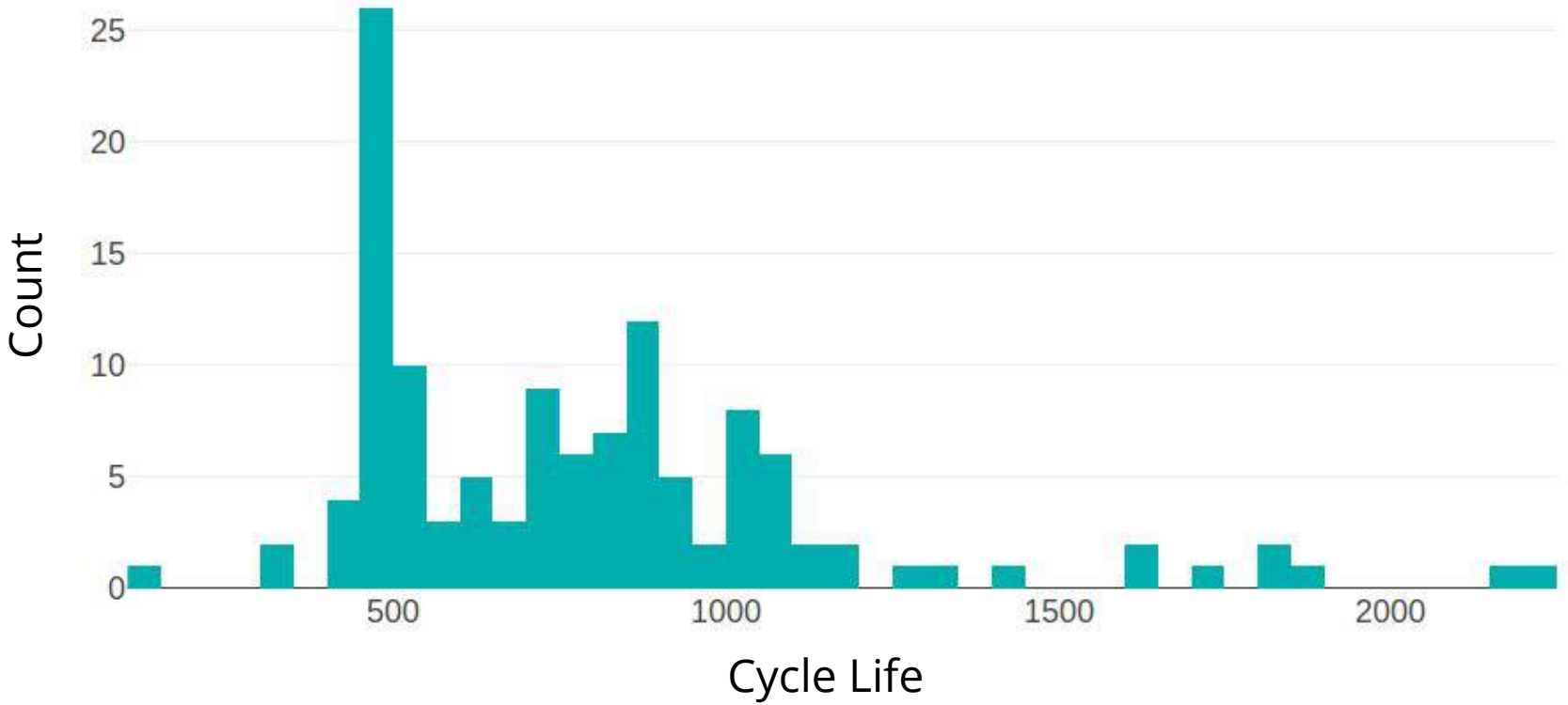

ION AGE
Forecasting battery lifetime



Lithium-ion batteries



Lithium-ion batteries

Quality assessment

How good is my battery right now?

Long-term planning

When do I have to react to a failing battery?

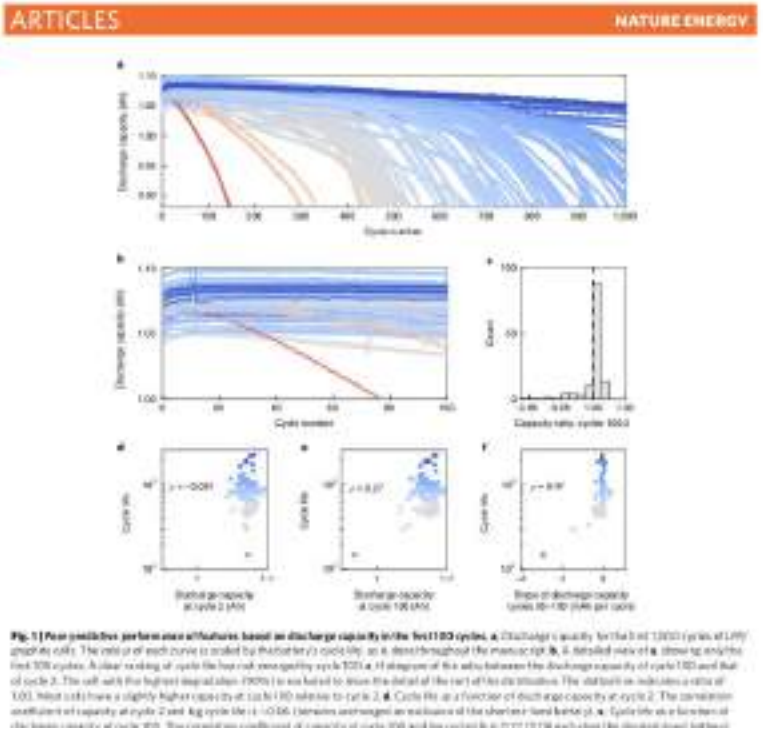
DEMO


DATA

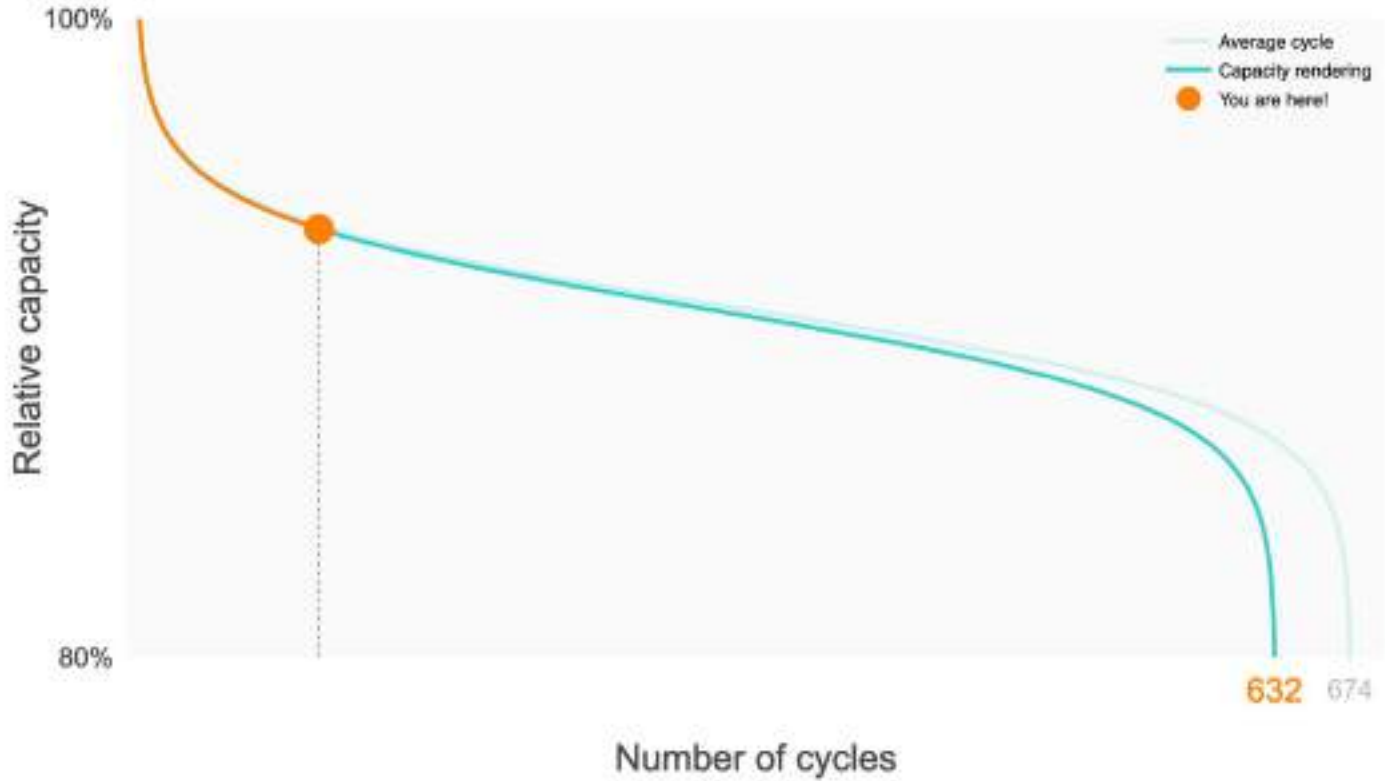
Dataset

‘Data driven prediction of battery cycle life before capacity degradation' by K.A. Severson, P.M. Attia, et al.

