Welcome!

How Data Analysis Can Help to Better Understand the Degradation in PV Modules

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OUTLINE

- Introduction
- Technical Challenges in I-V Curve Analysis
- Overview of the Ongoing Project
- Data-Driven Feature Extraction for PV Module Degradation
- Outlook

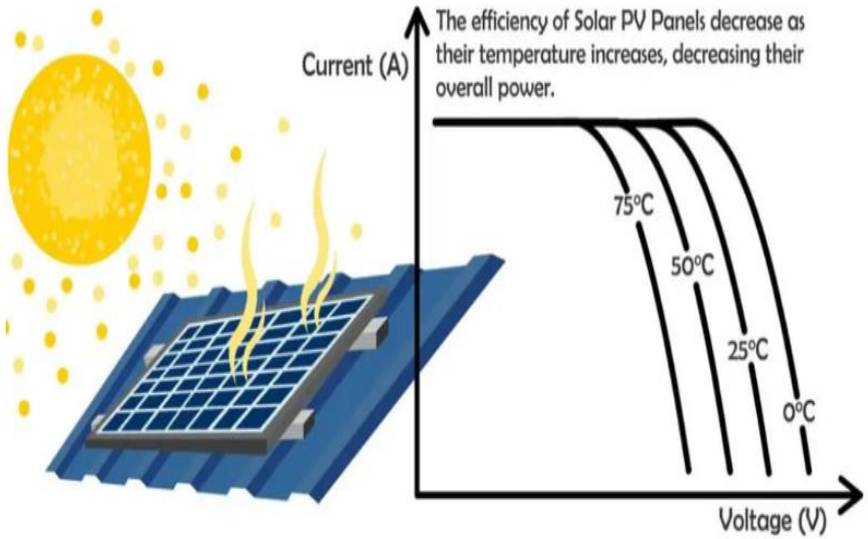
Introduction

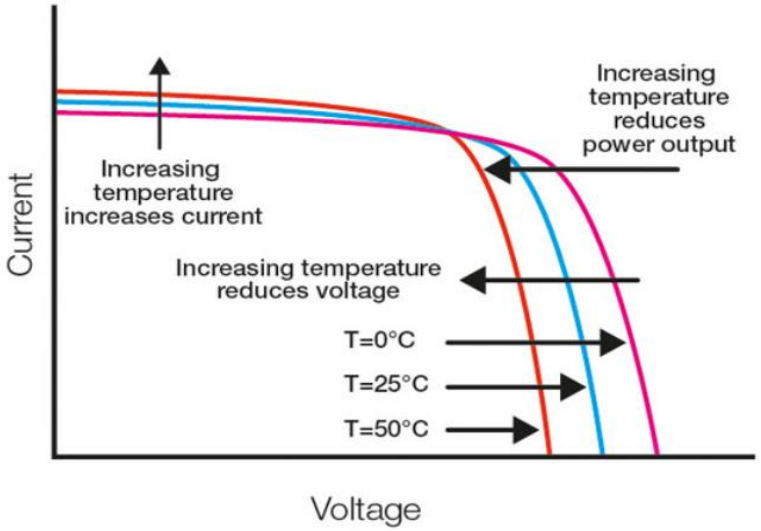
The Role of Data Analysis in Understanding Degradation in PV Modules

PV Degradation

PV Degradation is a natural phenomenon that occurs over time due to factors such as temperature, humidity and exposure to sunlight.

I.e. hot climate, intense sunshine and the heat generated from solar panels can individually or collectively cause your panels to reach temperatures that can negatively affect their efficiency.



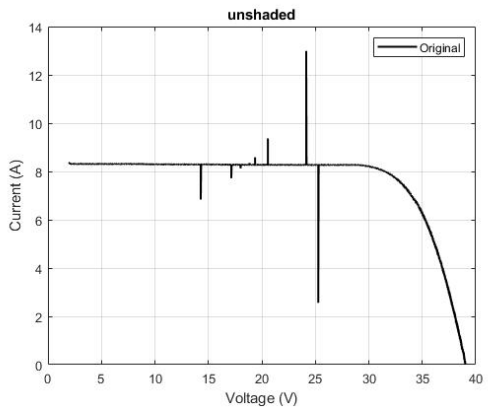


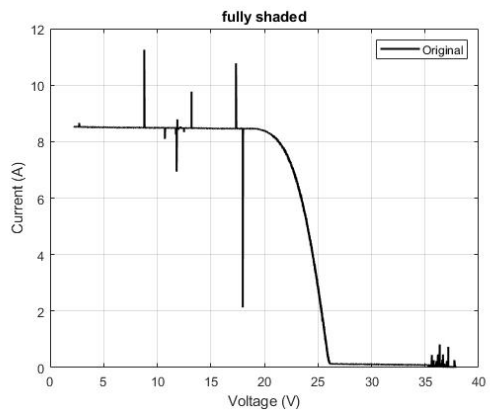
An illustration of how temperature can affect the efficiency of solar PV panels.
Credit to: couleenergy.com

Technical Challenges

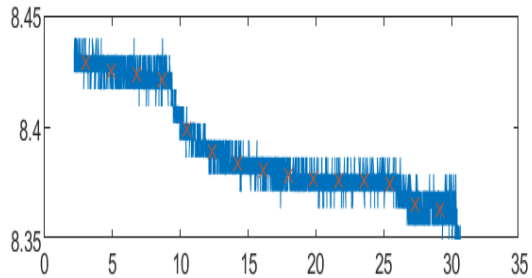
Analyzing the I-V curve, to assess the performance of the PV module, can be challenging for non-standard I-V curves, which can result from shading or wiring concerns.

