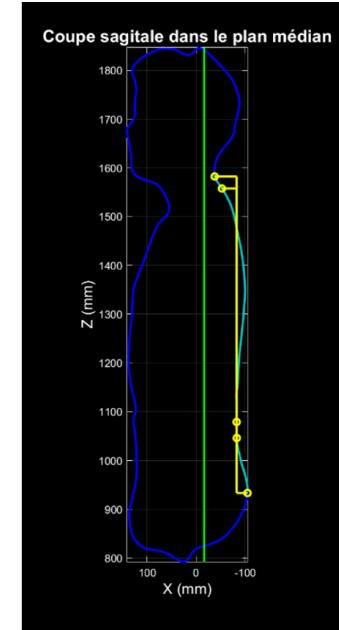
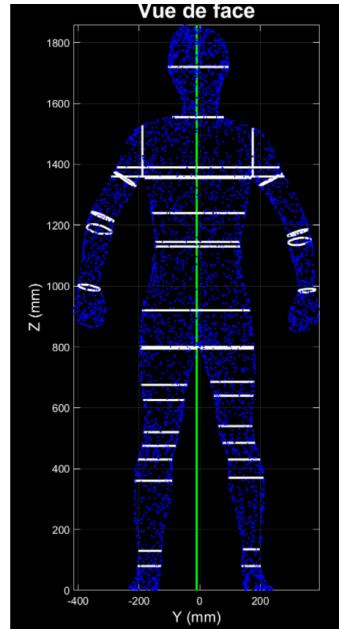
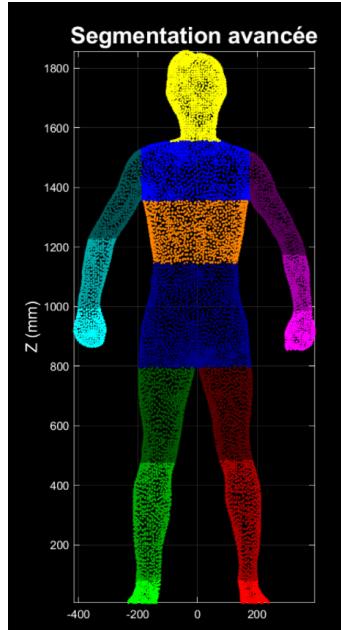
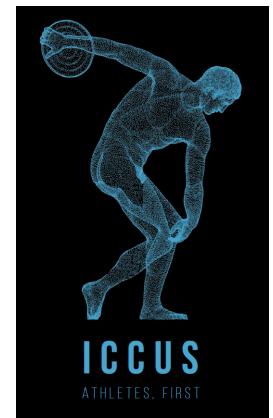


Youdome 3D avatar reconstruction and measurement software

For pro sport and health care diagnosis



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



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

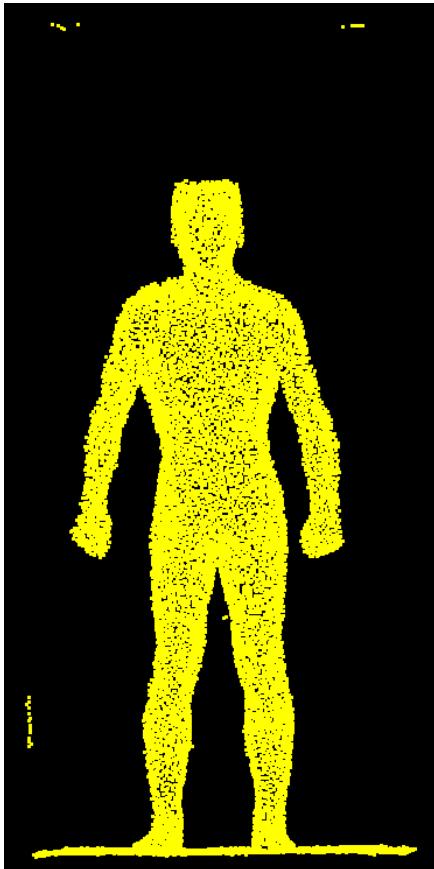


- Geodesic dome (truncated v-2-0 geoid)
- Acquisition system and computer inside.
- 20 IR sensors.

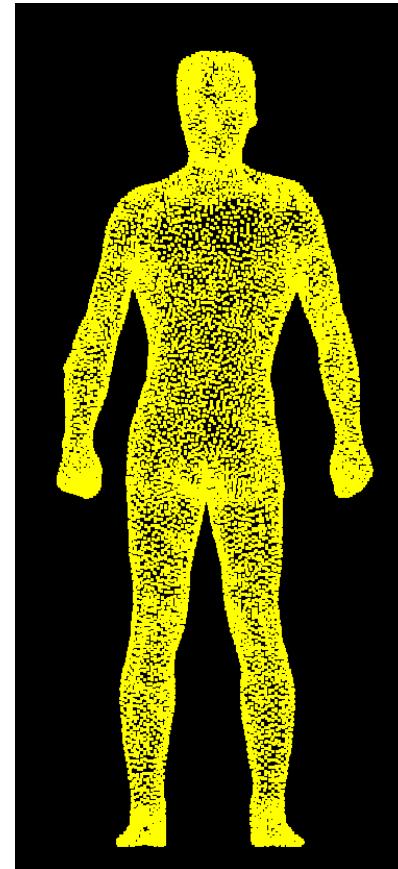
Point set processing steps

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

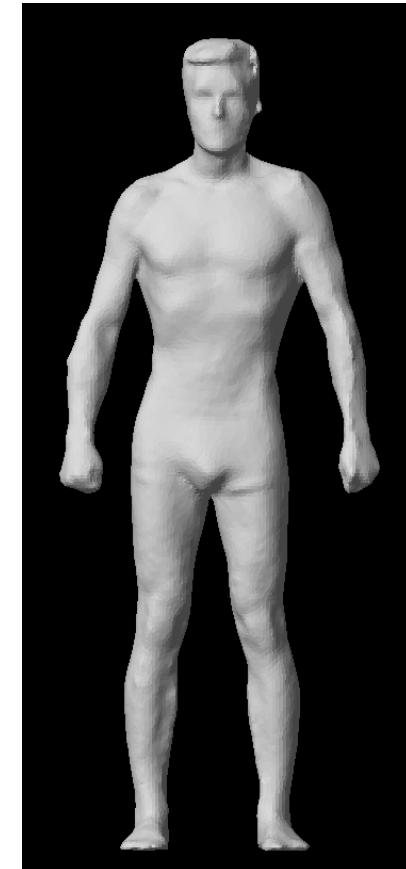
Point set processing



Raw noisy point set
With artefacts



Processed point set



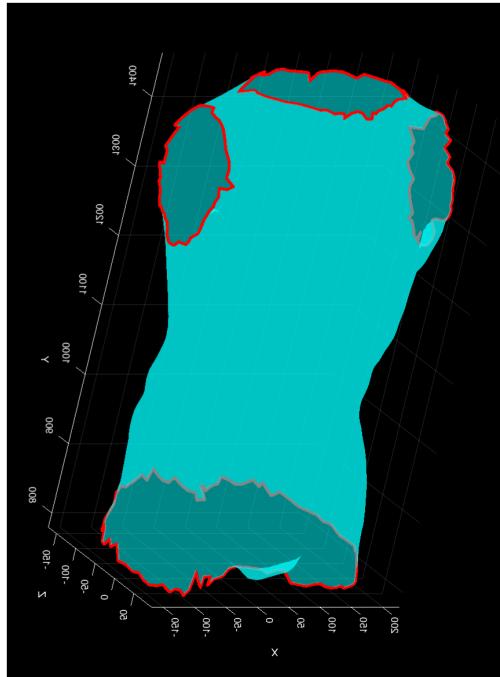
Reconstructed surface
(triangular mesh)

Mesh processing steps

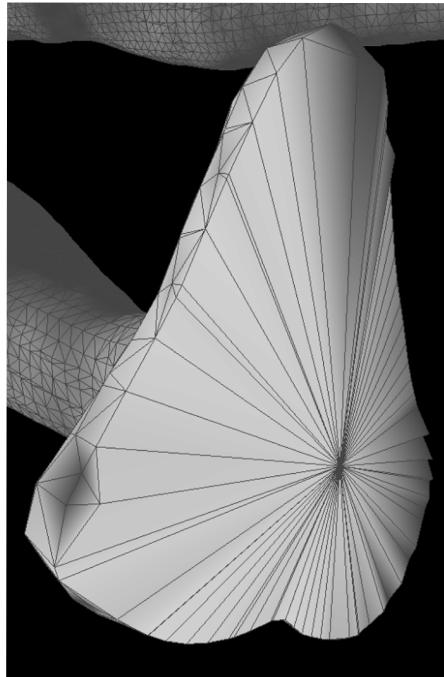
- (1) : Holes and boundary detection, simplification, smoothing, hole filling
- (2) : Mesh subselection and substripe selection
- (3) : Isotropic **mesh slicing** algorithm
- (4) : Avatar **slicing video**
- (5) : Avatar **stick skeleton**
- (6) : Avatar **advanced segmentation** and labelling
- (7) : Vectorized / oriented slicing

Hole and boundary detection, hole filling

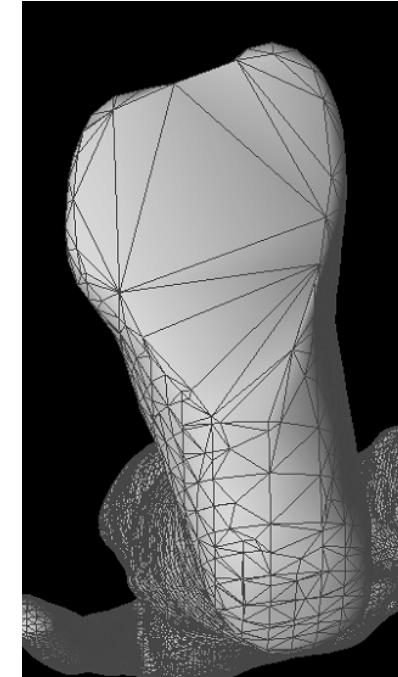
→ Need to cut the mesh above the ground (~zero level altitude thresholding) to correct Poisson mesh bulky reconstructed feet.