Nature Energy vol. 4, 383–391 (2019)



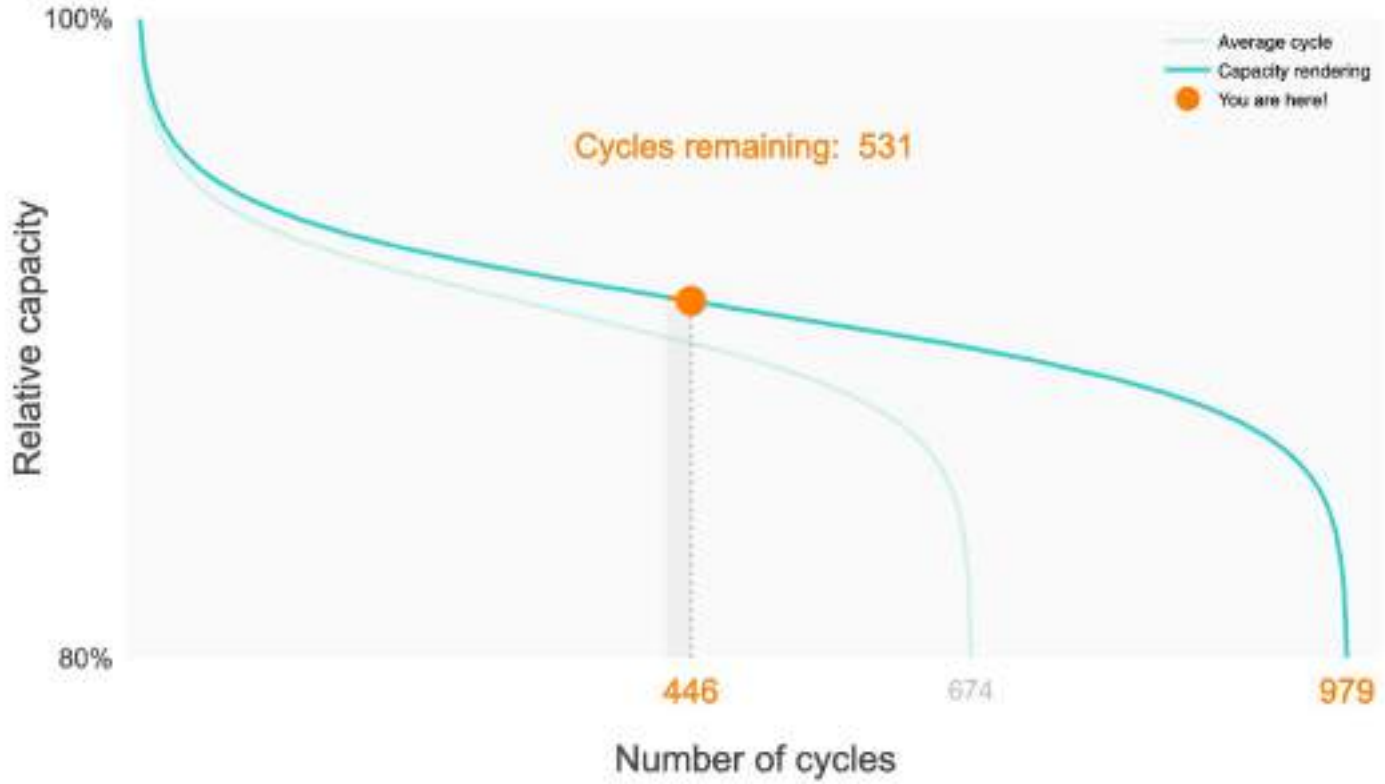
Dataset


100%
80%
Relative capacity
Average cycle
Capacity rendering
You are here!
632
674
Number of cycles

Dataset

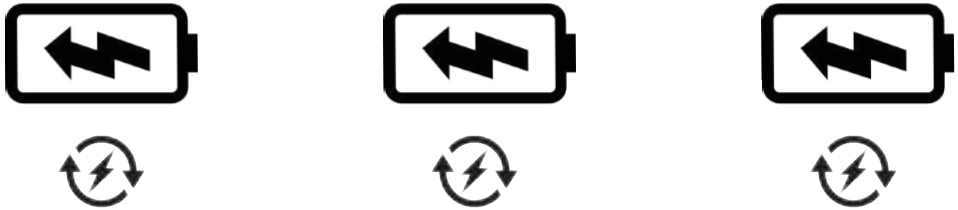
Original Paper	Ion Age
feature engineering	raw data
linear regression	deep learning
first 100 cycles	any 20 cycles

Dataset


100%
80%
Relative capacity
Average cycle
Capacity rendering
You are here!
Cycles remaining: 531
446
674
979
Number of cycles

Dataset

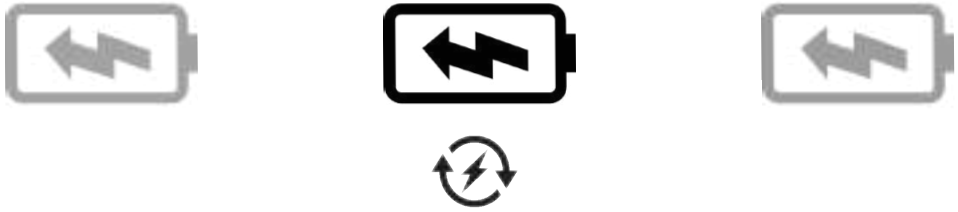
124 cells



630 **560** **1105**

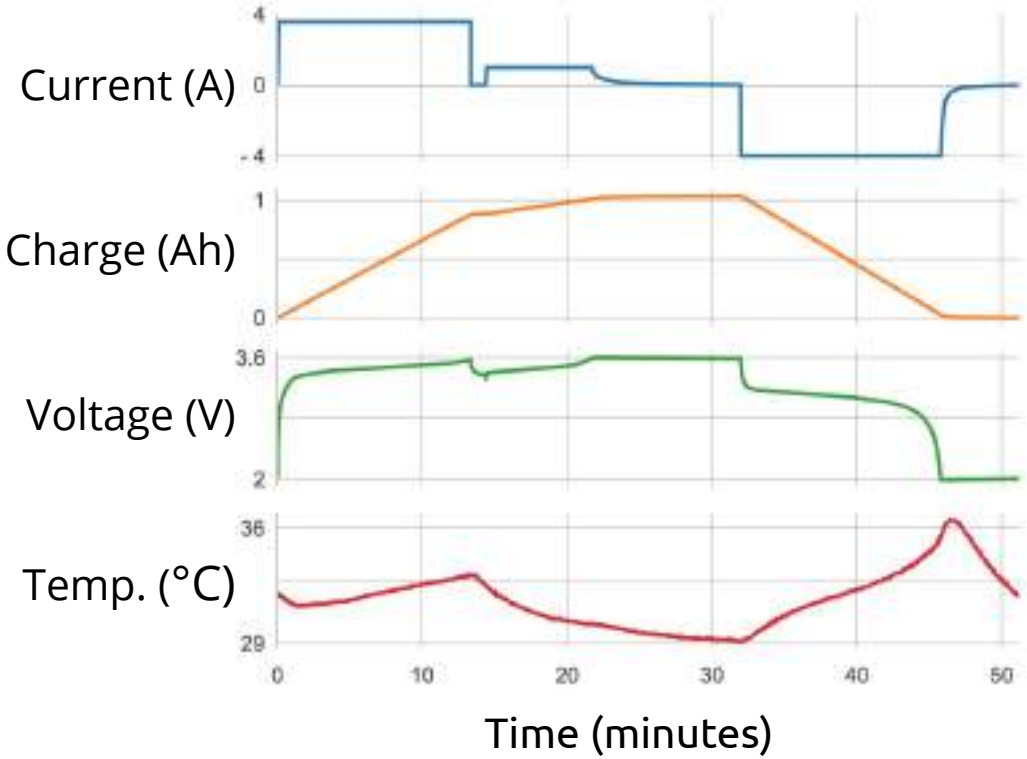
Dataset

124 cells



Inside One Cycle

Time-Scale Features

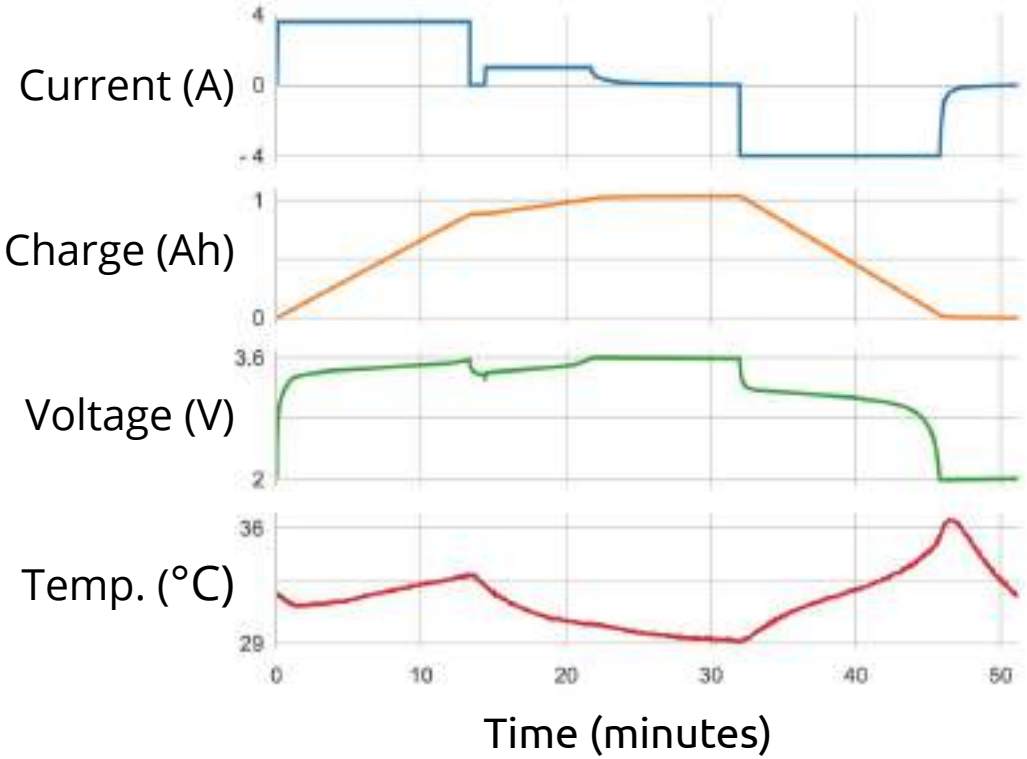


Scalar Features
Internal Resistance (Ω)
Total Charge (Ah)
Total Time (minutes)
Temperature Stats (°C)

