User's Guide

BSMART Graphical User Interface (GUI)

Contents

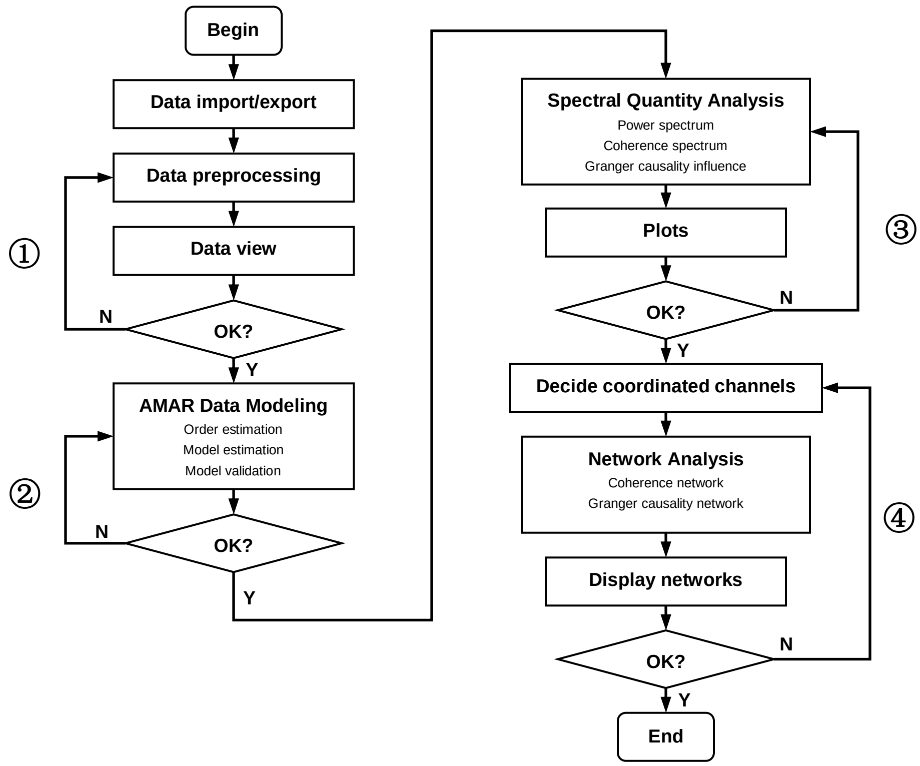
Download BSMART software package

- Browse to BSMART GitHub repository at: https://github.com/jiecui/b-smart
- Download the package of BSMART according to the instructions provided on the website.
- The software is in a compressed ZIP file. Extract the package into a user defined directory. Throughout this manual, the root directory of BSMART is assumed to be at *C:\bsmart*.

Start BSMART

- Start Matlab.
- Add the root directory *C:\bsmart* and all its subdirectories into Matlab Search Path:
    - Type *pathtool* on Matlab command line
    - On the “Set Path” dialog, click “Add with Subfolders…”
    - Navigate to BSMART root directory
    - Click “OK”
    - Click “Close” to close “Set Path” dialog
- On Matlab command line, type *bsmart* to start BSMART

Recommended procedure of using BSMART



① Neural time series importing and preprocessing

② AMAR data modeling and validation

③ Spectral quantity analysis

④ Network analysis

BSMART menus overview

BSMART
Start GUI

- **File** — Data format conversion
- **Tools** — Preprocessing and FFT
- **Model** — Estimation and validation
- **Analysis** — Power, coherence and causality influence
- **Plots** — Signal waveform and network map
- **Help** — Documentation

Model

- **AIC order estimation** — AIC measure as function of model order
- **Fixed window** — Model estimation in a fixed window (bivariate and multivariate)
- **Moving window** — Model estimation in a sliding window (bivariate and multivariate)

- **Whiteness test** — Test assumption of white residuals
- **Stability test** — Test if model generated process is stationary and convergent
- **Consistency test** — Quantify portions of variance in the data captured by the model

Plots

- **Data view** — Multi-trial, multi-channel signals shown in chart view or grid view
- **Power view** — Power density between specified channels (spectrum, time-frequency representation)
- **Coherence view** — Pairwise and multivariate based coherence spectrum
- **Granger causality view** — Causal influence between specified two channels (pairwise analysis)

File

- **Import data** — From binary data to MATLAB format data
- **Export data** — From MATLAB format data to binary data

Tools

- **Preprocessing** — Different methods of normalization and signal average removal
- **FFT** — Power spectrum by FFT

Analysis

- **Power** — Auto power and partial power spectra
- **Coherence** — Ordinary and partial coherence spectra
- **Granger causality** — Pairwise Granger causality influence

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- **Coherence network** — Topographic maps of channels where coherence strength above threshold
- **Granger causality network** — Topographic maps showing direction and strength of causal influence flow

Help

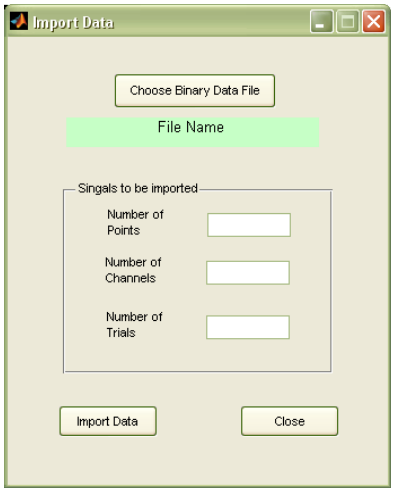
- **How to use BSMART** — HTML/PDF introduction to BSMART suite and concepts
- **Function reference** — M-File descriptions
- **About BSMART** — Version information, credits and history

How to use BSMART

1 To Convert Data

1.1 To Import data

- **File** menu ► **Import Data**



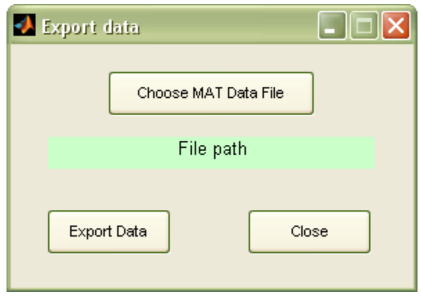
This window allows the user to convert a data file from binary format to MATLAB (.mat) format for use in **BSMART**.A sample data file, called 'test71.bin', is provided for testing in *bsmart\data*. This file contains a data set having 15 channels, 137 trials, 18 points and 200 points/sec as the sampling rate. The following instructions use the *test71* data set as an example.

- Click the **Choose Binary Data File** (.bin) button.
- Navigate to *C:\bsmart\data* in the **Pick a file** window.
- Open 'test71.bin'. The path *C:\bsmart\data\test71.bin* appears in the **File path** pane. Enter "18" in the **Number of Points** pane. Enter "15" in the **Number of Channels** pane. Enter "137" in the **Number of Trials** pane.
- Click the **Import Data** button.
- In the **Save Workspace Variables** window, save the MATLAB format data file as *test71.mat* in *C:\bsmart\test*.
- Click the **Close** button.

Your data file is now in the format that **BSMART** requires. (You may verify that *bsmart\test\test71.mat* exists.) Then you can use **Plot** ► **View data** to visualize the data.

1.2 To Export data

- **File** menu ► **Export Data**

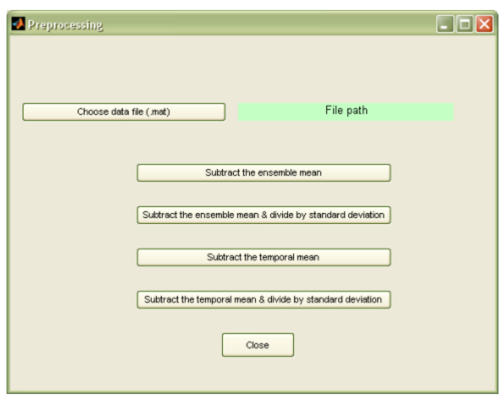


This window allows the user to convert a data file from MATLAB format (.mat) to binary format. This is sometimes desirable to save disk space.

2 To Preprocess Data

2.1 To normalize data

- **Tools** menu ► **Preprocessing**



This window allows the user to preprocess a data set in MATLAB format.The following instructions use the *test71* data set as an example.

