KU LEUVEN

Design and use of an energy measurement module for speed pedelecs

EVS35
OSL2022

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Content

- Speed pedelec
- Reason for the designing of a measurement module
- Development
- Performance
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What is a speed pedelec?

- Light electrical vehicle (LEV)
  - Electrically Pedal Assisted Cycles (EPACs)
    - 250 W
    - 25 km/h max speed assistance
  - Speed pedelec
    - Max 4 kW motor power (typ: 350-800 W)
    - 45 km/h max speed assistance
    - Helmet, license plate, mirror, …

Speed pedelec benefits and drawbacks

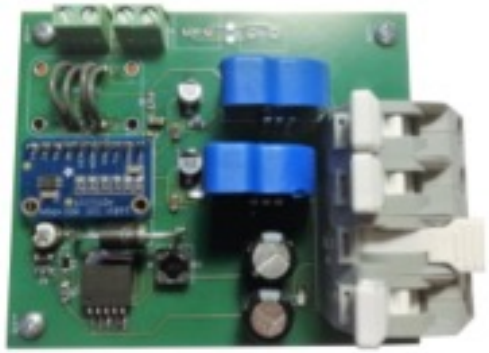
- Why use a speed pedelec?
  - High speed
  - Travel time
  - Smaller CO_2 footprint
  - Outside, active travel
- Challenges
  - Uncertainties (no external verifications)
    - Travel range (inaccurate/verification)
    - Power consumption (verification)
    - Assistance factor $= \frac{P_{\text{Motor}}}{P_{\text{Cyclist}}}$ (verification)

