Lab Work

Geometry Description and Mesh Construction from Medical Imaging

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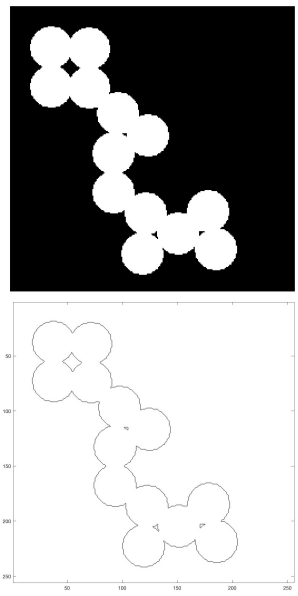
Overview

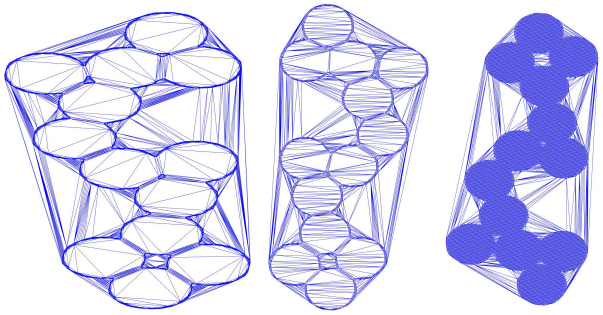
- **First week**
  - From 2D images to 2D meshes
  - Image/mesh transformation
  - Image/mesh Distortion evaluation
  - From 3D images to 3D volumetric meshes
  - …
- Next weeks
  - Image & mesh co-registration
  - Co-segmentation
  - …

Day 1 & Day 2

- **2D Image processing**
  - Load a 2D image (toy example)
  - Extract the boundary components (black-white adjacent pixels): set of 2D pixels
  - Consider pixels as 2D points (with integer coordinates)
- **2D Mesh processing**
  - Generate a Delaunay triangulation of the input point set
  - Visualise the triangulation (vertices, edges, triangles)
  - Mesh data structures for mesh representation and visualisation
- **Discussion**
  - Delaunay triangulation
  - Different data structures for mesh representation
  - …

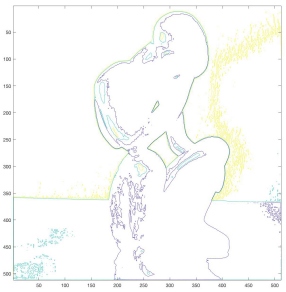
Day 1 & Day 2

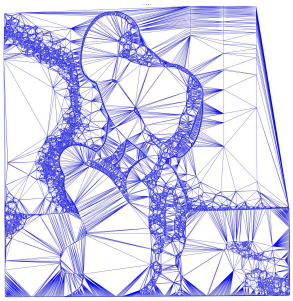




Triangle meshes with a different sampling density

Day 1 & Day 2



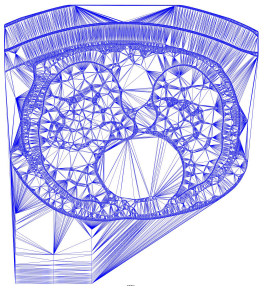
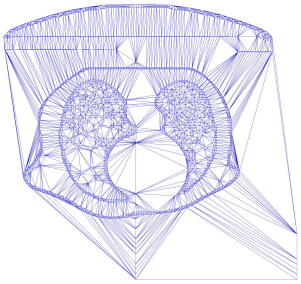


Colour images & complex 2D shapes

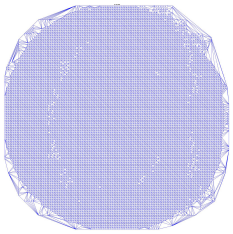
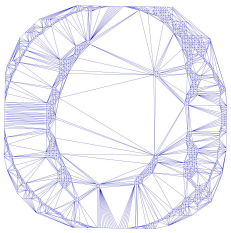
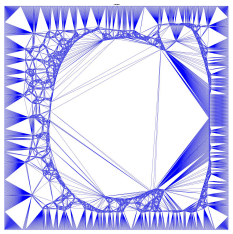
Day 1 & Day 2