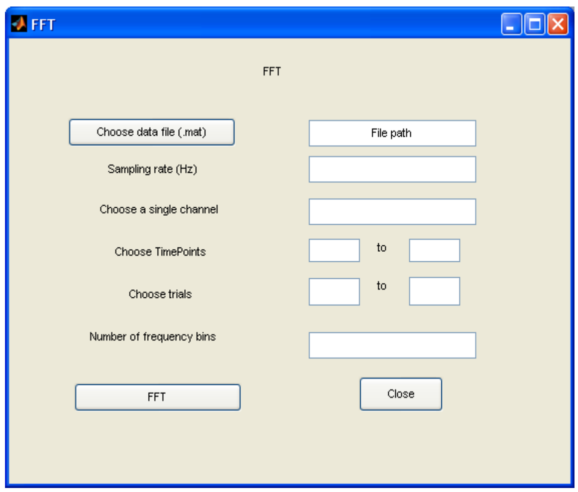
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'test71.mat'. The path *C:\bsmart\test\test71.mat* appears in the **File path** pane.
- Four preprocessing steps are available:
  - Click the **Subtract the ensemble mean** button to subtract the ensemble mean from each trial in the data set.
  - Click the **Subtract the ensemble mean & divide by ensemble standard deviation** button to subtract the ensemble mean and divide by the ensemble standard deviation for each trial in the data set.
  - Click the **Subtract the temporal mean** button to subtract from each trial in the data set its temporal mean.

- Click the **Subtract the temporal mean & divide by standard deviation** button to subtract from each trial in the data set the temporal mean and divide by the temporal standard deviation.

- In the **Save Workspace Variables** window, save the preprocessed MATLAB format data file in *bsmart\test*. You can either save to a new file, e.g. *bsmart\test\test71_pre.mat*, or overwrite the same file, i.e. *bsmart\test\test71.mat*.
- Click the **Close** button. Then you can use **Plot ► View data** to visualize the data.

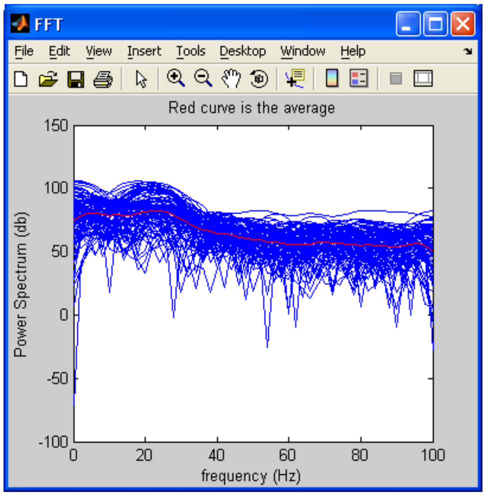
2.2 To do FFT analysis

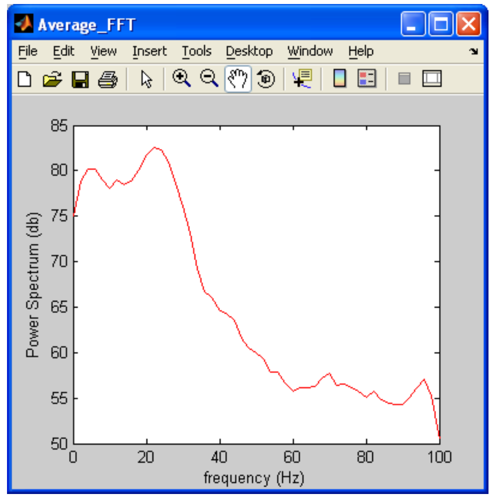
- **Tools** menu ► **FFT**



This window allows the user to do FFT analysis from a data set in MATLAB format. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'test71_pre.mat'. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired channel (e.g. 9) in the **Choose a single channel** pane.
- Enter desired starting position (e.g. 1) and ending position (e.g. 15) in the **Choose TimePoints** pane.
- Enter desired starting trial (e. g. 1) and ending trial (e.g. 100) in the **Choose trial** pane.
- Enter desired number of frequency bins (e.g. 100) in the **number of frequency bins** pane.
- Click the **FFT** button.
- Click the **Close** button.

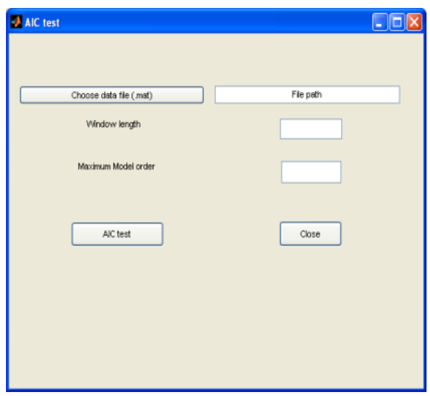




3 To Create Autoregressive Model

3.1 To estimate model order

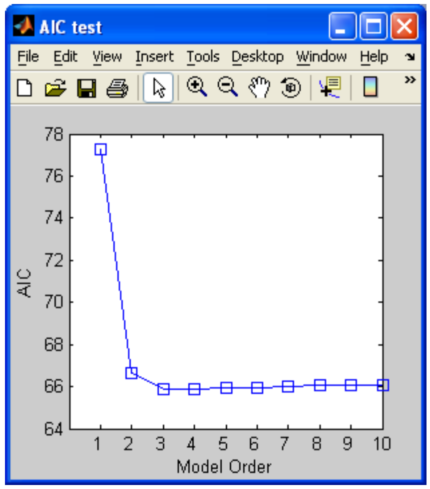
- **Model** menu ► **AIC Model Order Estimation**



This window allows the user to do AIC test from a data set in MATLAB format. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired window (e.g. 12) in the **Window length** pane.
- Enter desired maximum model order (e.g. 10) in the **Maximum model order** pane.
- Click the **AIC test** button.
- In the **Save as** window, save the result as *bsmart\test\AIC*.

- In the **AIC order** window**,** enter desired window (e.g. 2) in the **Window** pane.
- Click the **Plot** button.
- Click the **Close** button.
- Click the **Close** button in **Aic test** window.



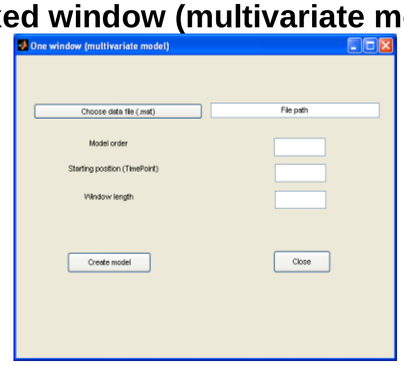
Note: The Akaike Information Criterion (*AIC*) as a function of model order. Using the AIC to determine the model order which makes the AIC reaches the minimum. In the above figure, model order 5 is sufficient since there is very little change in the AIC beyond that value. And the shape of the curve is similar for all other window.

3.2 To create AR model

There are four ways to create AR model: (1) Fixed window (multivariate model) (section 3.2.1), (2) Fixed window (bivariate model) (section 3.2.2), (3) Moving window (multivariate models) (section 3.2.3), and (4) Moving window (bivariate models) (section 3.2.4).

3.2.1 3.1 To Create a Multivariate Autoregressive Model from One Time Window

- **Model** menu ► **Fixed window (multivariate model)**

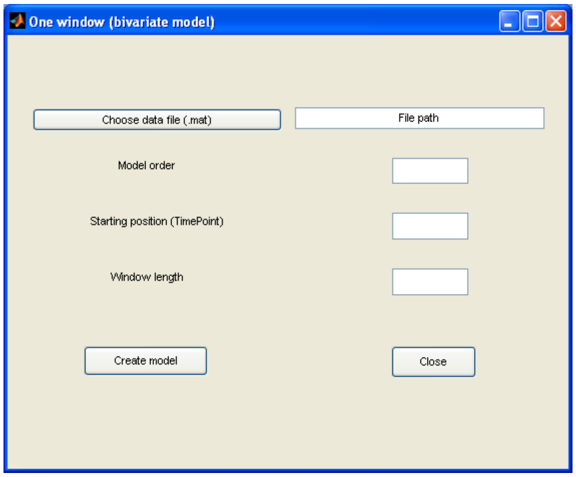


This window allows the user to create a Multivariate (for multiple channels) Autoregressive Model from a data set in MATLAB format for one time window. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'test71_pre.mat'. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired starting position (e.g. 1) in the **Starting position** pane.
- Enter desired window length (e.g. 10) in the **Window length** pane.
- Click the **Create model** button.
- In the **Save as** window, save the autoregressive model coefficients as *bsmart\test\AR_coefficient*, and the noise coefficients as *bsmart\test\AR_noise*.
- Click the **Close** button. Then you can use **Analysis ► Power (multivariate model)**, **Coherence (multivariate model)**, and **Granger causality (multivariate model)** to analyze the data.

