electronRx Cardio Challenge

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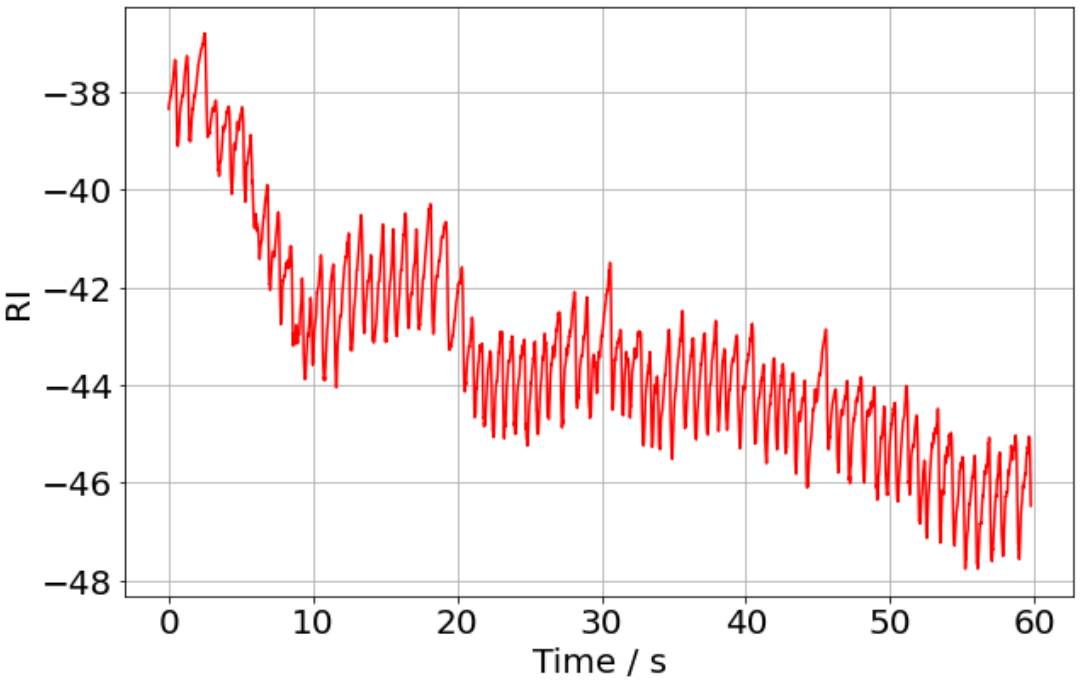
The task

- Signal processing & feature extraction from 10 raw PPG datasets.
  - Cleaning
  - Missing data
  - …
- Compare to expected results & modify strategy if necessary
- Discriminate SR & AF
- Visualisation

Thinking process rather than full code.

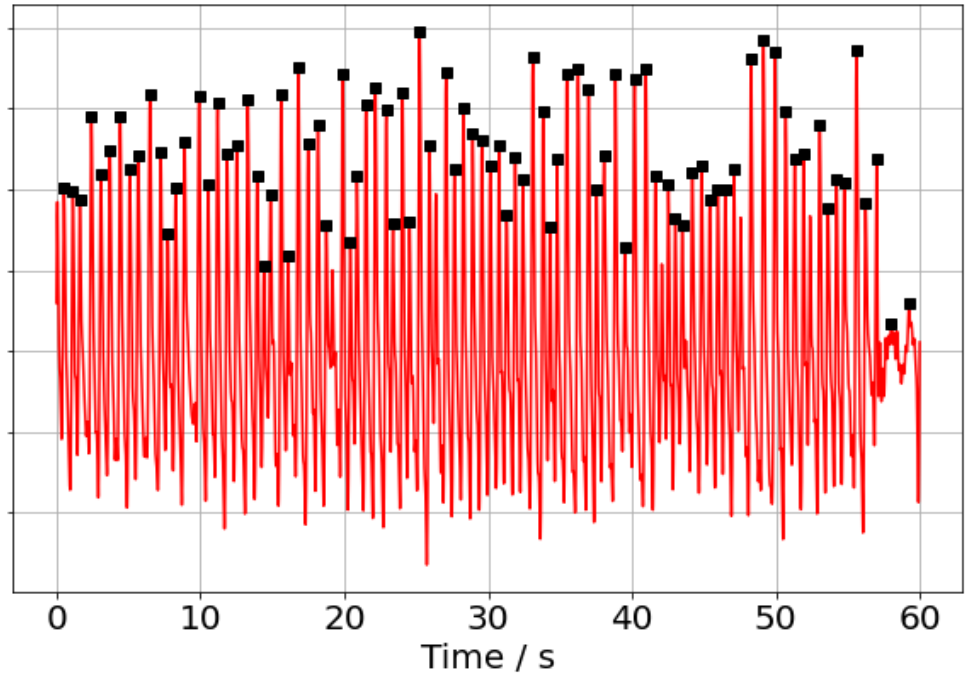
Signal Processing First approach: FT (C-code)

