Sports & Health applications of a versatile electronic architecture for e-bikes: Preliminary study

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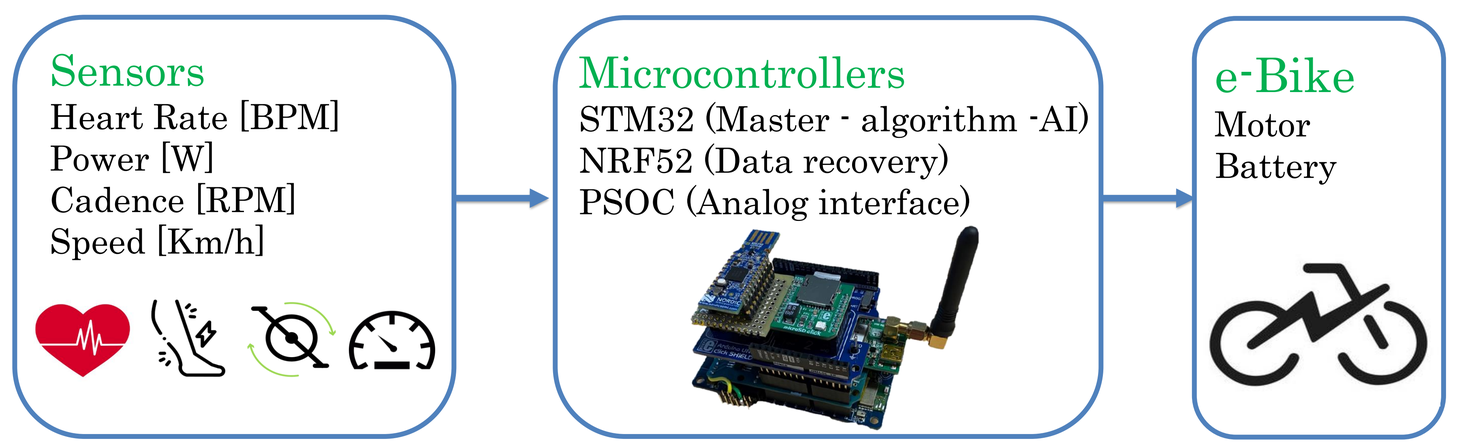
Abstract: In recent years, electric bikes have gained popularity among persons that wants to do active mobility or start doing sport with diminished effort. Our work focuses on taking advantage of the available electric motor and the rider's physiological data to adjust the effort, keep the rider in a specific training zone, or respect a medical directive. Doing so will allow sedentary and ill persons to start doing physical activity in a controlled environment. On the other hand, sporty persons can target a heart rate (HR) zone to ensure working out a specific aerobic or anaerobic phase.

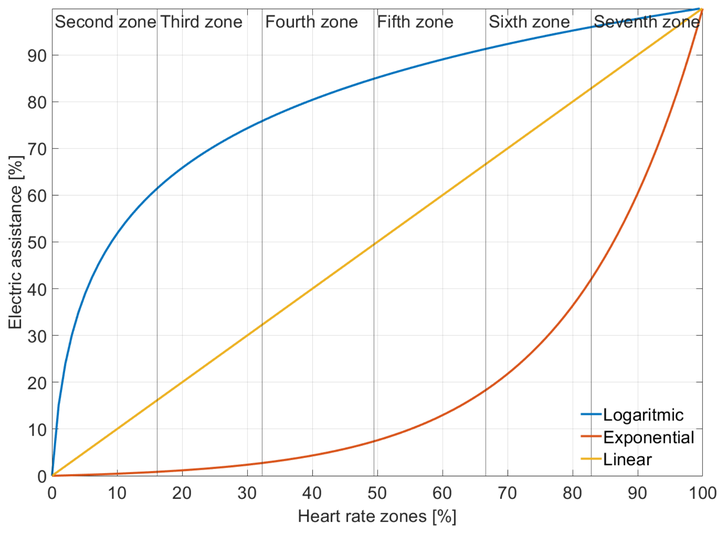
DATA FLOW

Off the shelf sensors are used to measure the subject's physiological data.

The data is recovered using the ANT+ protocol and processed in the master microcontroller, where a decision is made; depending on the HR zone and the chosen electrical assistance (EA) command, the motor gives an aid accordingly.