Boundary detection



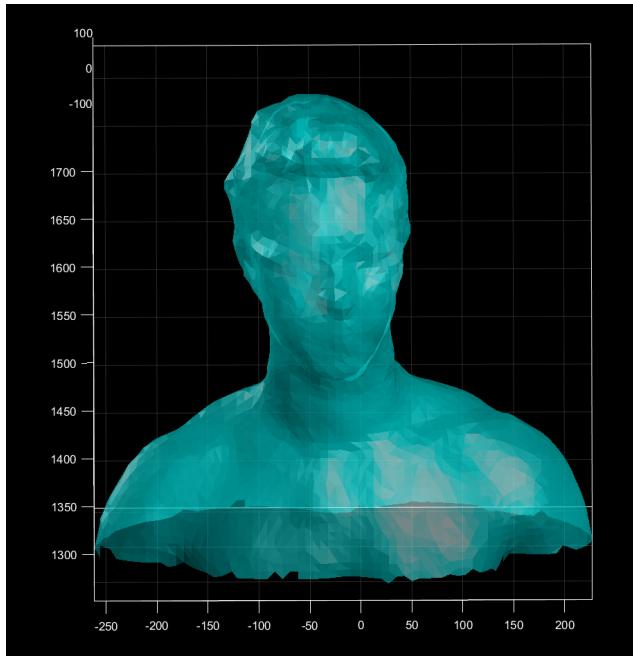
Feet cut hole filling I
Contour isobarycentre



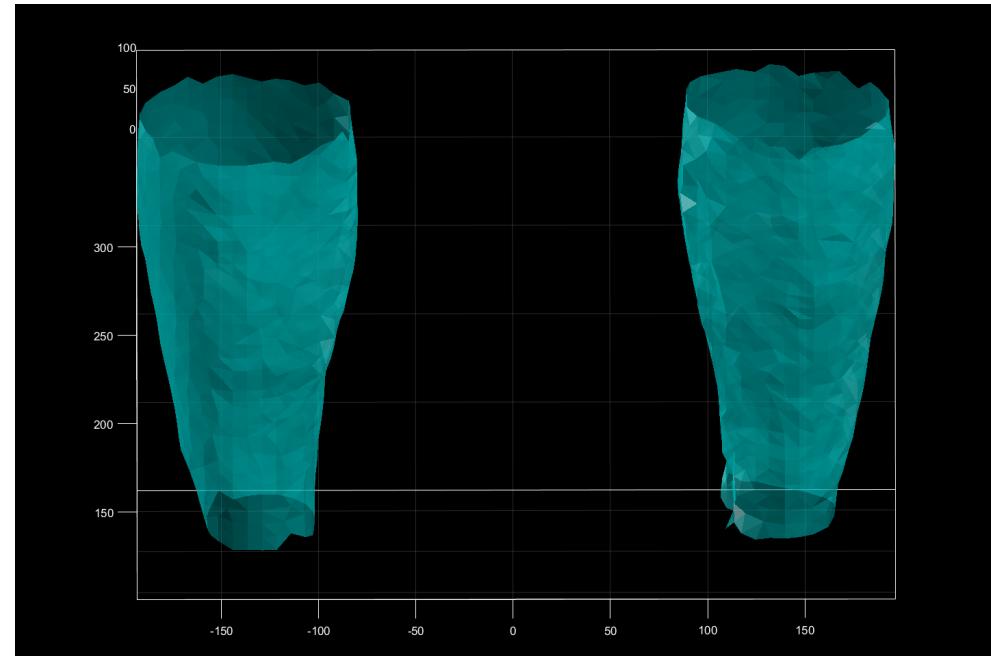
Feet cut hole filling II
Ensure curvature continuity

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

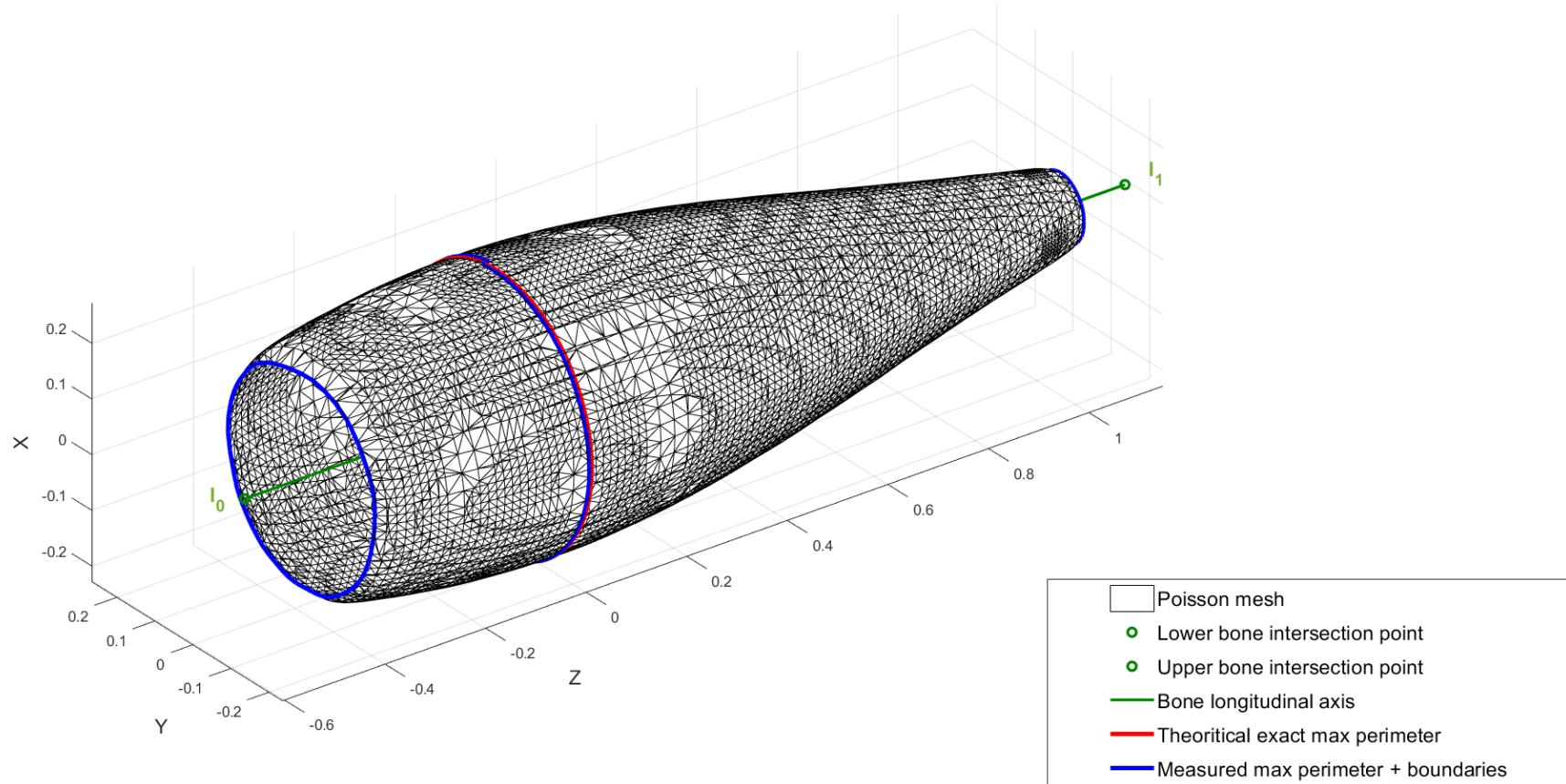


Calves

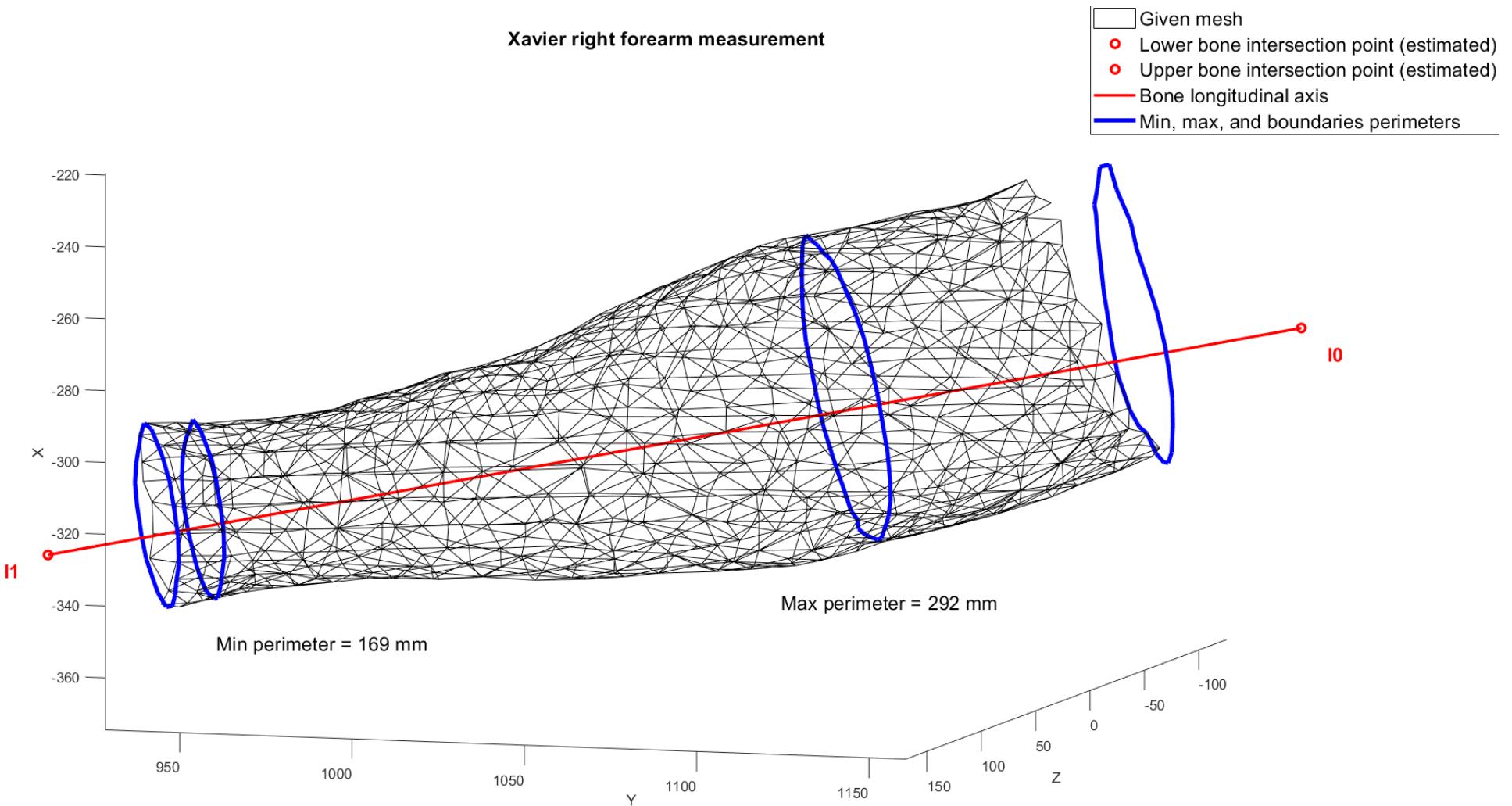
Mesh slicing beginings 1 : simulation data

