Inhomogeneity Correction

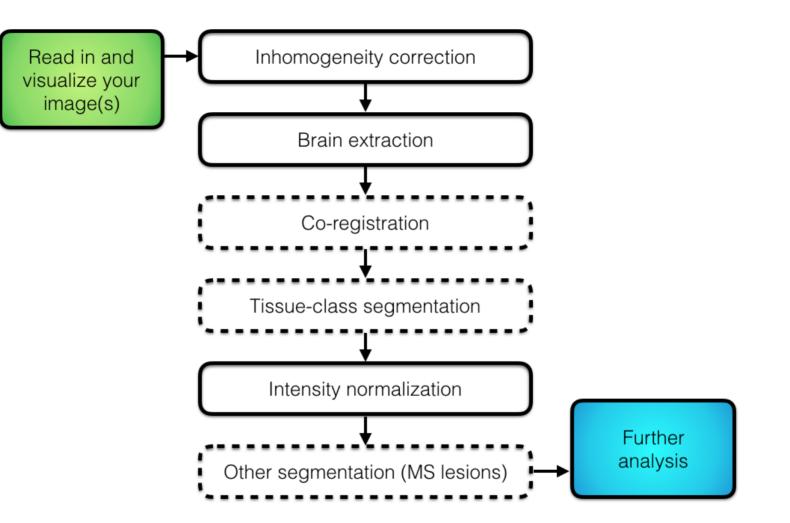
Processing math: 100%

MS Lesion

Let's reset and read in the T1 image from a MS lesion data set:

```
t1 = neurobase::readnii("training01_01_t1.nii.gz")
t1[ t1 < 0 ] = 0</pre>
```

Overall Pipeline



Inhomogeneity correction

- Scans can have nonuniform intensities throughout the brain
- Usually low frequency smooth over the brain (assumed)
- Referred to as bias, bias field, or inhomogeneity

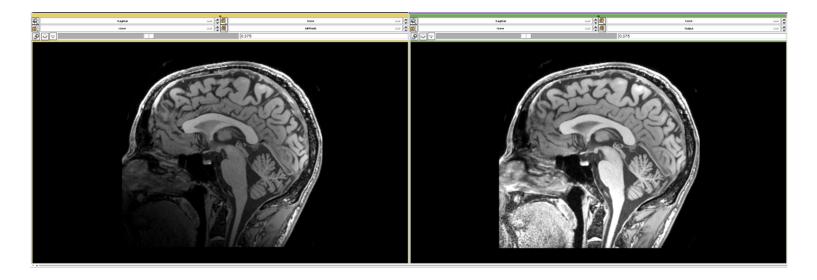


Image From https://www.slicer.org/w/images/7/77/MRI_Bias_Field_Correction_Slicer3_close_up.png

Image Data

It's hard to see subtler bias fields, but sometimes they can be seen visually.

ortho2(robust_window(t1))

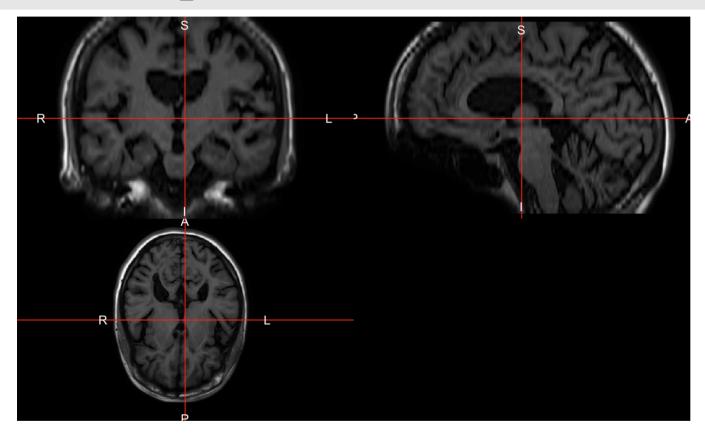


Image Data

flair = neurobase::readnii("training01_01_flair.nii.gz")
ortho2(robust_window(flair))

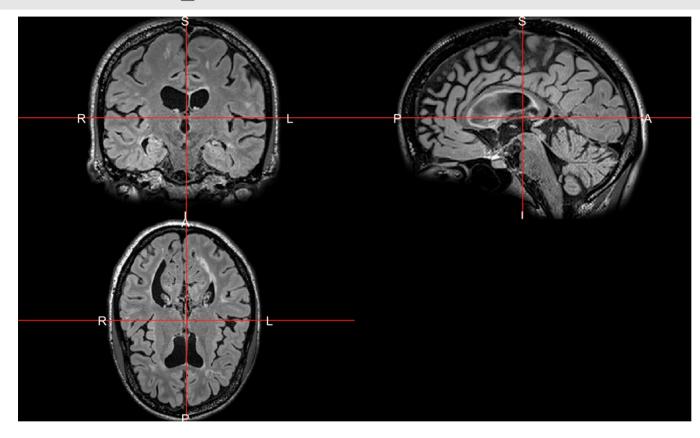
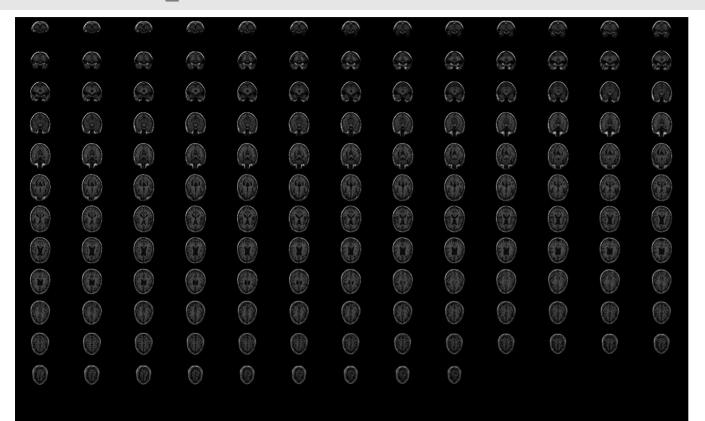


