Hacking the Brain: Machine Learning and Human Behavior

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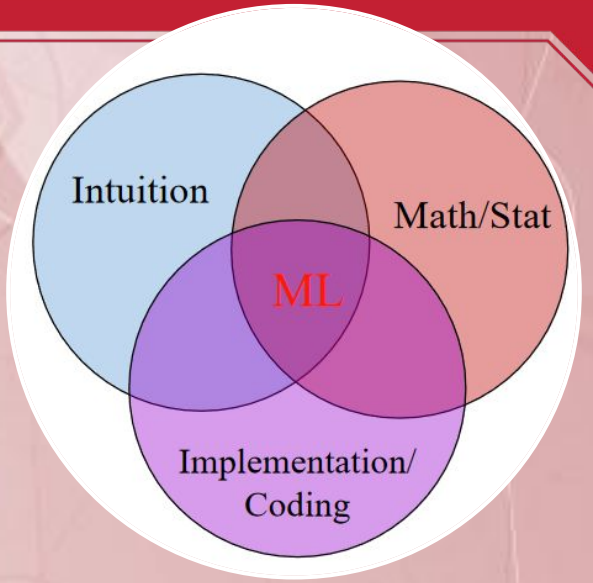
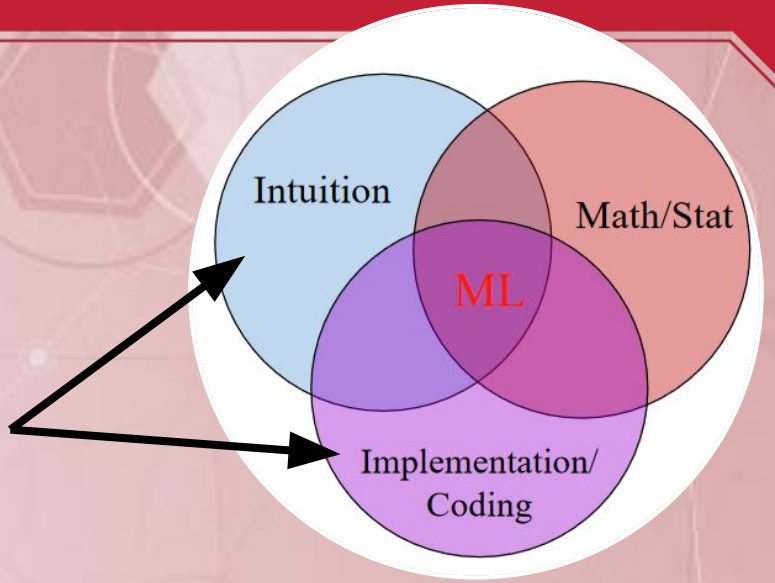


Machine Learning

The capability of a machine to imitate intelligent human behavior

We will be focusing on these two today!



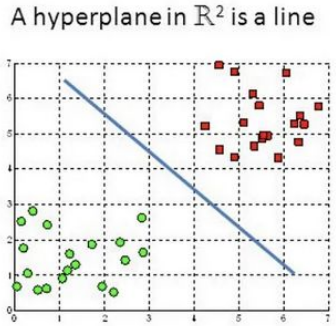
Machine Learning

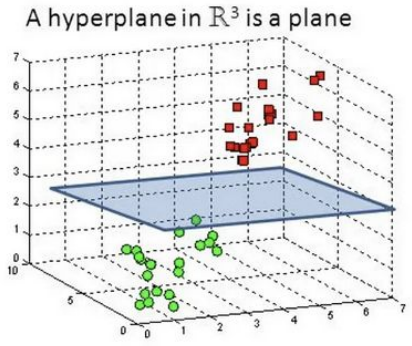
The capability of a machine to imitate intelligent human behavior

Machine Learning Classification

Intuition

Dividing data by a “decision boundary”

