BCITimeFrequency extracts time-domain or frequency-domain data from BCI2000 Files and produces ASCII output files. It is based on the BCI state model. For the P300 Speller task this model is shown below:
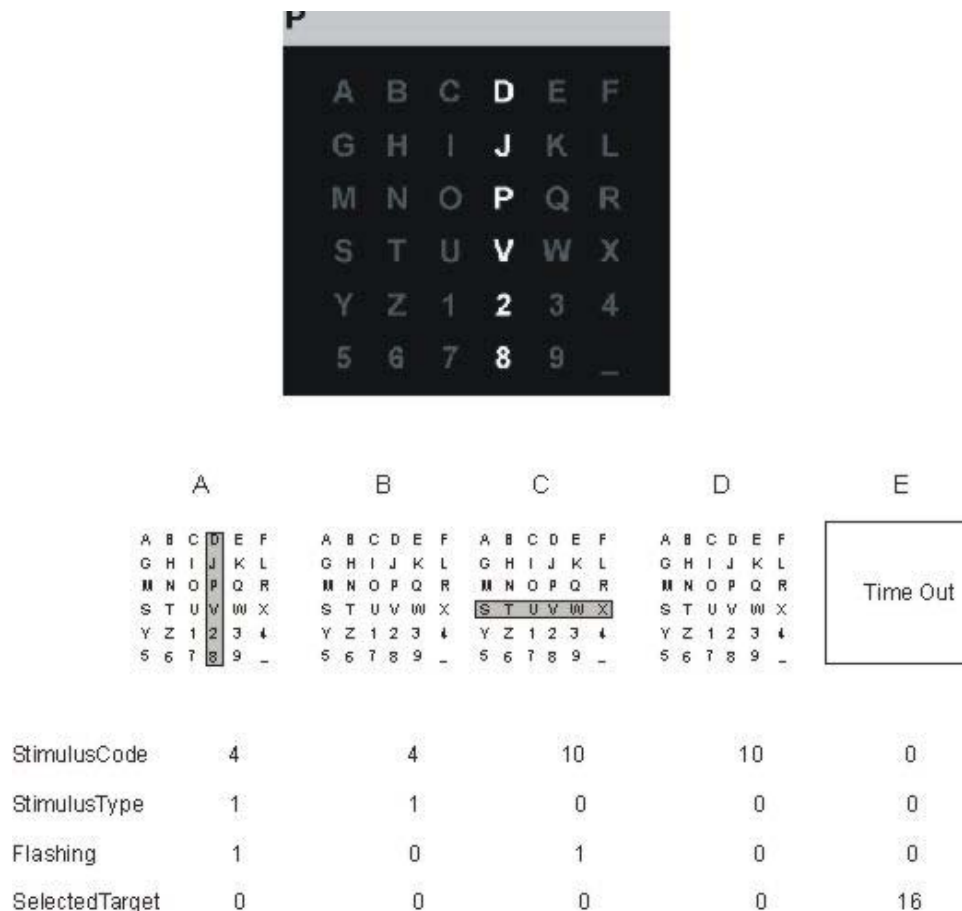
There are 4 state variables illustrated here. StimulusCode refers to the currently active row/column number. StimulusType refers to whether the current row/column is a target or standard. Flashing refers to whether or not the current stimulus is intensified. Finally, SelectedTarget refers to the row/column combination that is selected at the end of one complete scan sequence. In the example above, the letter P is the target (values of stimulus code being 4 (for row #) and 9 (for column #). The example illustrates a successful selection (SelectedTarget being 16).

The state model for the RJB task is illustrated below:

| State | | | | | | | |
|---|---|---|---|---|---|---|
| TargetCode | 0 | 2 | 2 | 2 | 2 | 0 | 3 |
| Baseline | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Feedback | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| IntertrialInterval | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| ResultCode | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Four target rjb task. 1 is the intertrial interval were the screen is blank and baseline data can be collected (optional). In 2 the target is presented but the cursor is absent (no feedback). In 3 the cursor is present and it's vertical movement is controled by the user's EEG. Horizontal cursor movement is under computer control and is at a constant rate. In 4 the cursor approaches a the target and in 5 the target has been hit and trial-outcome feedback is presented. In 6 the screen is blank (intertrial interval again) and in 7 another target is presented.

