<https://ro-journal.biomedcentral.com/articles/10.1186/s13014-020-01617-0> -->atlas based segmentation

<https://www.youtube.com/watch?v=TyV-9K_8w20>

**Point based registration:**

We already commented on this slightly, but not suitable in this application because of varying accuracy and it is non suitable for nonlinear registration.

**Object/ surface based registration**

Makes use of least squares distances between transformed point and point on a surface. The main advantage is that it is supposedly faster than voxel based registration. What could be interesting is to try and see the performance differences between the two methods w.r.t computation time. 🡪 in that case we would have to set a minimum required performance for the task.

**How to define the surface?**

**Voxel-based registration 🡪 most popular**

-Voxel based with mean squared difference:

is more sensitive to the modality, so it only works well for monomodal registration. I think we can assume all images will be acquired with the same modality so that should not be a problem for our project.

-Normalized cross correlation: Can deal with linear intensity changes in the image, this might be useful to use since intensities in images can differ.

🡪 There is a variation called gradient correlation which is the normalized cross correlation between gradient images obtained by sobel operators.

🡪 Or local cross correlation: allows robust matching of images despite the presence of a strong bias field affecting the image quality <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2276735/>

-Mutual information: Suitable for multimodal registration (different modalities) 🡪 Since our data is mainly CT images, it does not specifically make sense to use this metric

- I also found something called Pattern intensity.

**Comparison voxel based registration and surface based registration (for 3D assessment )**

There were no significant statistical differences between the two registration methods and it was unlikely to have any clinical significance. Voxel based registration was associated with less variability.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3973674/>

**Optimization methods:**

From lecture:

-gradient descent : Can encounter problems with step size?

**-multiresolution optimization:** Should give good results and be reasonably fast.

-sampling: Could give more local minima in loss function and be less precise. Selecting voxels from the fixed image for metric computation. If we use knowledge-based it could be interesting since only voxels in the region of interest will contribute, making the optimization faster and region oriented.

In general there are two types of optimizations possible differential objective functions and non-differential objective functions.

Non differential methods are used because of some difficulties on objective functions for the classical differential algorithms:

* No analytical description of the function (e.g. simulation).
* Multiple global optima (e.g. multimodal).
* Stochastic function evaluation (e.g. noisy).
* Discontinuous objective function (e.g. regions with invalid solutions).

I found several other optimization methods in a source on gradient correlation and examples of non-differential method would be

* Powell-Brent🡪 The method is useful for calculating the local minimum of a continuous but complex function, especially one without an underlying mathematical definition, because it is not necessary to take derivatives. **However,  its performance is found to be strongly dependent on the initial solution. 🡪 more for rigid formations.**
* Evolutionary strategy🡪 covariant matrix adaptation (CMA) is considered the state-of-the-art implementation of this optimization technique. The method comprises three evolutionary phases: offspring generation, selection, and recombination. During offspring generation, a set of λ trial search directions is obtained from a normal distribution

Powell Brent method was found, by the paper, found to be the best in their case for x-ray images.

“From the results we can conclude that for the image data used in this study, the best 2D-3D registration re- sults are obtained by a Powell-Brent search strategy. Because of its good performance with all three similarity measures, we recommend Powell-Brent as a reliable optimization method for intensity-based 2D-3D registration in cerebral interventions”

<https://elastix.lumc.nl/marius/downloads/2011_c_SPIEMI.pdf>

-Elastix based on b-splines

-Why use certain matrix

-It depends on the region of interest which performance you need.

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