cogniLink: A Non-Invasive Brain-Computer Interface That Enables Seamless Execution of Commands Through Thought Recognition

Project cogniLink

Abstract

Although great strides have been achieved in making computers more accessible, its indisputable that there remains huge prospects for improvement. Given that technology is designed for the masses, it offers every individual a platform to do what is needed; this includes, but isnt limited to, support for individuals with motor, dexterity, and/or speech impairments. In this proposal, we will discuss cogniLink, a tool that assists developers in making computers more accessible for persons with afflictions. cogniLink is a brain-computer interface that allows the user to trigger the execution of a command simply by thinking of the trigger. A training data set is to be collected from n-users in order to train n-models using an ElectroEncephaloGram (EEG). Each model is programmed to recognize one or more trigger thoughts. The same model interacts with a stack of software which allows it to map positive outputs from the model and transform it into an actionable command. For the purpose of demonstration, the model will be trained to recognize commands from one user which will be mapped to a virtualHID in such a way that allows the user to play Super Mario Bros. After an extensive process of training n-models, a universal model (UM) will be trained using data from the aforementioned n-models in order to have a simpler training process for new users. cogniLink will allow disabled people to execute commands in a very seamless and orderly fashion, thus making computers more accessible to persons with digital input impairments. Two of cogniLinks long term goals are to allow an amputee to be able to effortlessly be able to control a wheelchair in real time, and for someone suffering from Locked-In Syndrome to be able to interact with the world around them with ease.

1 Implementation

1.1 Tool Chain

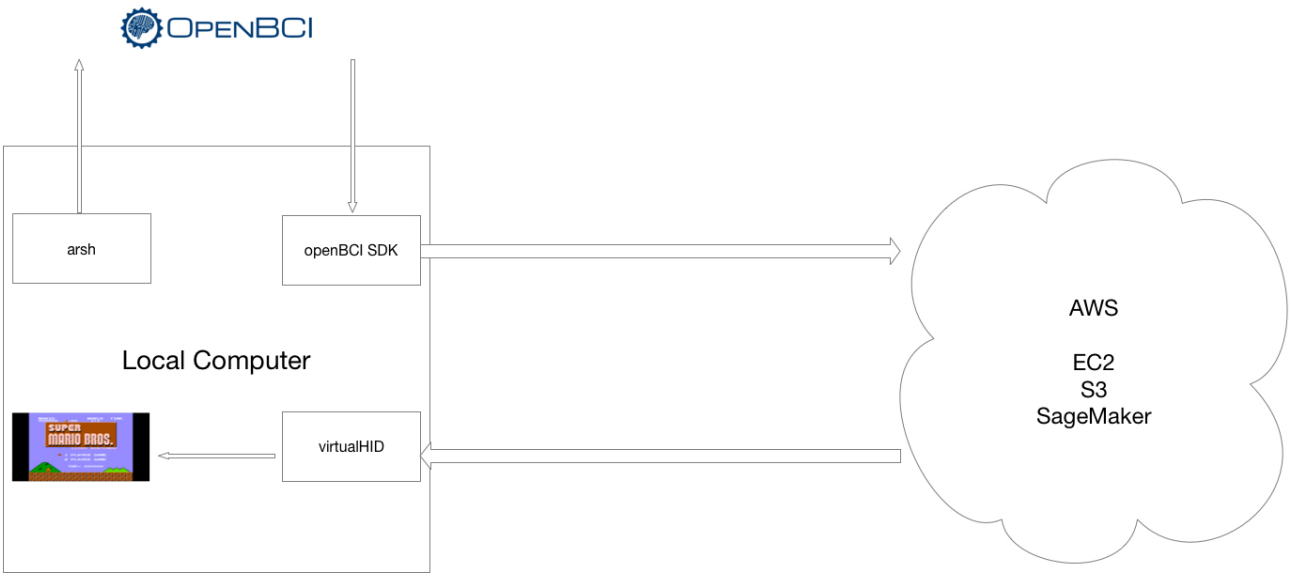

Figure 1: Tool Chain Diagram

Text about tool chain here Figure 1.

1.2 Project work plan

Work package description

Work package number	WP1	Starting week	1
Work package title	Virtual HID, Data Collection, and ML Code		
Participant number	1		
Short name	georgio		
Person-weeks	2		

Objectives

This work package has the following objectives:

1. To develop a Virtual Human Interface Device;
2. To develop an API that gathers raw data from the Cyton board and feeds it to a CSV file;

3. To write code needed to efficiently store and manage datasets;
4. To write code needed to start training Model 1 on Command A.