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

Theoretical exact perimeter, $\pi/2 = 1.5708$; measured perimeter, 1.5948 ; Relative error $\Delta \epsilon / \epsilon = 1.53\%$

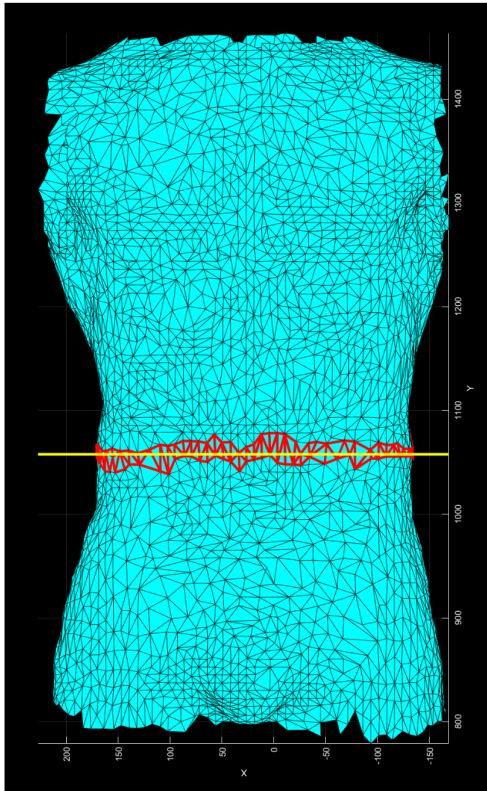


Mesh slicing beginings 2 : real data

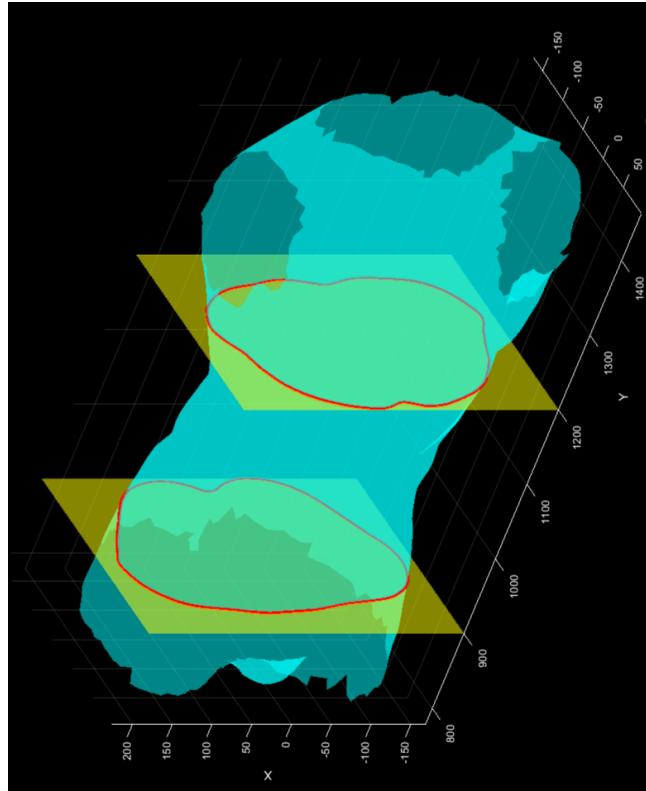


Mesh slicing

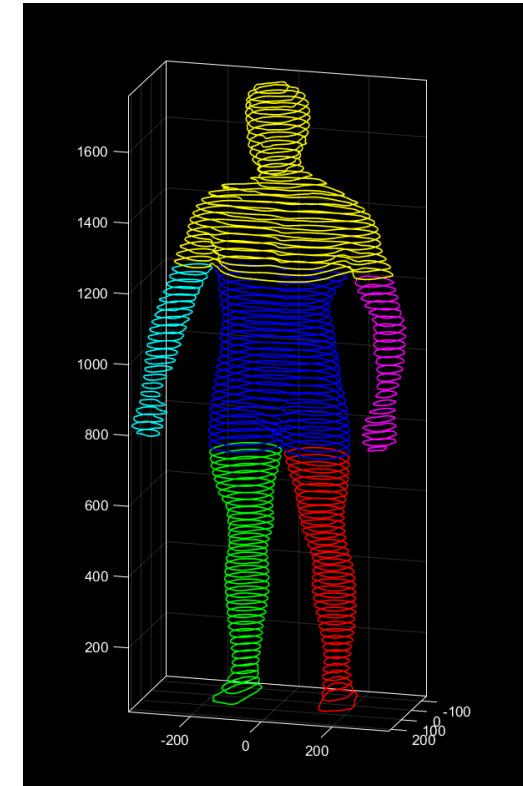
- Exact and robust slices
- Compute new points (intersections)



