1 Program 3dttest

Program 3dttest performs a t-test on sets of 3D datasets. This test is used to determine, on a voxel by voxel basis, if the two sets of data are significantly different from each other (or, if a single set of data is significantly different from a fixed constant). When two sets of data are to be compared, the user has the option of using a paired t-test.

1.1 Usage

The command line format for program 3dttest depends on whether the program is to be used for a 1-sample or a 2-sample t-test:

Usage 1: 3dttest [options] -set1 datasets . . . -set2 datasets . . . This usage is for comparing the means of 2 sets of datasets (voxel by voxel).

Usage 2: 3dttest [options] -base1 bval -set2 datasets . . . This usage is for comparing the mean of 1 set of datasets against a constant.

1.2 Outputs

A single dataset is created that is the voxel-by-voxel difference of the mean of set2 minus the mean of set1 (or minus 'bval'). The output dataset will be of the intensity+Ttest ('fitt') type. The t-statistic at each voxel can be used as an interactive thresholding tool in *AFNI*.

The *AFNI* 'fitt' type dataset consists of two sub-bricks. In the case of a 2 sample unpaired t-test, the first sub-brick contains the estimated differences $\hat{D} = \bar{Y}_{2.} - \bar{Y}_{1.}$, where $\bar{Y}_{1.}$ and $\bar{Y}_{2.}$ are the average, at each voxel, over the 1st and 2nd datasets, respectively:

$$\begin{aligned} \bar{Y}_{1.} &= \frac{\sum_i Y_{1i}}{n_1} \\ \bar{Y}_{2.} &= \frac{\sum_i Y_{2i}}{n_2} \end{aligned}$$

The second sub-brick contains the corresponding t-statistics.

$$\textit{AFNI} \text{ “fitt” dataset} \quad \left\{ \begin{array}{l} \boxed{\hat{D} = \bar{Y}_{2.} - \bar{Y}_{1.}} \\ \\ \boxed{t^* = \dfrac{\hat{D}}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}} \end{array} \right.$$

Here, s^2 is the estimator of the common variance:

$$s^2 = \frac{\sum_i \left(Y_{1i} - \bar{Y}_1\right)^2 + \sum_i \left(Y_{2i} - \bar{Y}_2\right)^2}{n_1 + n_2 - 2} \; .$$

Under the hypothesis that the mean of set 1 is equal to the mean of set 2, t^* has the t-distribution with $n_1 + n_2 - 2$ degrees of freedom.

1.3 t-Testing Options

-set1 datasets . . .

Specifies the collection of datasets to put into the first set. The mean of set1 will be tested with a 2-sample t-test against the mean of set2. Note that options -set1 and -base1 are mutually exclusive!

-base1 bval

'bval' is a numerical value that the mean of set2 will be tested against with a 1-sample t-test.

When the -base1 option is used, the output dataset looks like:

$$\textit{AFNI}\ \text{“fitt” dataset} \quad \left\{ \begin{array}{l} \boxed{\hat{D} = \frac{1}{n}\sum_i (Y_{2i} - bval)} \\ \\ \boxed{t^* = \dfrac{\hat{D}}{\sqrt{s^2\left(\frac{1}{n}\right)}}} \end{array} \right.$$

where

$$s^2 = \frac{\sum_i \left(Y_{2i} - bval - \hat{D}\right)^2}{n-1}$$

.

-set2 datasets . . .

Specifies the collection of datasets to put into the second set. There must be at least 2 datasets in each of set1 (if used) and set 2.

-paired

Specifies the use of a paired-sample t-test to compare set1 and set2. If this option is used, set1 and set2 must have the same cardinality. Note that a paired t-test is intended for use when the set1 and set2 dataset function values may be pairwise correlated. If they are in fact uncorrelated, this test has less statistical 'power' than the unpaired (default) t-test. This loss of power is the price that is paid for insurance against pairwise correlations.

