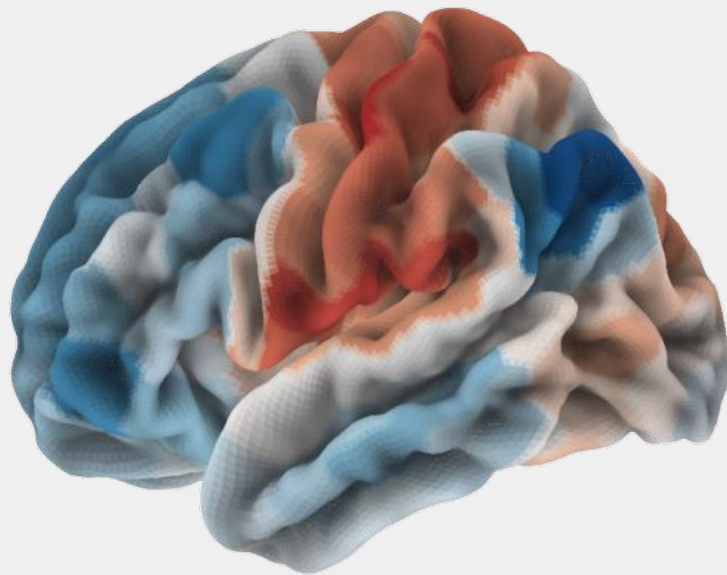


Fundamentals of fMRI data analysis

Karolina Finc

Centre for Modern Interdisciplinary Technologies

Nicolaus Copernicus University in Toruń



COURSE #2: fMRI data manipulation and plotting in python

Study plan

Open science &
neuroimaging

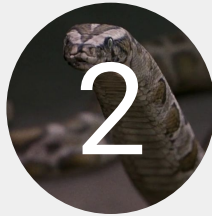


BEFORE

fMRI data
preprocessing



fMRI data manipulation
in python



Functional
connectivity



General
Linear Model



AFTER



Machine Learning
on fMRI data

Study plan

Open science &
neuroimaging



BEFORE

fMRI data
preprocessing



fMRI data manipulation
in python

Functional
connectivity



General
Linear Model



AFTER

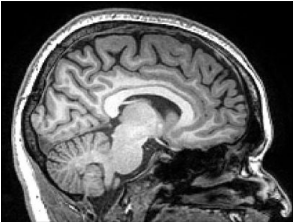


Machine Learning
on fMRI data

Structural vs. functional neuroimaging

Structural

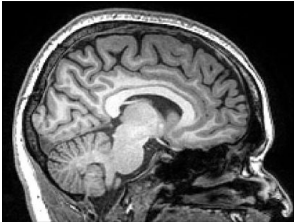
MRI (T1)



Structural vs. functional neuroimaging

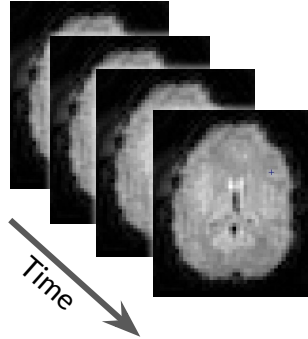
Structural

MRI (T1)



Functional

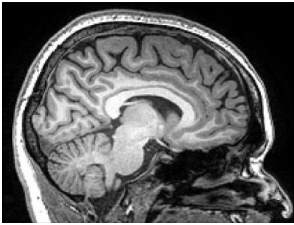
fMRI (T2*)



Structural vs. functional neuroimaging

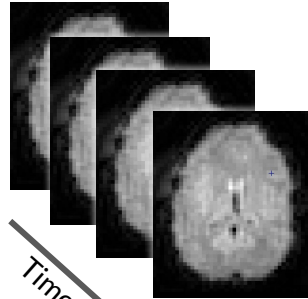
Structural

MRI (T1)

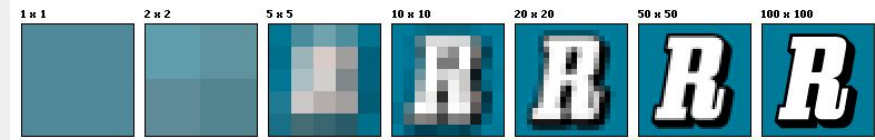


Functional

fMRI (T2*)



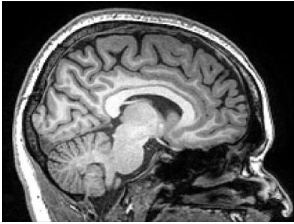
Spatial resolution - determines our ability to distinguish changes in an image across spatial location.



Structural vs. functional neuroimaging

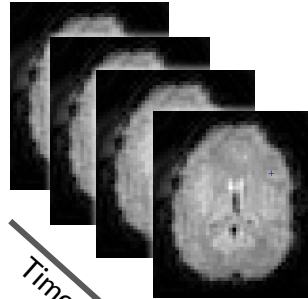
Structural

MRI (T1)

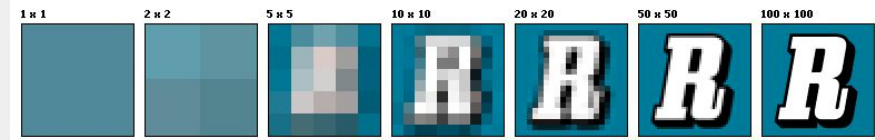


Functional

fMRI (T2*)



Spatial resolution - determines our ability to distinguish changes in an image across spatial location.



spatial resolution



Structural vs. functional neuroimaging

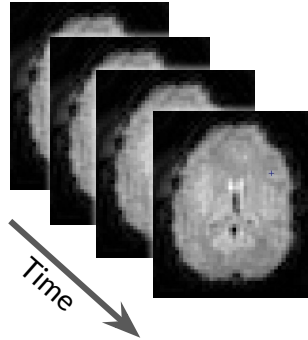
Structural

MRI (T1)



Functional

fMRI (T2*)



Spatial resolution - determines our ability to distinguish changes in an image across spatial location.