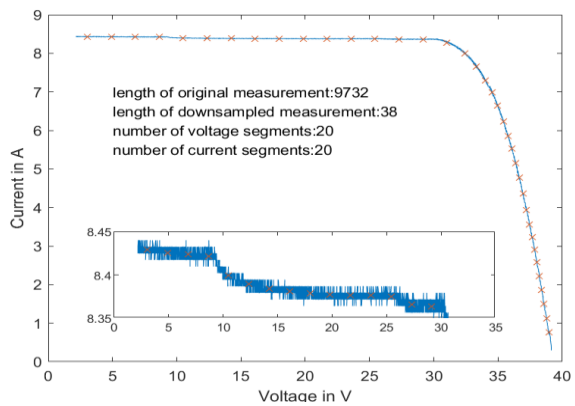
Outliers



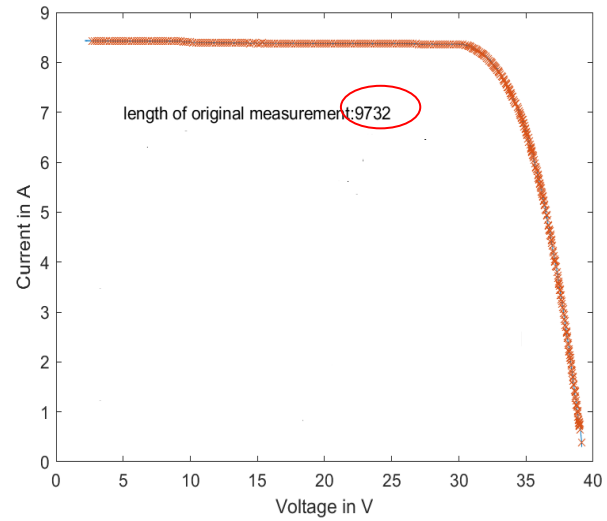


Noise





Data length



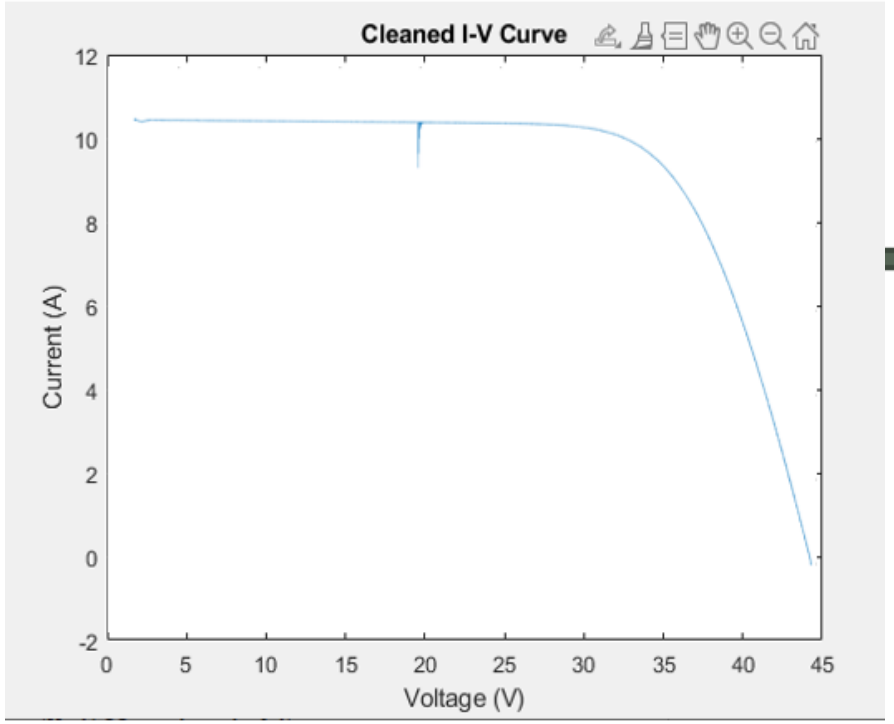
Outliers

Developed algorithm calculates the std of the I_deff, all the pts outside the area based on the std are considered as outliers.