3.2.2 To Create a Bivariate Autoregressive Model from One Time Window

- **Model** menu ► **One window (bivariate model)**



This window allows the user to create a Bivariate (for two channels) Autoregressive Model from a data set in MATLAB format for one time window. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.

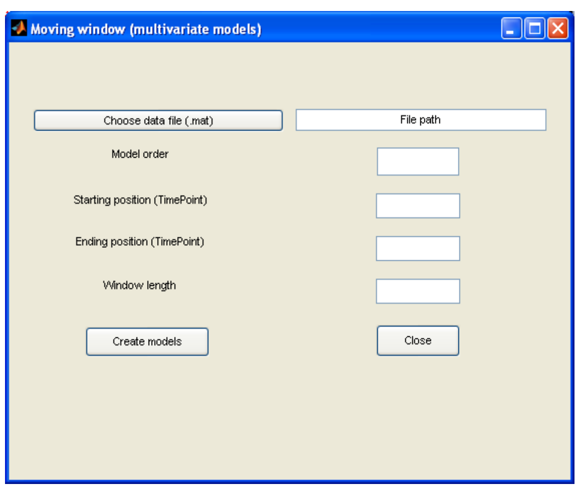
- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired starting position (e.g. 1) in the **Starting position** pane.
- Enter desired window length (e.g. 10) in the **Window length** pane.
- Click the **Create model** button.
- The autoregressive model coefficients will be saved as *AR_C** files, and the noise coefficients as *AR_N** files, in the *C:\bsmart\Onewindow_Coefficient* directory.
- Click the **Close** button.

  Important Note: Please do not delete the ‘*Onewindow_Coefficient*’ directory, or rename the files in this directory. You may delete the files in this directory. Every time you click the **Create model** button, BSMART first deletes all files existing in the ‘*Onewindow_Coefficient*’ directory, and then generates new files there.

  Then you can use **Analysis ► Power (bivariate model)**, **Coherence (bivariate model)**, and **Granger causality (bivariate model)** to analyze the data.

3.2.3 To Create a series of Multivariate Autoregressive Models from a Moving Time Window

- **Tools** menu ► **Moving window (multivariate models)**



This window allows the user to create Multivariate (for multiple channels) Autoregressive Models from a data set in MATLAB format from a moving time window. The following instructions use the *test71_pre* data set as an example.

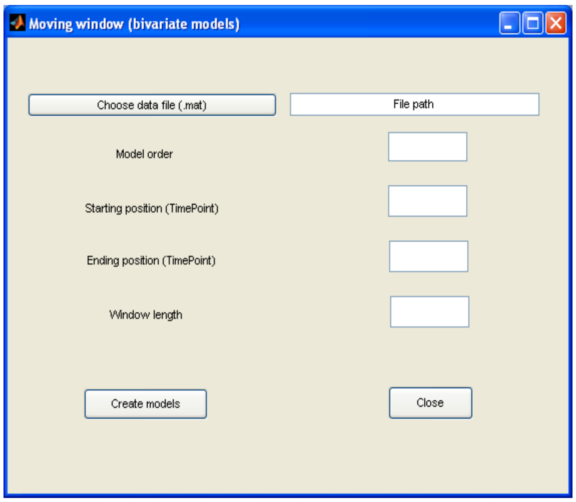
- Click the **Choose data file (.mat)** button.

- Navigate to *bsmart\test* in the **Pick a file** window.
- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired position of the first window (e.g. 1) in the **Starting position (TimePoint)** pane.
- Enter desired position of the last window (e.g. 15) in the **Ending position (TimePoint)** pane.
- Enter desired window length (e.g. 10) in the **Window length** pane.
- Click the **Create models** button.
- In the **Save as** window, save the autoregressive model coefficients as *bsmart\test\AR_coefficientm*, and the noise coefficients as *bsmart\test\AR_noisem*.
- Click the **Close** button.

Then you can use **Analysis ► Power (multivariate model)**, **Coherence (multivariate model)**, and **Granger causality (multivariate model)** to analyze the data.

3.2.4 To Create a series of Bivariate Autoregressive Models from a Moving Time Window

- **Tools** menu ► **Moving window (bivariate models)**



This window allows the user to create Bivariate (for two channels) Autoregressive Models from a data set in MATLAB format from a moving time window. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.

- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired position of the first window (e.g. 1) in the **Starting position (TimePoint)** pane.
- Enter desired position of the last window (e.g. 15) in the **Ending position (TimePoint)** pane.
- Enter desired window length (e.g. 10) in the **Window length** pane.
- Click the **Create models** button.
- The autoregressive model coefficients will be saved as *AR_C** files, and the noise coefficients as *AR_N** files, in the *C:\bsmart\Movingwindow_Coefficient* directory.
- Click the **Close** button.

Important Note: Please do not delete the ‘*Movingwindow_Coefficient*’ directory, or rename the files in this directory. You may delete the files in this directory. Every time you click the **Create models** button, BSMART first deletes all files existing in the ‘*Movingwindow_Coefficient*’ directory, and then generates new files there.

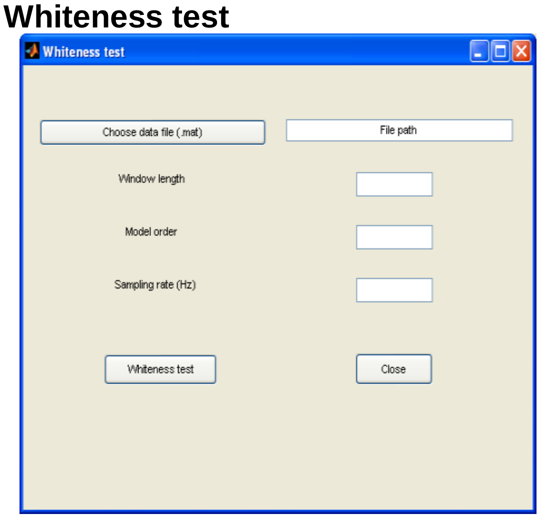
Then you can use **Analysis ►Power (bivariate model)**, **Coherence (bivariate model)**, and **Granger causality (bivariate model)** to analyze the data.

3.3 To test Autoregressive Model

There are three tests (1) Whiteness test (Section 3.3.1), (2) Consistency test (Section 3.3.2) and (3) Stability test (Section 3.3.3) to test Autoregressive model.

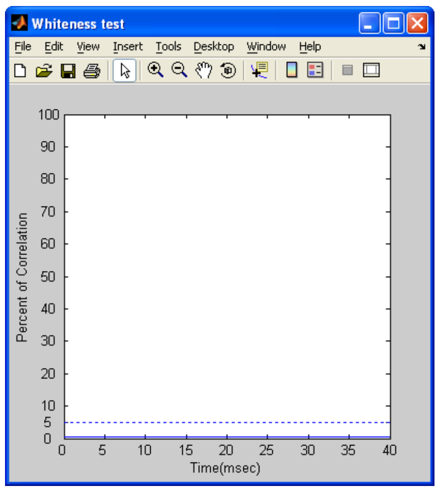
3.3.1 To Do Whiteness Test

- **Test** menu ► **Whiteness test**



This window allows the user to do whiteness test from a data set in MATLAB format. The following instructions use the *test71_pre* data set as an example.

- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired window (e.g. 10) in the **Window length** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Click the **Whiteness test** button.
- In the **Save as** window, save the result as *bsmart\test\resid.out*.
- Click the **Close** button.

