

Technical report of the preprocessing pipeline for the work on schizophrenia detection with Diffusion Weighted Images

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1 Database description

This database is public available in:

http://www.insight-journal.org/midas/collection/view/190?path_navigation=17

It was made available by the National Alliance for Medical Image Computing (NAMIC).

In each case folder, there are 10 files, described here:

- 01###-t1w.nrrd is the weighted T1 scan.
- 01###-t2w.nrrd is the weighted T2 scan.
- 01###-t2w_mask.nrrd is a labelmap of the ICC based on the T2.
- 000008.SER-anon.tgz is the fMRI scan (zipped tar ball) - - Note: there is no fMRI scan for case01073
- 01###-dwi.nhdr (references 01###-dwi.raw.gz) is the raw DTI scan.
- 01###-dwi-filt-Ed.nhdr (references 01###-dwi-filt-Ed.raw.gz) is the dwi scan after noise filtering and eddy current and head motion correction.
- brainmask.mgz is a T1 grayscale image that has the skull & dura-matter stripped.
- aparc+aseg.mgz is a freesurfer segmentation of the t1w image.

2 Filetype conversions

- Some files downloaded were zip compressed, to unzip all these files:

```
- find -name *zip | while read line; do unzip -o $line; rm $line; done;
```

- Convert `aparc+aseg.mgz` and `brainmask.mgz` to NIFTI (.nii) using Freesurfer's `mri_convert`
 - `find -name *mgz | while read line; do name=${line%.*}; mri_convert $line $name.nii; done;`
- Convert `raw.gz` and `.nhdr` files to `.nii` using FreeSurfer's `mri_convert`
 - 1. GUnzip the `raw.gz` file
 - 2. Change in `nhdr`: (make a copy of this file to `*_unzip.nhdr` and perform the changes in the copy)
 - * 2a. Erase the “.gz” in “data file” field
 - * 2b. Change “encoding” from “gzip” to “raw”
 - 3. `mri_convert file_unzip.nhdr file.nii`
- Convert file type from short to float (needed to calculate eigens with `unrrdu` software) THIS WAS NOT DONE FOR FSL DTIFIT
 - `find -name *dwi-filt-Ed.nhdr | while read line; do unu convert -t float -i $line ${line%.*}_float.nhdr; done;`

3 Registration and normalization

- Apply ANTS to perform nonlinear registration procedures (this was done in a Sun Grid Engine (SGE) cluster)

