

Corregistro de DTI usando epi_reg y ANTs

Tomado de [aqui](#)

1. ¿Porqué epi_reg?

Cuando se registra el T1 a espacio nativo DTI usando solo ANTS los resultados no son muy buenos. Con epi_reg el registro resulta ser mucho mejor.

1. Entonces, ¿Porqué ANTS?

La matriz resultado de epi_reg se usa con *flirt* o con *fnirt* pero realmente los mejores resultados en los atlas se alcanzarían utilizando *antsApplyTransforms* y utilizando la matriz resultado de *epi_reg*.

tl;dr

```
#!/bin/sh

Usage() {
    echo ""
    echo "Usage: dti_proc.sh <study> <file_name> <T1> <name> <output_dir>"
    echo ""
    echo "You must have FSL installed in order to run this script"
    echo ""
    exit 1
}

[ "$5" = "" ] && Usage
debug=1
study=$1
shift
in=`${FSLDIR}/bin/remove_ext $1`
shift
t1=`${FSLDIR}/bin/remove_ext $1`
shift
b_in=$1
shift
out=`${FSLDIR}/bin/remove_ext $1`
shift
td=${out}/.tmp_`${b_in}`
p2a=$(dirname ${in}.nii.gz)/`${b_in}`_p2a_b0'
if [ ! -d "$td" ]; then
    mkdir $td
fi
if [ ! -d "$out" ]; then
    mkdir $out
fi

echo "DTI preprocessing begins on `${b_in}` ..."
```

```

echo [ `date` ]
echo
${FSLDIR}/bin/fslroi $in ${td}/a2p_b0 0 1
if [[ -f ${p2a}.nii.gz ]]; then
    echo "Preparing topup"
    ${FSLDIR}/bin/imcp ${p2a} ${td}/
    ${FSLDIR}/bin/fslmerge -t ${td}/a2p_p2a_b0 ${td}/a2p_b0
    ${td}/${b_in}_p2a_b0
    echo "Running topup"
    ${FSLDIR}/bin/topup --imain=${td}/a2p_p2a_b0 --
    datain=${out}/../acqparams.txt --out=${td}/topup_results --
    iout=${td}/hifi_b0
    ${FSLDIR}/bin/fslmaths ${td}/hifi_b0 -Tmean ${td}/hifi_b0
else
    echo "No P>>A so will continue uncorrected"
    ${FSLDIR}/bin/fslmaths ${td}/a2p_b0 -Tmean ${td}/hifi_b0
    echo ${in} >> ${out}/../dti_uncorrected_subjects.txt
fi
${FSLDIR}/bin/bet ${td}/hifi_b0 ${td}/hifi_b0_brain -m

echo "Copying files for ${b_in} to ${td}/"
echo
cp ${in}.bval ${td}/bvals
cp ${in}.bvec ${td}/bvecs

echo "Doing correction on ${td}/${b_in}_hifi"
echo [ `date` ]
echo
${FSLDIR}/bin/eddy_cuda --imain=${in} --mask=${td}/hifi_b0_brain --
acqp=${out}/../acqparams.txt --index=${out}/../dti_index.txt --
bvecs=${td}/bvecs --bvals=${td}/bvals --topup=${td}/topup_results --
out=${td}/data

echo "Running dtifit on ${td}/data"
echo [ `date` ]
echo
${FSLDIR}/bin/dtifit --data=${td}/data --out=${td}/dti --
mask=${td}/hifi_b0_brain --bvecs=${td}/bvecs --bvals=${td}/bvals
echo "I will copy all output files to ${out}/${b_in}_XXXXX"
echo
for x in ${td}/dti*; do ${FSLDIR}/bin/imcp ${x} ${out}/${b_in}_$(basename
$x); done;
${FSLDIR}/bin/imcp ${td}/hifi_b0_brain ${out}/${b_in}_dti_brain_mask
${FSLDIR}/bin/imcp ${td}/data ${out}/${b_in}_dti_data

echo "I need the T1 image"
${FSLDIR}/bin/fslreorient2std ${t1} ${out}/${b_in}_t1_reoriented

echo "I get the extracted brain"
${FREESURFER_HOME}/bin/mri_vol2vol --mov
${SUBJECTS_DIR}/${study}_${b_in}/mri/brain.mgz --targ

