Accelerometry-Guided Inter-Beat-Interval Assessment from Wrist Photoplethysmography

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Stroke Association, "State of the Nation," 2017.
Public Health England, "Atrial fibrillation prevalence estimates in England …", 2015.

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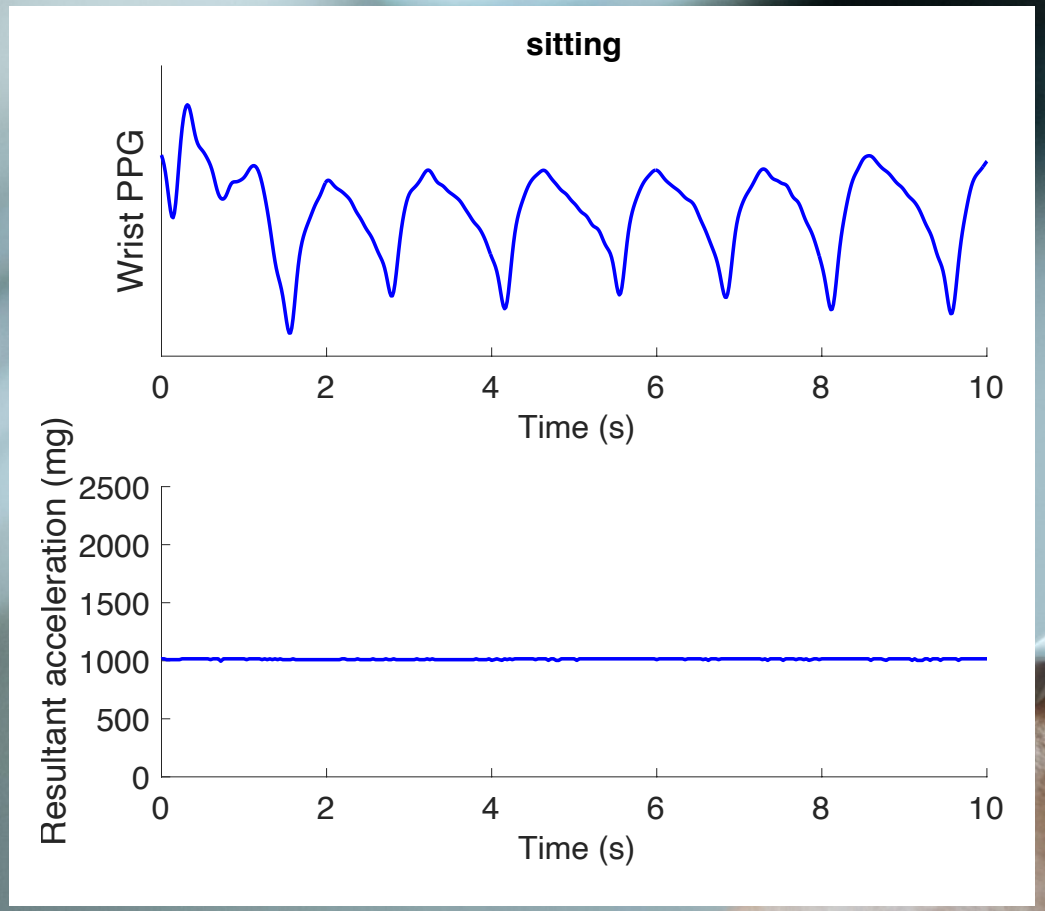

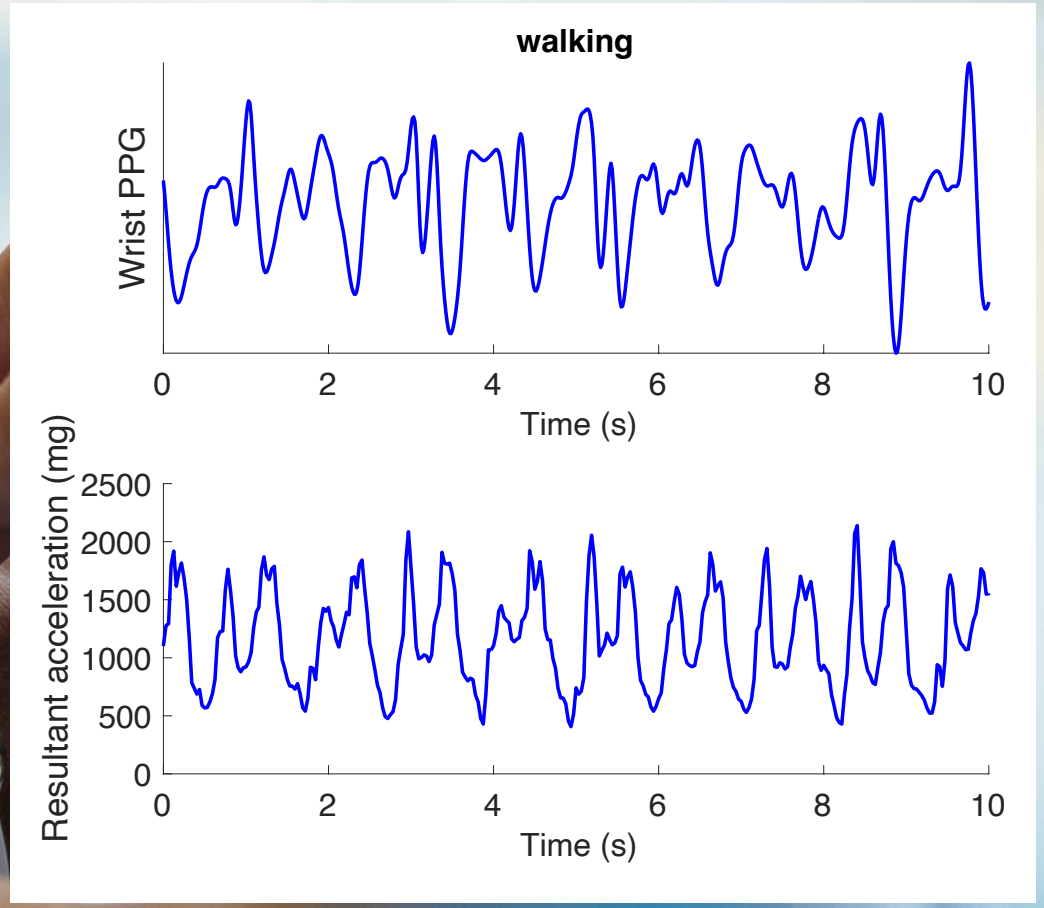

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Aim:

To investigate whether accelerometry signals could be used to predict whether or not IBIs could be accurately measured from simultaneous PPG signals at the wrist.