Triangles belt selection

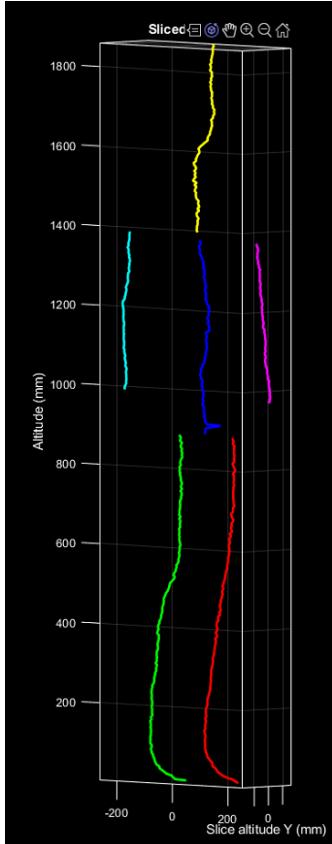


Avatar slices

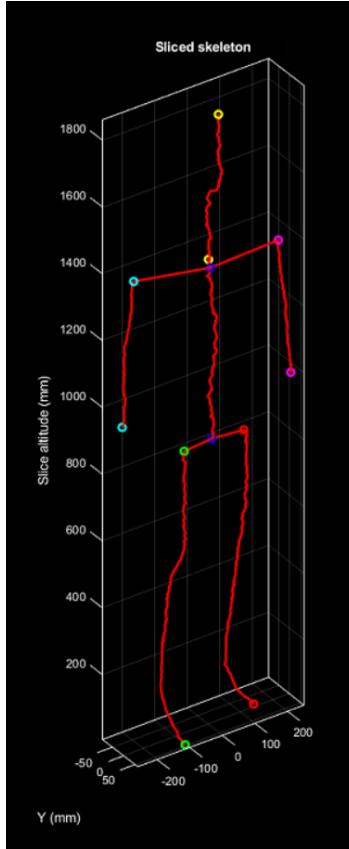


Sliced rebuilt avatar

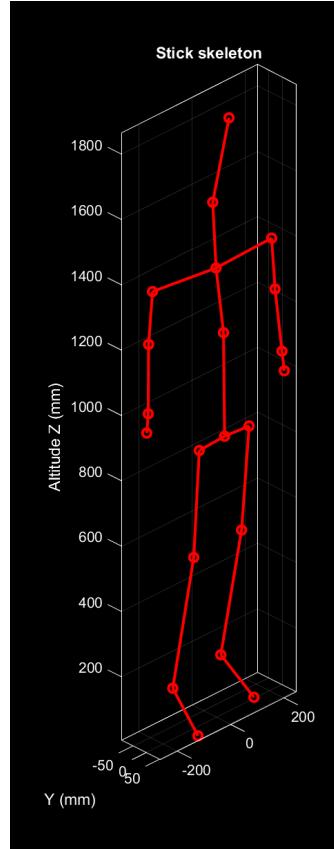
Stick skeleton computational steps



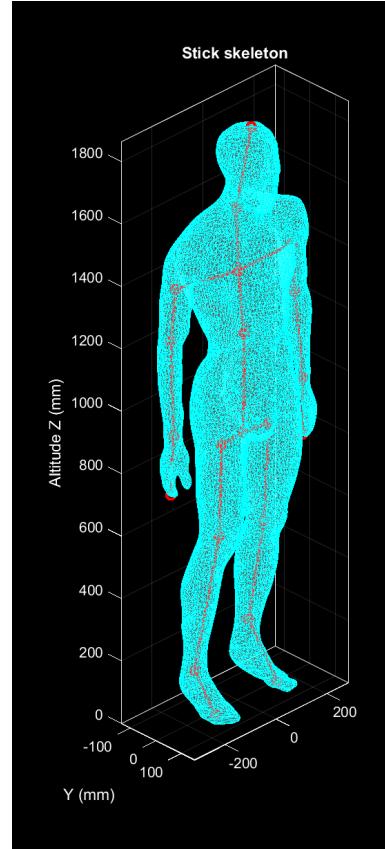
Sliced skeleton



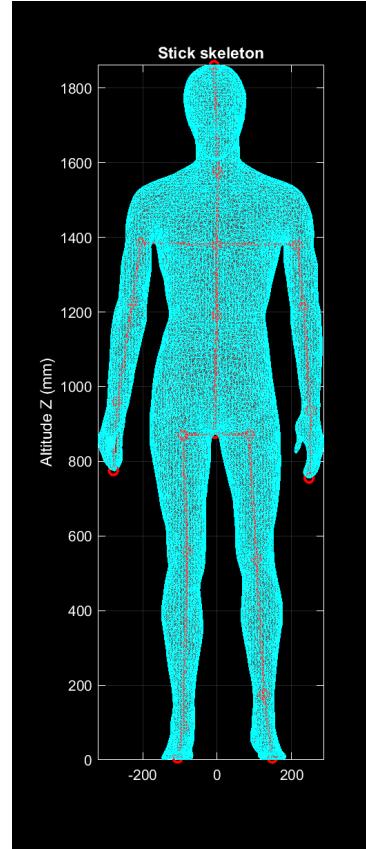
+ extremities
& junctions



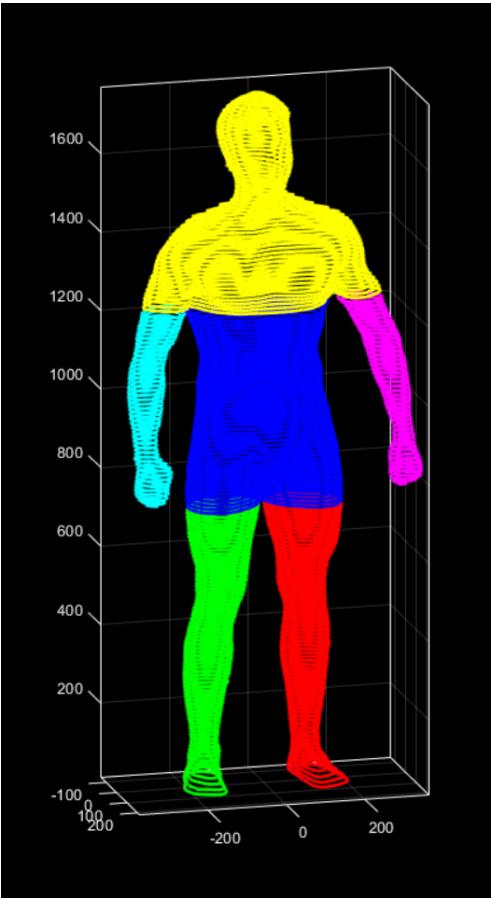
+ landmarks



→ Avatar advanced segmentation

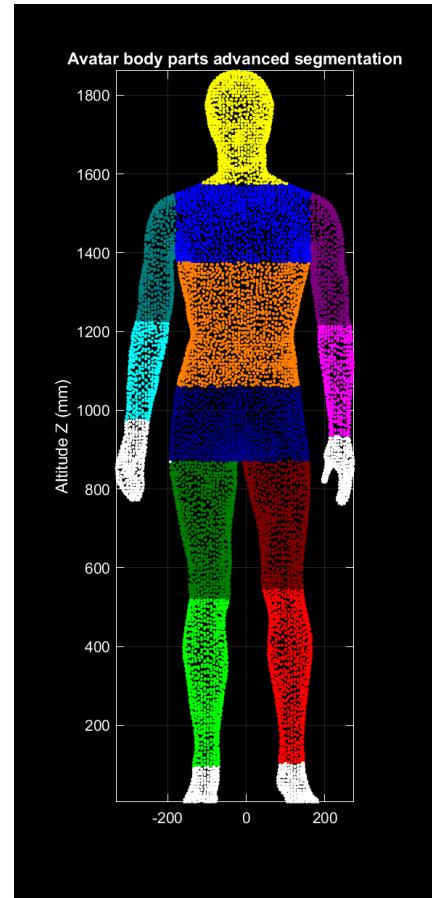


Segmentations steps



Avatar 1st rough segmentation

- 4 limbs + trunk
+ bust
- based on evolution
of contours number
- Robust, but lacks of
accuracy for further
measurements



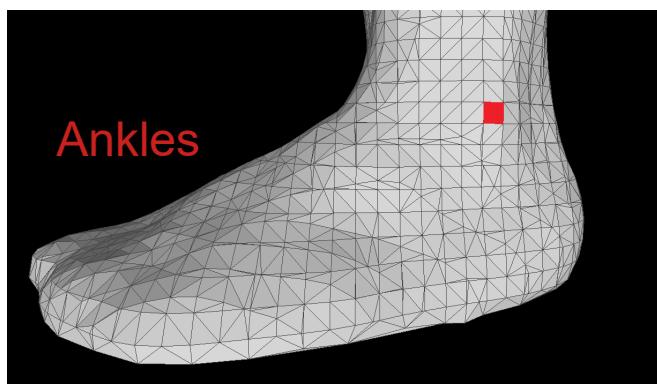
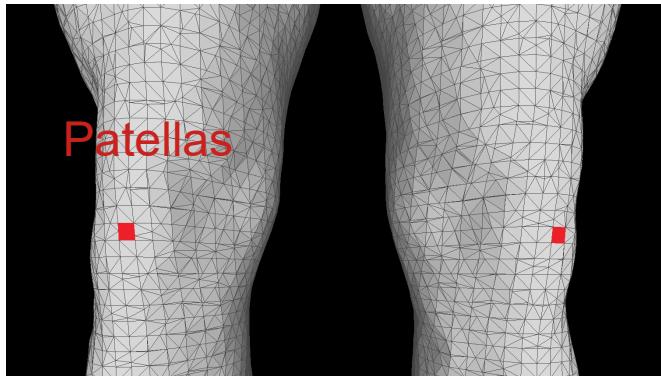
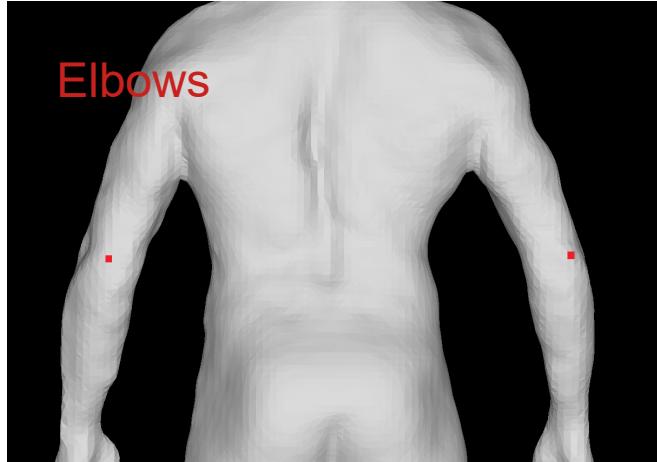
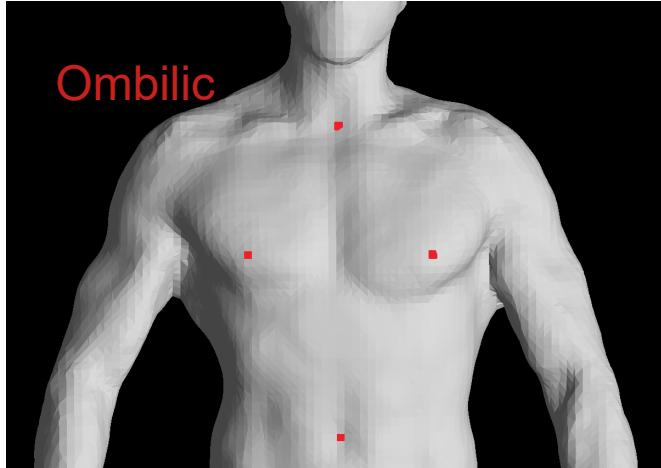
Avatar 2nd full segmentation

- 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

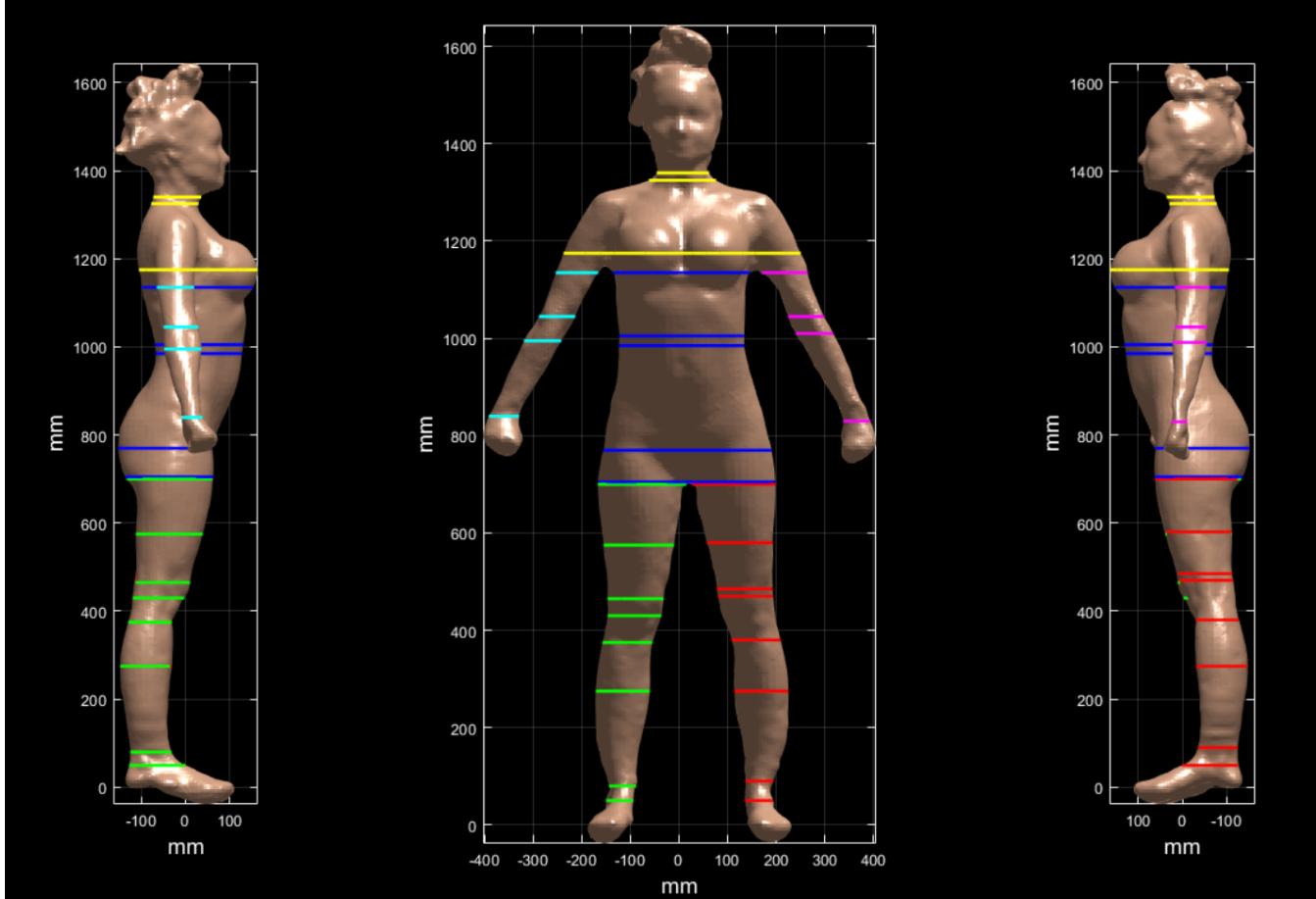
- (1) : **Landmarks** level / altitude detection
- (2) : **Limb girths** and body perimeter curves
- (3) : **Lumbar profile** extraction and bending values estimation
- (4) : 2D Convex hull in 3D option for slices girth

