Name and Surname	**Sara LUCIANI**
PhD in	**INGEGNERIA MECCANICA (Ciclo XXXV – Anno di corso I)**
Department	**Dipartimento di Ingegneria Meccanica ed Aerospaziale (DIMEAS)**
Coordinator	**Prof. Luca GOGLIO**
Tutor	**Prof. Andrea TONOLI**
Funded by	**IVECO**

Macroarea

Lead-Acid batteries monitoring in medium and heavy commercial vehicles, estimation techniques for the State of Charge (SoC) and the State of Health (SoH) based on Artificial Neural Networks (ANNs).

Research activity

1. Design of algorithms for the estimation of the State of Charge for Lead- Acid batteries in commercial vehicles.
2. Validation of the algorithm in a simulation environment.
3. Laboratory experiments set-up to collect data for the validation of SOC and SOH estimation algorithms.
4. Design of algorithm for the estimation of the State of Health.

Further research activity

Participation in the research activities investigated by the Interdisciplinary Laboratory of Mechatronics (LIM) on the design and implementation of control and trajectory planning strategies in an electric racing vehicle participating in the Formula Student championship for the Driverless category.

Participation in the research activities investigated by the Interdisciplinary Laboratory of Mechatronics (LIM) on the design and implementation of techniques to improve the passenger's comfort in assisted and autonomous vehicles.

Training activities carried out during the year

Politecnico di Torino

- 01LCPRV - Experimental modeling: costruzione di modelli da dati sperimentali
- 01RGBRV - Optimization methods for engineering problems
- 01SFURV - Programmazione scientifica avanzata in Matlab
- 01QORRO - Writing Scientific Papers in English

