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SSVEP BCI V2.12.01

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g.USBamp and g.MOBIlab+ are biosignal acquisition systems for EEG, ECG, EMG, EOG and other sensors. In this tutorial the usage of the devices for a SSVEP BCI will be shown. For the proper working of the device also g.STIMbox and g.SSVEPbox are necessary. The Simulink Highspeed On-line Processing blockset allows to read in data into Simulink in real-time and to perform the parameter estimation and classification. No additional compilation of the Simulink model is required for the on-line processing.

PREPARATION

Before start there are a few important things to check:

- The g.USBamp or g.MOBIlab+ must be connected to the computer and switched on
- g.GAMMAbox must be connected and switched on
- The g.STIMbox and the g.SSVEPbox must be connected to the computer
- Make sure that the COM ports for all devices are set correctly (see gSTIMbox Help).

APPLYING THE ELECTRODES

Apply the electrodes to the positions depicted below. Make sure that they are connected to the g.GAMMAbox in the right order. The following figure lists the correct configuration.



INSTALLATION

Copy the directory **gSSVEP_8ch** to your local hard disc. You have to manually set the path for MATLAB by selecting **Set Path** in the **File** menu. Click the **Add with Subfolders** button, and select the directory

Your Installation path:\gSSVEP_8ch\

📣 Set Path		
All changes take effect imme	diately.	
-	MATLAB search path:	
Add Folder	C:\Program Files\gtec\gSVEP_8ch	A
	🔒 C:\Program Files\gtec\gSSVEP_8ch\Batch	
Add with Subfolders	🕌 C:\Program Files\gtec\gSSVEP_8ch\Help	E
	🎍 C:\Program Files\gtec\gSSVEP_8ch\Help\gSSVEP_8ch	
	🎍 C:\Program Files\gtec\gSSVEP_8ch\Testdata	
	🎍 C:\Program Files\gtec\gSSVEP_8ch\Toolboxes	
	🕌 C:\Program Files\gtec\gSSVEP_8ch\Toolboxes\epuck	
	C:\Users\Bernhard\Documents\MATLAB	
	C:\Program Files\gtec\gP300_8ch	
	C:\Program Files\gtec\gP300_8ch\Batch	
	📙 C:\Program Files\gtec\gP300_8ch\Help	
	C:\Program Files\gtec\gP300_8ch\Help\gP300_8ch	
Move to Top	C:\Program Files\gtec\gP300_8ch\Toolboxes	
	C:\Program Files\gtec\gP300_8ch\Toolboxes\MLDA	
Move Up	📙 C:\Program Files\gtec\gP300_8ch\Toolboxes\gt	
	C:\Program Files\gtec\gP300_8ch\Toolboxes\gt\3rdParty	
Move Down	C:\Program Files\gtec\gP300_8ch\Toolboxes\gt\3rdParty\libsvm_mex	
	C:\Program Files\gtec\gP300_8ch\Toolboxes\gt\lib	
Move to Bottom	C:\Program Files\gtec\gP300_8ch\Toolboxes\gt\opt	
	C:\Program Files\gtec\gP300_8ch\Toolboxes\gt\wrapper	
	C:\Program Files\gtec\gtecHS	
	📙 C:\Program Files\gtec\gtecHS\Examples	
	C:\Program Files\gtec\gtecHS\Examples\COMMON	
	C:\Program Files\gtec\gtecHS\Examples\COMMON\Batch	
	📙 C:\Program Files\gtec\gtecHS\Examples\gMOBIlab	
	📙 C:\Program Files\gtec\gtecHS\Examples\gUSBamp	
	🐌 C:\Program Files\gtec\gtecHS\Help	
	📔 C:\Program Files\gtec\gtecHS\Help\gMOBIlab	
Remove	C:\Program Files\gtec\gtecHS\Help\gUSBamp	_
	Ch Dan annan Eileah aka ah 101 ik	•
	Default	Halp
Save Close R		Help

Click **Save** and **Close** to finish the path settings.

START-UP

The corresponding Simulink models can be started from the MATLAB Start button



or by typing the name of the Simulink model into the MATLAB command line.