Landmarks detection : examples



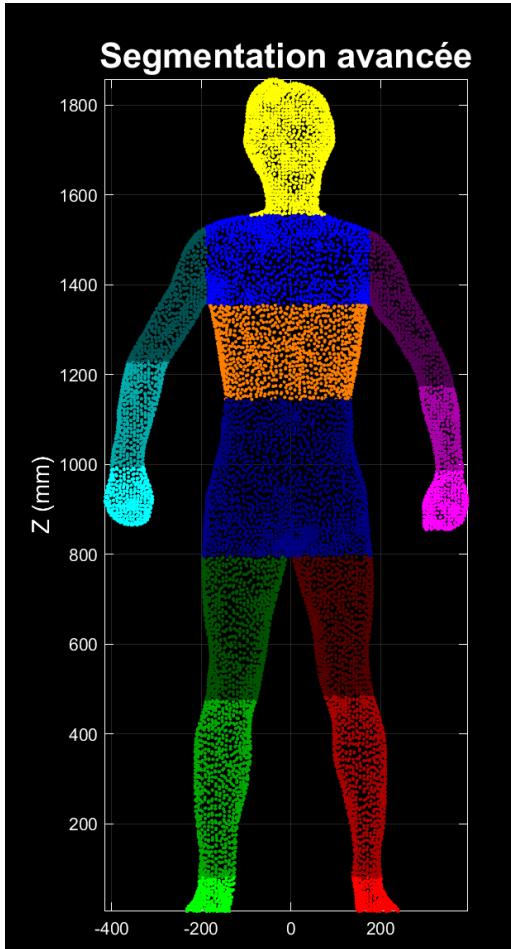
Required precision on landmarks location : ~5 cents coin diameter