Data Processing

Challenges

- Charging conditions not uniform
- Time measurements not uniform



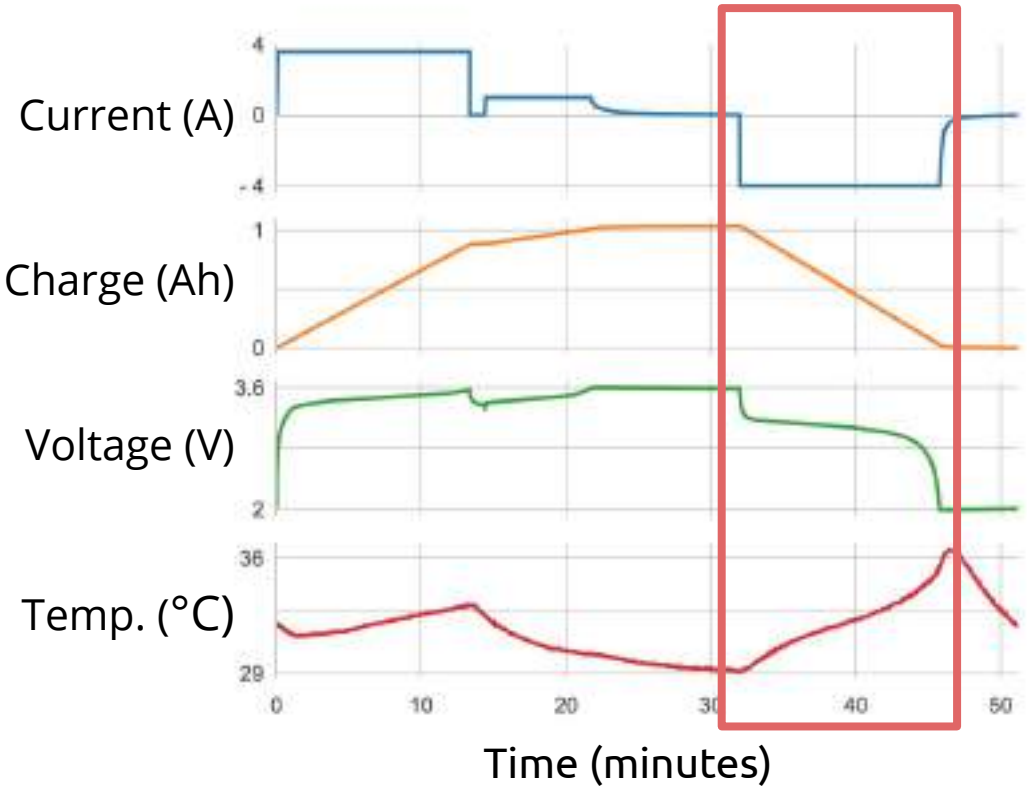
Data Processing

Challenges

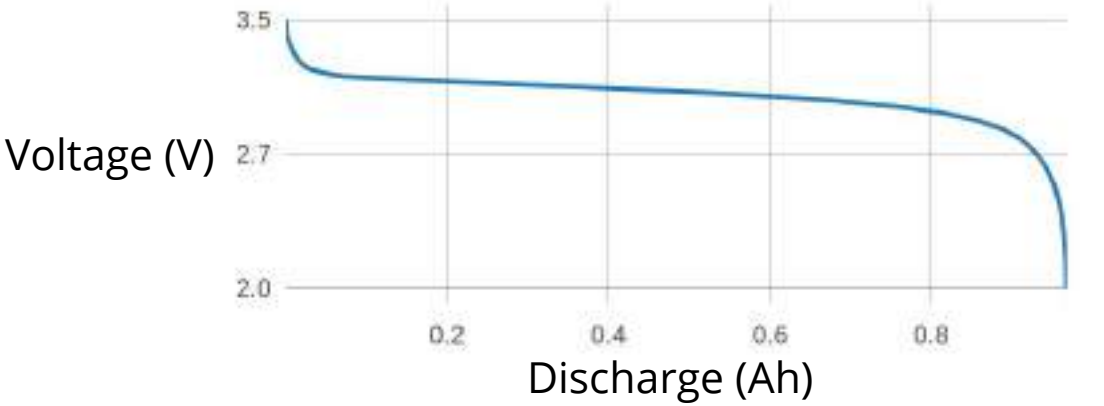
- Charging conditions not uniform
- Time measurements not uniform

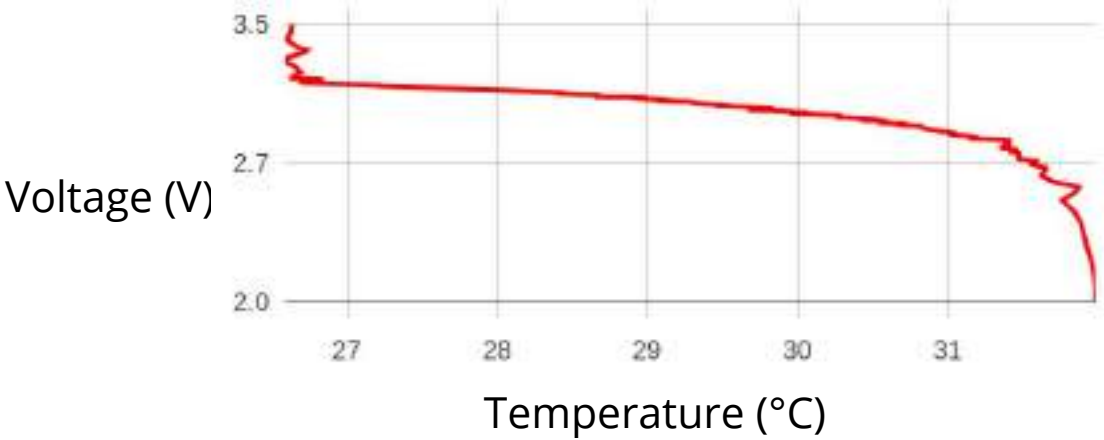
Solutions

- Focus on discharge curve
- Resample uniformly across voltage range

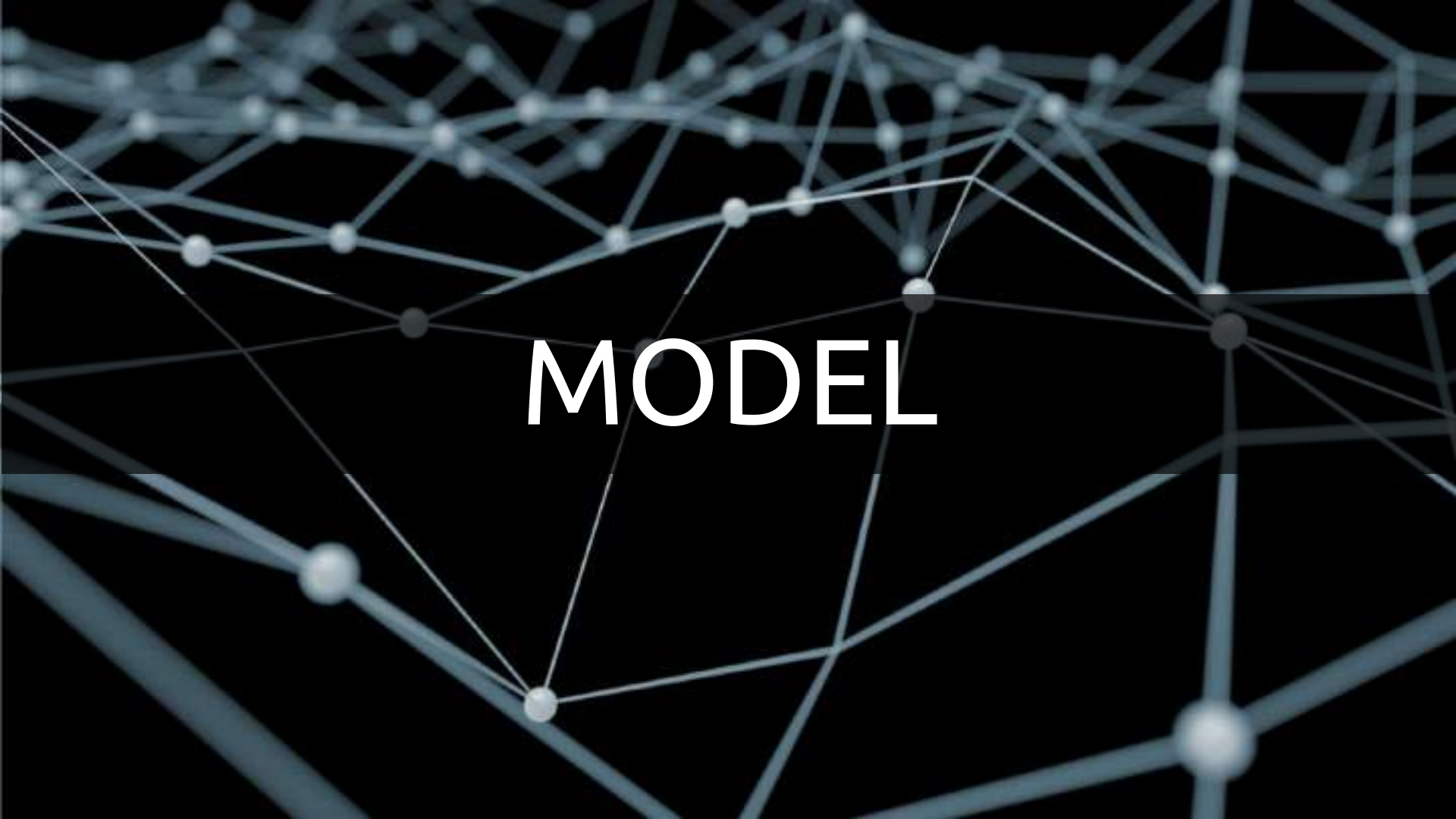


Data Processing



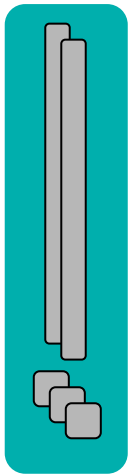


Scalar Features
Internal Resistance (Ω)
Total Charge (Ah)
Discharge Time (minutes)