Description of work

Task T1.1: Task1 (W1-W1)
The virtualHID will be created using macOS' IOKit Library.

Task T1.2: Task2 (W1-W1)
The Cyton board will be programmed using arsh.

Task T1.3: Task3 (W1-W1)
API to gather data from Cyton Board will be built

Task T1.4: Task4 (W1-W2)
Code to manage raw EEG data will be done here.

Task T1.5: Task5 (W2-W2)
EC2, S3, and SageMaker instances will be configured.

Task T1.6: Task6 (W2-W2)
Code to feed raw data to S3 bucket will be done here.

Task T1.7: Task7 (W2-W2)
Code to start training the model will be done here.

Deliverables

D1.1 WP1 W1 Progress Report. **(W1)**

D1.2 Demonstration of APIs **(W2)**

D1.3 End of WP1 - Overall Progress Report. **(W2)**

D1.4 WP1 Code+Tools Merged to master. **(W2)**

Work package number	WP2	Starting week	2
Work package title	Model 1 Command A		
Participant number	1		
Short name	georgio		
Person-weeks	4		

Objectives

1. To collect training, validation, and test datasets for Model 1 Command A;
2. Training Model 1 using aforementioned data;
3. Testing/Patching Model 1.

Description of work

Task T2.1: Task1 (W2-W3)
Ways to efficiently collect data with high accuracy will be looked into; validated datasets will be used (if found) as a point of reference.

Task T2.2: Task2 (W3-W4)
The training dataset will be collected.

Task T2.3: Task 3 (W4-W5)
Model 1 will be trained using the aforementioned dataset.

Task T2.4: Task 4 (W4-W5)
Test and Validation datasets will be collected.

Task T2.5: Task 5 (W4-W5)
Test and Validation datasets will be collected.

Task T2.6: Task 6 (W4-W5)
All collected datasets will be uploaded to an AWS S3 Bucket.

Task T2.7: Task 7 (W4-W5)
Accuracy of trained model will be studied.

Task T2.8: Task 8 (W5-W6)
Patches and optimizations will be pushed in attempt to improve model accuracy, if possible.

Deliverables

D2.1 Report 1 about the data collection process and initiation of the first round of training. **(W4)**

D2.2 First iteration of the model. **(W5)**

D2.3 Report 2 about model accuracy after inputing initial test and validation datasets. **(W5)**

D2.4 Report 3 will include a comparative view of accuracy for each patch/iteration of the model. **(W6)**

D2.5 Second iteration of the model. **(W6)**

D2.6 Main Report with full progress update after the end of WP2. **(W6)**

D2.7 Video demonstration of thought recognition process. **(W6)**

Work package number	WP3	Starting week	6
Work package title	Model 1 n Commands		
Participant number	1		
Short name	georgio		
Person-weeks	6		

Objectives

This work package has the following objectives:

1. Link the output from the Model to the virtual HID created in WP1;
2. Map trigger thoughts to button presses;
3. Play a game of 1P Super Mario Bros.

Description of work

Task T3.1: Task1 (W6-W12)
Code for linking model to virtual HID will be rechecked and finalized.

Task T3.2: Task2 (W6-W12)
Model 1 will be trained for command B, and other commands simultaneously.

Task T3.3: Task3 (W12-W12)
A game of 1P Super Mario Bros will be played.

Deliverables

D3.1 A demonstration of the execution of alternating commands, after successful training of the second command to model 1. **(W8)**

D3.2 Report 1 on findings made while training new commands. **(W11)**

D3.3 Report 2 will comapre the variation of latency between the model and the virtual HID for each code patch. **(W12)**

D3.4 Code for virtual HID and updated Model 1 with multiple command recognition will be pushed to master. **(W12)**

D3.5 A demonstration of the ability to play a game of 1P Super Mario Bros using cogniLink. **(W12)**

D3.6 Main Report update with full progress accomplished after the end of WP3. **(W12)**

Work package number	WP4	Starting week	1
Work package title	Model 2 n Commands		
Participant number	1		
Short name	georgio		
Person-weeks	12		

Objectives

This work package has the following objectives:

1. Replicate all steps in WP2 and WP3 so that we get a Model 2 for a different individual trained on n the same n Commands as Model 1;
2. Play a game of 2P Super Mario Bros.

Description of work

Task T4.1: Task1 (W1-W12)
Here we will test the WP Task code.

Task T4.2: Task2 (W6-W9)
In this task UZH will integrate the work done in **??**.

Task T4.3: Task3 (W9-W12)
Here all the WP participants will apply the results to...