Temporal resolution - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).



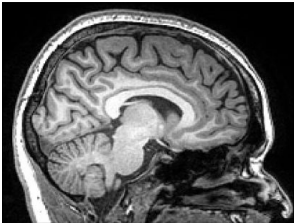
spatial resolution



Structural vs. functional neuroimaging

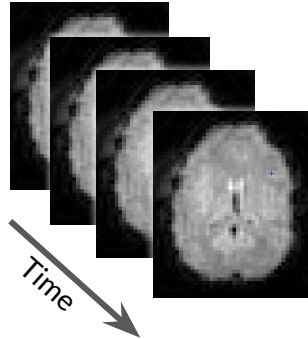
Structural

MRI (T1)



Functional

fMRI (T2*)



Spatial resolution - determines our ability to distinguish changes in an image across spatial location.

Temporal resolution - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

Frequency - number of measurements per second (Hz)



spatial resolution





EEG? fMRI?
**Which one has better
temporal resolution?**

Structural vs. functional neuroimaging

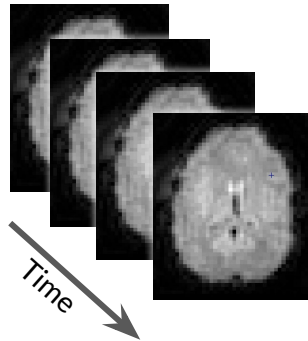
Structural

MRI (T1)



Functional

fMRI (T2*)



spatial resolution



Spatial resolution - determines our ability to distinguish changes in an image across spatial location.

Temporal resolution - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

Frequency - number of measurements per second (Hz)

Structural vs. functional neuroimaging

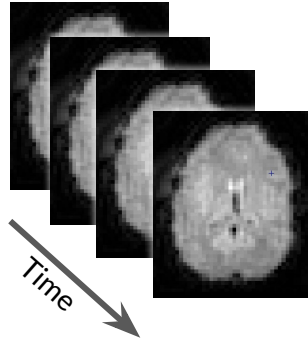
Structural

MRI (T1)



Functional

fMRI (T2*)



spatial resolution



Spatial resolution - determines our ability to distinguish changes in an image across spatial location.

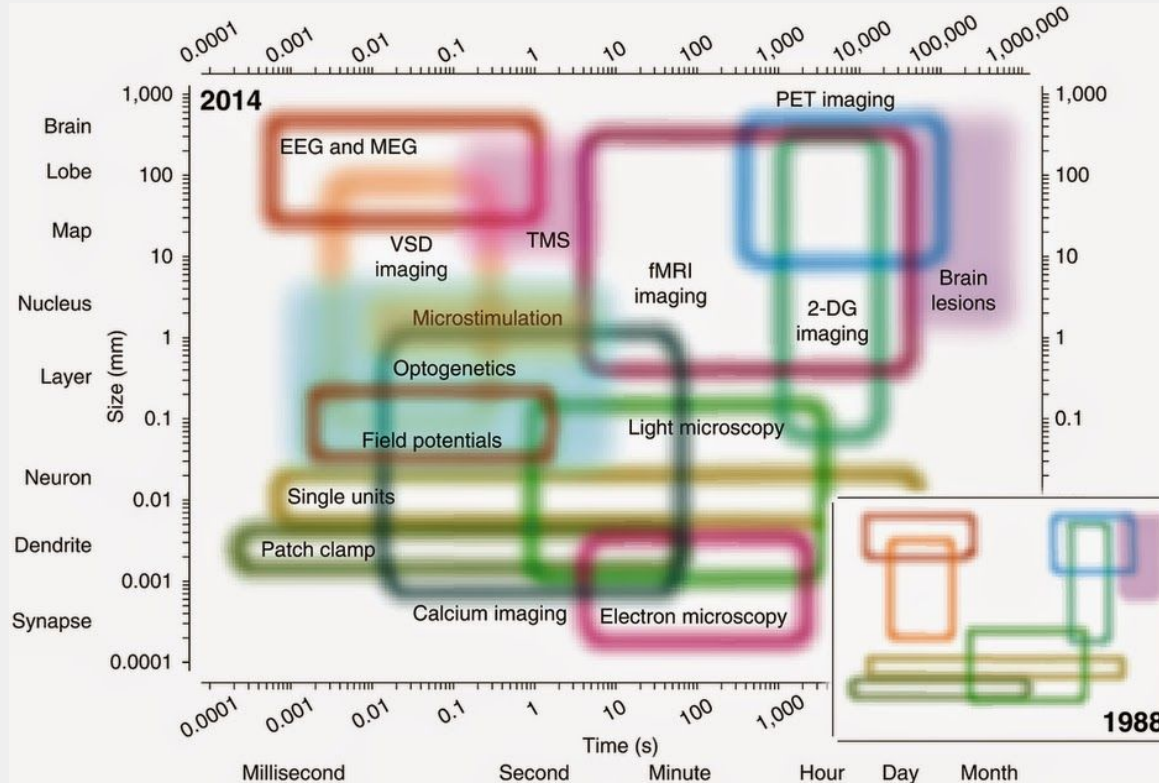
Temporal resolution - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