Algorithm 1 SGE script for ANTS Elastic registration of subjects' brainmask to the MNI152_T1_1mm template

```
#!/bin/sh
case $SGE_TASK_ID in
1) SUBJ_FILE=nc_01019_brainmask.nii;;
2) SUBJ_FILE=nc_01020_brainmask.nii;;
3) SUBJ_FILE=nc_01025_brainmask.nii;;
4) SUBJ_FILE=nc_01026_brainmask.nii;;
5) SUBJ_FILE=nc_01029_brainmask.nii;;
6) SUBJ_FILE=nc_01033_brainmask.nii;;
7) SUBJ_FILE=nc_01034_brainmask.nii;;
8) SUBJ_FILE=nc_01035_brainmask.nii;;
9) SUBJ_FILE=nc_01041_brainmask.nii;;
10)SUBJ_FILE=nc_01104_brainmask.nii;;
11)SUBJ_FILE=sz_01011_brainmask.nii;;
12)SUBJ_FILE=sz_01015_brainmask.nii;;
13)SUBJ_FILE=sz_01017_brainmask.nii;;
14)SUBJ_FILE=sz_01018_brainmask.nii;;
15)SUBJ_FILE=sz_01028_brainmask.nii;;
16)SUBJ_FILE=sz_01039_brainmask.nii;;
17)SUBJ_FILE=sz_01042_brainmask.nii;;
18)SUBJ_FILE=sz_01044_brainmask.nii;;
19)SUBJ_FILE=sz_01045_brainmask.nii;;
20)SUBJ_FILE=sz_01073_brainmask.nii;;
esac
ROOT_DIR=/opt/work/alexandre/schizophrenia
SOURCE_FILES=$ROOT_DIR/skstr_t1w_data
WORKDIR=/local_opt/temp
RESULTSDIR=$ROOT_DIR/skstr_t1w_synwtime
FIXED_IMG=/opt/work/alexandre/vbm_svm/templates/MNI152_T1_1mm_brain.nii.gz
MOVING_IMG=$WORKDIR/$SUBJ_FILE
LOGFILE=$RESULTSDIR/$SUBJ_FILE.log;
ANTS=/usr/local/bin/ANTS/ANTS DIM=3
ITS=" -i 100x100x30 " # 3 optimization levels
TSYNWTHTIME1=" -t SyN[1,2,0.05] -r Gauss[3,0.5] "
TGREEDYSYN1=" -t SyN[0.25] -r Gauss[3,0] "
TELAST1=" -t Elast[1] -r Gauss[0,3] "
TEXP1=" -t Exp[0.5,10] -r Gauss[0,3] "
INTMSQ=" -m MSQ[$FIXED_IMG,$MOVING_IMG,1,0] "
INTMI=" -m MI[$FIXED_IMG,$MOVING_IMG,1,32] "
INTPR=" -m PR[$FIXED_IMG,$MOVING_IMG,1,4] "
INTCC=" -m CC[$FIXED_IMG,$MOVING_IMG,1,5] "
INT=$INTPR
TRAN=$ELAST1
SUFFIX=_elast_1.nii
echo "cp $SOURCE_FILES/$SUBJ_FILE $WORKDIR" >> $SUBJ_FILE.txt echo "$ANTS $DIM -o
$MOVING_IMG.$SUFFIX $ITS $TRAN $INT --use-Histogram-Matching" >> $SUBJ_FILE.txt
echo "mv $WORKDIR/$SUBJ_FILE* $RESULTSDIR" >> $SUBJ_FILE.txt
if [ ! -e $WORKDIR/$SUBJ_FILE ]
then
cp $SOURCE_FILES/$SUBJ_FILE $WORKDIR;
fi
$ANTS $DIM -o $MOVING_IMG.$SUFFIX $ITS $TRAN $INT --use-Histogram-Matching
mv $WORKDIR/$SUBJ_FILE* $RESULTSDIR;
```

