

MazeSuite Tutorial: Interfacing with BCI2000 (P300)

This module includes tutorial, instructions and settings files for describing how to set up a basic P300 Brain Computer Interface (BCI) controller for MazeSuite's MazeWalker together with BCI2000. The system developed in this regard is similar to the controls published in the following paper. And, the basic principle can be adapted to allow a number of different BCI protocols and experimental formats to be handled.

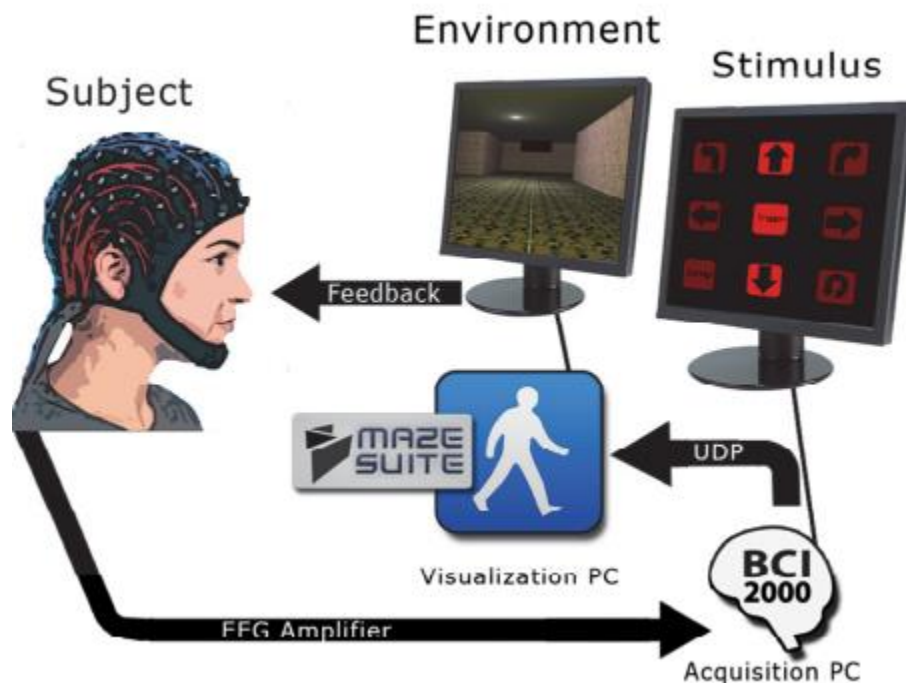
Curtin, A., Ayaz, H., Liu, Y., Shewokis, P. A., & Onaral, B. (2012). A P300-based EEG-BCI for spatial navigation control. In *Engineering in Medicine and Biology Society (EMBC), 2012 Annual International Conference of the IEEE* (pp. 3841-3844). IEEE.

<http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6346805>

BCI2000 is a free and open source platform for BCI development used for data acquisition, stimulus presentation and other signal processing applications. By linking BCI2000 to MazeSuite with the MazeCOMM API, BCI2000 can be used to control MazeWalker and produce a variety of experimental protocols and exciting applications.

This tutorial is intended to function alongside the BCI2000 P3Speller tutorial found at the link below.

http://www.bci2000.org/wiki/index.php/User_Tutorial:P300_BCI_Tutorial



Step 1: Create a user account and setting up BCI2000

In order to download the latest version of BCI2000 it is first necessary to make an account for the BCI2000 FTP server. First go to the BCI2000 license page at

http://www.bci2000.org/wiki/index.php/Creating_a_User_Account and follow the necessary instructions to create an account.

Next use the account provided to download the BCI2000 setup file here:

<http://bci2000.org/downloads/bin/BCI2000Setup.exe>

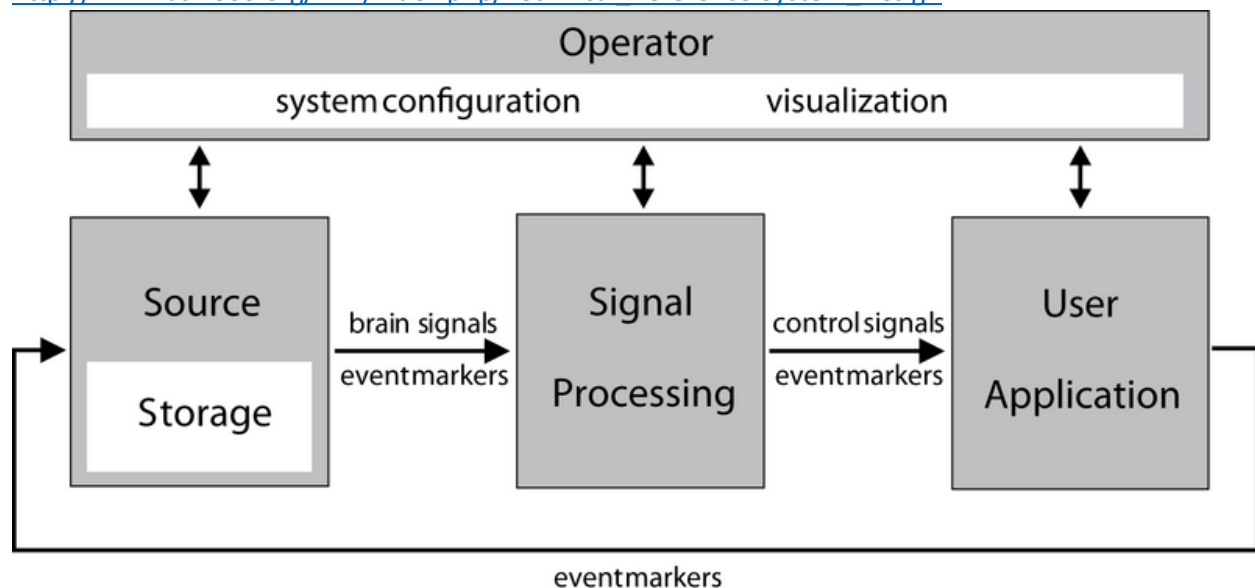
Finally install BCI2000 to an appropriate folder.

Step 2: Understanding the basics of BCI2000

BCI2000 is somewhat tricky program to understand and for an additional reference the user is referred to the tutorials available here http://www.bci2000.org/wiki/index.php/User_Tutorial:BCI2000_Tour

BCI2000 consists of 4 modules, the operator module which handles the configuration and the stimulus and/or signal display. Data is collected through the Source/Storage module, which is handled by interfacing BCI2000 with individual EEG devices. Information is then passed from the Source module to the Signal processing module which performs classification operations based on the signal. The user application handles stimulus presentation and completes the loop by passing event markers back to be stored. Further details regarding this setup are available here:

http://www.bci2000.org/wiki/index.php/Technical_Reference:System_Design



In this particular implementation of the BCI2000 P300 Speller with MazeWalker, the user application refers to the BCI2000 P300 speller, and output from the Speller application actually is routed to MazeWalker to control the movement. In the implementation described in the IEEE paper, MazeWalker was run on a separate computer for performance reasons, however both applications can potentially operate on the same computer.

Step 2: BCI2000 setup and configuration

BCI2000 is controlled through the BCI2000 Operator Program which handles communication through all other portions of the application. However BCI2000 must be started through an appropriate batch file specifying each module so they can be launched simultaneously.

The Batch (.bat) file

When setting up the BCI2000 application, each module must be specified. In this tutorial the **SignalGenerator** module is used as the data source, the **P3SignalProcessing** is the module used for to

process the data, and the **P3Speller** is used to present the stimulus to the user and communicate with MazeWalker. In a real application the SignalGenerator module should be replaced with the appropriate acquisition program for the EEG amplifier or other signal source. The P3SignalProcessing module can be replaced with other classification programs depending on the required needs but is suitable for demonstration purposes. Additionally the batch file can specify a default configuration for BCI2000 as specified by a parameter file; in this case **Maze Practice.prm**.

```
1  #! ../prog/BCI2000Shell
2  @cls & ..\prog\BCI2000Shell %0 %* #! && exit /b 0 || exit /b 1\n
3  Change directory $BCI2000LAUNCHDIR
4  Show window; Set title ${Extract file base $0}
5  Reset system
6  Startup system localhost
7  Start executable SignalGenerator --local
8  Start executable P3SignalProcessing --local
9  Start executable P3Speller --local
10 Wait for Connected
11 Load parameterfile "../parms/Maze Practice.prm"
```

Figure 1: Text from provided batch file

The Operator Module

Once the components have been specified in the batch file, run the batch file to open the configured BCI2000 Operator program. Shown below, the BCI2000 Operator module controls the launching of all modules.