When the -paired option is used, the output dataset looks like:

$$\textit{AFNI}\ \text{“fitt” dataset} \quad \left\{ \begin{array}{l} \boxed{\hat{D} = \frac{1}{n}\sum_i (Y_{2i} - Y_{1i})} \\ \\ \boxed{t^* = \dfrac{\hat{D}}{\sqrt{s^2\left(\frac{1}{n}\right)}}} \end{array} \right.$$

where

$$s^2 = \frac{\sum_i \left(Y_{2i} - Y_{1i} - \hat{D}\right)^2}{n-1}$$

-unpooled
Specifies that the variance estimates for set1 and set2 be computed separately (not pooled together). This only makes sense if -paired is NOT given. N.B.: If this option is used, the number of degrees of freedom per voxel is a variable, rather than a constant. NOT RECOMMENDED.

-workmen mega
'mega' specifies the number of megabytes of RAM to use for statistical workspace. It defaults to 12. The program will run faster if this is larger (see the NOTES section below).

The -base1 or -set1 command line switches must follow all other options (including those described below) except for the -set2 switch.

1.4 Input Editing Options

The same as are available in 3dmerge.

1.5 Output Options

These options control the output files.

-session dirname
Write output into given directory (default = ./).

-prefix pname
Use 'pname' for the output directory prefix (default = tdif).

-datum type
Use 'type' to store the output difference in the means; 'type' may be short or float. How the default is determined is described in the notes below.

1.6 Notes

- To economize on memory, 3dttest makes multiple passes through the input datasets. On each pass, the entire editing process will be carried out again. For efficiency's sake, it is better to carry out the editing using 3dmerge to produce temporary datasets, and then run 3dttest on them. This applies with particular force if a 'blurring' or 'filtering' option is used. Note also that editing a dataset requires that it be read into memory in its entirety (so that the disk file is not altered). This will increase the memory needs of the program far beyond the level set by the -workmem option.
- The input datasets are specified by their .HEAD files, but their .BRIK files must exist also! This program cannot 'warp-on-demand' from other datasets.

- This program cannot deal with time-dependent or complex-valued datasets! By default, the output dataset function values will be shorts if the first input dataset is byte- or short-valued; otherwise they will be floats. This behavior may be overridden using the -datum option. However, the t-statistic at each voxel will always be stored as a short integer that is 1000 times the actual t-value.

1.7 Examples

Example 1: A researcher wishes to test whether left-handed and right-handed people have significantly different neural activation when performing a particular task. The collection of 3D data for left-handed people, selected at random, is stored in files L001+tlrc through L005+tlrc (both .HEAD and .BRIK files). The collection of 3D data for right-handed people is stored in files R001+tlrc through R007+tlrc (both .HEAD and .BRIK files). A command sequence for performing a t-test on this data is:

```
3dttest -prefix LRttest
-set1 L001+tlrc L002+tlrc L003+tlrc L004+tlrc L005+tlrc \
-set2 R001+tlrc R002+tlrc R003+tlrc R004+tlrc R005+tlrc \
R006+tlrc R007+tlrc
```

Example 1 illustrates the 2-sample, unpaired t-test. The output is stored in the *AFNI* 3D dataset LRttest+tlrc.BRIK (and .HEAD). For Example 1, $n_1 = 5$ and $n_2 = 7$.

Example 2: An investigator is trying to determine if there is a significant difference between two tasks. Each of the 10 randomly selected subjects is asked to perform both tasks, and the resulting set of 20 functional images is used as input to program 3dttest. To "remove" person-to-person variation, a paired t-test is used:

```
3dttest -prefix ttestabc -paired \
-set1 subj01.task1+tlrc subj02.task1+tlrc ... subj10.task1+tlrc \
-set2 subj01.task2+tlrc subj02.task2+tlrc ... subj10.task2+tlrc
```

Example 2 illustrates the paired t-test. In this example, $n = 10$ (the number of pairs of datasets). The output *AFNI* 'fitt' dataset is stored in file ttestabc+tlrc.HEAD (and .BRIK).

Example 3: To determine for which voxels in a dataset the mean is significantly different from the predicted value of 34.5, the following command line is used:

```
3dttest -prefix ttestout -base1 34.5 \
-set2 fim001+tlrc fim002+tlrc fim003+tlrc fim004+tlrc fim005+tlrc \
fim006+tlrc fim007+tlrc fim008+tlrc fim009+tlrc fim010+trlc \
fim011+tlrc fim012+tlrc
```

Example 3 illustrates the -base1 option. The mean of set2 is to be tested against the value *bval* = 34.5. In this example, $n = 12$ (the number of datasets). The output is stored in file ttestout+tlrc.HEAD (and .BRIK).