Algorithm 2 SGE script for ANTS Symmetric Normalization with Time (synwtime) registration of subjects' brainmask to the MNI152_T1_1mm template

```
#!/bin/sh
case $SGE_TASK_ID in
1) SUBJ_FILE=nc_01019_brainmask.nii;;
2) SUBJ_FILE=nc_01020_brainmask.nii;;
3) SUBJ_FILE=nc_01025_brainmask.nii;;
4) SUBJ_FILE=nc_01026_brainmask.nii;;
5) SUBJ_FILE=nc_01029_brainmask.nii;;
6) SUBJ_FILE=nc_01033_brainmask.nii;;
7) SUBJ_FILE=nc_01034_brainmask.nii;;
8) SUBJ_FILE=nc_01035_brainmask.nii;;
9) SUBJ_FILE=nc_01041_brainmask.nii;;
10)SUBJ_FILE=nc_01104_brainmask.nii;;
11)SUBJ_FILE=sz_01011_brainmask.nii;;
12)SUBJ_FILE=sz_01015_brainmask.nii;;
13)SUBJ_FILE=sz_01017_brainmask.nii;;
14)SUBJ_FILE=sz_01018_brainmask.nii;;
15)SUBJ_FILE=sz_01028_brainmask.nii;;
16)SUBJ_FILE=sz_01039_brainmask.nii;;
17)SUBJ_FILE=sz_01042_brainmask.nii;;
18)SUBJ_FILE=sz_01044_brainmask.nii;;
19)SUBJ_FILE=sz_01045_brainmask.nii;;
20)SUBJ_FILE=sz_01073_brainmask.nii;;
esac
ROOT_DIR=/opt/work/alexandre/schizophrenia
SOURCE_FILES=$ROOT_DIR/skstr_t1w_data
WORKDIR=/local_opt/temp
RESULTSDIR=$ROOT_DIR/skstr_t1w_synwtime
FIXED_IMG=/opt/work/alexandre/vbm_svm/templates/MNI152_T1_1mm_brain.nii.gz
MOVING_IMG=$WORKDIR/$SUBJ_FILE
LOGFILE=$RESULTSDIR/$SUBJ_FILE.log;
ANTS=/usr/local/bin/ANTS/ANTS DIM=3
ITS=" -i 100x100x30 " # 3 optimization levels
TSYNWITHTIME1=" -t SyN[1,2,0.05] -r Gauss[3,0.5] "
TGREEDYSYN1=" -t SyN[0.25] -r Gauss[3,0] "
TELAST1=" -t Elast[1] -r Gauss[0,3] "
TEXP1=" -t Exp[0.5,10] -r Gauss[0,3] "
INTMSQ=" -m MSQ[$FIXED_IMG,$MOVING_IMG,1,0] "
INTMI=" -m MI[$FIXED_IMG,$MOVING_IMG,1,32] "
INTPR=" -m PR[$FIXED_IMG,$MOVING_IMG,1,4] "
INTCC=" -m CC[$FIXED_IMG,$MOVING_IMG,1,5] "
INT=$INTPR
TRAN=$SYNWITHTIME1
SUFFIX=_synwtime_1.nii
echo "cp $SOURCE_FILES/$SUBJ_FILE $WORKDIR" >> $SUBJ_FILE.txt echo "$ANTS $DIM -o
$MOVING_IMG.$SUFFIX $ITS $TRAN $INT --use-Histogram-Matching" >> $SUBJ_FILE.txt
echo "mv $WORKDIR/$SUBJ_FILE* $RESULTSDIR" >> $SUBJ_FILE.txt
if [ ! -e $WORKDIR/$SUBJ_FILE ]
then
cp $SOURCE_FILES/$SUBJ_FILE $WORKDIR;
fi
$ANTS $DIM -o $MOVING_IMG.$SUFFIX $ITS $TRAN $INT --use-Histogram-Matching
mv $WORKDIR/$SUBJ_FILE* $RESULTSDIR;
```

- Apply transformation to brainmask

– Elastic transformation:

Algorithm 3 Apply elastic warp to subjects

```
ls *brainmask.nii | while read line;
do
/usr/local/bin/ANTS/WarpImageMultiTransform 3 $line
$line\_elast_1registered.nii $line\_elast_1Warp.nii
$line\_elast_1Affine.txt;
done;
```

– Symmetric Transformation:

Algorithm 4 Apply synwtime warp to subjects

```
ls *brainmask.nii | while read line;
do
/usr/local/bin/ANTS/WarpImageMultiTransform 3 $line
$line\_synwtime_1registered.nii $line\_synwtime_1Warp.nii
$line\_synwtime_1Affine.txt;
done;
```

- FSL DTIFit to calculate diffusivity measures

Algorithm 5 Apply FSL dtifit to calculate diffusivity measures on subjects' dwi Eddy Current filtered volumes

```
cd dwi_nii_data;
ls | while read line;
do
bet $line ../brain_mask/${line%.*}_brain_nodif -f 0.4 -g 0 -m
-n;
done;
cd ..;
ls brain_mask | while read line;
do
id=${line:0:5};
mask='ls brain_mask/*$id*';
dwi='ls dwi_nii_data/*$id*';
outdir=diffusion_data/$id;
mkdir -p $outdir;
dtifit --data=$dwi --out=$outdir/$id-dti --mask=$mask
--bvecs=bvecs --bvals=bvals; echo $mask;
done;
```

