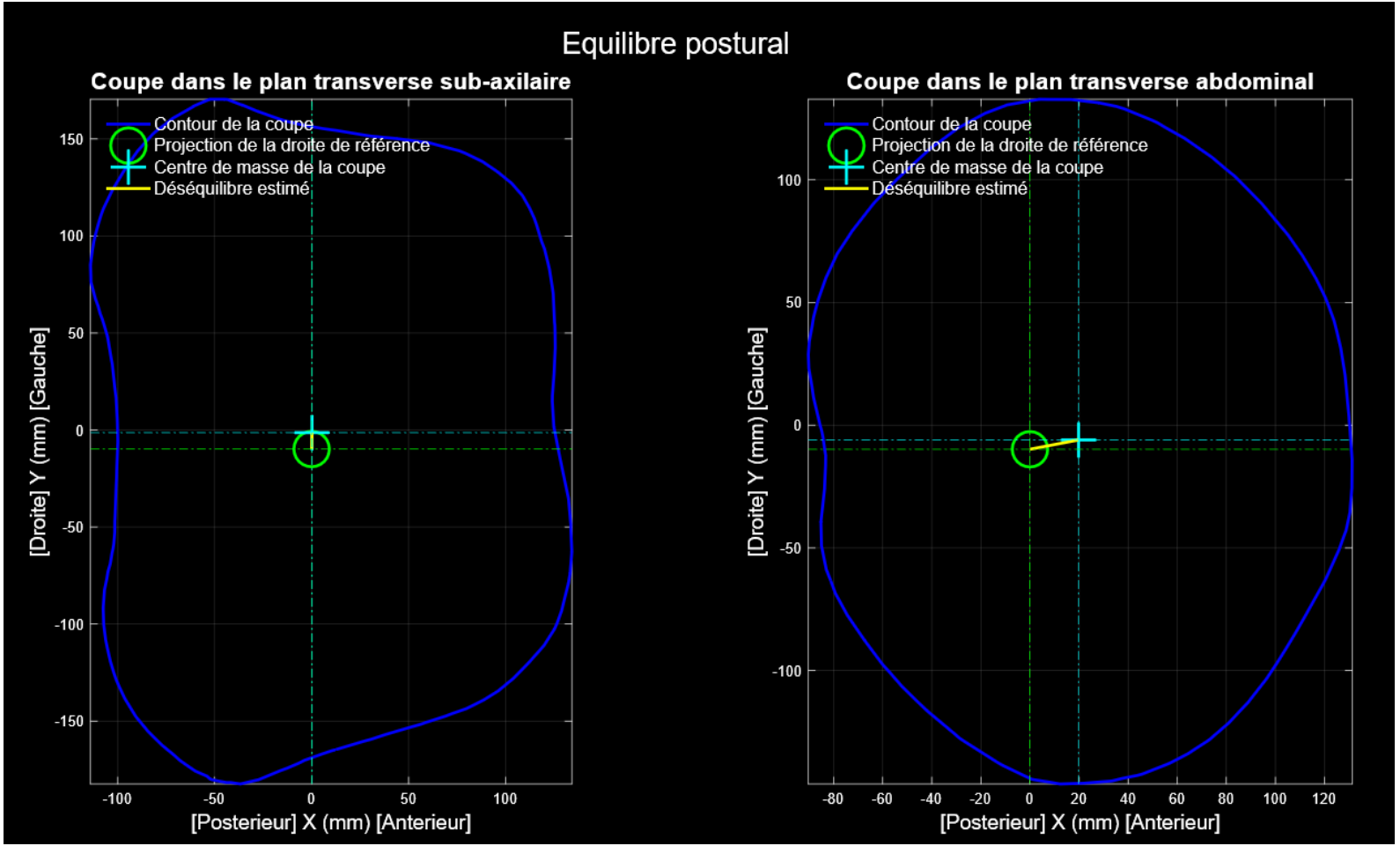


Lumbar profile

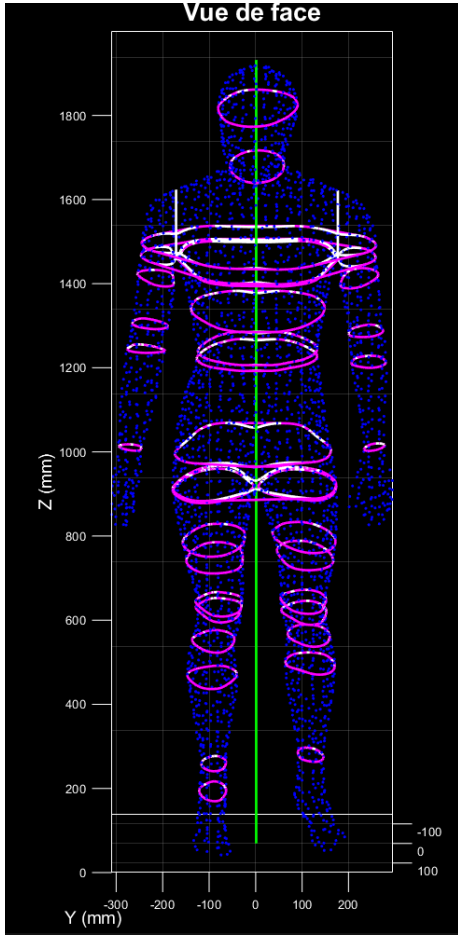