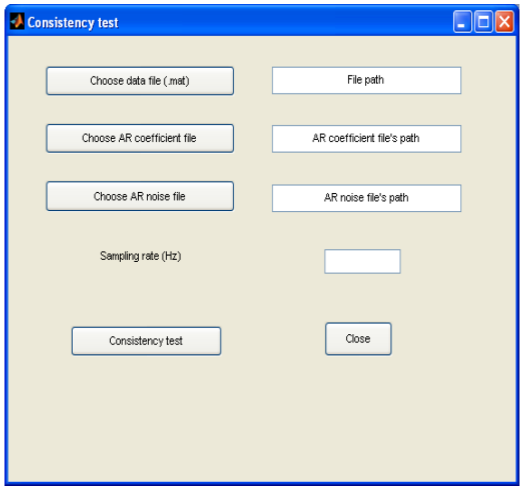


Note: Above figure shows that the percentage of auto- and cross-correlation coefficients that are outside the $[-2/\sqrt{5}, 2/\sqrt{5}]$ is below 5%, which means the residual noise is white and the data set could be represented as AR process.

3.3.2 To Do Consistency Test

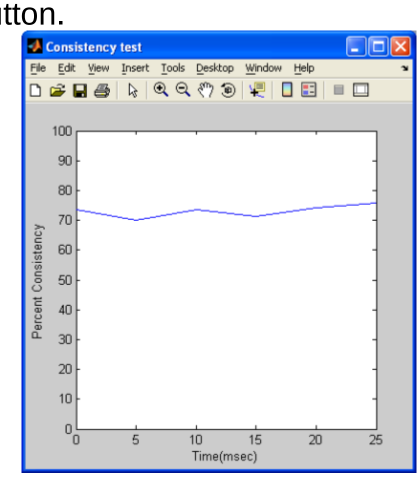
- **Model** menu ► **Consistency test**

This window allows the user to do consistency test from AR coefficient file, AR noise file and the data set in MATLAB format.



The following instructions use the *AR_coeffecientm, AR_noisem and test71_pre* data set as an example.

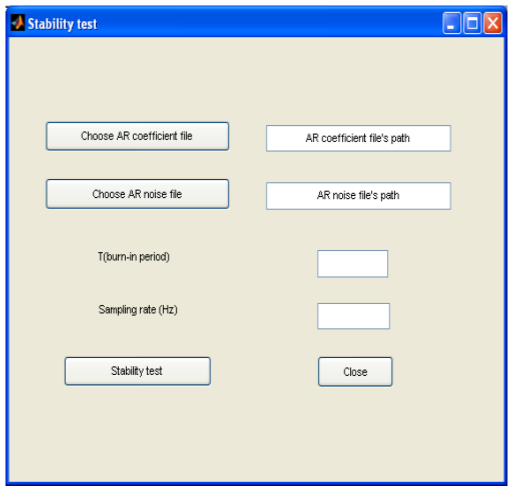
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'test71_pre.mat'. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Click the **Choose AR coefficient file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_coefficientm'. The path *C:\bsmart\test\AR_coefficientm* appears in the AR coefficient file pane.
- Click the **Choose AR noise file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_noisem'. The path *C:\bsmart\test\AR_noisem* appears in the AR noise file pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Click the **Consistency test** button.
- In the **Save Workspace Variables** window, save the result as *bsmart\test\ratio*.
- Click the **Close** button.



Note: Percent consistency as a function of time, indicating the similarity between the correlation structure of the real data and Autoregressive Model simulated data. In the above figure, this measure is near 80% which means a high consistency.

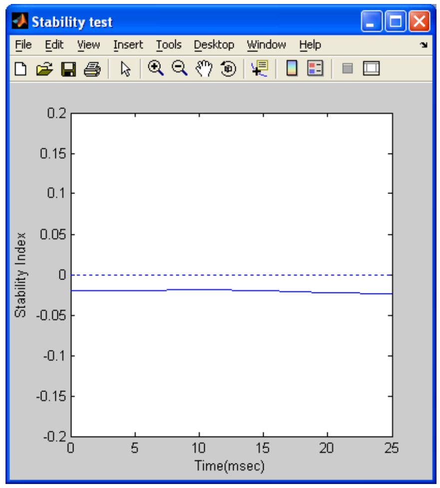
3.3.3 To Do Stability Test

- **Model** menu ► **Stability test**



This window allows the user to do stability test from AR coefficient file and AR noise file. The following instructions use the *AR_coeffecientm and AR_noisem and test71_pre* data set as an example.

- Click the **Choose AR coefficient file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_coefficientm'. The path *C:\bsmart\test\AR_coefficientm* appears in the data file pane.
- Click the **Choose AR noise file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_noisem'. The path *C:\bsmart\test\AR_noisem* appears in the data file pane.
- Enter desired burn-in period (e. g. 100) in **T (burn-in period)** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Click the **Stability test** button.
- In the **Save Workspace Variables** window, save the result as *bsmart\test\le*.
- Click the **Close** button.

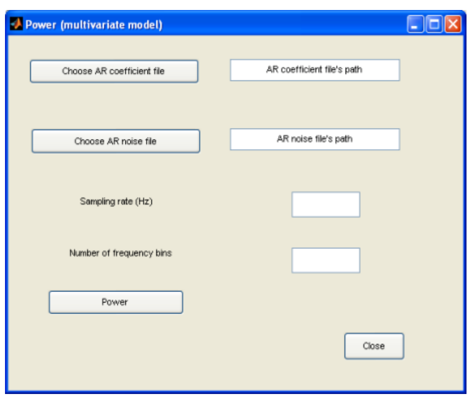


Note: The Stability Index as a function of time. In the above figure, all the values of Stability Index are negative, indicating that all of the fitted models are stable.

4 To Compute Spectral Quantities

4.1 To compute spectral power from multivariate AR models

- **Analysis** menu ► **Power (multivariate model)**



This window allows the user to compute spectral power from Multivariate Autoregressive Models from one or a series of time windows by specifying the AR coefficient and AR noise files. The following instructions use the *AR_coefficient* and *AR_noise* files generated on Page 4 to compute the spectral power from a Multivariate Autoregressive Model in one window.

- Click the **Choose AR coefficient file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_coefficient'. The path *C:\bsmart\test\AR_coefficient* appears in the AR coefficient file pane.

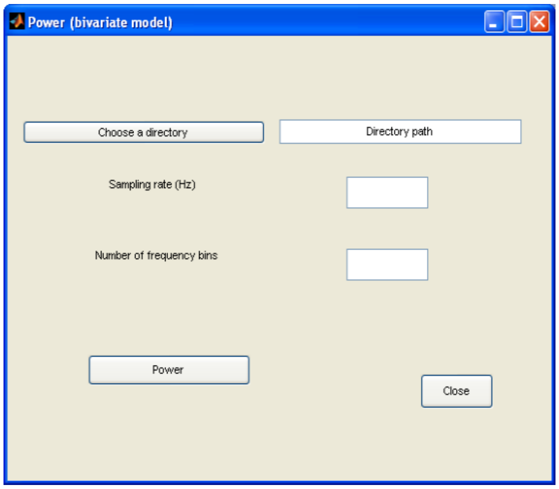
- Click the **Choose AR noise file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'AR_noise'. The path *C:\bsmart\test\AR_noise* appears in the AR noise file pane.
- Enter desired sampling rate (e.g. 200) in the **Sampling rate (Hz)** pane.
- Enter desired number of frequency bins (e.g. 100) in the **Number of frequency bins** pane.
- Click the **Power** button.
- In the **Save Workspace Variables** window, save the spectral power as *bsmart\test\power_one*.
- Click the **Close** button.

Note: You may also use *AR_coefficientm* and *AR_noisem* files generated on Page 6 as an example to compute the spectral power from a series of Multivariate Autoregressive Models in the **Power (multivariate model)** window. Using the same parameter as above, the result is saved as *bsmart\test\power_mov.*

Then you can use **Plot ► Power view** to visualize data.

4.2 To compute spectral power from bivariate AR models

- **Analysis** menu ► **Power (bivariate model)**



This window allows the user to compute spectral power from Bivariate Autoregressive Models from one or a series of time windows by specifying the AR coefficient and AR noise directory. The following instructions use the files in the *C:\bsmart\Onewindow_Coefficient* directory generated on Page 5 to compute the spectral power from a Bivariate Autoregressive Model in one window.