To start the g.USBamp SSVEP model type gSSVEP_gUSBamp_8ch into the MATLAB command line.

The following Simulink model opens:



To start the g.MOBIlab+ SSVEP model type $\tt gSSVEP_gMOBIlabplus_8ch$ into the MATLAB command line.

In that case this Simulink model opens:



DRIVER CONFIGURATION

g.USBamp

Double click on the **g.USBamp** block to open the following window:

Configure g.US	Bamp SNR.: UB-2010.03.26				-	-		• X
- Specify AM	PLIFIER SETTINGS:							
Common ground	: Common reference:	Sampling rate (Hz):	Fra	ame length:	A	nalog outpi	ut:	
Group A	Group A	256 🗸		1	s	ine	-	
Group B	Group B	Ontions:		Mode:			400	
Group C	Group C			Massaure	Am	plitude:	100	(mv)
Group D	Group D	Trigger		 Measure Test signal 		Offset:	0	(mV)
Serial number:	UB-2010.03.26	Slave			Freq	uency:	10	(Hz)
		Shortcut						
CHANNEL select	tion:							
🗸 СН01 🔍 СН	юз 🔽 сноз 🔽 снот 📄 сно	9 📄 CH11 📄 CH1	3 📃	CH15				
🗸 СН02 🔍 СН	104 🔽 CH06 🔽 CH08 🔲 CH1	0 🔲 CH12 🔲 CH1	4	CH16				
Specify CHA	ANNEL SETTINGS:							
			Ch#	.BipHighpass.	Lo	wpass	Notch	1
			10	HP: 0.50	0 / LP:	30.000	50	
Bipolar:	0 👻	apply >>	3 0) HP: 0.50	0 / LP:	30.000	50	
Bandnace:	HP: 0 100 / LP: 0 000 -	apply >>	4 0	HP: 0.50	0 / LP:	30.000	50	=
Danapass.	······································	dipping and	50 60) HP: 0.50 HP: 0.50	0 / LP: 0 / LP:	30.000	50 50	
Notch:	50 👻	apply >>	7 0	HP: 0.50	0 / LP:	30.000	50	-
					1	. 1		
Load	Save			Help	C	ancel		OK

Enter the serial number of your g.USBamp, select a **Sampling rate** of 256 Hz and a **Frame length** of 1. Then select channels CH01-CH08, set **Common ground** and **Common reference** for **Group A** and **Group B**. Apply a **Bandpass** filter with lower-cut-off frequency of 0.5Hz and upper-cut-off frequency of 30Hz and a 50Hz Notch filter.

Now g.USBamp is correctly initialized.

Save the settings by clicking on the **Save** ... button and enter a filename to store the settings.

Press **OK** to accept the settings and to close the window.

g.MOBIIab+

Double click on the **g.MOBIlab+** block to open the following window:

J.MOBIlab+ Configuration							
g.MOBIlab+ configuration dialog allows selection of analog and digital channels as well as providing other necessary settings for the device.							
Analog Channels and Notch Filters:							
CH 1 0.50-100.00Hz U ±500	IV Notch:	OFF 🔻					
☑ CH 2 0.50-100.00Hz U ±500µ	V Notch:	OFF 💌					
CH 3 0.50-100.00Hz U ±500	IV Notch:	OFF 🔻					
CH 4 0.50-100.00Hz U ±500	V Notch:	OFF •					
CH 5 0.50-100.00Hz U ±500	V Notch:	OFF 💌					
CH 6 0.50-100.00Hz U ±500	V Notch:	OFF 🔻					
CH 7 0.50-100.00Hz U ±500	V Notch:	OFF 🔻					
CH 8 0.50-100.00Hz U ±500	V Notch:	OFF 🔻					
Digital Inputs and Outputs:							
Digital Input 1:	OFF	•					
Digital Input 2:	OFF						
Digital Input 3:	OFF	•					
Digital Input or Output 1:	OFF	•					
Digital Input or Output 2:	Digital Input or Output 2: OFF						
Digital Input or Output 3:	OFF	•					
Digital Input or Output 4:	OFF	•					
Digital Input 4:	OFF	•					
Settings:							
Serial port:	COM7:	-					
Filename:							
'GMOBILAB'							
Maximum delay:							
10000							
Enable writing to SDCard (977 MB free)							
OK Cancel Help							

Select **CH 1-8**, set the **Digital Channel 1-8** parameters to OFF and select the **COM Port** where your amplifier is connected to the PC.

