HPRnet

Understanding Soldier Performance

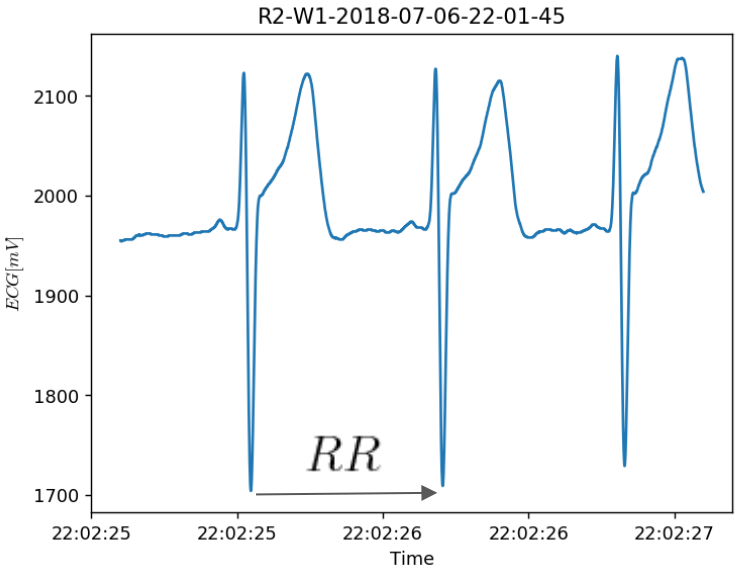
Applied Artificial Intelligence Institute
Deakin University

Soldier Performance ←→ Human Performance

- Work heavily influenced and inspired by research into human performance (in particular sports)
- Analysis of biosignal data (heart, respiratory, movement)
- Investigating if we can map heart rate (variability) to sleep (patterns) & stress
- Initial data collected was made available 4 weeks ago.

Data

- Stage 1:
  - Heart Rate Variability (HRV)
    - ECG profiles at 1000 Hz, in units of mV
    - RR time intervals
    - $HR[\text{bpm}] = 60/RR[\text{secs}]$



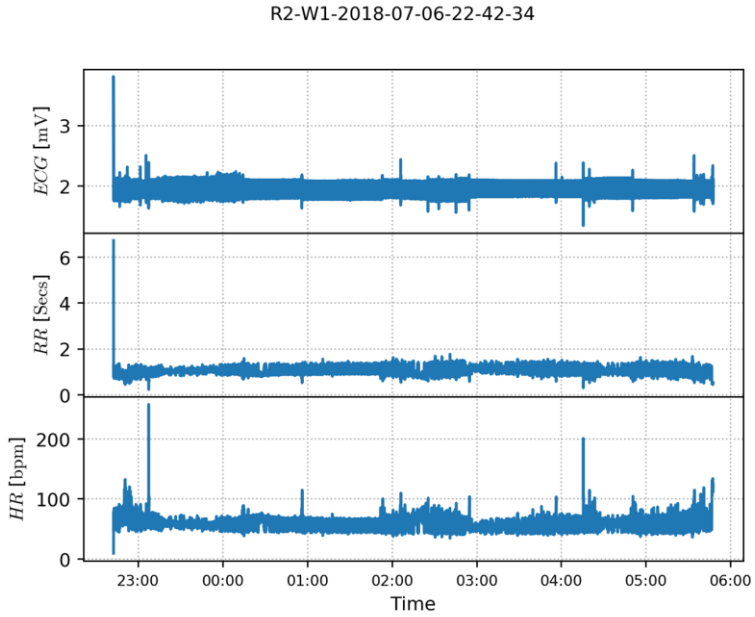
- Stage 2, complement HRV data with
  - Respiratory Data
  - Acceleration Data

- Check with data from other sleep studies (we do not have ground truth in AU)
  - MIT-BIH database: ECG profiles with labels every 30 seconds showing the sleep stage of a patient

Data Landscape

- Participant size & collection rate:
  - Up to 48 Recruits on a time interval of 12 Weeks
  - 1-2 days per week of data
  - Approximate time interval: 10 - 11 pm → 5 - 6 am (to analyse sleeping pattern)