Results : athlete’s body shape profile

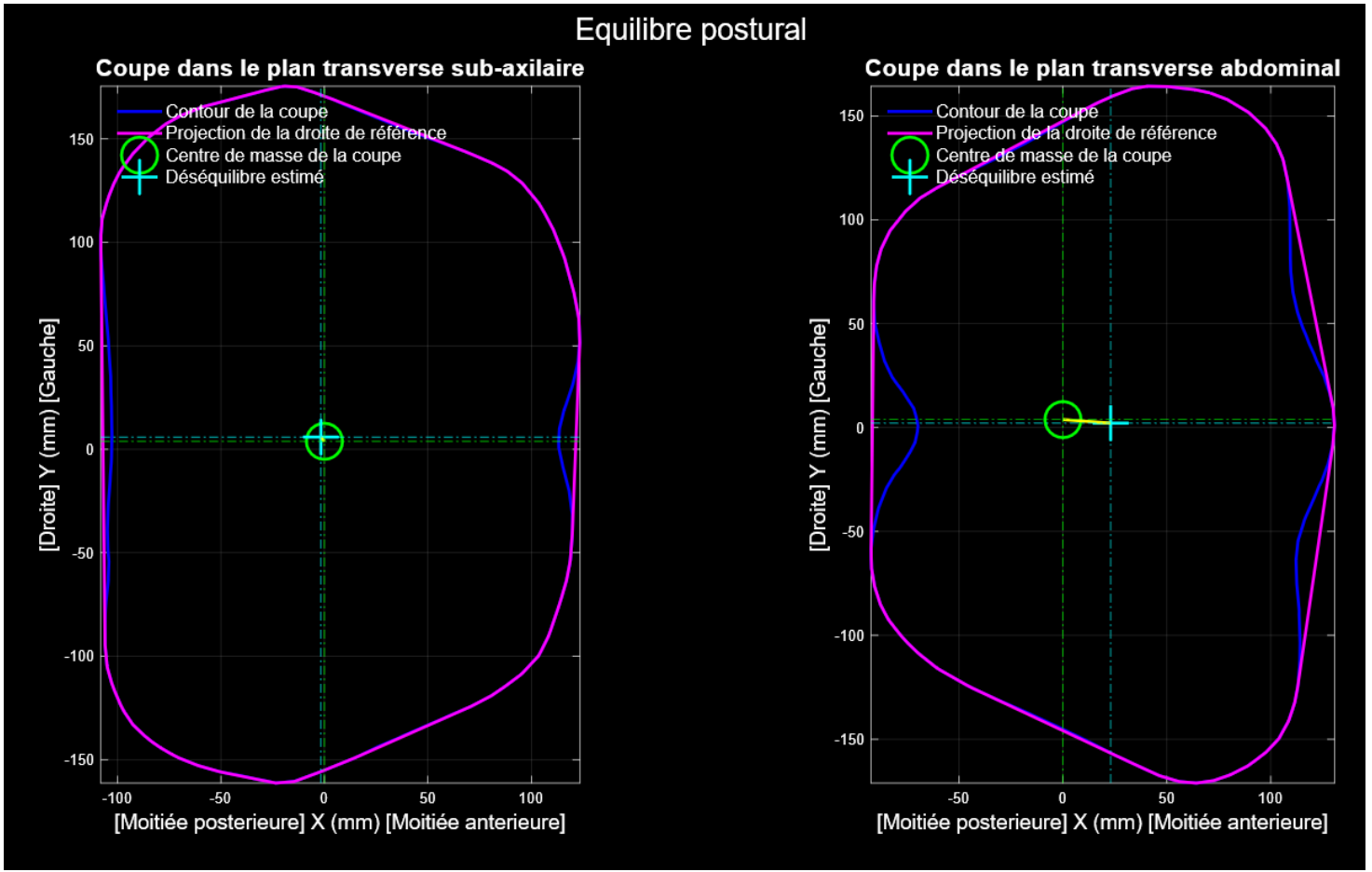