Press **OK** to accept the settings and to close the window.

MINIMUM ENERGY

The sampling frequency of g.USBamp is 256 Hz. It is connected to an **Unbuffer** block and **Data Type Conversion** block to work with data in double precision format. The data is passed to the **Minimum Energy** block to calculate the signal-to-noise ratio (SNR) for the frequencies, specified in the **Stimulation Frequencies** block, with respect to the base EEG-signal.

A double-click on the Minimum Energy block opens the following dialog:

Function Block Parameters: Minimum Energy				
SSVEP Minimum Energy (mask) (link)				
Uses the minimum energy approach to compute the signal to noise ratio of specific frequencies which may be contained in the input data.				
Parameters				
Buffer Length				
768				
Reestimate every N seconds				
0.20				
Number of Harmonics to include in model				
1				
Order of AR model				
7				
OK Cancel Help Apply				

Buffer Length is the number of used samples for estimating the SNR, the minimum is 128 samples. A buffer length between 512 and 1024 samples is recommended. For the tutorial please enter 768 samples.

Reestimate every N seconds: Time period after which the SNR shall be reestimated, minimum is 0.1 seconds.

Enter 0.2 s, that is a re-estimation rate of 5Hz.

Number of Harmonics to include in model: The number of harmonics the Minimum Energy estimator shall consider when building the signal models for each frequency, minimum is 0. 1, which includes the first order harmonic is used within this tutorial.

Order of AR model: The minimum energy estimator uses the Levinson AR model to estimate the frequency spectrum of the signals. The order of the model is defined through this parameter. Minimum model order is 3. A model order between 5 and 7 is recommended.

Set the Order of AR model to 7.

MEDIAN FILTER

The **Moving Median** Filter smoothes the output signal of the **Minimum Energy** block by calculating the median of the data.

Double click on the Median Filter block to open the following window:

Function Block	Parameters: Median Filter	×
Subsystem (mask)		
Parameters		
The Level		
Filter Length		
10		
		<u> </u>
	<u>OK</u> <u>C</u> ancel <u>H</u> elp	Apply

Filter Length: The number of samples which are used for calculating the median. Set the **Filter Length** to 10.

PARADIGM

Double click on the **Paradigm** block to open the following window:

Source Block Parameters: Paradigm
Subsystem (mask)
Parameters
Class Info File
dassinfo_20tr.m
Mode Training Paradigm
Trial Period [s] (>= 8s)
10.5
Active Part [%]
70
Initial Offset [s] (>= 10s)
10
<u>Q</u> K <u>C</u> ancel <u>H</u> elp

Class Info File: Set the path of the Class Info File.

Mode:

The window allows selecting between three modes: (i) Training Paradigm, (ii) Paradigm with feedback and (iii) Free running.

Trial period defines the length of one trial in seconds. It should not be shorter than 8s

Active Part [%] defines the time duration the user has to concentrate on a LED during one single trial period. It is specified as percentage of the trial period.

Initial Offset defines the length before starting with the first trial in seconds. It should not be set to values less than 10s.

CLASSIFIER GENERATION

The SSVEP Device uses Linear Discriminant Analysis for feature classification. To use this signal processing algorithms you have to generate corresponding classifiers first.

Double click the Paradigm block.

Enter classinfo_20tr.m as Filename and select Training Paradigm as Mode.

Set the Trial Period to 10.5 s, the Active Part to 70 % and the Initial Offset to 10 s.

Press **OK** to close the window.

Then double-click onto the **To File** block:

🙀 Sink Block Parameters: To File 🔀
To File
In a timeseries or an array, incrementally write time and input into the specified MAT file.
Use Timeseries format for writing multidimensional, real or complex inputs, with different data types.
Use Array format only for one-dimensional, double, noncomplex inputs. Time is saved in the first row. Additional rows correspond to input elements.
Parameters
File name:
training_session_1.mat
Variable name:
У
Save format: Array
Decimation:
1
Sample time (-1 for inherited):
-1
OK Cancel Help Apply

Enter under Filename training_session1.mat and under Variable Name y. This stores the data into matrix y.