RAW PPG



Noisy, drifting baseline

bandpass filter & SciPy peak finding * (see .c file on GitHub)



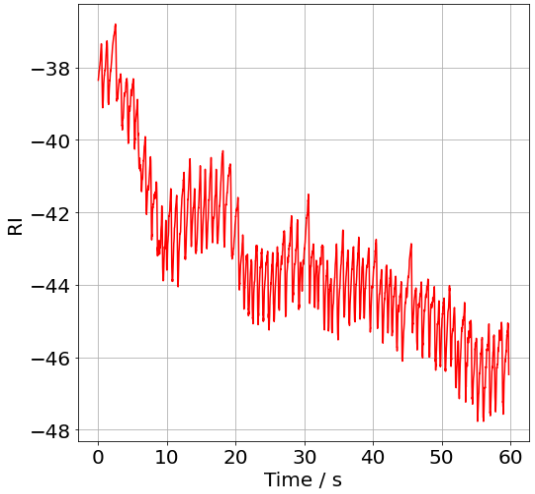
Improved! But:

- Results not a great match to expected
- FT can't handle missing data (see later slide)

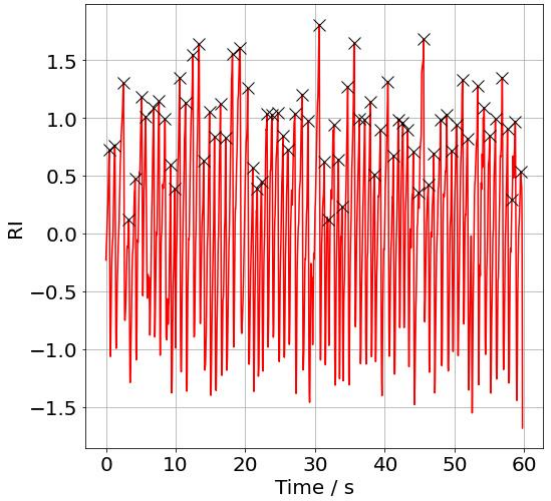
* `peaks, _ = find_peaks(df.r, height = 0.1, distance = 35)`