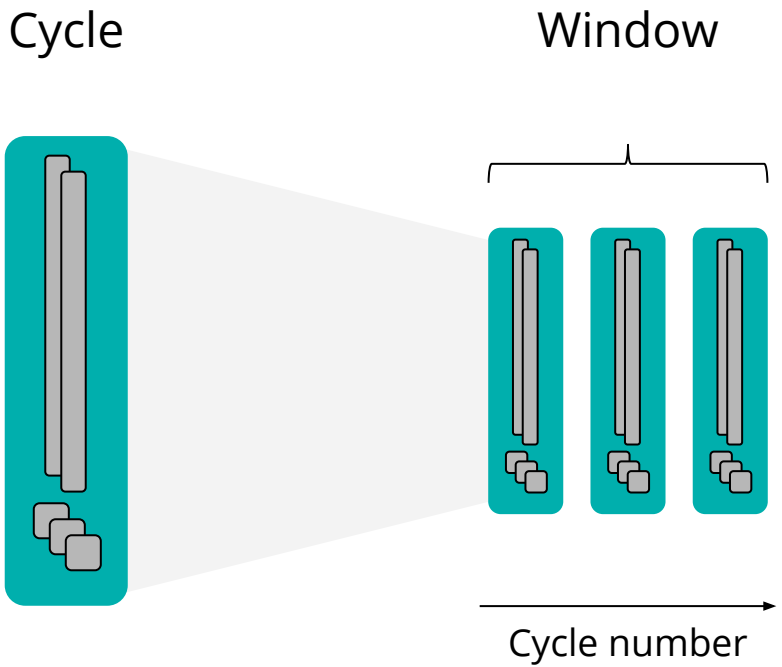

MODEL

Model input and output

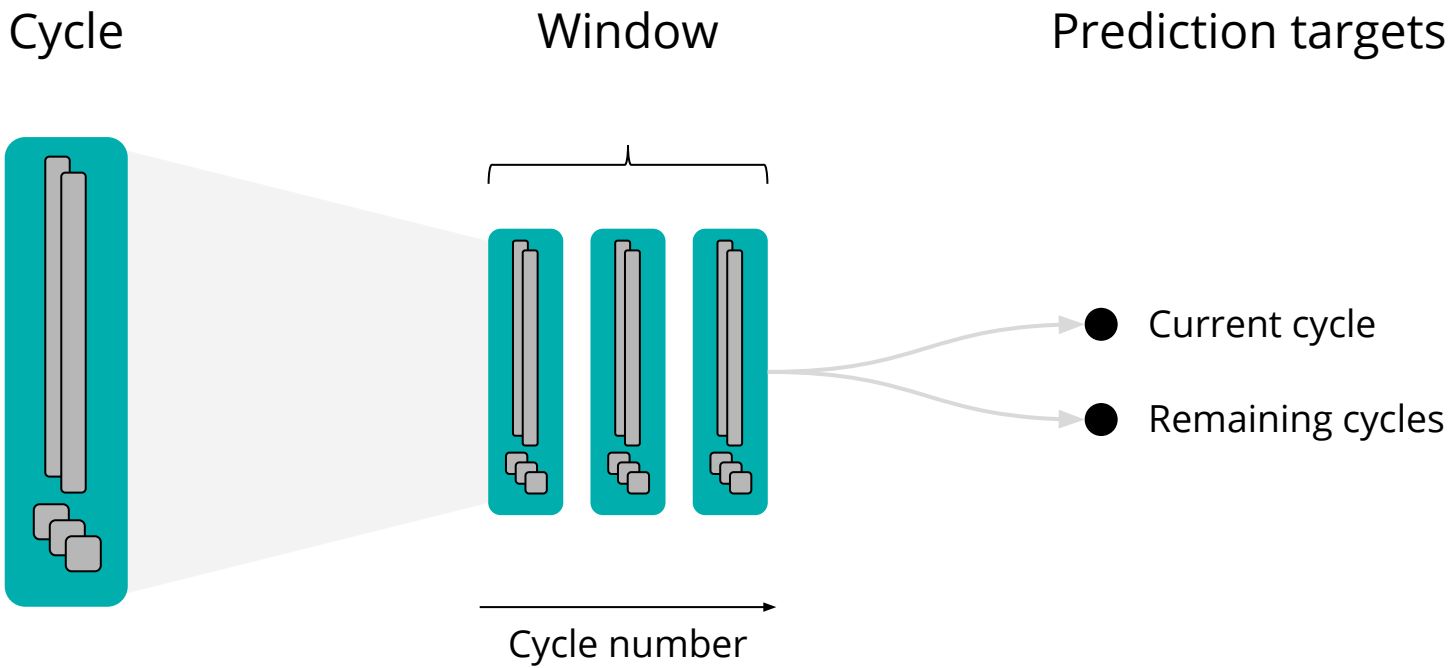
Cycle



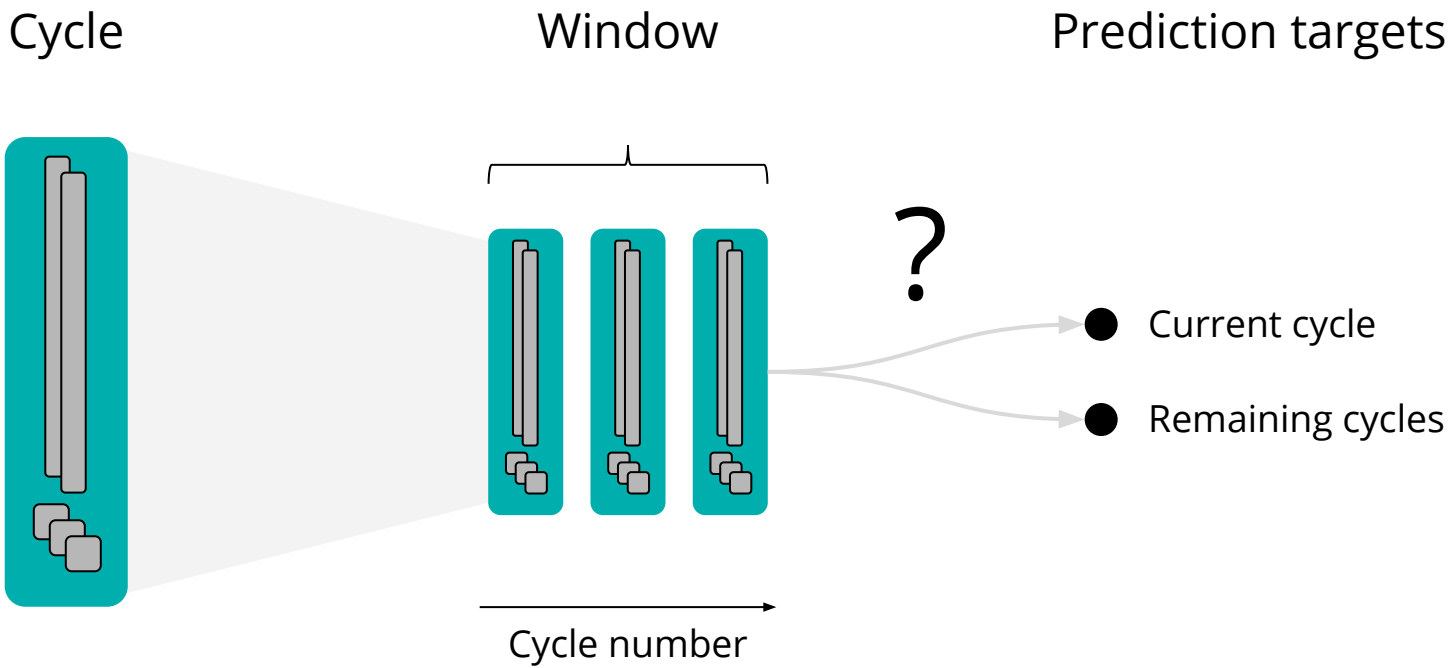
Model input and output



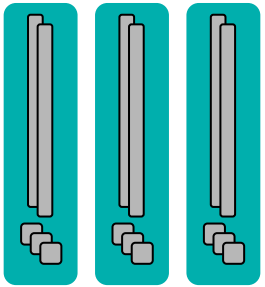
Model input and output



Model input and output

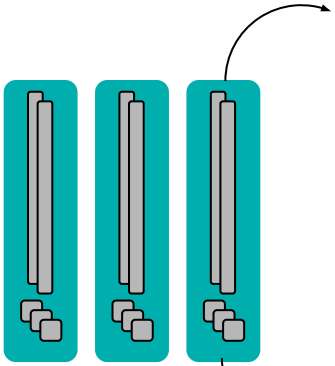


Model ideas



- Current cycle
- Remaining cycles

Model ideas



Array Features

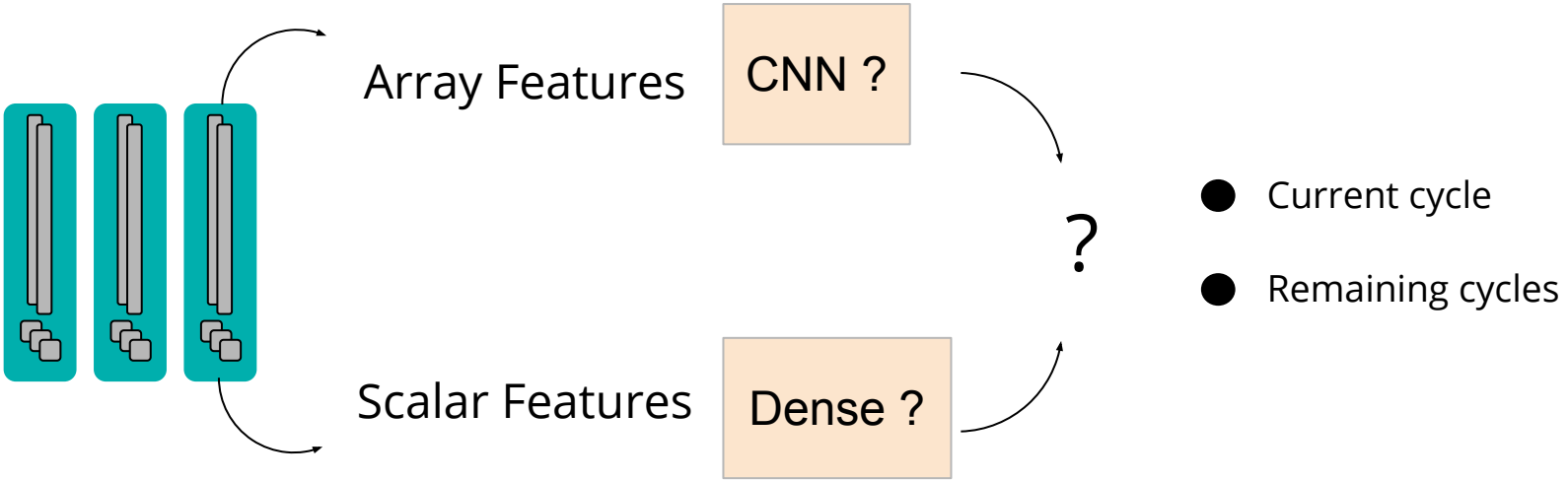
CNN ?

