EEG for real-time neurofeedback and BCI

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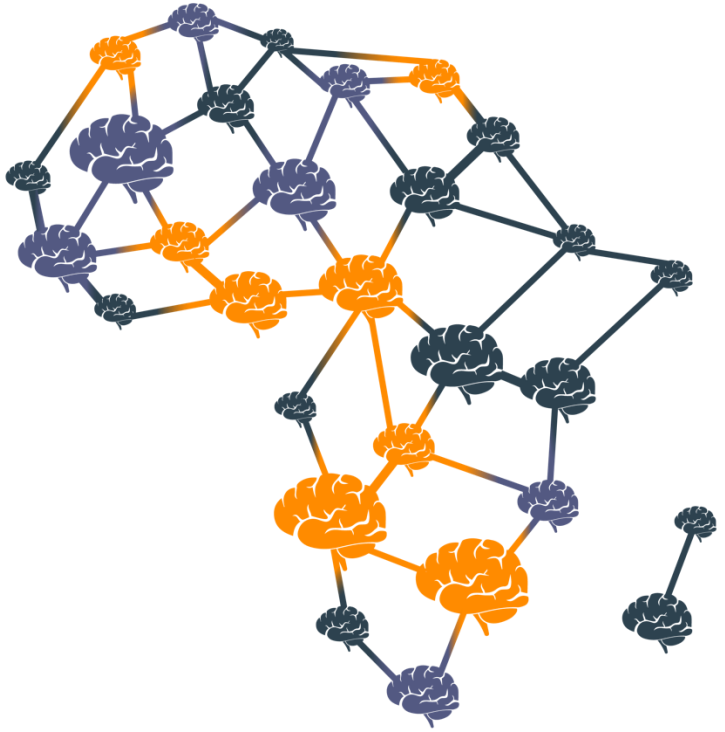
Port Harcourt, Nigeria



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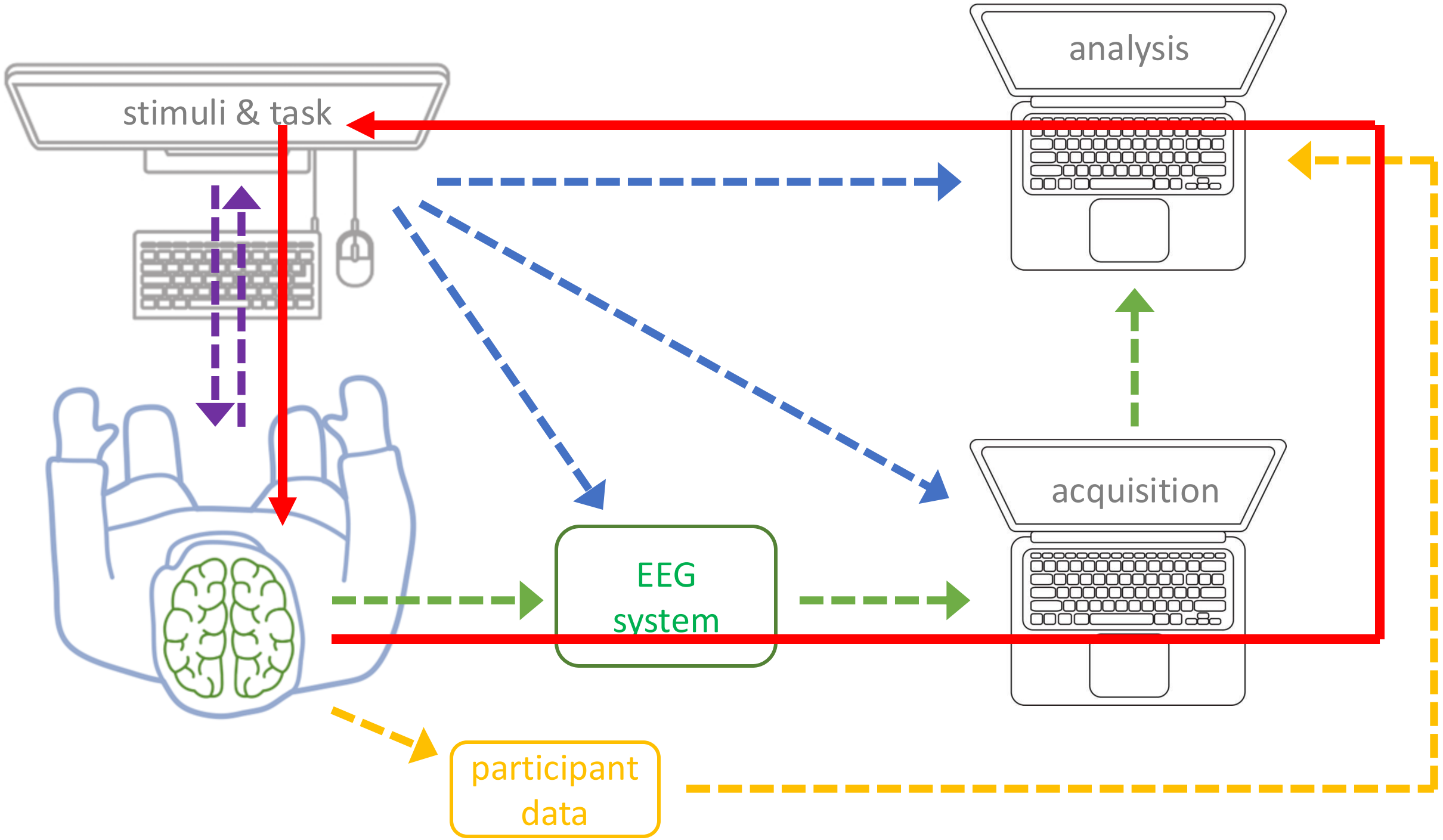
Outline and topics to cover

