

# CortexType: Typing with your mind

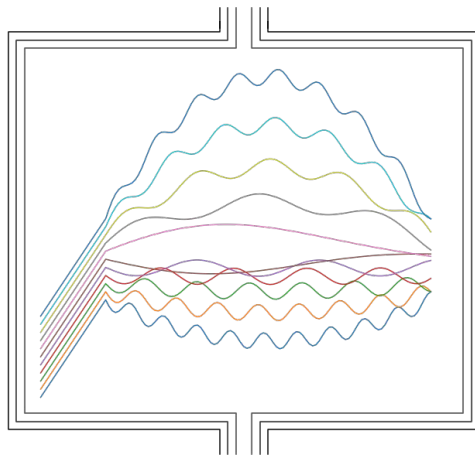
Neureality Hackathon (March 2024)

Team **Electric Sheep**:

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## Meet our team - **Electric Sheep!**



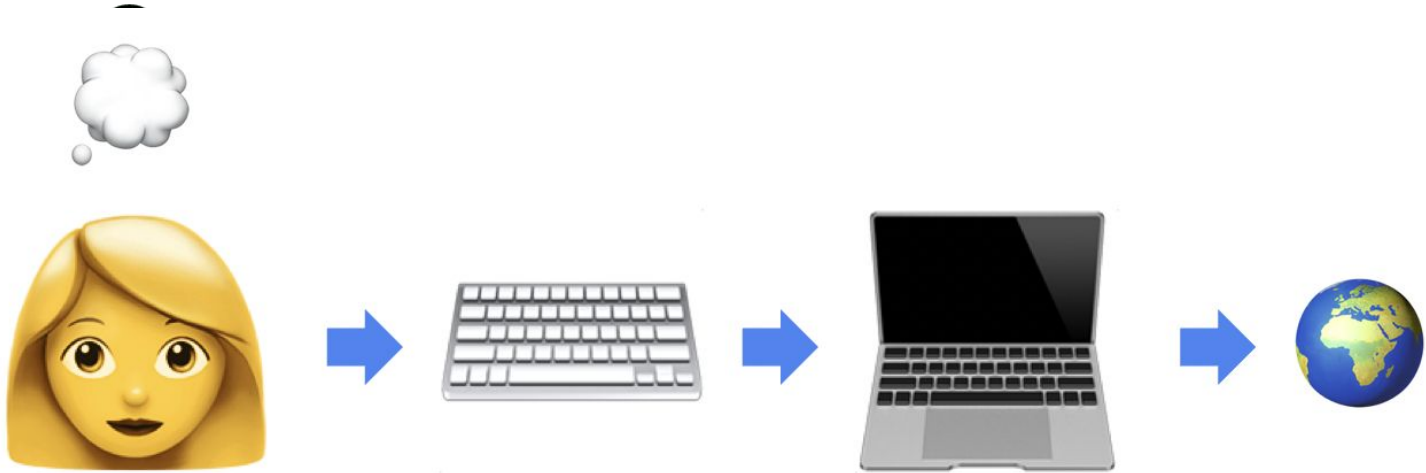
### **Our teammates (left to right):**

**@Joanna** - biomedical engineering grad at Columbia → responsible for BCI hardware and software setup

**@Kate** - data science grad at Carnegie Mellon University → responsible for modelling and coding scripts, team lead

**@Hussain** - phd at University of Toronto → participated in the final testing of the algorithm

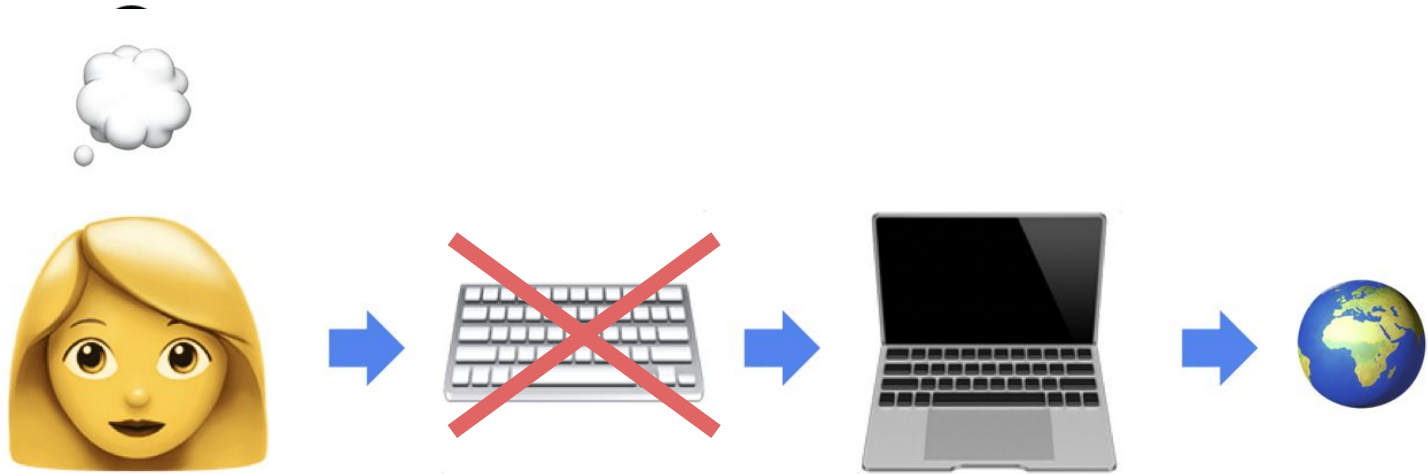
# Present communication



Typing is hard, slow, and boring.

But more importantly, it's not accessible for many people.

# What if...



What if there is no physical barrier between your mind and digital interface?

What if you could type just with your mind?