Proof of concept speed pedelec measurement module

Garmin Edge 510

Assioma duo power pedals

Battery power measurement module



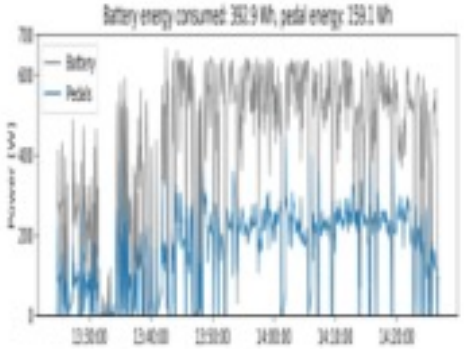
Database

GPS-data
Speed-data
Cyclist power-data

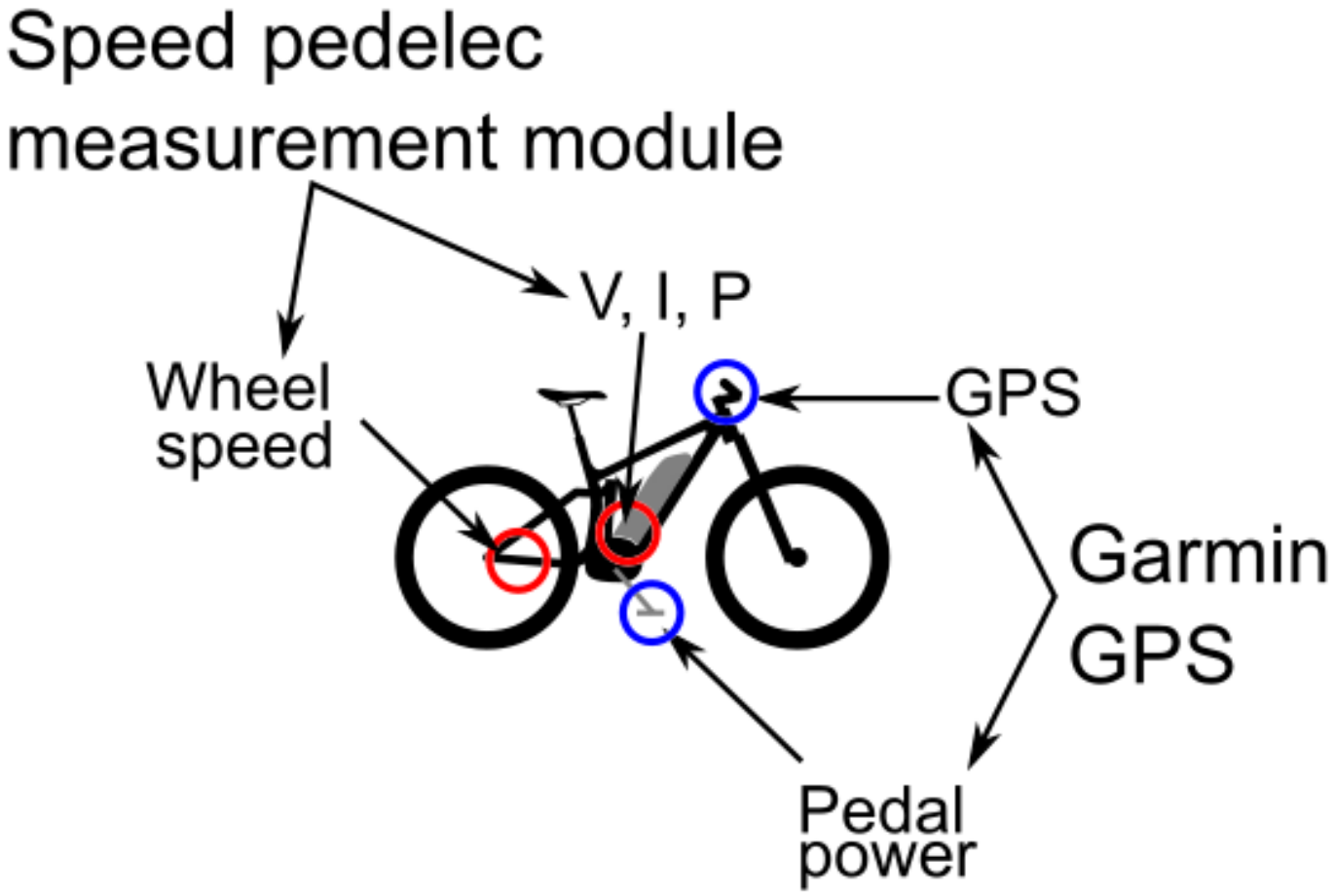
