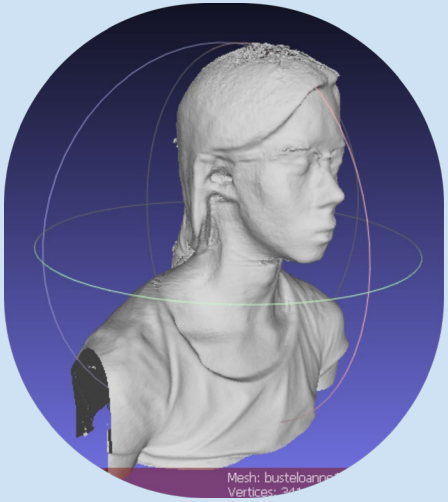
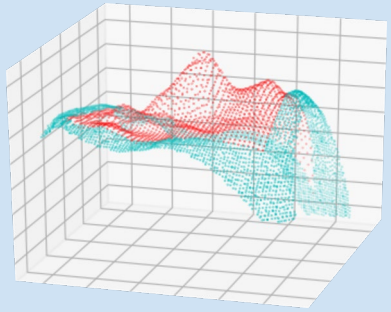
Acquisition, Reconstruction and Deformation

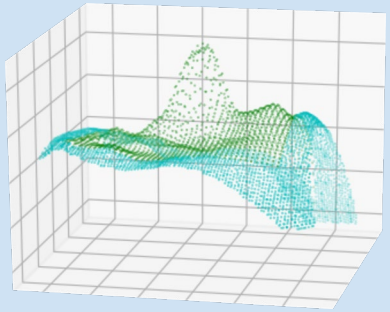
UGA-Myanmar Project
in
Applied Maths

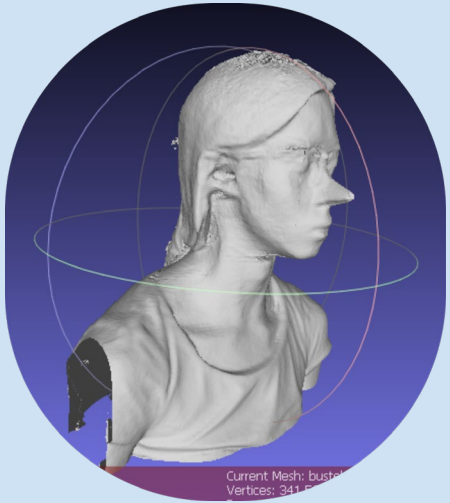
managed by Hugo, Linda, Adjamé, Eva, Naomi, Luc