- Click the **Choose a directory** button.
- Navigate to *C:\mar\bsmart* in the **Browse for Folder** window.

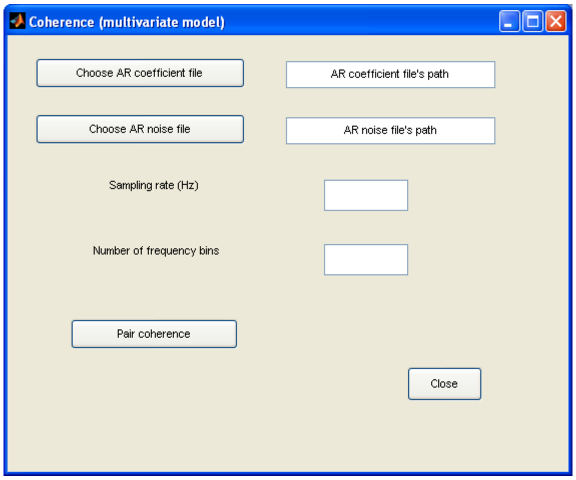
- Select the *C:\mar\bsmart\Onewindow_Coefficient* directory. Click the **OK** button.
- The path *C:\bsmart\test\Onewindow_Coefficient* appears in the **Directory path** pane.
- Enter desired sampling rate (e.g. 200) in the **Sampling rate (Hz)** pane.
- Enter desired number of frequency bins (e.g. 100) in the **Number of frequency bins** pane.
- Click the **Power** button.
- In the **Save Workspace Variables** window, save the spectral power as *bsmart\test\power_one_bi*.
- Click the **Close** button.

Note: You *may* also use directory path *C:\bsmart\Movingwindow_Coefficient* mentioned in Page 7 as an example to compute the spectral power from a series of Bivariate Autoregressive Models in **Power (bivariate model)** window. Using the same parameter as above, the result is saved as *bsmart\test\power_mov_bi.*

Then you can *use* **Plot ►Power view** to visualize data.

4.3 To compute spectral coherence from multivariate AR model

- **Analysis** menu ► **Coherence (multivariate model)**



This window allows the *user* to compute spectral coherence from one or a series of Multivariate Autoregressive Models by specifying the AR coefficient and AR noise files. The following instructions use the *AR_coefficient* and *AR_noise* generated in Page 4 as an example to compute the spectral coherence from a Multivariate Autoregressive Model.

- Click the **Choose AR coefficient file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.

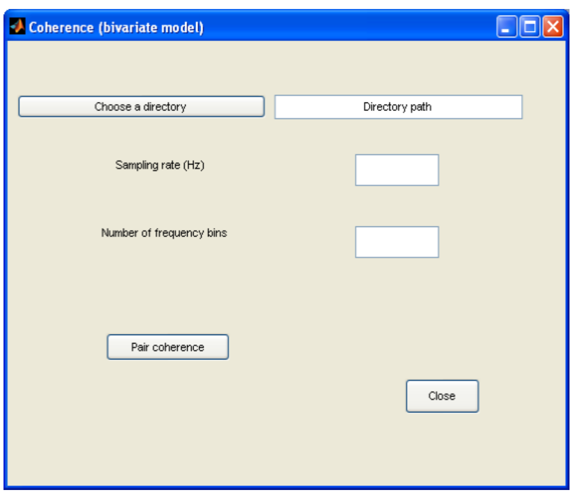
- Open ‘AR_coefficient’. The path *C:\bsmart\test\AR_coefficient* appears in the AR coefficient file pane.
- Click the **Choose AR noise file** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open ‘AR_noise’. The path *C:\bsmart\test\AR_noise* appears in the AR noise file pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired number of frequency bins (e.g.100) in the **Number of frequency bins** pane.
- Click the **Pair coherence** button.
- In the **Save Workspace Variables** window, save the coherence as *bsmart\test\ coherence_one*.
- Click the **Close** button.

Note: You can also use *AR_coefficientm* and *AR_noisem* generated in Page 6 as an example to compute the spectral coherence from a series of Multivariate Autoregressive Models in **Coherence (multivariate model)** window. Using the same parameter as above, the result is saved as *bsmart\test\coherence_mov.*

Then you can use **Plot ►Coherence view** to visualize data.

4.4 To compute spectral coherence from bivariate AR model

- **Analysis** menu ► **Coherence (bivariate model)**



This window allows the user to compute spectral coherence from one or a series of Bivariate Autoregressive Models by specifying the AR coefficient and AR noise directory. The following instructions use the *C:\bsmart\Onewindow_Coefficient* generated in Page 5 as an example to compute the spectral coherence from a Bivariate Autoregressive Model.

- Click the **Choose a directory** button.

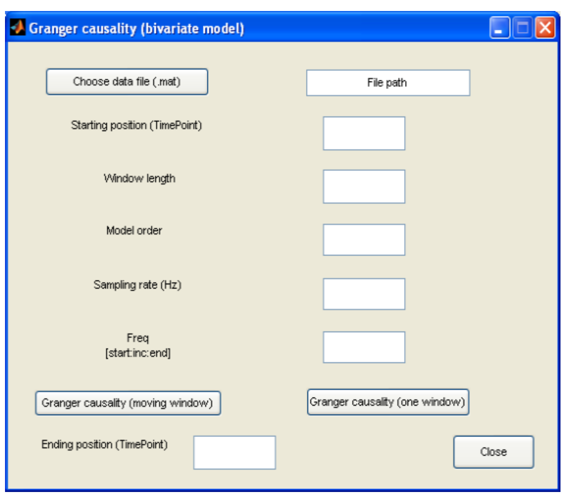
- Navigate to *C:\mar\bsmart* in the **Browse for Folder** window.
- Select the *C:\mar\bsmart\Onewindow_Coefficient* directory. Click the **OK** button.
- The path *C:\bsmart\test\Onewindow_Coefficient* appears in the **Directory path** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired number of frequency bins (e.g.100) in the **number of frequency bins** pane.
- Click the **Pair coherence** button.
- In the **Save Workspace Variables** window, save the spectral power as *bsmart\test\coherence_one_bi*.
- Click the **Close** button.

Note: You can also use directory path *C:\bsmart\Movingwindow_Coefficient* mentioned in Page 7 as an example to compute the spectral coherence from a series of Bivariate Autoregressive Models in **Coherence (bivariate model)** window. Using the same parameter as above, the result is saved as *bsmart\test\coherence_mov_bi.*

Then you can use **Plot** ► Coherence **view** to visualize data.

4.5 To compute Granger causality using Bivariate AR model

- **Analysis** menu ► **Granger causality (bivariate model)**



This window allows the user to compute granger causality from a data set in MATLAB format using Bivariate Autoregressive Model method. The following instructions use the *test71_pre* data set as an example.

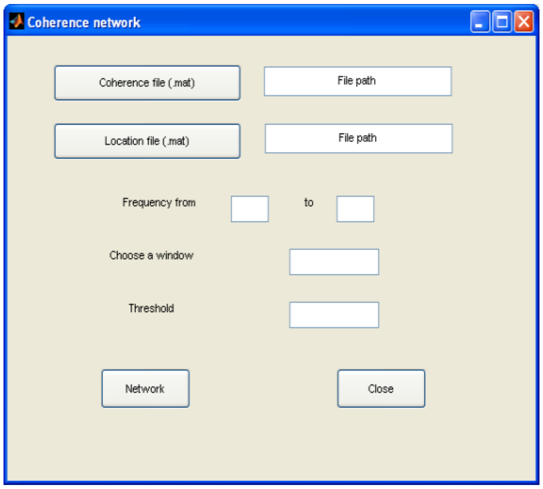
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.

- Open ‘test71_pre.mat’. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Enter desired starting position (e.g. 1) in the **Starting position** pane.
- Enter desired window (e.g. 10) in the **Window length** pane.
- Enter desired model order (e.g. 5) in the **Model order** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired frequency range (e.g. 1:100) in the **Freq** pane.
- Click the **Granger causality (one window)** button.
- In the **Save Workspace Variables** window, save the granger causality as *bsmart\test\Fx2y_one_bi*, and *bsmart\test\Fy2x_one_bi*.
- Enter desired ending position (e.g. 15) in the **Ending position** pane.
- Click the **Granger causality (moving window)** button.
- In the **Save Workspace Variables** window, save the granger causality as *bsmart\test\Fxy_mov_bi*, and *bsmart\test\Fyx_mov_bi*.
- Click the **Close** button.