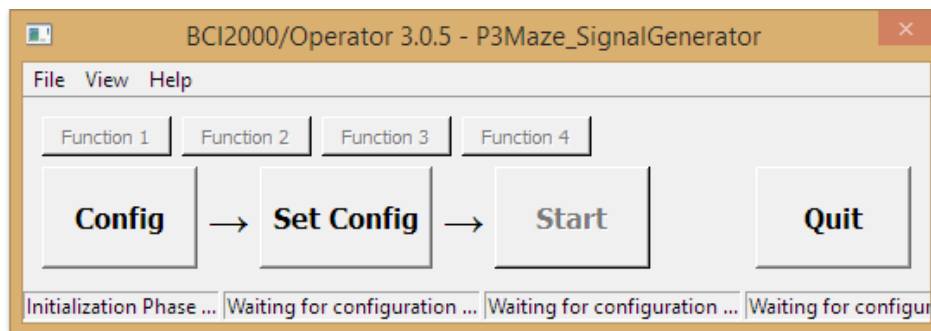


Figure 2: BCI2000 Operator program

Running the batch program with the “Load parameter file” will automatically load all settings from the parameter file specified. These settings can be modified in the BCI2000 operator application by pressing the **Config Button**. Use the configuration page to add information such as the Subject name, session or other information as well as change the desired configuration of the setup.

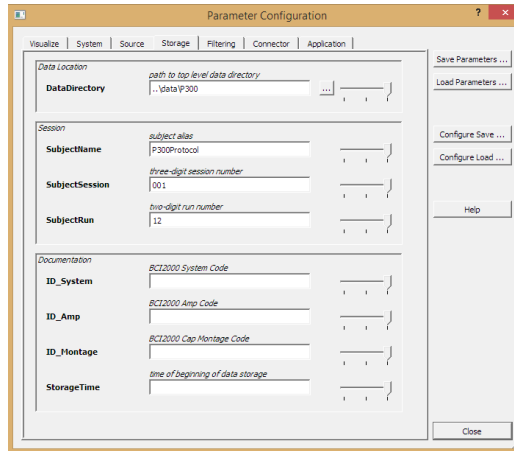


Figure 3: Parameter Configuration Window

Using the provided **Maze Practice.prm** file, the application settings preconfigure the **Application** tab of the Parameter Configurations. Since BCI2000 does not communicate directly with MazeSuite, control of MazeWalker is achieved using a bridge program listening to the UDP output of the P3Speller application. This UDP port number is configured under the **Speller: DestinationAddress** setting. In the provided listening application, the default port of 3000 is used.

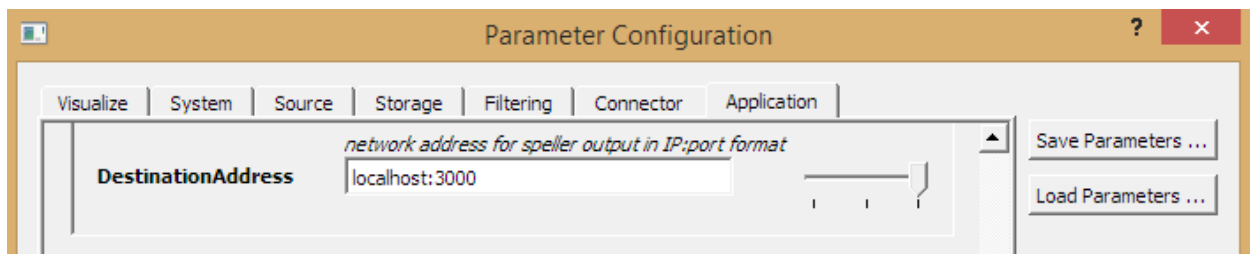


Figure 4: UDP output settings for P3Speller output

The provided parameter file also automatically loads navigation icons to use instead of the standard letters. These icons can be configured in the **Speller Targets: TargetDefinitions** settings to create custom

or alternate matrices. These settings also control the output letters passed through the DestinationAddress IP port.

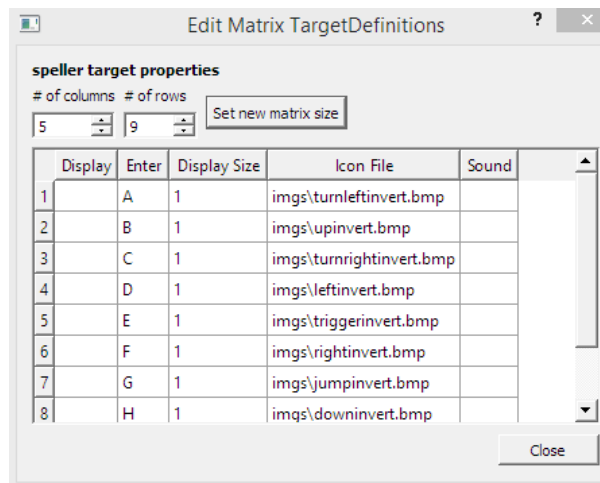


Figure 5: Matrix target definition

To properly set up a P300 BCI, appropriate data collection must be set up for the EEG amplifier. To calibrate the system for your particular setup please refer to the wiki article:
http://www.bci2000.org/wiki/index.php/User_Tutorial:Preparing_your_BCI2000_system_for_P300_BCI_experiments_for_the_first_time