Second approach: Python toolkit

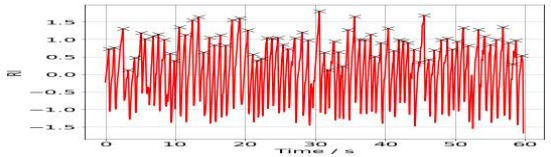
RAW PPG



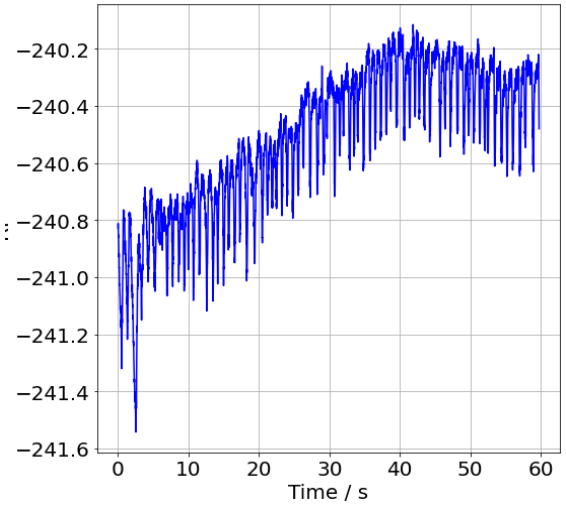
SciPy Savitzky-Golay noise filter, polynomial baseline correction & peak find

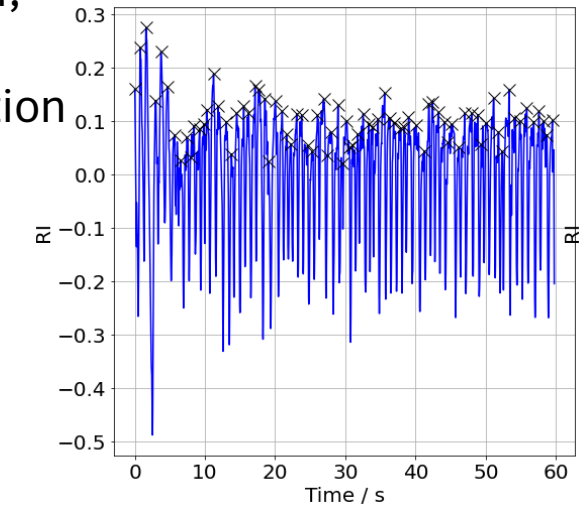


(Rescaled)

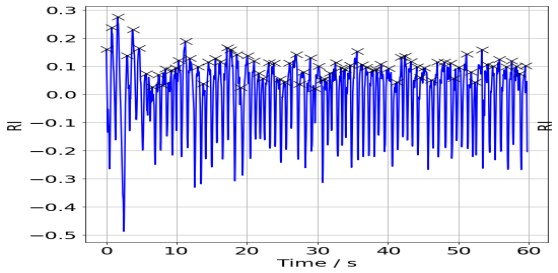


RAW PPG





(Rescaled)