Results : limb girths I

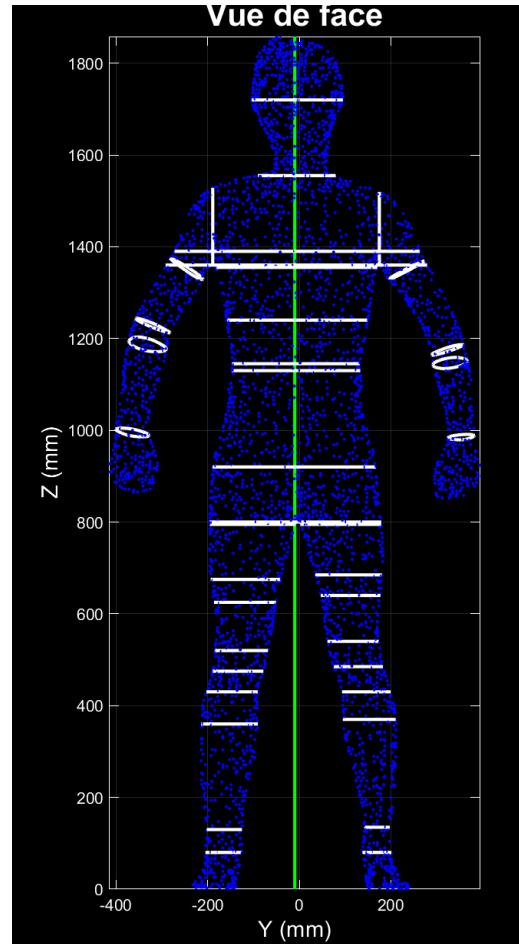


Horizontal 1st
slicing

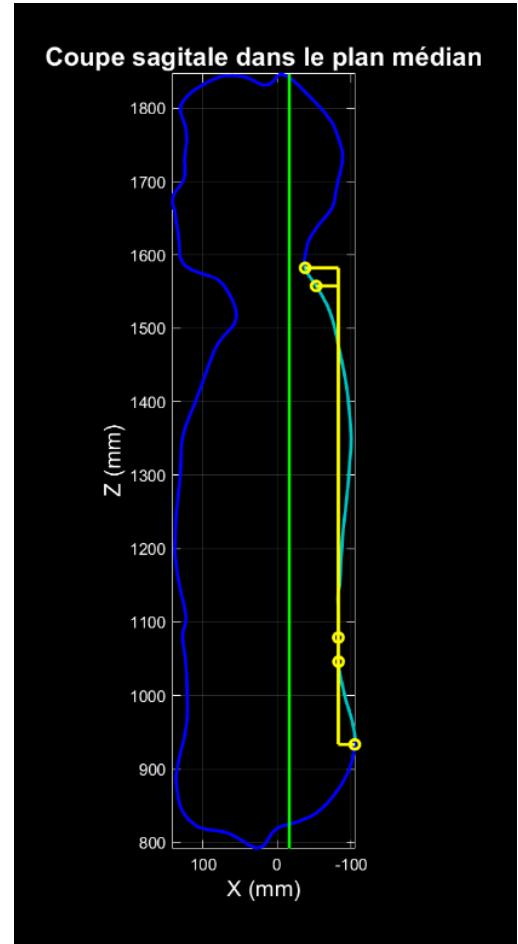
Results : limb girths II



Advanced
segmentation

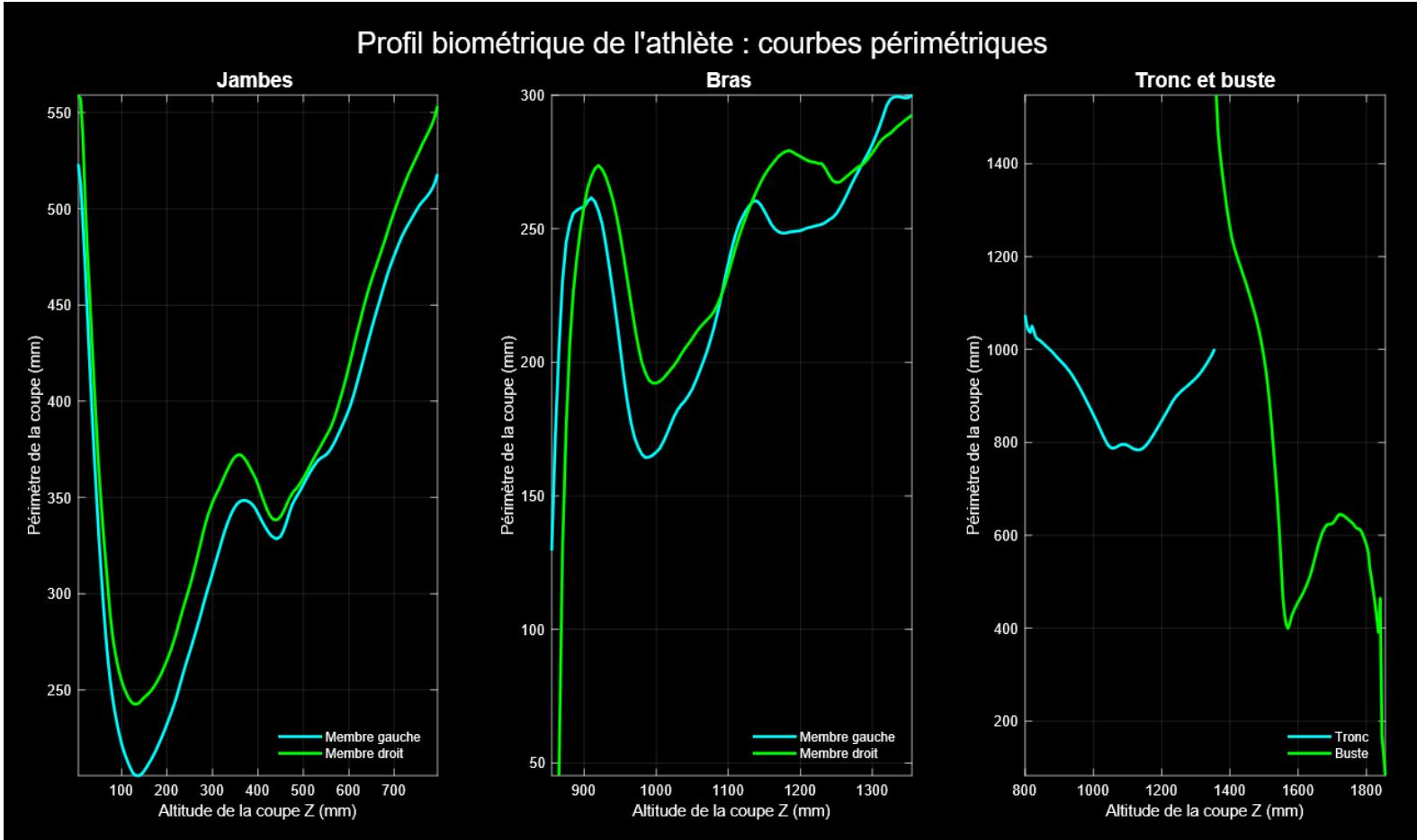


Vectorized
slicing

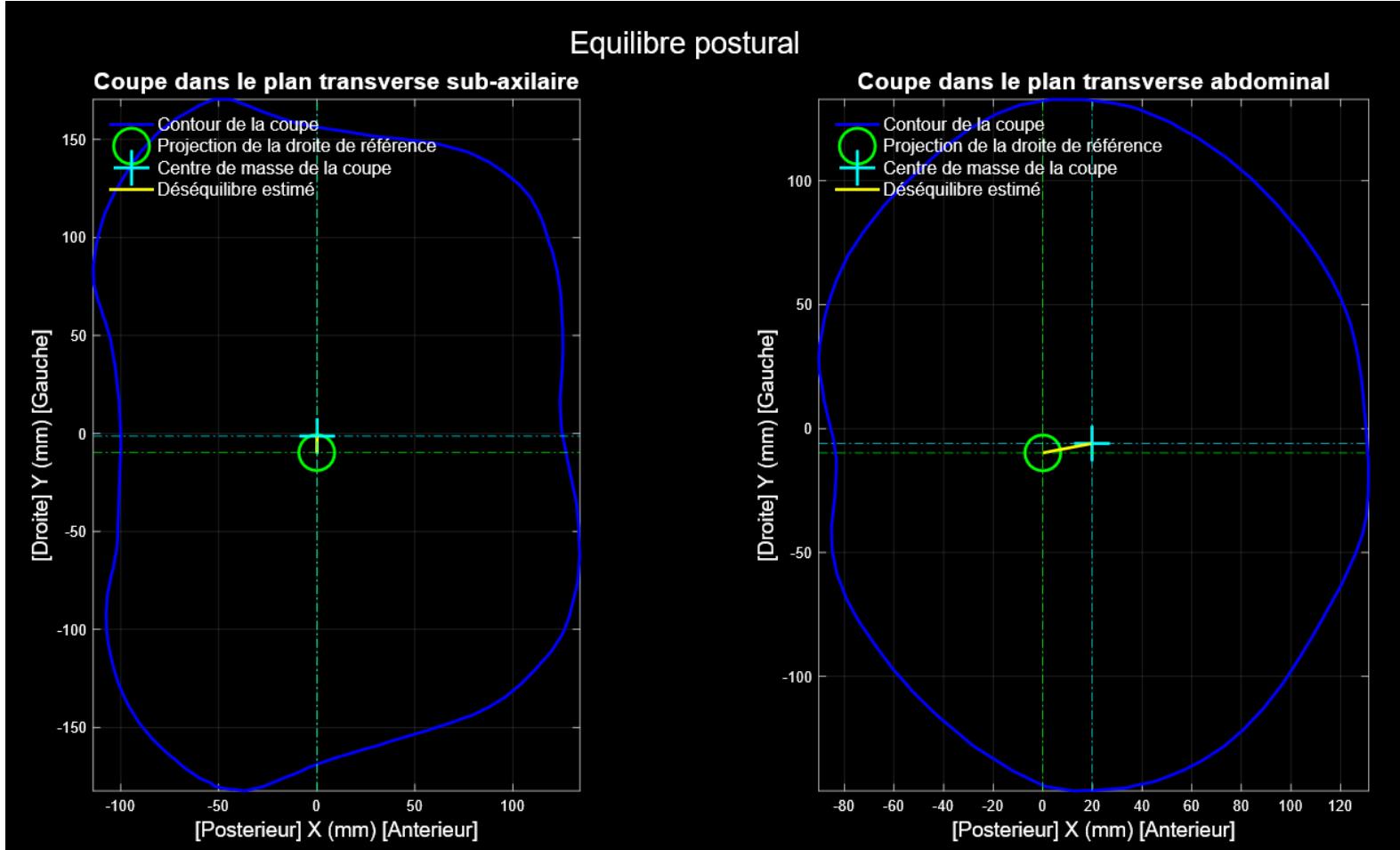


Lumbar
profile

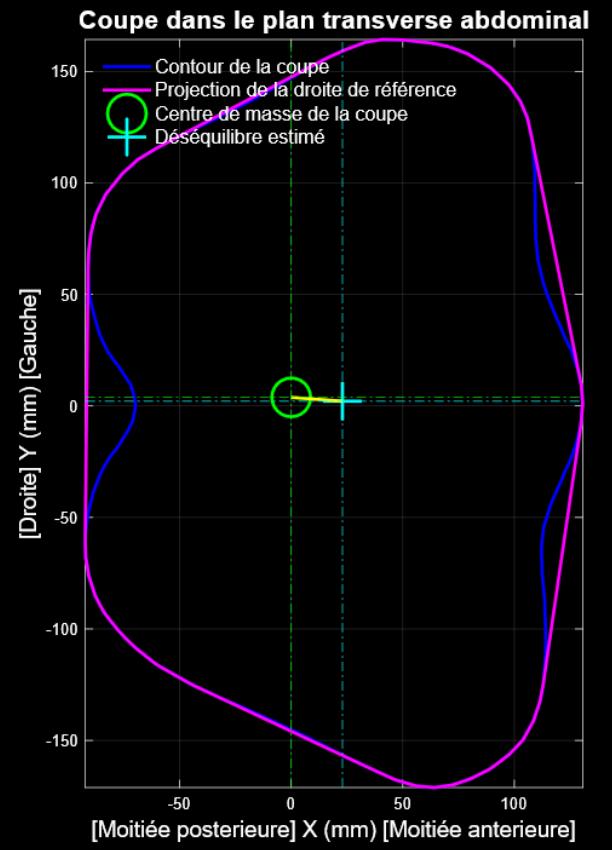
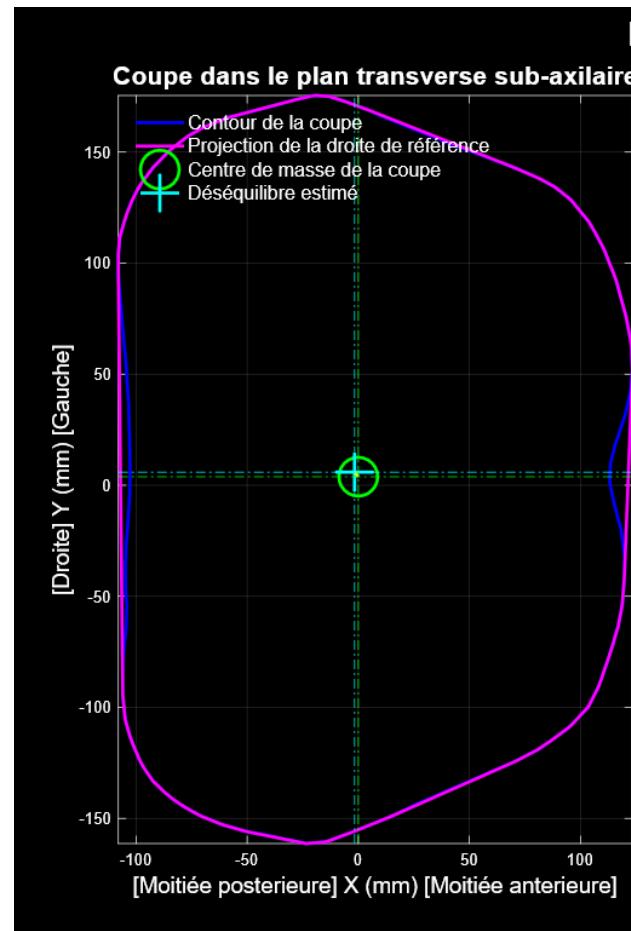
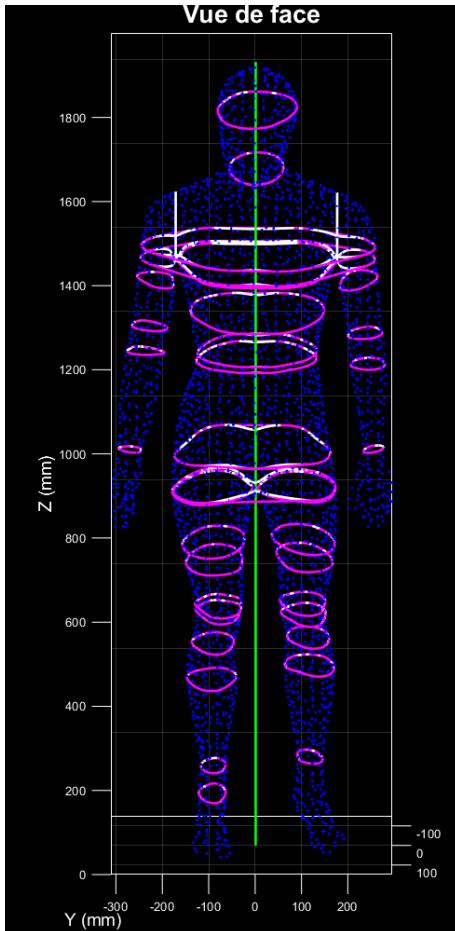
Results : athlete's body shape profile