Summary & Objective





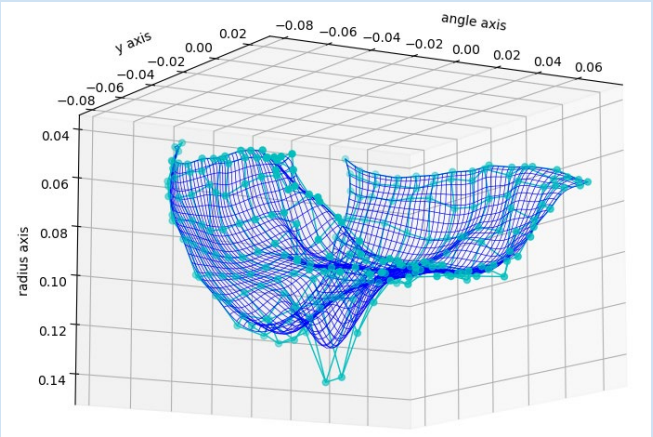




Acquisitions

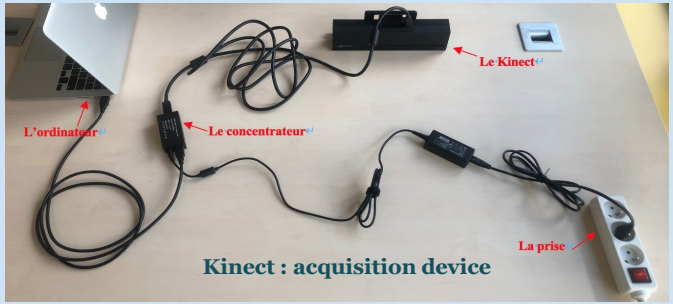
3D Reconstruction

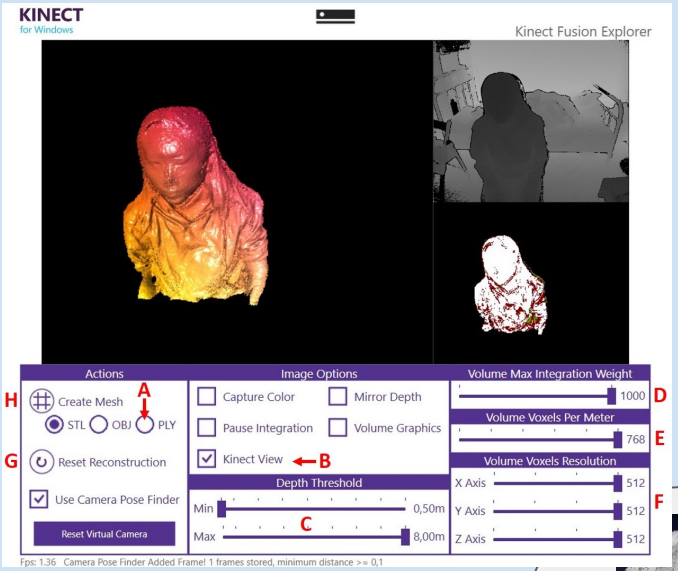
Deformation

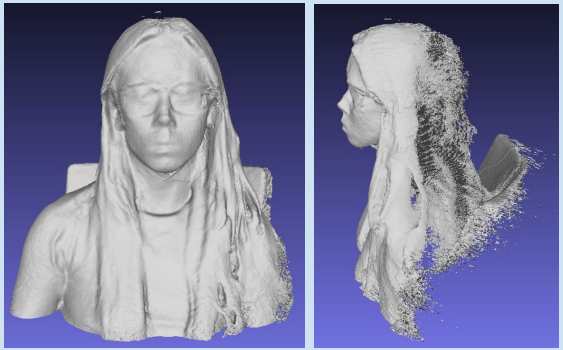


TASK 1 : Acquisition

Getting started with the Kinect and the SDK

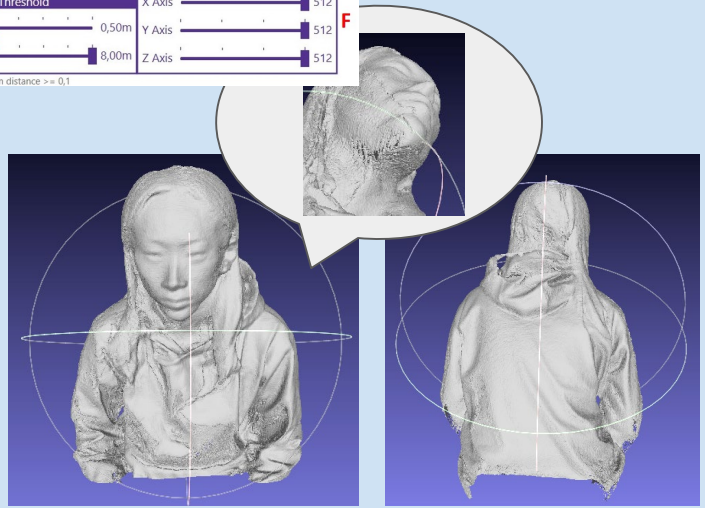






341 569 vertices, 660 407 faces

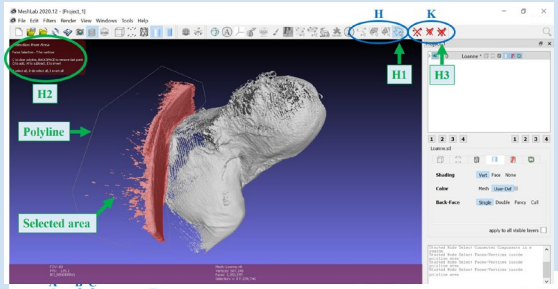
First acquisitions : not so easy….

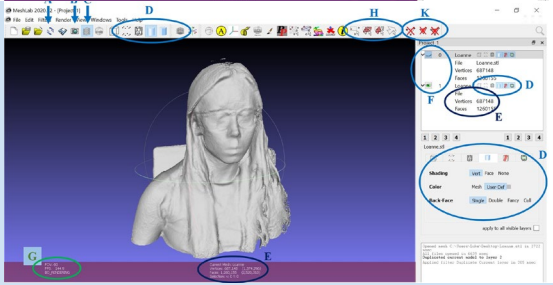


5 658 024 vertices, 1 886 008 faces

TASK 2 : MeshLab

- Mesh format : OBJ, STL, PLY
- Getting started with MeshLab
- Meshlab pre-processing





acquisition

Physical Modele

Kinect

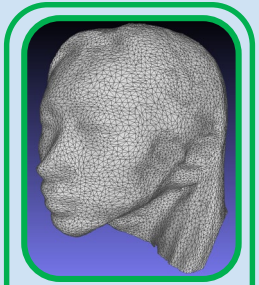
mesh STL

MeshLab pre-treatment

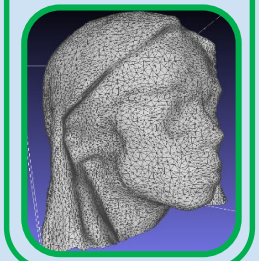
Area selection (typically the head)

Cleaning & repairing

Remeshing & simplification



mesh PLY

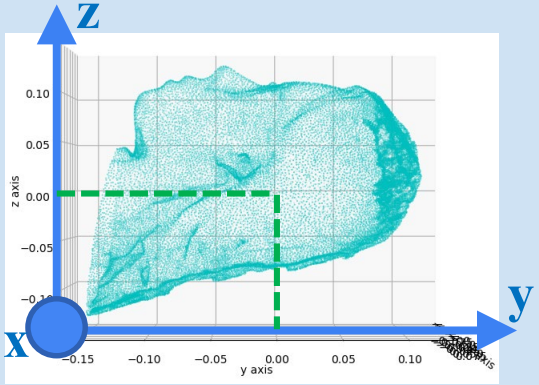


Python

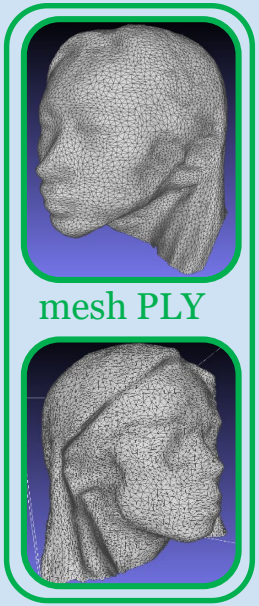
TASK 3 : Python pre-processing

- Import of data from PLY in Python
- Translation (barycenter at origin)
- Rotations (2)

