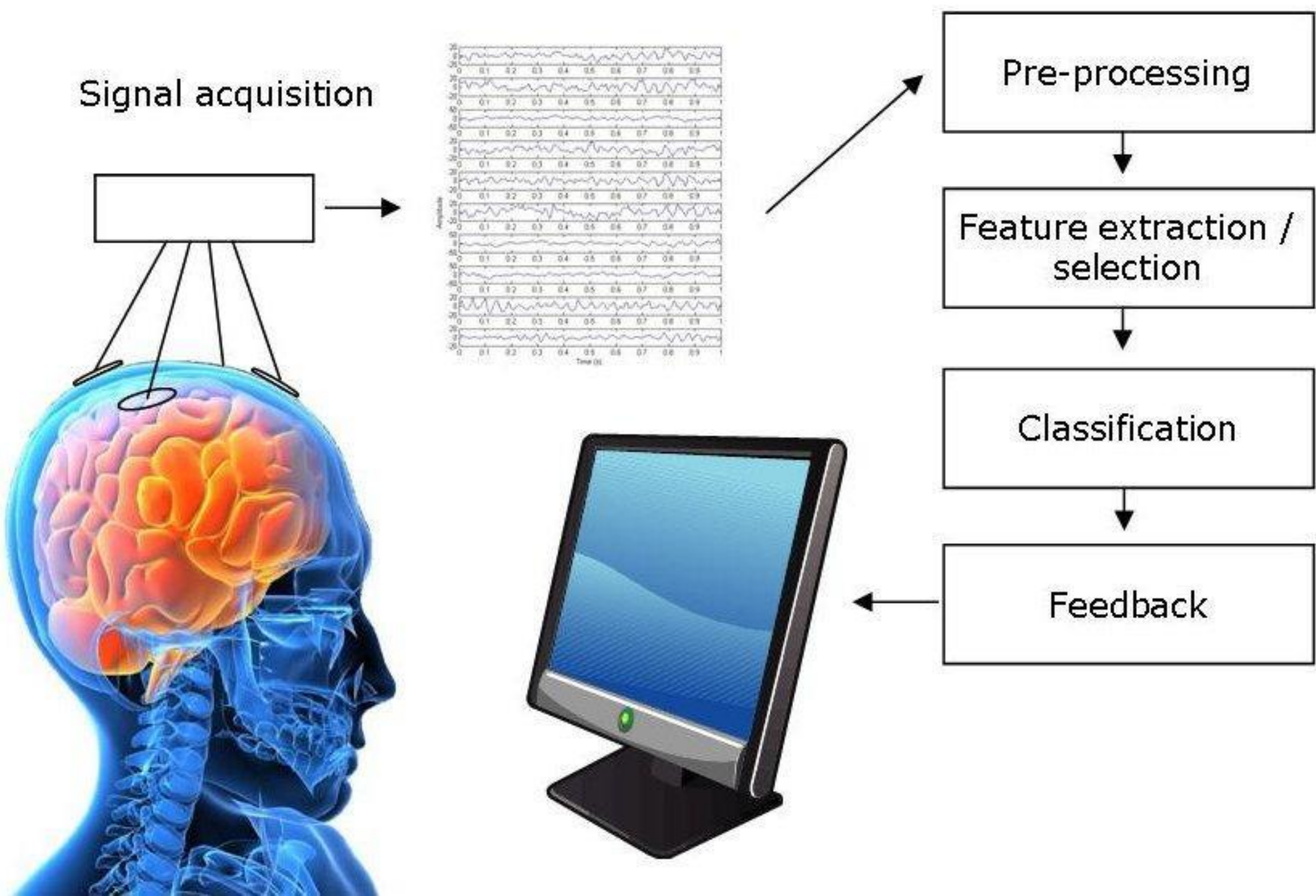


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Concepts and Abbreviations

- **Brain-computer interface (BCI)** – an integrated hardware and software device, designed to serve as a direct communication channel between the human brain and a computer application.
- **Aim of BCIs** – to open a window for paralyzed patients to communicate and regain control over the environment.
- **Noninvasive BCI systems** – monitor brain EEG signals; constantly searching for recognized patterns.
- **The “recognizable” patterns** – those that were previously learned by the BCI’s training module.
- **Command & Control** – The BCI online monitor maps the recognized patterns to online commands passed to the software application allowing the user to control it.



“Mind the Gap”

- **Dictation task** – “P300-speller paradigm”
- **Gap** – between the research-oriented systems and a practical “off the shelf” system for people who actually need it, such as the ALS patient community.
- **Challenges** – overcoming inherent noise of systems with dry EEG electrodes, suitable for daily usage / with minimal installation instructions suitable for uneducated support.
- **Reference Gold Standard** – systems with conducting gel (injected for each recorded electrode separately) with high standard signal quality levels.