Results : athlete's body balance estimation

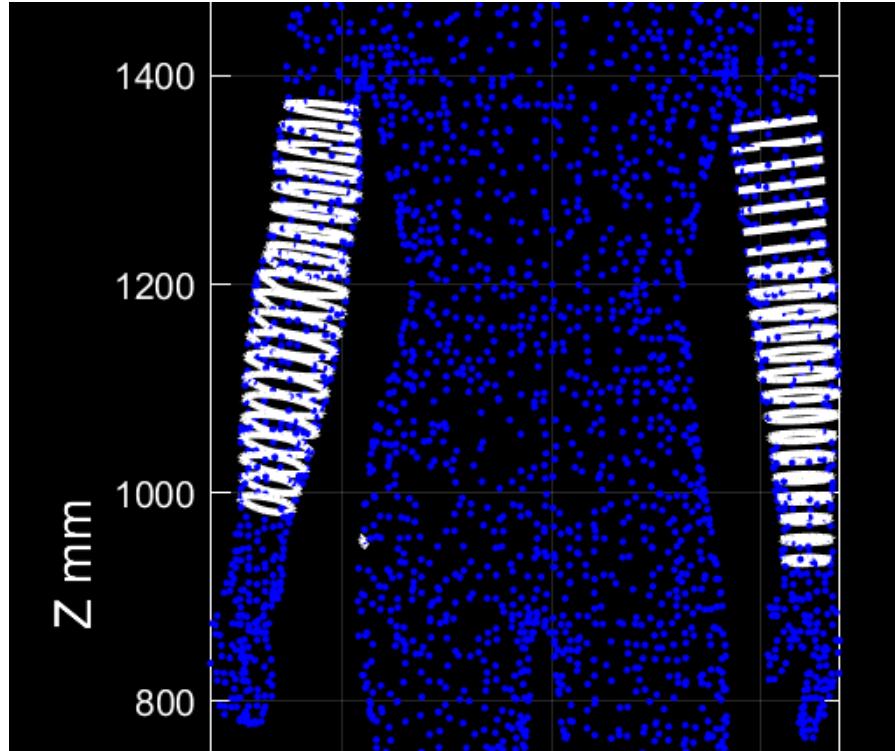


Convex hull of the slice



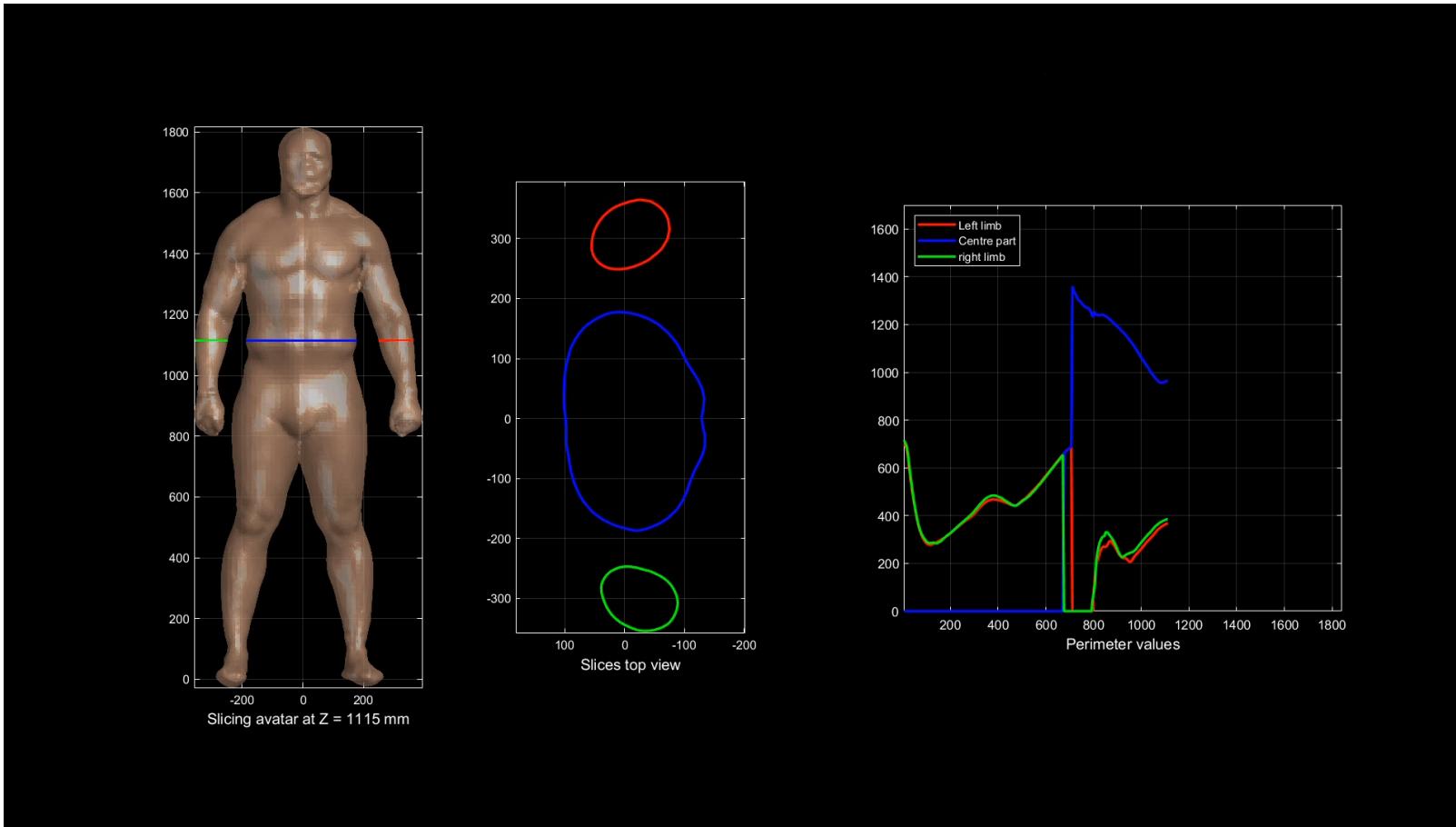
→ Allows measurements closer to tape measure ones

Vectorized / oriented slicing

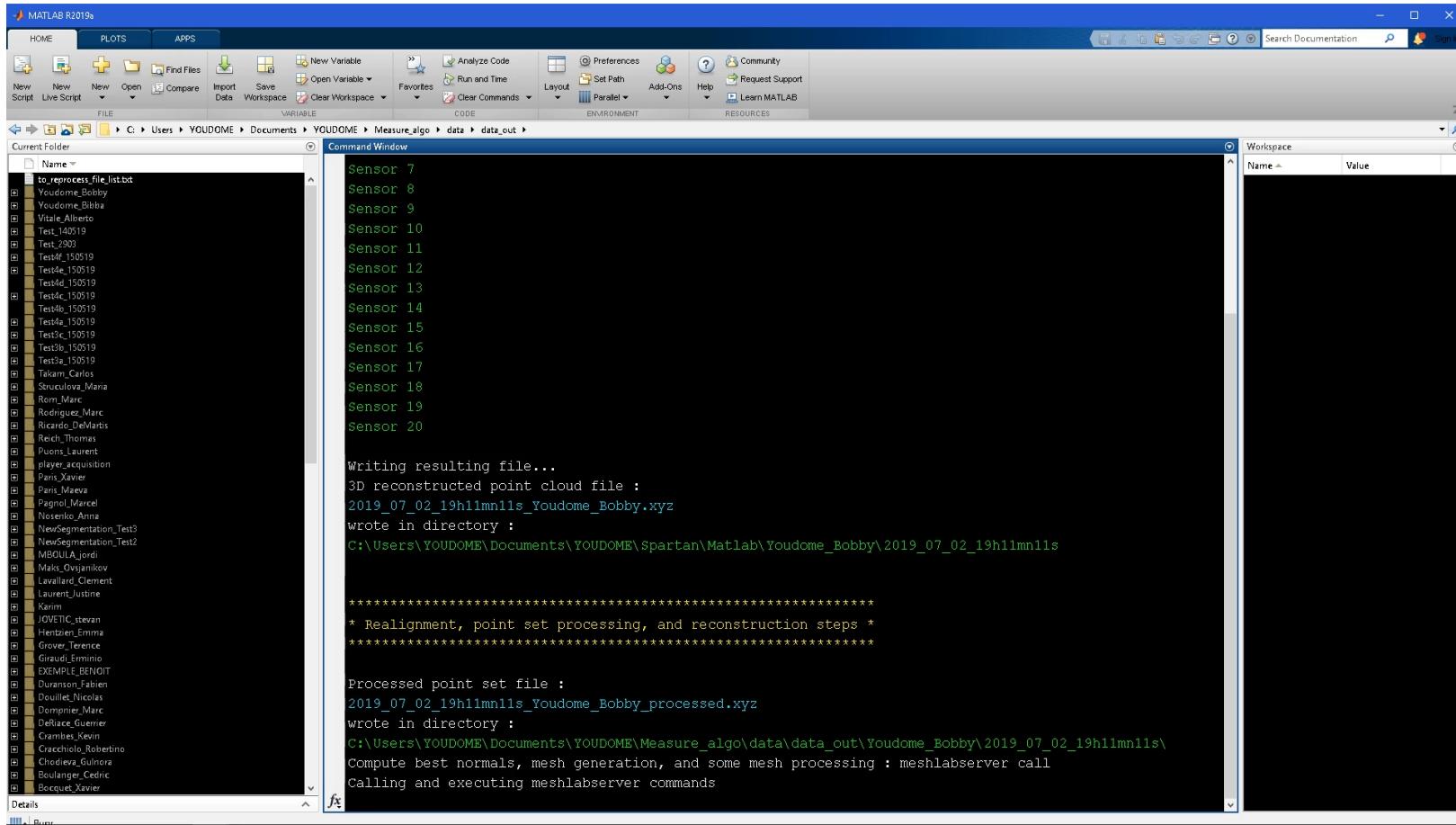


Advanced segmentation allows to perform a second slicing, which axis is oriented following the limb longitudinal direction, and provides the **best measurement accuracy for avatar upper limb girths especially**.