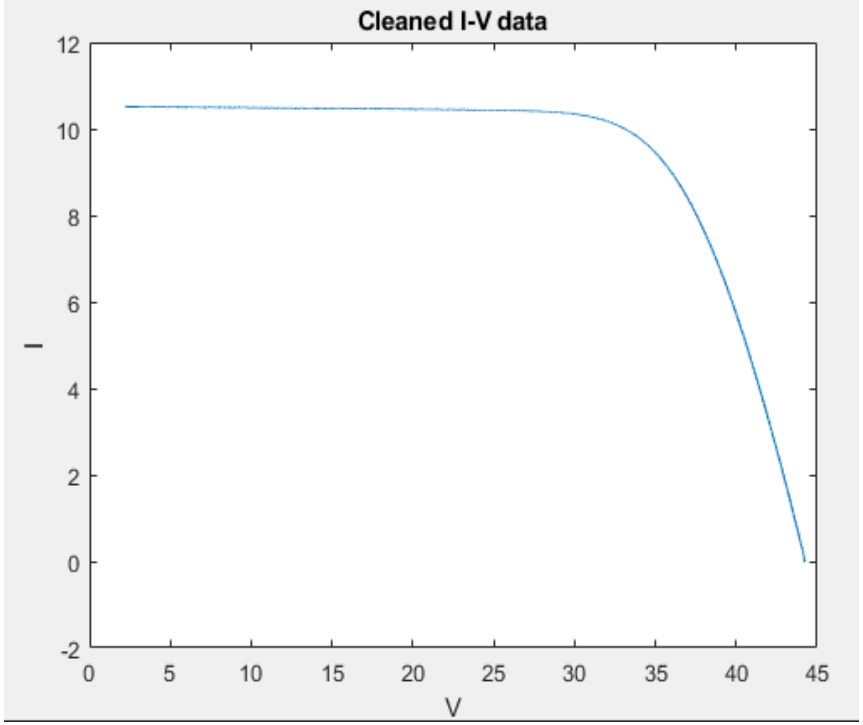
Algorithm:

- ✓ fast and robust;
- ✓ only I_deff necessary;
- ✓ threshold adapted to various sections of the curve.