Why realtime analysis?

Some examples

Things to consider


analysis
stimuli & task
acquisition
EEG
system
participant
data

Neurofeedback

Use a real-time displays of the brain activity to teach self-regulation of brain function.

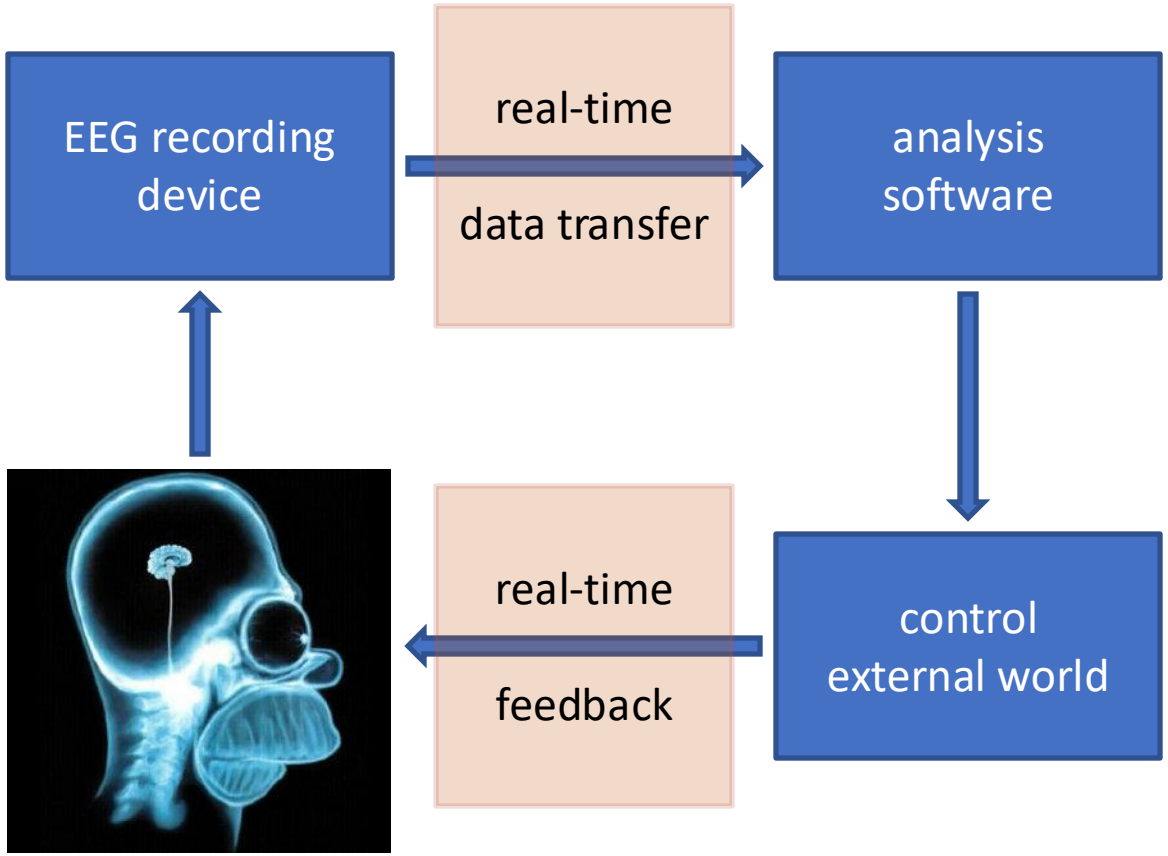
Has been investigated in relation to Mental Health Disorders, Cognitive Enhancement, Peak Performance, Sleep Disorders, Neurological Conditions, Stress Management, Brain Injury Rehabilitation, Addiction Treatment.