Video demo I : slicing + athlete's biometric profile



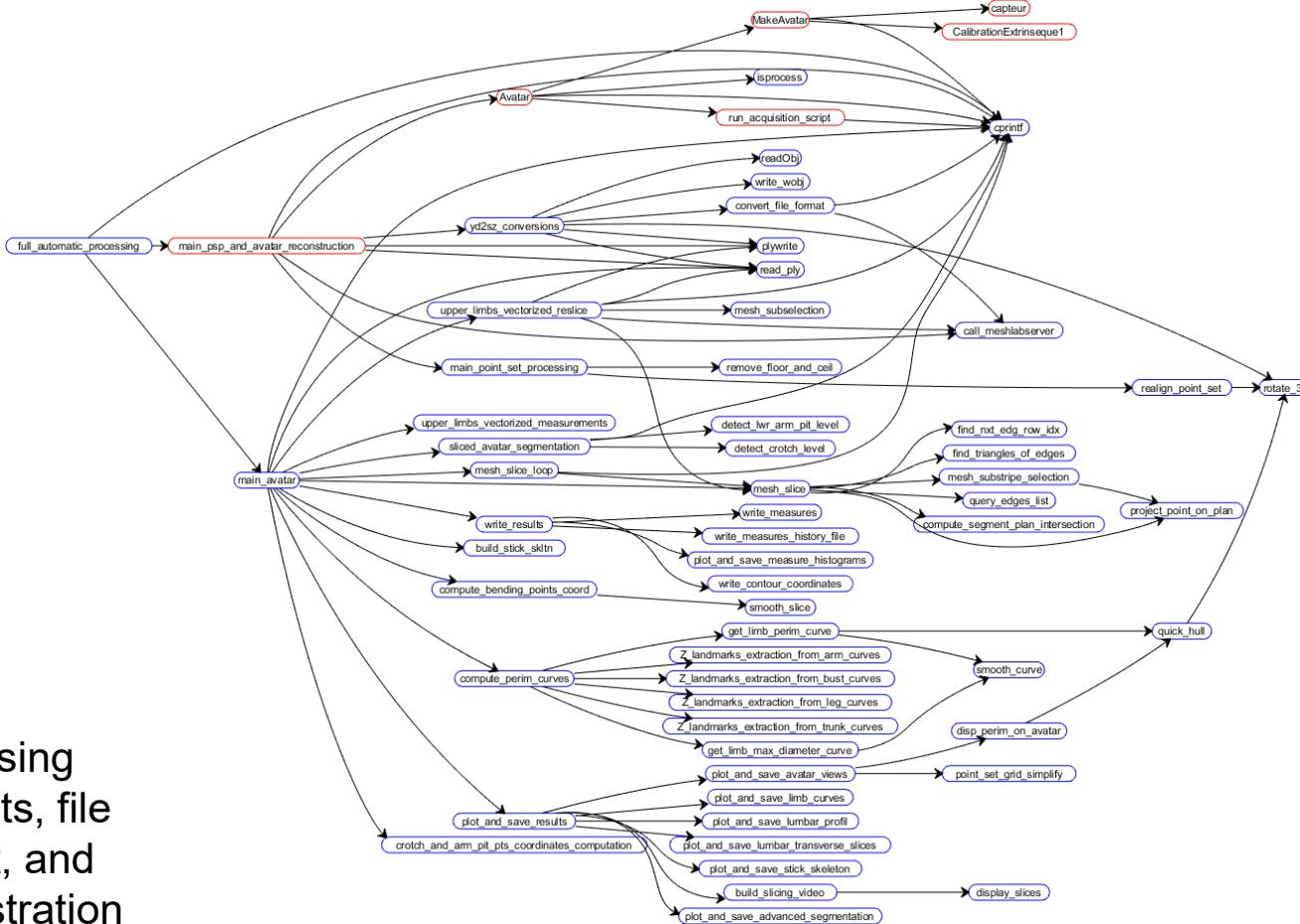
Video demo II : whole process



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
<ul style="list-style-type: none">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.).
<ul style="list-style-type: none">Body imperfections and asymmetries.	→ Global approach but no projection on an average morphology avatar.
<ul style="list-style-type: none">Human morphological positioning and ratio a priori.	→ Local and relative landmarks positioning, human ratio tables.
<ul style="list-style-type: none">Body positioning, hands, long « wild » hairs.	→ Body positioning protocole + beany.
<ul style="list-style-type: none">Landmarks location algorithm and location precision.	→ Advanced segmentation and relative landmarks positioning
<ul style="list-style-type: none">Computational ressources minimization (time, memory).	→ Vectorization, // processing, submesh selection, code optimization, point set and mesh simplifications.

Main partnerships and customers

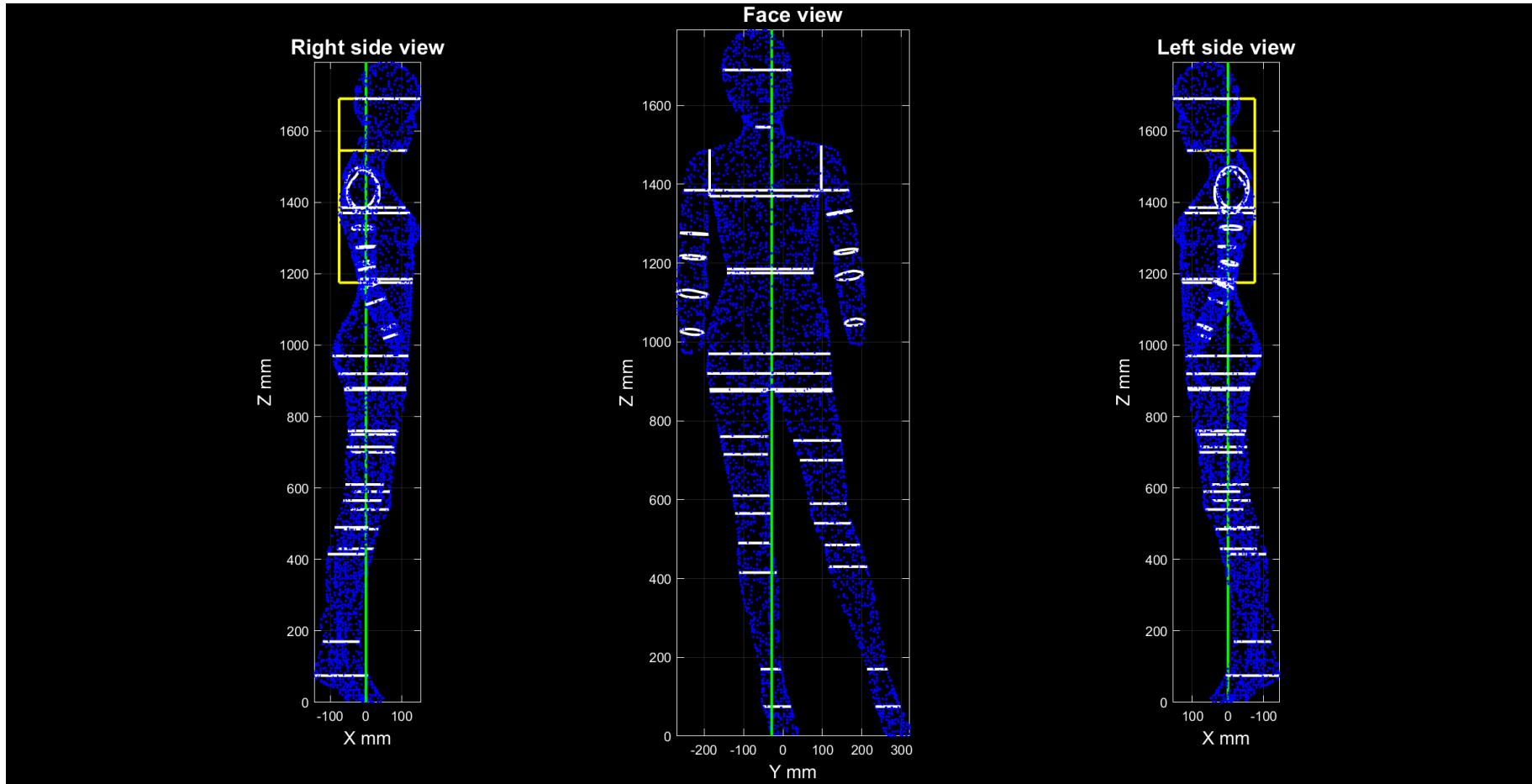
-  Monaco football club
-  Les ballets de Monte Carlo (Monaco princess dance academy)
- Reknown sportsmen in tennis, boxing, bodybuilding swimming, etc... (confidential)

Main collaborations

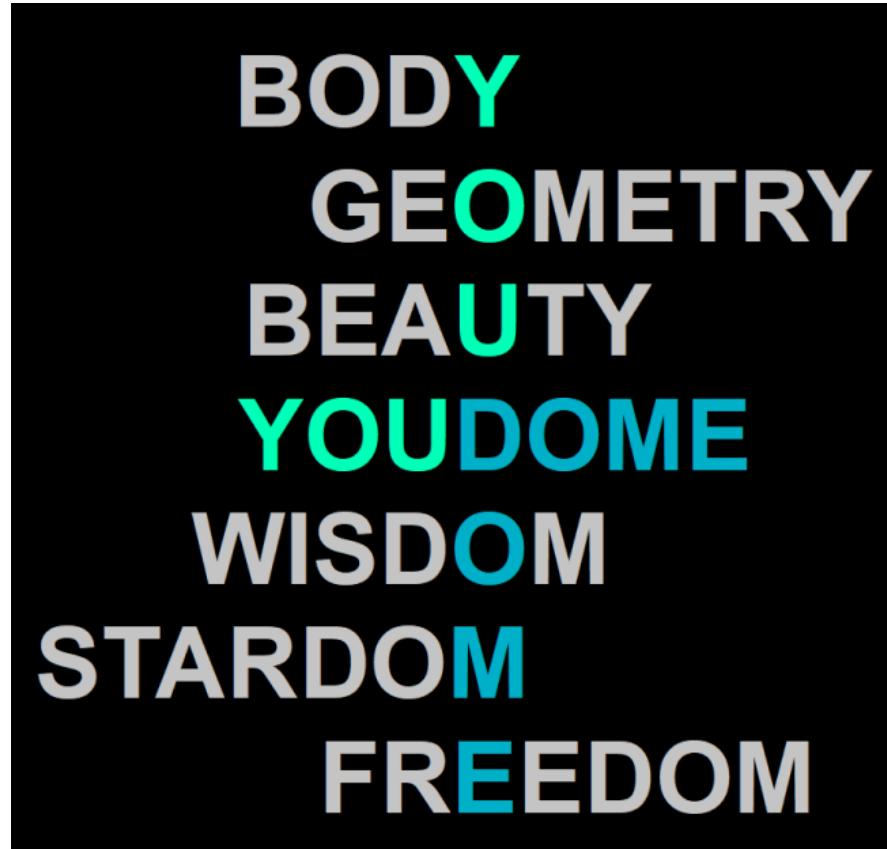
- Christian Barat, I3S / INRIA
Acquisition, point set generation,
3D reconstruction
- Maks Ovsjanikov, LIX Polytechnique
Landmarks detection
- Clément Lavallard, Iccus / Diocles CEO

Thank you !

Algorithm robustness to bad positioning



Slogan



BODY
GEOMETRY
BEAUTY
YOUSOME
WISDOM
STARDOM
FREEDOM