Setting threshold



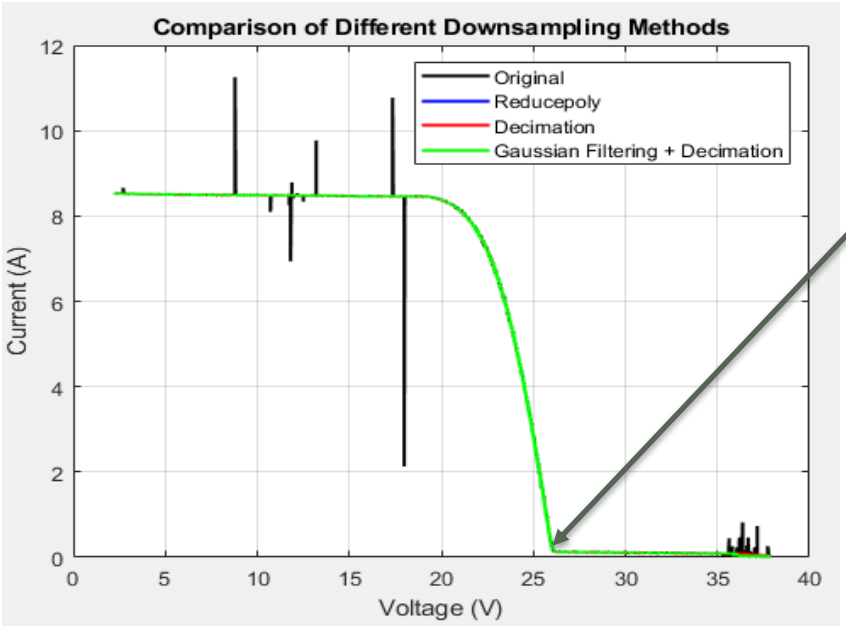
I_deff & Standard Deviation

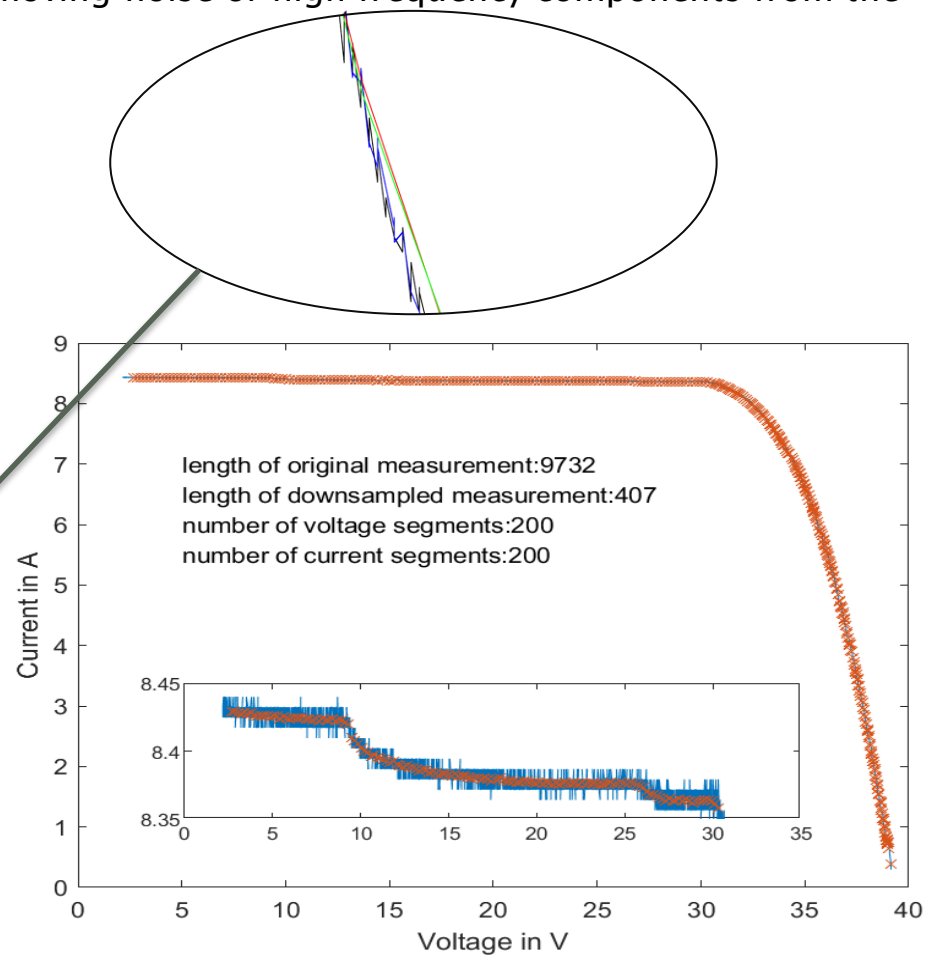


Downsampling

- Reducepoly→ if the signal is smooth and can well be approx. by a low order polynomial
- Decimation → if the signal has a high sampling rate and contains high-frequency components that are not of interest.
- Gaussian filtering + decimation → useful for removing noise or high frequency components from the signal while preserving its important features.

- The I-V curve has a complex shape and it is important to preserve as much Information as possible.
- The developed algorithm divides the signal into sectors and calculates the mean values within each subsectors.





Data-Driven Feature Extraction

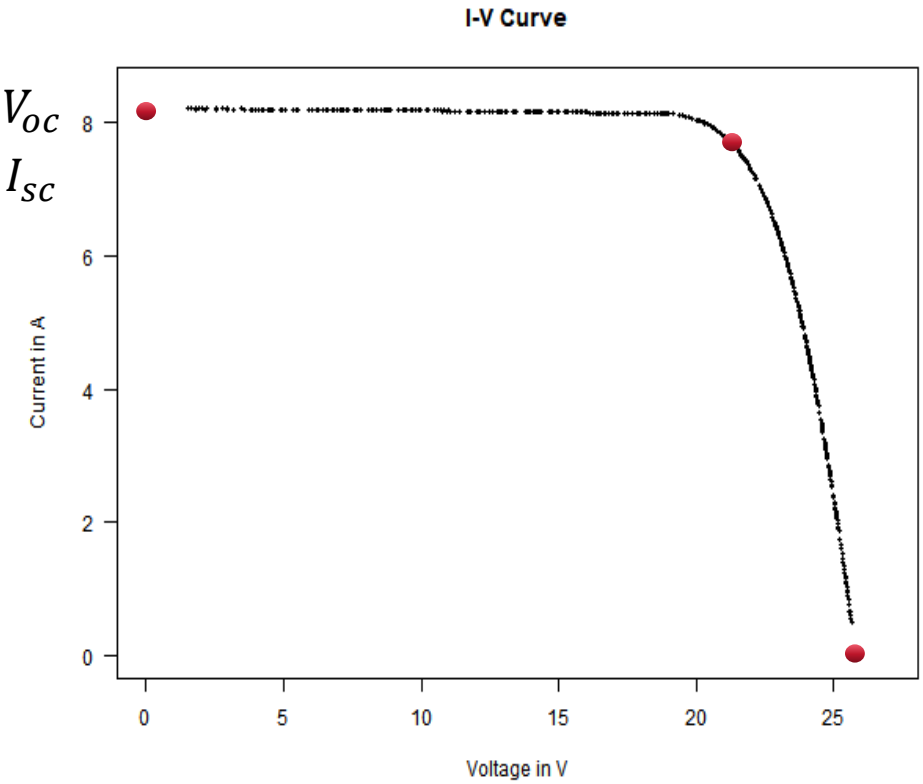
Where the statistician comes into play …