- Apply deformation fields

Algorithm 6 Apply rigid (FSL flirt) and then elastic and synwtime warps to the subject's FA and MD volumes

```
find -name "*dti_FA.nii.gz" -or -name "*dti_MD.nii.gz" | while
read line;
do
filename='basename $line .nii.gz';
dirname='dirname $line';
filepath=$dirname/$filename;
id=${filename:0:5};
oriented=$filepath.oriented.nii;
reference='ls ../data/*$id/brainmask*nii';
flirted=$filepath.oriented.rigid_flirt.nii.gz;
linmat=$filepath.oriented.rigid_flirt.mat;
datadir='../nonlinear_registrations/skstr_t1w_nonlinear_registrations';
elastreg=$filepath.oriented.flirt.elast1_registered.nii;
elastwarp='ls $datadir/skstr_t1w_elastic/*$id*_elast_1Warp*';
elastwarp=${elastwarp:0:${#elastwarp}-8}.nii;
elastaffine='ls $datadir/skstr_t1w_elastic/*$id*_elast_1Affine*';
synreg=$filepath.oriented.flirt.synwtime1_registered.nii;
synwarp='ls $datadir/skstr_t1w_synwtime/*$id*_synwtime_1Warp*';
synwarp=${synwarp:0:${#synwarp}-8}.nii;
synaffine='ls $datadir/skstr_t1w_synwtime/*$id*_synwtime_1Affine*';
mri_convert $line $oriented;
/usr/share/fsl/bin/flirt -in $oriented -ref $reference -out
$flierted -omat $linmat -bins 256 -cost mutualinfo -searchrx
-180 180 -searchry -180 180 -searchrz -180 180 -dof 6 -interp
trilinear;
/usr/local/bin/ANTS/WarpImageMultiTransform 3 $flierted $elastreg
$elastwarp $elastaffine;
/usr/local/bin/ANTS/WarpImageMultiTransform 3 $flierted $synreg
$synwarp $synaffine;
done;
```

4 Registration results visualization

- Visualize brainmask to MNI152 registration quality

Algorithm 7 Use FSL slicesdir to visualize elastic registration results of brainmask to MNI template

```
cd /opt/schizophrenia/nonlinear_registrations;
cd skstr_t1w_nonlinear_registrations/skstr_t1w_elastic;
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz
slicesdir -p $template
nc_01019_brainmask.nii._elast_1registered.nii
nc_01020_brainmask.nii._elast_1registered.nii
nc_01025_brainmask.nii._elast_1registered.nii
nc_01026_brainmask.nii._elast_1registered.nii
nc_01029_brainmask.nii._elast_1registered.nii
nc_01033_brainmask.nii._elast_1registered.nii
nc_01034_brainmask.nii._elast_1registered.nii
nc_01035_brainmask.nii._elast_1registered.nii
nc_01041_brainmask.nii._elast_1registered.nii
nc_01104_brainmask.nii._elast_1registered.nii
sz_01011_brainmask.nii._elast_1registered.nii
sz_01015_brainmask.nii._elast_1registered.nii
sz_01017_brainmask.nii._elast_1registered.nii
sz_01018_brainmask.nii._elast_1registered.nii
sz_01028_brainmask.nii._elast_1registered.nii
sz_01039_brainmask.nii._elast_1registered.nii
sz_01042_brainmask.nii._elast_1registered.nii
sz_01044_brainmask.nii._elast_1registered.nii
sz_01045_brainmask.nii._elast_1registered.nii
sz_01073_brainmask.nii._elast_1registered.nii
```

- Visualize FA volumes to brainmask rigid registration quality

Algorithm 9 Use FSL slicesdir to visualize flirt registration results of FA volumes to MNI template

```
cd /opt/schizophrenia/dtifit;
find -name *dti_FA.oriented.rigid_flirt.nii.gz | while read line;
do
filename='basename $line .nii.gz';
id=${filename:0:5};
reference='ls ../data/*$id/brainmask*nii';
pairs="$pairs $line $reference";
echo $pairs;
done;
slicesdir -o $pairs
```