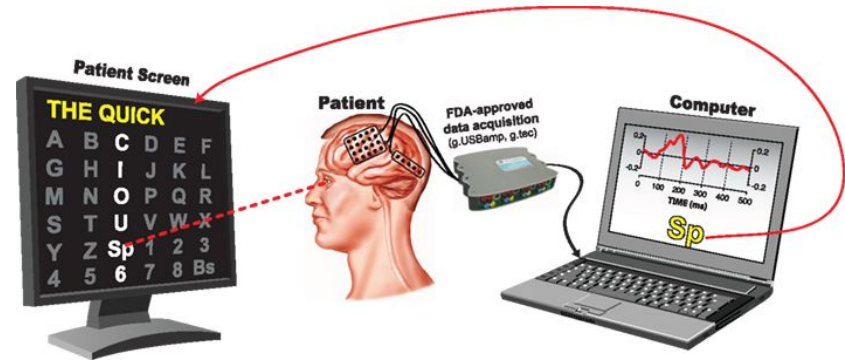
# Current tools - P300 BCI Speller

## Pros:

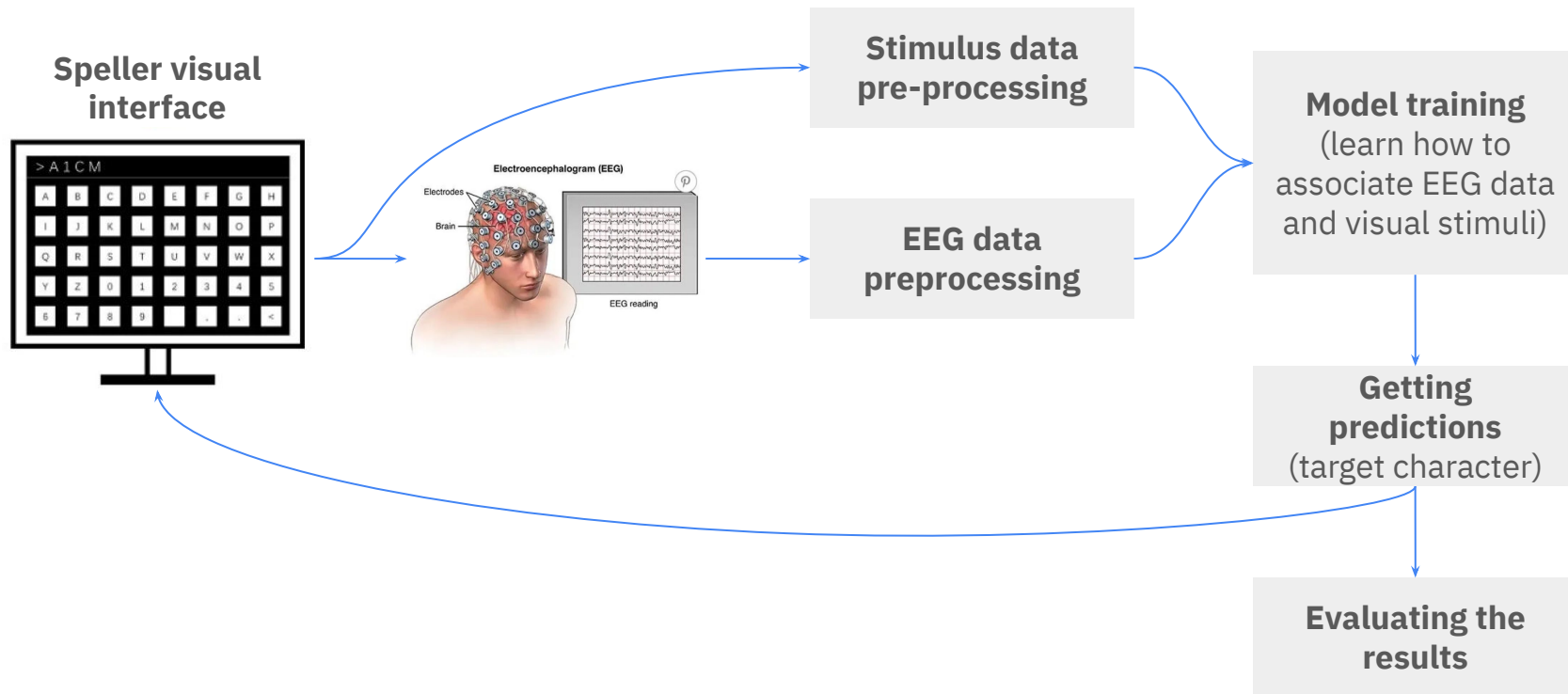
- Relatively high accuracy in detecting the focused character.