```

```

${SUBJECTS_DIR}/${study}_${b_in}/mri/rawavg.mgz --regheader --o
${td}/${b_in}_tmp_brain_in_rawavg.mgz
${FREESURFER_HOME}/bin/mri_convert --in_type mgz --out_type nii
${td}/${b_in}_tmp_brain_in_rawavg.mgz ${td}/${b_in}_tmp_brain.nii.gz
${FSLDIR}/bin/fslreorient2std ${td}/${b_in}_tmp_brain ${out}/${b_in}_brain

echo "Calculating transformation from MNI to T1"
echo [ `date` ]
echo
antsRegistrationSyN.sh -d 3 -f ${out}/${b_in}_t1_reoriented.nii.gz -m
${FSLDIR}/data/standard/MNI152_T1_1mm.nii.gz -o ${td}/${b_in}_mni_t1_warp
antsApplyTransforms -d 3 -i ${FSLDIR}/data/standard/MNI152_T1_1mm.nii.gz -r
${out}/${b_in}_t1_reoriented.nii.gz -t ${td}/${b_in}_mni_t1_warp1Warp.nii.gz
-t ${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_mni_t1_warped.nii.gz

echo "Calculating transformation from T1 to B0"
echo [ `date` ]
echo
${FSLDIR}/bin/epi_reg --epi=${out}/${b_in}_dti_data --
t1=${out}/${b_in}_t1_reoriented --t1brain=${out}/${b_in}_brain --
out=${td}/${b_in}_tmp_diff2std
${FSLDIR}/bin/convert_xfm -omat ${td}/${b_in}_tmp_std2diff.mat -inverse
${td}/${b_in}_tmp_diff2std.mat
c3d_affine_tool -ref ${td}/hifi_b0.nii.gz -src
${out}/${b_in}_t1_reoriented.nii.gz ${td}/${b_in}_tmp_std2diff.mat -fsl2ras
-oitk ${td}/${b_in}_epi_reg_ANTs.mat
antsApplyTransforms -d 3 -i ${out}/${b_in}_t1_reoriented.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_t1_b0.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_mni_t1_warped.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_mni_to_b0.nii.gz

echo "Applying transformations to JHU Atlas (ICBM-labels)"
antsApplyTransforms -d 3 -i ${FSLDIR}/data/atlas/JHU/JHU-ICBM-
labels-1mm.nii.gz -r ${out}/${b_in}_t1_reoriented.nii.gz -t
${td}/${b_in}_mni_t1_warp1Warp.nii.gz -t
${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_JHU_labels_tmp.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_JHU_labels_tmp.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_JHU_labels.nii.gz

echo "Applying transformations to JHU Atlas (ICBM-tracts)"
antsApplyTransforms -d 3 -i ${FSLDIR}/data/atlas/JHU/JHU-ICBM-tracts-
maxprob-thr25-1mm.nii.gz -r ${out}/${b_in}_t1_reoriented.nii.gz -t
${td}/${b_in}_mni_t1_warp1Warp.nii.gz -t
${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_JHU_tracts_tmp.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_JHU_tracts_tmp.nii.gz -r

```

```

${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_JHU_tracts.nii.gz
${FSLDIR}/bin/imcp ${td}/hifi_b0 ${out}/${b_in}_hifi_b0

echo "Game over :-P"
echo [`date`]
exit 0

```

Correccion con topup y preprocesamiento

Esto se hace del modo usual,

```

${FSLDIR}/bin/fslroi $in ${td}/a2p_b0 0 1
if [[ -f ${p2a}.nii.gz ]]; then
    echo "Preparing topup"
    ${FSLDIR}/bin/imcp ${p2a} ${td}/
    ${FSLDIR}/bin/fslmerge -t ${td}/a2p_p2a_b0 ${td}/a2p_b0
    ${td}/${b_in}_p2a_b0
    echo "Running topup"
    ${FSLDIR}/bin/topup --imain=${td}/a2p_p2a_b0 --
    datain=${out}/../acqparams.txt --out=${td}/topup_results --
    iout=${td}/hifi_b0
    ${FSLDIR}/bin/fslmaths ${td}/hifi_b0 -Tmean ${td}/hifi_b0
else
    echo "No P>>A so will continue uncorrected"
    ${FSLDIR}/bin/fslmaths ${td}/a2p_b0 -Tmean ${td}/hifi_b0
    echo ${in} >> ${out}/../dti_uncorrected_subjects.txt
fi
${FSLDIR}/bin/bet ${td}/hifi_b0 ${td}/hifi_b0_brain -m

```

Solo que para correr *topup* se necesita un *scan* en direccion contraria (P>A). Si este no existe no se puede realizar la correccion. Para poder continuar se toma el *B0* como si estuviera corregido pero se anota en un archivo por separado los que no estan corregidos. Por aquello de comprobar que ha pasado.