Objectives:

1. Assess the classification performance of such an approach
2. Identify an optimal classification threshold
3. Assess performance across different activities

Methods

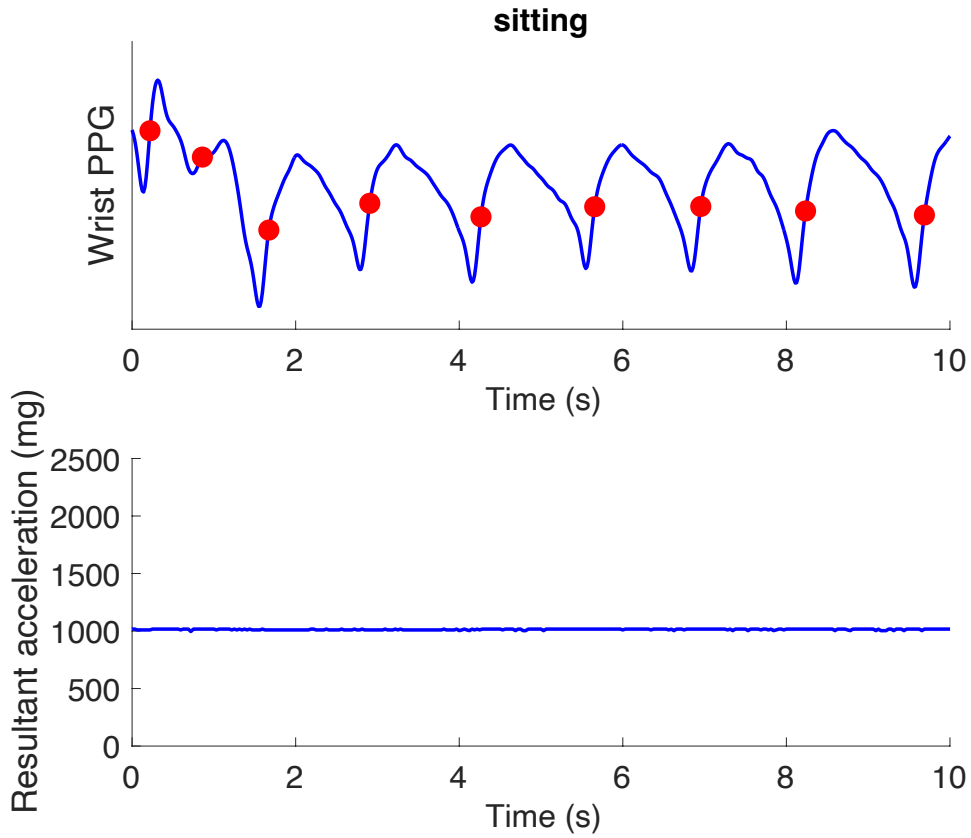
Datasets

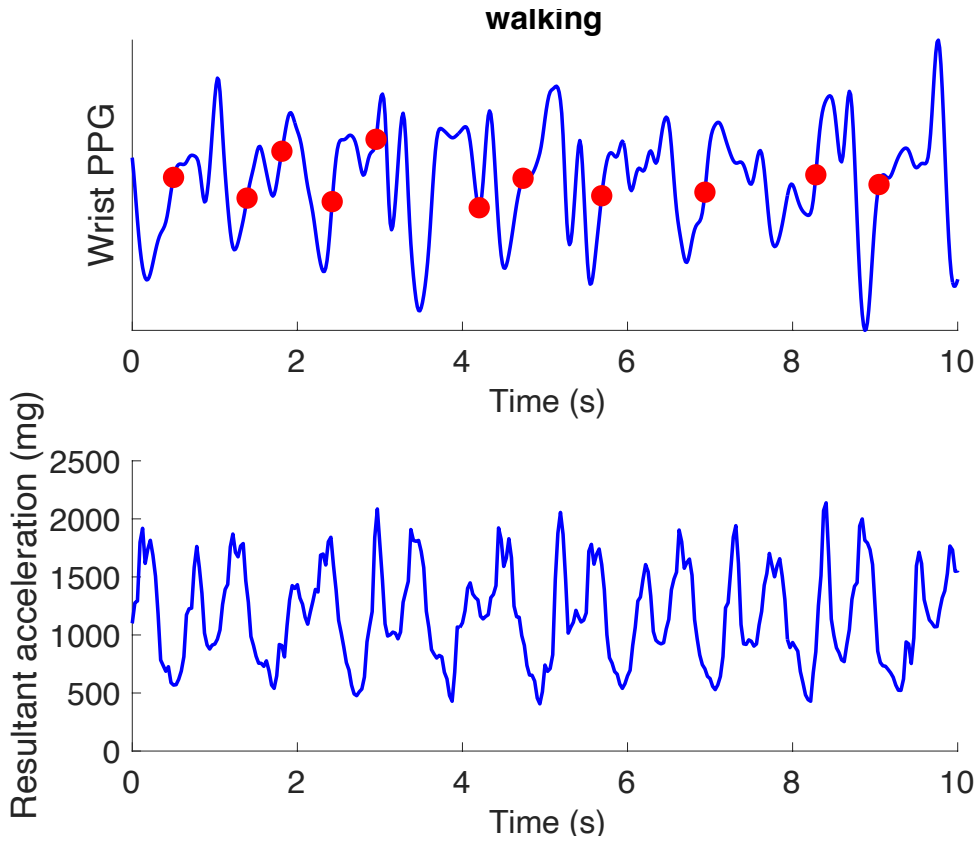
- Wrist PPG (from Empatica E4)
- Reference chest ECG