- Webinar: Online training Orbit Express (1h) 16/09/2020

IVECO

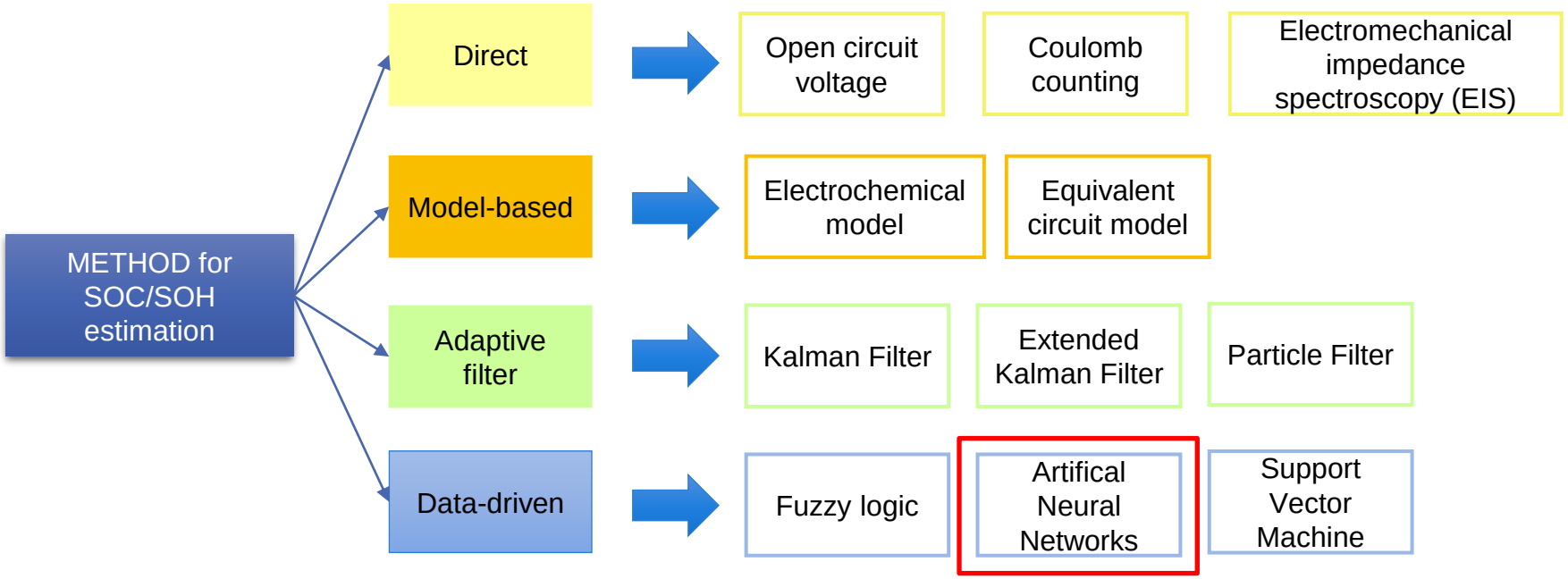
- Webinar: Corso su reti LIN/CAN,

Formula Student Germany Academy

- Webinar: Driverless Workshop 2020 (powered by Waymo), 29/08/2020 (11h) e 26/09/2020

- **Why SOC and SOH estimation?**
  1. They are crucial parameters of the battery to ensure in predicting the energy and power availability.
  2. They cannot be directly measured.

- **SOC and SOH estimation should be:**
  - accurate
  - robust
  - indipendent of the battery chemistry
  - low computational cost for the implementation on Battery Management System (BMS) microcontrollers



Method – Artificial Neural Networks

Advantages:

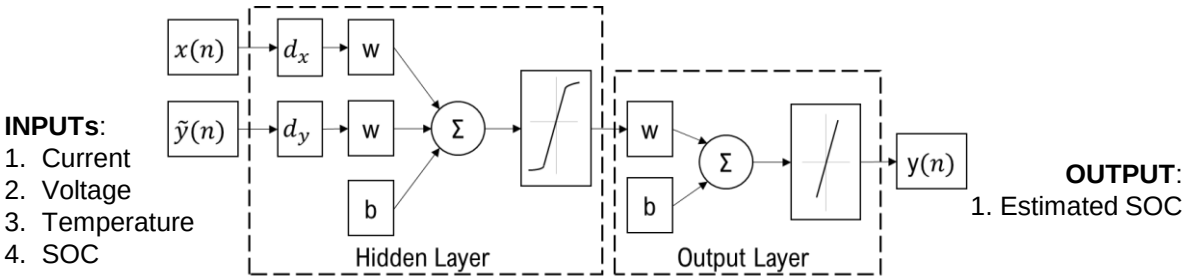
- ✓ Online estimation method
- ✓ Estimation using discrete life span data of the battery instead of whole life span
- ✓ Effectively capture the non-linearity
- ✓ Battery model or knowledge of the battery's internal parameters is not needed.
- ✓ Battery temeperature effect can be considered.
- ✓ Robust and stable.

Disadvantages:

- X Need large amount of data to train the network.
- X Precision depends on the accuracy of the model applied for the experimental dataset.

SOC estimation method - NARX

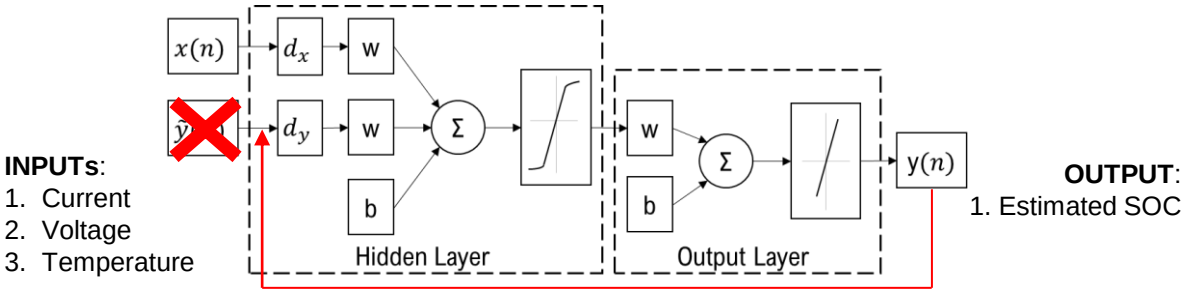
❑ **Net configuration in the training process**