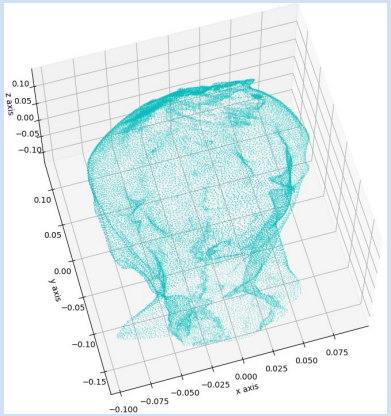
Objective :



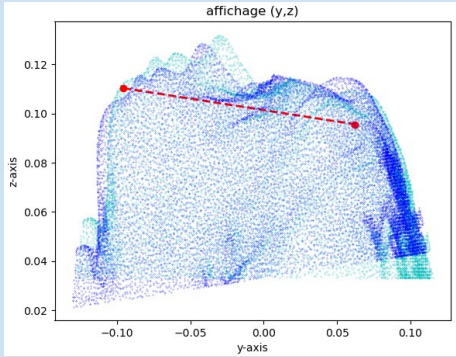
Import data from PLY file



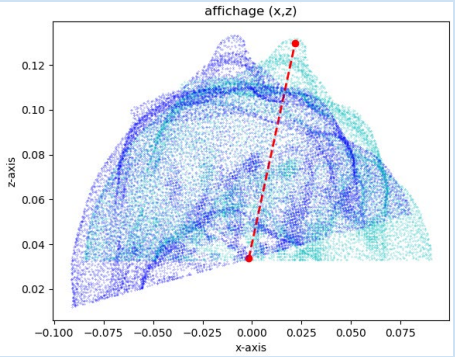
translation



Rotation 1

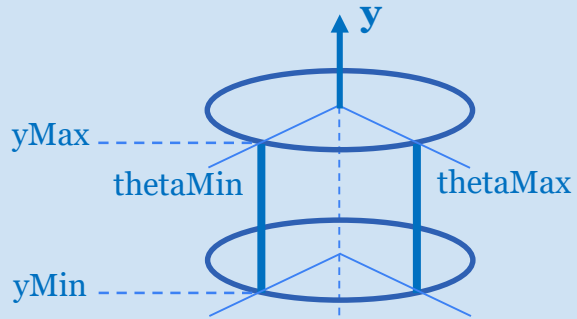


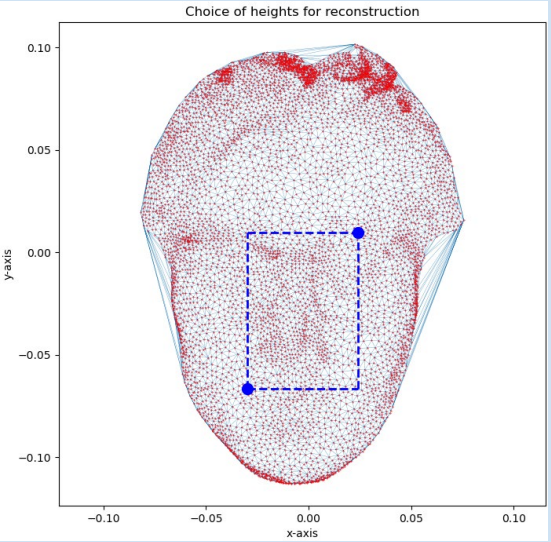
Rotation 2



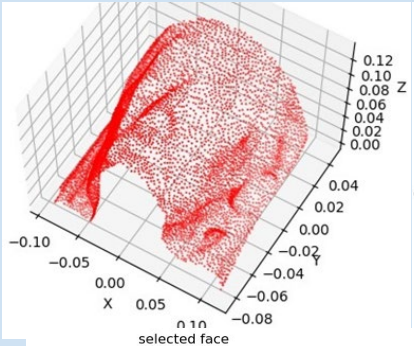
TASK 4 : Face selection

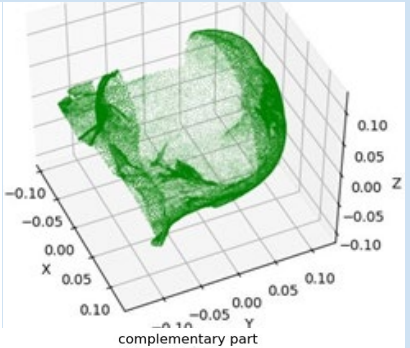
- Plot “ front ” points
- Heights : choice of yMin & yMax → function rectangle
- Angles : choice of thetaMin & thetaMax
- Face selection : points x3,y3,z3 with indices t3
- Complementary : points x3c,y3c,z3c with indices t3c



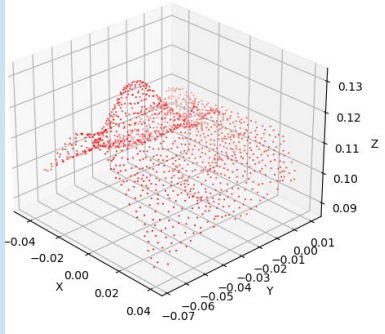


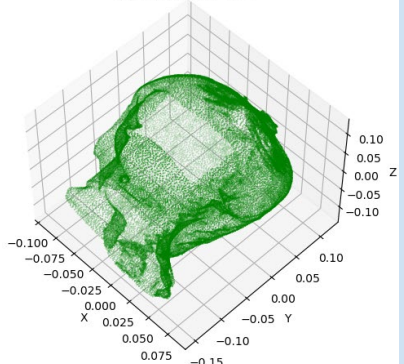
Whole face :





