HUB4045F Assignment 4 2023

August 28, 2025

HUB4045F Assignment 4: 30% of final mark

Due date: 17 May 2023 @ 23h59.

0.0.1 Instructions :

- Solutions to be submitted as a jupyter notebook called "**HUB4045F - Yourname - Your student number - Assignment 4**".

- Explanations to questions should be done in formatted markdown cells. Code should be presented in code cells.

- All required libraries for your code to run should be clearly stated at the beginning of the notebook with full instructions of how to install them.

- All code should be well commented.

- Part marks will be given for non running code provided that an explanation is provided for why the code is not working.

- Add appropriate references to other peoples work or code.

- All data should references using relative paths and ofocurse you will need to upload them with your python file when submitting.

- NB: We will submit the code for similarity tests (http://www.tareeinternet.com/scripts/comparison-tool/). As much as we encourage sharing ideas and working together its important that the final submission be inidvidual work

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0.0.2 Question 1 [20 marks]: Segmentation

Load dicom image provided CTimage.dcm. It is a crosss-sectional image slice from a CT volume which is taken around the mid femur region. It is common necessity to demarcate specific regions in such cross-sections in order to facilitate downstream quantification of anatomies (e.g. areas, moment inertia's)

a) Display the image [**2 marks**]

b) Isolate and dispaly the leg on the left (white) [**4 marks**]

c) Segment and display the bone region (yellow) [**4 marks**]

d) Calculate the total area of the bone [**3 marks**]

e) Segment and display the muscles (red) [**4 marks**]

f) Calculate the total area of the muscle [**3 marks**]

As a guide the images below describe what is expected. (Note that the demarcated regions in the image may not necessarily be accurate, it is only meant to serve as a guide)

0.0.3   Question 2 [10 marks]: Import surfaces

Once image data has been labelled, some studies may require a comparison or study of the shape of the object (anatomy). Such an analysis can be done either in 2D or 3D depending on the domain of the source image(s) in the study. In 2D, shape is represented by contours. In 3D, shape is typically represeted by triangular surface meshes. As an example the image volume that the above image slice is from, results in the displayed segmented image in 3D when all image slices are segmented.

Import surface meshes of the two femurs provided (femur1 & femur2) using any python library of your choice (you can try **trimesh** or other such)

a) Display each mesh [**2 marks**]

b) Speculate on requirements to compare the two shapes. That is, what would correspondence mean in the context of surfaces? [**2 marks**]

c) A mesh used to represent a surface is constituted of vertices (or nodes) that are points on the surface of the object. The topology of the mesh is described by an array (often called 'faces') that describes how the vertices are connected to each other. Thus, the relationship between 'vertices' is contained in 'faces'. If two surfaces, that are in correspondence, are described by the same mesh structure then they are 'iso-topological'. The two surfaces provided here are iso-topological where the vertices are in correspondence. That is, vertex id# describes the same anatomical location on both the surfaces.

   i) How many vertices does each surface have? [**2 marks**]

   ii) How many faces? [**2 marks**]

   iii) How would you confirm that they are indeed iso-topological? [**2 marks**]

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0.0.4   Question 3 [20 marks]: Shape matching

Once correspondence is established between shapes, it is possible to proceed towards large sample shape analyses. The most basic of such endeavours is the procedure of finding the "average" shape that would describe a given database. Thus, given the 2 surfaces from QN 2, calculate the average of two shapes using the two methods below.

a) **Direct method** > i) Calculate the average spatial position of each point on the surface *(Hint: use the correspondence between the points of the surfaces (at the vertices)* [**5 marks**]

      ii) Display the resulting average surface [**2 marks**]

      iii) Does it look as a representative shape that would describe the 2 surfaces in our dataset? If so, Why ? *(Hint: Think of the pose differences in the dataset)* [**3 marks**]

b) **Rigid alignment method**

      i) Calculate the average surface *(Hint: think of procrustes analysis* **Link1 Link2**) [**5 marks**]

c) Display the resulting surfaces from both methods (3a and 3b) in one scene [**3 marks**]

d) Can you think of other ways to improve the registration process? [**2 marks**]

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