Note that control of the state of the user screen depends upon the values of several state codes. In the present 4-target example, TargetCode specifies which of the 4 targets is currently present. When it is 0, no targets are present. Feedback specifies the presence of the cursor. Normally we are interested in analyzing data associated with specific targets when the cursor is present.

The BCI time main menu appears below:
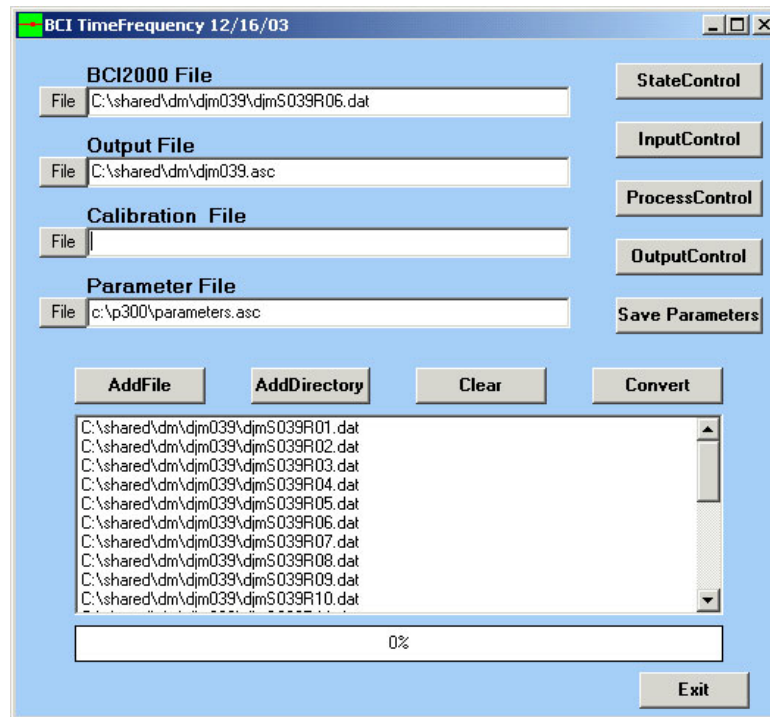
This menu contains 4 controls for entering files, several buttons for process control, and a Memo box for channel selection. If the File button for BCI File is selected the following dialog box appears:
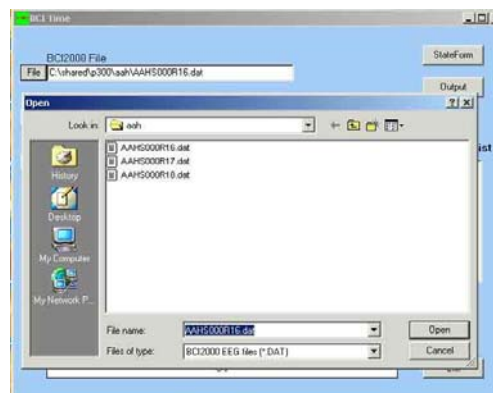
This allows selection of the input directory.

The lower memo box has buttons for "add file" and "add directory". These are used for adding either the individual file or all bci data files contained in the current directory. The list can be added to considerably so that files from several directories can be concatenated.

The OutputFile field is for the name of the ascii output file and the Calibration parameter file is for the calibration file for all channels generated by the Calibgen program.