Then you can use **Plot ► Granger causality view** to visualize data.

4.6 To do coherence network analysis

- **Analysis** menu ► **Coherence network**

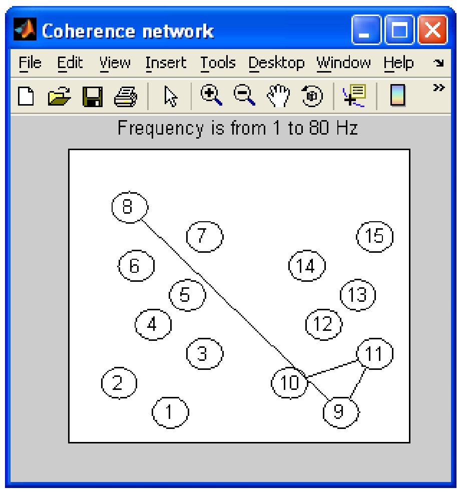


This window allows the user to view coherence network from the data sets in MATLAB format. The following instructions use the *coherence_mov, location* data sets as an example.

- Click the **Coherence file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open ‘coherence_mov.mat’. The path *C:\bsmart\test\coherence_mov.mat* appears in the **File path** pane.
- Click the **Location file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.

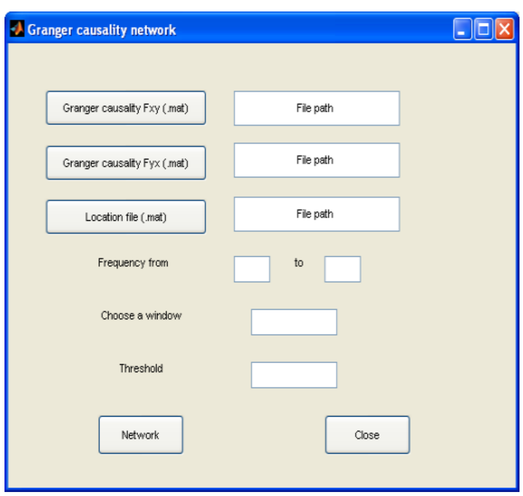
- Open 'location.mat'. The path *C:\bsmart\test\location.mat* appears in the **File path** pane.
- Enter desired starting frequency (e.g. 1) and ending frequency (e.g. 80) in the **Frequency** pane.
- Enter desired time (e.g. 2) in the **Choose a window** pane.
- Enter desired threshold (e. g. 0.25) in the **Threshold** Pane.
- Click **Network** button in the bottom.
- Click **Close** button.

Note: Section 4.8 talks about more information about location file.



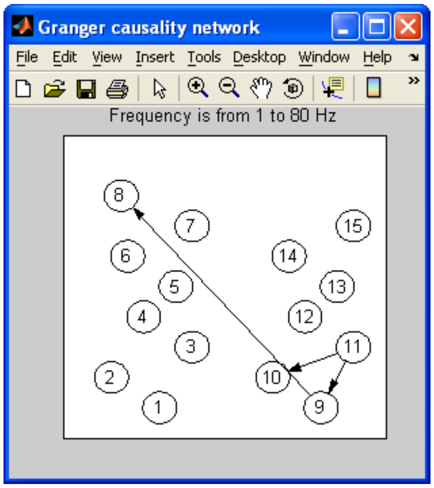
4.7 To do Granger causality network analysis

- **Analysis** menu ► **Granger causality network**



This window allows the user to view granger causality network from the data sets in MATLAB format. The following instructions use the *Fxy_mov, Fyx_mov, location* data sets as an example.

- Click the **Granger causality Fxy (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'Fxy_mov.mat'. The path *C:\bsmart\test\Fxy_mov.mat* appears in the **File path** pane.
- Click the **Granger causality Fyx (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'Fyx_mov.mat'. The path *C:\bsmart\test\Fyx_mov.mat* appears in the **File path** pane.
- Click the **Location file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'location.mat'. The path *C:\bsmart\test\location.mat* appears in the data file pane.
- Enter desired starting frequency (e.g. 1) and ending frequency (e.g. 80) in the **Frequency** pane.
- Enter desired time (e.g. 2) in the **Choose a window** pane.
- Enter desired threshold (e. g. 0.16) in the **Threshold** Pane.
- Click **Network** button in the bottom. (Figure shows in Page 22).
- Click **Close** button.



For, coherence network and granger causality network, refer to Graph Layout Generation Package (Ver 1.0, 08-May-2000) by Ali Taylan Cemgil (cemgil@mbfys.kun.nl)

4.8 How to write the location file

The location file is a matrix in MATLAB format. The matrix has two rows. The first row is the X coordinate and the second row is the Y coordinate on the unit square. Every column which has one X coordinate and one Y coordinate indicates the location of one site.

In the location file which can be found in *C:\bsmart\test*

```
Columns 1 through 8
  0.3000    0.1500    0.4000    0.2500    0.3500    0.2000    0.4000    0.1800
  0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000    0.8000

Columns 9 through 15

  0.8000    0.6500    0.9000    0.7500    0.8500    0.7000    0.9000
  0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000
```

It has 15 columns which mean locations for 15 sites. If you would like to change the location file, do the following steps. In MATLAB command window, type “location=[x coordinates; y coordinates]”. For example, in order to get the above location file, type below in the command line:

```
location = [0.3000    0.1500    0.4000    0.2500    0.3500    0.2000    0.4000    0.1800 0.8000
0.6500    0.9000    0.7500    0.8500    0.7000    0.9000; 0.1000    0.2000    0.3000    0.4000
0.5000    0.6000    0.7000    0.8000  0.1000    0.2000    0.3000    0.4000    0.5000    0.6000
0.7000]
```

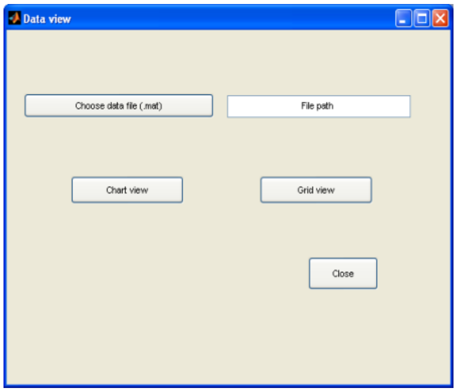
Save “location” in a file at C:\bsmart.
In MATLAB command window, type “save location location”.

5 To Plot Data

This section explains the Data view (Section 5.1), Coherence view (Section 5.2), power view (Section 5.3) and granger causality view (Section 5.4).

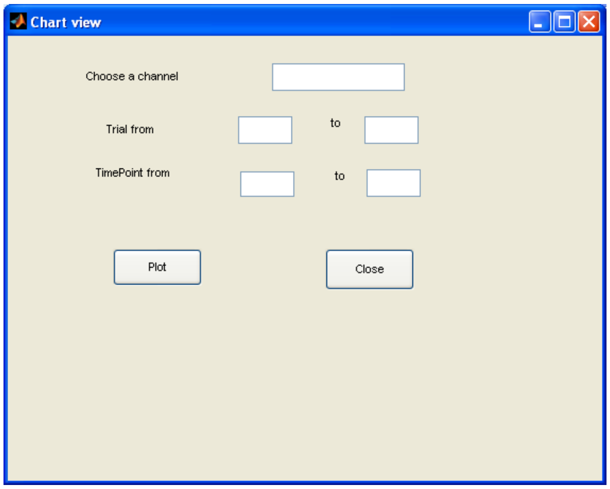
5.1 To View Data

- **Plot** menu ► **Data view**

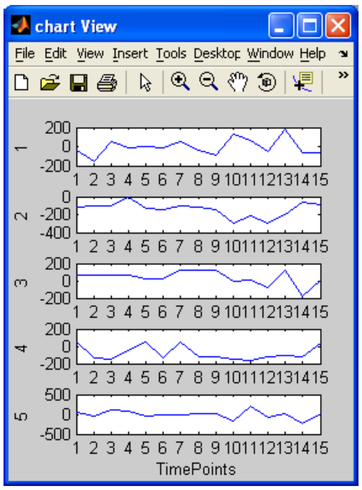


This window allows the user to view data in two ways from a data set in MATLAB format. The following instructions use the *test71_pre* data set as an example.