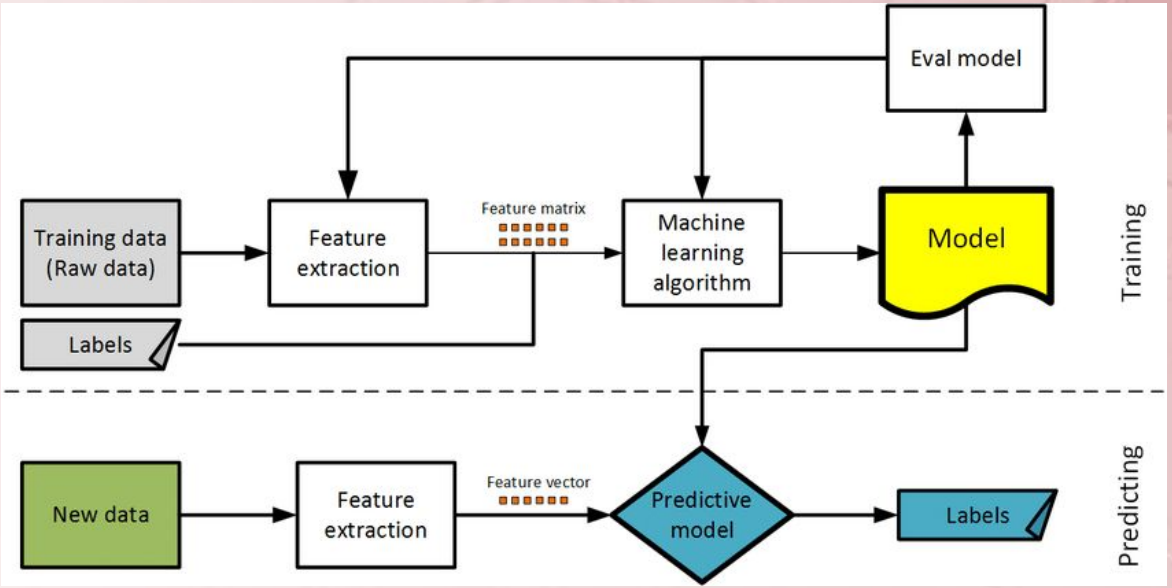




Implementation/Coding

Python packages

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import ruptures as rpt
import scipy.optimize as scp
from sklearn.preprocessing import StandardScaler
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis as LDA
from sklearn.model_selection import train_test_split
from sklearn.utils import shuffle
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import RepeatedStratifiedKFold
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn import svm
```



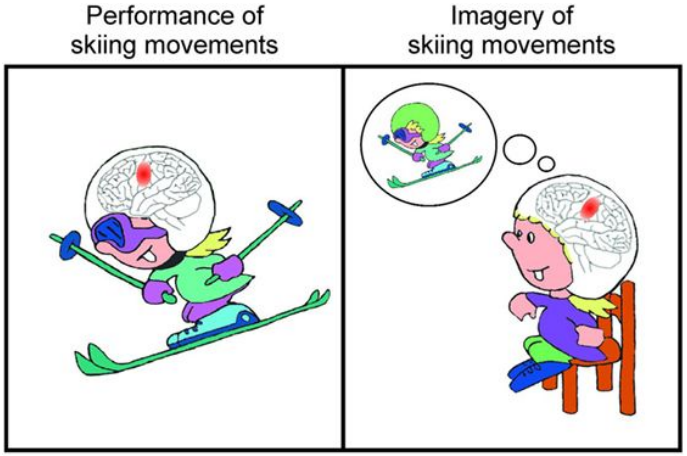
1. Raw data
2. Feature Extraction
3. Training
4. Testing

Machine Learning in a Nutshell

Today: Machine Learning in Motor Imagery

https://www.bbci.de/competition/iv/#dataset2a

Experimental Setup



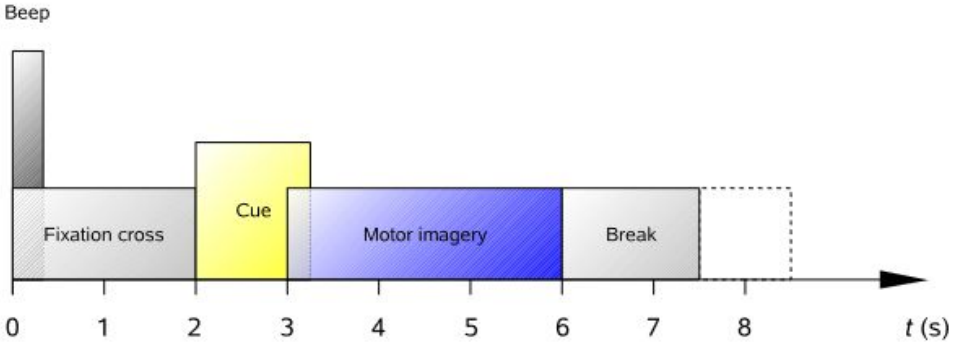


Figure 2: Timing scheme of the paradigm.

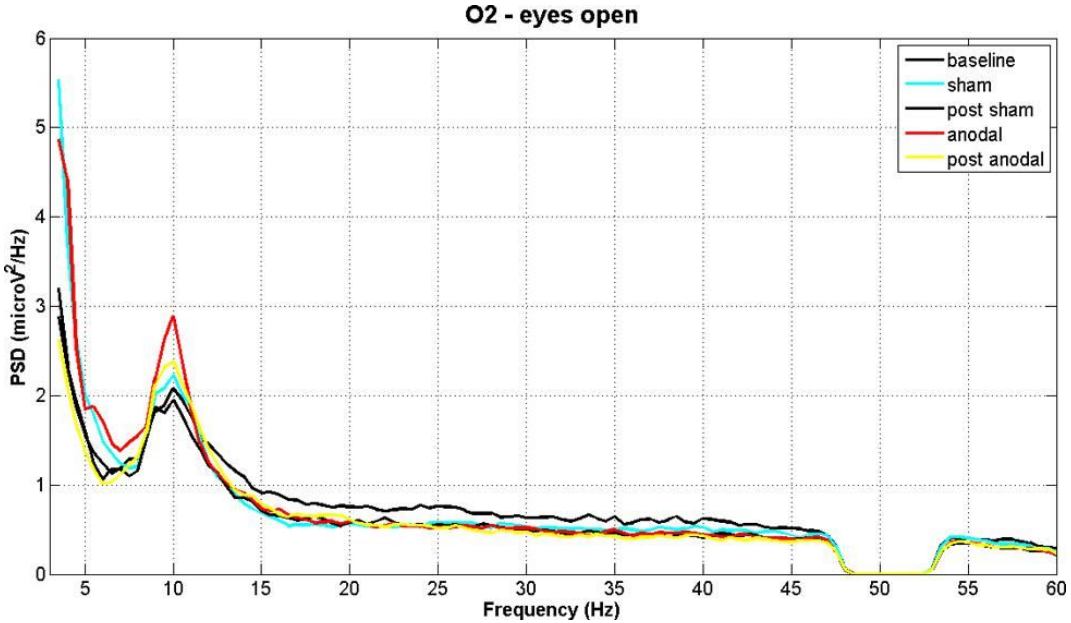
Experimental Setup

Event	type	Description
276	0x0114	Idling EEG (eyes open)
277	0x0115	Idling EEG (eyes closed)
768	0x0300	Start of a trial
769	0x0301	Cue onset left (class 1)
770	0x0302	Cue onset right (class 2)
771	0x0303	Cue onset foot (class 3)
772	0x0304	Cue onset tongue (class 4)
783	0x030F	Cue unknown
1023	0x03FF	Rejected trial
1072	0x0430	Eye movements
32766	0x7FFE	Start of a new run

1. Raw Data - Visualization

Need a way to view raw data