If the stateForm button on the main menu is clicked (upper right) the following dialog box appears:
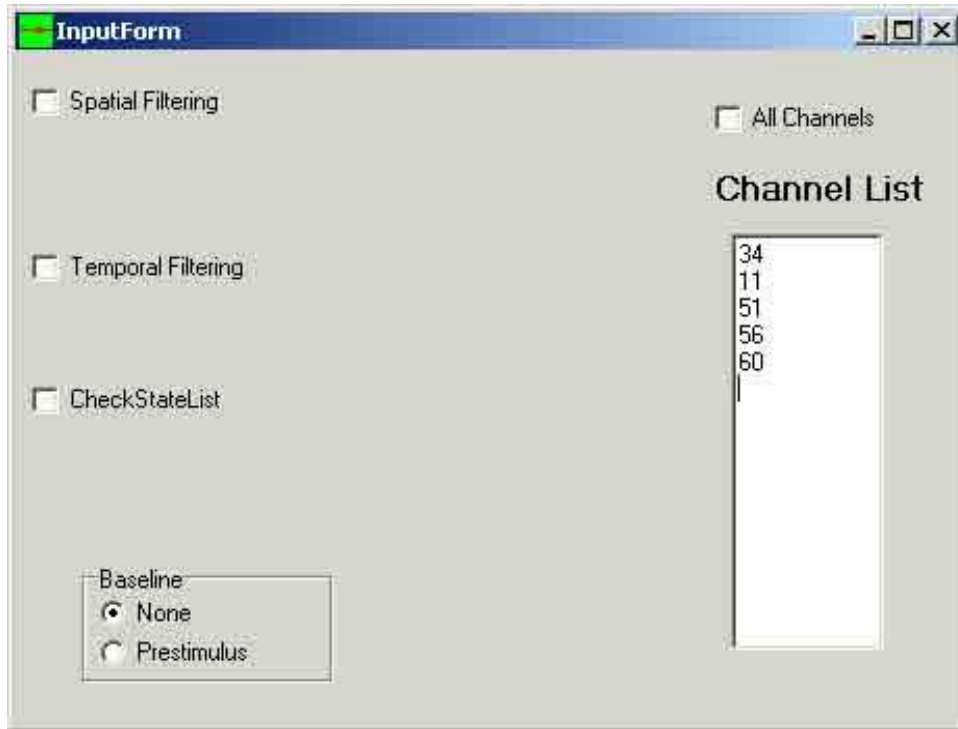
Entries here are based on the BCI state model shown in the beginning. The values shown appear as the default. They show two states (1 and 2) defined as the conjunction of statecode being 1 or 2 and flashing being 1. These groups will then correspond to target and standards. Other configurations could be entered manually or input/saved with the file buttons. The checkbox "Use 2nd State Regressively" causes the 2nd state value in the list to apply at the start of the 1st state value in the list. This is useful for situations where the two do not entirely overlap. The checkbox "Include Next Sample" causes the 1st sample following the selected state values to be included in the output. This is useful when one wants to use some outcome value.

The InputControl button on the main form produces the InputForm shown below.

This allows for selection of a list of channels. If the "All Channels" box is checked the Channel List box will be filled with 64 entries. If this box is then unchecked the list is cleared.