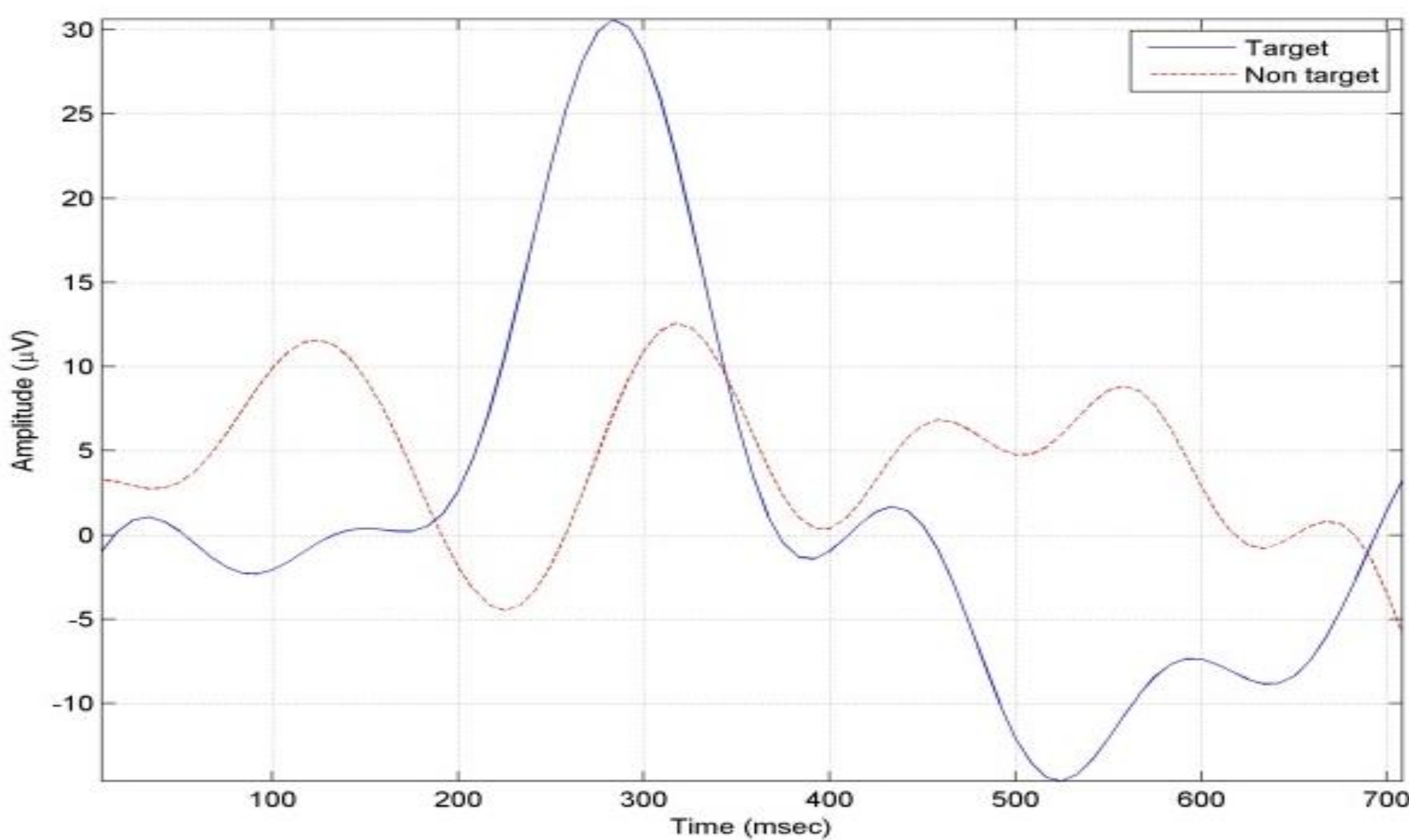
Goals

- Delivering a BCI spelling system of high performance in terms of letters per second suitable to low cost / easy-to-install EEG hardware.
- Open generic framework supporting various EEG systems and P300 analysis algorithms in a modular fashion. Such a framework allows for comparing the performance of different algorithms and of different wireless EEG systems.