- Visualize MD volumes to brainmask rigid registration quality

Algorithm 8 Use FSL `slicesdir` to visualize synwtime registration results of brainmask to MNI template

```
cd /opt/schizophrenia/nonlinear_registrations;
cd skstr_t1w_nonlinear_registrations/skstr_t1w_synwtime;
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz
slicesdir -p $template
nc_01019_brainmask.nii._synwtime_1registered.nii
nc_01020_brainmask.nii._synwtime_1registered.nii
nc_01025_brainmask.nii._synwtime_1registered.nii
nc_01026_brainmask.nii._synwtime_1registered.nii
nc_01029_brainmask.nii._synwtime_1registered.nii
nc_01033_brainmask.nii._synwtime_1registered.nii
nc_01034_brainmask.nii._synwtime_1registered.nii
nc_01035_brainmask.nii._synwtime_1registered.nii
nc_01041_brainmask.nii._synwtime_1registered.nii
nc_01104_brainmask.nii._synwtime_1registered.nii
sz_01011_brainmask.nii._synwtime_1registered.nii
sz_01015_brainmask.nii._synwtime_1registered.nii
sz_01017_brainmask.nii._synwtime_1registered.nii
sz_01018_brainmask.nii._synwtime_1registered.nii
sz_01028_brainmask.nii._synwtime_1registered.nii
sz_01039_brainmask.nii._synwtime_1registered.nii
sz_01042_brainmask.nii._synwtime_1registered.nii
sz_01044_brainmask.nii._synwtime_1registered.nii
sz_01045_brainmask.nii._synwtime_1registered.nii
sz_01073_brainmask.nii._synwtime_1registered.nii
```

Algorithm 10 Use FSL slicesdir to visualize flirt registration results of MD volumes to MNI template

```
cd /opt/schizophrenia/dtifit;
find -name *dti_MD.oriented.rigid_flirt.nii.gz | while read line;
do
filename='basename $line .nii.gz';
id=${filename:0:5};
reference='ls ../data/*$id/brainmask*nii';
pairs="$pairs $line $reference";
echo $pairs;
done;
slicesdir -o $pairs
```

- Visualize FA volumes to MNI152 template elastic registration quality

Algorithm 11

```
cd /opt/schizophrenia/dtifit;
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz
slicesdir -p $template
./diffusion_data/01025/01025-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01033/01033-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01015/01015-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01026/01026-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01011/01011-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01028/01028-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01104/01104-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01035/01035-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01034/01034-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01039/01039-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01029/01029-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01020/01020-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01041/01041-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01018/01018-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01045/01045-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01017/01017-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01073/01073-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01044/01044-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01042/01042-dti_FA.oriented.flirt.elast1_registered.nii
./diffusion_data/01019/01019-dti_FA.oriented.flirt.elast1_registered.nii
```

- Visualize FA volumes to MNI152 template synwtime registration quality

Algorithm 12

```
cd /opt/schizophrenia/dtifit;
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz
slicesdir -p $template
./diffusion_data/01025/01025-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01033/01033-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01015/01015-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01026/01026-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01011/01011-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01028/01028-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01104/01104-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01035/01035-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01034/01034-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01039/01039-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01029/01029-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01020/01020-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01041/01041-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01018/01018-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01045/01045-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01017/01017-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01073/01073-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01044/01044-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01042/01042-dti_FA.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01019/01019-dti_FA.oriented.flirt.synwtime1_registered.nii
```

- Visualize MD volumes to MNI152 template elastic registration quality

Algorithm 13

```
cd /opt/schizophrenia/dtifit;  
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz  
slicesdir -p $template  
./diffusion_data/01025/01025-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01033/01033-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01015/01015-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01026/01026-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01011/01011-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01028/01028-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01104/01104-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01035/01035-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01034/01034-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01039/01039-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01029/01029-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01020/01020-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01041/01041-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01018/01018-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01045/01045-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01017/01017-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01073/01073-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01044/01044-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01042/01042-dti_MD.oriented.flirt.elast1_registered.nii  
./diffusion_data/01019/01019-dti_MD.oriented.flirt.elast1_registered.nii
```

- Visualize MD to brainmask synwtime registration quality

Algorithm 14

```
cd /opt/schizophrenia/dtifit;
template=/usr/share/fsl/data/standard/MNI152_T1_1mm_brain.nii.gz
slicesdir -p $template
./diffusion_data/01025/01025-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01033/01033-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01015/01015-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01026/01026-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01011/01011-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01028/01028-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01104/01104-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01035/01035-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01034/01034-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01039/01039-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01029/01029-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01020/01020-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01041/01041-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01018/01018-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01045/01045-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01017/01017-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01073/01073-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01044/01044-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01042/01042-dti_MD.oriented.flirt.synwtime1_registered.nii
./diffusion_data/01019/01019-dti_MD.oriented.flirt.synwtime1_registered.nii
```