Results : athlete’s body balance estimation



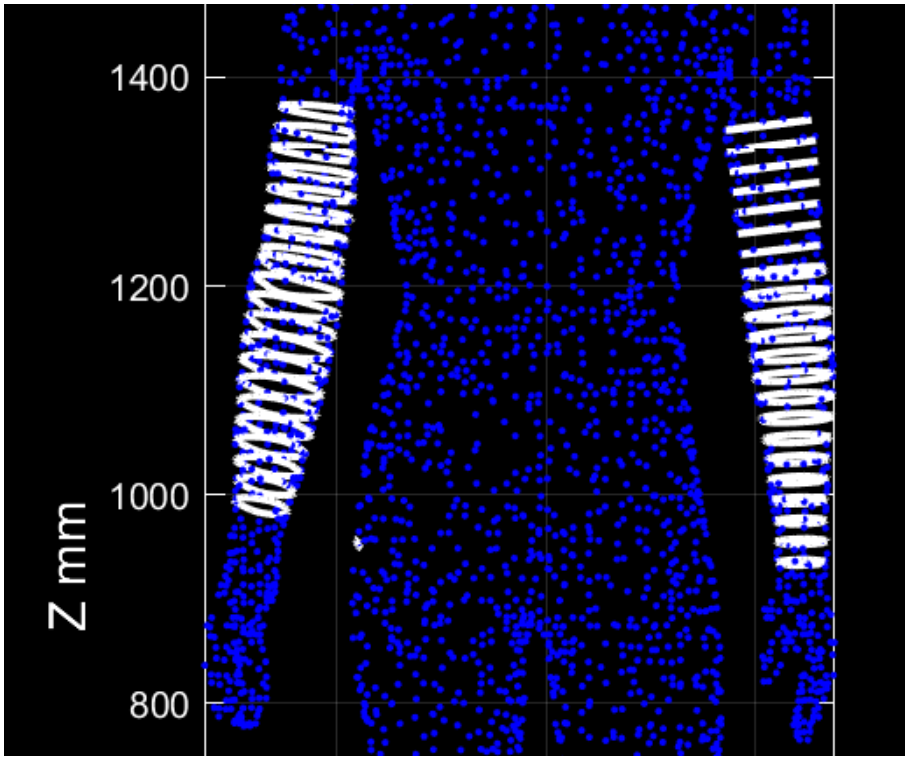
Slice convex hull