Database

Battery current-data
Battery voltage-data
Speed-data

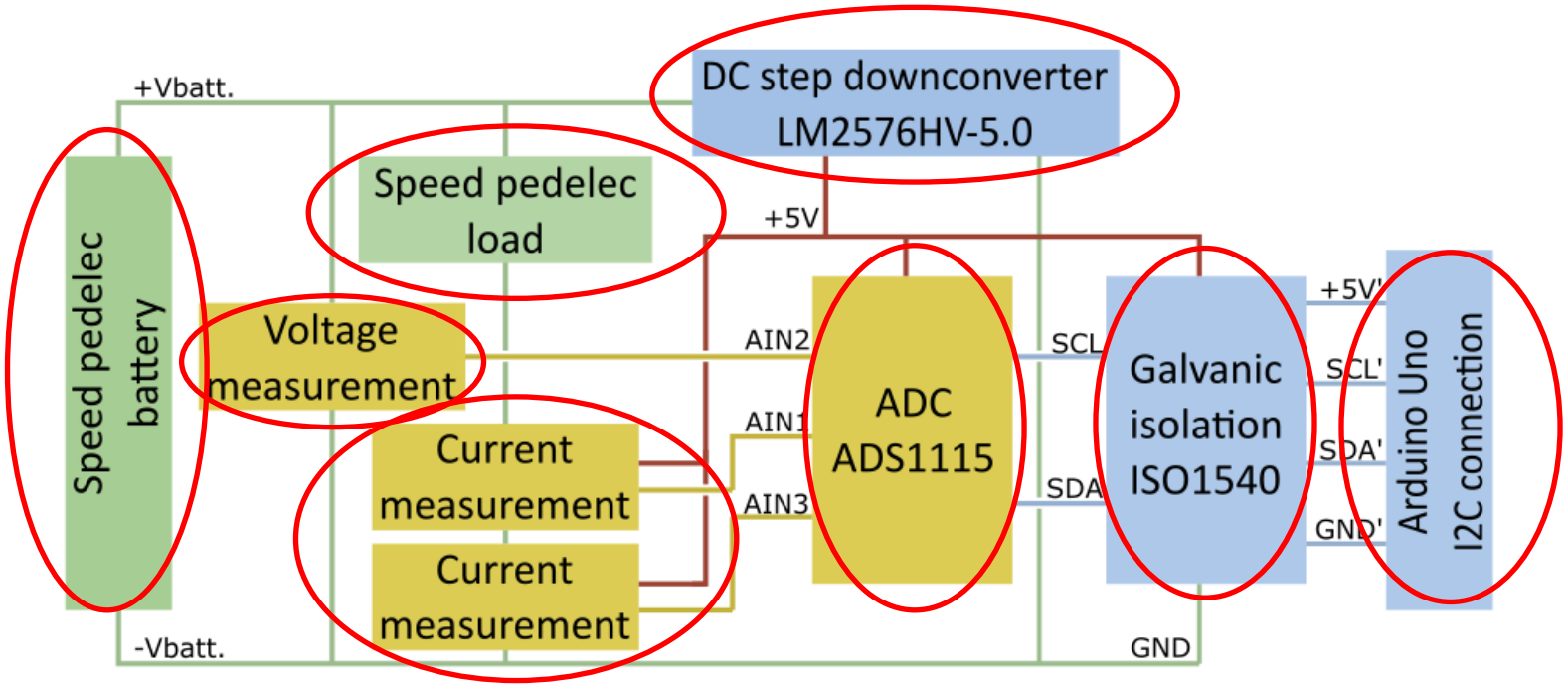
Python code

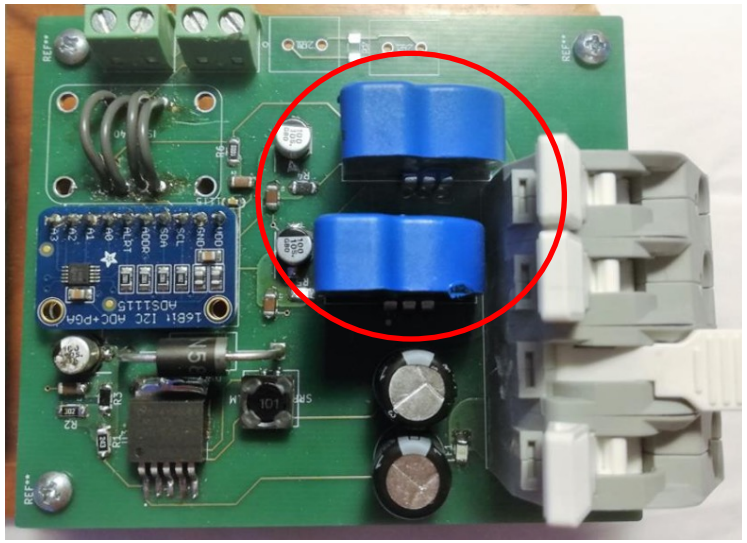


Sensor placement on the speed pedelec



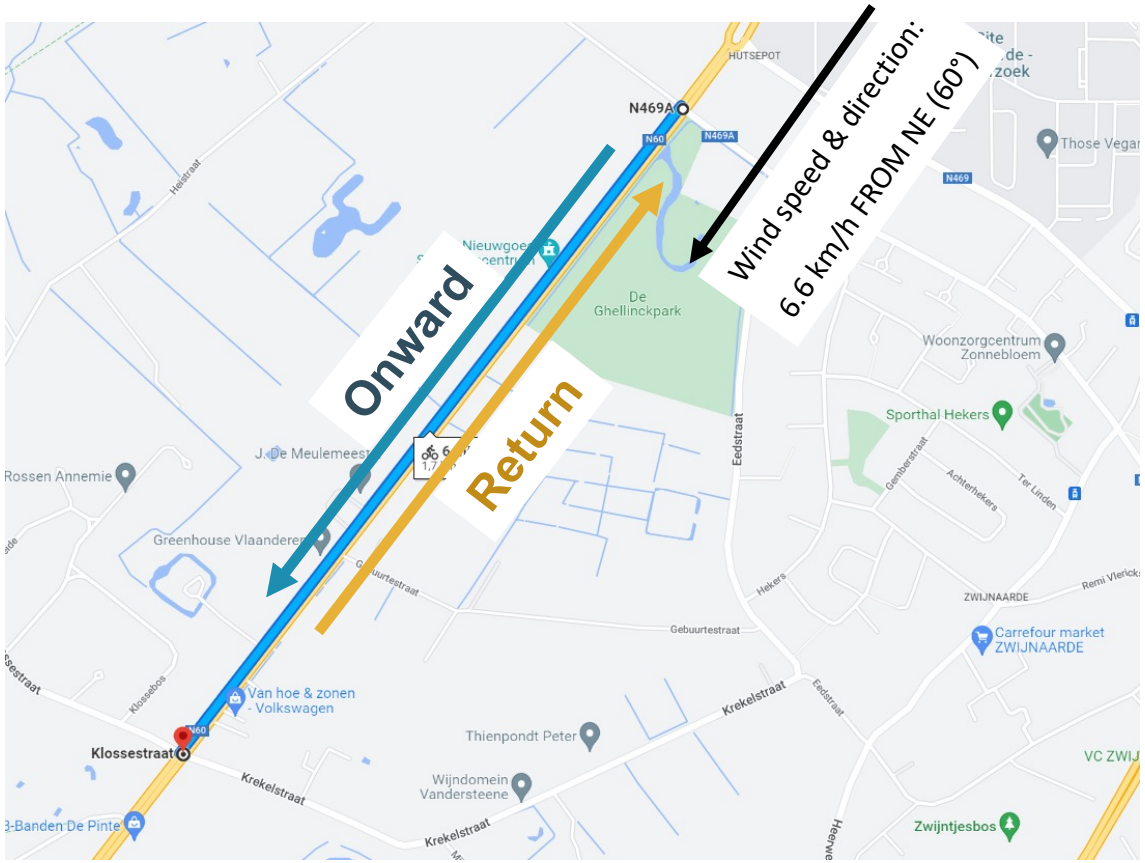
Structural diagram





Performance of the speed pedelec measurement module

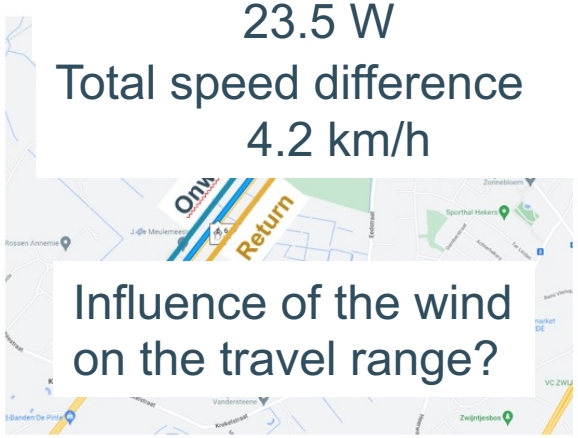
- **Test 1**
  - 100 W ± 10% and 80 rpm ± 5%
  - Different assistance modes
  - Two trips
    - Onward trip with tail wind
    - Return trip with head wind