PV Module under Operation

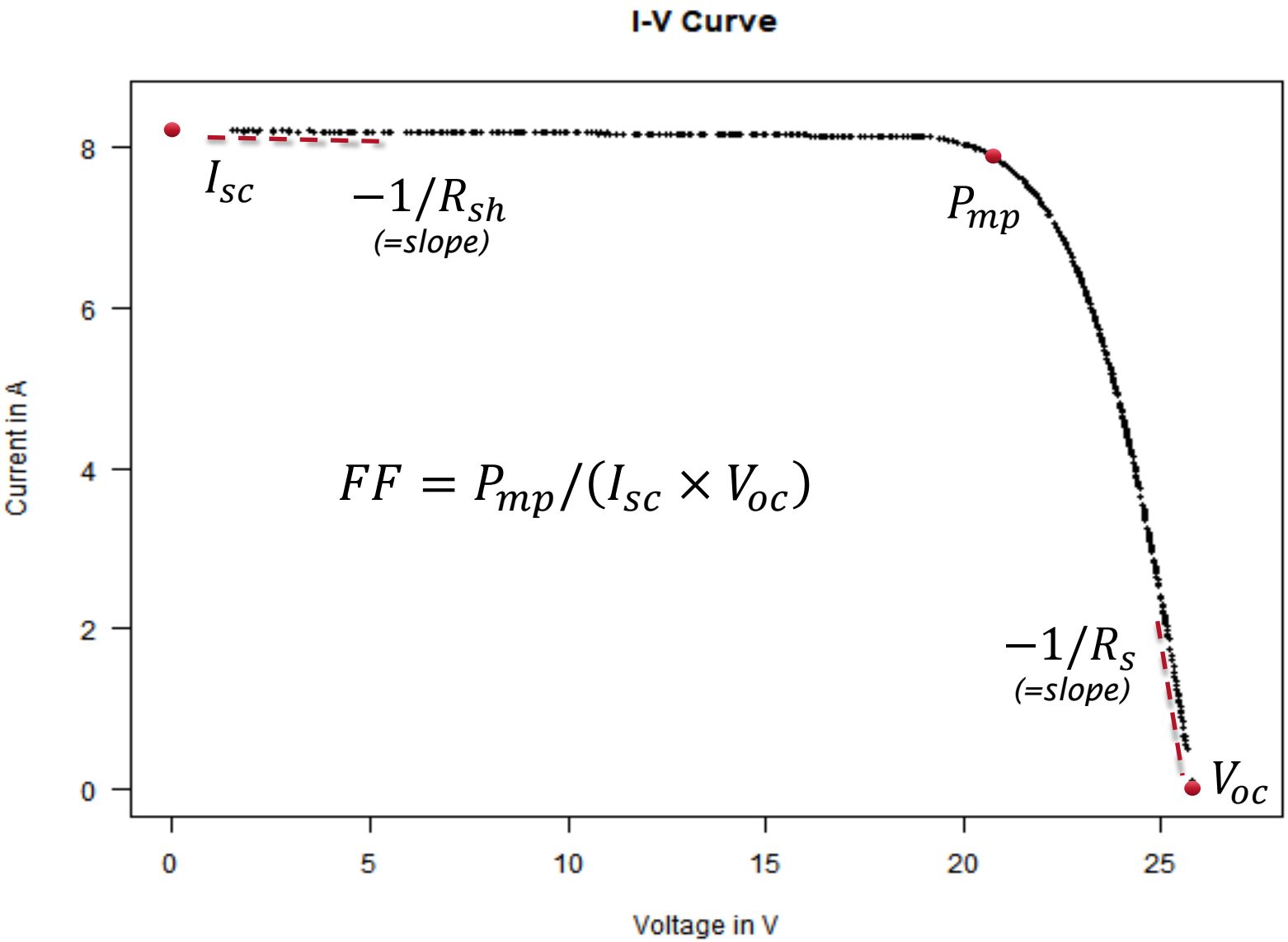
- Extreme conditions:
  - open-circuit: voltage is maximal at V_{oc}
  - short-circuit: current is maximal at I_{sc}