Luego viene la correccion con *eddy*. Para esto uso *eddy_cuda* que aunque me limita el numero de maquinas a usar es muchas veces mas rapido.

```

cp ${in}.bval ${td}/bvals
cp ${in}.bvec ${td}/bvecs
${FSLDIR}/bin/eddy_cuda --imain=${in} --mask=${td}/hifi_b0_brain --
acqp=${out}/../acqparams.txt --index=${out}/../dti_index.txt --
bvecs=${td}/bvecs --bvals=${td}/bvals --topup=${td}/topup_results --
out=${td}/data

```

Ahora si, preprocesamiento con *dtifit*,

```

${FSLDIR}/bin/dtifit --data=${td}/data --out=${td}/dti --
mask=${td}/hifi_b0_brain --bvecs=${td}/bvecs --bvals=${td}/bvals

```

Registro con epi_reg

Primero voy a tomar todos los archivos necesarios. Para empezar, los resultados del preprocesamiento

```
for x in ${td}/dti*; do ${FSLDIR}/bin/imcp ${x} ${out}/${b_in}_$(basename $x); done;
${FSLDIR}/bin/imcp ${td}/hifi_b0_brain ${out}/${b_in}_dti_brain_mask
${FSLDIR}/bin/imcp ${td}/data ${out}/${b_in}_dti_data
```

Ahora el T1,

```
${FSLDIR}/bin/fslreorient2std ${t1} ${out}/${b_in}_t1_reoriented
```

Tambien voy a necesitar el cerebro extraido pero el lugar de hacer un *bet* voy a tomar el que sale de *Freesurfer*

```
${FREESURFER_HOME}/bin/mri_vol2vol --mov
${SUBJECTS_DIR}/${study}_${b_in}/mri/brain.mgz --targ
${SUBJECTS_DIR}/${study}_${b_in}/mri/rawavg.mgz --regheader --o
${td}/${b_in}_tmp_brain_in_rawavg.mgz
${FREESURFER_HOME}/bin/mri_convert --in_type mgz --out_type nii
${td}/${b_in}_tmp_brain_in_rawavg.mgz ${td}/${b_in}_tmp_brain.nii.gz
${FSLDIR}/bin/fslreorient2std ${td}/${b_in}_tmp_brain ${out}/${b_in}_brain
```

Ahora, el template MNI se lleva a T1 con ANTs sin problemas,

```
antsRegistrationSyN.sh -d 3 -f ${out}/${b_in}_t1_reoriented.nii.gz -m
${FSLDIR}/data/standard/MNI152_T1_1mm.nii.gz -o ${td}/${b_in}_mni_t1_warp
antsApplyTransforms -d 3 -i ${FSLDIR}/data/standard/MNI152_T1_1mm.nii.gz -r
${out}/${b_in}_t1_reoriented.nii.gz -t ${td}/${b_in}_mni_t1_warp1Warp.nii.gz
-t ${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_mni_t1_warped.nii.gz
```

Pero para ir al espacio nativo DTI voy a usar *epi_reg*. Ojo que tendre que hacer el registro de T1 a DTI nativo, invertir l matriz y convertir la matriz inversa. Esta ya la puedo usar con ANTs.

```
${FSLDIR}/bin/epi_reg --epi=${out}/${b_in}_dti_data --
t1=${out}/${b_in}_t1_reoriented --t1brain=${out}/${b_in}_brain --
out=${td}/${b_in}_tmp_diff2std
${FSLDIR}/bin/convert_xfm -omat ${td}/${b_in}_tmp_std2diff.mat -inverse
${td}/${b_in}_tmp_diff2std.mat
c3d_affine_tool -ref ${td}/hifi_b0.nii.gz -src
${out}/${b_in}_t1_reoriented.nii.gz ${td}/${b_in}_tmp_std2diff.mat -fsl2ras
-oitk ${td}/${b_in}_epi_reg_ANTs.mat
antsApplyTransforms -d 3 -i ${out}/${b_in}_t1_reoriented.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_t1_b0.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_mni_t1_warped.nii.gz -r
```

```

${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_mni_to_b0.nii.gz

```

Atlas

Ya solo queda aplicar las transformaciones calculadas a los atlas de JHU y copiar el *B0* al directorio de trabajo para hacer el QC.