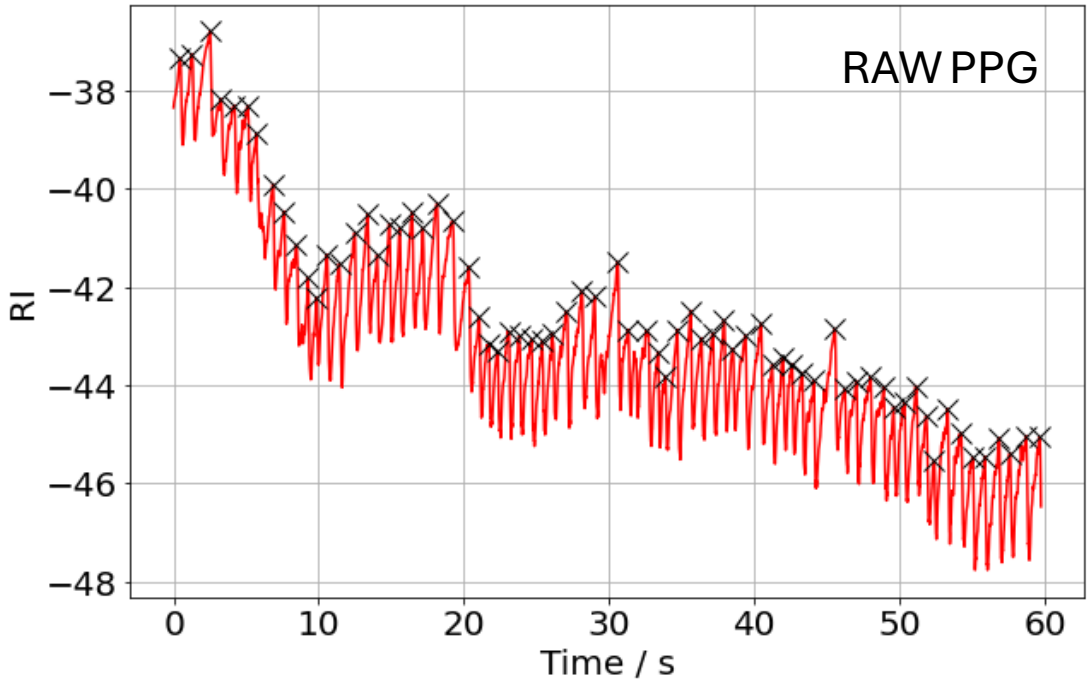


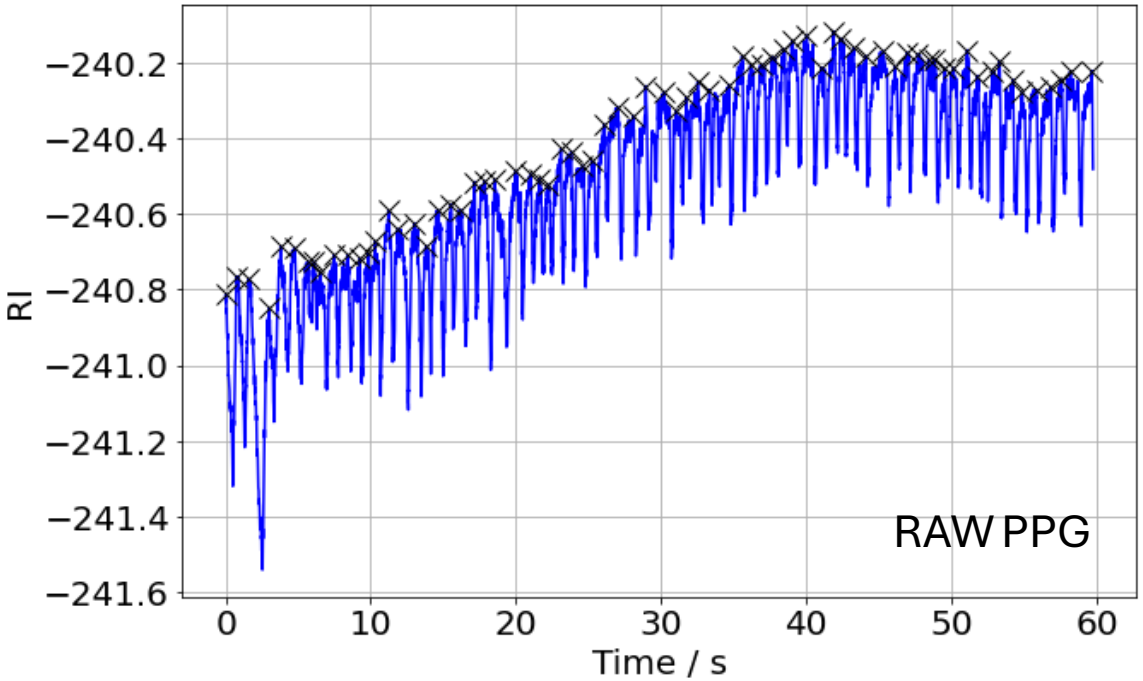
Better!

- Can handle gaps in data
- Results closer to expected

Peak find on raw data?