Dataset	Phases	No. Subjects
WESAD	*Stress protocol:* Baseline, Meditation, Amusement, Stress	15
PPG-DaLiA	*Activities of daily living:* Sitting, Working, Lunch break, Car driving, Cycling, Table soccer, Walking, Stair climbing	15

Inter-beat interval estimation from PPG

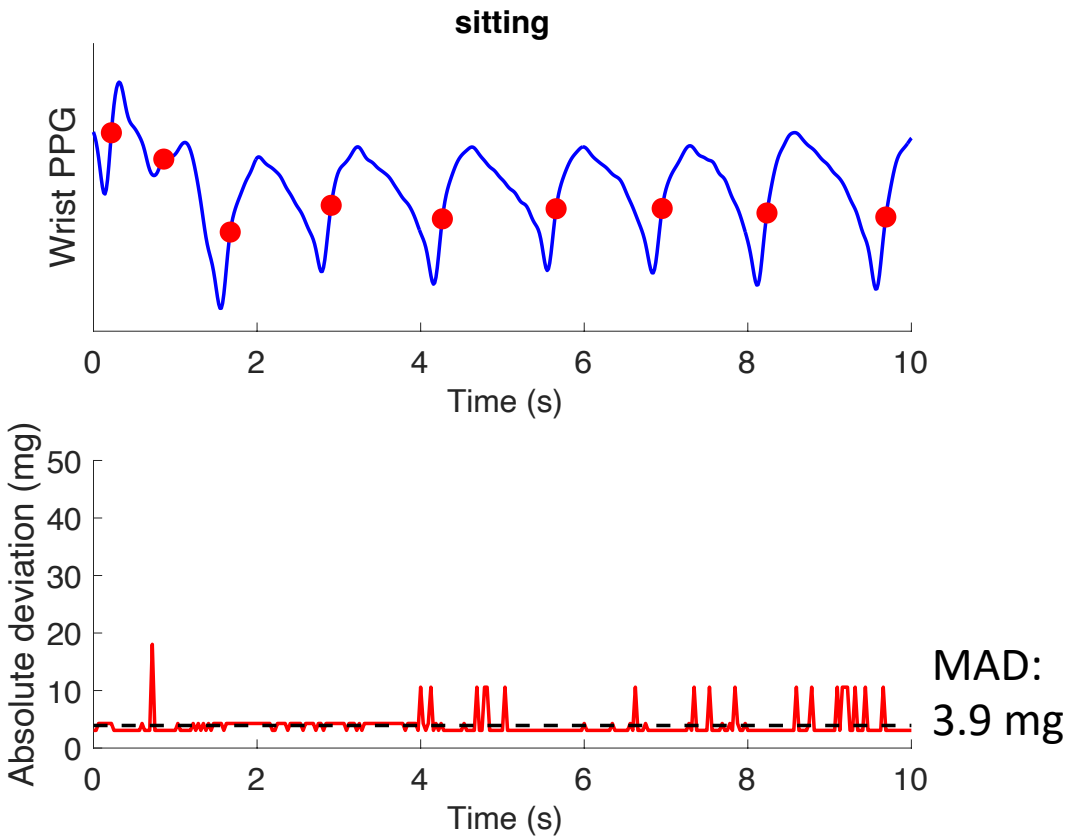
- Open-source ‘MSPTD’ beat detector from ppg-beats: https://ppg-beats.readthedocs.io/
- Middle-amplitude points