- Power = Current × Voltage
  ↳ maximal at P_{mp}

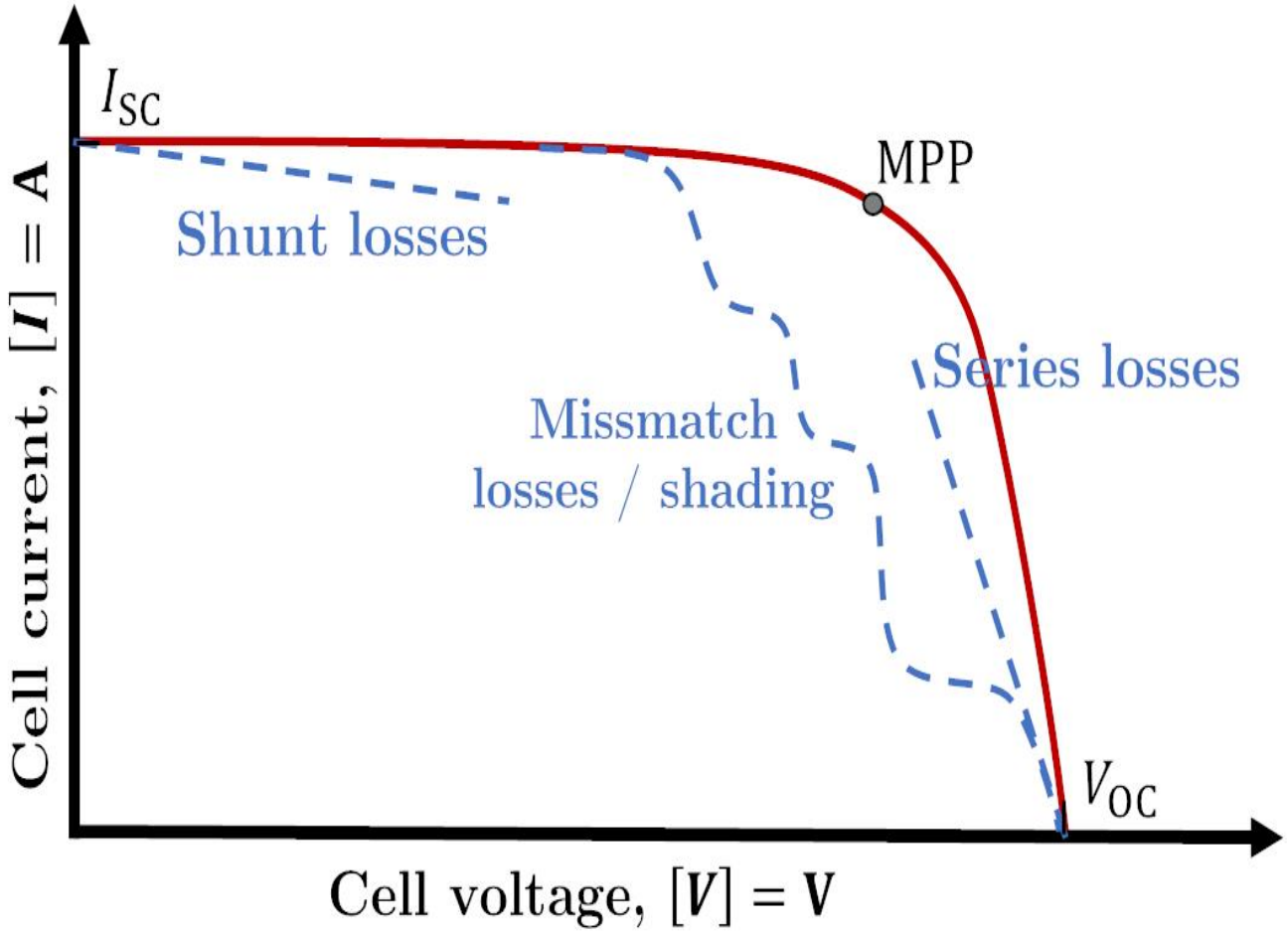
- Quality via Fill Factor:
  $$FF = P_{mp}/(I_{sc} \times V_{oc})$$
  ↳ «squareness of the I-V curve»



Data-Driven Feature Extraction



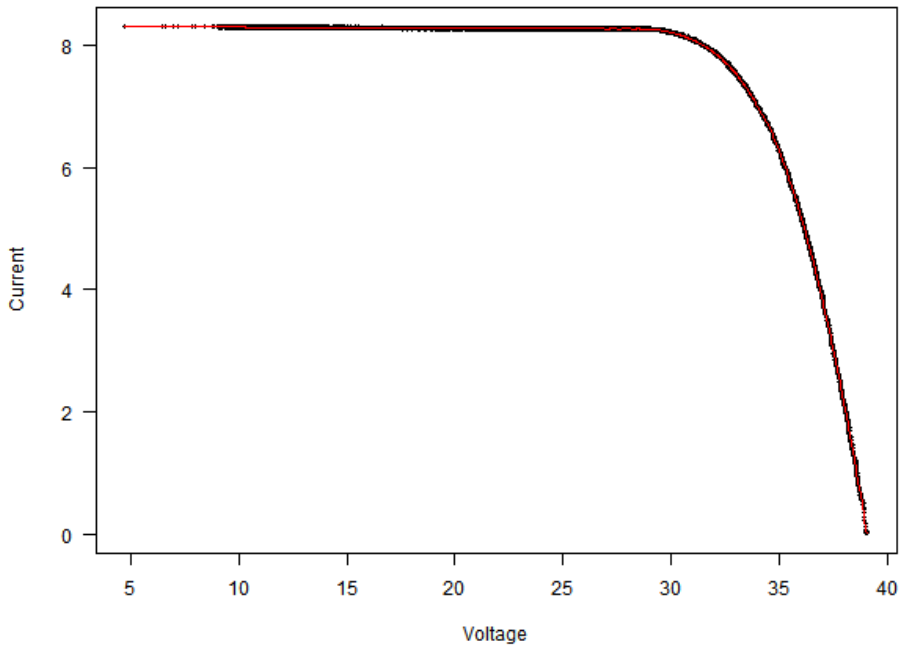
Non-Ideal I-V Curve



(source: wikipedia.org)