P3Speller modes

A typical P300 BCI setup follows the initial setup of the subject with a “Copy Spelling” task in which the subject observes pre-directed letters. The P300 response of the subject is the recorded and used to train the classifier for future online classification. In the MazeSuite P300 navigation task, the process is similar, with the subject being directed to specific directions to train the classifier. The process through which to calibrate subject-specific P300 Parameters is covered by the following BCI2000 tutorial

http://www.bci2000.org/wiki/index.php/User_Tutorial:Obtaining_P300_Parameters_in_a_Calibration_Session

Once subject -specific parameters have been acquired, it is necessary to switch the **Result Processing: InterpretMode** of the P3Speller application from **copy mode** to **online free mode**. Because online free mode is the goal of this tutorial, ensure that this is selected.

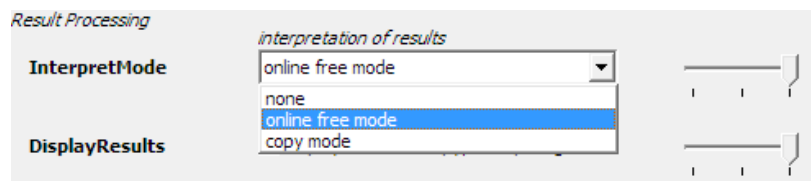


Figure 6: P3Speller Interpretation Modes

In this example the SignalGenerator module is used which generates arbitrary data for use in testing so an additional option must be specified before running the test. Under the Application configuration, enable the **Speller: Test Mode** setting. This enables the P3Speller test mode which allows classification

to be bypassed by specifying the desired letter/icon for output by clicking the target. When using an actual signal source, this should be disabled.



Figure 7: TestMode Setting to bypass Classifier

Once all configured options are set, close the Parameter Configuration window and click **Set Config** on the operator module.

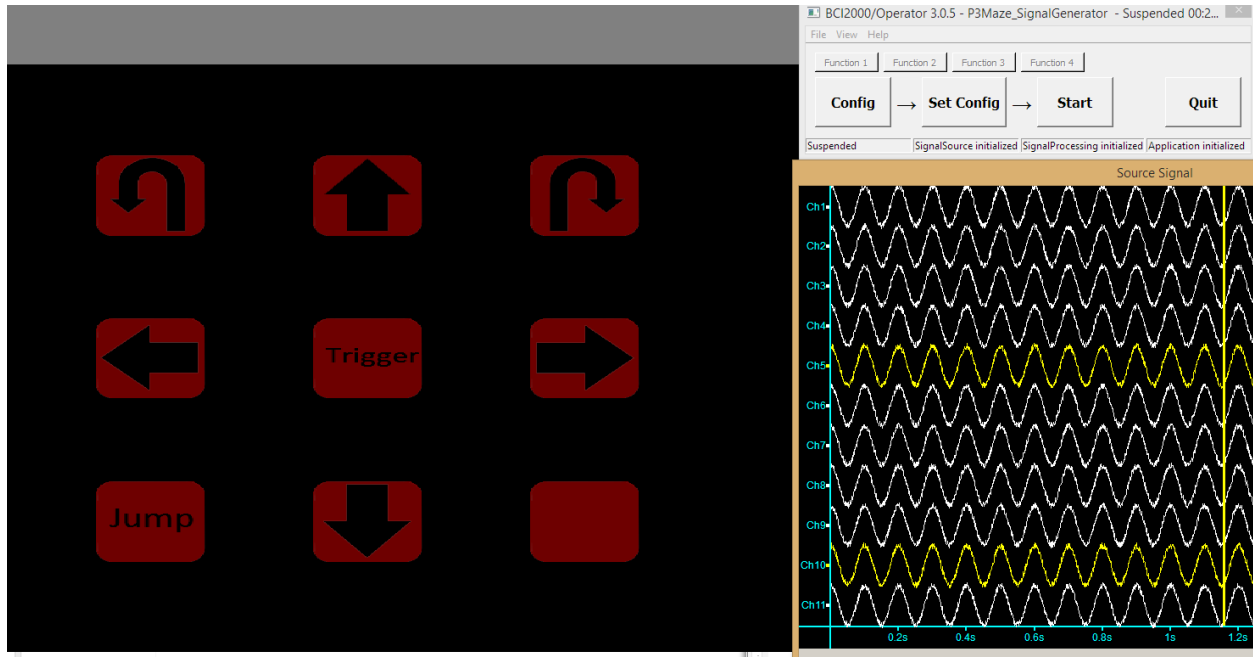
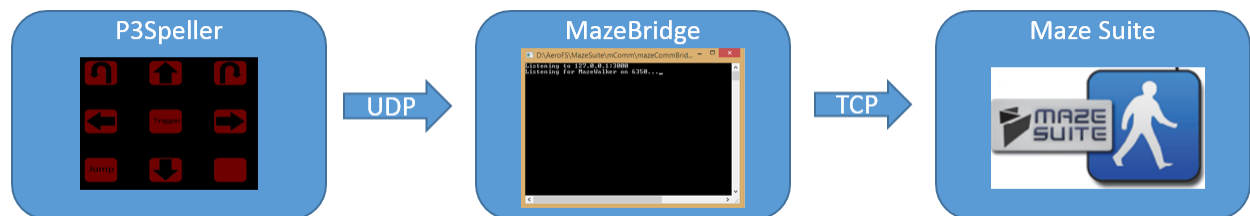