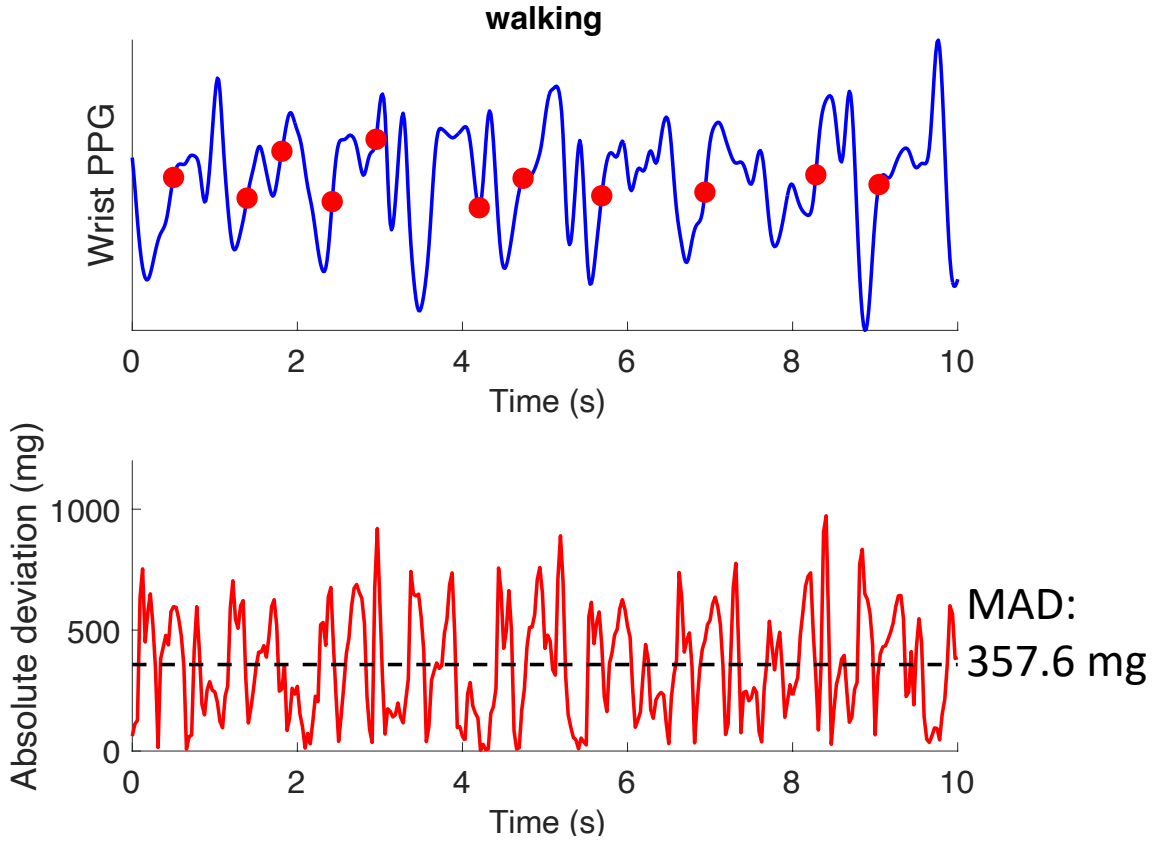




Assessing level of movement

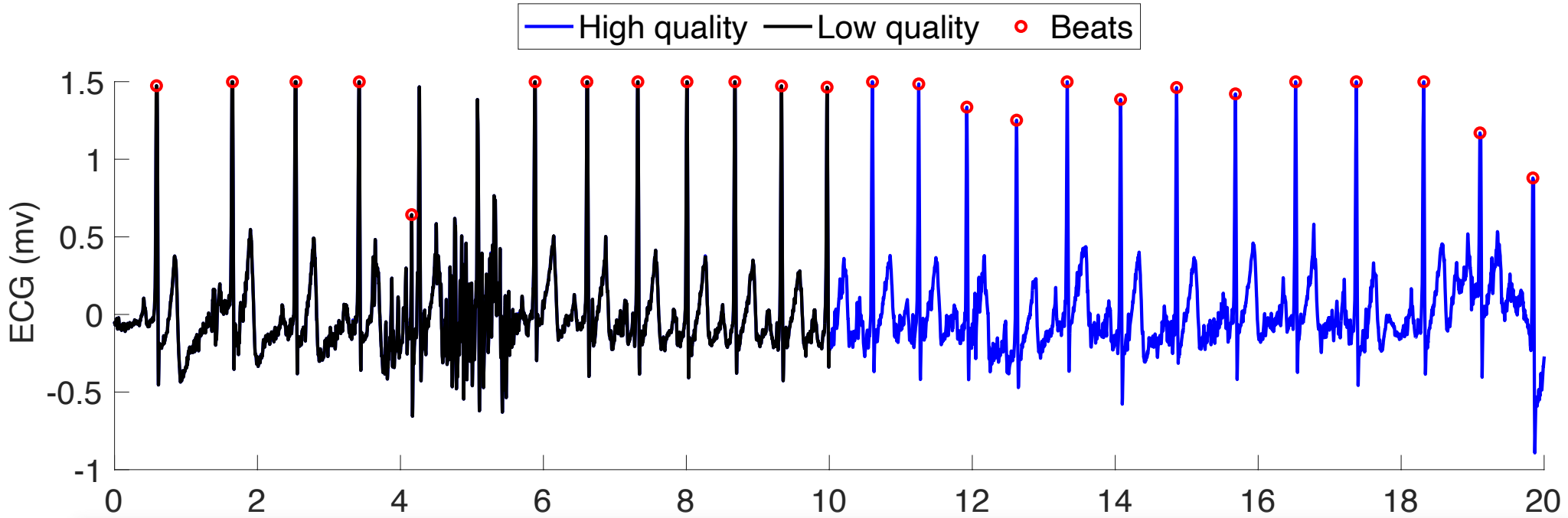
- Mean absolute deviation (MAD)