5 Feature extraction

5.1 Merge the volumes for further analysis

- Merge elastic registered FA volumes (ordered, first 10 controls then 10 patients)

Algorithm 15

```
find -name *FA*elast*nii | grep nc >> FA_elastic_reg_list find
-name *FA*elast*nii | grep sz >> FA_elastic_reg_list fslmerge -t
merged_FA_nc_then_sz_elastic_reg 'cat FA_elastic_reg_list'
```

- Merge elastic registered MD volumes (ordered, first 10 controls then 10 patients)

Algorithm 16

```
find -name *MD*elast*nii | grep nc >> MD_elastic_reg_list find
-name *MD*elast*nii | grep sz >> MD_elastic_reg_list fslmerge -t
merged_MD_nc_then_sz_elastic_reg 'cat MD_elastic_reg_list'
```

- Merge synwtime registered FA volumes (ordered, first 10 controls then 10 patients)

Algorithm 17

```
find -name *FA*synw*nii | grep nc >> FA_synw_reg_list find
-name *FA*synw*nii | grep sz >> FA_synw_reg_list fslmerge -t
merged_FA_nc_then_sz_synw_reg 'cat FA_synw_reg_list'
```

- Merge diffeomorphic registered MD volumes (ordered, first 10 controls then 10 patients)

Algorithm 18

```
find -name *MD*synw*nii | grep nc >> MD_synw_reg_list find
-name *MD*synw*nii | grep sz >> MD_synw_reg_list fslmerge -t
merged_MD_nc_then_sz_synw_reg 'cat MD_synw_reg_list'
```

5.2 Correlation analysis

These steps were performed on Matlab. Patients have label “1” and controls “0”.

- Pearson Correlation

Algorithm 19

```

sched=findResource('scheduler','type','local');
sched.DataLocation = '/local_opt/matlab/local_scheduler_data';
#Select one:
#root_dir='/opt/schizophrenia/dtifit/diffusion_data/'
#root_dir='/opt/work/alexandre/schizophrenia/'
#Select one:
#subjects = load_nii(strcat(root_dir, 'merged_FA_nc_then_sz_elastic_reg.nii'));

#subjects = load_nii(strcat(root_dir, 'merged_MD_nc_then_sz_elastic_reg.nii'));

#subjects = load_nii(strcat(root_dir, 'merged_FA_nc_then_sz_synw_reg.nii'));

#subjects = load_nii(strcat(root_dir, 'merged_MD_nc_then_sz_synw_reg.nii'));
subjects=subjects.img;
[x,y,z,n] = size(subjects);
labels=zeros(n,1);
labels((n/2)+1:n)=1;
if (matlabpool('size') > 0) matlabpool close; end; matlabpool
open 4
for i=1:x;
for j=1:y;
parfor k=1:z;
correlation_values (i,j,k)=corr(reshape(subjects(i,j,k,:), [n
1]),labels);
end;
end;
end;
matlabpool close
#creating feature mask
#tests
imhist(v,1000)
hist(abs(v), 1000)
prctile(abs(v),75)
prctile(abs(v),95)
prctile(abs(v),98)
prctile(abs(v),999)
prctile(abs(v),99.9)
sum(abs(v)>prctile(abs(v),99.9))
sum(abs(v)>prctile(abs(v),99.99))
features=v(abs(v)>prctile(abs(v),99.99));
correlation_values(isnan(correlation_values))=0;
feature_mask=correlation_values(abs(correlation_values)>0.65);
#definitive 99.99 percentile
X=load_nii('/opt/schizophrenia/dtifit/diffusion_data/sz_01018/01018-dti_FA_oriented.flirt.e
load corr_MD_elastic.mat
c=correlation_values(:);
v=abs(c(~isnan(c)));
prc99=prctile(v, 99.99);
correlation_values(isnan(correlation_values))=0;
abs_corr=abs(correlation_values);
feat_mask=abs_corr>prc99;
X.img=feat_mask;
save_nii(X,'feat_mask.nii');
save feat_mask