Frequency - number of measurements per second (Hz)

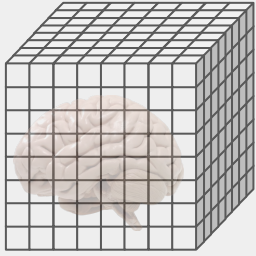
EEG: ~ 1000 Hz

fMRI: ~ 0.5 Hz

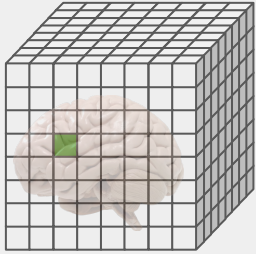
Neuroimaging techniques resolution



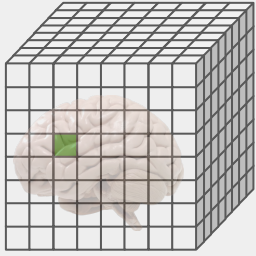
MRI data structure



MRI data structure



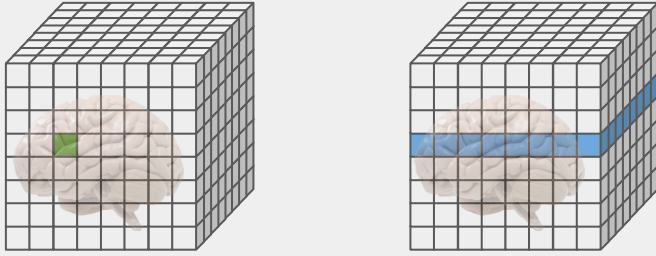
MRI data structure



Voxel

Voxel size
(e.g. $1 \times 1 \times 1$ mm)