Press **OK** to close the window.

Double-click on the g.STIMbox block to set the stimulation frequencies.

n g.STIMbo	х	Dens	
Digital (Port Fre Dialog F	output quency Input Parameter 👻		Communication COM-Port 17
Output	Port Configuration		Input Sampling Rate
	Mode	Frequency	32
СН	1 On/Off 🚽	-	Input Frame Length
СН	2 On/Off 🚽	-	1
СН	3 On/Off 🚽	-	
CH	4 On/Off 🚽	-	Digital Input
СН	5 On/Off 🚽	-	Activate Digital Inputs
CH	6 On/Off 🚽	- E	Driving Mode
CH	7 On/Off 🚽	-	Driving mode
CH	8 On/Off 🚽	-	Input Channel Inversion
CH	9 Frequency -	10	
CH	10 On/Off 🚽	-	5 6 7 8
CH	11 Frequency 🗸	11	9 10 11 12
CH	12 On/Off 🗸	-	13 14
CH	13 Frequency 🗸	12	
<u></u>		•	OK Apply Cancel

Set the COM Port of the g.STIMbox correctly (see g.STIMbox Help).

Enter an Input Sampling Rate of 32 Hz and an Input Frame Length of 1.

Change the Mode of CH 9, CH 11, CH 13, CH 15 to Frequency and enter the frequencies 10 Hz, 11 Hz, 12 Hz and 13 Hz (same as in the **Stimulation Frequencies** block).

Press **OK** to close the window.

Start the SSVEP model in the Simulink model menu.

After the **Initial Offset** the LED will start flashing. Look at the left white LED. After the **Trial Period** the next LED will flash (clockwise). The current LED you have to concentrate on is marked with the green LED. Between two trials all green LEDs are lighting and the user has enough time to switch the focus to the next LED.

CLASSIFIER CALCULATION

- 1. Enter gbsanalyze on the MATLAB command line to start g.BSanalyze.
- 2. Select Load Data from the g.BSanalyze File menu and load the acquired data file training session1.mat.
- 3. Enter a Sampling Rate of 256 Hz.

📣 Enter Sampling Fre	quency
Please ent	r the sampling frequency that was used to acquire the
DAQ-Setting:	
	Sampling rate [Hz]: 256
	OK !

4. The first channel is a time step signal, channel 2 to 9 are the EEG-signals, channel 10 is the trigger signal and channel 11 shows the current classification result (Paradigm with Feedback).

Trigger Data

- 5. To split the data-set into equal trials open the **Trigger** window under the **Transform** menu.
- 6. Set the Time before trigger to 3000 ms and the Time after trigger to 7000 ms. Select channel 10 as Physical channel for triggering and set the Threshold level to 90 % of maximum. Select e.g. the name TRIG in Assign attribute to resulting trials and press button add to list ->.

🛃 Trigger
The trigger function splits your recorded data into trials related to trigger timepoints defined by physical channels or markers. The use of different markers or channels allows to assign attributes automatically to resulting trials. Channel attributes and markers remain in the triggered data.
Time before trigger: 3000 [ms] Time after trigger: 7000 [ms] Accept incomplete 768 [samples] 1792 [samples] last trial
Specify TRIGGERS and ATTRIBUTES:
Physical channel: 9(CH9) 9(CH9) 10(CH10) 11(CH11) Slew rate: 0.23 [µ∨]
Marker: BEGIN Chan. (Marker)/ Name/ Edge/ Value/ Attribute/ Overlap/ Color
Assign attribute to resulting trials: TRIG Ch.10/10/rise/90%/TRIG/no/red
Accept overlap add to list -> <- remove from list apply changes -> Change color:
red blue green yellow pink orange purple olive brown grey
Generate LINED UP TRIALS:
O Line up trials (no trigger) Length of trials: 1000 [ms] Overlap: 0 [ms] 256 [samples] 0 [samples] 0
Select CHANNELS for the triggered file:
Help Cancel Start !