```

- Blobs in percentile 75

Algorithm 20

```

cd /opt/schizophrenia/feature_extraction
cd correlation_values/
load corr_FA_elastic.mat
c=correlation_values(:);
v=abs(c(~isnan(c)));
prc75=prctile(v, 75);
correlation_values(isnan(correlation_values))=0;
abs_corr=abs(correlation_values);
feat_mask=abs_corr>prc75;
X=load_nii('/opt/schizophrenia/dtifit/diffusion_data/sz_01018/01018-dti_FA_oriented.flirt.el
MNI_mask=load_nii('/opt/schizophrenia/template/MNI152_T1_1mm_brain_mask.nii');
feat_mask=feat_mask.*(MNI_mask.img>0);
X.img=feat_mask;
save_nii(X,'feat_mask.nii');
[L, num_clusters] = bwlabeln (feat_mask);
mean_idx=1;
std_idx =2;
subjects=load_nii('../subjects/merged_FA_nc_then_sz_elastic_reg.nii');
subjects=subjects.img;
for s=1:n;
subj=subjects(:,:,s);
for k=1:num_clusters;
feat_vecs (s,k,mean_idx) = mean(double(subj(L==k)));
feat_vecs (s,k,std_idx) = std(double(subj(L==k)));
end;
end;
#extract features
load feat_mask_FA_elast_99dot99perc_thr.mat
subjects=load_nii('merged_FA_nc_then_sz_elastic_reg.nii');
subjects=subjects.img;
[x y z n]=size(subjects);
for s=1:n;
subj=subjects(:,:,s);
feat_vecs(s,:)=subj(feat_mask==1);
end;
labels=zeros(n,1);
labels((n/2)+1:n)=1;
clear s subj;