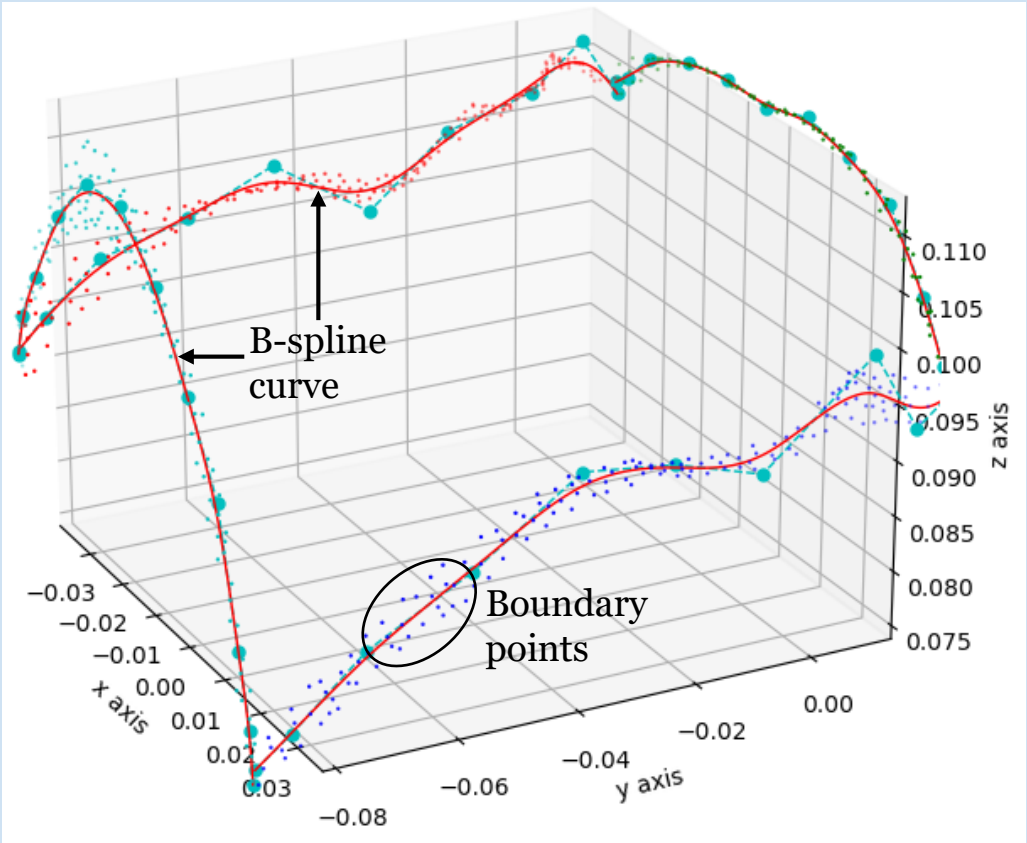
Nose :





TASK 5 : Boundary curves

- Uniform B-spline knots (in each direction)
- Boundary points detection
- B-spline curve approximation

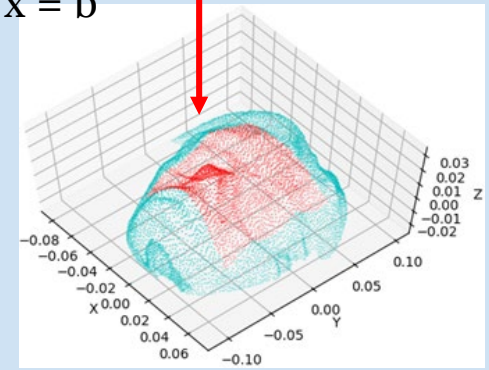


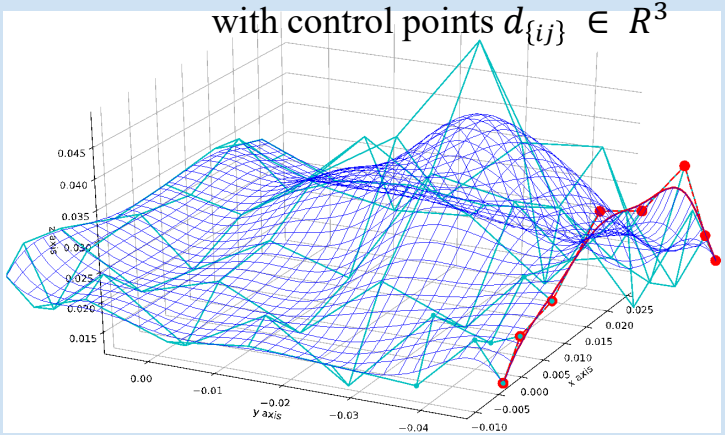
TASK 6a : Least squares approximation

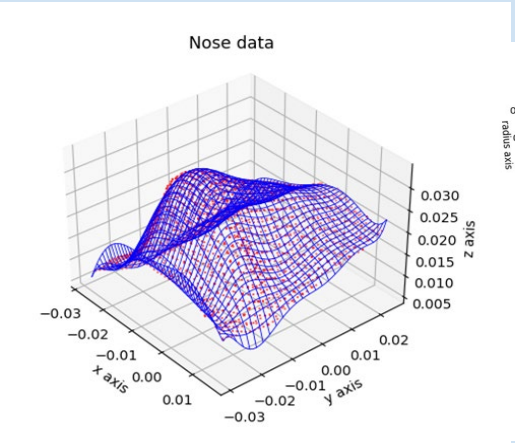
- Model : parametric tensor cubic B-spline surface
- cylindrical parametric approximation of “red data”
- Approximation linear system : A x = b
- Normal equations
- Resolution with numpy