Inter-beat interval estimation from ECG

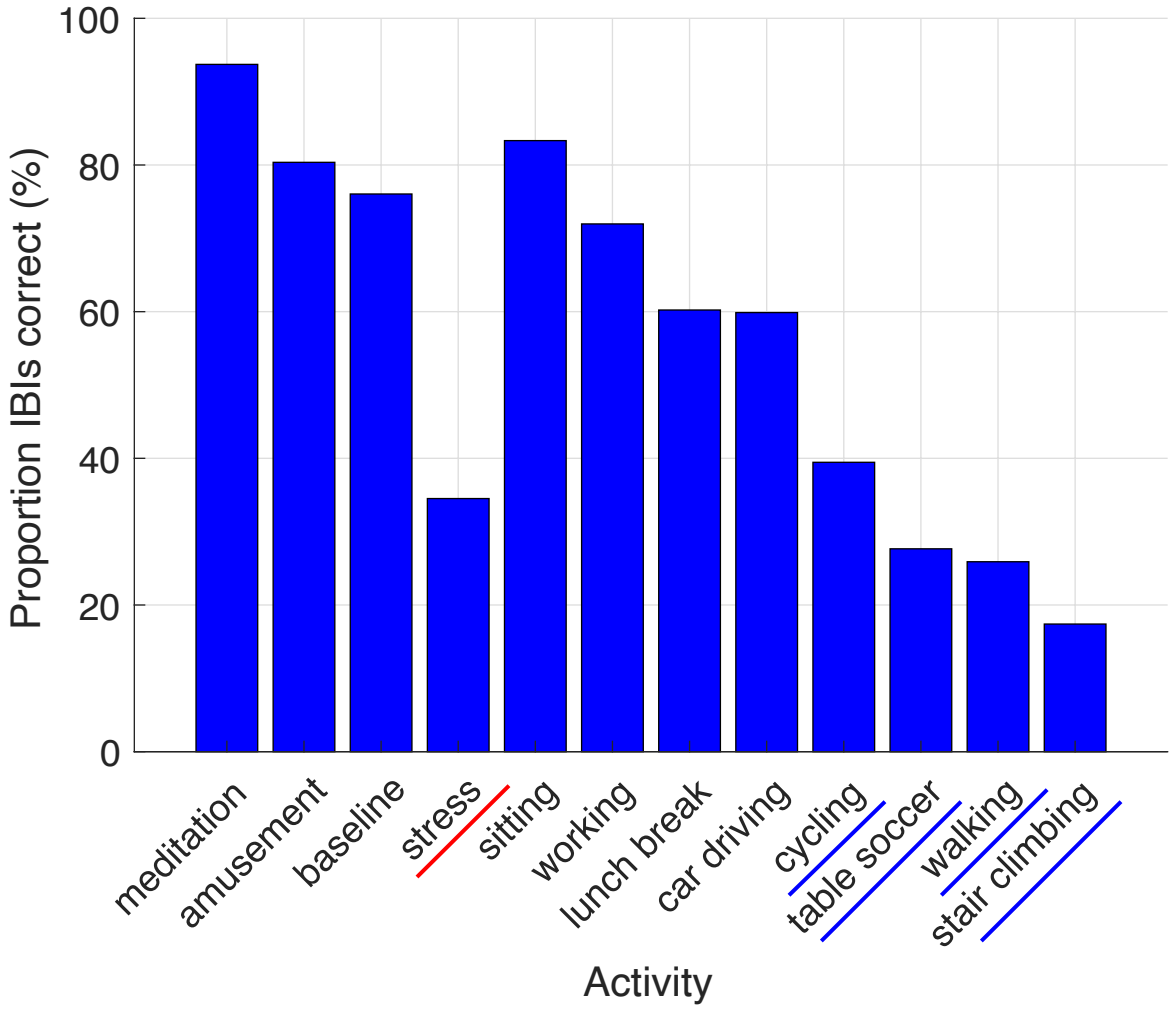
- Two beat detection algorithms
- For each 20 s period: deemed to be high quality if beat detectors agree



Charlton P.H. *et al.*, **Detecting beats in the photoplethysmogram: benchmarking open-source algorithms**, *Phys* Meas, 2022: https://doi.org/10.1088/1361-6579/ac826d

Results

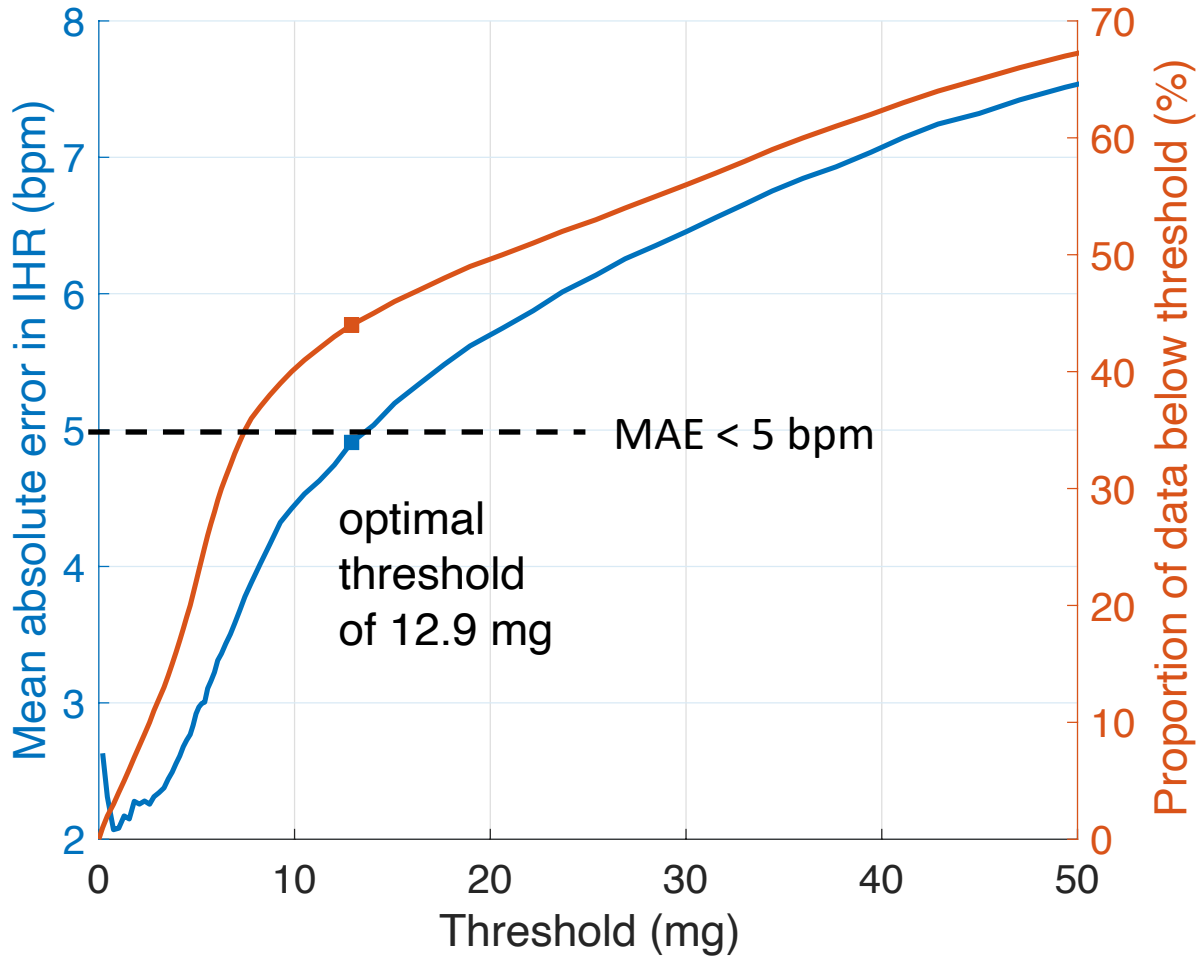
Dataset Characteristics



Classification Performance

Dataset	Area under receiver operatory curve (AUROC)	Area under precision-recall curve (AUPRC)
Combined dataset	0.78	0.82