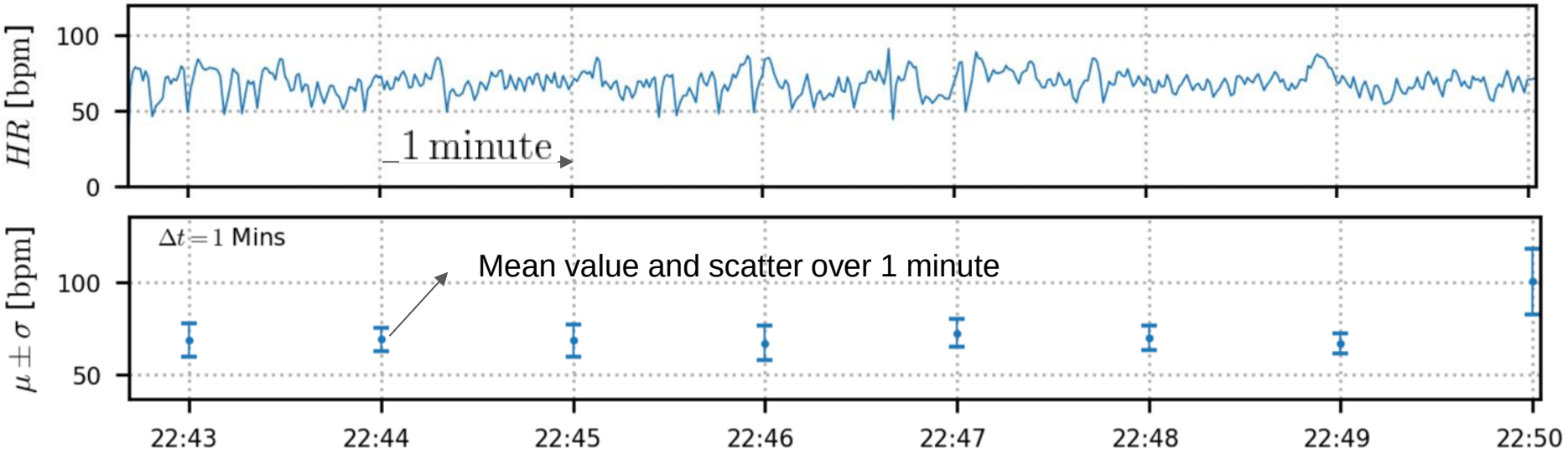
- Data we are collecting,
  - ECG/RR: Via chest worn strap (Zephyr Units)
  - Acceleration: Via Actigraph GT3X devices



Analysis Method

- Default subsampling window: 1 minute (for heart rate measurement)
  - Following the guidelines for time scale in sleep studies (from 30 secs to 1 minute)
- Investigate heart-rate variability using entropy based methods (High variability implies healthy heart function)
- Investigate viability of geometrical analysis to track abrupt rate of changes -- for instance, gradient and curvature