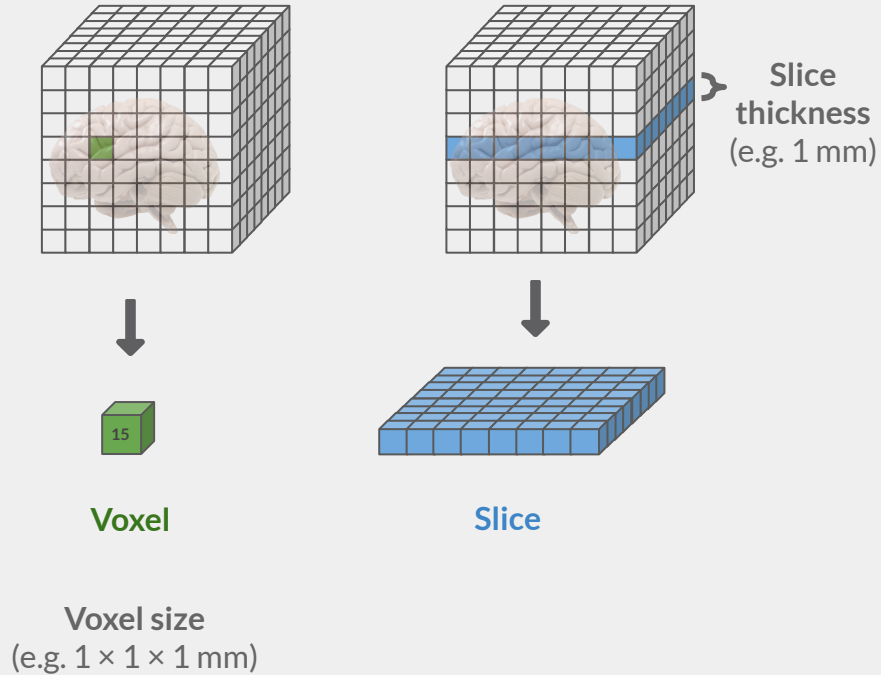
MRI data structure



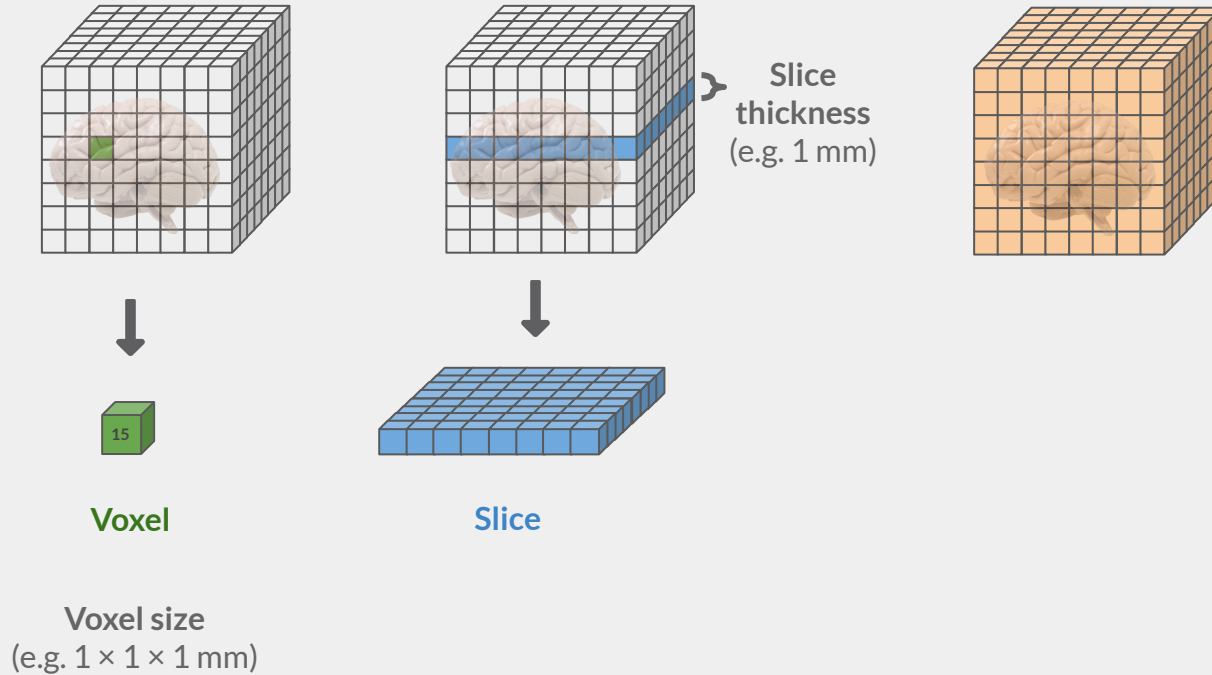
Voxel

Voxel size
(e.g. $1 \times 1 \times 1$ mm)