Identifying an Optimal Threshold



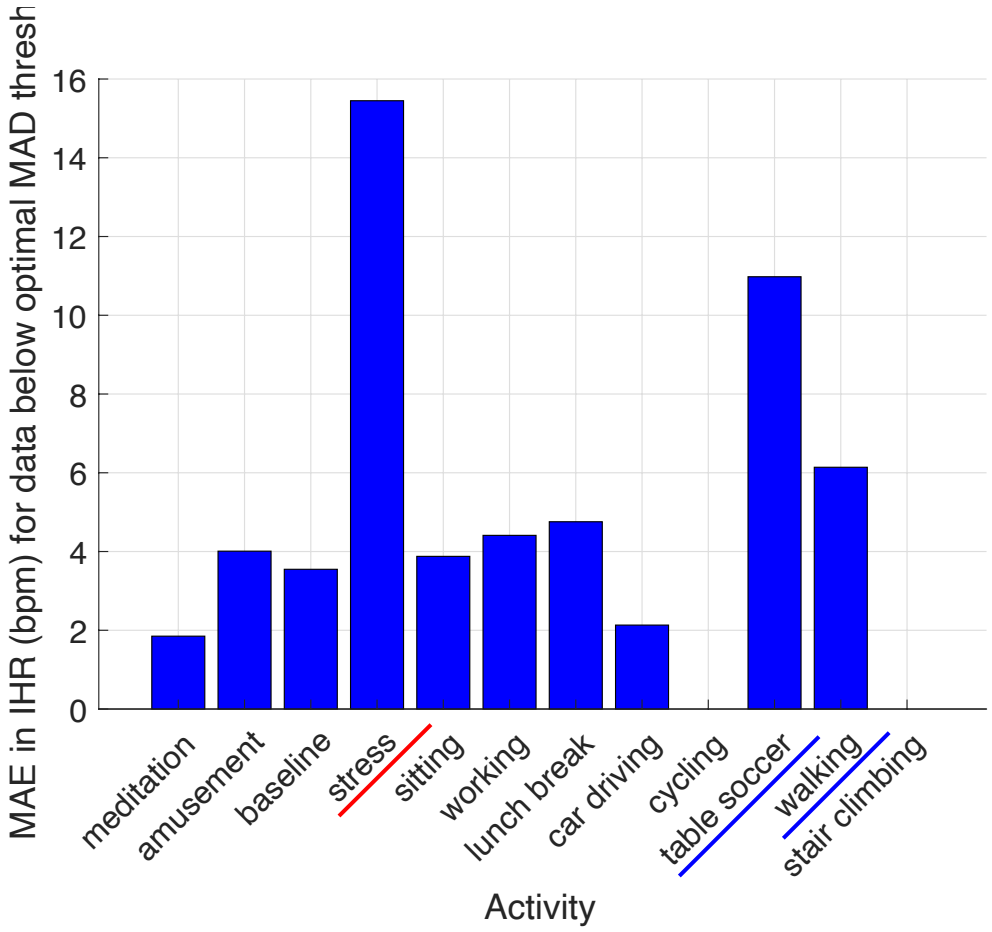
Identifying an Optimal Threshold

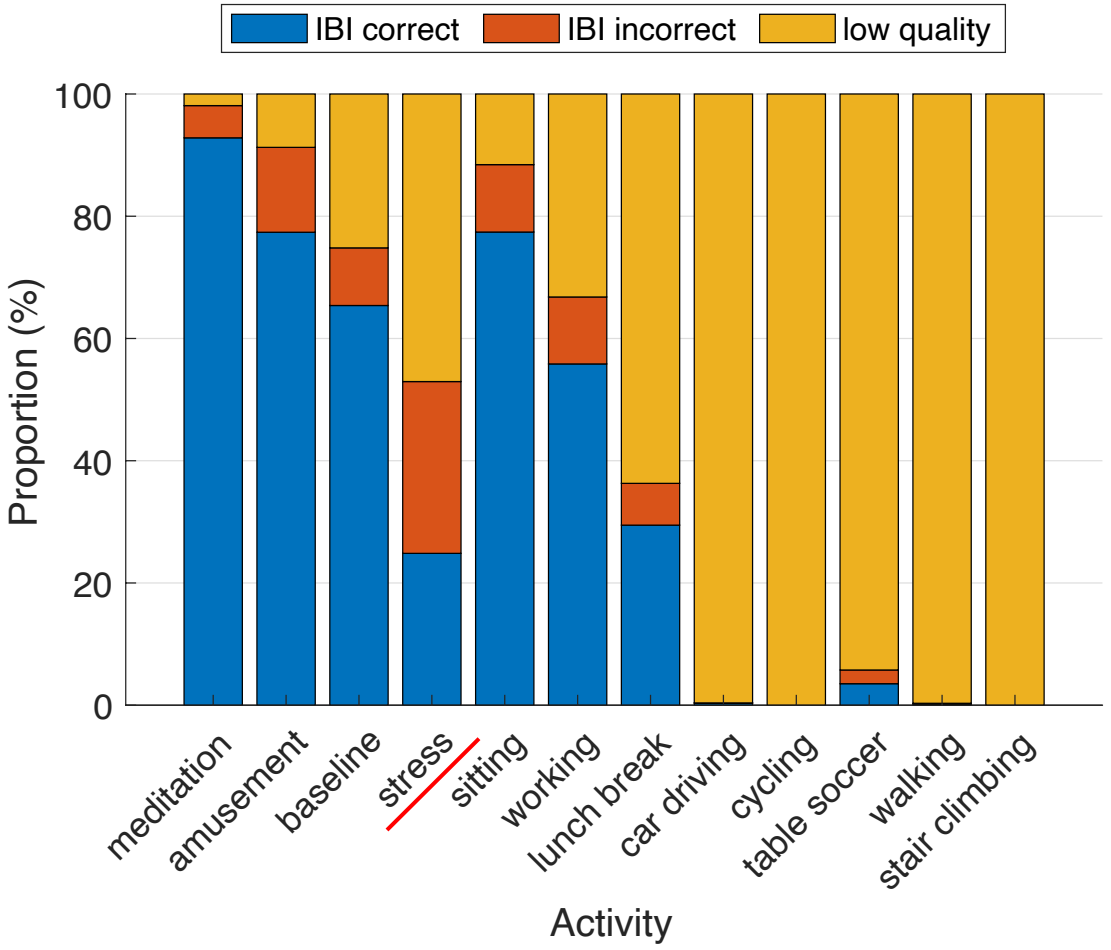
Activity	MAD, measured using ActiGraph at wrist (mg) Mean (standard error)
Sedentary behaviours: lying, sitting	6.7 (0.5)
Standing still	7.5 (1.1)
Washing pots	100.2 (8.3)
Walking	151.5 (6.2)