ELECTRIC ASSISTANCE COMMANDS



- **Linear**
- **Logarithmic**
  Suitable for untrained subjects, great aid from the start
- **Exponential**
  Suitable for trained subjects, significant aid only on the last zones

*HR zones based on ESIE F. Grappe's table

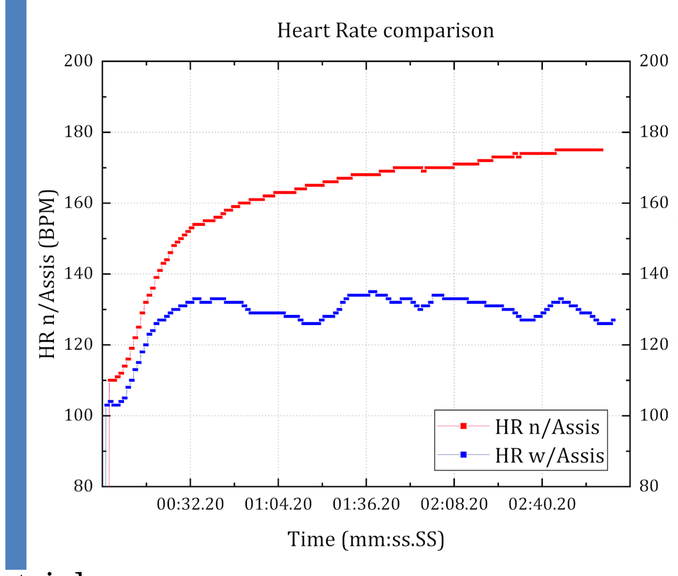
F. Grappe, *Cyclisme et optimisation de la performance: sciences et méthodologie de l'entraînement*. 2018.

ARCHITECTURE VALIDATION

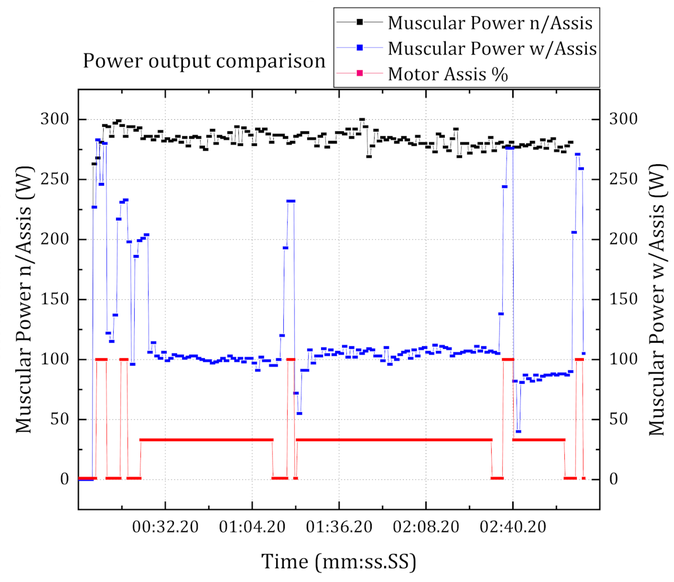
Indoor conditions: With a home trainer, the resistance is fixed at 280W. Comparing the test results done with and without EA, the assistance's effect on the HR and the power output is noticeable.

HR is maintained in a particular zone impeaching it to increase further (in case the subject is not allowed to strain too much).