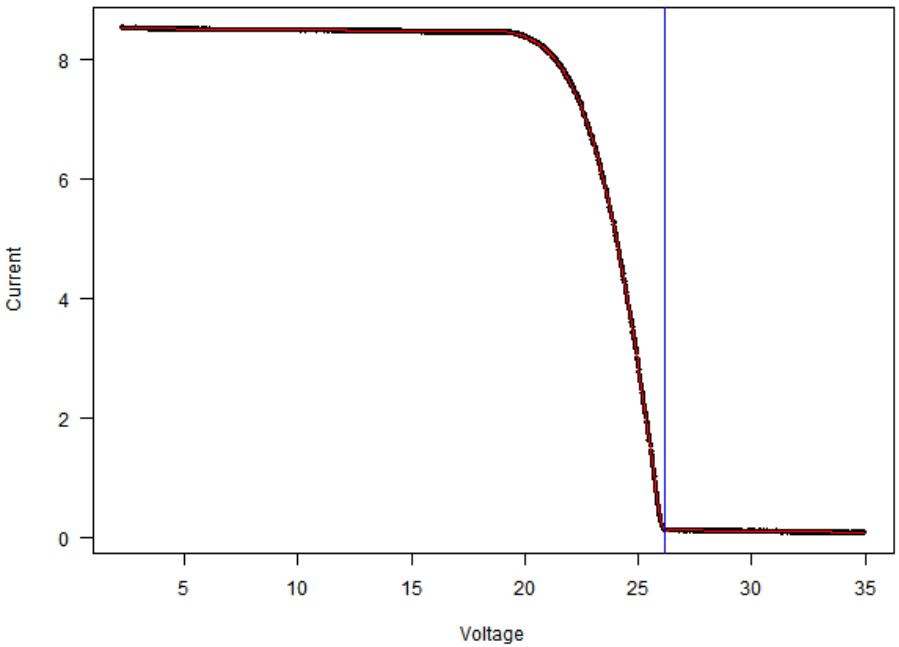
Data-Driven Feature Extraction

- Smoothing spline on raw data to model I-V curve

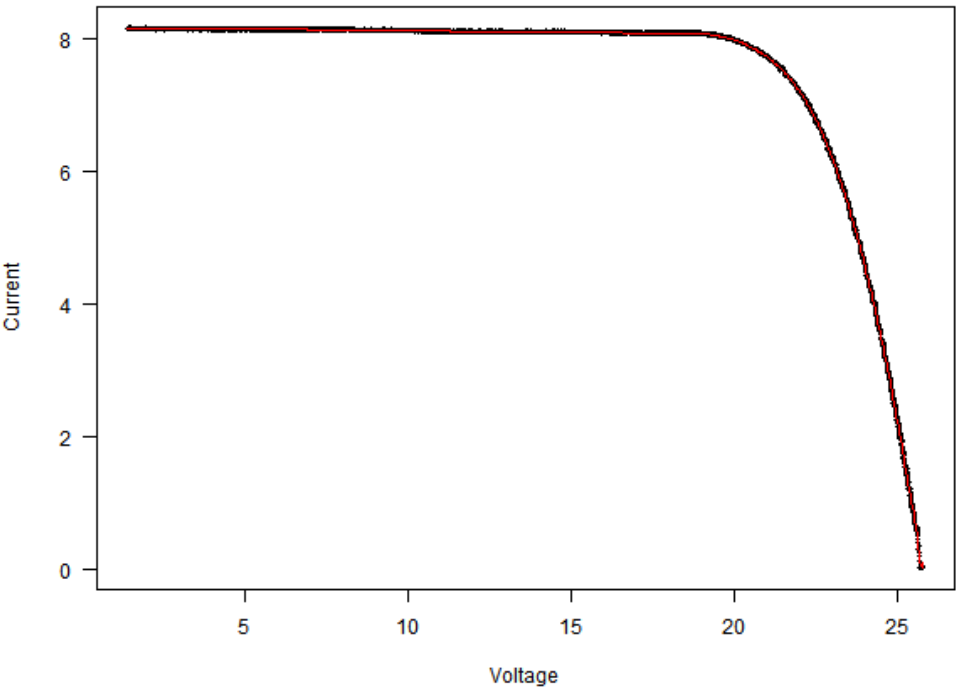


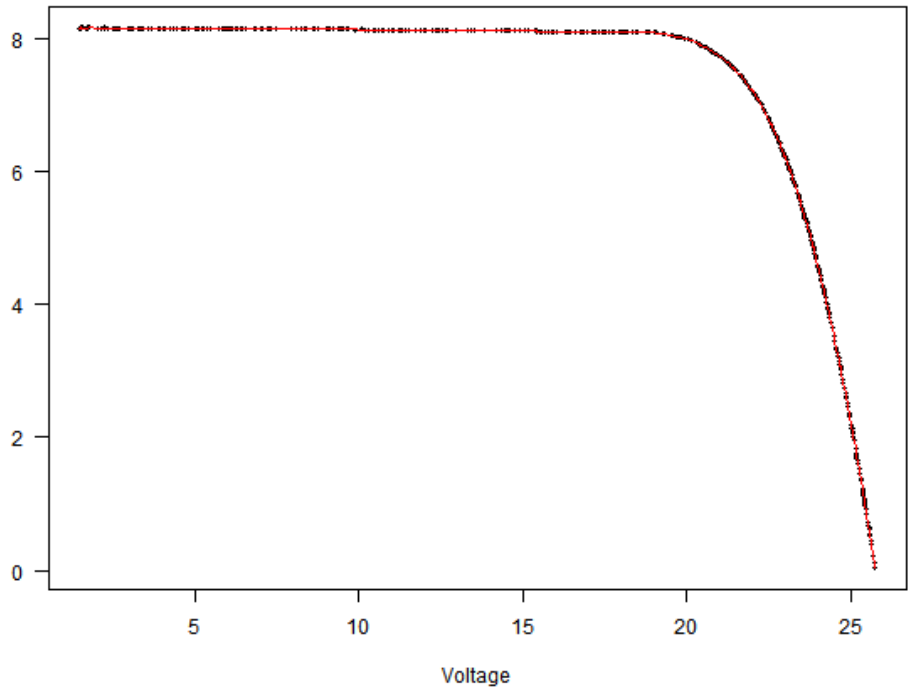
Data-Driven Feature Extraction

- Smoothing spline on raw data to model I-V curve
- Use segmented regression to find number of change points
- Estimate I-V parameters for each step
  - simple regression on moving window for $I_{sc}, V_{oc}, R_{sh}, R_s$
  - P_{mp} straight forward
- Check robustness via random subsampling



