NeuroGeriatricsMotionToolbox (NGMT)

A Python Toolbox for Motion Data Processing in Neuroscience and Biomechanics

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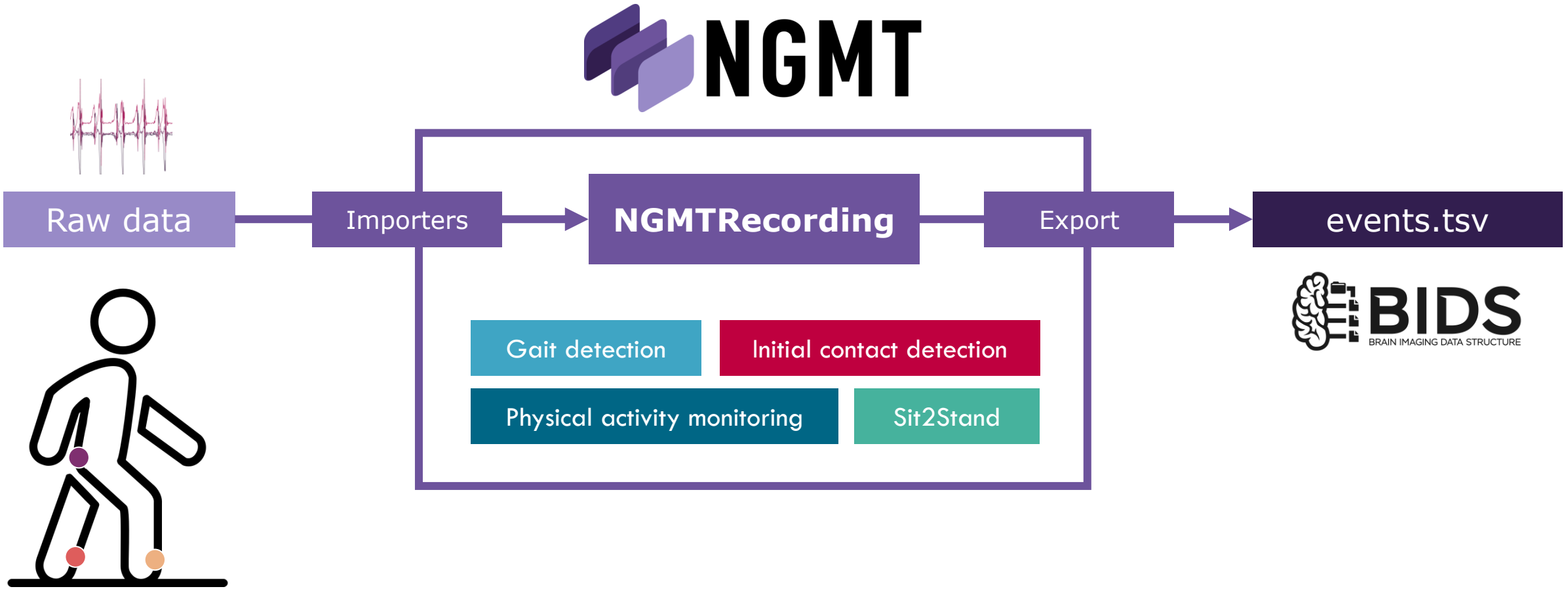
Motivation

1. Open Source toolbox for processing motion data

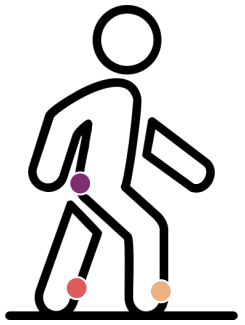
2. Collection of validated algorithms for different kind of motion data (in clinical cohorts)

3. Use extracted information (e.g. gait events) as context information for other brain imaging modalities by utilizing Motion BIDS principles