Scalar Features

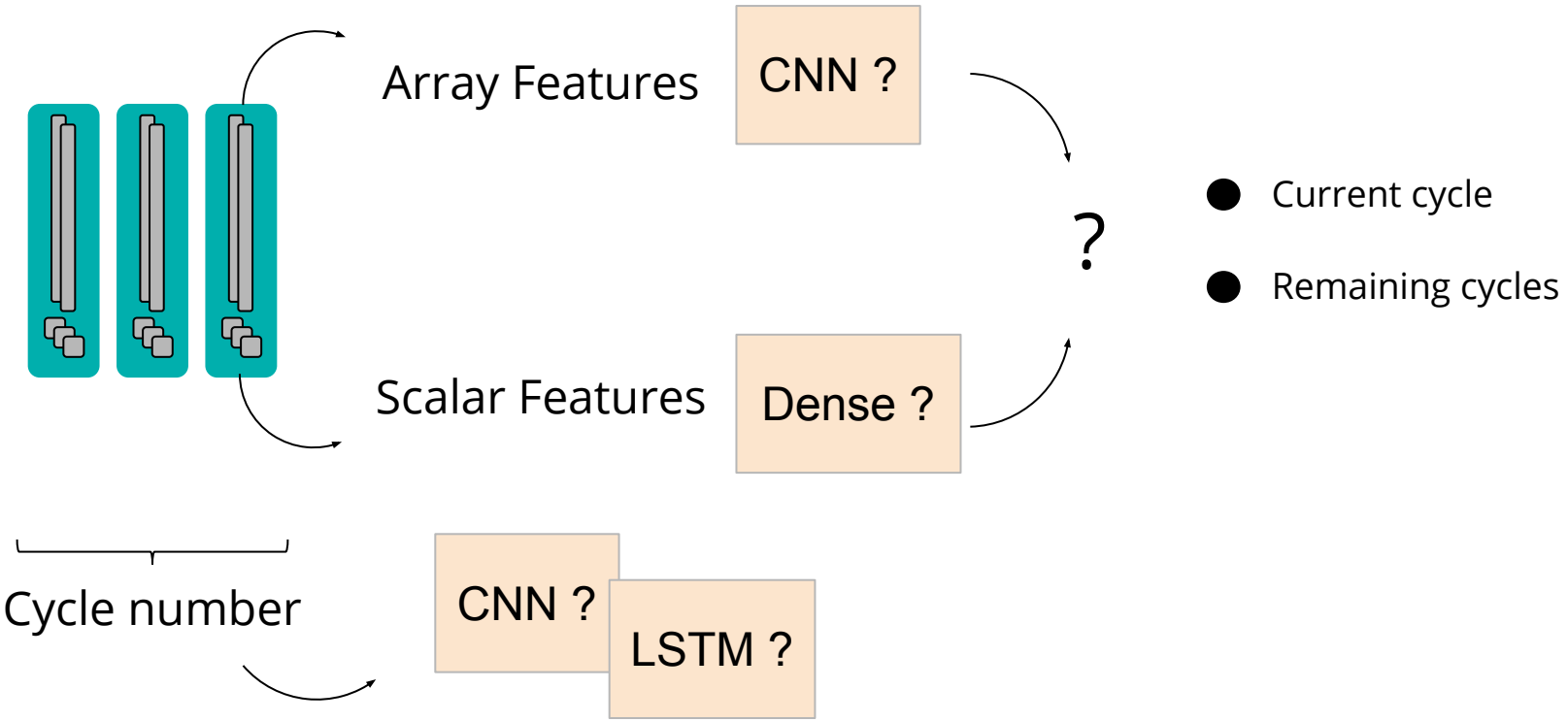
Dense ?

- Current cycle
- Remaining cycles

Model ideas

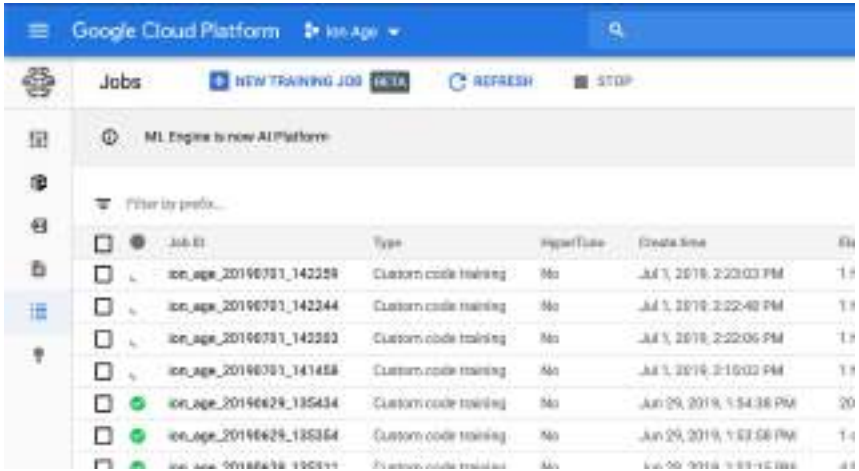

Array Features
CNN ?
Scalar Features
Dense ?
?
Current cycle
Remaining cycles

Model ideas

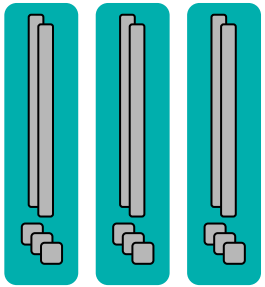

Array Features
CNN ?
Scalar Features
Dense ?
?
Current cycle
Remaining cycles
Cycle number
CNN ?
LSTM ?

Engineering

- Parallel job runs
- Keep track of test setups and results
- Free hardware access
- Easy to work in a team