- 17.6% mean HR reduction



- 42.5% mean power reduction

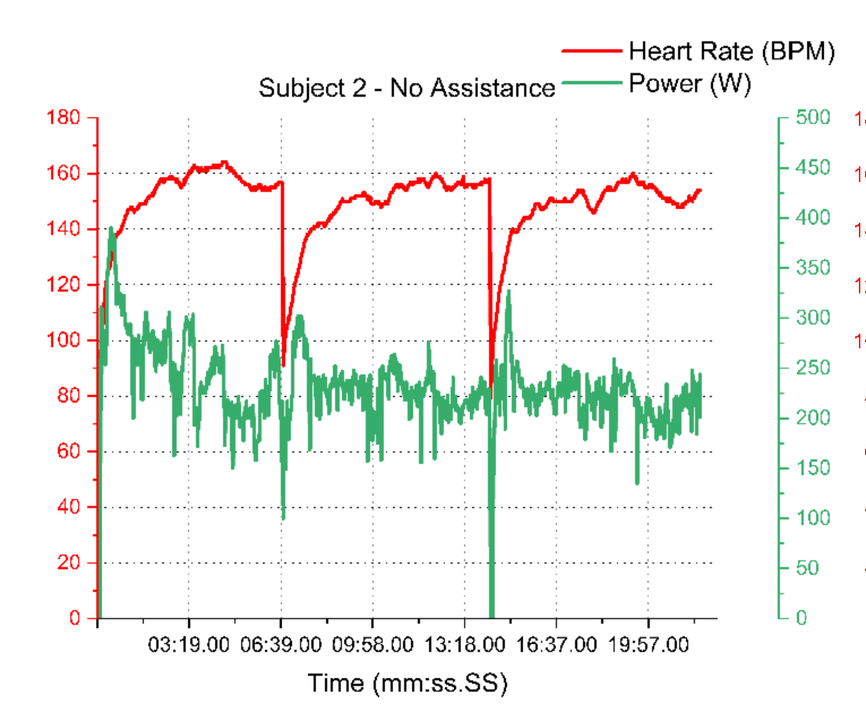


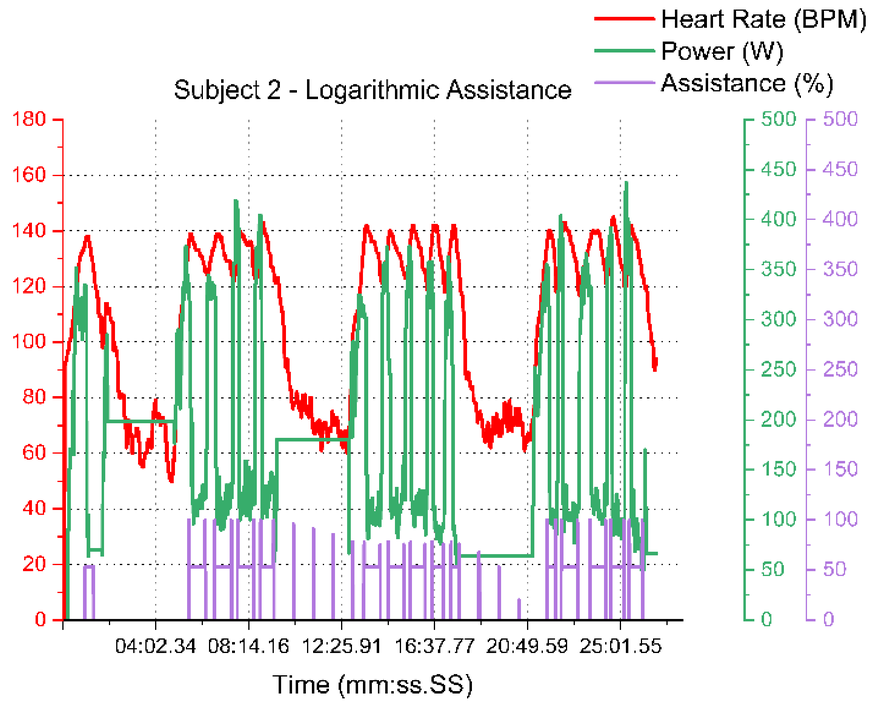
PRELIMINARY RESULTS

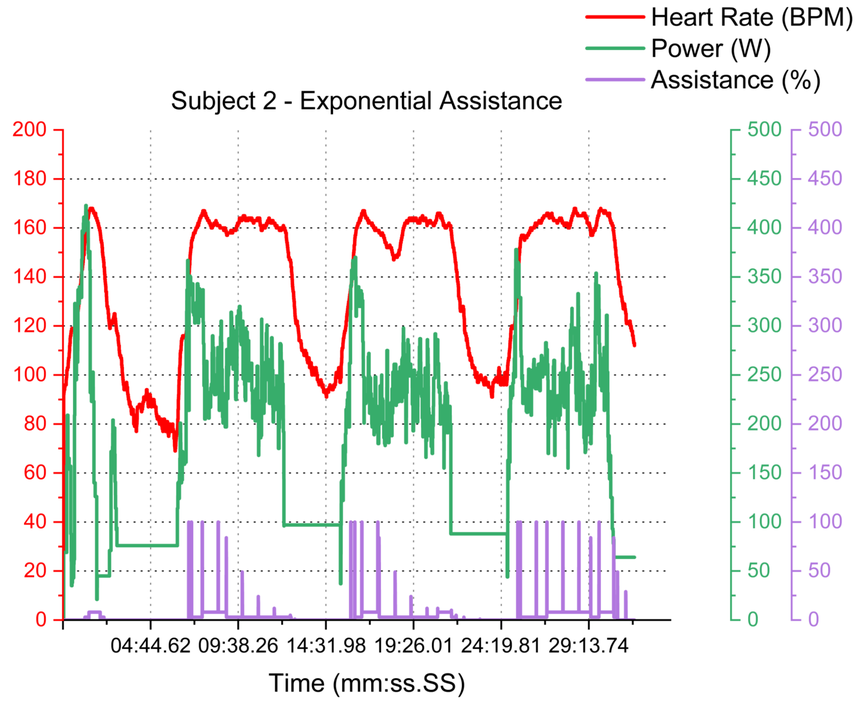
Outdoor conditions: Tests were carried out on a 6% climb for 1.5 km each trial.

With the logarithmic command, the heart rate is maintained at I2 HR zone on each climb, compared to I3 HR on exponential.

Mean power on each climb is 63.0% PMA (+/- 1%) for logarithmic and 74.6% (+/- 1%) for exponential. (PMA: Maximal Aerobic Power)







Conclusion: This architecture allows the implementation of control laws that directly impact the subject state during physical activity. Complex as the human body is, the control laws need to consider each person's uniqueness and adjust to it, granting a personalized law. Future works will focus on developing such control laws to ensure that ill and untrained subjects can use this e-bike safely and respect a medical directive.

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