If the Spatial Filtering box is checked a button appears to allow selection of a spatial filter file. This file follows the format of spatial filter files saved by WinLaps.exe.
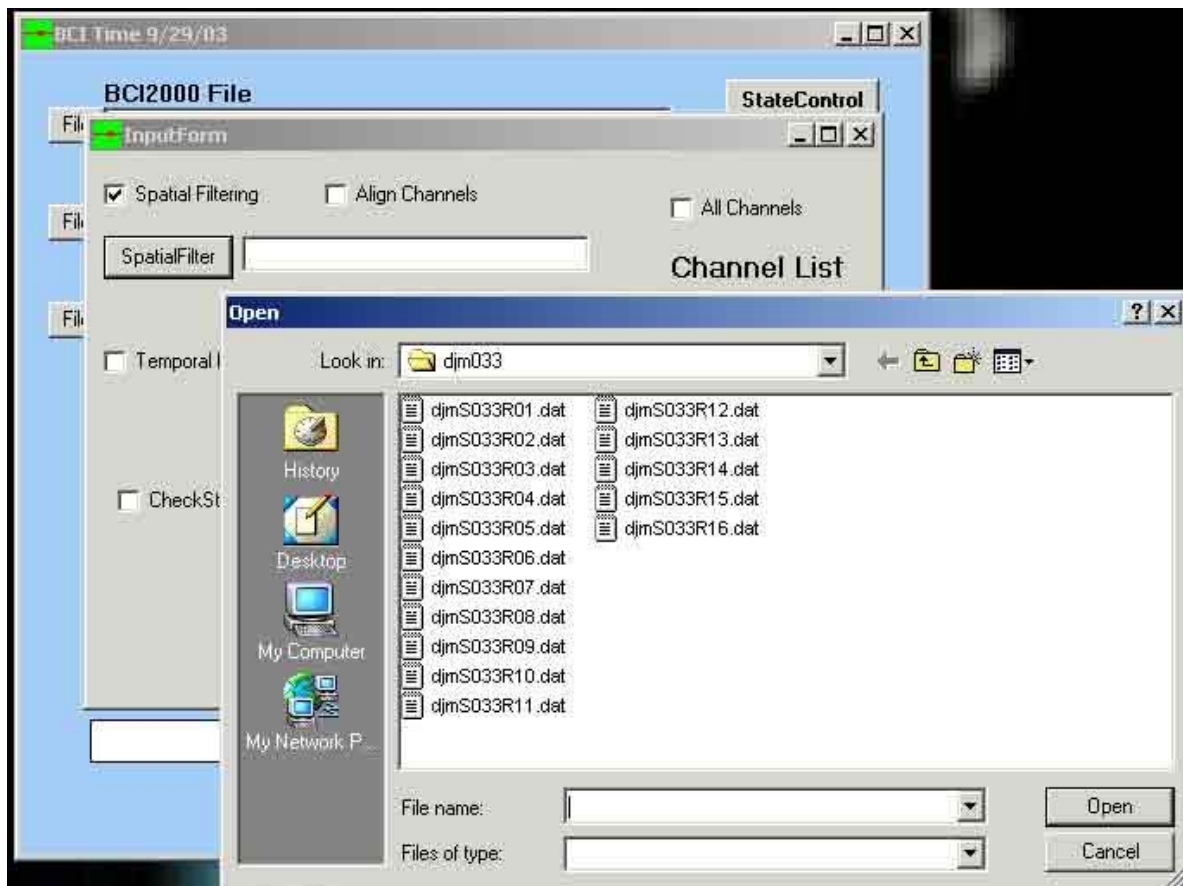
If the Temporal Filtering box is checked an input dialog box appears for inclusion of a file of FIR filter coefficients. This file can be produced by the "MakeFir.exe" program.