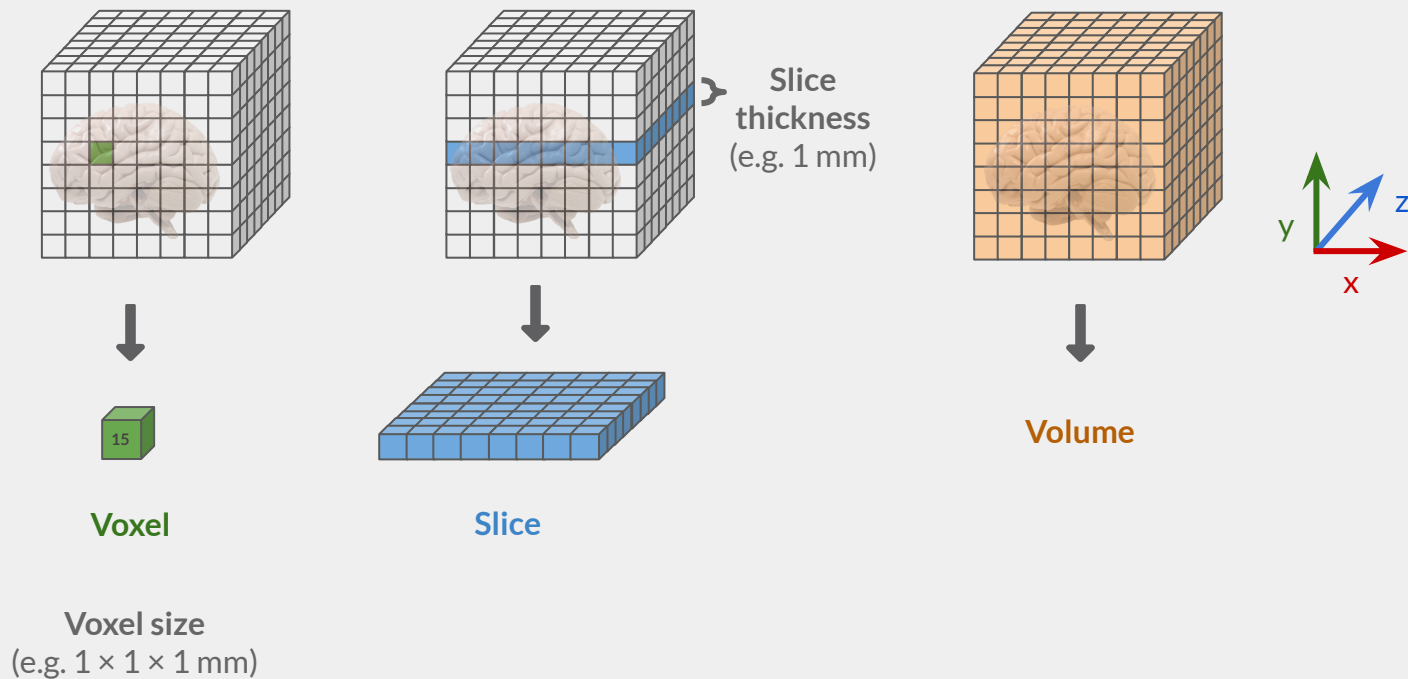
MRI data structure



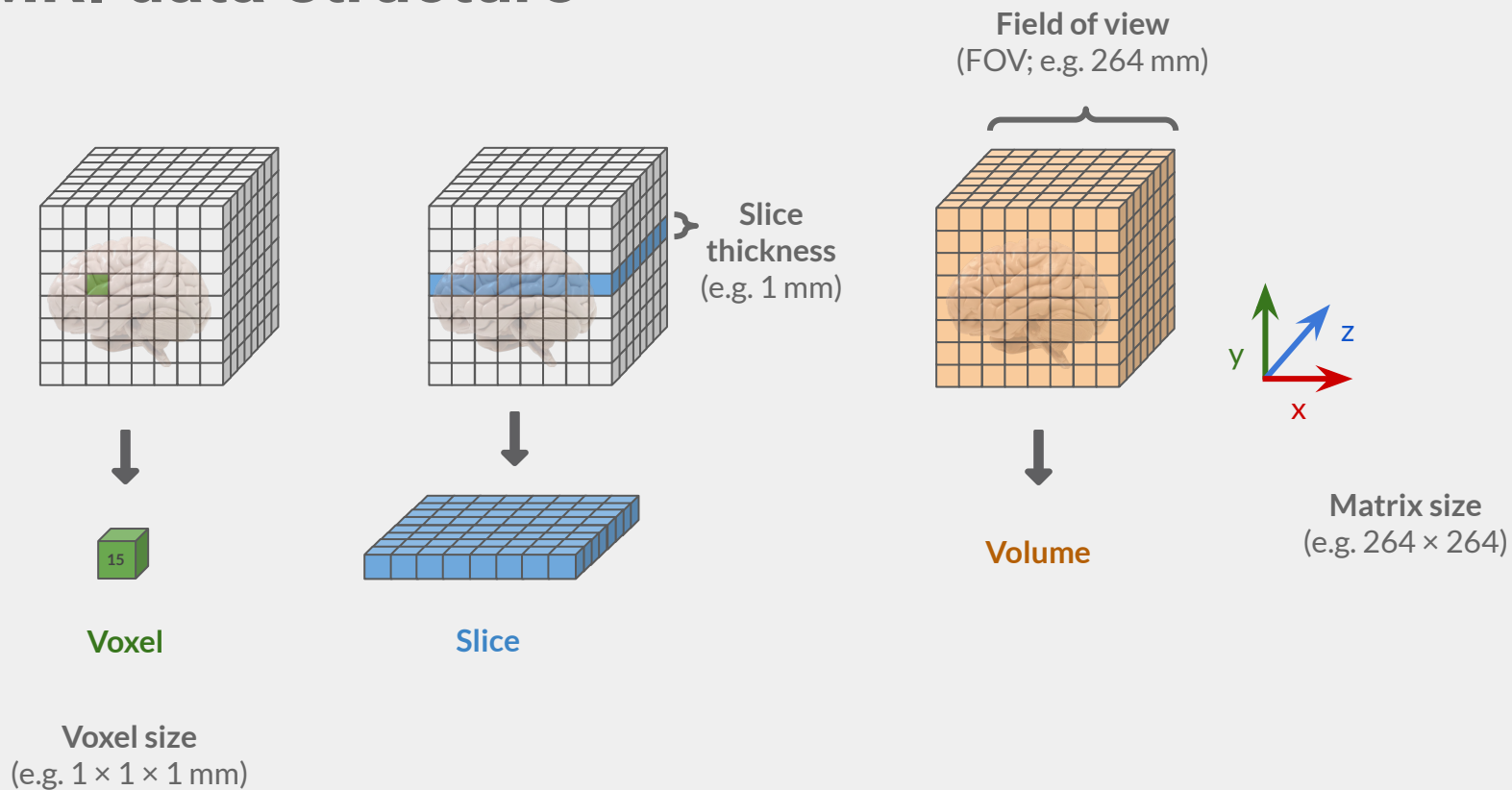
MRI data structure



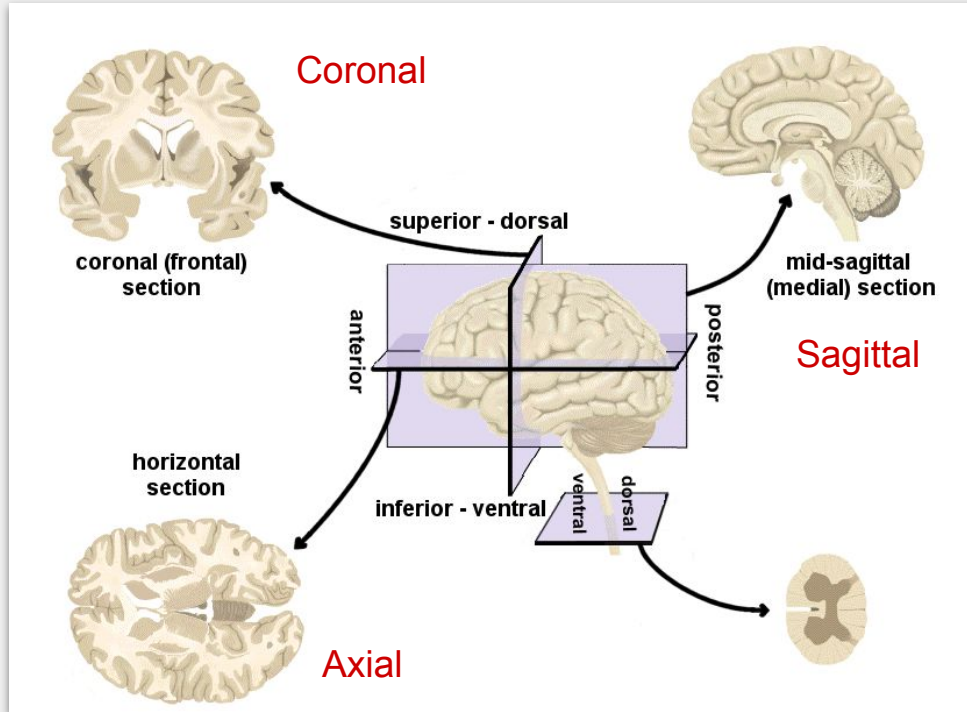
MRI data structure



MRI data structure



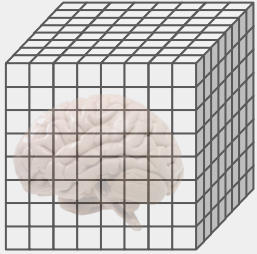
Brain sections



http://homepage.smc.edu/russell_richard/Psych2/Graphics/human_brain_directions.htm