Data Example

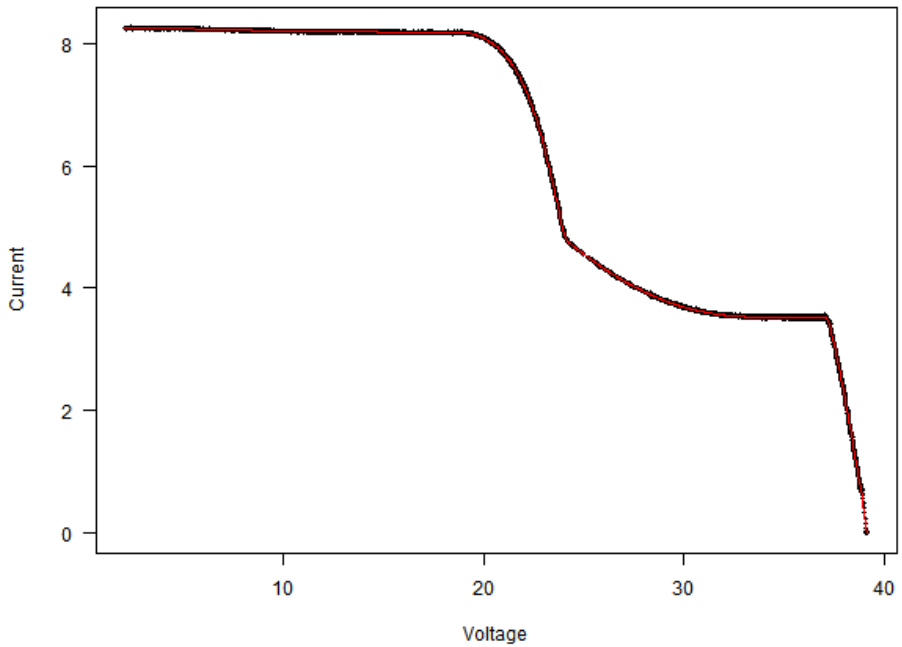




	I_{sc}	V_{oc}	P_{mp}	FF
Full data	8.11 ± 0.001	25.77 ± 0.001	162.44 ± 0.005	77.75 ± 0.005
Reduced	8.47 ± 0.001	25.76 ± 0.001	162.45 ± 0.002	74.42 ± 0.003

Work in Progress …

- Compare goodness of fit of data driven approach to physical models
- What is the optimal downsampling strategy?
- How to deal with partially shaded modules in the field?
- What are good «quality parameters» for non-ideal I-V curves?



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Best last sentence for a talk?

The best last sentence for a talk depends on the content of your presentation and your desired outcome. However, a strong last sentence should leave a lasting impression on your audience and reinforce the main message of your talk. Here are a few examples of effective last sentences for different types of talks:

- For an inspirational talk: "Remember, the only limits in life are the ones you set for

For an informative talk: "Now that you understand the importance of this issue, let's work together to make a positive change."

together to make a positive change."

- For a persuasive ta , because together we can make a real differen
- For a personal story ersity, there is always hope. Thank you for listening to my story."

In general, the best last sentence for a talk should be memorable, inspiring, and leave a clear call to action or takeaway message for your audience.

Any Questions or Thoughts?

Next seminars

Biel / Bienne
Quellgasse 21, Aula

27.4.2023 | Die digitale Transformation des Exportgeschäfts Prof. Dr. Paul Ammann, Institute for Data Applications and Security IDAS, BFH-TI

11.5.2023 | The Relevance and Hands-on Application of Biomedical Record Linkage in the Big Data Era Prof. Dr. Murat Sariyar, Institute for Medical Informatics I4MI, BFH-TI

1.6.2023 | Averaging Model for Feedback Control of Ultrasonic Transducers Diego Stutzer, Institute for Human Centered Engineering HuCE, BFH-TI

Burgdorf / Berthoud
Pestalozzistrasse 20, E013

4.5.2023 | TPV 5000 – Beitrag zur Defossilisierung des Verkehrs Dr. Albrecht Tribukait, CEO ad int., Silent-Power AG

25.5.2023 am Jlcoweg 1 | **What is High Voltage Engineering about?** Prof. Dr. Roman Grinberg, Institute for Energy and Mobility Research IEM, BFH-TI

8.6.2023 | Waghalsige Holzkonstruktionen unter Anwendung moderner Technologie neu denken Matias Penrroz, Institut für digitale Bau- und Holzwirtschaft IdBH, BFH-AHB