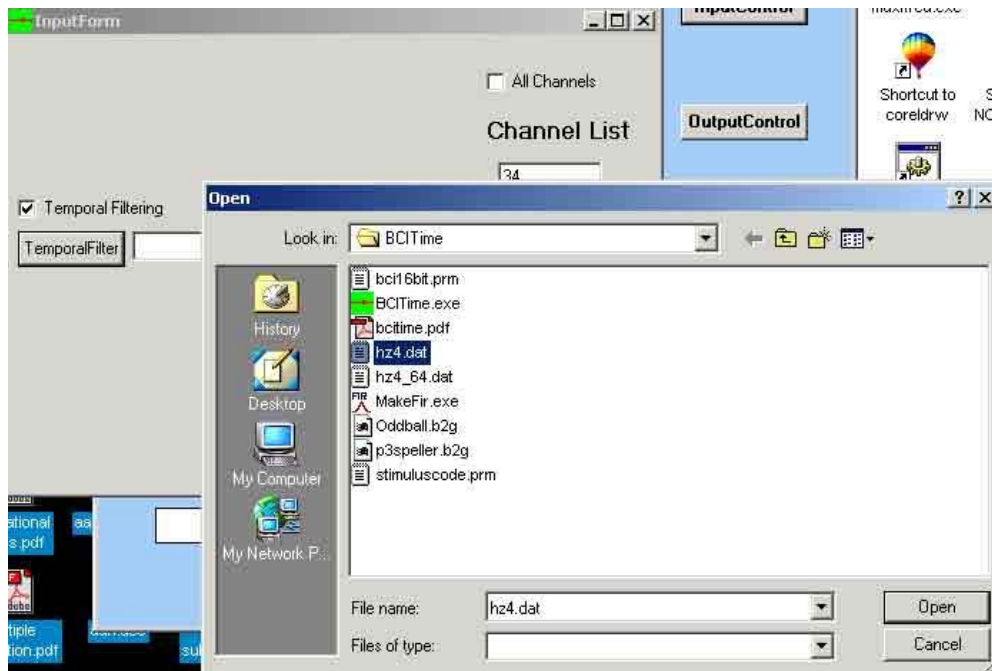
If the CheckStateList box is checked a dialog box appears that allows entry of state names. Values of the entered states will appear in the output in addition to EEG values.
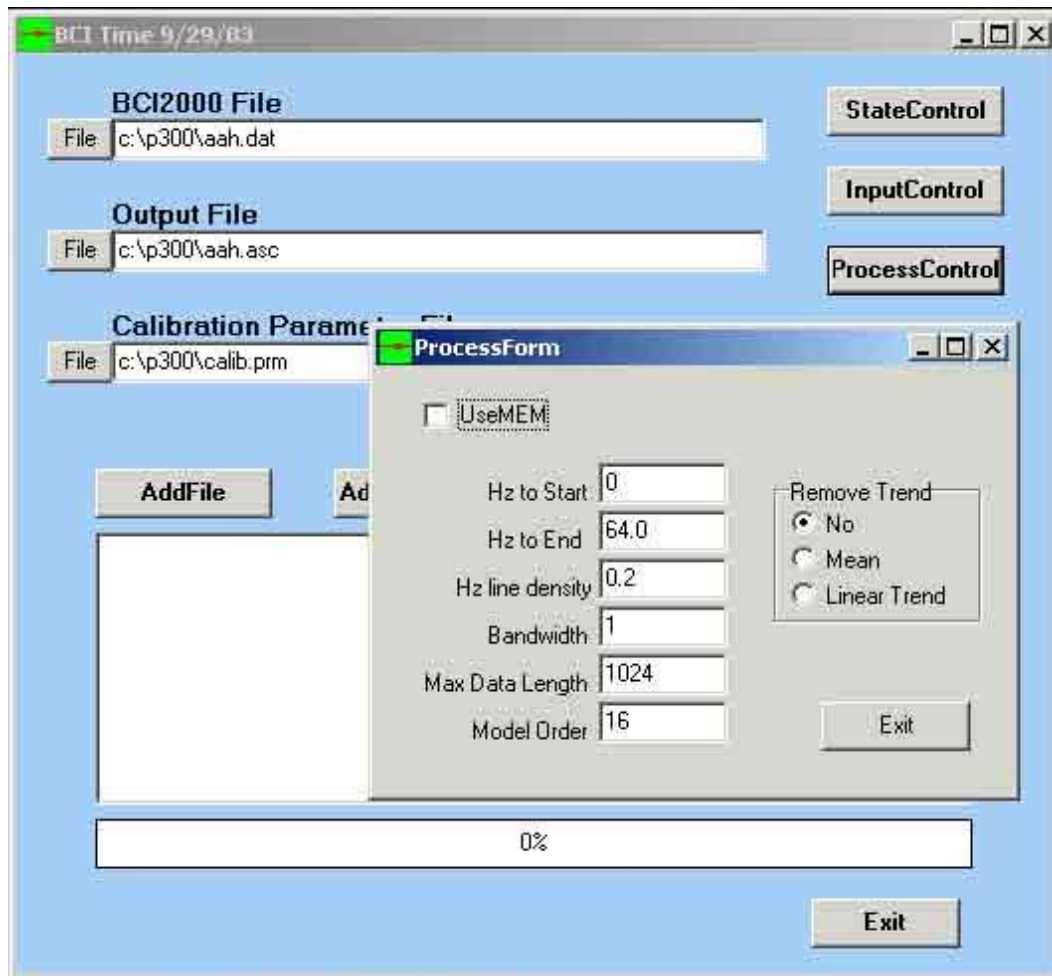
If the ProcessControl button is selected the ProcessForm menu appears that allows entry of parameters for spectral analysis.