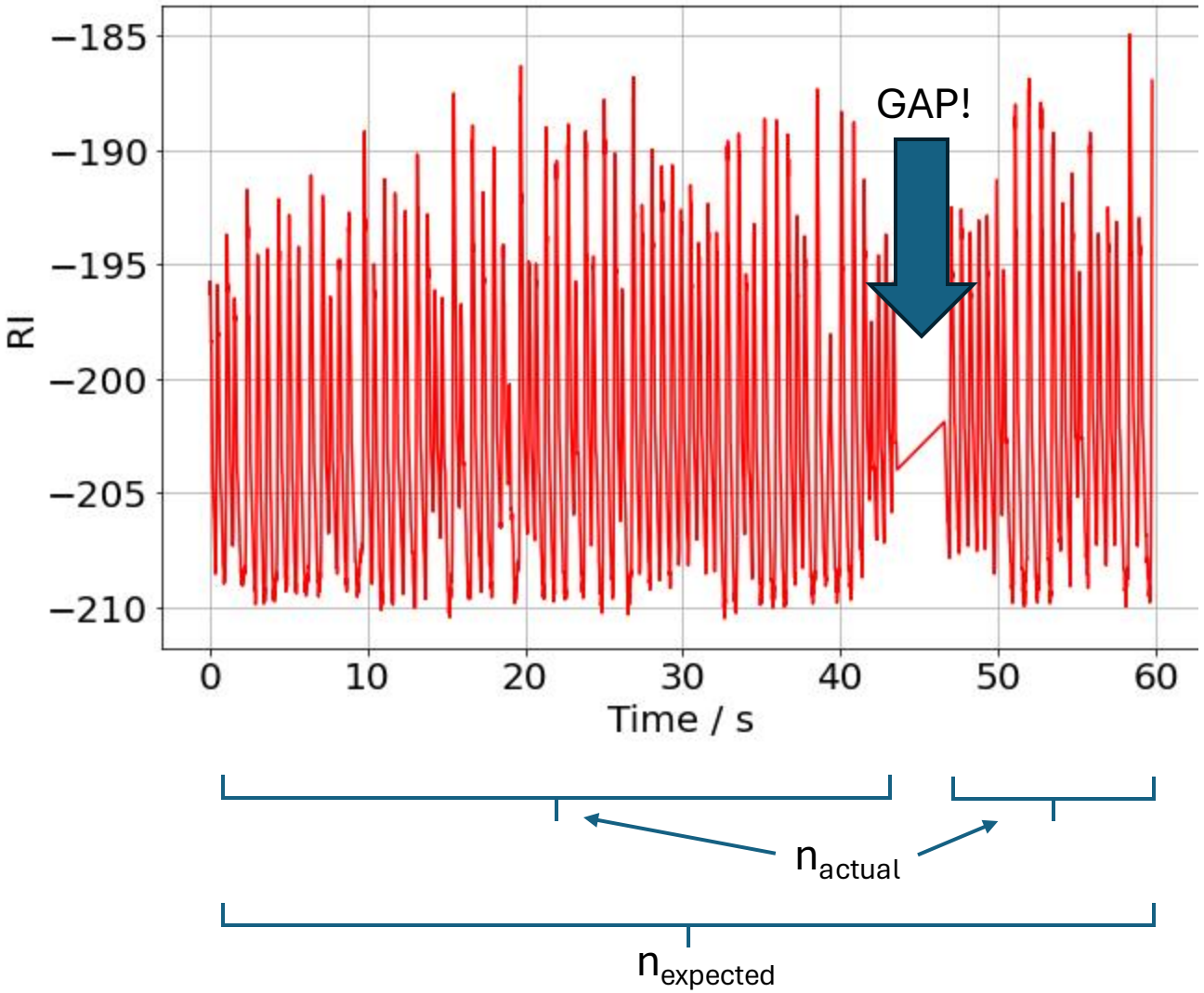
- To see if the signal preprocessing was having a positive effect, I coded my own peak detection program that didn't need filtered data.
- This worked by finding the positions of the local maxima within incremented windows of data, and yielded visually correct results.





Missing Data

- Some of the raw PPG files were missing rows of data.
- As a quick and crude workaround, obtained heart rate was multiplied by the fraction: $n_{expected}/n_{actual}$
- With more time, small gaps could be filled by maximum entropy interpolation, and larger ones by deep learning models such as recurrent neural networks.