INPUTs:
1. Current
2. Voltage
3. Temperature
4. SOC

OUTPUT:
1. Estimated SOC

❑ **Net configuration in the real application**

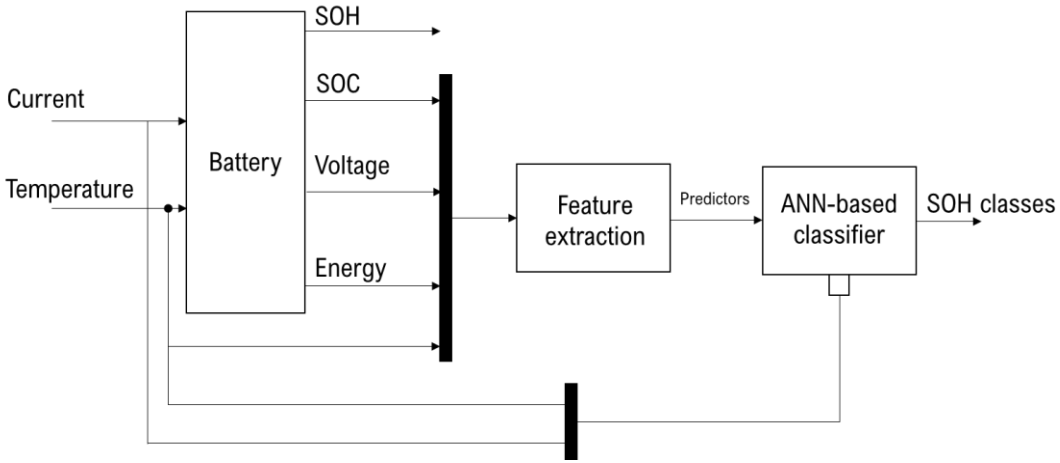


INPUTs:
1. Current
2. Voltage
3. Temperature

OUTPUT:
1. Estimated SOC

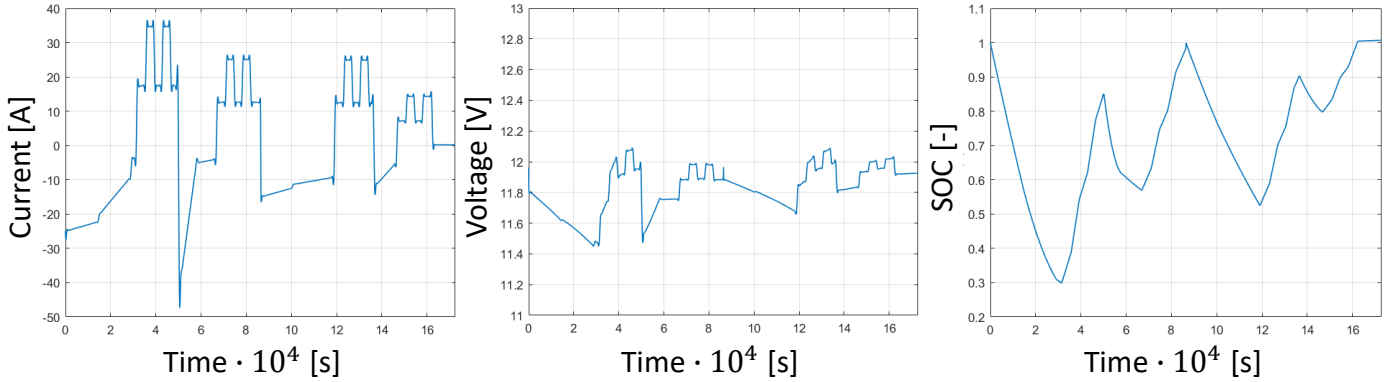
SOH estimation method (under development)

❑ A feed-forward pattern recognition classifier is under study to estimate the SOH for Lead-Acid batteries.