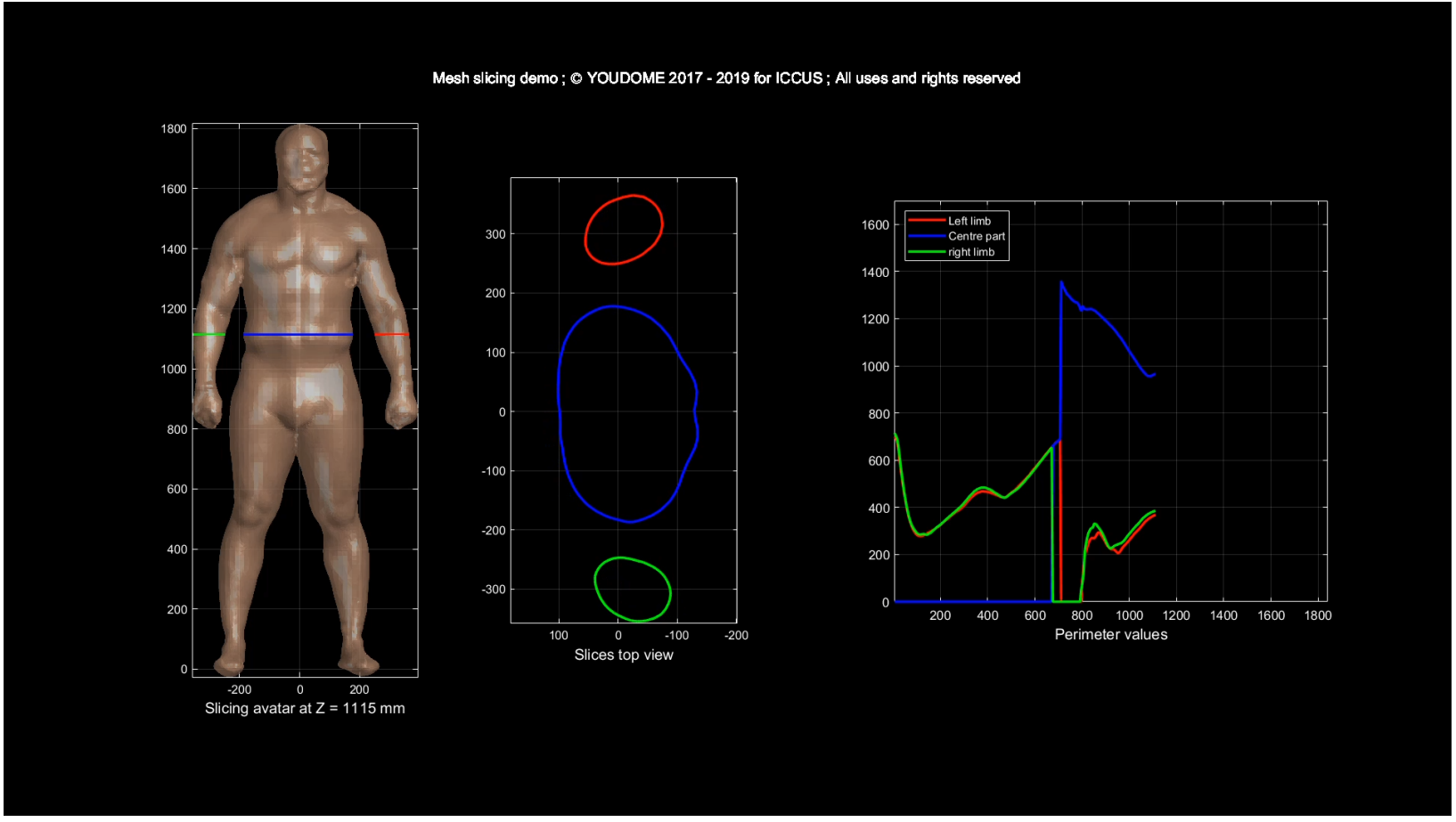
→ Allows measurements closer to tape measure ones

