University of Salzburg — Lecturer: Roland Kwitt

Imaging Beyond Consumer Cameras – Proseminar (911.422)

Exercise sheet **C**

Image registration

Exercise 1. 20 P.

In this multi-step exercise, you will learn how to use image registration to *automatically segment an MR image of the human brain into medically relevant regions*. In medical image analysis, the pipeline that is outlined below is referred to as *atlas-based image segmentation*.

Background. The idea is the following: say, we would have an MR image, where medical experts have hand-segmented certain regions (e.g., the brain stem, the ventricles, etc.). In medical imaging, such an image is often referred to as an *atlas* (see figure below), or a *template*. Sometimes, the atlases are constructed from images of *multiple* patients, or from a *single* patient only.

To automatically segment a new image (from a new patient), e.g., to study the size of certain brain structures related to some disease (e.g., Alzheimer's, etc.), we could try (1) to *map* this patients' MR image onto the atlas, then (2) transfer the labels from the atlas to the new image, and eventually transform the MR image back into its original space.

Caution: An important detail that we need to take care of is to *strip* the skull from the MR images, since image registration would immediately hinge onto the skull structure, instead of the soft-tissue structures (because of very strong gradients). For affine registration this is not a big issue, however, when a more advanced registration model (e.g., non-linear) is used, *skull-stripping* typically makes a huge difference.

The exercise is split into multiple parts:

1. Download example brain MRI scans (CUMC12 dataset) from here and select 1-2 images
2. Download the SPL 2008 brain atlas from here
3. Register the image **affinely** to the atlas (using `aladdin` of NiftyReg for instance)
4. Register the image **non-linearly** to the atlas (using `f3d` of NiftyReg for instance)
5. Visualize the registration result (just one slice) via 3DSlicer's *Checkerboard Filter*
6. Transform labels from atlas to image (using `reg_resample` of NiftyReg for instance)
7. Extract the *corpus callosum* (using `Convert3D (c3d)`; read the documentation for how to extract a label with a certain number)
8. Visualize the corpus callosum (e.g., using ParaView, or ITKSnap)
9. Document the process in 1-2 pages with visualizations and parameter settings of the tools that you used

Resources

Below, you can find links to software packages that you can use (I do recommend using `NiftyReg` in combination with `BET`):

- NiftyReg
- ANTs
- 3DSlicer
- FSL Brain Extraction Tool (BET)

Additional help

Note that the registration and label transfer steps can be (almost) exactly replicated from the Segmentation Propagation Tutorial.

Some of the images come in the format of a `.img` and a `.hdr` file. In case NiftyReg can't directly process these, I do recommend converting them using `Convert3D (c3d)`, e.g., using

```
c3d OAS1_0001_MR1_mpr_n4_anon_111_t88_masked_gfc.img OAS1_0001_MR1_mpr_n4_anon_111_t88_masked_gfc.nii
```

I would also check if the conversion has worked by (1) visually checking the registration results and (2) checking the meta information, e.g., via the `-info` parameter of `Convert3D`.

Evaluation criteria. 5 points for affine registration; +5 points for non-linear registration; +5 points for tranforming the labels back and +5 points for visualization.

Total #points: 20 P.