```

5.3 Pipelines

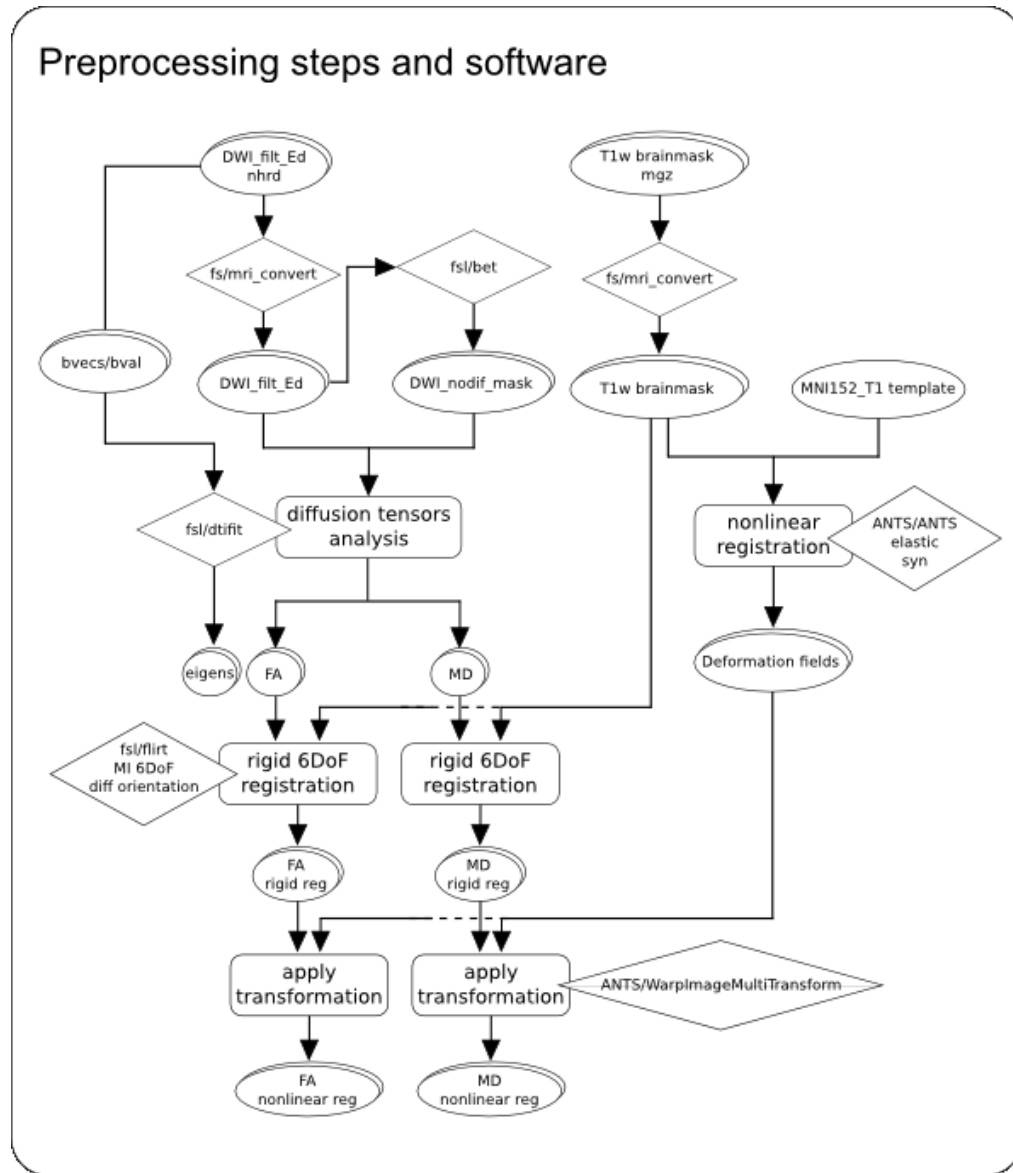


Figure 1: Preprocess pipeline scheme with the software used

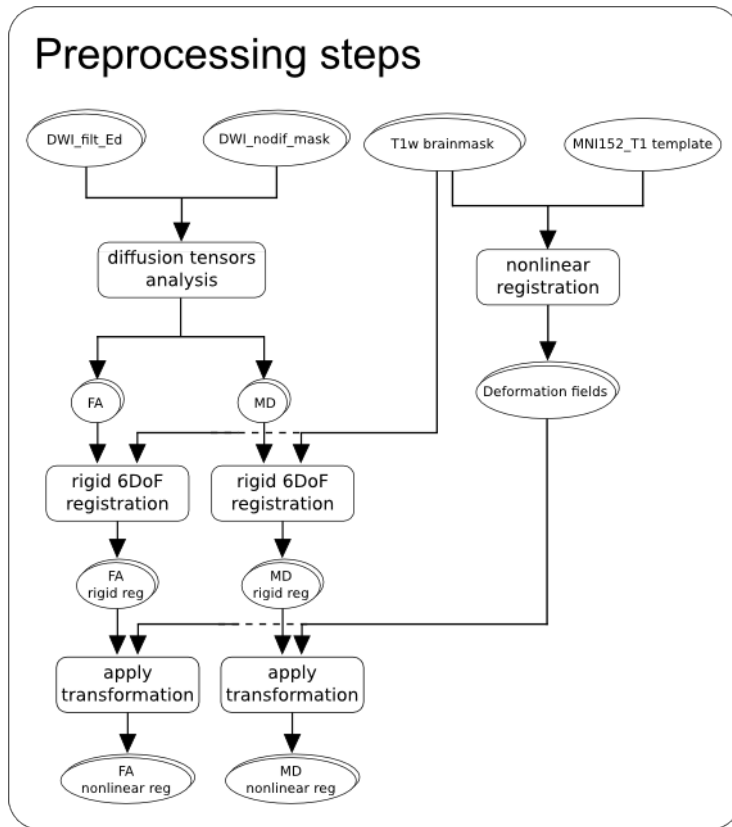


Figure 2: Preprocess pipeline scheme

5.4 Reference URLs

- http://www.insight-journal.org/midas/collection/view/190?path_navigation=17
- <http://www.na-mic.org/>
- http://www.fmrib.ox.ac.uk/fsl/fdt/fdt_dtifit.html
- <http://www.fmrib.ox.ac.uk/fsl/flirt/index.html>
- http://surfer.nmr.mgh.harvard.edu/fswiki/mri_convert
- <http://www.picsl.upenn.edu/ANTS/>
- <http://teem.sourceforge.net/nrrd/>
- <http://www.picsl.upenn.edu/ANTS/morphom.php>