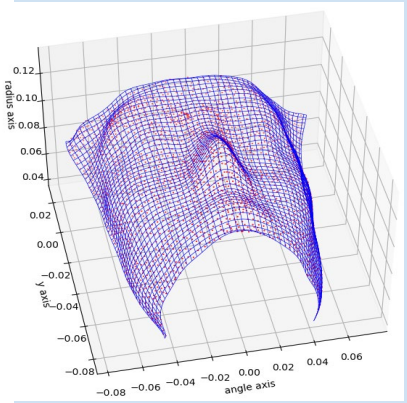
$$S(u,v) = \sum_{i=0}^{n} \sum_{j=0}^{m} d_{i,j}\, N_{u,i}^{3}(u)\, N_{v,j}^{3}(v)$$

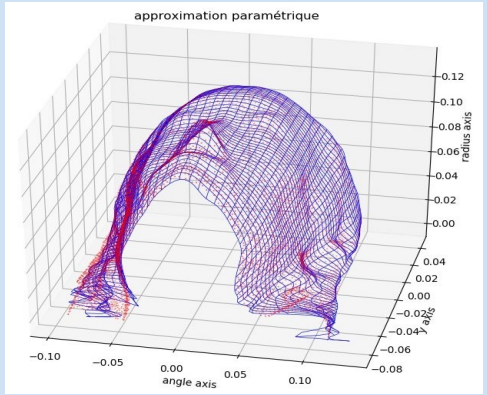
with control points $d_{\{ij\}} \in R^3$

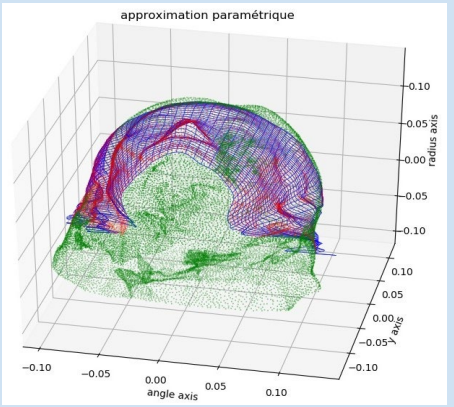












TASK 6a : Appendix

Method

Data $(x_k, y_k, z_k) = (r_k, \theta_k, y_k)$

1. Explicit data in **cylindrical** form $r_k = G(\theta_k, y_k)$
2. **Scattered** data (i.,e. unstructured according a grid)
3. (θ_k, y_k) in a rectangle $[\theta_{min}, \theta_{max}] \times [y_{min}, y_{max}]$

]

Model :

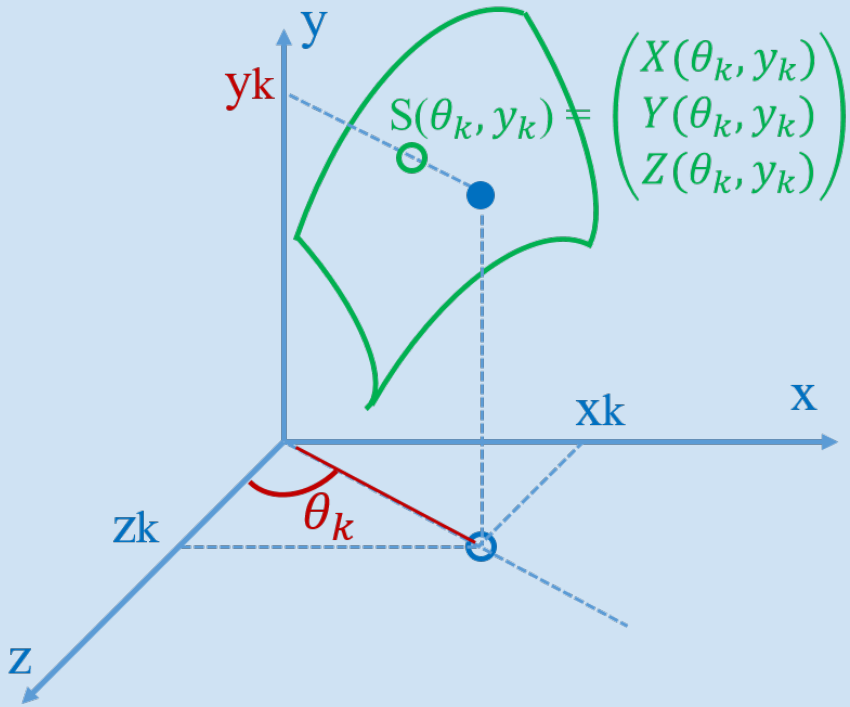
B-spline parametric tensor cubic surface

$$S(\theta, y) = \begin{pmatrix} X(\theta, y) \\ Y(\theta, y) \\ Z(\theta, y) \end{pmatrix}$$

Reconstruction :

Least squares approximation :