Threshold: 12.9 mg

AF Detection Study	Approach
Apple Heart Study	”while participants were at rest”
FitBit Heart Study	“participants were stationary (as determined by device accelerometers)”

Performance for Different Activities





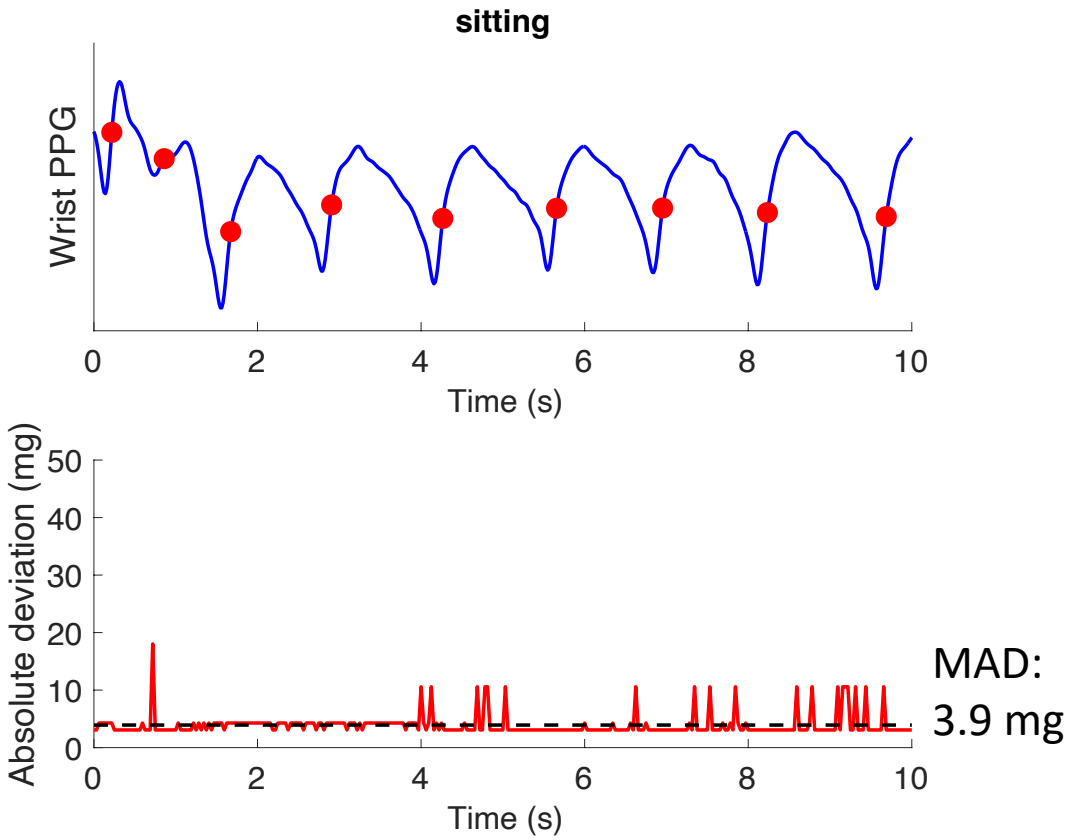
Accelerometry-based approach performed well during physical activities, but not during mental stress.