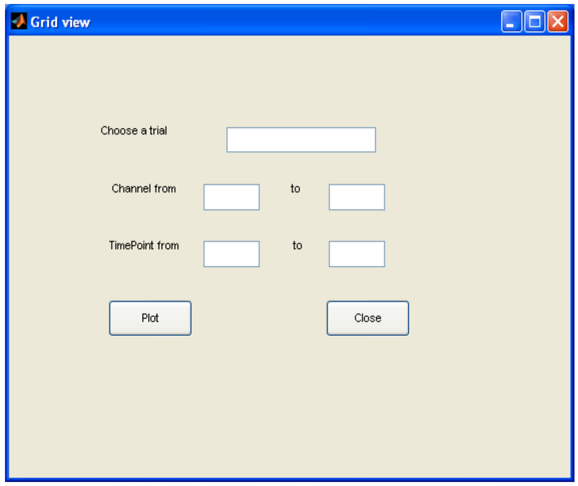
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'test71_pre.mat'. The path *C:\bsmart\test\test71_pre.mat* appears in the **File path** pane.
- Click the **Chart view** button.



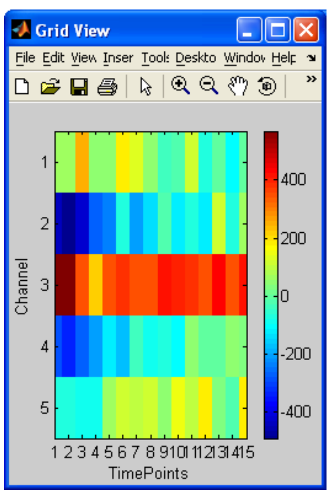
- Enter desired channel (e.g. 8) in the **Choose a channel** pane.
- Enter desired starting trial (e.g. 1) and ending trial (e.g. 5) in the **Trial** pane.
- Enter desired starting point (e.g. 1) and ending point (e.g. 15) in the **TimePoint** pane.
- Click **Plot** button.
- Click the **Close** button.

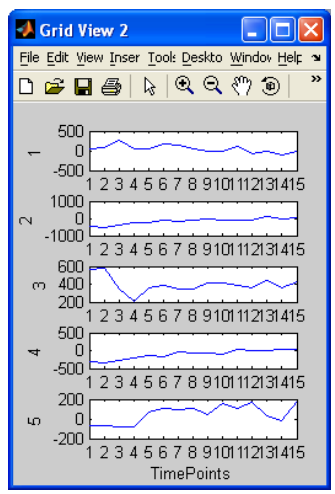


- Click the **Grid view** button.



- Enter desired trial (e.g. 8) in the **Choose a trial** pane.
- Enter desired starting channel (e.g. 1) and ending channel (e.g. 5) in the **Channel** pane.
- Enter desired starting point (e.g. 1) and ending point (e.g. 15) in the **TimePoint** pane.
- Click **Plot** button.
- Click **Close** button.
- Click **Close** button in the **View data** window.

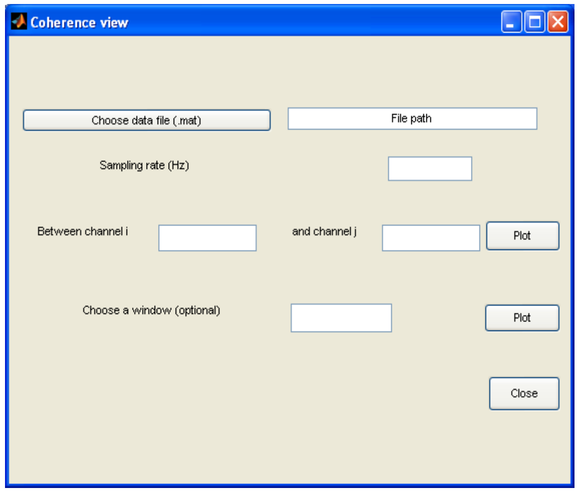




5.2 To View Coherence

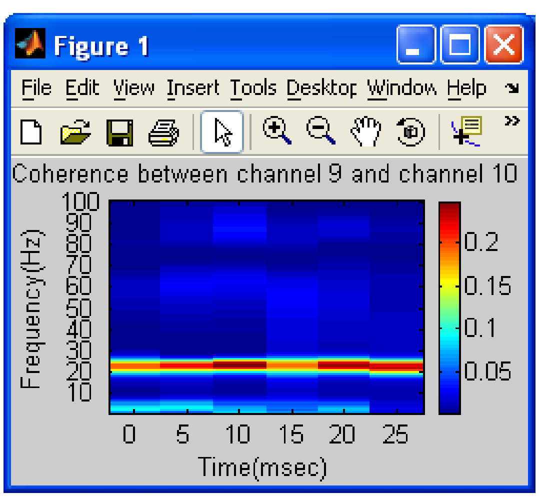
- **Plot** menu ► **Coherence view**

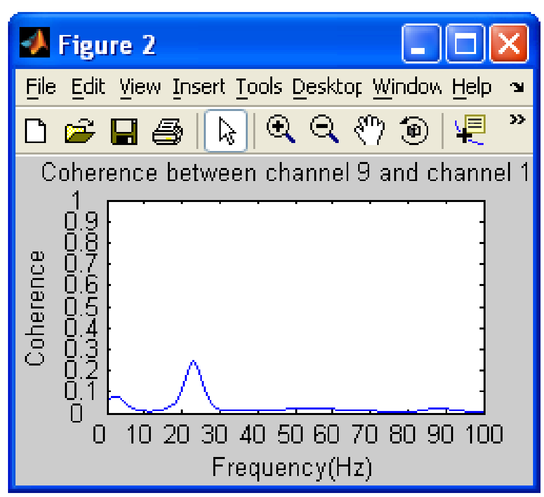
This window allows the user to view coherence from a data set in MATLAB format.



The following instructions use the *coherence_mov* data set as an example.

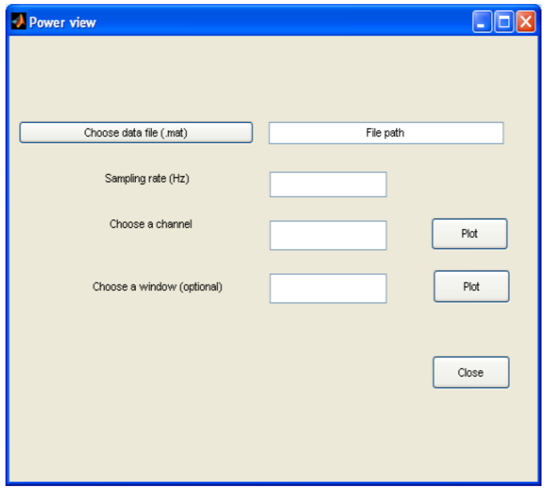
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'coherence_mov.mat'. The path *C:\bsmart\test\coherence_mov.mat* appears in the **File path** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired channel i (e.g. 9) in the **channel i** pane and channel j (e.g. 10) in the **Channel j** pane.
- Click **Plot** button on the right side. (Figure1)
- Enter time (e.g. 5) in the **Choose a window** pane.
- Click **Plot** button on the right side. (Figure 2)
- Click **Close** button.