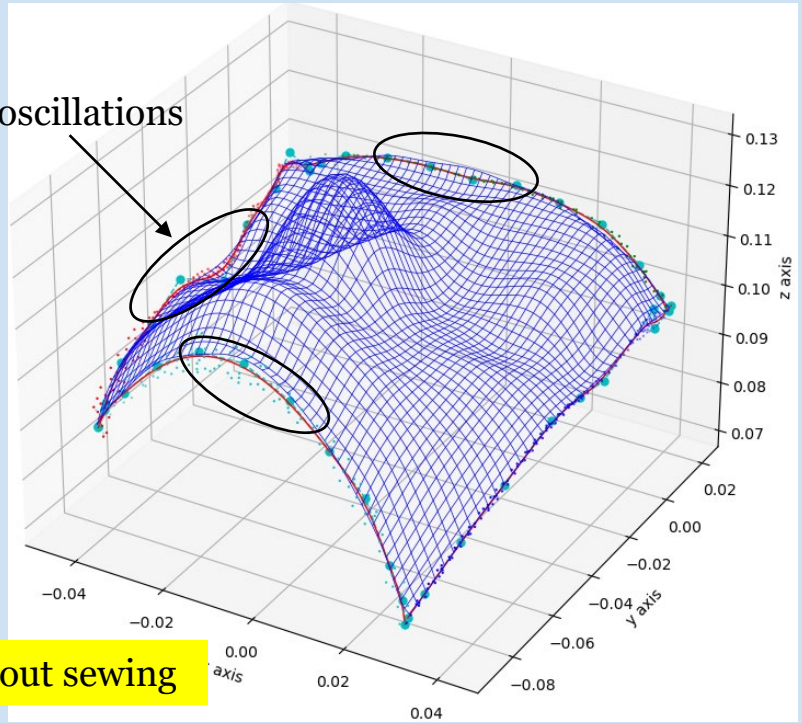
$$\text{Min } \sum_k | X(\theta_k, y_k) - x_k |^2$$
$$\text{Min } \sum_k | Y(\theta_k, y_k) - y_k |^2$$
$$\text{Min } \sum_k | Z(\theta_k, y_k) - z_k |^2$$



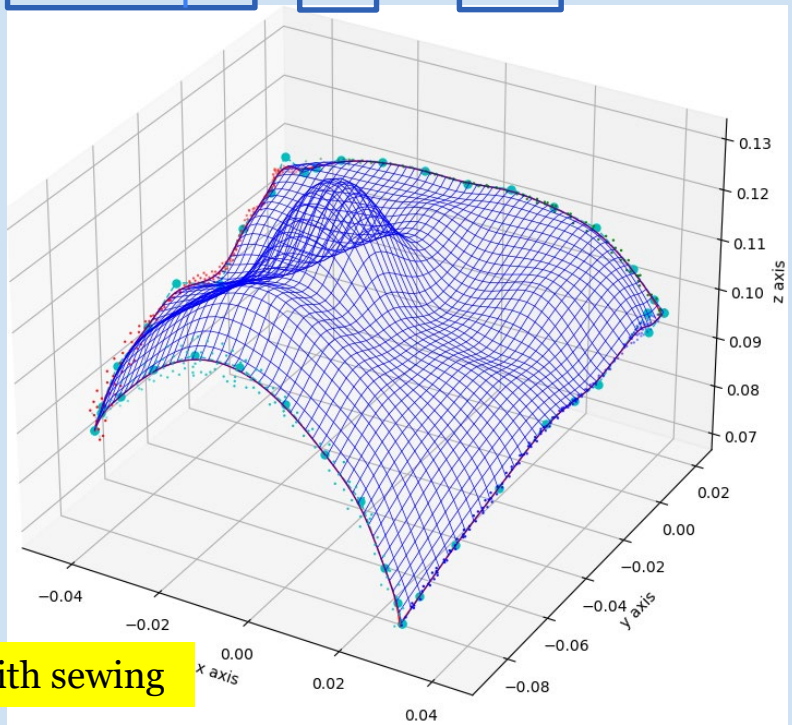
TASK 6b : Least squares approximation with constraints

- Approximation linear system : A x = b
- System of constraints : H x = c (sewing)
- Generalized normal equations
- Resolution with numpy

$$\begin{bmatrix} A^T A & H^T \\ H & 0 \end{bmatrix} \begin{bmatrix} x \\ \lambda \end{bmatrix} = \begin{bmatrix} A^T b \\ c \end{bmatrix}$$