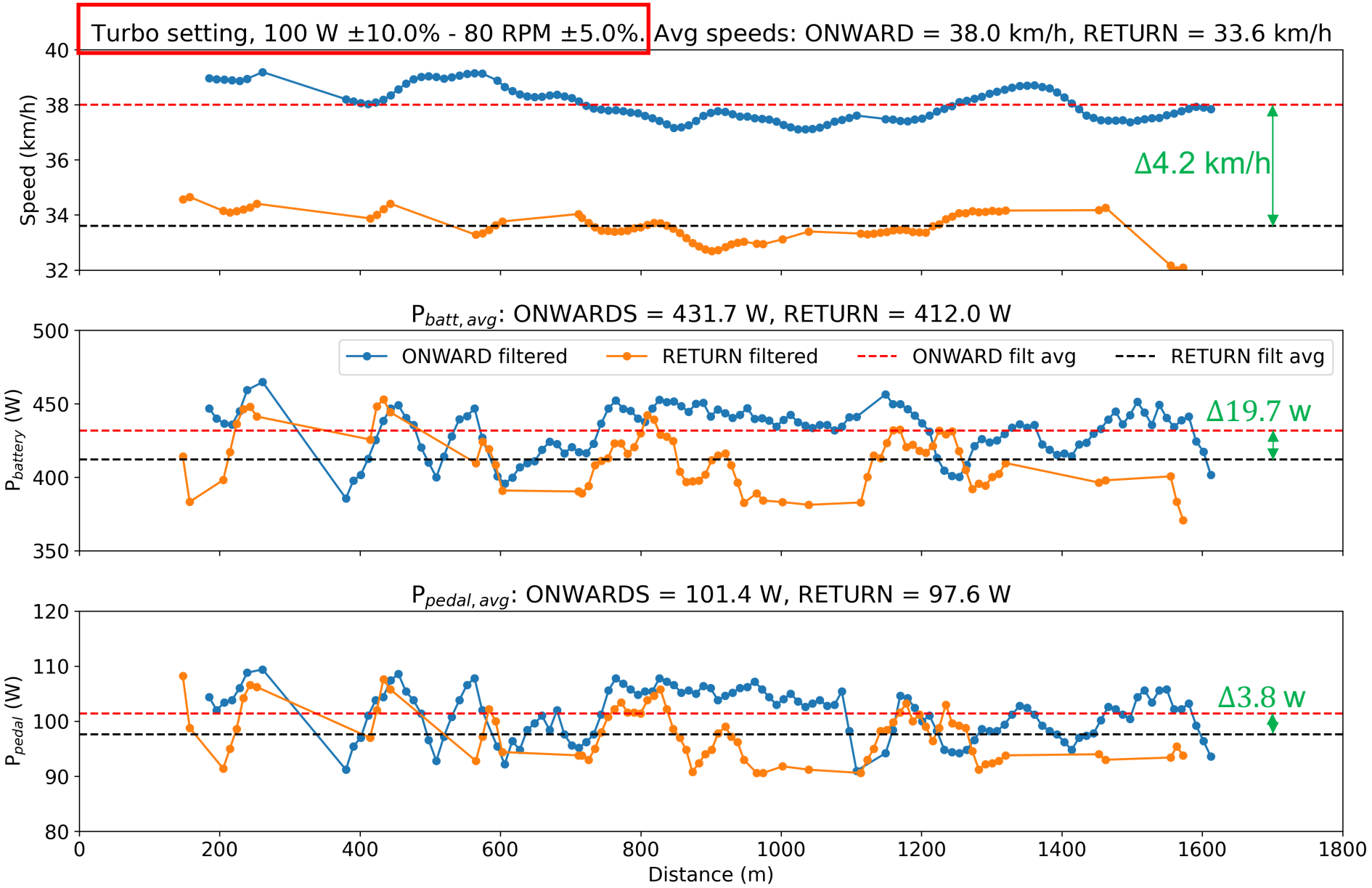
Test 1

Filtered data set
- Speed
- Battery power
- Pedal power

Avg. total power onwards
533.1 W
Avg. total power return
509.6 W
Avg. total power difference
23.5 W
Total speed difference
4.2 km/h



Influence of the wind on the travel range?