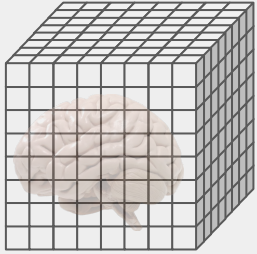
fMRI data structure

Structural data

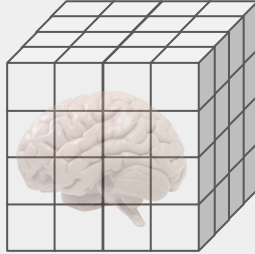


fMRI data structure

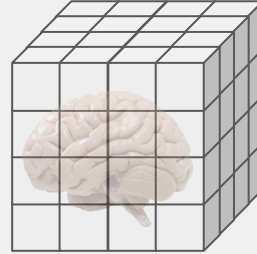
Structural data



Functional data

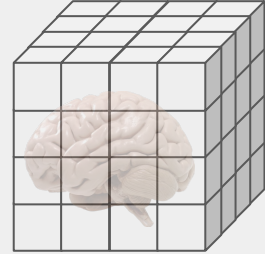


1



2

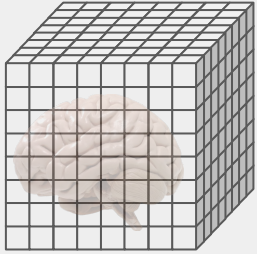
...



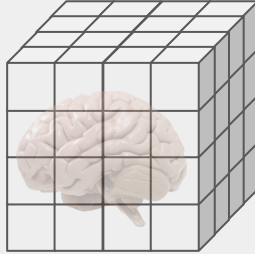
T

fMRI data structure

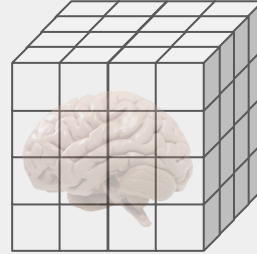
Structural data



Functional data

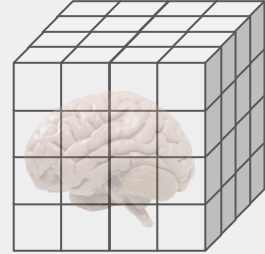


1



2

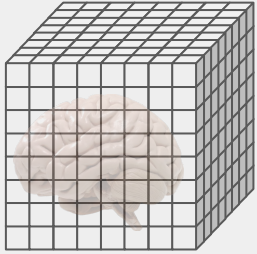
...



T

fMRI data structure

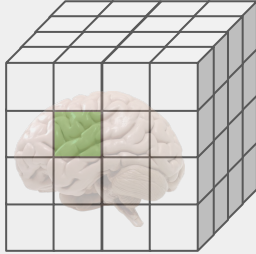
Structural data



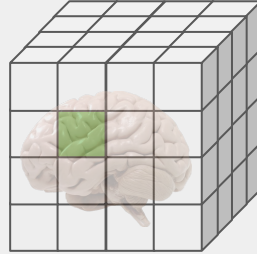
Voxel

Voxel size
(e.g. $3 \times 3 \times 3$ mm)

Functional data

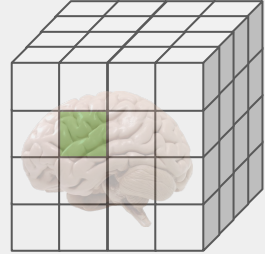


1



2

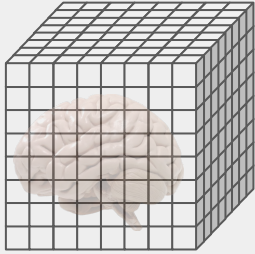
...



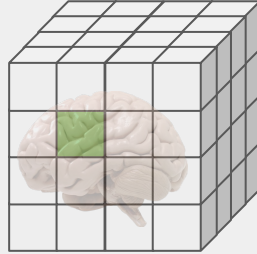
T

fMRI data structure

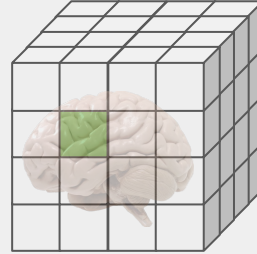
Structural data



Functional data

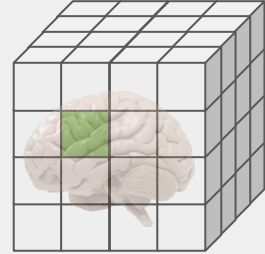


1

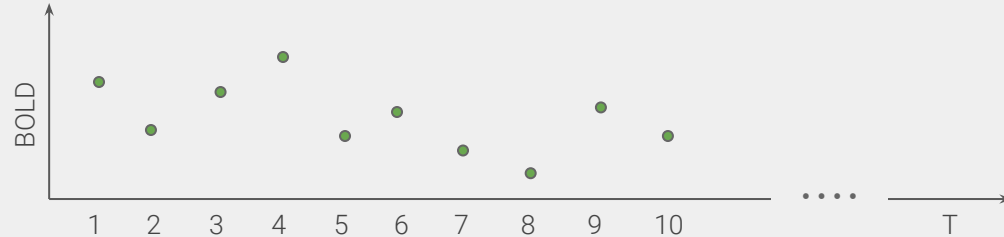


2

...