Deliverables

D4.1 Report on the definition of the model specifications. **(W36)**

D4.2 Report on Feasibility study for the model implementation. **(W12)**

D4.3 Prototype of model implementation. **(W24)**

Work package number	WP5	Starting week	1
Work package title	Optimizations		
Participant number	1		
Short name	georgio		
Person-weeks	12		

Objectives

This work package has the following objectives:

1. Optimizing the code in such a way that a trigger thought is recognized in realtime.

Description of work

Task T5.1: Task1 (W1-W12)
Here we will test the WP Task code.

Task T5.2: Task2 (W6-W9)
In this task UZH will integrate the work done in **??**.

Task T5.3: Task3 (W9-W12)
Here all the WP participants will apply the results to...

Deliverables

D5.1 Report on the definition of the model specifications. **(W36)**

D5.2 Report on Feasibility study for the model implementation. **(W12)**

D5.3 Prototype of model implementation. **(W24)**

Work package number	WP6	Starting week	1
Work package title	Real Life Application		
Participant number	1		
Short name	georgio		
Person-weeks	12		

Objectives

This work package has the following objectives:

1. Implement cogniLink to work on a controller of a wheelchair;

Description of work

Task T6.1: Task1 (W1-W12)
Here we will test the WP Task code.

Task T6.2: Task2 (W6-W9)
In this task UZH will integrate the work done in **??**.

Task T6.3: Task3 (W9-W12)
Here all the WP participants will apply the results to...

Deliverables

D6.1 Report on the definition of the model specifications. **(W36)**

D6.2 Report on Feasibility study for the model implementation. **(W12)**

D6.3 Prototype of model implementation. **(W24)**

Work package number	WP7	Starting week	1
Work package title	Universal Model, n Commands		
Participant number	1		
Short name	georgio		
Person-weeks	12		

Objectives

This work package has the following objectives:

1. Implement cogniLink to identify a thought and provide a way to communicate for a person suffering from Locked-In Syndrome;
2. To develop an API that gathers raw data from the Cyton board and feeds it to a CSV file;
3. To write code needed to efficiently store and manage datasets;
4. To write code needed to start training Model 1 on Command A.

Description of work

Task T7.1: Task1 (W1-W12)
Here we will test the WP Task code.

Task T7.2: Task2 (W6-W9)
In this task UZH will integrate the work done in **??**.

Task T7.3: Task3 (W9-W12)
Here all the WP participants will apply the results to...

Deliverables

D7.1 Report on the definition of the model specifications. **(W36)**

D7.2 Report on Feasibility study for the model implementation. **(W12)**

D7.3 Prototype of model implementation. **(W24)**

List of work packages

Table 1.2b: List of work packages

Work package number	Work package title	Lead participant no.	Lead participant name	Person-weeks	Start week	End week
WP1	Virtual HID, Data Collection, and ML Code	1	georgio	2	1	2
WP2	Model 1 Command A	1	georgio	4	2	6
WP3	Model 1 n Commands	1	georgio	6	6	12
WP4	Model 2 n Commands	1	georgio	12	1	36
WP5	Optimizations	1	georgio	12	1	36
WP6	Real Life Application	1	georgio	12	1	36
WP7	Universal Model, n Commands	1	georgio	12	1	36
	TOTAL			60		

List of deliverables

[1]

Table 1.2c: Deliverable list

Deliverable number	Deliverable name	WP no.	Lead participant name	Nature	Dissemination Level	Delivery date (proj. week)
D1.1	WP1 W1 Progress Report.	WP1	georgio	R	PU	1
D1.2	Demonstration of APIs	WP1	georgio	D	PU	2
D1.3	End of WP1 - Overall Progress Report.	WP1	georgio	R	PU	2
D1.4	WP1 Code+Tools Merged to master.	WP1	georgio	P	PU	2
D2.1	Report 1 about the data collection process and initiation of the first round of training.	WP2	georgio	R	PU	4
D2.2	First iteration of the model.	WP2	georgio	P	PU	5
D2.3	Report 2 about model accuracy after inputing initial test and validation datasets.	WP2	georgio	R	PU	5
D2.4	Report 3 will include a comparative view of accuracy for each patch/iteration of the model.	WP2	georgio	R	PU	6
D2.5	Second iteration of the model.	WP2	georgio	P	PU	6
D2.6	Main Report with full progress update after the end of WP2.	WP2	georgio	R	PU	6
D2.7	Video demonstration of thought recognition process.	WP2	georgio	D	PU	6

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[1] If your action taking part in the Pilot on Open Research Data, you must include a data management plan as a distinct deliverable within the first 6 weeks of the project. This deliverable will evolve during the lifetime of the project in order to present the status of the project's reflections on data management. A template for such a plan is available on the Participant Portal (Guide on Data Management).