## Cons:

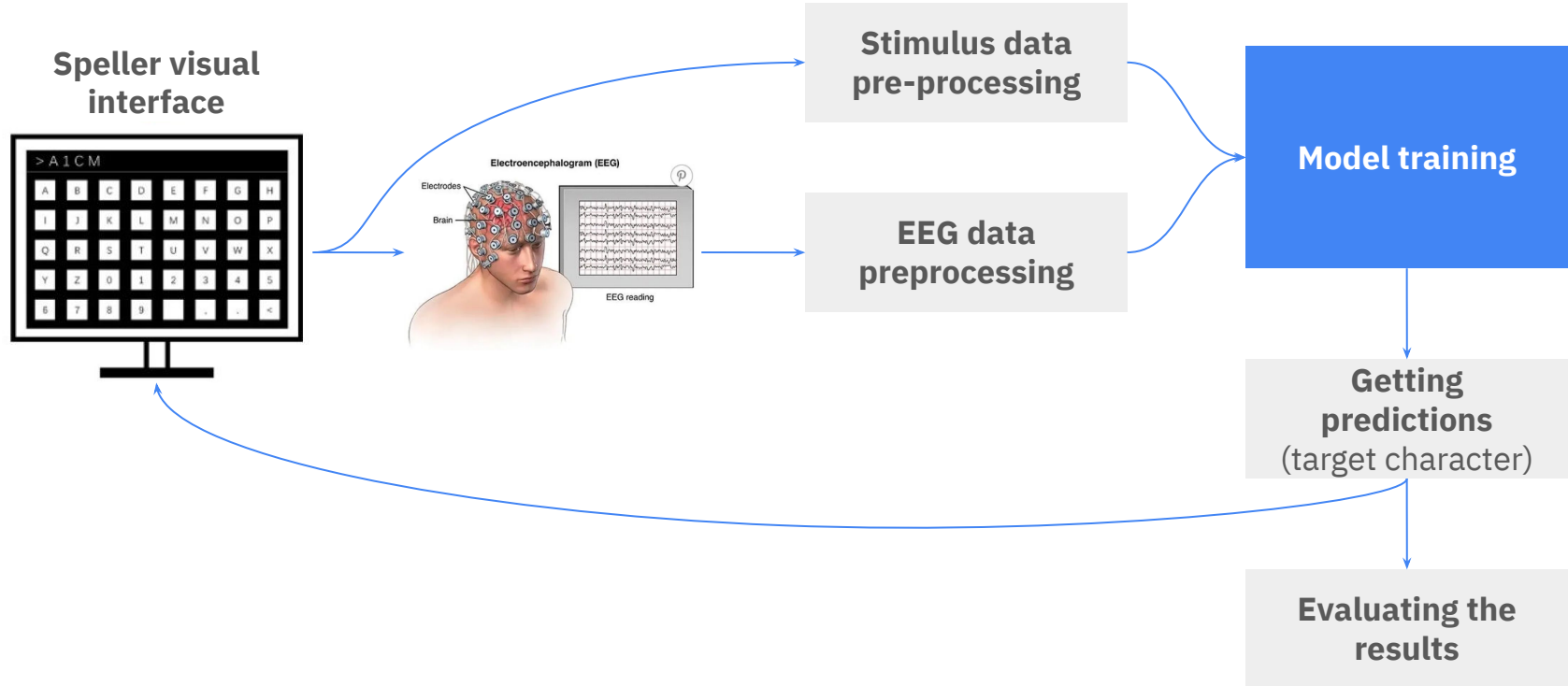
- Require extensive training and calibration for each user.
- Slow typing speed.
- Sensitive to external disturbances.