- **2D Mesh processing**
  - Change the sampling density of the Delaunay triangulation
  - Crop (if necessary) the Delaunay triangulation in order to fit the image size
  - Make the input image a square image
  - …
- **Discussion**
  - Strategies to handle the sampling densities
  - Main differences between 2D images & meshes
  - …

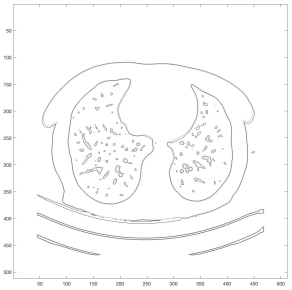
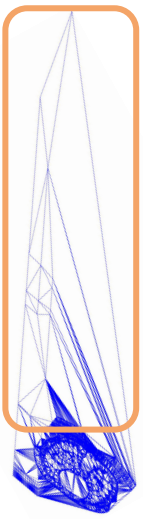
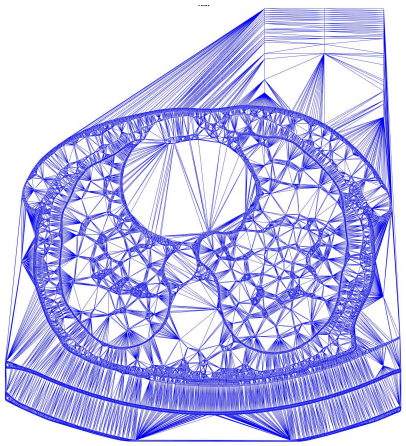
Day 1 & Day 2

Different samplings &
Delaunay triangulations

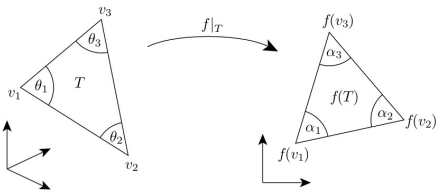
Day 1 & Day 2

Crop Delaunay triangulation

Day 1 & Day 2

- **2D Mesh processing**
  - Compute and plot the main properties of the triangle mesh
    - Edge length
    - Angles
    - Triangle area
  - Handle triangle degeneracies



- **Discussion**
  - Mesh properties in terms of geometry & connectivity
  - Efficient computation of mesh properties
  - Mapping distortion & related metrics/applications
  - …

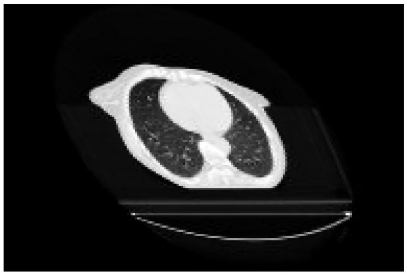
Day 2

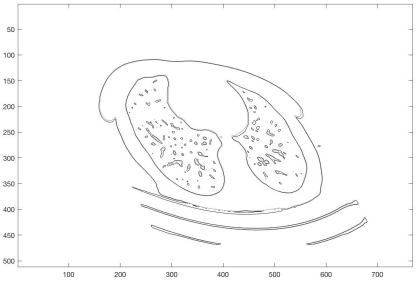
- **2D Remesh**
  - **Goal:** define “equivalent” representations of a given mesh
    - eg., up-to a given accuracy and/or according to a set of optimality constraints
  - **Criteria:** uniform sampling density, feature preservation, guarantee on min-max angles of triangles (eg., for FEMs)
  - **Tools:** MeshLab
  - **Tests:** remesh the surfaces that we have generated in the previous examples by
    - optimizing 1 or more of the previous criteria (or other criteria→Meshlab routines for remeshing)
    - adding geometric noise to the input data

Day 3

- Applying a **transformation** to the input image
  - Compute the image deformation
  - Generate a 2D mesh of the input and deformed images
- Analyse the **2D mesh distortion** in terms of
  - Edge length (*isometry-preserving*)
  - Triangle area (*area-preserving*)
  - Triangle angle (*conformal*)
- **Discussion**
  - Image&mesh distortion
  - Bounds to the image/mesh distortion
  - …