Brain-computer interface

Replace the normal “muscular” interaction with a device (such as controlling a computer with a mouse or joystick) by direct control from the brain.

Has been investigated in ALS, spinal cord injuries, comatose patients, but also in gaming application of healthy individuals

Streaming data in closed-loop systems



Note this goes clockwise, whereas the previous figure was counterclockwise

What features can we use in EEG-based BCI

Same analyses as in regular (offline) EEG analysis

- Event-related potentials
- Power in specific frequency bands (or power ratio's)

Which one is used depends on whether the brain activity is externally controlled and therefore whether the brain activity *timing* is known or not.

Synchronous BCIs versus Asynchronous BCIs

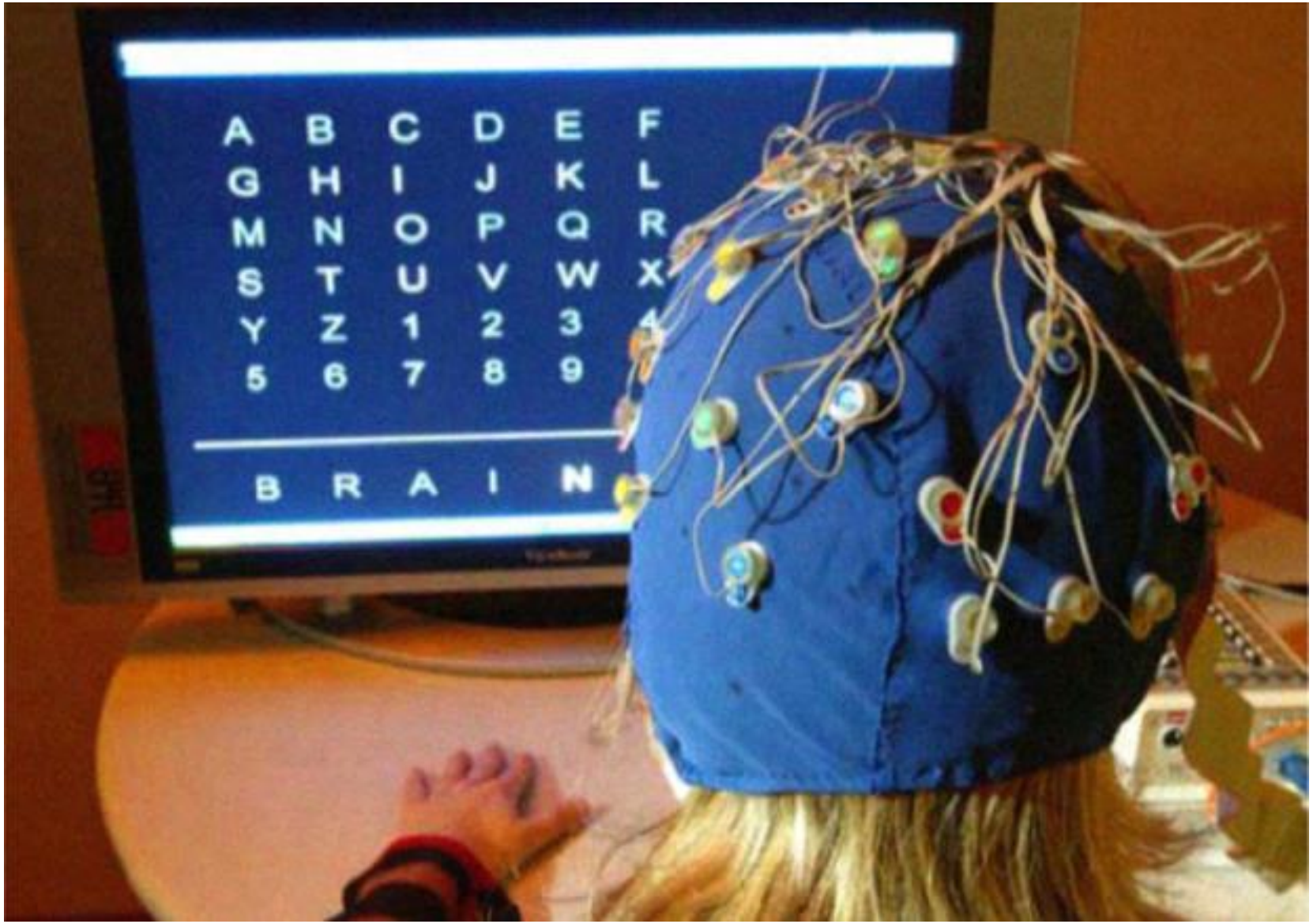
Active BCIs versus Passive BCIs