Intended workflow



Dataclass



`NGMTRecording` `dataclass`

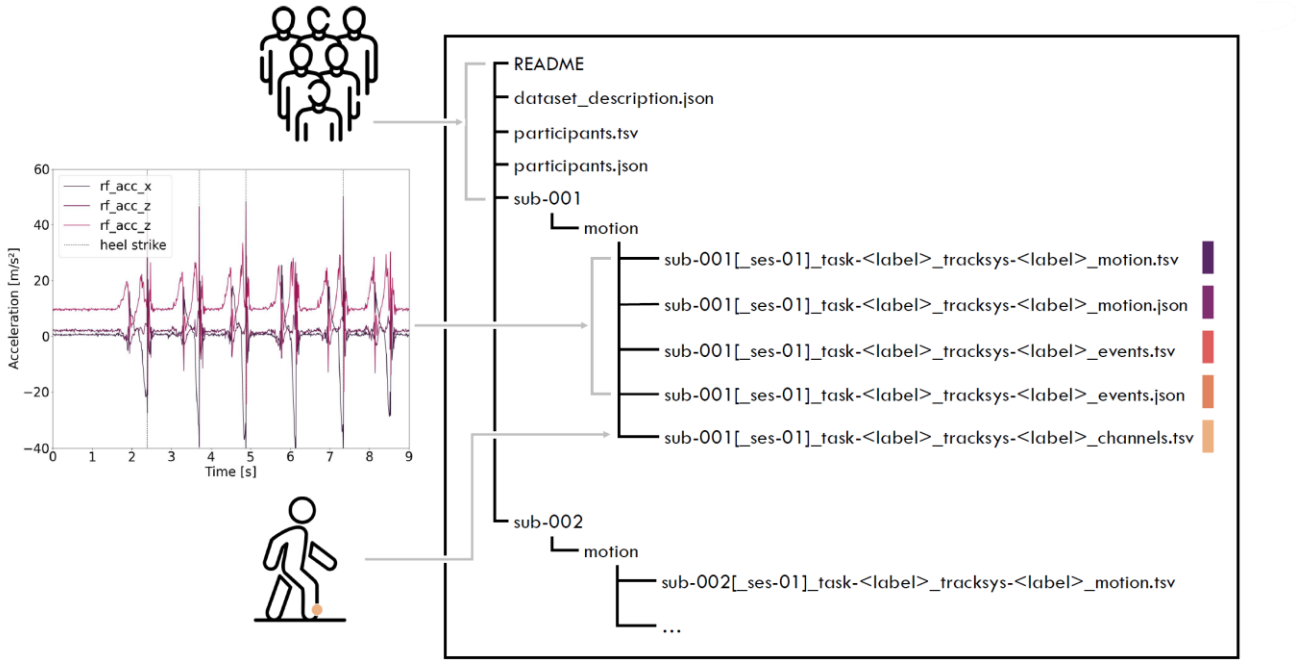
Dataclass to hold any data and associated infos for a NGMT recording.

Attributes:

Name	Type	Description
`data`	`dict`	The data is stored as a pandas DataFrame for each unique tracking system.
`channels`	`dict`	The channels descriptions are stored as a pandas DataFrame for each unique tracking system.
`info`	`dict`	The infos on the subject, task, and more, are stored as a nested dictionary.
`events`	`dict`	The events are stored as a pandas DataFrame for each unique tracking system.
`events_info`	`dict`	The event infos are stored as a nested dictionary.

https://neurogeriatricskiel.github.io/NGMT/dataclass/#utils.ngmt_dataclass.NGMTRecording

Dataclass



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Data & channels

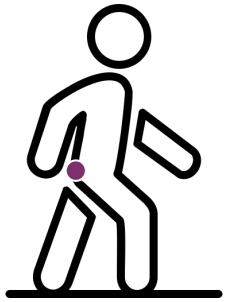
0,315	0,509	0,415	0,777	0,257	0,541
0,029	0,361	0,786	0,937	0,232	0,011
0,106	0,058	0,027	0,453	0,73	0,57
0,61	0,369	0,983	0,135	0,99	0,523
0,545	0,09	0,276	0,459	0,85	0,412
0,587	0,874	0,904	0,421	0,683	0,055
0,841	0,93	0,766	0,418	0,577	0,754
0,18	0,283	0,927	0,183	0,837	0,258
0,113	0,825	0,978	0,165	0,761	0,065
0,872	0,369	0,039	0,624	0,81	0,361
…	…	…	…	…	…