7. Press Select channels ... and exclude CH 1, CH 10 and CH 11.

You are going to execute a t attributes to specify trials an	ransform- or analyze- function. Usually d/or channels that should be included or	t is appropriate not to include all channel excluded for this step. Hold the 'Strg' ke	Is and all trials in this function. Use y to make multiple selections.
Specify TRIALS:	Specify CHANNELS:	_ Specify CHANNEL TYPE:	Specify CHANNEL NUMBERS:
exclude include only	exclude include only	exclude include only	exclude include only
ARTIFACT REMOVE	BAD CUT	N.S *	1 2 3 4 5 6 7 8 9 10 11 •
Current selection:	Current selection:	Current selection:	Current selection:
0 out of 1 trials	0 out of 11 ch.	0 out of 11 ch.	3 out of 11 ch.
		Help	Cancel OK !

8. Press **Start!** to perform the triggering.

The process results in 20 trials with a length of 10000ms each.

Load Class Information

9. To assign class information to the 20 trials open Load Class Information of the File menu in the Data Editor. Click on the Browse... button and select the file classinfo 20tr.m from the following directory:

Your Installation path:\gSSVEP 8ch\

10. Change the names of the attributes e.g. to 10Hz, 11Hz, 12Hz, 13Hz. Click OK!

Parameter Extraction - Minimum energy

11. Open the **Minimum Energy** window from the **Parameter_Extraction** menu.

Minimum Energy							
Calculates the minimum energy of a given data set. The output signals represent the signal-to-noise ratio (SNR) for the specified frequency with respect to the base EEG-signal.							
_ Select CHANNELS:				Select channels			
C Specify METHOD and PA	RAMETERS:						
Frequencies [Hz]:			10,11,12,13	(e.g.: 10,11,12,13)			
Number of harmonics:	1	Order of AR model:	7				
Specify window: Length:	3000 [ms] 768 [samples]	Evaluation step:	199.2188 51	[ms] [samples]			
Result procedure: Repl Repl Save	new channels ace all channels e result data	Automatic Filename:	treemaker is: er	enabled			
		Help	Cancel	Start !			

12. Press Select channels and Select all ->>.

Enter the **Frequencies 10**, **11**, **12**, **13** Hz. Set the **Number of harmonics** to 1 and the **Order of AR model** to 7.

The window length is 3000 ms and the Evaluation step is 200 ms.

Select **Add new channels** to add the calculated channels to the data channels in the Data Editor.

13. Press **Start!** to perform the calculation.

Parameter Smoothing – Moving Window Filter

14. Open Moving Window Filter window from Pre-Processing menu

📣 Moving Window Filter
This function smoothes the selected trials/channels by applying a moving window onto the last N samples of the data. The length N of the smoothing window can be selected.
Select CHANNELS: Select trials/chan.
Specify METHOD and PARAMETERS:
O Moving average O Moving median
Specify length of smoothing window: 1992.1879 [ms]
Help Cancel Start !

- 15. Select Moving median
- 16. Specify length of smoothing window 10 Samples.
- 17. Click on Select trials/chan, select channels 9, 10, 11 and 12 to be smoothed only and confirm the settings with the OK button.
- 18. Press Start to smooth the data.

Baseline Correction

19. Open Arithmetic window from Transform menu

📣 Arithmetic					
Perform an arithmetic operation on the selected trials and channels.					
C Specify METHOD					
Apply on multiple channels:		O Apply on two channels:			
First operand:	Select trials/chan.	First operand:	Channel 1 💌		
Operation:	Z-MEDIAN	Operation:	SUB 🔽		
Second operand:	€ 5 µV -	Second operand:	Channel 2		
		ImportWizard			
		Help Cancel	Start !		

20. Select Apply on multiple channels for **Specify Method** and set **Operation** to Z-Median for subtracting the median of all channels from each sample.

21. Click on Select trials/chan, select channels 9, 10, 11 and 12 to be baseline corrected only and confirm the settings with the OK button.