Vectorized / oriented slicing

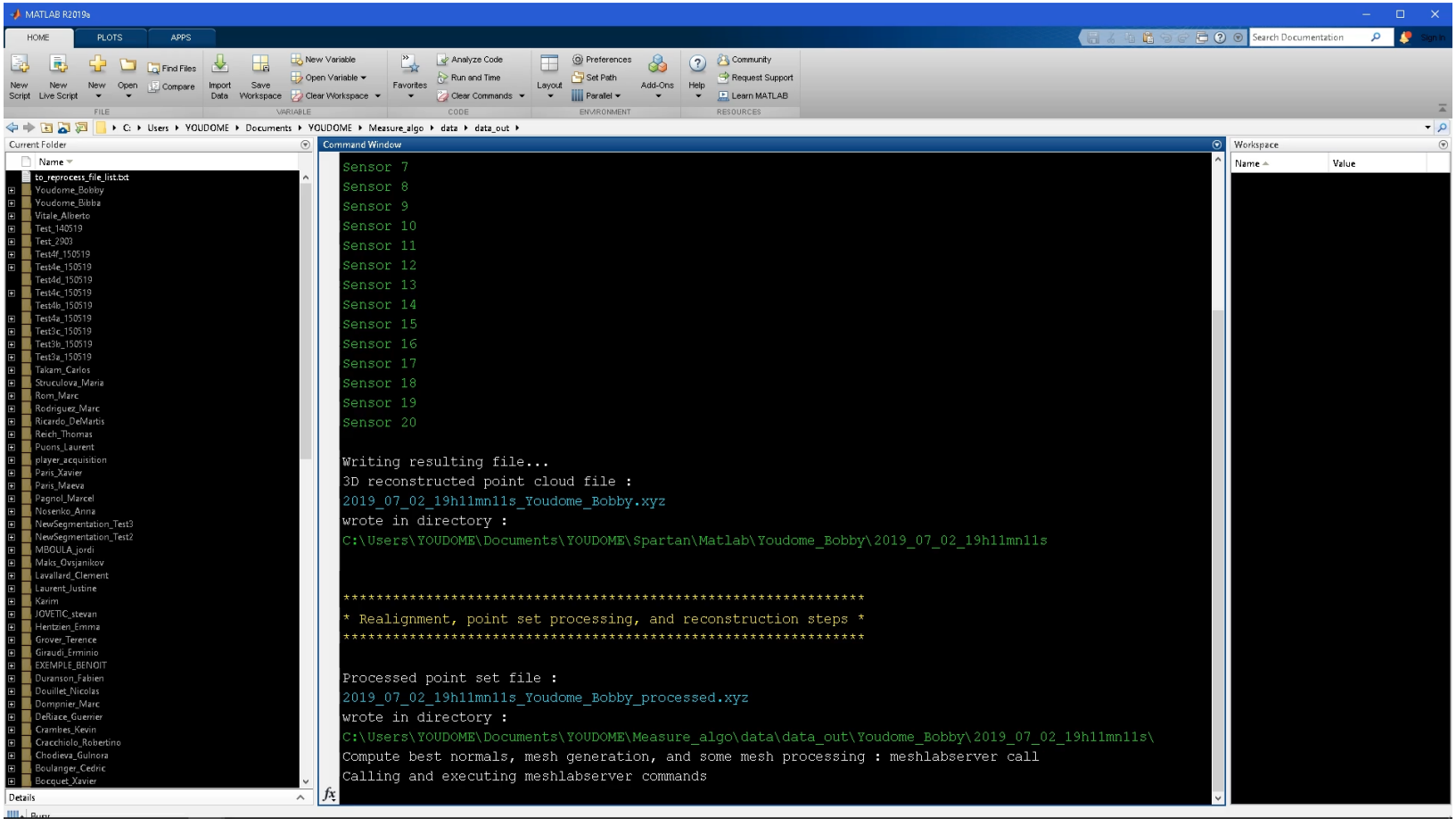


Advanced segmentation allows to perform a second slicing, which axis is oriented following the limb longitudinal direction, and provides the best measurement accuracy for avatar upper limb girths especially.

Video demo I : slicing + athlete’s biometric profile



Video demo II : whole process



Data management and computation optimization

- Body scan (x3) + avatar point set generation : < 5s (Christian Barat)