Results

- My code yields the rMSSD, SDNN, and pNN50, but for simplicity only HR is displayed here
- In five cases the filtered results are better than the unfiltered ones – my filtering hasn't changed information content, but has visually improved the data

- I investigated the significant outlier in filtered …

	Expected	Processed	Raw
File	**HR (exp)**	**HR (SG, P)**	**HR (raw)**
2022-06-07 09-15-58	76.0	76.6	77.6
2022-06-07 11-04-55	56.4	56.3	55.3
2022-06-07 11-22-35	89.3	92.0	85.6
2022-06-14 09-42-01	70.6	83.1	70.1
2022-06-07 09-51-55	88.3	87.4	88.4
2022-06-14 09-31-19	54.3	87.0	63.7
2022-06-14 12-55-43	57.1	65.3	52.2
2022-06-14 11-07-24	74.2	79.4	73.3
2022-06-14 11-55-02	66.4	66.1	67.1
2022-06-07 10-03-36	65.4	65.1	63.1

Non-matching Metrics

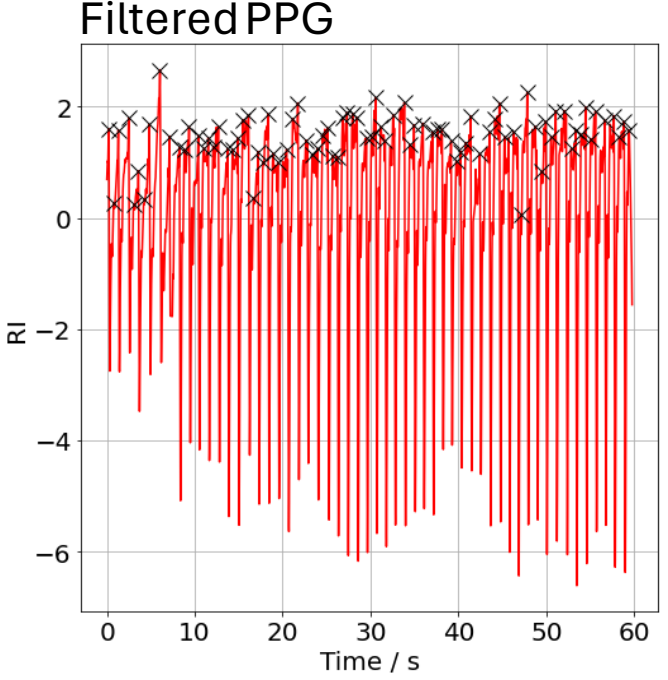
87.4

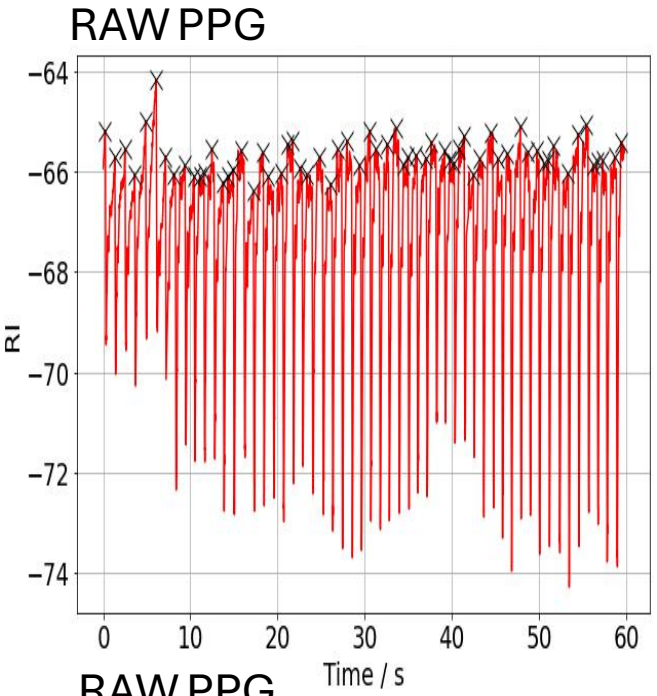
87.0

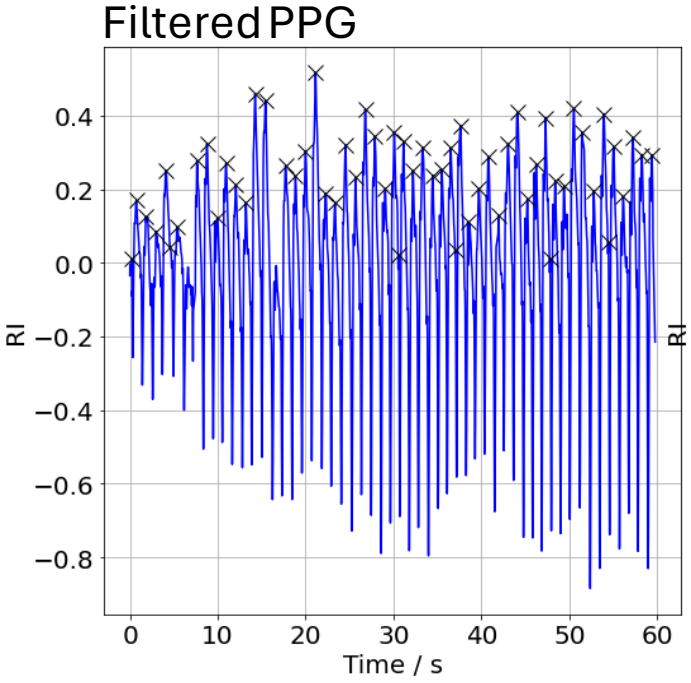