Introduction

- **Event related potentials (ERPs)** – measurements of brain responses to specific cognitive, sensory or motor events.
- **Oddball paradigm** – presentations of sequences of repetitive audio/visual stimuli that are infrequently interrupted by a deviant stimulus. The subject is commonly asked to react by counting the deviant stimulus. This procedure, produces a positive peak in the EEG, ~300 msec after onset of the stimulus (**P300**).
- **P300** – a major peak of an ERP signal / one of the most used components for BCI.
- **P300 Wave** – amplitude of 2 to 5 μV with duration of 150 to 200 msec – low relative to background activities of the brain (in the rage of 50 μV).
- **Ensemble averaging** – summation of multiple EEG responses enhances the P300 amplitude while suppressing background EEG activities.

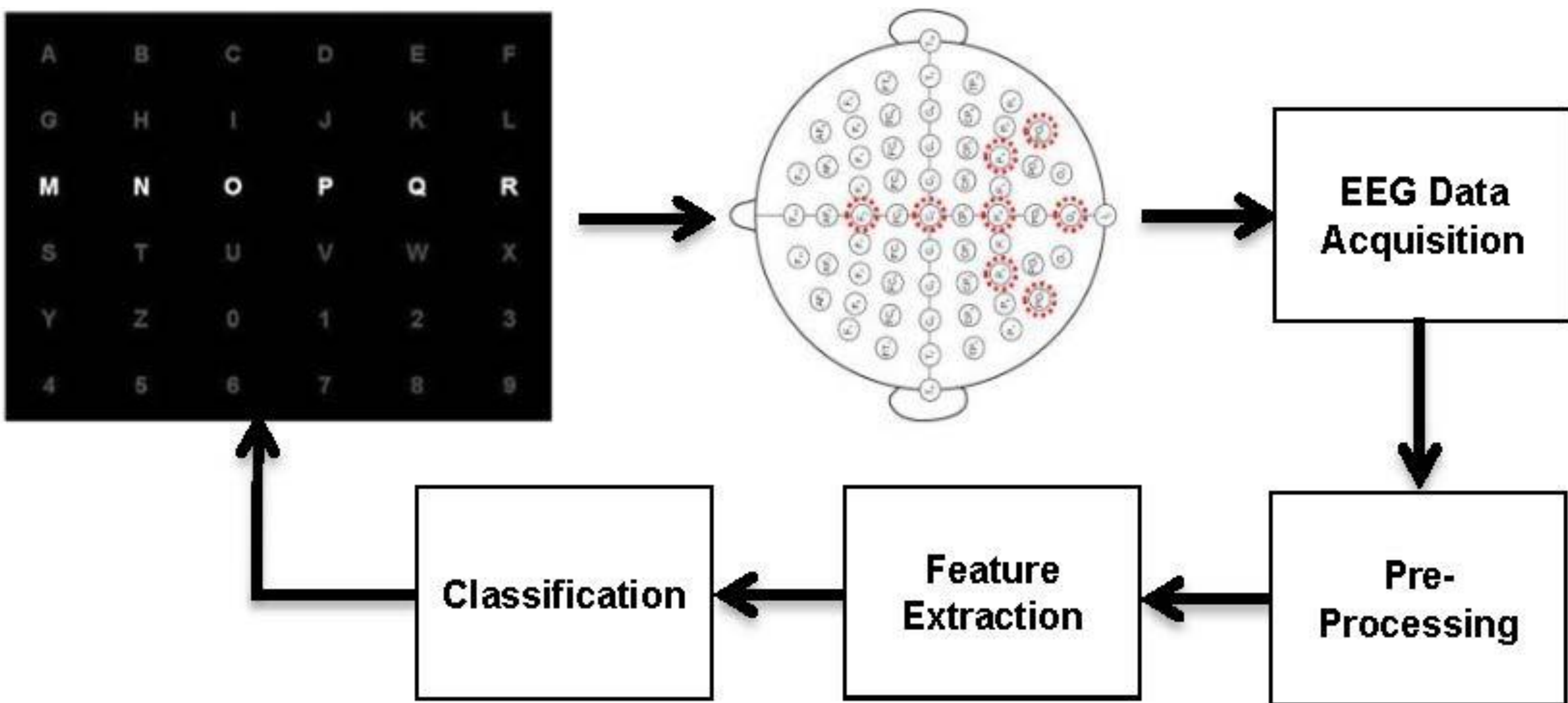
Setare Amiri et. al.; 2013 <http://cdn.intechopen.com/pdfs-wm/44907.pdf>



Classical paradigm

- P300-based BCI speller was originally introduced by Farwell and Donchin in 1988.
- A Row-Column (RC) 6 \times 6 matrix of characters presented on a computer screen.
- The RC are flashed in a random order.
- The user is instructed to select a character by focusing on it.
- The flashing RC evokes P300 response in EEG -> The computer determines the desired RC after averaging several responses -> the desired character is selected.