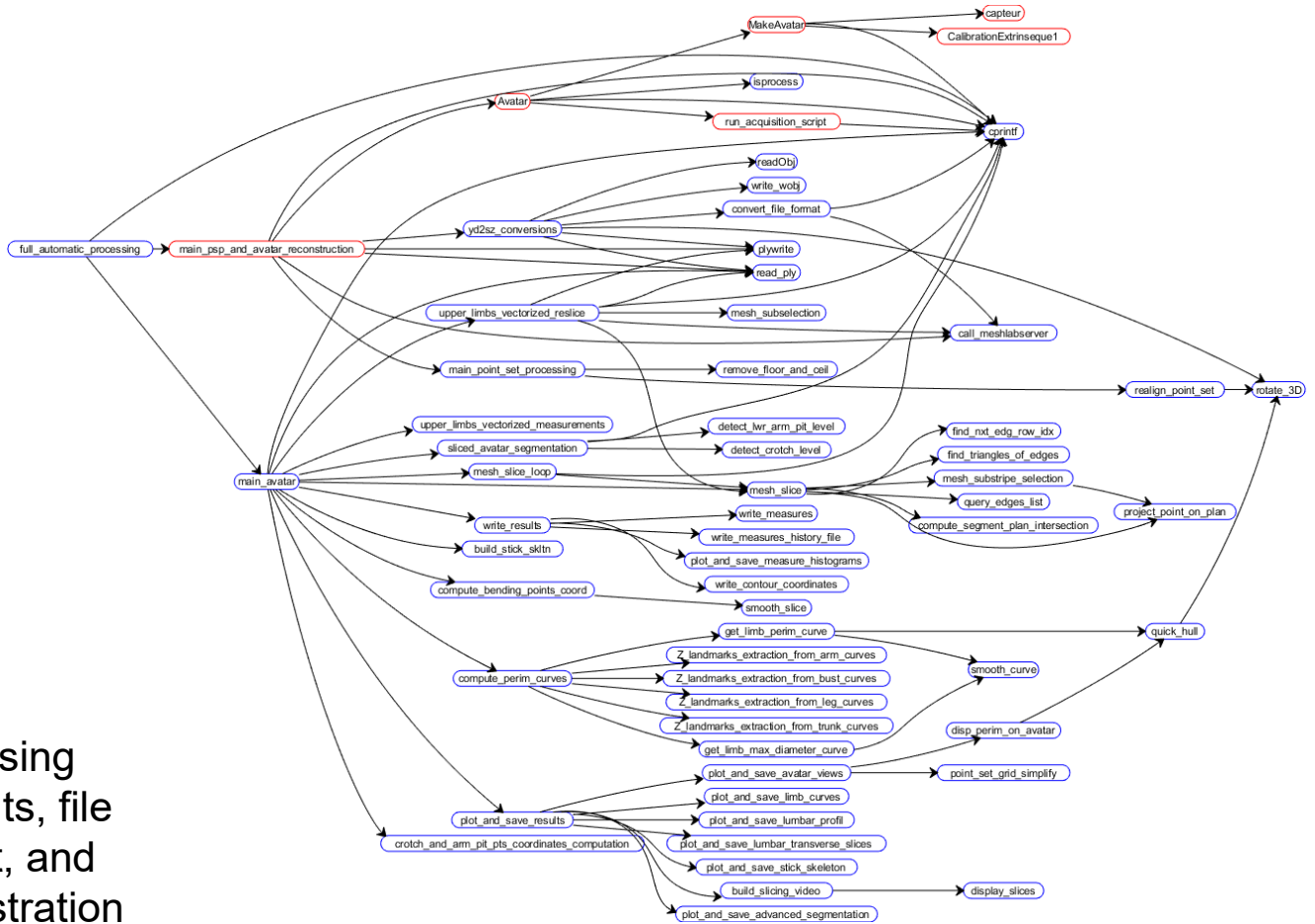
- Point set processing + mesh generation + mesh processing + measurements : ~45s highly depending on avatar resolution (number of triangles).

- Code vectorization

- Parallel processing : for and while loops for the slicing algorithm

- Anonymous (RGPD) athlete scan automatic folder and files creation and biometric data analysis update.

Functions graph



- Point set processing
- Mesh processing
- Measurements, file management, and
- pictures registration
- Platform interface

Main challenges to rise and solutions found

Challenges	Solutions
• Wide range of body shapes and morphologies (men / women, body mass index, young, old, body shape adaptation / specialization to sport).	→ Integration of lots of test avatars with various morphologies (boxers, dancers, tennismen, climbers, swimmers, football players, bodybuilders, etc.).
• Body imperfections and asymetries.	→ Global approach but no projection on an average morphology avatar.
• Human morphological positioning and ratio a priori.	→ Local and relative landmarks positioning, human ratio tables.
• Body positioning, hands, long « wild » hairs.	→ Body positioning protocole + beany.
• Landmarks location algorithm and location precision.	→ Advanced segmentation and relative landmarks positioning
• Computational ressources minimization (time, memory).	→ Vectorization, // processing, submesh selection, code optimization, point set and mesh simplifications.