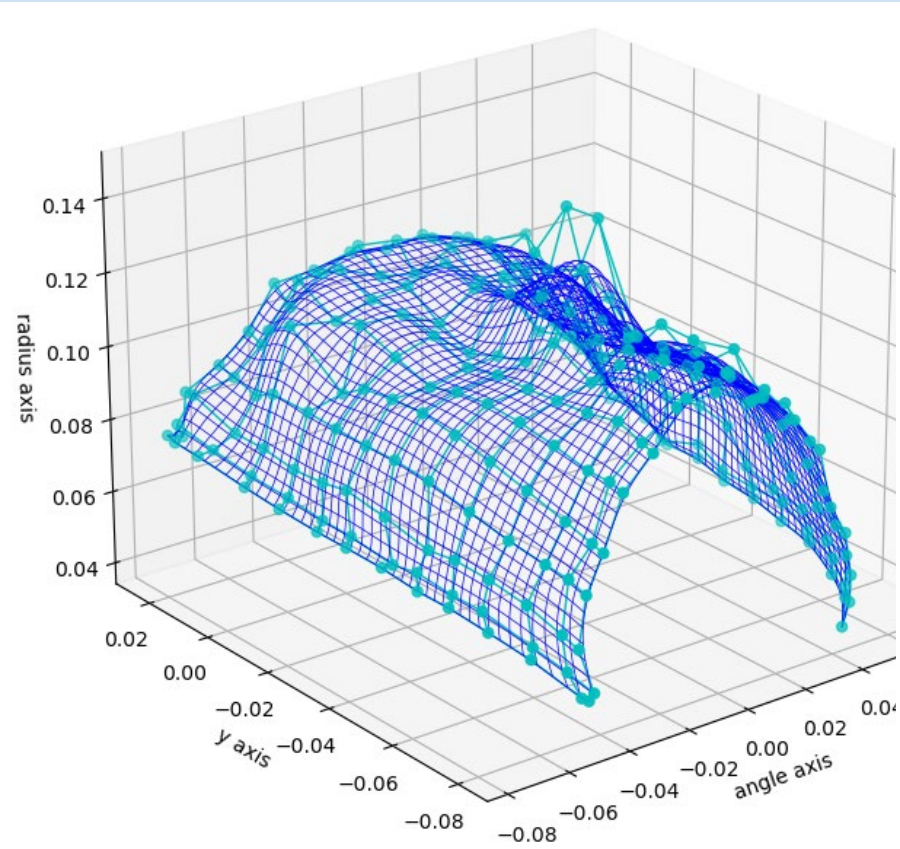


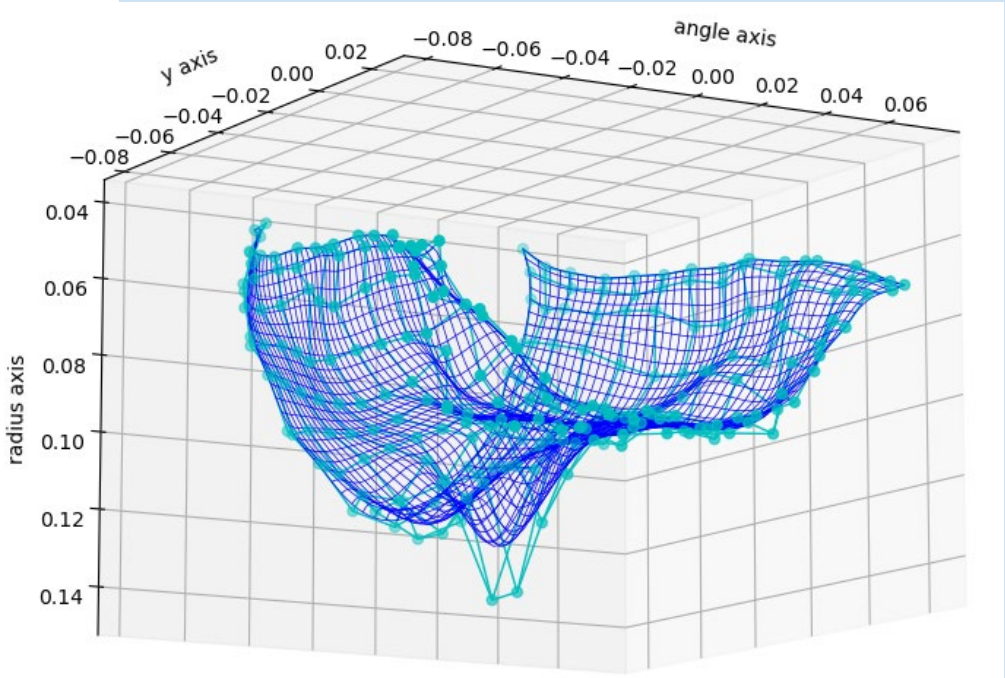
without sewing



with sewing

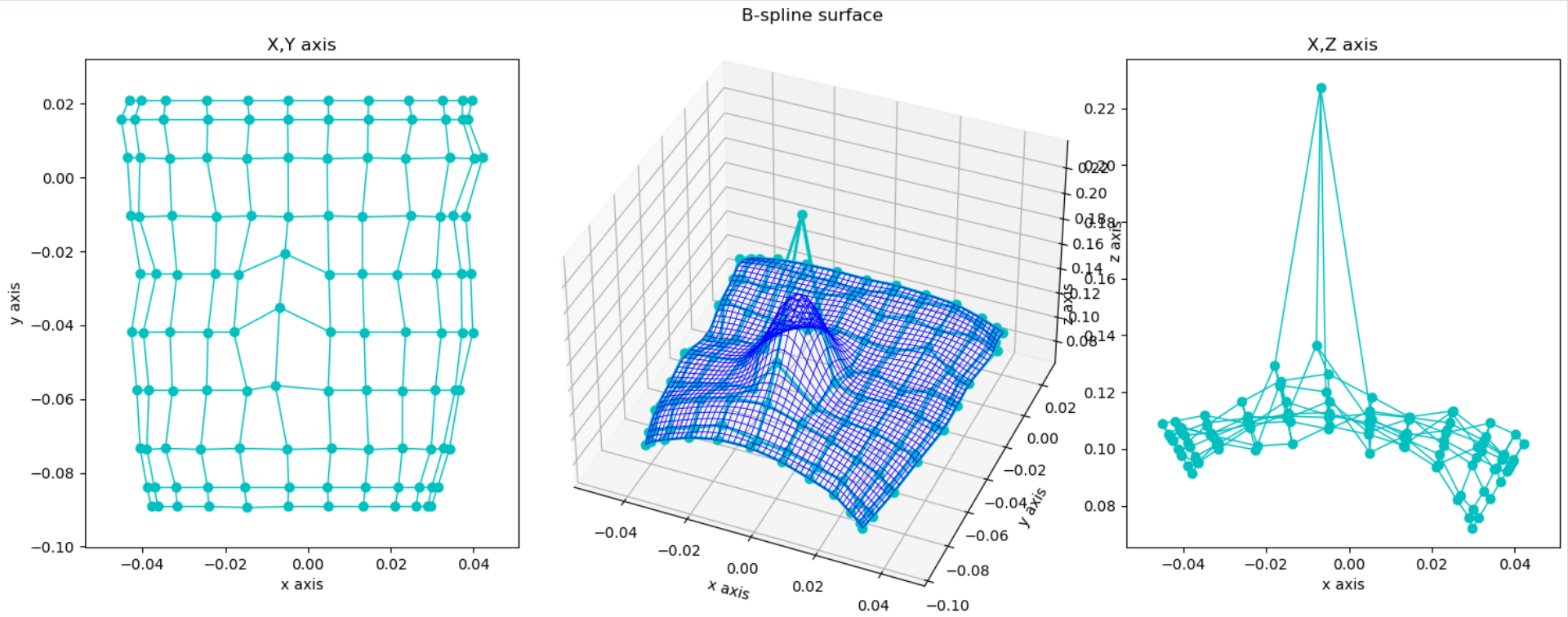
TASK 6b : results with control points





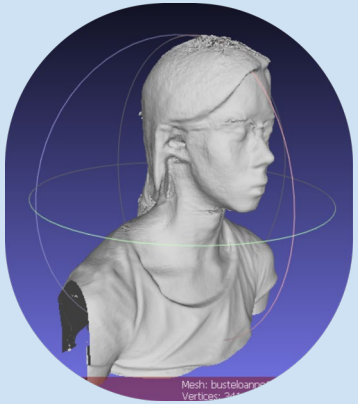
TASK 7 : Deformation

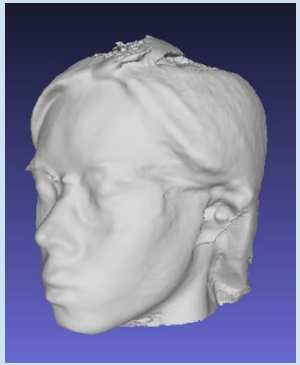
- Experiment deformations by moving control points
- in the 2D left and 2D right axes

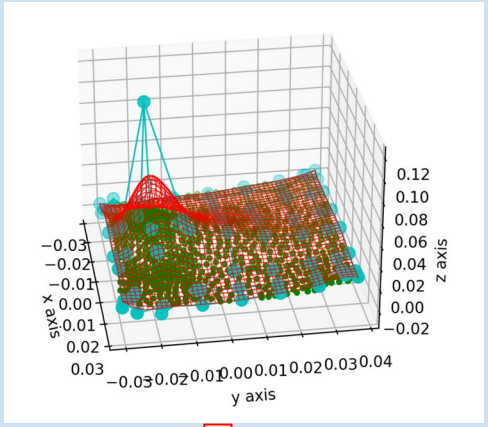


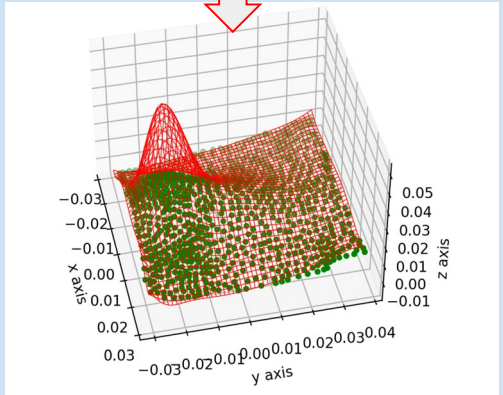
TASK 8 : Back in Meshlab

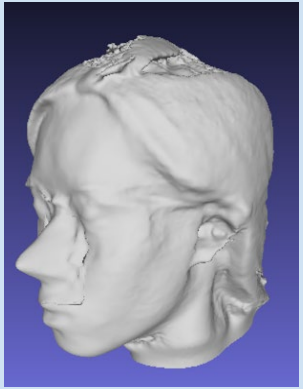
- Back in meshLab with function WholeMeshToPly()
- Fill holes with Screened Poisson filter

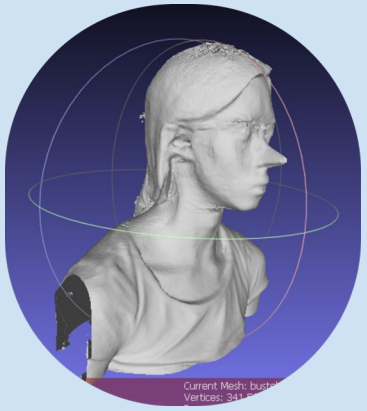












Planning

Organization

- mid-September → end of November
- working by groups : 3 to 5 students

- Task 1 : 2 weeks (end of september)
  Task 2, 3 & 4: 2 weeks (mid-october)
- Task 5 : 1week (November 12)
- Task 6a : 1 week
- Task 6b : 1 week
- Task 7 & 8 1 week (end of November)

Skills :

- Getting started with the Kinect SDK and MeshLab software
- 3D geometry
- Mesh formats
- Python programming
- 3D interpolation
- Least squares approximation (2D & 3D)
- Approximation under linear constraints (Lagrange multipliers)
- CAGD : Bézier and B-spline curves and surfaces