Setare Amiri et. al.; 2013 <http://cdn.intechopen.com/pdfs-wm/44907.pdf>



Identified limitations of classical approach

- A limited and non familiar character layout
- Low spelling rate – 10-15 seconds for a single letter
- Annoying row / column flashes

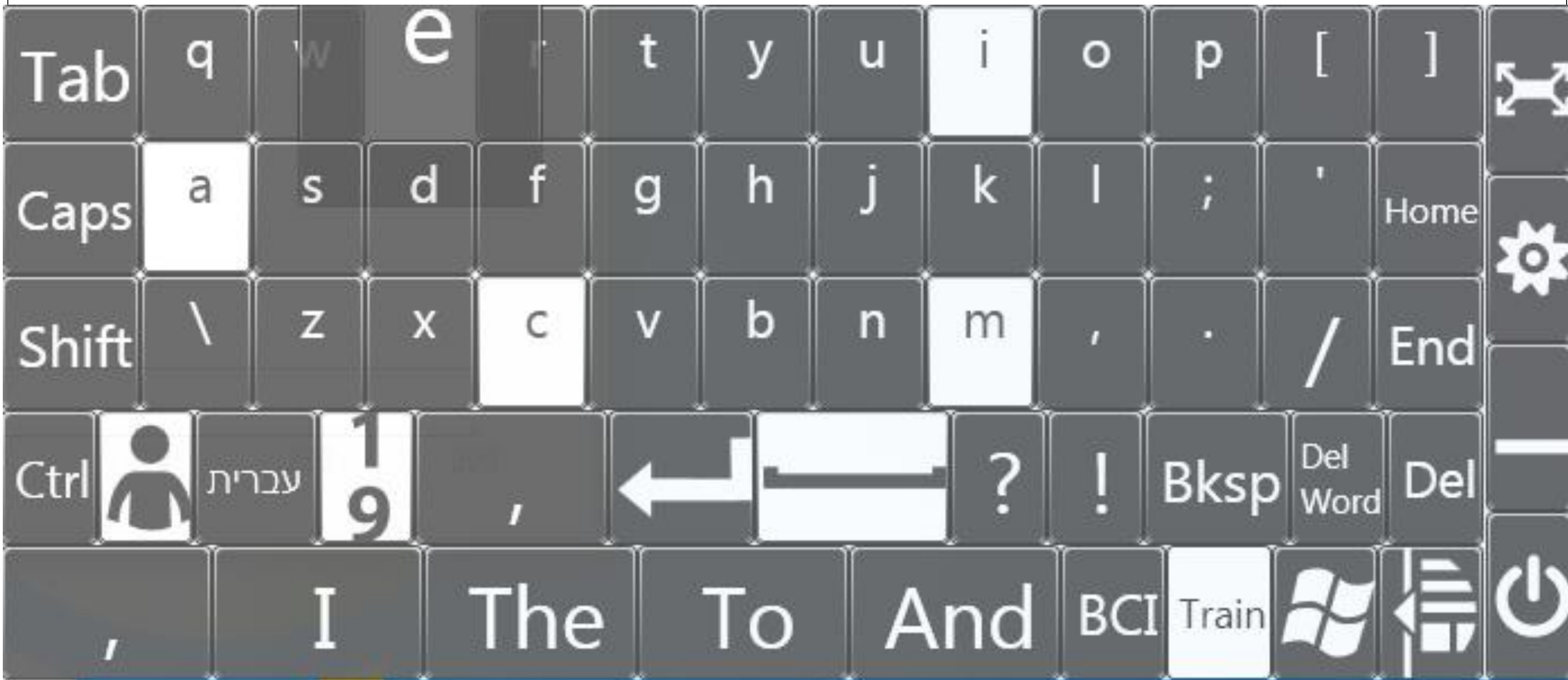
Suggested solution

- A standard (qwerty) virtual keyboard, with layout supporting around 70 keys.
- Keys with dynamic content are used by an auto-completion / spelling correction algorithms developed by third parties – accelerate spelling rate.
- A simultaneous "click like" UX (user experience) on a group of keys at a time spread in a “random like” manner across the entire layout, replaces the annoying Row/Column flashes. A settings panel lets the user choose his “click like” UX preference.
- Machine learning logic controls the “random like” clicks to facilitate single key readout replaces traditional two clusters (Row/Column) intersection logic.
- Support of multiple algorithmic objects performing different P300 classification approaches – all feeding a novice confidence decision logic.



Gal Sont was diagnosed with ALS 6 years ago. This doesn't stop him from doing the thing he loves most – writing code. Gal is in charge of writing the code for the client side of the project on top of being our test subject.

In this photo, his is wearing a wireless EEG system (g.Tec, g.Nautilus) that we are using for the project.



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