- Introducing: Power Spectral Densities!
  - Measure of the signal's power at each frequency



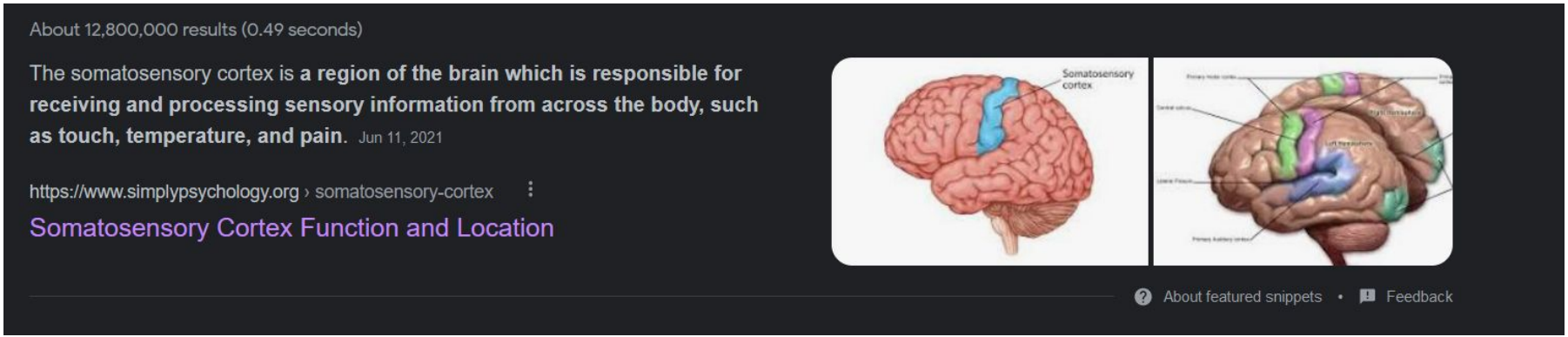
2. Feature Extraction

Need a way to extract meaningful features from our data!

2. Feature Extraction

We can find EEG channels that are associated with this cortex!

- C3, C4, Cz

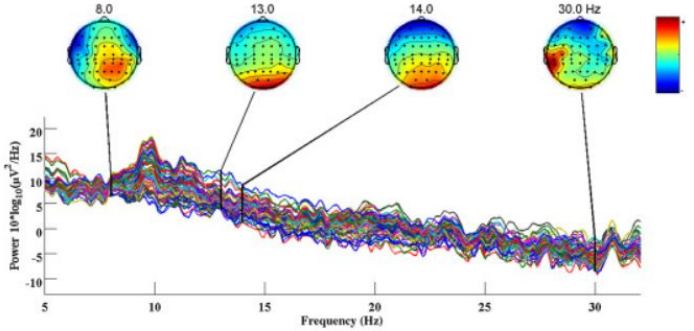


2. Feature Extraction

Are there relevant frequencies that we should be looking at?

2.2 Motor imagery classification

In addition, to examine the motor imagery classification, the BCI Competition IV calibration dataset, which is a two-class dataset, is used [24]. The data were recorded using the appropriate sensors from 59 different positions, which correspond to seven different subjects and represent the left hand and right foot motor imagery. For motor imagery classification, the desired frequency band is 8–30 Hz. This frequency band contains alpha (8–13 Hz) and beta (14–30 Hz) waves. These frequency bands are shown in Fig. 2.2. So, a band-pass filter is used for the filtering process that passes the desired frequency band and rejects others. The type of the filter is third Butterworth.



5. Iterate and Update Processes

Are there any other processing techniques we could use?

Enter: Common spatial patterns!

- Common signal processing technique in neuroscience:
  - Idea: Separate two classes as much as possible