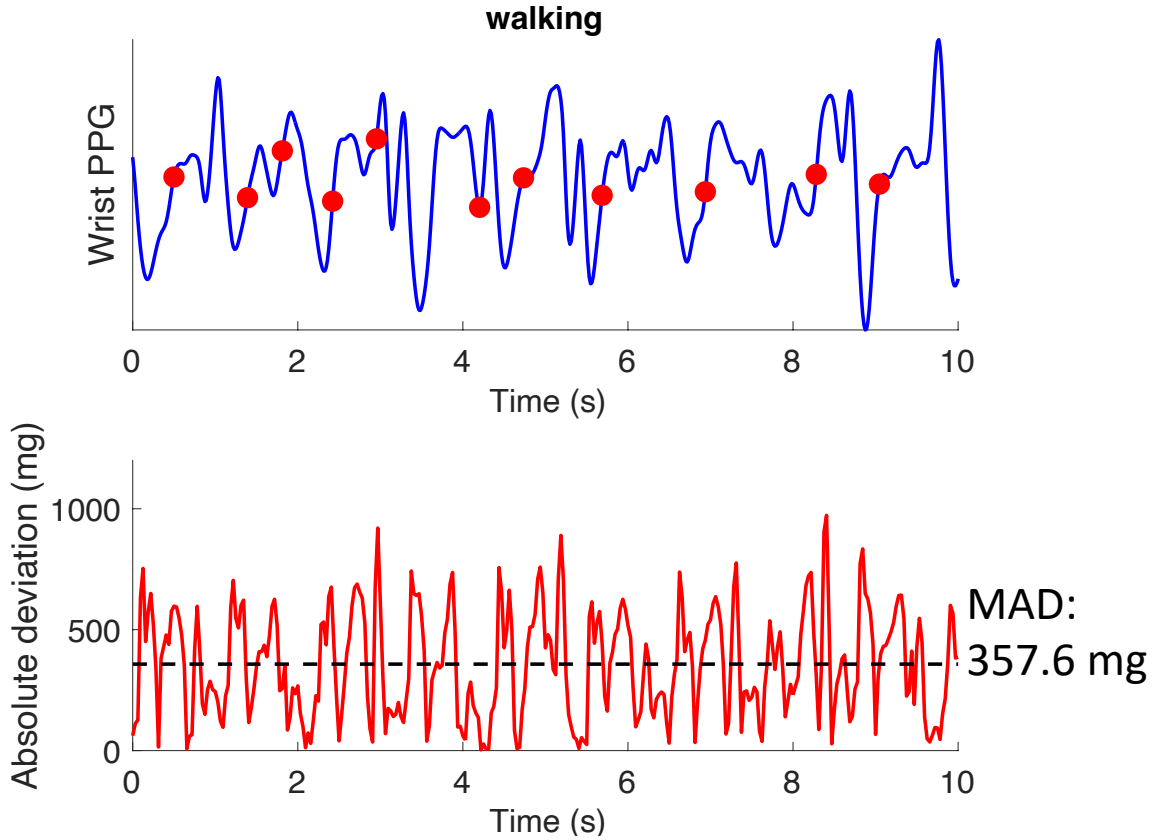
Source: Charlton PH *et al.*, Accelerometry-Guided Inter-Beat-Interval Assessment from Wrist Photoplethysmography, *CinC 2023* [in press] (CC BY 4.0)

Discussion

Why does it work (or not work)?

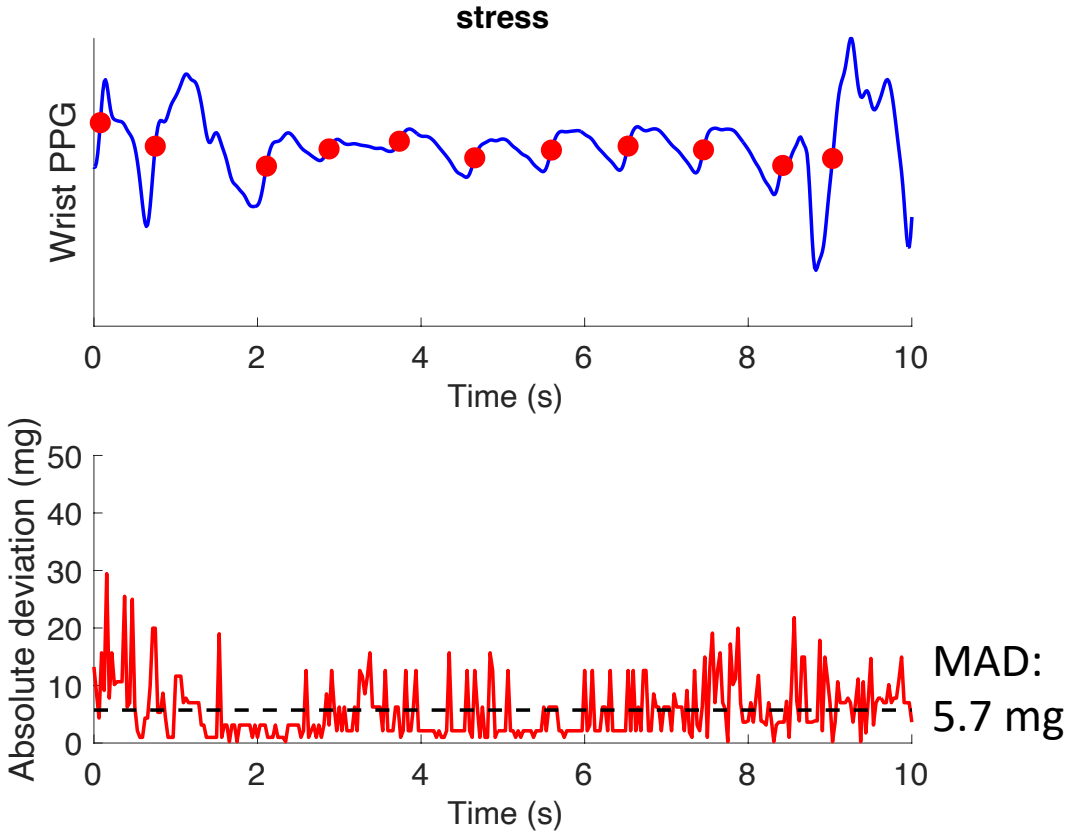
It works when noise is due to movement:





Why does it work (or not work)?

It does not work when noise is not associated with movement:



MAD: 5.7 mg

"Signal quality index (SQI) is generally used to evaluate signal quality, such as signal-to-noise ratio"

Park J *et al.*, Photoplethysmogram Analysis and Applications:An Integrative Review, 2022

"participants were stationary (as determined by device accelerometers)"

Lubitz S *et al.*, Detection of atrial fibrillation in a large population using wearable devices: The Fitbit Heart Study, 2022

With thanks to…

Panicos Kyriacou	University of Cambridge
Jonathan Mant	Technion-IIT
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Marton Aron Goda	British Heart Foundation

Accelerometry can be used to identify periods when IBIs can be accurately measured from PPG signals during physical activities with reasonable performance.

A threshold of 12.9 milli-gravitational units corresponds to a cutoff between sedentary and low-intensity activities.

Combining accelerometry and PPG-based assessments may provide improved performance compared to using either approach on its own.

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Slides available at: https://doi.org/10.5281/zenodo.8403222