- The channels descriptions are stored as a pandas DataFrame for each unique tracking system

- Allowed channel types, components and required columns (in consistency with Motion BIDS)

```
{
'lb_imu':
name        component   type        tracked_point        units       sampling_frequency
lb_ACCEL_x  x           ACCEL       lowerBack            m/s^2       100
lb_ACCEL_y  y           ACCEL       lowerBack            m/s^2       100
lb_ACCEL_z  z           ACCEL       lowerBack            m/s^2       100
},
'rf_imu':
name        component   type        tracked_point        units       sampling_frequency
rf_ACCEL_x  x           ACCEL       rightFoot            m/s^2       200
rf_ACCEL_y  y           ACCEL       rightFoot            m/s^2       200
rf_ACCEL_z  z           ACCEL       rightFoot            m/s^2       200
}
```

Events



- Motion or gait events can be derived from the raw motion data and can be stored in a pandas Dataframe
- Events DataFrame has some minimal (same) requirements as BIDS task events
- Multiple types of events from different tracking systems can be merged

```
events: {
‘lb_imu’:
onset     duration     event_type
17.450    6.525        gait sequence
96.500    5.350        gait sequence
145.150   7.500        gait sequence
451.425   21.375       gait sequence
500.700   6.775        gait sequence
}
```

NGMT modules

GSD, **ICD**, PAM, S2S

Gait sequence detection

Purpose and Input:

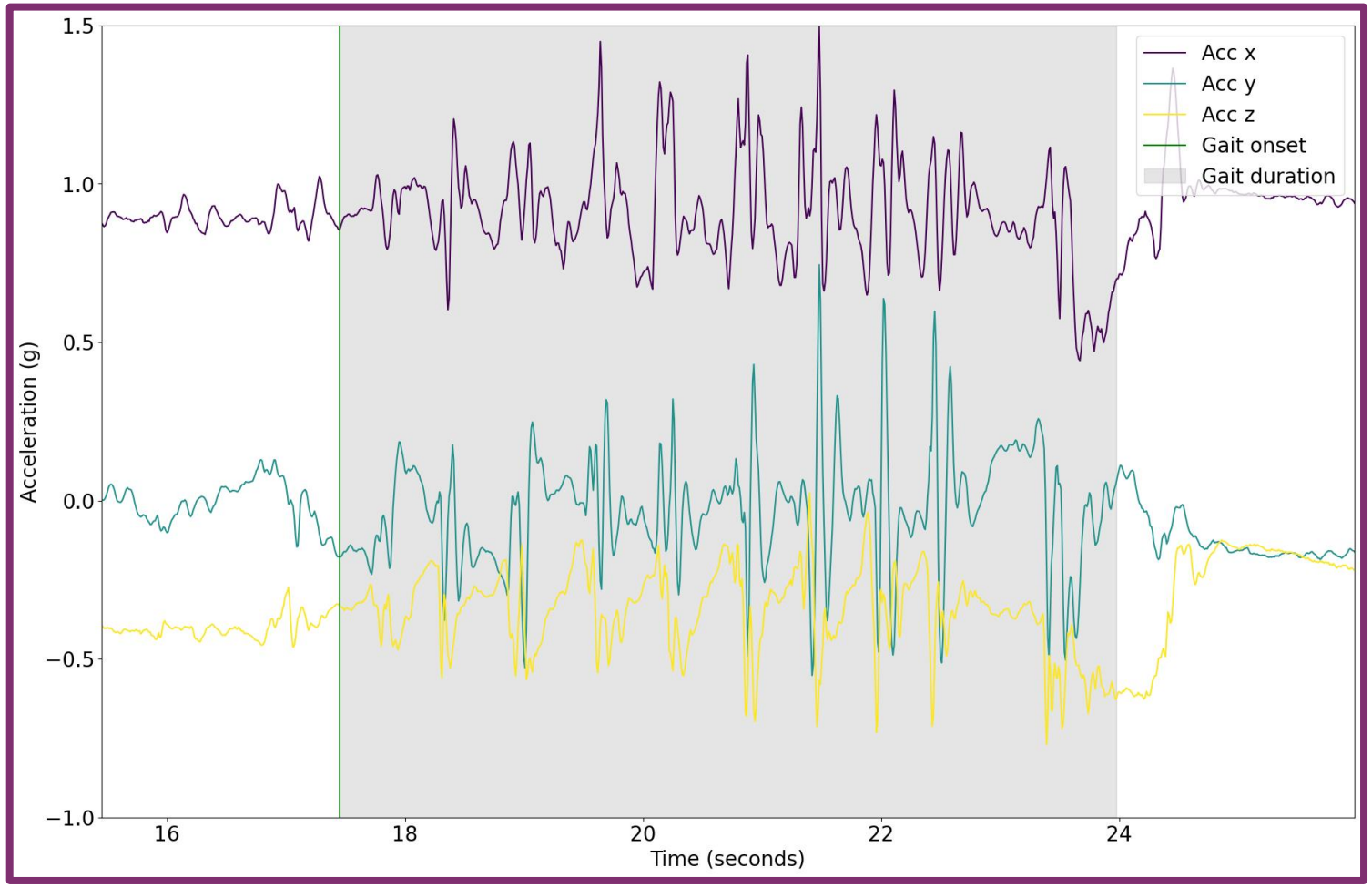
- Detects Gait sequences of 4 or more steps on **lower back acceleration data**