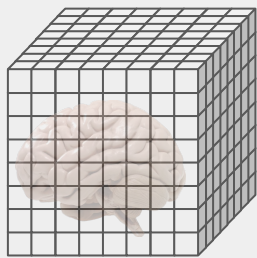


T

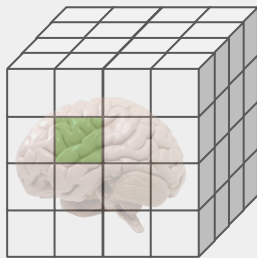


fMRI data structure

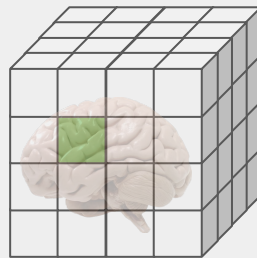
Structural data



Functional data

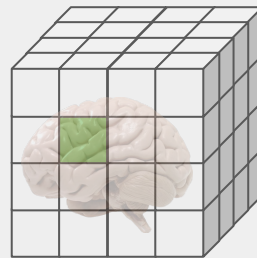


1

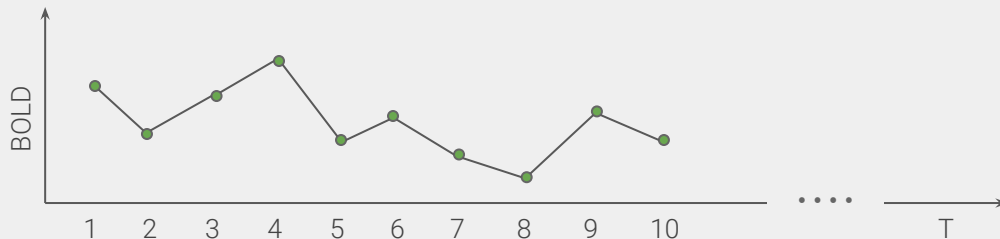


2

...

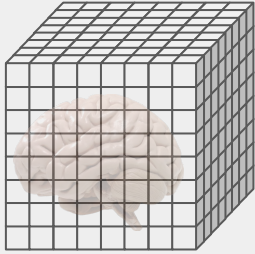


T

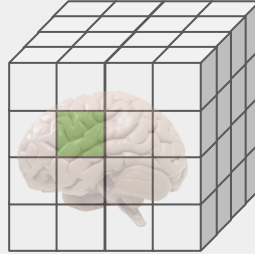


fMRI data structure

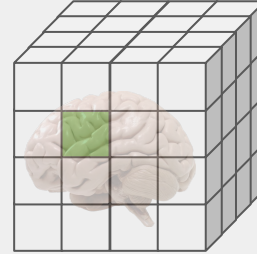
Structural data



Functional data

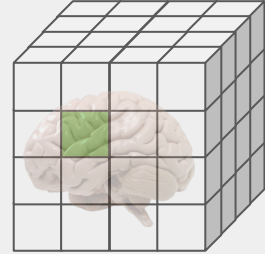


1



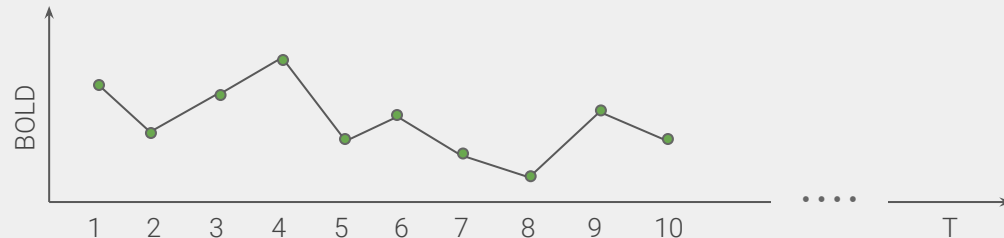
2

...



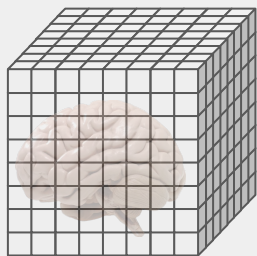
T

Time series - is a series of data points listed in time order.

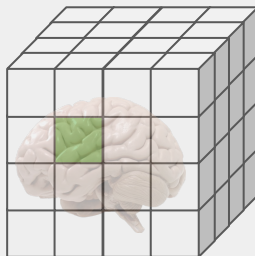


fMRI data structure

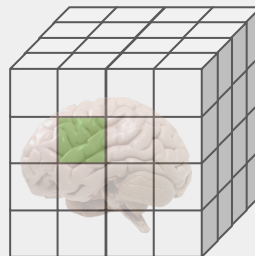
Structural data



Functional data

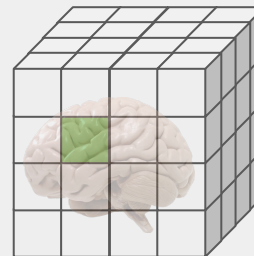


1



2

...



T

Time series - is a series of data points listed in time order.

Every voxel has its own time-series.



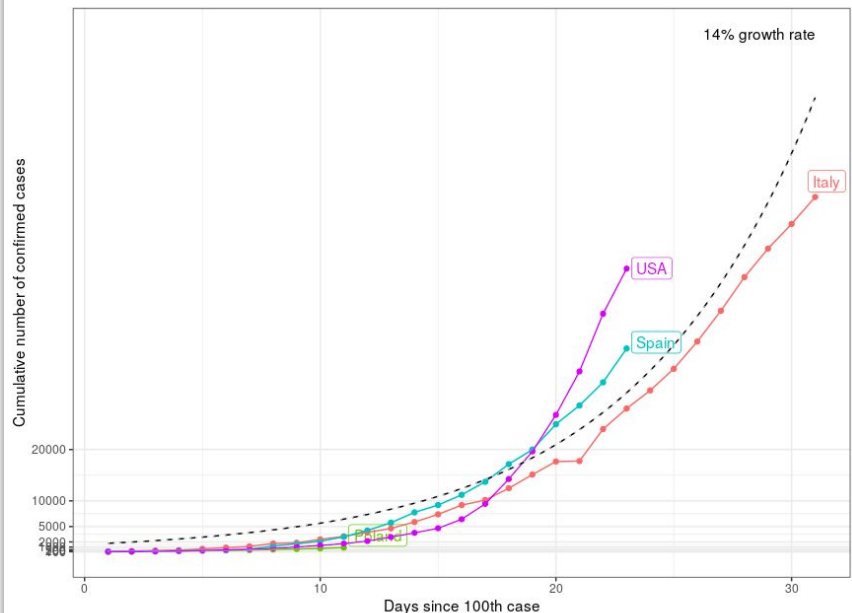
The background of the image is a dense, overlapping collage of various brain MRI scans. The scans are in different orientations (axial, sagittal, coronal) and show different internal structures of the brain. Overlaid on these scans is a large, bold, white text question. The text is centered and reads: "What data can also be represented as time-series?".