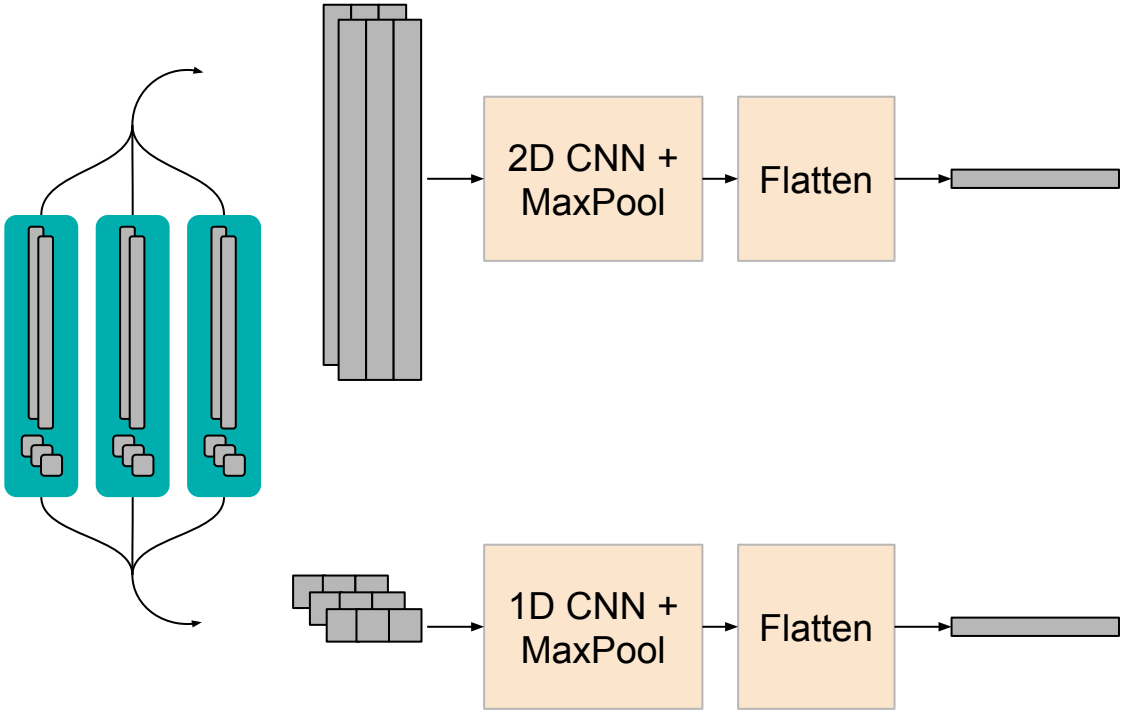


Model architecture



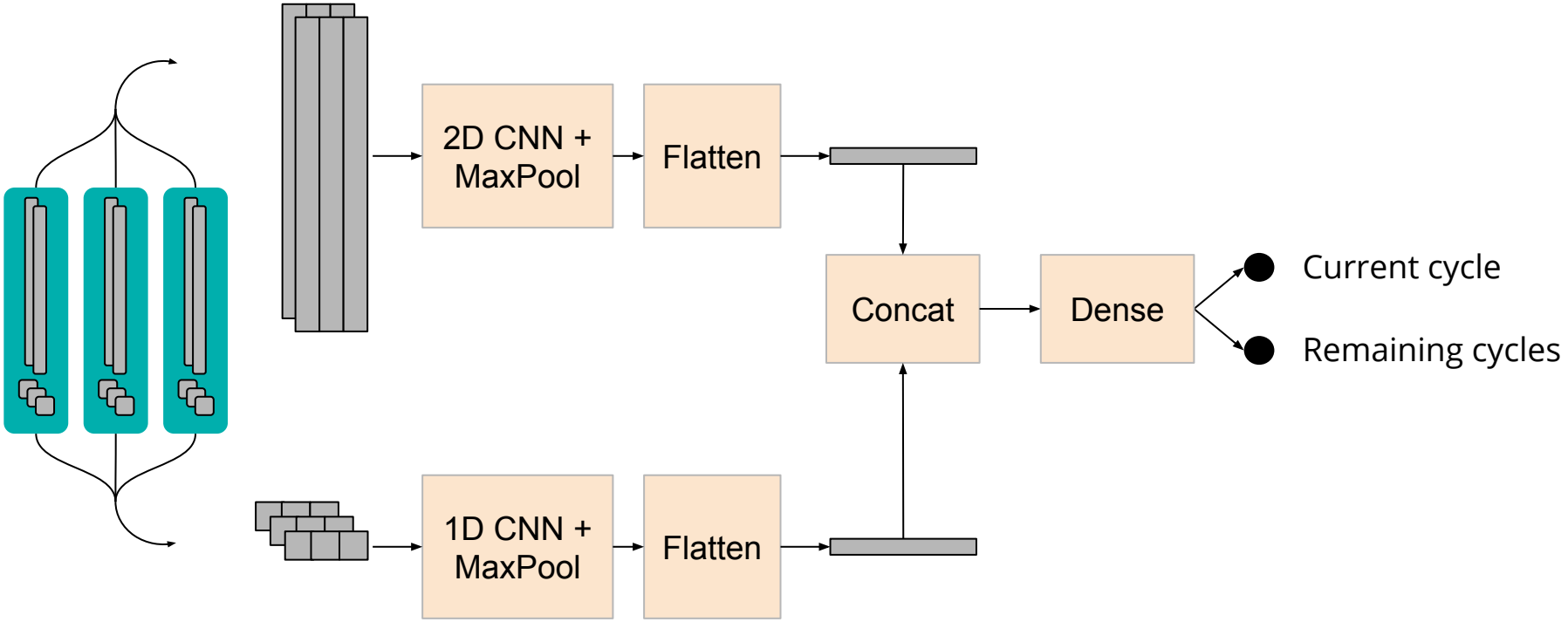
- Current cycle
- Remaining cycles

Model architecture

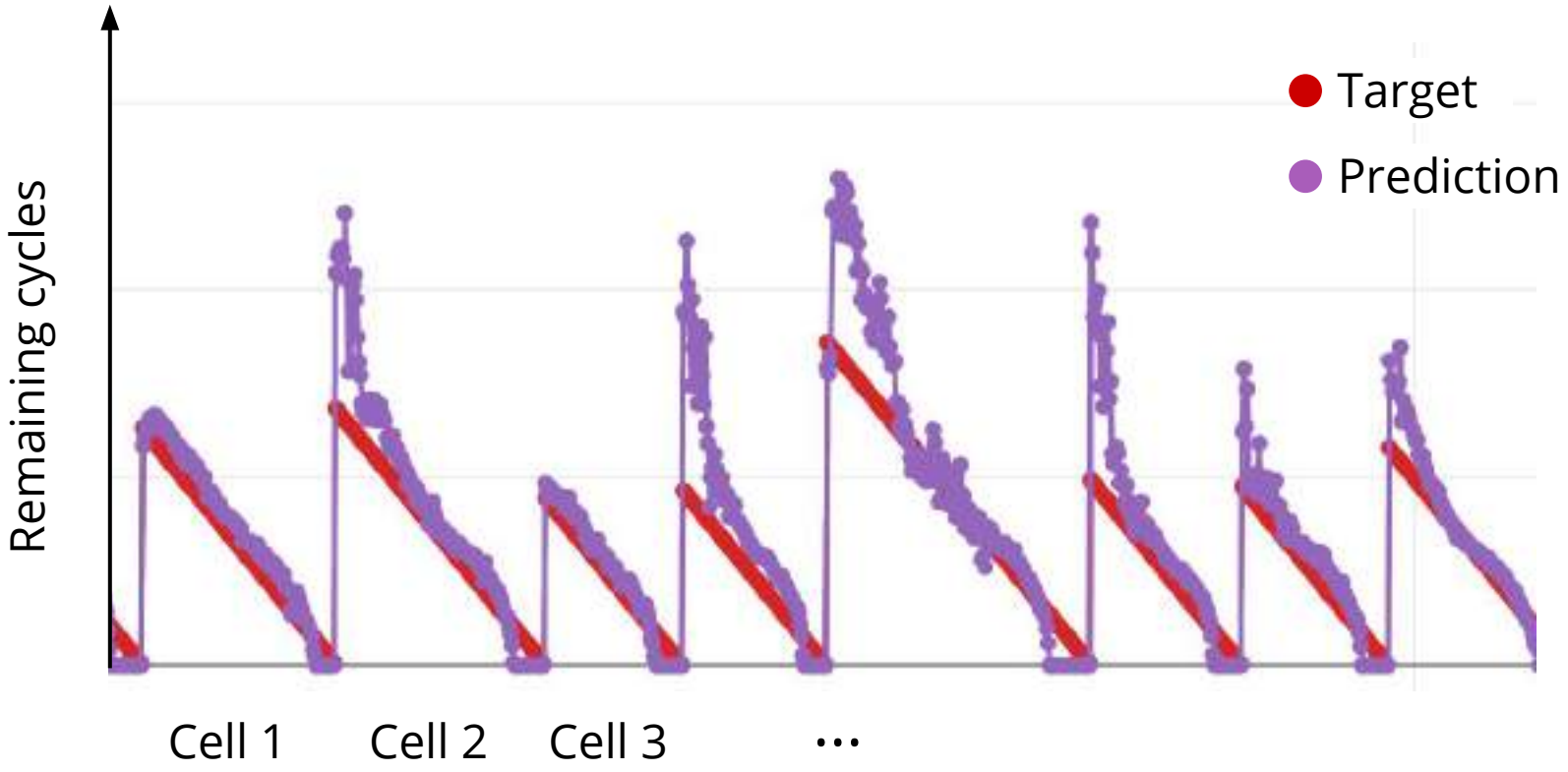


- Current cycle
- Remaining cycles

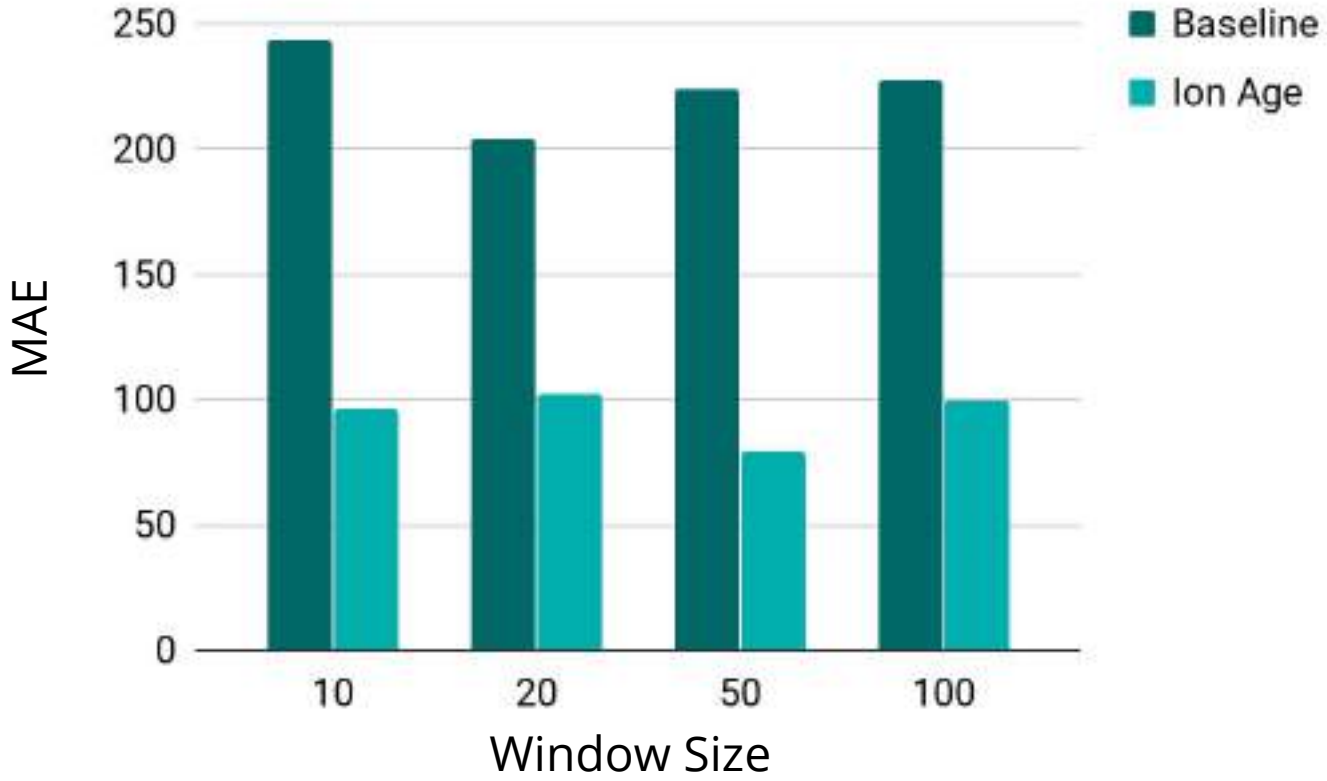
Model architecture



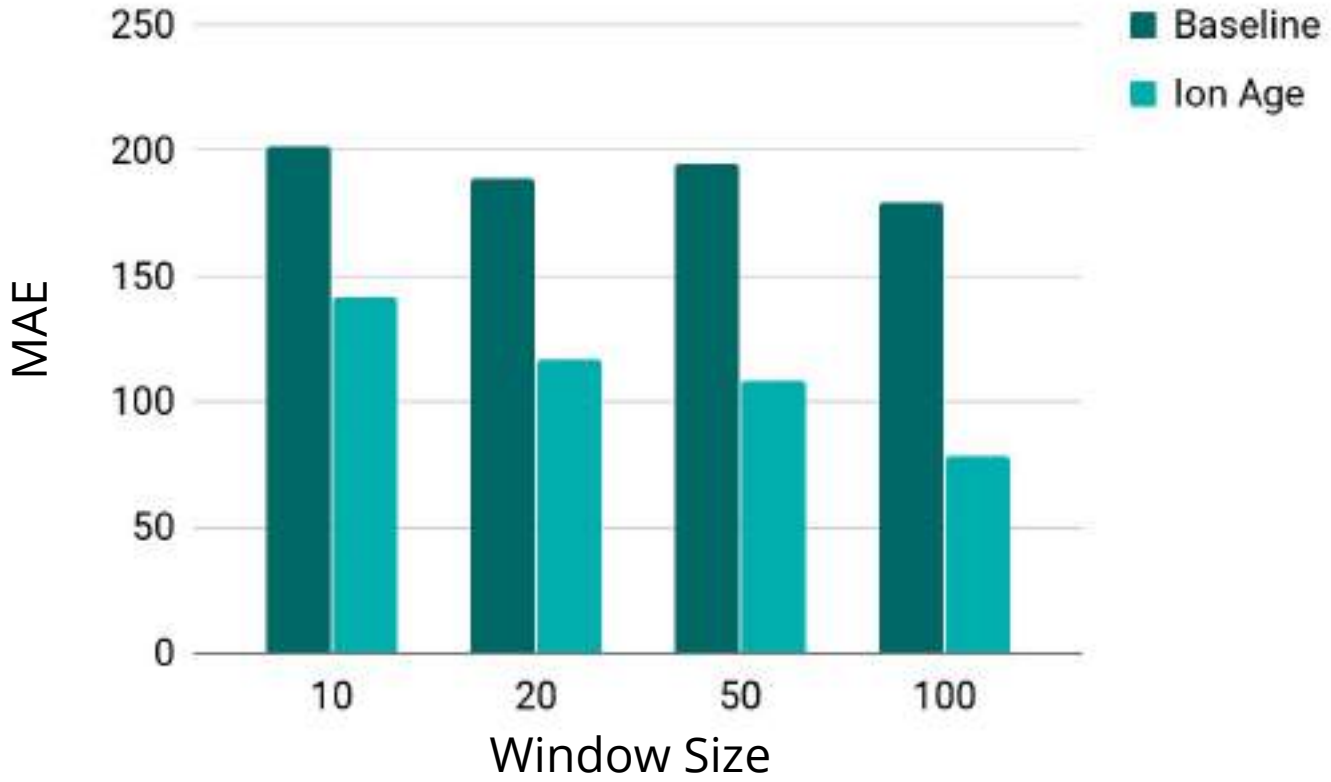
Predictions – Remaining cycles



Mean Absolute Error – Current cycles



Mean Absolute Error – Remaining cycles



Who we are

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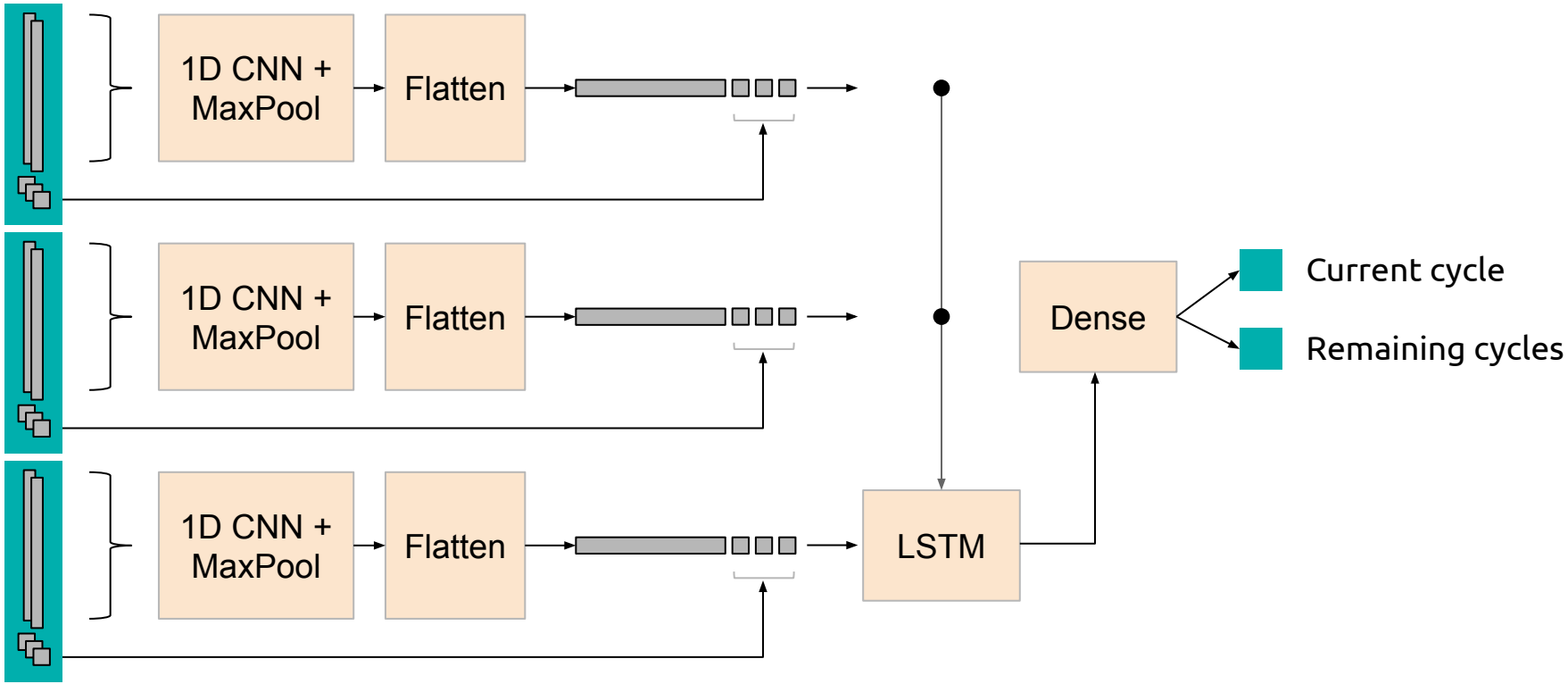