D3.1	A demonstration of the execution of alternating commands, after successful training of the second command to model 1.	WP3	georgio	D	PU	8
D3.2	Report 1 on findings made while training new commands.	WP3	georgio	R	PU	11
D3.3	Report 2 will comapre the variation of latency between the model and the virtual HID for each code patch.	WP3	georgio	R	PU	12
D3.4	Code for virtual HID and updated Model 1 with multiple command recognition will be pushed to master.	WP3	georgio	P	PU	12
D3.5	A demonstration of the ability to play a game of 1P Super Mario Bros using cogniLink.	WP3	georgio	D	PU	12
D3.6	Main Report update with full progress accomplished after the end of WP3.	WP3	georgio	R	PU	12
D4.2	Report on Feasibility study for the model implementation.	WP4	georgio	R	PU	12
D5.2	Report on Feasibility study for the model implementation.	WP5	georgio	R	PU	12
D6.2	Report on Feasibility study for the model implementation.	WP6	georgio	R	PU	12
D7.2	Report on Feasibility study for the model implementation.	WP7	georgio	R	PU	12
D4.3	Prototype of model implementation.	WP4	georgio	R	PU	24
D5.3	Prototype of model implementation.	WP5	georgio	R	PU	24
D6.3	Prototype of model implementation.	WP6	georgio	R	PU	24
D7.3	Prototype of model implementation.	WP7	georgio	R	PU	24
D4.1	Report on the definition of the model specifications.	WP4	georgio	R	PU	36
D5.1	Report on the definition of the model specifications.	WP5	georgio	R	PU	36
D6.1	Report on the definition of the model specifications.	WP6	georgio	R	PU	36
D7.1	Report on the definition of the model specifications.	WP7	georgio	R	PU	36

1.3 Management and risk assessment

List of milestones

Table 1.3a: List of milestones

Milestone number	Milestone name	Related WPs	Estimated date	Means of verification
M1	Completed Development of Model 1 for Command A	WP 2	End of WP2 (add week number)	Execution of command using trigger thought

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Table 1.5a: Summary of staff effort

Partic. no.	Partic. short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total person weeks
1	georgio	**2**	**4**	**6**	**12**	**12**	**12**	**12**	60
Total		2	4	6	12	12	12	12	60

M2	Completed Development of Model 1 for Commands A and B	WP 3	mid WP3 (add week number)	Execution of alternating commands using trigger thoughts
M3	Completed Development of Model 1 for n-Commnands	WP 3	End WP3 (add week number)	Playing a game of 1P Super Mario Bros
M4	Completed Development of Model 2 for n-Commnands	WP 4	End WP4 (add week number)	Playing a game of 2P Super Mario Bros
M5	Transitioning from using virtual-HID on OpenEmu to Wheelchair in Realtime	WP 6	mid WP7 (add week number)	Driving a wheelchair with no hands
M6	Integration with Locked-In Patient	WP 6	End of WP7 (add week number)	Enabling a Locked-in patient to communicate using cogniLink
M7	Training Universal Model for n-Commands	WP 7	End of WP8 (add week number)	Ease of training models for new users

Critical risks for implementation

Table 1.3b: Critical risks for implementation

Description of Risk	WPs involved	Proposed risk-mitigation measures
The dedicated chip sent to fabrication is not functional.	WP **??**	Resort to Software simulations

1.4 Consortium as a whole

1.5 Resources to be committed

Summary of staff efforts

Other direct cost items (travel, equipment, other goods and services, large research infrastructure)

Participant no. 1 (georgio)	Cost (EUR)	Justification
Travel	2500	3 pairwise meetings for 2 people, 2 conferences for 3 people, 3 internal project meetings for 3 people
Equipment	3000	CAD workstation for chip design
Other goods and services	60000	Fabrication of 2 VLSI chips
Total	65500	

Participant no. 1 (georgio)	Cost (EUR)	Justification
Large research infrastructure	400000	Synchrotron

2 Ethics and Security

2.1 Ethics

2.2 Security

[2]

[2]Article 37.1 of the Model Grant Agreement: Before disclosing results of activities raising security issues to a third party (including affiliated entities), a beneficiary must inform the coordinator – which must request written approval from the Commission/Agency. Article 37.2: Activities related to "classified deliverables" must comply with the "security requirements" until they are declassified. Action tasks related to classified deliverables may not be subcontracted without prior explicit written approval from the Commission/Agency. The beneficiaries must inform the coordinator – which must immediately inform the Commission/Agency – of any changes in the security context and –if necessary – request for Annex 1 to be amended (see Article 55).