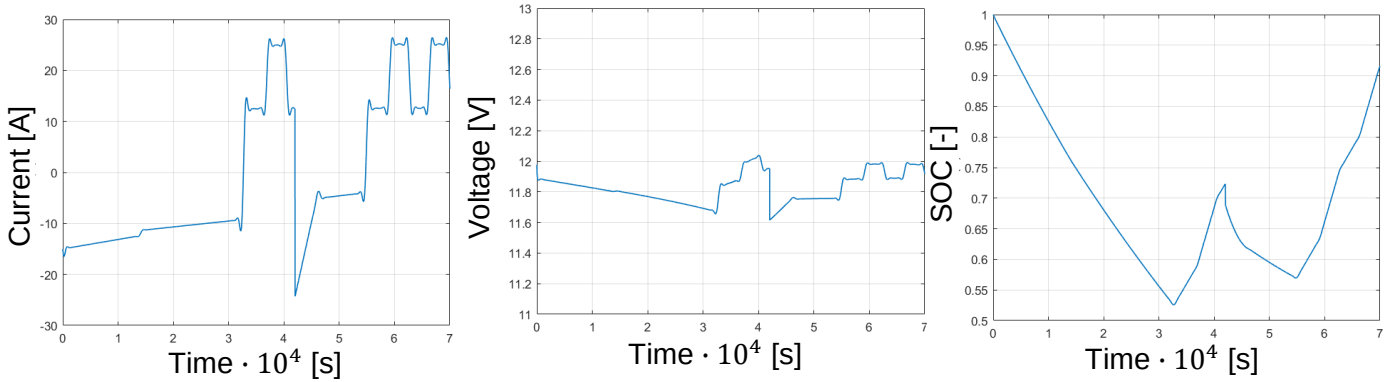


Results – SOC Estimation

❑ Training dataset @ 25 °C



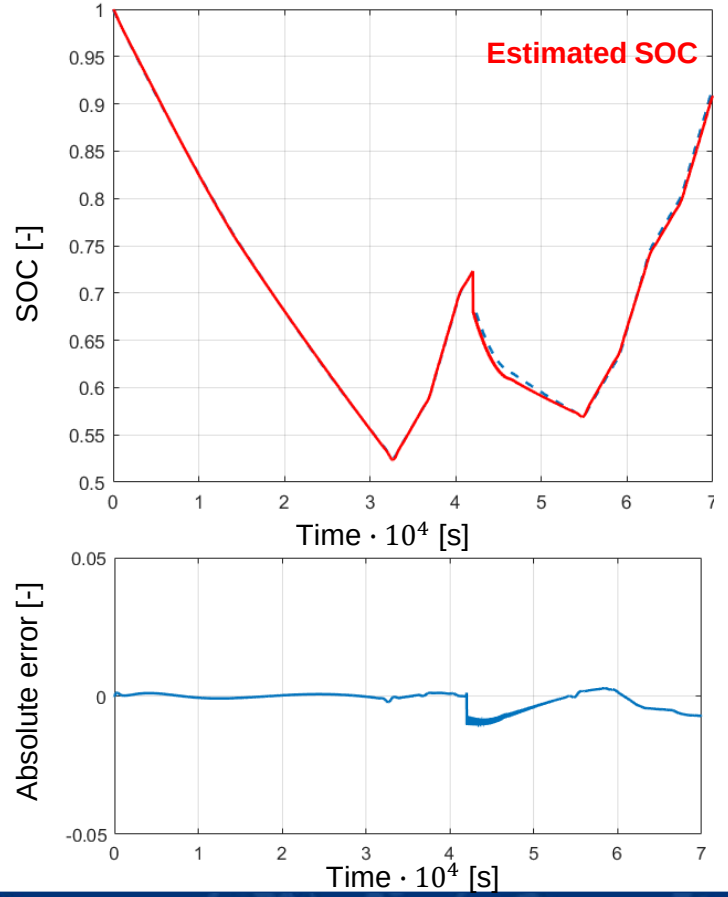
❑ Validation dataset @ 25 °C



❑ Neural network

Architecture: Recurrent NARX ANN
Training algorithm: Levenberg-Marquardt backpropagation
Hidden layer size: 5
Delay: 2

❑ SOC estimation results



- Validation of both SOC and SOH estimation algorithms on real data in a simulation environment.
- Validation of SOC and SOH estimation algorithms on vehicle.
- Design of algorithm for the combined estimation of the State of Charge and the State of Health.
- Validation on a simulation environment.
- Deployment of the resulting algorithm on a real Battery Monitoring System (BMS) of a commercial vehicle and test in real operating conditions.

Thanks for your attention!