Invasive BCIs versus Non-invasive BCIs

EEG-only BCIs versus Hybrid BCIs

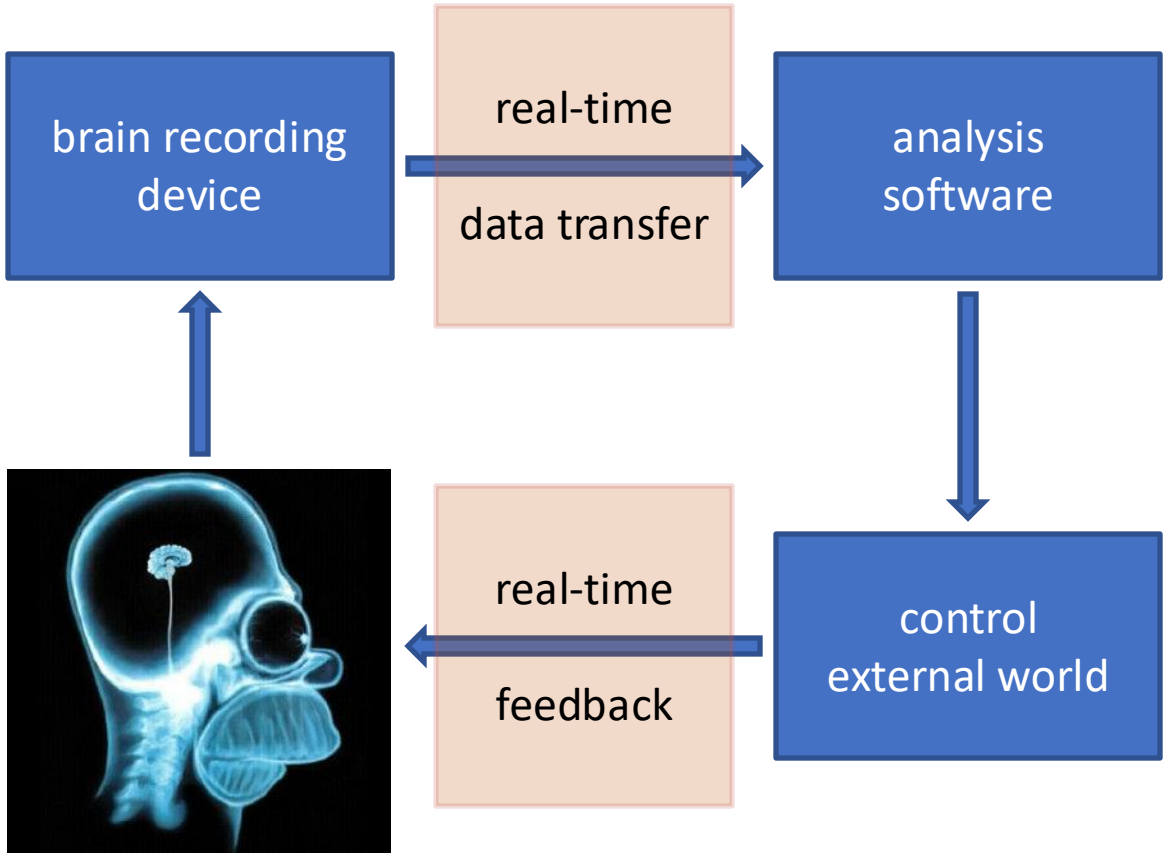
Brain pong

P300 matrix speller



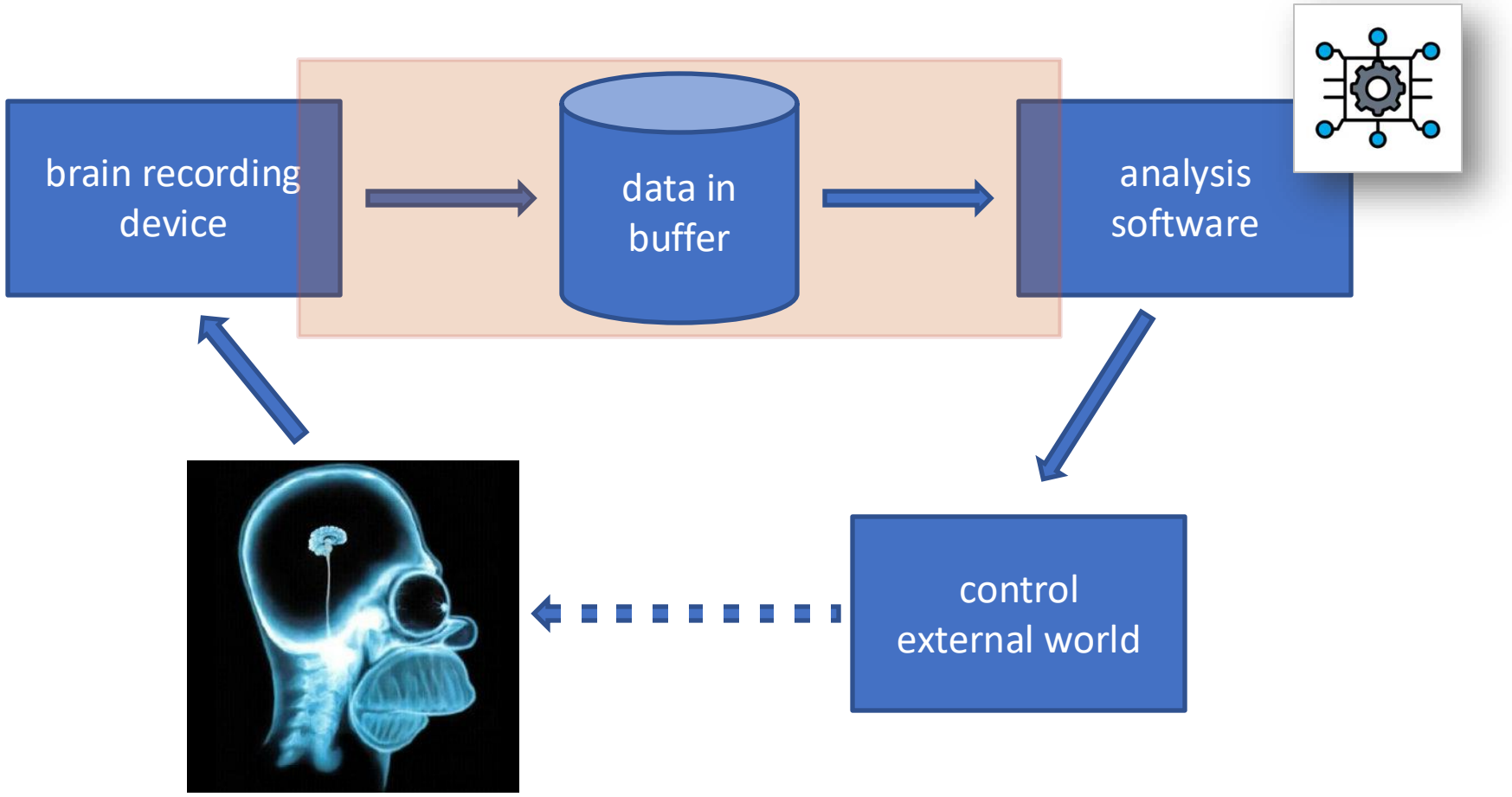
Invasibe BCIs for patients

Streaming data in closed-loop systems



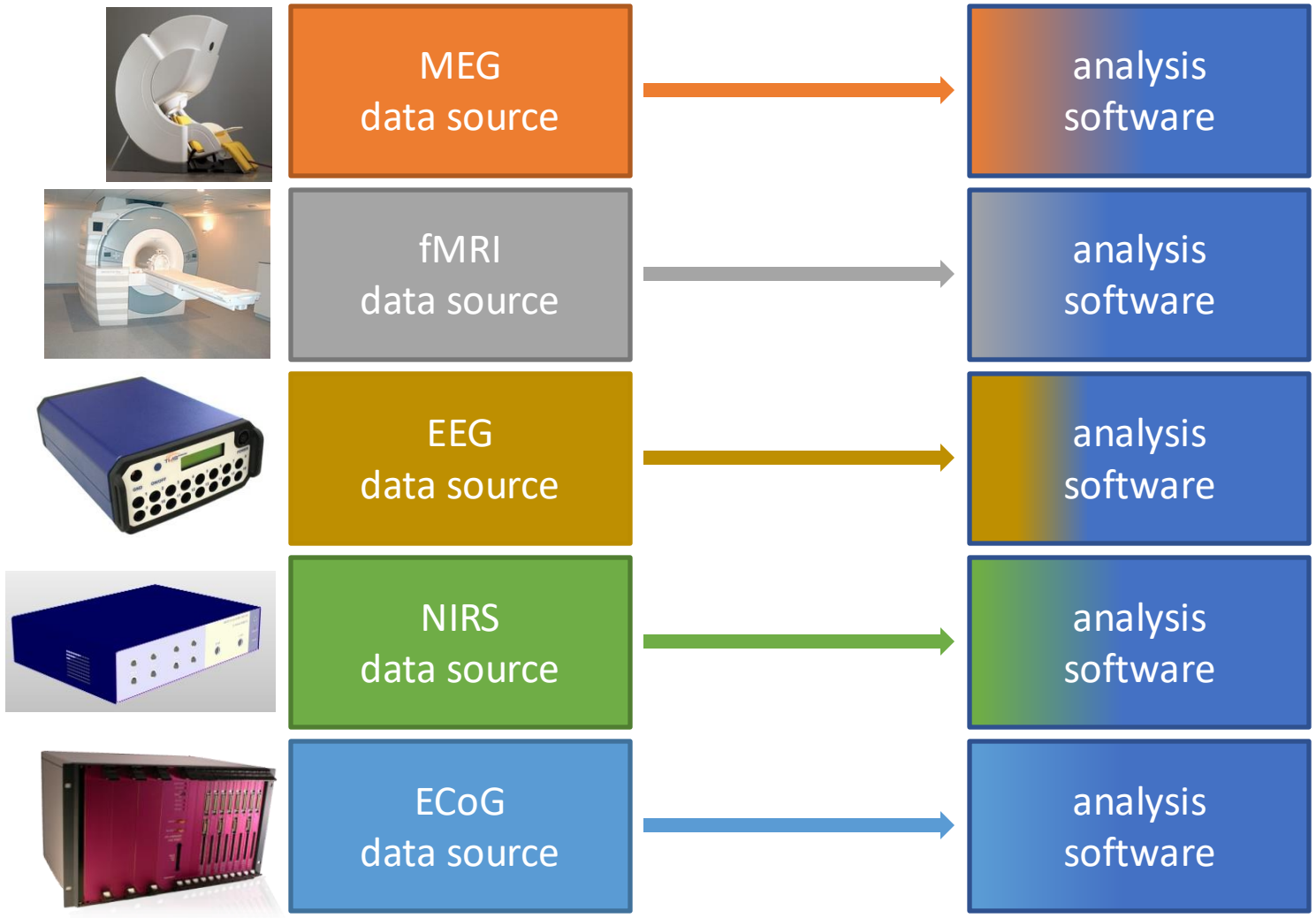
Handle the incoming data, do artifact detection, processing, translating to control signal … a pure real-time streaming protocol is hard to work with