Figure 8: BCI2000 Set up ready to start

Step 3: Set up MazeBridge



MazeBridge is a UDP listening application which runs on port 3000 and acts as a bridge between BCI2000's P3Speller output and MazeWalker. MazeBridge uses the MazeAPI to control actions in MazeSuite and interpret specific actions based on ASCII UDP commands. The program itself represents a simple way to translate any UDP based signal to a MazeWalker action. Out of the box, the MazeBridge program will translate the given commands from the matrix into their respective actions. However, these actions can be modified as seen fit in the MazeBridge project included in the API.

Figure 9: Modifiable actions in MazeBridge source

```
if(outputChar=='_')
    mComm.SendCue();
else if(outputChar=='A')
    mComm.LookLeft(90);
else if(outputChar=='B')
    mComm.MoveForward(5.3);
else if(outputChar=='C')
    mComm.LookRight(90);
else if(outputChar=='D')
    mComm.StrafeLeft(5.3);
else if(outputChar=='G')
    mComm.Jump();
else if(outputChar=='F')
    mComm.StrafeRight(5.3);
else if(outputChar=='H')
    mComm.MoveBackward(5.3);
else if(outputChar=='I')
    mComm.LookLeft(360);
else if(outputChar=='E')
    mComm.Jump();
```

Run MazeBridge prior to starting MazeSuite.

Step 4: Set Up MazeWalker

To use MazeBridge and BCI2000 with MazeWalker, it is necessary to enable the API through the **API Settings** menu in MazeWalker.

Once accessed, enable a device and set the port number to match the port used in MazeBridge (default 6350). Then specify an IP address for the MazeAPI server (MazeBridge). If MazeBridge is located on the same computer as MazeWalker, **Local Device** may be selected to identify an IP address of 127.0.0.1.

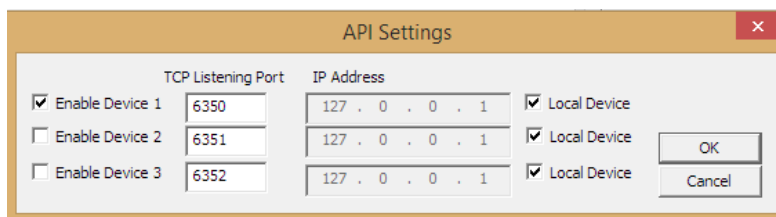


Figure 10: MazeWalker API settings page

It may also be desired to disable mouse and other inputs to MazeWalker to prevent non-BCI2000 related movements.

Once all settings have been set up, BCI2000 operation can be tested by:

1. Running MazeBridge
2. Starting MazeWalker
3. Running the BCI2000 Batch File
4. Enabling "Test Mode"
5. Clicking SetConfig
6. Clicking Start

Once running simply click the classified icon to send the desired output to MazeWalker.

To use this setup with an actual BCI input, the reader is referred to the BCI2000 P300 tutorial

http://www.bci2000.org/wiki/index.php/User_Tutorial:P300_BCI_Tutorial