Classification

- 22. To classify the data open the Feature Matrix from the Classification menu.
- 23. Set the Start at time to 0 ms (the first sample will be chosen), the Step size to 500 ms and Stop at to 51 samples (10160.2 ms). Select classes 10Hz, 11Hz, 12Hz, 13Hz.
- 24. Click on **Select feature channels** and select only channels 9 to 12 for the classification.
- 25. Select Linear Discriminant Analysis (LDA) as Classification method.

🛃 Feature Matrix 🗖 🗖 💌
Generate a feature matrix as input for the classification methods. Select class allows to select trials with a certain attribute. Each attribute corresponds to a class. Select time point allows to select specific time points. Each time point corresponds to a class. Specify CLASSIFICATION INTERVAL: Start at: 199.219 [ms] Step: 597.656 [ms] Stop at: 10160.2 [samples] 3
Specify CLASS LABELS / TIME POINT: Select class: ARTIFACT REMOVE TRIG 10HZ 11HZ 12HZ 13HZ TRIG 10HZ 12HZ 13HZ 13HZ 10HZ
Select FEATURE CHANNELS:
Classification method: Linear Discriminant Analysis (LDA) Randomly permutate the matrix
Result procedure: V Classify data Automatic treemaker is: enabled
Help Cancel Start

26. Press **Start** to create the feature matrix and to open the **Linear Classifier** window.

27.Perform the classification with a Linear Discriminant Analysis (LDA) and with a 10 x 10 cross-validation by pressing again Start. The 10 x 10 cross-validation mixes the testing and training data.

gResult2D opens automatically with the classification result. The y-axis shows the classification error in %.

For the Online Classification it is recommended to select a timepoint where the classification error is 0%. In the following figure (...\Testdata\training_testsubj1.mat) you would chose a timepoint between 6-6.5.



28. Close the Result2D, Linear Classifier and Feature Matrix window and repeat steps 14-19 but now select in the Linear Classifier window as Training / testsets Train 100% - Test 100% and save the results in

Your Installation path:\gSSVEP 8ch\train lda session1.mat

OPTIONAL: CLASSIFIER CALCULATION WITH BATCH

Steps 5-20 can be also performed automatically with a batch. Note: You have to use the same parameters as used within this tutorial.

- 1. Enter gbsanalyze in the MATLAB command line to start g.BSanalyze.
- 2. Load the acquired data file training_session1.mat (Sampling frequency 256Hz).
- 3. Select Appearance Settings from the Options menu and set the USER DIRECTORY to

Your Installation path:\gSSVEP_8ch\Batch

4. Go to the User menu in g.BSanalyze and select the batch for classifier calculation (SSVEP LDA ME Batch 8ch 256Hz).

Run! Help	User	
		SSVEP_LDA_ME_Batch_8ch_256Hz
		SSVEP_online_accuracy_batch

ONLINE CLASSIFICATION

Double click on the **Apply Classifier** block to load the classifier.

📣 Apply Classifier	_ <u> </u>
This block applies a classifier (i.e. a weight vector) calculated be correct feature channels (same as for generation) are used.	fore to the input data. Make sure that the
Load and select CLASSIFIER:	
Select classifier from lis	50 3785.1563 🔺
Load Classifier: (classification time) 40 4382.8125
the second	35 4980.4688
	10 5578.125
Matheast	0 6175.7813
Method: LDA	0 6//3.43/5
	0 7371.0938
Combine classification result in one channel	018566 4063
	019164.0625
Compute probabilities	
Add zero class Confidence interval [%]	
Help	Cancel Accept

Load Classifier: Select the *.mat file which contains the classifier results. If you followed the tutorial it should be saved under:

Your Installation path:\gSSVEP 8ch\train lda session1.mat

Select classifier from list: Select the classifier which should be used for the online classification. The left value is the classification error and the right value the time point the error was observed.

Enable **Combine classification result in one channel** to compute the probability that a sample belongs to a specific class. The class with the highest probability is selected on the output of the **Apply Classifier** block.

Enable Add zero class and set the Confidence interval [%] to 1. This activates the rejection of any sample for which no class can be assigned with an uncertainty of less than 1%.

Double click the **Paradigm** block.

Select Paradigm with feedback as Mode. This mode allows to calculate the accuracy of the online classification.

Set the Trial Period to 10.5 s, the Active Part to 70% and the Initial Offset to 10 s.