# Our goal - Make the P300 BCI Speller more accurate and fast

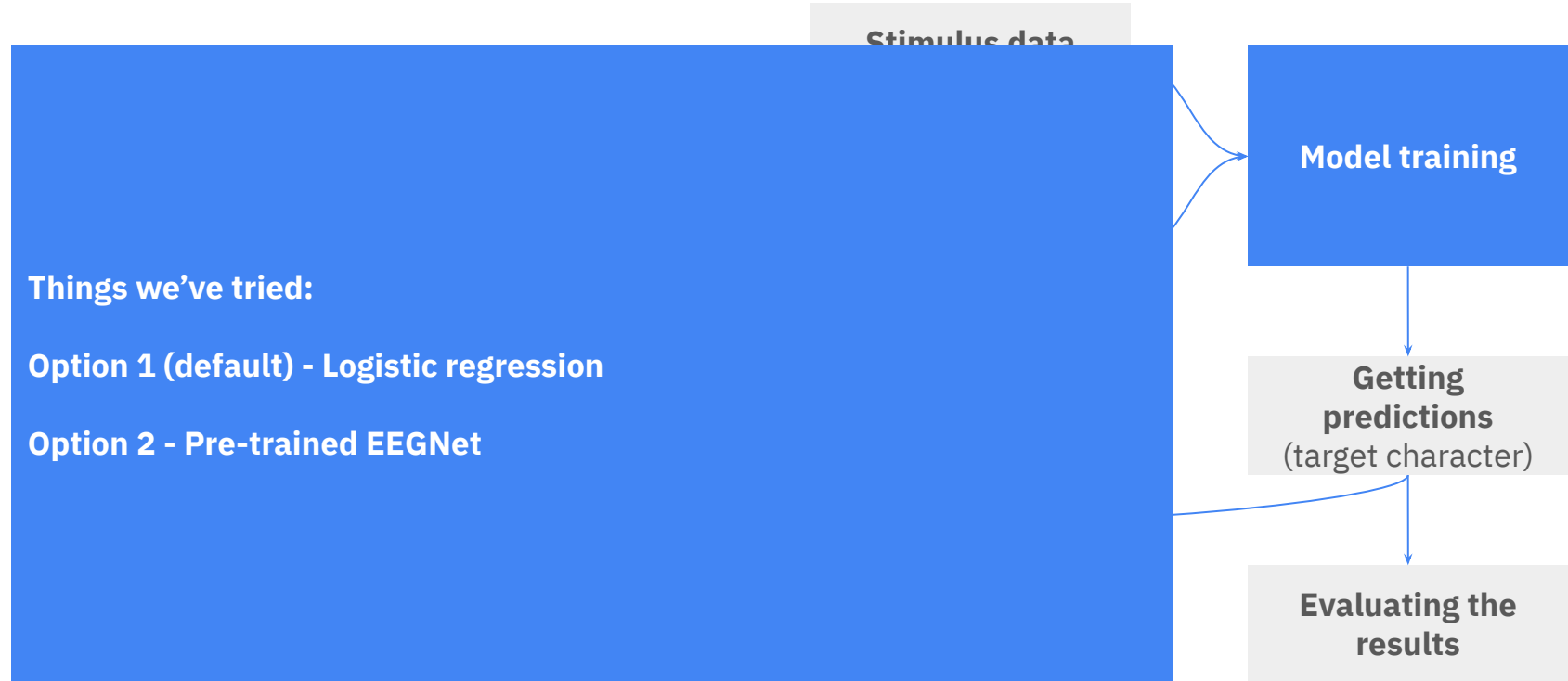


# Improving the model - classifier

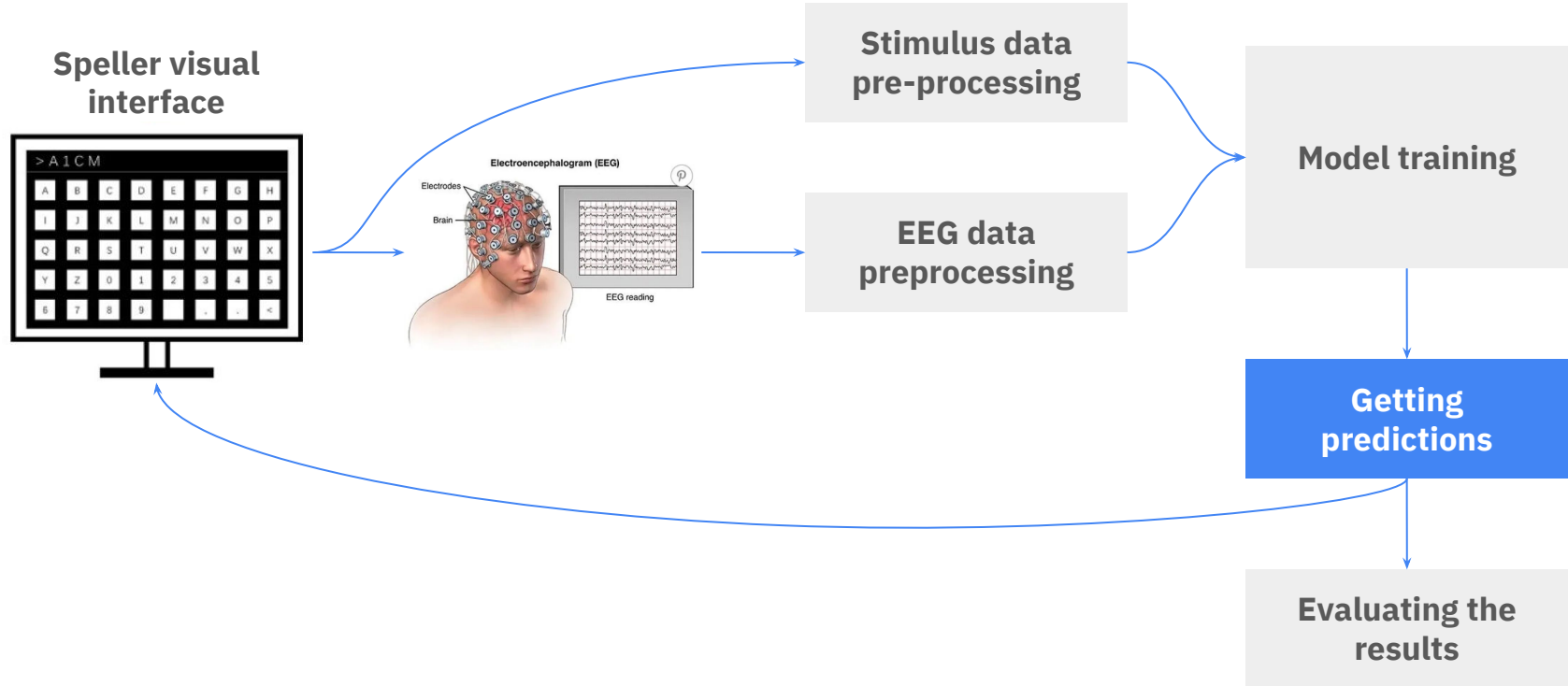




# Improving the model - classifier



# Improving the model - getting predictions



# Improving the model - **getting predictions**

Stimulus data

Things we've tried:

Option 1 (default) - Simple greedy decoding based on EEG (argmax)

Option 2 - Supplemented with 2 LLMs (BERT AND GPT-2) for next character prediction

Option 3 - Supplemented Option 2 with an LLM-module (GPT-2) fine-tuned on news about neuroscience-related hackathons

Model training

Getting predictions

Evaluating the results

# Improving the model - getting predictions

Stimulus data

Option 3 example (a mix of LLMs + finetuning):

The subject is trying to spell “N-E-U-R-E-A-L-I-T-Y”

The user already typed in “N-E-U-R-” and currently tries to add “-A”

```
EEG Predicted: A with probability 0.363
Bert Predicted: I with probability 0.009
GPT-2 Predicted: 0 with probability 0.168
GPT-2 Fine-tuned Predicted: 0 with probability 0.193
Final Prediction: A
Accumulated Text: NEURA
```

Model training

Getting  
predictions

Evaluating the  
results

## Training & testing - set up



- **EEG device:** g.tec Unicorn Hybrid Black Headset
- **Human subject:** our teammate Hussain (thanks, Hussain!)
- **Training:** multiple approaches (repeat trials of single or multiple letters)
- **Testing:** spell out the word N-E-U-R-E-A-L-I-T-Y

## Training & testing - demo



[LINK TO THE DEMO](#)

# Evaluation

- **Accuracy:** 53-60%\*
- **Speed:** 4-5 minutes to spell out N-E-U-R-E-A-L-I-T-Y

\* More comprehensive testing is required.

## Next steps

- Experiment with other EEG signal preprocessing and feature extraction techniques.
- Complete testing and adaptation of models developed during the hackathon the using the EEG equipment.
- Check the correlation between EEG-based model and LLMs.
- Consider introducing additional subject-specific layer to account for variability between users.
- Probably rearrange the keyboard (find the best combo of characters, consider grouping, and viz)



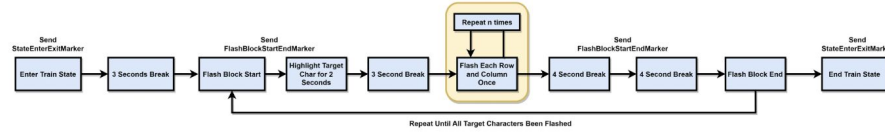
**Thanks, organizers! We had  
fun and learned a lot!**

# References

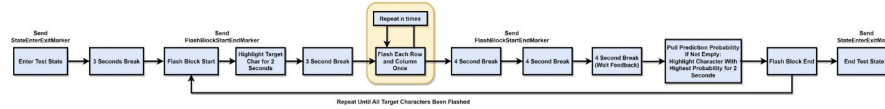
- PhysioLabXR-Community:  
<https://github.com/PhysioLabXR/PhysioLabXR-Community/tree/master>
- Neureality Hackathon: <https://neureality-cu.github.io/Neureality/hackathon.html>
- Pre-trained motor-imagery models:  
[https://neurotechlab.socsci.ru.nl/resources/pretrained\\_imagery\\_models/](https://neurotechlab.socsci.ru.nl/resources/pretrained_imagery_models/)

# Annex

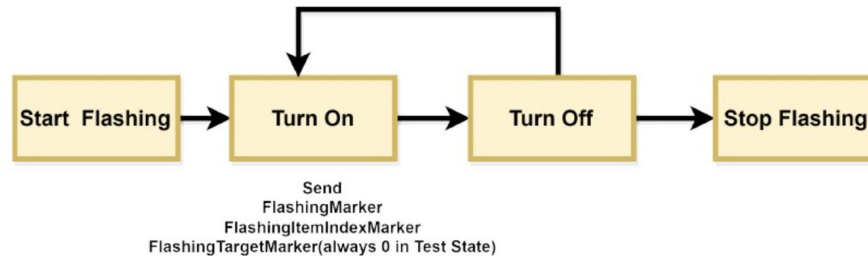
## Train State



## Test State



## Flash Block



Source: <https://physiolabxrdocs.readthedocs.io/en/latest/PhysioLabXRP300SpellerDemo.html>