Writing to disk (or buffering) relaxes timing constraints



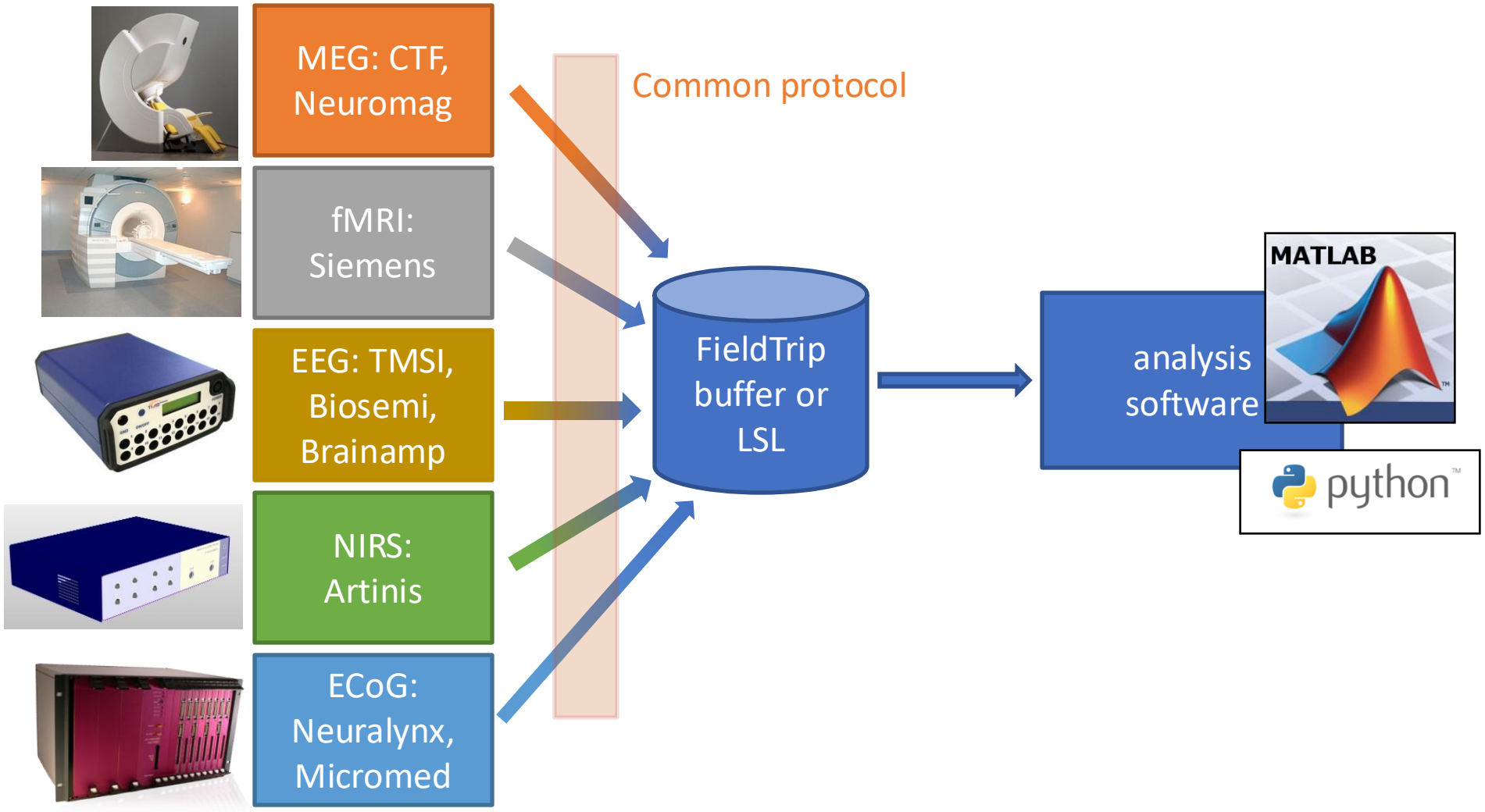
Most BCI systems are developed with data on disk and the loop is not really closed in real-time.
Often the interactive experimental