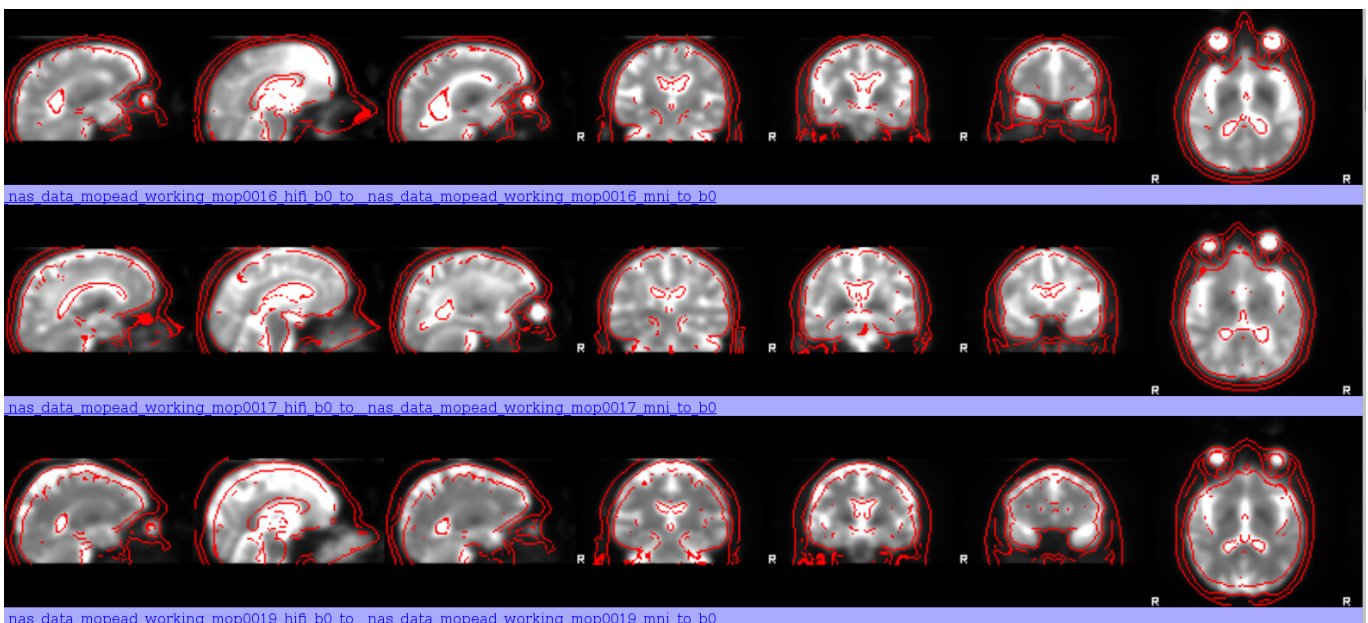
```

antsApplyTransforms -d 3 -i ${FSLDIR}/data/atlas/JHU/JHU-ICBM-
labels-1mm.nii.gz -r ${out}/${b_in}_t1_reoriented.nii.gz -t
${td}/${b_in}_mni_t1_warp1Warp.nii.gz -t
${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_JHU_labels_tmp.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_JHU_labels_tmp.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_JHU_labels.nii.gz
antsApplyTransforms -d 3 -i ${FSLDIR}/data/atlas/JHU/JHU-ICBM-tracts-
maxprob-thr25-1mm.nii.gz -r ${out}/${b_in}_t1_reoriented.nii.gz -t
${td}/${b_in}_mni_t1_warp1Warp.nii.gz -t
${td}/${b_in}_mni_t1_warp0GenericAffine.mat -o
${td}/${b_in}_JHU_tracts_tmp.nii.gz
antsApplyTransforms -d 3 -i ${td}/${b_in}_JHU_tracts_tmp.nii.gz -r
${td}/hifi_b0.nii.gz -t ${td}/${b_in}_epi_reg_ANTs.mat -o
${out}/${b_in}_JHU_tracts.nii.gz
${FSLDIR}/bin/imcp ${td}/hifi_b0 ${out}/${b_in}_hifi_b0

```

QC

El Qc se realiza basicamente comprobando la superposicion del B0 con la plantilla MNI trasladada al espacio B0. Esta es, desde lejos, la mejor aproximacion al registro a DTI que he logrado.



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