Press **OK** to close the window.

Enter into the To File block fb_session1.mat and Start the Simulink model.

The task for the subject remains the same as with Training Paradigm.

If you would choose Free running the white LEDs would flash all the time and you will get a continuous online classification result (can be seen in the **Display** block or as movement of the robot) but you are not able to calculate the accuracy with g.BSanalyze.

To control the **epuck**, set the constant of the **Enable epuck** block to 1.



DATA STORAGE AND VISUALIZATION

MMM Markey	planting plant My have a chart	Martin Warmun	MANNANANA	Vallat ave bly scarallad	Muradeels, Jurijanaia	the at the hard and the state of the state o	immant have barr	Yunnaddyraanadw	www.www.hy/v/u
HANNIN MANNA	drah _{ingga} dhyhohovja	had a faith the second	Multinations	Yulamuyyhtyannyhh	is Armady Mrs. Juris Against	New Manual Manual Manual And Manual	www.www.hum	www.whymwic.new	vasellanet A.A.A.
White Marken	here all the second second	had you with the second	Wybrittennethernet	Vindernaanden	(Managhan), loon, pagail	When the state of	wir-incernation/infra	Nappolichymraticaethe	norther And
mmyperminektm	aring and the second	.http://www.wv	12 your way and	Viullymanhhyllimanhh	hundrad have been and	www.www.	anter anni band	Unpopulatoportionista de la	www.www.y.A.Mayk_
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appayyyinterylanik.her	nahalanda halimaa	MH4414W	^{De} Wennermanner	VelVisandypenally	(Awardhany)kanyanya	Allow white an all and a	waters are a subject of the	ugiquedden water and the	www.www.
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Double-click onto the **Scope** block to investigate the signals:

The channels 1-8 show the EEG data. The 9th channel displays the **trigger signal**, if it is high you have to concentrate on a LED and the 10^{th} channel indicates the **classification result** 1 – 4 (10Hz, 11Hz, 12Hz and 13Hz.) or 0 in case no class could be assigned.

The **To File** block stores these 10 channels plus the automatically stored time stamp of each sample (see documentation of **Simulink To File** .block for further details)

OFF-LINE PROCESSING

Type into the MATLAB command window <code>gbsanalyze</code> to start the Data Editor. Load the data file acquired during the <code>Paradigm with feedback</code> (fb_session1.mat) trial to calculate the accuracy of the online classification.

If your user directory is not already set, select **Appearance Settings** from the **Options** menu and set the **USER DIRECTORY** to

Your Installation path:\gP300_8ch\Batch

Go to the User menu in g.BSanalyze and select the batch SSVEP_online_accuracy_batch.



The x-axis specifies the time and the y-axis shows the classification error (blue line) and the false positive classifications (green line) in %. A sample is considered to be false positive classified if the assigned class is greater than 0 and not equal to the class expected for each trial. The red line marks the trigger, the LEDs start to flash. Before the trigger the classification result should be 0 and after the Trigger the error should be reduced significantly. The buffer length of 3s selected for the **Minimum Energy** and the **Moving Median** block of 2s causes an average delay of about 3s before the user action can be detected. In the shown example the break between two trials was selected to be 3s which is equal to the pre trigger time and the average interval required to detect that the user is not looking anymore at the previous LED. This is the main reason for the false positive classifications prior to the trigger.

SUMMARY

The new Simulink Highspeed On-line Processing blocks **g.USBamp** and **g.MOBIIab+** allows setting up a SSVEP Brain Computer Interface.

The parameter extraction is independent from the paradigm and the classifier, so it can be replaced by other algorithms. Also different classification methods can be used (Linear Discriminant Analysis, Support Vector Machine...).

To perform the tutorial the following components are required:

g.USBamp or g.MOBIlab+ biosignal acquisition device Simulink Highspeed On-line Processing blocks for g.USBamp or g.MOBIlab+ g.RTanalyze g.BSanalyze off-line processing toolbox g.STIMbox g.SSVEPbox g.GAMMAbox EEG electrodes and an EEG cap PC or notebook with USB connector or Bluetooth MATLAB and Simulink Release 2012a



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