What data can also be represented as time-series?

Time-series example - COVID-19

Visualization based on data from ECDC.

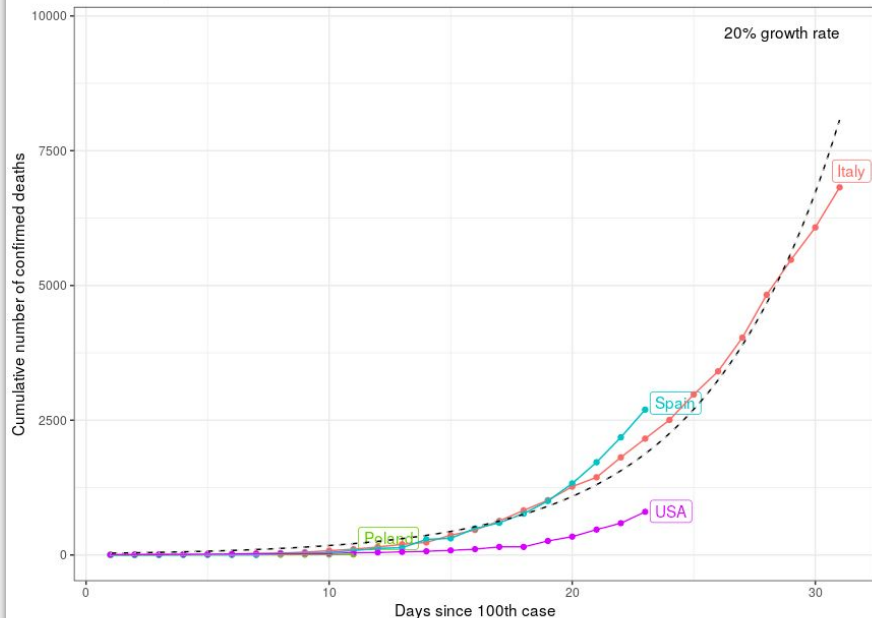
Data set from 2020-03-25



Source: <http://shinyapps.org/apps/corona/>

Visualization based on data from ECDC.

Data set from 2020-03-25



Source: <http://shinyapps.org/apps/corona/>
Adjusted cumulative cases per capita: 100,000 x (cumulative cases / population)

DICOM & NifTI formats

DICOM (*Digital Imaging and Communications in Medicine*) format:

- Raw data format for storing and transmitting medical images
- Extension: **.dcm**
- One slice, one file



NifTI (*Neuroimaging Informatics Technology Initiative*) format:

- Extensions: **.nii, nii.gz**
- Standardized representation of brain images
- Developed to facilitate cross-platform, cross-software interpretability
- 3-dimensional (3D) or 4-dimensional (4D) array: stacking individual slices on top of each other



Python exercises



<https://github.com/fMRIAnalysisCourse/fmri-analysis-course>



Homework

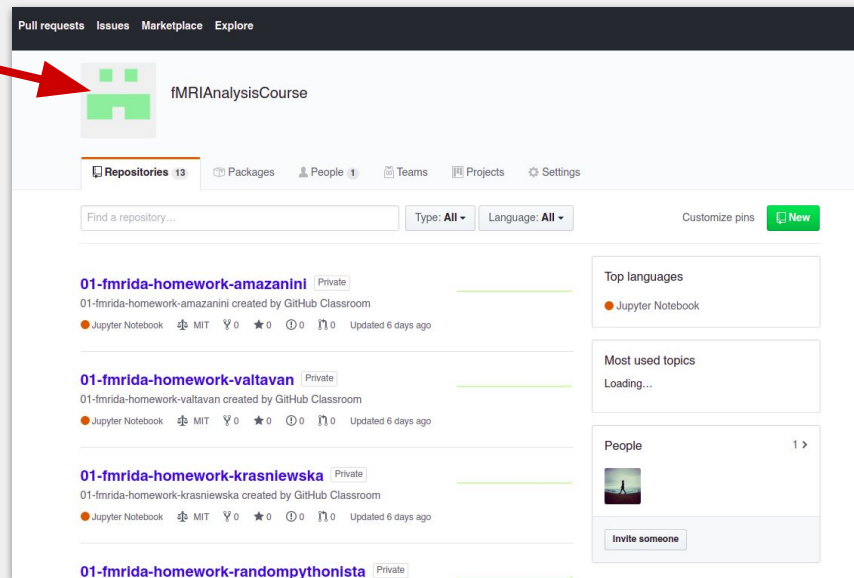
1. GitHub Classroom

Data manipulation in Python

2. Data Camp Classroom

Introduction to Data Visualization
with Matplotlib

Logo contest!



Next



Preprocessing