design and the actual control are not even implemented.
Most BCI research focussed on the upper right corner.

Every device has its own interface



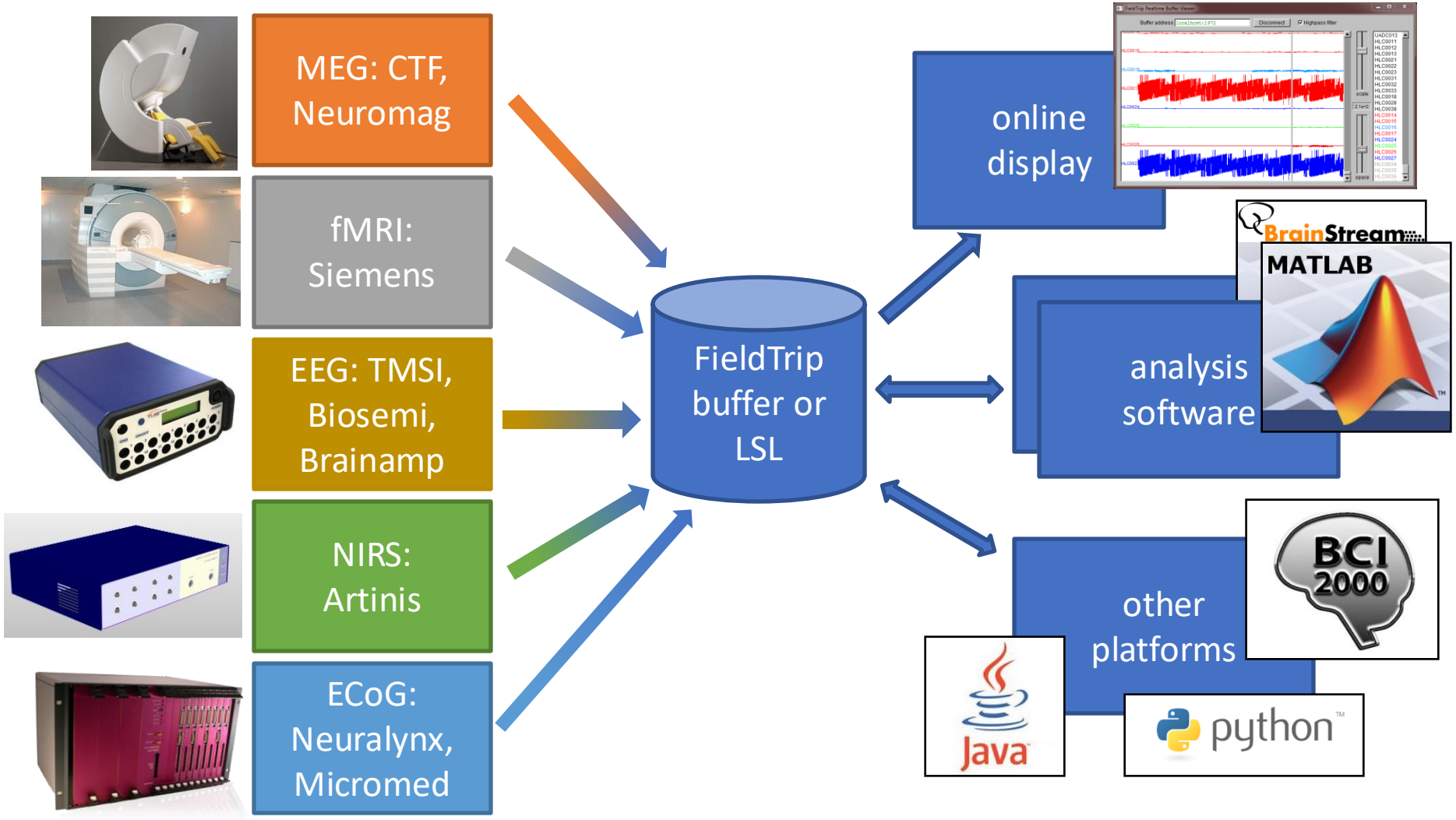
→ lots of device-specific code on analysis side