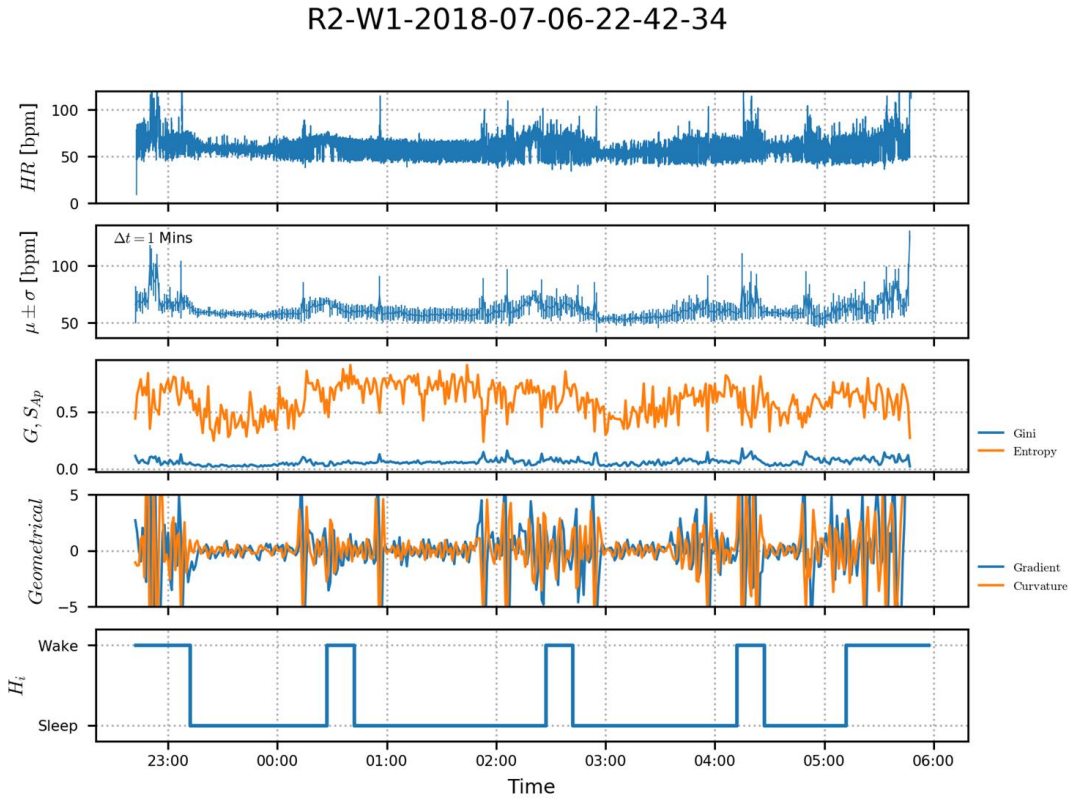
Analysis Method (II): 1 minute time window



- Variability Metrics (also in time windows of 1 minute)
  - Entropy to track regularity/variability
  - Gradient/Curvature to track an abrupt change

Initial results (I)

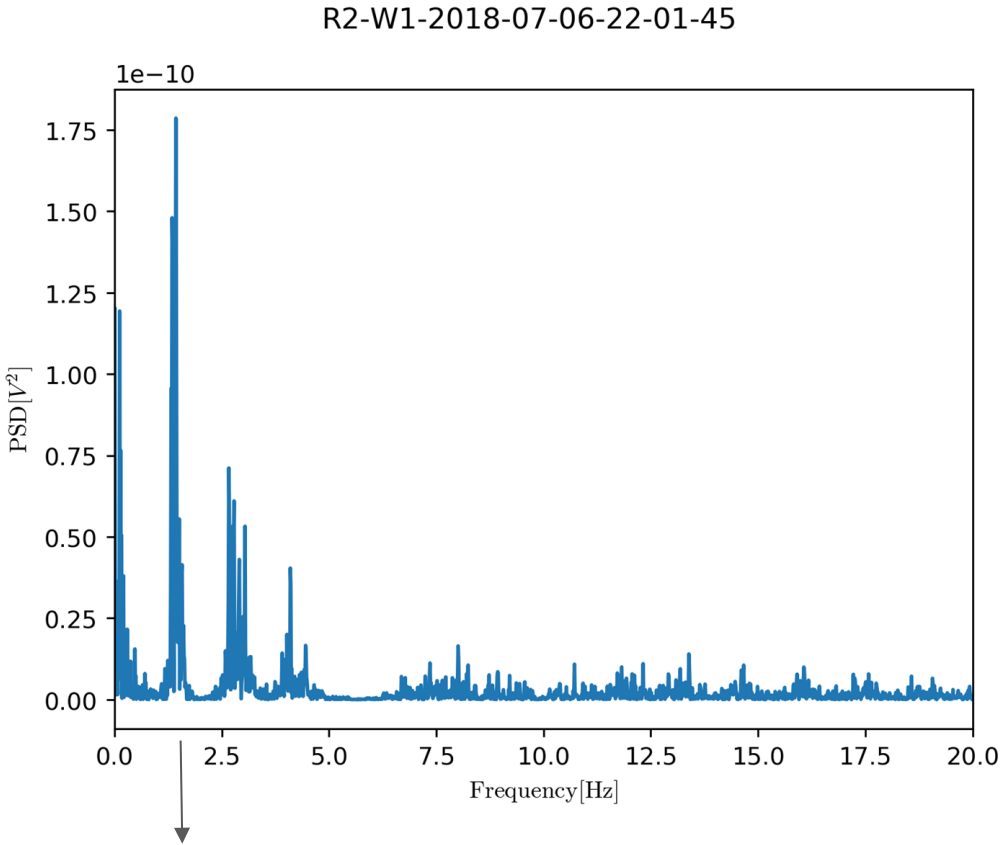
- Picking up 4-5 sleeping cycles per day (normal)
- Valleys/Peaks in the HR profile correlated with sleep stage (peaks -> light sleep or awake)
- We have a simple model for sleep classification
- Analysis of heart-rate during sleep is critical as it reduces noise