Gait Sequence Identification:

- Resampling and smoothing of the signal
- Detects active periods using the envelope and an adaptive threshold based on peak amplitude
- Identifies mid-swing peaks and filters out sequences with **fewer than four steps**
- Groups walking periods when overlapping

Output:

- Stores detected gait sequences in a BIDS compatible format



Paraschiv-Ionescu et al. (2020). Real-world speed estimation using a single trunk IMU: methodological challenges for impaired gait patterns. Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society.

Initial contact detection

Purpose and Input:

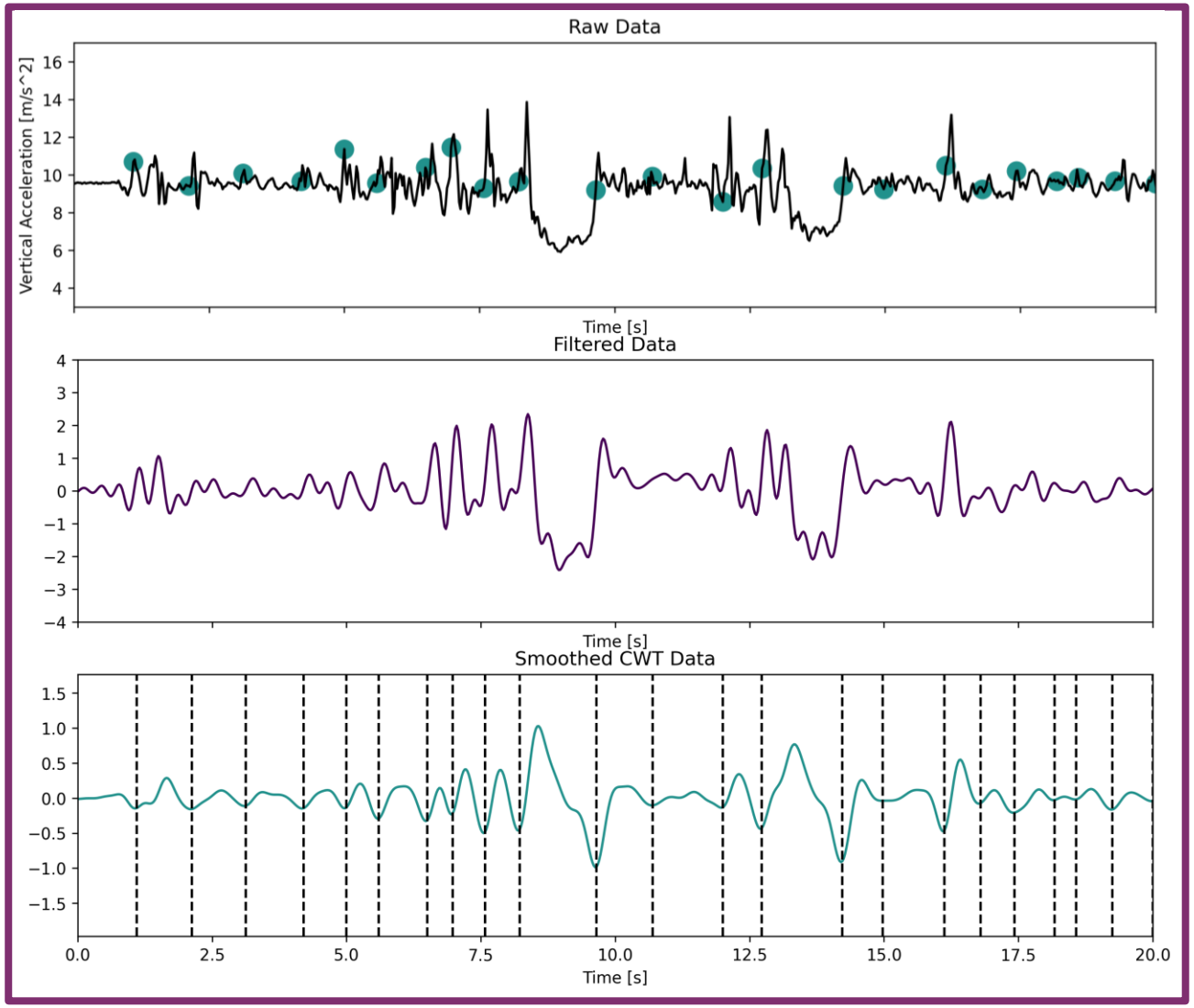
- Identifies initial contacts in accelerometer data from a **lower back acceleration sensor**