Use same protocol across devices



→ analysis side gets much simpler

Multiple „agent-based“ applications for analysis



→applications can also write to buffer, for example markers or events

What makes EEG-based BCI not so easy

Same artifacts as in normal EEG

Muscle, eye-blinks, movements

Detecting whether the patient/operator wants to use the BCI system or not requires another level of control. Imagine your fingers being glued to a keyboard and that you cannot stop typing.

What makes implementing a BCI system challenging

The task (or feedback) influences the EEG data.

The EEG data influences the task (or feedback).

You have to implement both, often in a single and tightly integrated programming environment.

It is not trivial to make either the realtime task, or the realtime analysis reusable.

Requires quite some programming and engineering skills.

Links

Software

https://www.bci2000.org

https://openvibe.inria.fr

https://labstreaminglayer.readthedocs.io

https://www.fieldtriptoolbox.org/development/realtime

https://pybci.readthedocs.io

https://eegsynth.org

Hardware

https://openbci.com

https://choosemuse.com

https://www.emotiv.com

http://unicorn-bi.com

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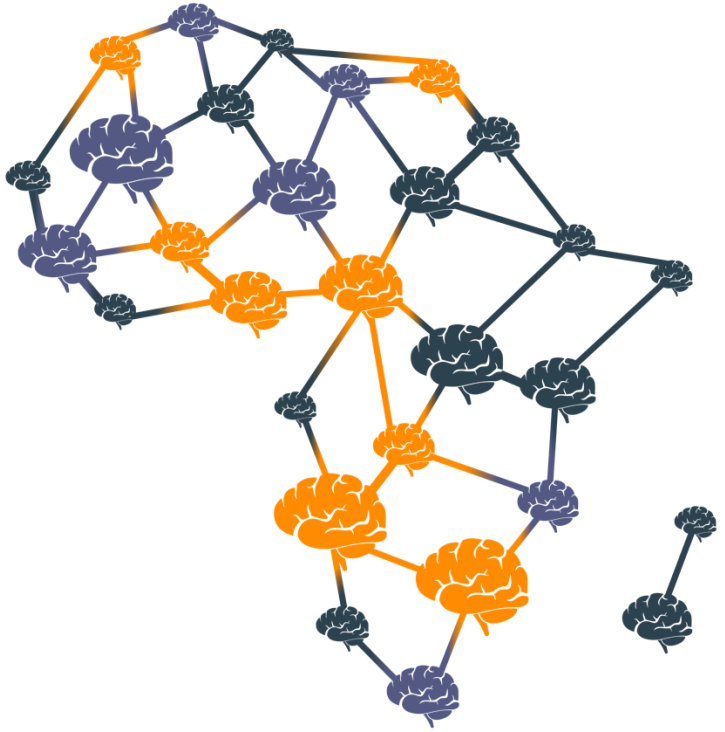

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