Day 3

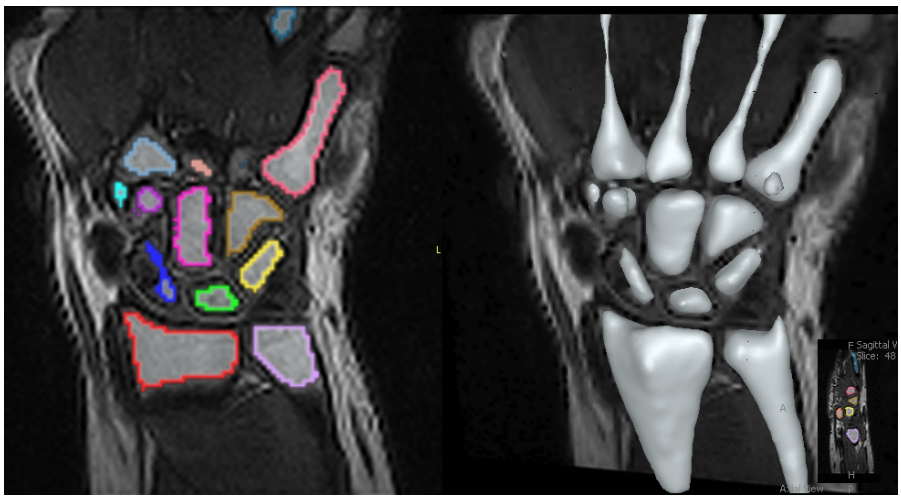




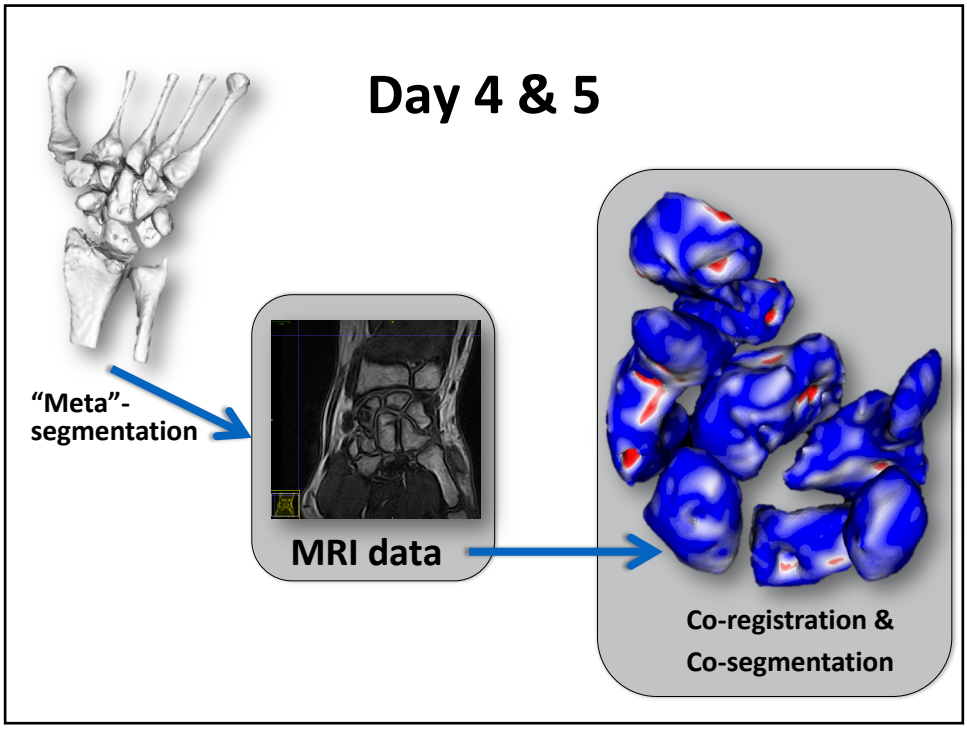
Day 4 & 5

- **3D Image & mesh processing**
  - Load a MRI data set and its deformation
  - Visualize the stack of 2D images
  - For each 2D image
    - Make the input image a square image
    - Compute the deformation
    - Evaluate the deformation distortion as 2D image and triangle mesh
  - Compute the distortion of the whole stack and discuss the results (eg, with respect to a different image crop/extension)

Day 4 & 5



$128 \times 128 \times 51$



Day 4 & 5

- Construct a 3D Delaunay triangulation
- Visualise MRI data & segmented 3D data
- …

Next steps

- For questions, I'll be available by
  - Email: patane@ge.imati.cnr.it
  - Skype: giuseppe-imati
- Next weeks
  - Silvia Bertoluzza
  - Micol Pennacchio