Test 2

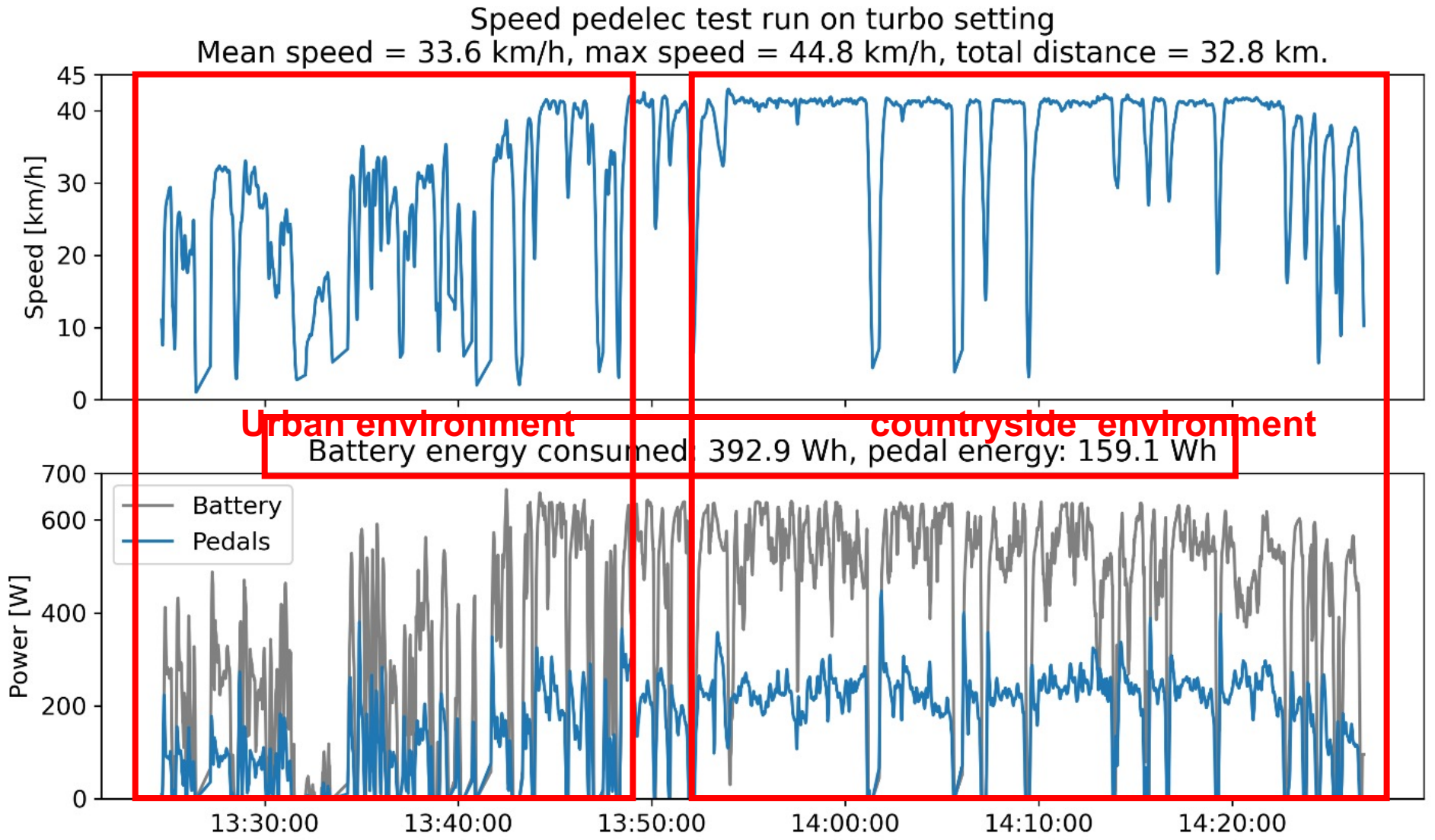
Realistic power consumption test

Assistance mode = Turbo
Distance travelled = 32.8 km

393 Wh battery energy consumed
159 Wh pedalled
Battery capacity = 500 Wh
100 Wh remaining < 393 Wh
Battery needs to be charged for return trip

Urban environment
- Speed and power
  - Fluctuation
    - Low average speed
      - Corners
      - Traffic lights

Countryside environment
- Speed and power
  - Steady
  - High average speed
    - Straight roads
    - Less crossings
    - Less traffic



Conclusion

- A proof of concept measurement module for speed pedelecs
  - Battery power
  - Pedal power
  - Speed
  - Trajectory
- Promising measurements
- More tests on more speed pedelecs.
  - To draw conclusions
    - Energy consumption between different speed pedelec manufacturers, commuters,…
    - Validation of the travel range
    - Gain insight in the data of speed pedelecs.

Questions or suggestions?

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