https://github.com/dsr-18/long-live-the-battery

https://bit.ly/2Lx0ywE

Q & A

Backup

Model architecture



Recap

- Predicting battery cycle life is a relevant but tough problem
- Measurement data requires a lot of preprocessing for deep learning
- It’s hard to have an intuition what makes a complex model perform well
- Having a solid infrastructure pays off
- CNNs work well for time series data

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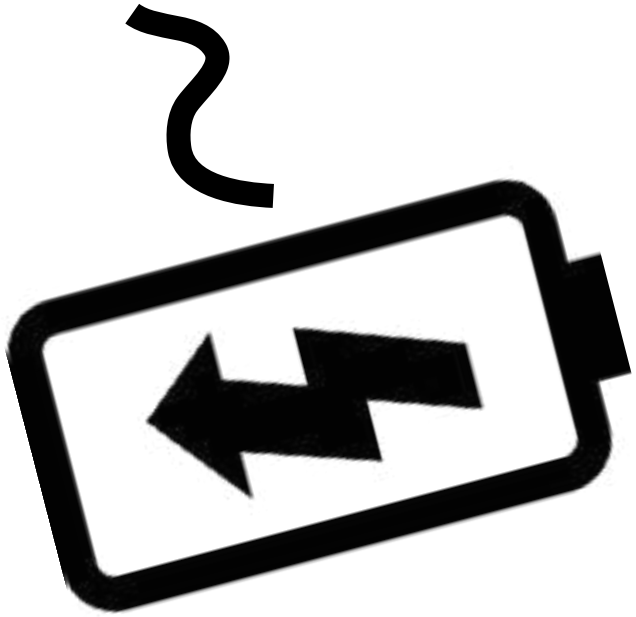
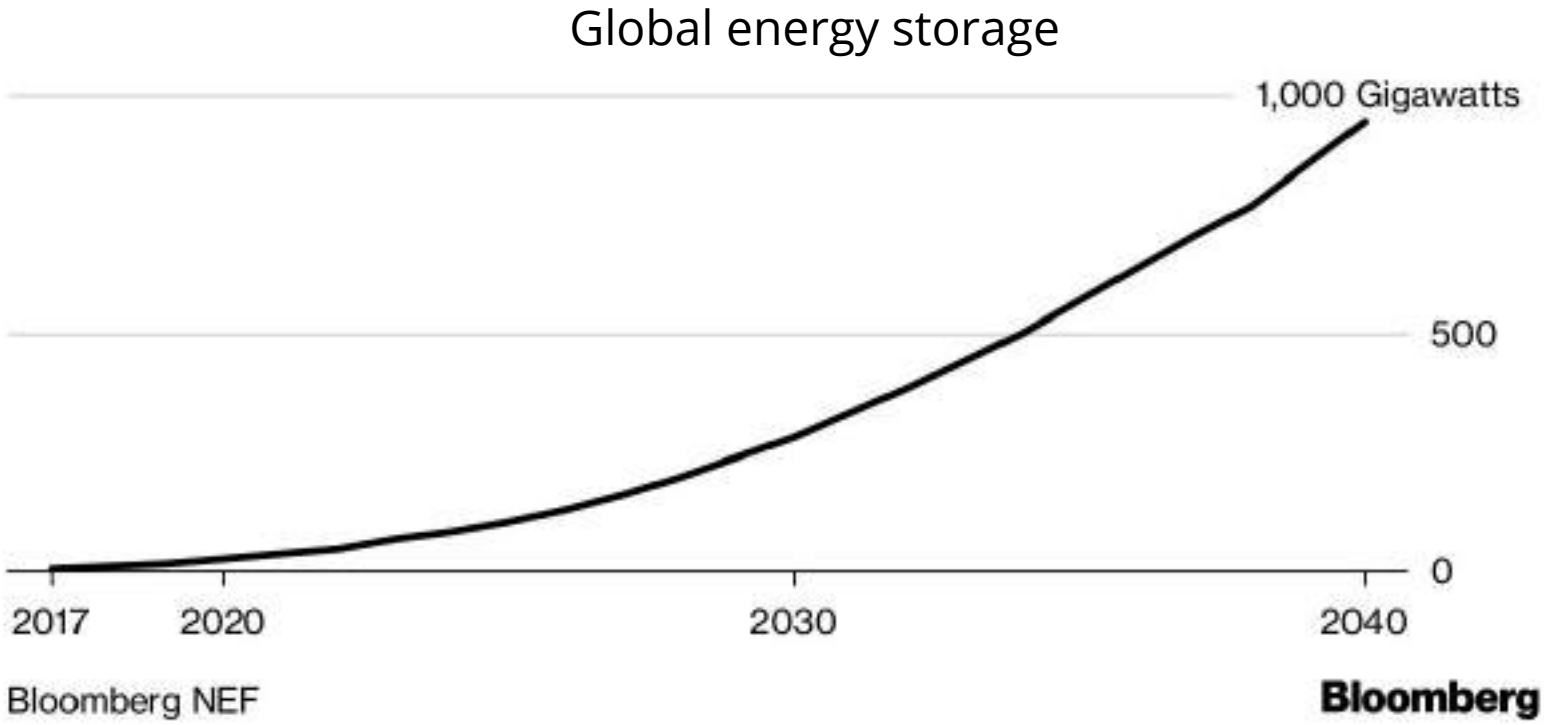
Forecasting battery life time

What did we do?