65.3

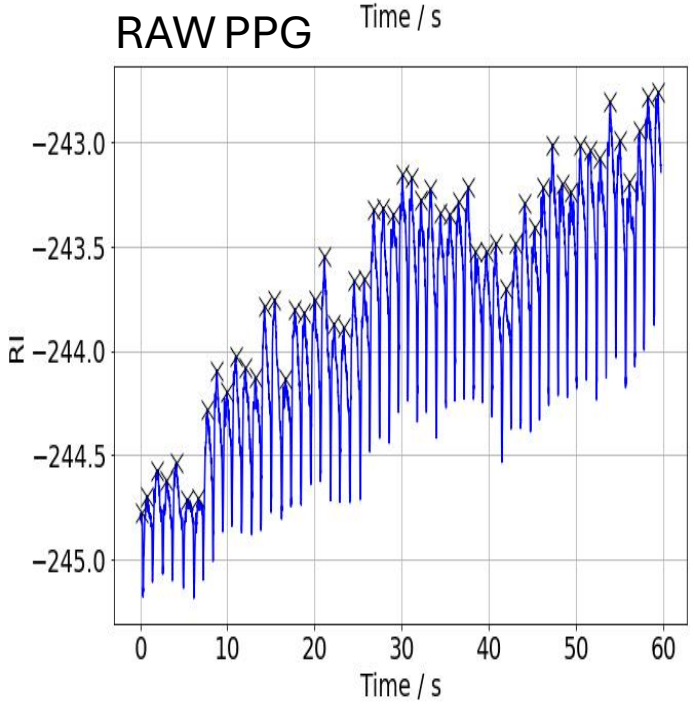
- The highlighted anomalous value was the only significantly different value
- The source of this error appears to stem from counting *secondary* peaks
- (May be clinically significant?)
- Could be fixed by a more sophisticated filtering technique or peak detection algorithm (e.g. AMPD*)

*Article link









Atrial Fibrillation vs Sinus Rhythm

- A study conducted in 2020 found that a deep learning approach was successful in detecting AF from raw PPG data.*
- Here, the rMSSD, SDNN, or pNN50 metrics could be used as crude differentiators between AF and SR.
- As AF is characterised by irregular heartbeats, it seems plausible that a larger range of heartbeat intervals would imply AF.
- A brief visual inspection of the raw PPG waveforms might also be an effective initial screening method.

*Article link

Thanks for watching!