Initial results (II)

- Frequency decomposition (Fourier analysis)
  We want to isolate fundamental Frequencies in the periodic ECG signal

- Power spectrum: proxy for energy content in a periodic signal

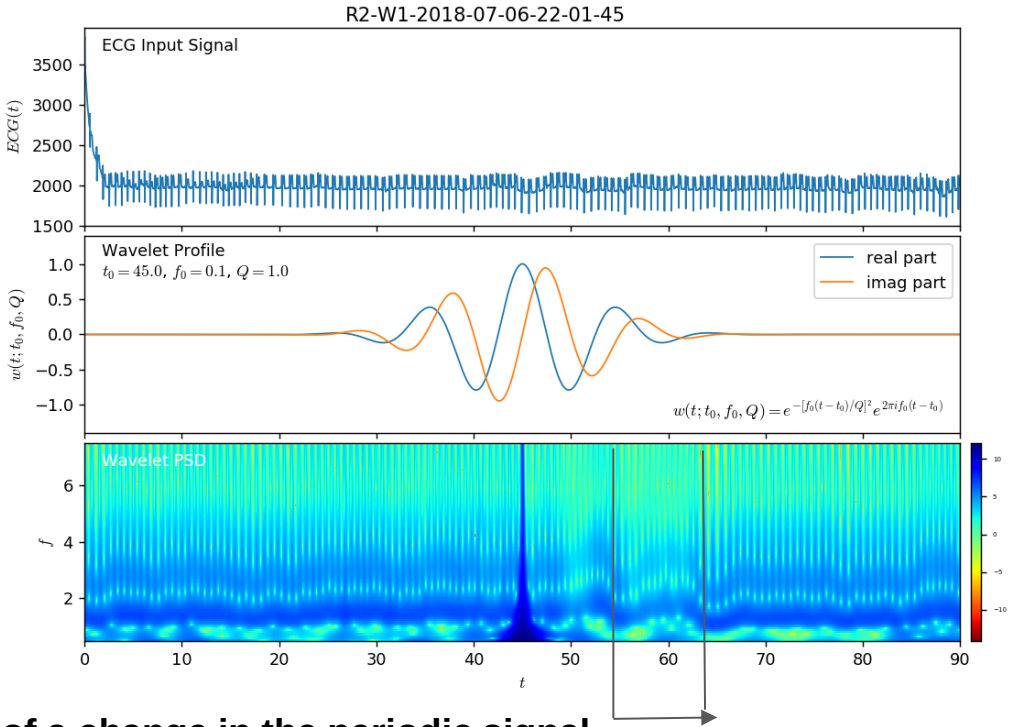


Fundamental heart rate frequency

Initial results (III) - Wavelets analysis

- Extension to Fourier analysis to handle the possibility of sharp peaks and non-periodic signals

- Recovery of the fundamental HR frequency at about 1 Hz. Isolating secondary frequency around 3 Hz.



Potential location of a change in the periodic signal

- Spectrogram: bottom panel, allows to compare time evolution of frequency

What is next…

- Collect more data & start to align with ground truth + qualitative data collected on the ground
- Tune the data processing pipeline
- Investigate other approaches to analyse the data (e.g. neural networks)
- Classify the participants into clusters & see if there are common patterns
- Discover the feedback loop -- i.e. how to use this information to improve performance & training procedures