43075-01 Shape modelling and analysis

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Exercise sheet 3

Introduction: 14. March 2023

Discussion: 21. March 2023

Introduction

In this exercise we will make the first step towards our goal of modelling the variation of the femur shape. We transform the data such that those effects are removed, which have nothing to with the effects we want to explain with our model. The most important such effect is the pose of the individual surfaces relative to each other. We will standardize the pose by aligning all surfaces to a common reference using Procrustes alignment.

1. Data preprocessing

1.1 Downloading the data

Download the project data from the Adam workspace:

- https://adam.unibas.ch/goto_adam_file_1563222_download.html

1.2 Rigid alignment

The femur shapes and corresponding landmarks you should use for alignment can be found in the downloaded zip-archive, under the folder `meshes` and `landmarks1`. There is also a reference mesh with corresponding landmarks in the folder `reference-mesh` and `reference-landmarks`.

Rigidly align all the meshes to the reference mesh. Visually check that the bones are well aligned. Use the relevant code snippets from the Scalismo tutorials (https://scalismo.org/docs/tutorials/). Particularly relevant tutorials for this task are tutorial 3 and tutorial 6.

Save all the aligned meshes in a separate folder. You may also want to transform and save the landmarks, as they might prove useful in a later step.

In order to load and save landmarks, use the methods in the class `LandmarksIO`:

```
val landmarks: Seq[Landmark[_3D]] =
    LandmarkIO.readLandmarksJson3D(new java.io.File("landmarkFile.json")).get
LandmarkIO.writeLandmarksJson(landmarks, new java.io.File("landmarkFile.json")).get
```

1.3 Coordinate origin and alignment of the reference surface

Investigate where the center of mass lies of the aligned shapes. Hint: you can find the center of mass of a mesh using the following code:

```
val centerOfMass : Point[_3D] = mesh.pointSet.centerOfMass
```

1.4 Analysing the data

Visualize one bone together with the landmarks. Note that landmark `L2` and `L5` characterize the length rather well. Landmarks `l3` and `l4` are a good proxy for the width of the bone. Compute the distances between these two pairs of landmarks for every bone. Create a scatter plot of the length and the width. Also compute the mean and variance for these measurements. You can either use our experimental plotting library *scalismo-plot* (recommended) or export the data to a csv file and create the plots using your favorite programming language and plotting library.

You can find documentation on how to use *Scalismo-plot* in the *quickstart guide*:

- https://github.com/marcelluethi/scalismo-plot/blob/main/docs/quickstart.md

Make sure that you add the following lines at the beginning of your Scala file, in order for `scala-cli` to import the dependency:

```
//> using repository "sonatype:snapshots"
//> using lib "ch.unibas.cs.gravis::scalismo-ui:0.91.0"
//> using lib "ch.unibas.cs.gravis::scalismo-plot:0.3-SNAPSHOT"
```

If you prefer to use a different plotting library, you can use the code below to export the landmarks to a csv file:

```
// Class to store the measurements
case class Measurement(id : String, length : Double, width : Double)

def writeCSV(csvFile : java.io.File, measurements :Seq[Measurement]) : Unit = {
    import java.io.PrintWriter
    val printWriter = new PrintWriter(csvFile)
    printWriter.write("id, length, width\n")
    for (measurement <- measurements) {
        printWriter.write(s"${measurement.id},
                          ${measurement.length},
                          ${measurement.width}\n")
    }
    printWriter.close()
}
```

2 Generalized Procrustes Analysis

Can you implement *Generalized Procrustes Analysis* as outlined in the article *Superimposing Shapes*?

- (https://shapemodelling.cs.unibas.ch/ssm-course/week2/step2-5#generalised-procrustes-alignment.

Note that the procedure does not involve the shapes themselves, but only the landmarks.

- How much do the mean landmarks you obtain differ from the reference landmarks?
- Is there a difference in the alignment compared to a simple alignment to the reference shape? When do you think the difference would be large?
- What is the advantage of using Generalized Procrustes Analysis for Alignment?

3 Theory

Work through the theory parts of week 3 of the online course

- https://shapemodelling.cs.unibas.ch/ssm-course/week3/

You can add questions and topics that you would like to discuss in class to the Etherpad on Adam:

- https://adam.unibas.ch/goto_adam_xpdl_1553025.html

Note, you don't have to work through the practical parts of the online course. We will work through it together in class.