Initial contact detection:

- Detrends and low-pass filters the vertical acceleration component
- Smoothing and continuous wavelet transform (CWT)
- Identifies initial contact events as negative peaks (--)

Output:

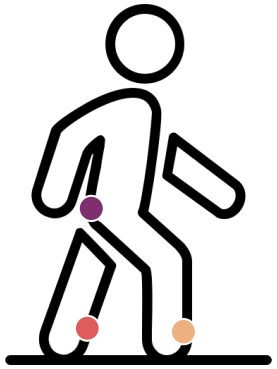
- Stores initial contacts in a BIDS compatible format



Paraschiv-Ionescu et al. (2020). Real-world speed estimation using a single trunk IMU: methodological challenges for impaired gait patterns. Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society.

Exporting events

- Use events from NGMT modules with other BIDS modalities
- Merged events from modules and tracking systems



```
events: {
onset           duration        event_type      tracking_system
15.450          6.525           gait sequence   lb_imu
16.500          0               initial contact rf_imu
18.150          0               initial contact lf_imu
19.425          0               initial contact rf_imu
21.700          0               initial contact lf_imu
}
```


https://neurogeriatricskiel.github.io/NGMT/dataclass/#utils.ngmt_dataclass.NGMTRecording.export_events

Contributing

Cycling on the Freeway: The Perilous State of Open Source Neuroscience Software

Britta U. Westner[1,2,*✉], Daniel R. McCloy[3,*], Eric Larson[3,*], Alexandre Gramfort[4], Daniel S. Katz[5], Arfon M. Smith[6], and invited co-signees