Main partnerships and customers

- Monaco football club
- 
- Monaco princess Grace dance academy

- Reknown sportsmen in tennis, boxing, bodybuilding swimming, etc... (confidential)

Main collaborations

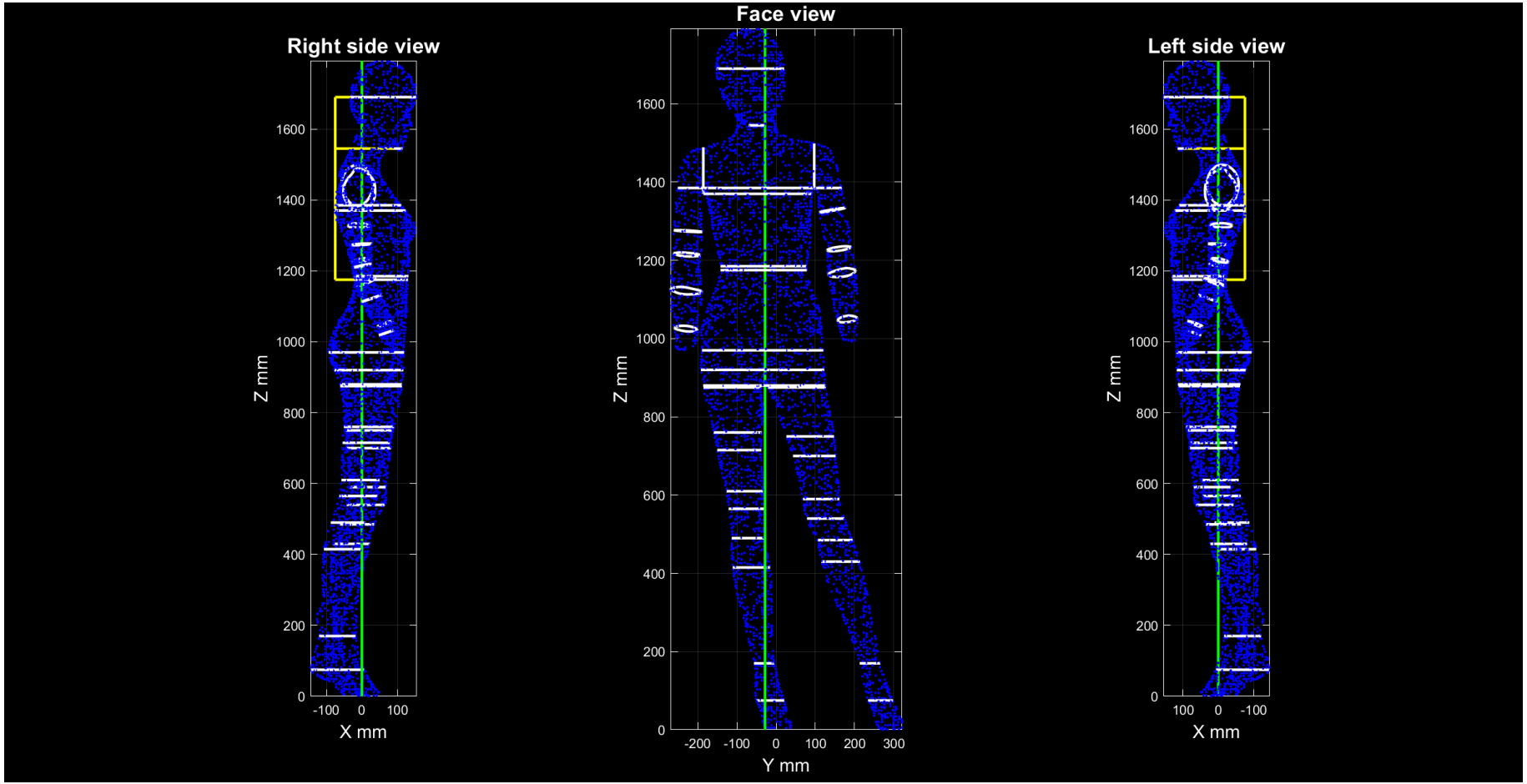
- Christian Barat, I3S / INRIA
  Acquisition, point set generation,
  3D reconstruction

- Maks Ovsjanikov, LIX Polytechnique
  Landmarks detection

- Clément Lavallard, Iccus / Diocles CEO

Thank you !

Algorithm robustness to bad positioning



Slogan