If the "UseMEM" box is checked the output will be in terms of the square root of power in spectral bins as determined with the Burg algorithm.

The main form also has an Output button which displays the following dialog box:

In the example, the waveform will start at the beginning of the state code and end 600 msec after the initial onset. Overlapmode is selected. This indicates that values specified above should be retained even if the state values that define grouping are not immediatly present. The box "Compute means when" contains the state name "SelectedTarget". This indicated that means will be computed every time SelectedTarget changes value. Since this happens at the end of a complete series of scans it will produce means for each target letter

The box at the lower left allows for selection of statistics that compare the groups defined in the UseStateForm.

Finaly the checkbox "OutputOrder (XY) has "Topographiesl" selected. This refers to the orientation of the output matrix. This causes the "Time Periods" memo box to appear. Time values for HzPlot compatable topographies are entered here.

If the OutputOrder (XY) selection is TimeXChan an output like that shown below (except that the range of time is truncated to allow a single line to fit on a page):

```
0 1 1   -1.514  -1.237  -1.386  -1.387  -1.207 -1.019 -1.018
0 1 2   -4.854  -4.458  -4.338  -4.285  -4.311 -4.169 -4.115
0 1 3   -4.448  -3.983  -3.621  -3.517  -3.643 -3.641 -3.632
0 2 1    4.610   4.734   4.799   4.795   4.820  3.988  2.565
0 2 2    2.642   2.980   3.142   3.010   2.941  2.103  0.640
0 2 3    4.386   4.742   4.763   4.338   4.098  3.338  2.114
0 1 1    0.513   0.416   0.249  -0.058  -0.291 -0.102  0.216
0 1 2   -1.326  -1.525  -1.668  -1.780  -1.881 -1.696 -1.478
0 1 3   -2.587  -2.496  -2.369  -2.331  -2.461 -2.448 -2.415
0 2 1    3.832   2.970   2.663   3.397   4.241  3.517  2.406
0 2 2    2.079   1.453   1.327   1.996   2.456  1.536  0.657
0 2 3    3.439   3.020   2.898   3.261   3.411  2.451  1.760
0 1 1    0.609   0.036  -0.245  -0.004  -0.064 -0.267  0.175
0 1 2   -1.836  -2.350  -2.566  -2.308  -2.390 -2.678 -2.527
0 1 3   -2.207  -2.293  -2.264  -2.190  -2.359 -2.476 -2.438
0 2 1    3.450   2.738   3.052   4.043   4.643  4.107  3.570
0 2 2    2.090   1.678   2.110   2.937   3.201  2.498  2.116
0 2 3    3.601   3.390   3.724   4.234   4.241  3.453  3.096
```

The first column contains the value of "SelectedTarget" (or whatever was entered into "Compute means when...") just prior to when it changed. The second column contains the grouping variable and the third column contains the channel number (numbered consecutively from the list in the main menu). The successive values of the mean waveform follow.

Other configurations can produce different outputs. For example, if "Compute means when ..." contains the statename "StimulusCode" separate values will be produced for each row or column intensification and the output will appear as below:

```
9 1 1 -11.586 -14.158 -13.987 -10.814 -10.042 -10.256 -10.685
9 1 2 -26.773 -28.784 -27.501 -23.865 -23.565 -23.694 -22.710
9 1 3 -20.919 -22.379 -20.232 -16.454 -16.583 -16.626 -15.553
9 2 1  -0.651   0.507  -4.639   -6.569  -5.797 -4.639   -2.581
9 2 2 -14.925 -13.385 -18.262 -19.801 -19.930 -19.801 -18.518
9 2 3  -3.317  -1.127  -4.991   -6.537  -6.537  -7.696  -7.696
5 1 1  -5.797  -3.481  -2.581   -4.125  -5.025  -5.925  -6.826
5 1 2 -24.036 -22.753 -22.368 -22.239 -20.571 -21.598 -24.549
5 1 3 -19.030 -20.028 -18.418 -15.359 -14.715 -14.812 -14.812
```

Here the first column is the specific row/column, the second is the group code (target/standard) and the third column represents the channel number. Likewise, if "Compute means when" is blank then an overall mean will be generated for all data in all files included in the run.

The StateForm menu can also be used to vary the output.