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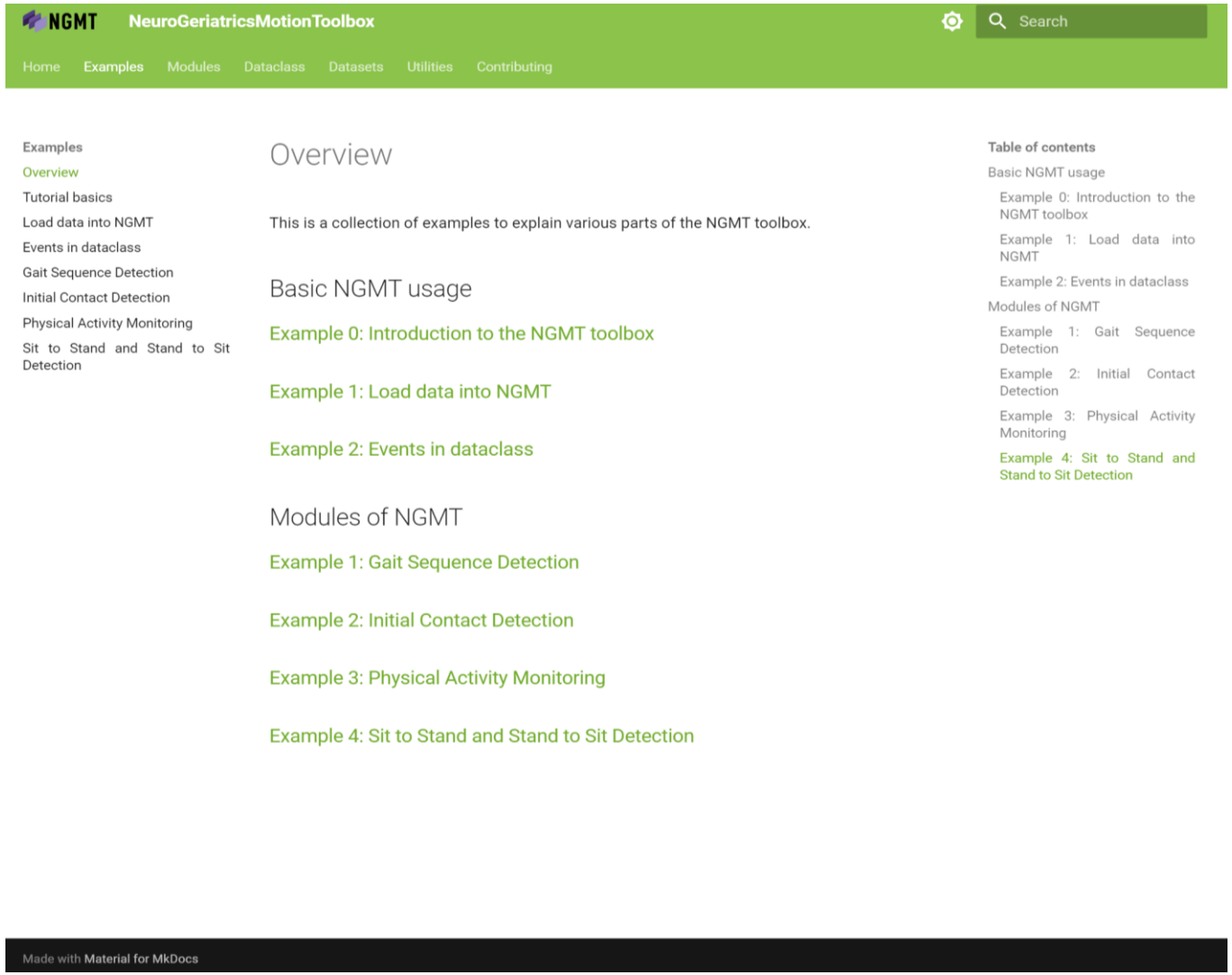
[3]Institute for Learning and Brain Sciences, University of Washington, Seattle, WA, United States
[4]Université Paris-Saclay, Inria, CEA, Palaiseau, France
[5]NCSA & CS & ECE & iSchool, University of Illinois Urbana-Champaign, Illinois, United States
[6]GitHub Inc.
[*] *Lead authors*

operating system and NGMT version, and (if applicable) include a reproducible code sample that is as short as possible and ideally uses one of our example datasets.

https://neurogeriatricskiel.github.io/NGMT/contributing/, Westner ea., Preprint, 2024

Summary & outlook

- Is data-compatible with **various devices** such as IMUs, optical & markerless MoCap, etc.
- NGMT provides a set of **(clinically) validated algorithms**
- Includes **examples and documentations** demonstrating functionality of modules
- Extracted information are stored in a BIDS compatible manner and can be used alongside other modalities



https://neurogeriatricskiel.github.io/NGMT/examples/

Thank you for listening carefully

A special thanks to the “Kellerkinder” for pushing this project in the past year.

Special thanks to Masoud for the algorithm implementation and to Robbin for the great steering of the loose ends.