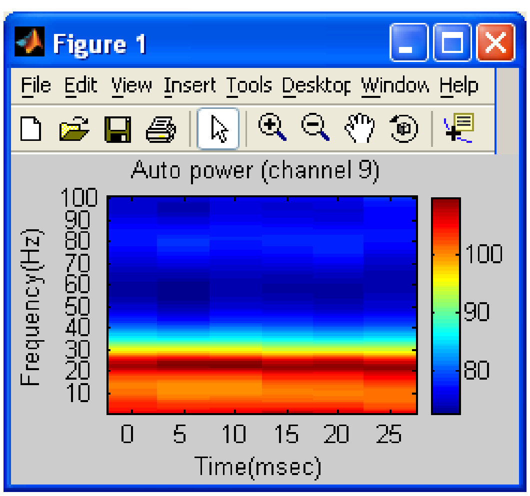
5.3 To View Power

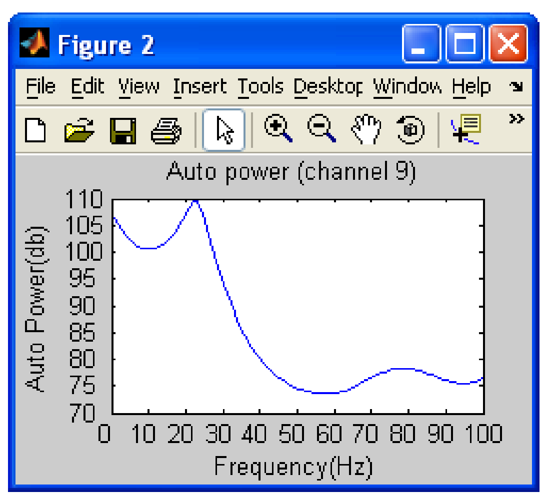
- **Plot** menu ► **Power view**



This window allows the user to view power from a data set in MATLAB format. The following instructions use the *power_mov* data set as an example.

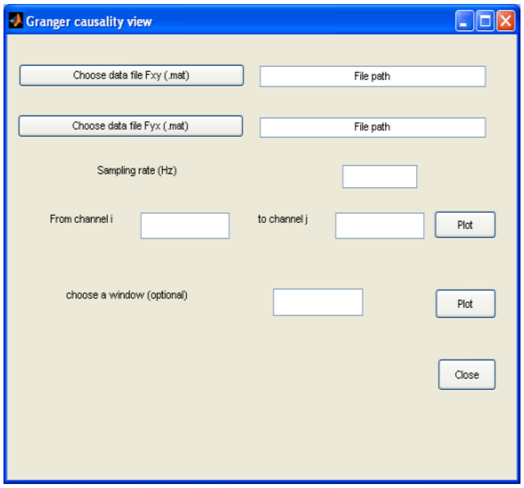
- Click the **Choose data file (.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'power_mov.mat'. The path *C:\bsmart\test\power_mov.mat* appears in the **File path** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired channel (e.g. 9) in the **channel** pane.
- Click **Plot** button on the right side.
- Enter time (e.g. 5) in the **Choose a window** pane.
- Click **Plot** button on the right side.
- Click **Close** button.





5.4 To View Granger Causality

- **Plot** menu ► **Granger causality view**



This window allows the user to view granger causality from the data sets in MATLAB format. The following instructions use the *Fxy_mov,Fyx_mov* data set as an example.

- Click the **Choose data file Fxy(.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'Fxy_mov.mat'. The path *C:\bsmart\test\Fxy_mov.mat* appears in the **File path** pane.
- Click the **Choose data file Fyx(.mat)** button.
- Navigate to *bsmart\test* in the **Pick a file** window.
- Open 'Fyx_mov.mat'. The path *C:\bsmart\test\Fyx_mov.mat* appears in the **File path** pane.
- Enter desired sampling rate (e.g.200) in the **Sampling rate** pane.
- Enter desired channel i (e.g. 9) in the **channel i** pane and channel j (e.g. 10) in the **Channel j** pane.
- Click **Plot** button on the right side. (Figure 1)
- Enter time (e.g. 5) in the **Choose a window** pane.
- Click **Plot** button on the right side. (Figure 3)
- Click **Close** button.
- Enter desired channel i (e.g. 10) in the **channel i** pane and channel j (e.g. 9) in the **Channel j** pane.
- Click **Plot** button on the right side. (Figure 2)
- Enter time (e.g. 5) in the **Choose a window** pane.
- Click **Plot** button on the right side. (Figure 4)
- Click **Close** button.

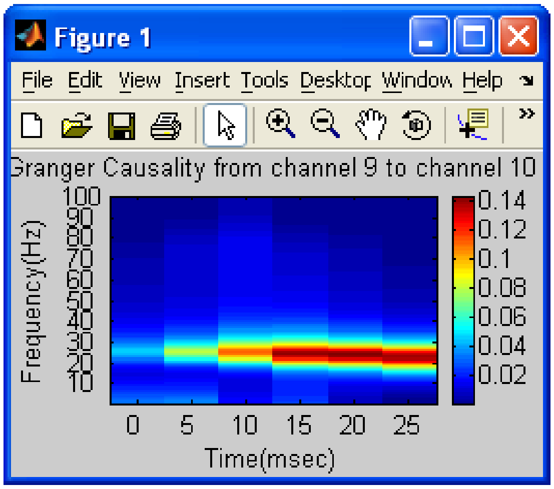


Figure 1
File Edit View Insert Tools Desktop Window Help
Granger Causality from channel 9 to channel 10
Frequency(Hz)
100 90 80 70 60 50 40 30 20 10
0 5 10 15 20 25
Time(msec)
0.14 0.12 0.1 0.08 0.06 0.04 0.02

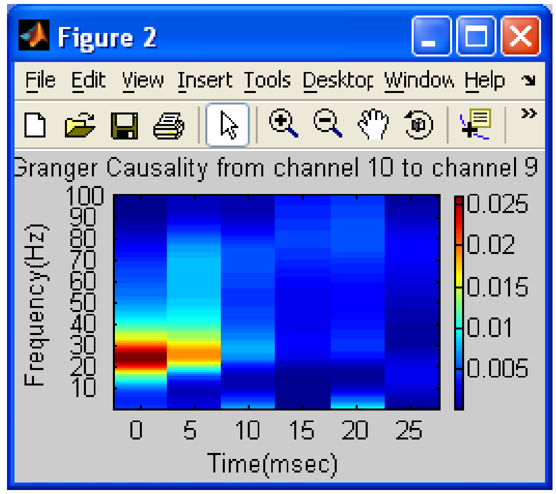


Figure 2
File Edit View Insert Tools Desktop Window Help
Granger Causality from channel 10 to channel 9
Frequency(Hz)
100 90 80 70 60 50 40 30 20 10
0 5 10 15 20 25
Time(msec)
0.025 0.02 0.015 0.01 0.005

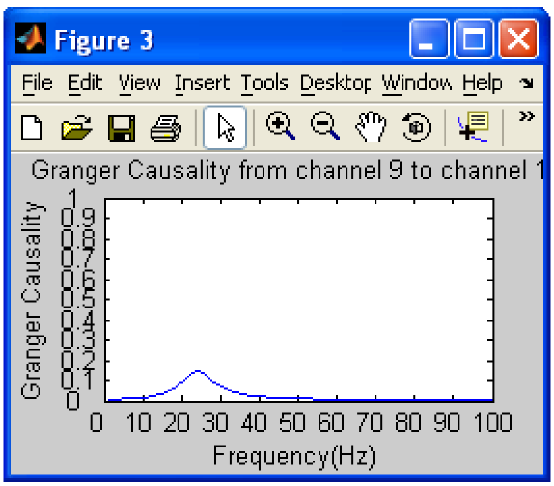


Figure 3
File Edit View Insert Tools Desktop Window Help
Granger Causality from channel 9 to channel 1
Granger Causality
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
0 10 20 30 40 50 60 70 80 90 100
Frequency(Hz)

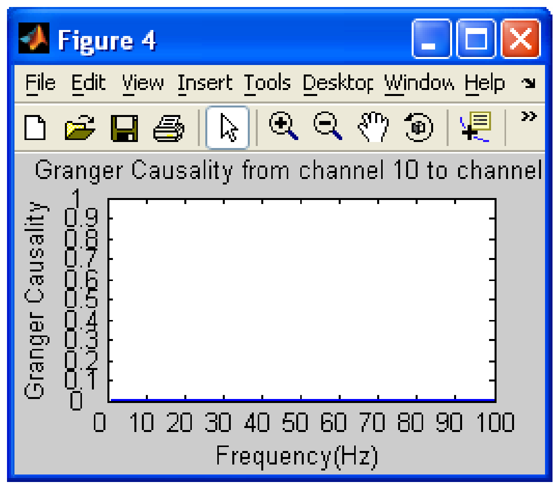


Figure 4
File Edit View Insert Tools Desktop Window Help
Granger Causality from channel 10 to channel
Granger Causality
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
0 10 20 30 40 50 60 70 80 90 100
Frequency(Hz)