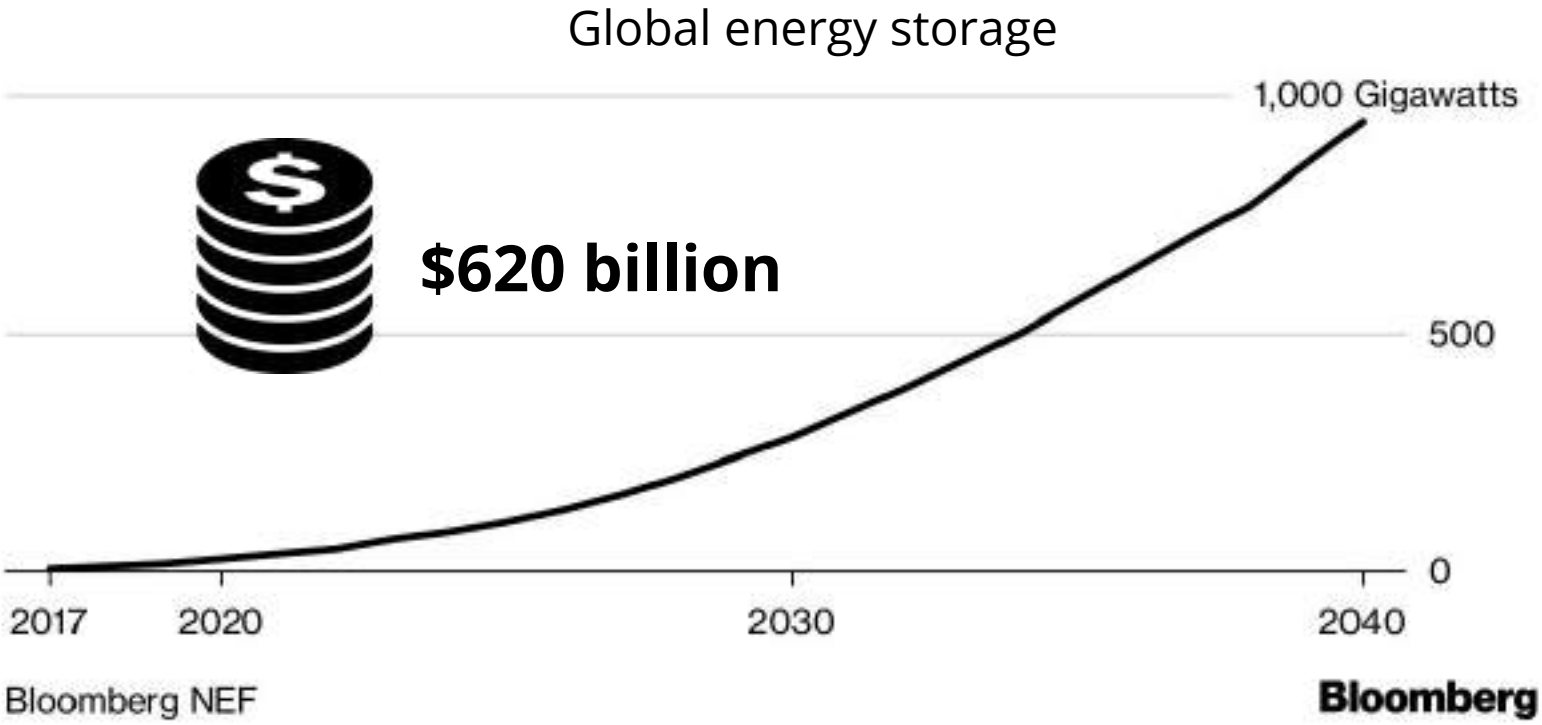
Predict the total lifetime of batteries, measured in remaining charging cycles



Lithium-ion batteries



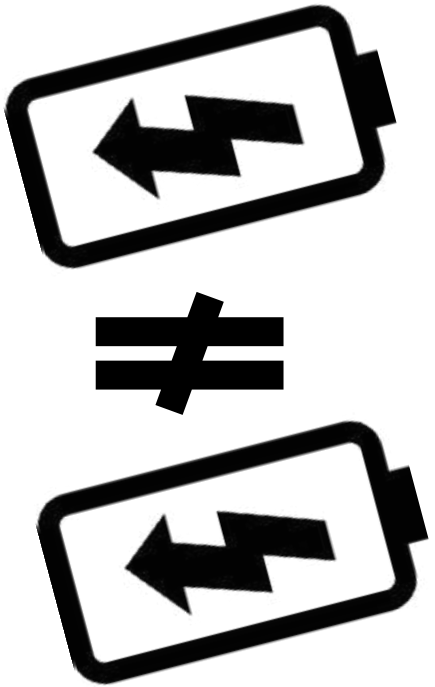
Lithium-ion batteries



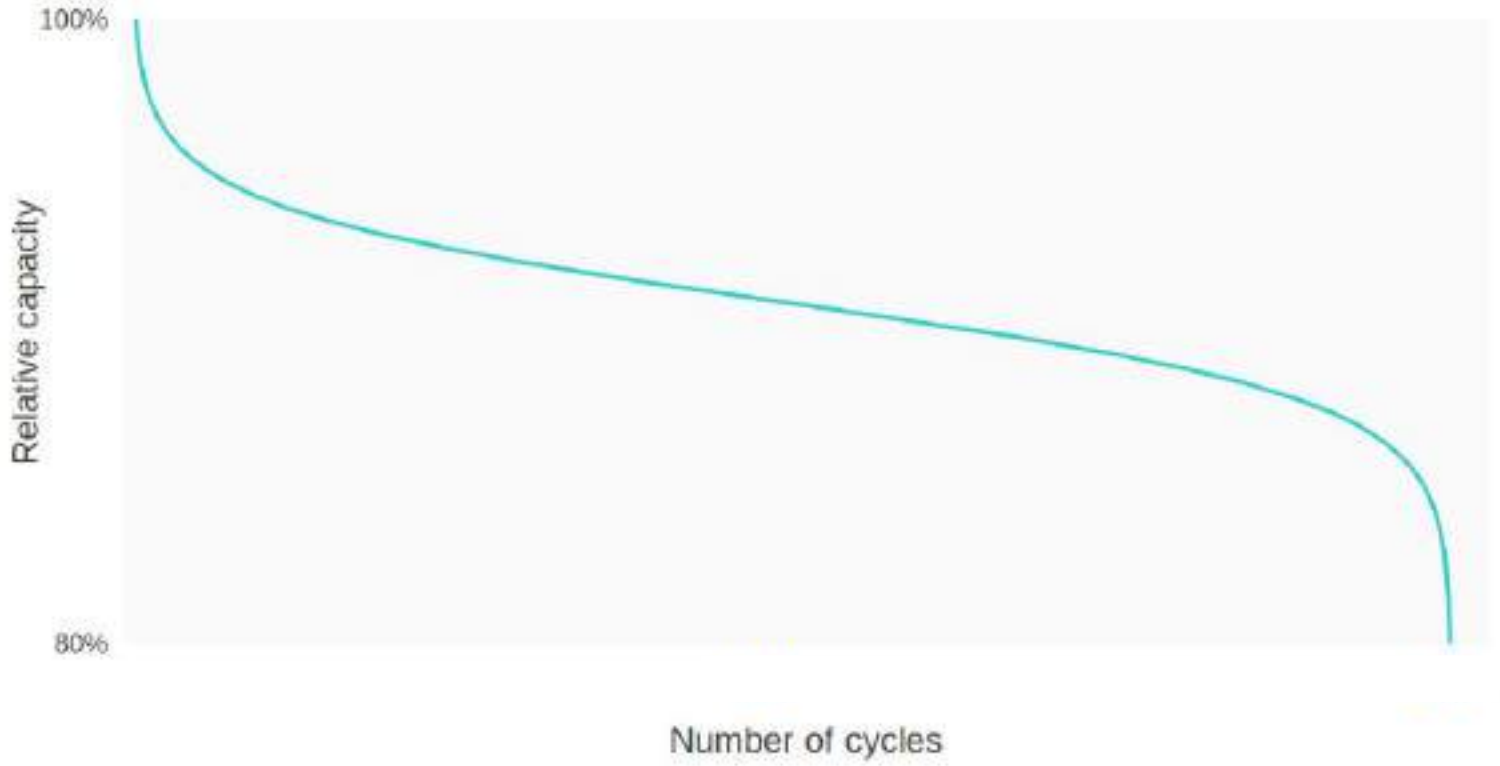
Lithium-ion batteries

vastly different lifetime expectations

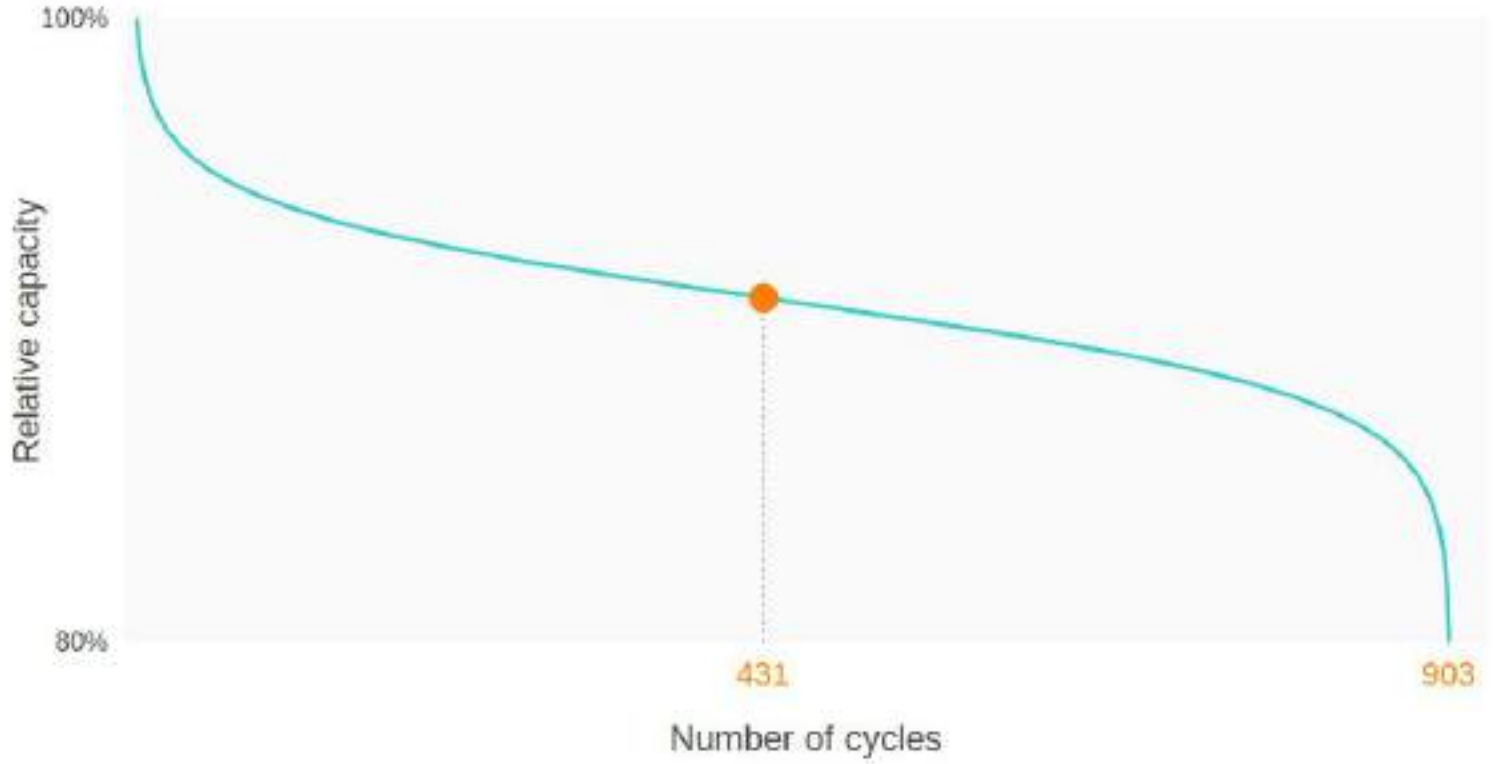
forecasts were expensive and time-consuming



Cell degradation



Cell degradation



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Forecasting
battery lifetime

Lithium-ion batteries


EMIRATES ST
Arsenal