Image Data: Lightbox

image(robust window(t1), useRaster = TRUE)



N4 Inhomogeneity Correction

We will use N4: Improved N3 Bias Correction (Tustison et al. 2010).

The model assumed in the N4 is: v(x) = u(x)f(x) + n(x)

- \cdot v is the given image
- u is the uncorrupted image
- \cdot f is the bias field
- n is the noise (assumed to be independent and Gaussian)
- \cdot x is a location in the image

N4 Inhomogeneity Correction

The data is log-transformed and assuming a noise-free scenario, we have:

 $\log(v(x)) = \log(u(x)) + \log(f(x))$

- N4 uses a B-spline approximation of the bias field
- It iterates until a convergence criteria is met
 - when the updated bias field is the same as the last iteration
- It outputs the data back in the original units (not log-transformed)

Bias Field Correction

Here we will use the bias_correct function in extrantsr, which calls n4BiasFieldCorrection from ANTsR.

You can pass in the image:

```
library(extrantsr)
bc t1 = bias correct(file = t1, correction = "N4")
```

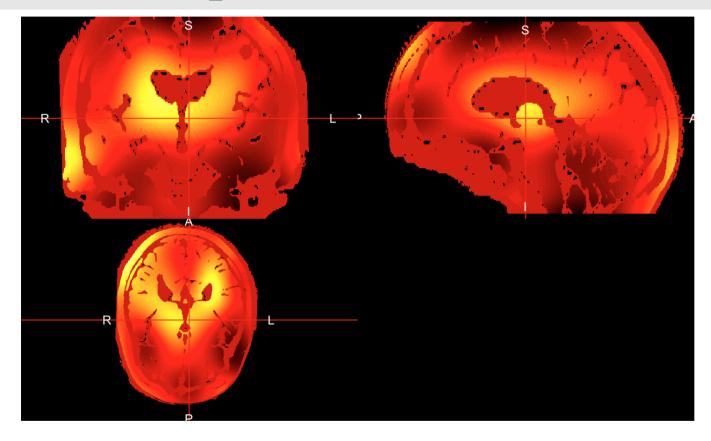
or the filename (but negatives are in there):

bc t1 = bias correct(file = "training01 01 t1.nii.gz", correction = "N4")

Visualizing Bias Field Correction

Here we take the ratio of the images and overlay it on the original image:

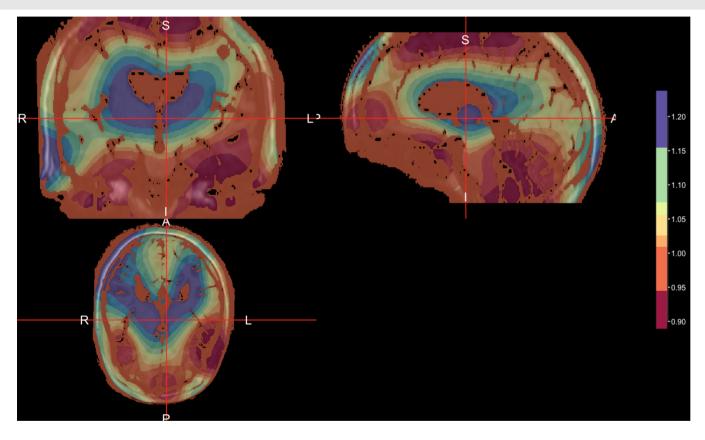
ratio = t1 / bc_t1; ortho2(t1, ratio)



Visualizing Bias Field Correction

We are breaking the ratio into quantiles:

ortho2(t1, ratio, col.y = colors, ybreaks = quantiles, ycolorbar = TRUE)



Conclusions

- Inhomogeneity correction is one of the first steps of most structural MRI pipelines
- Inhomogeneity can cause problems for other methods/segmentation
- Corrections try to make tissues of the same class to have similar intensities
- Use the extrantsr bias_correct function
 - There is also fsl_biascorrect from fslr (not as effective in our experience)
- \cdot You may also want to run corrections after skull stripping on the brain only
 - this is possible with the result after the brain extraction lecture
 - correction before skull-stripping may be necessary and can improve after correction

Website

http://johnmuschelli.com/imaging_in_r

References

Tustison, Nicholas J., Brian B. Avants, Philip A. Cook, Yuanjie Zheng, Alexander Egan, Paul A. Yushkevich, and James C. Gee. 2010. "N4ITK: Improved N3 Bias Correction." 29 (6):1310–20.

https://doi.org/10.1109/TMI.2010.2046908.