irt Institute of Automatic Control | RWTH AACHEN UNIVERSITY

WIND TO ENERGY®

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Enhancing Model Predictive Control of a 3 MW Wind Turbine with Machine Learning

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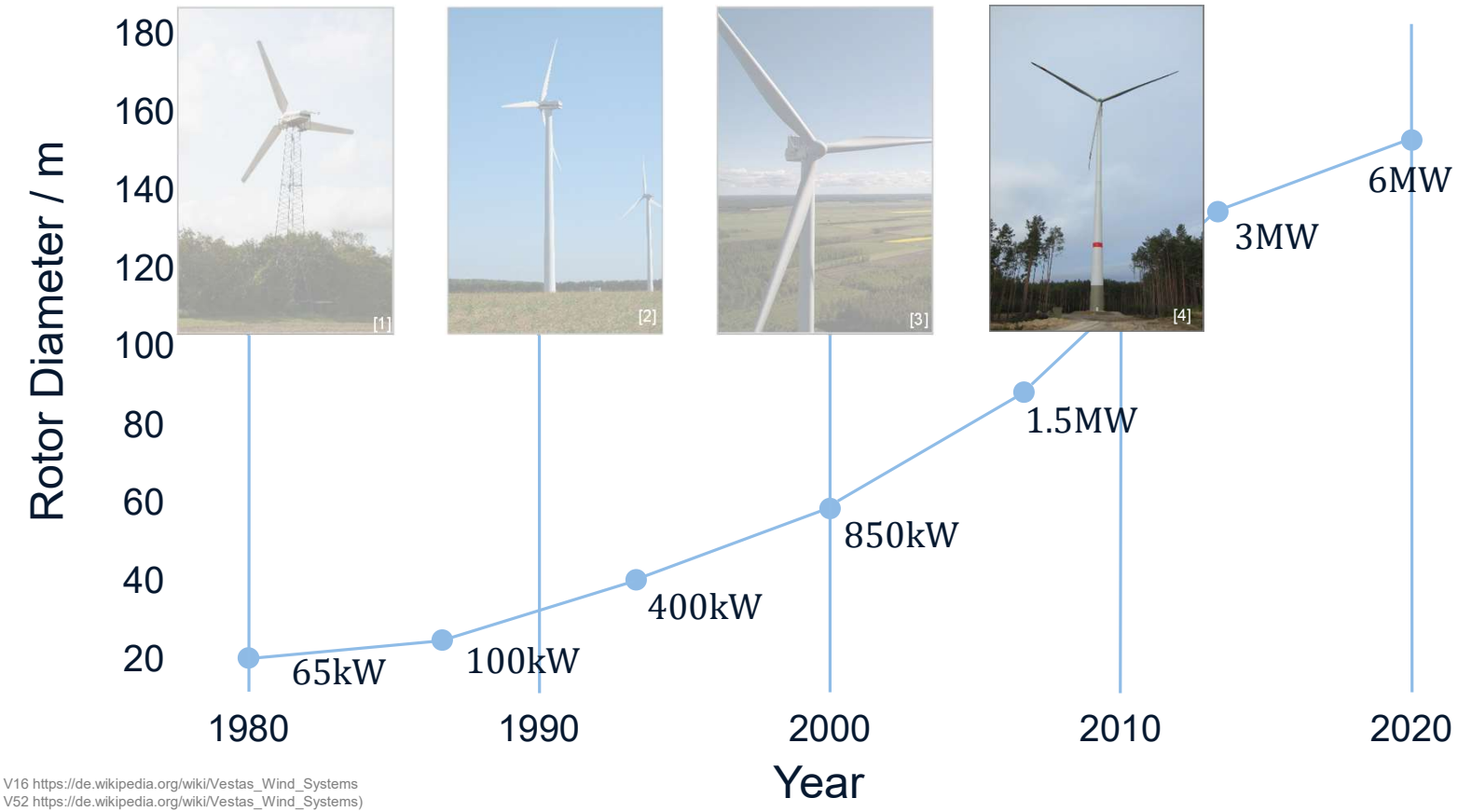
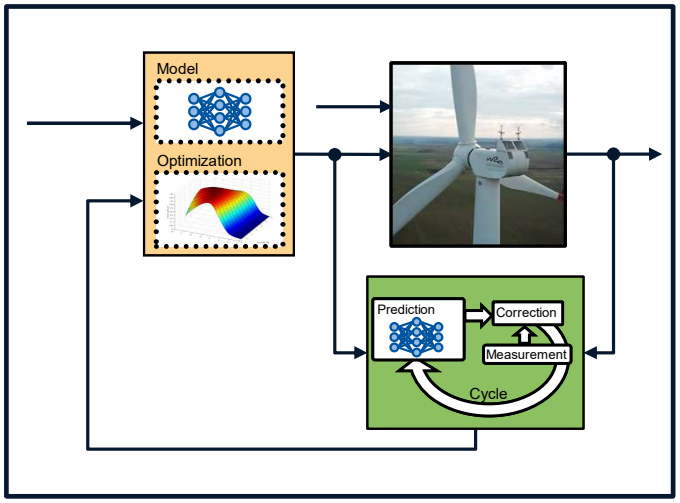
MATLAB EXPO

Ever Bigger Wind Turbines Increase Dynamic Requirements



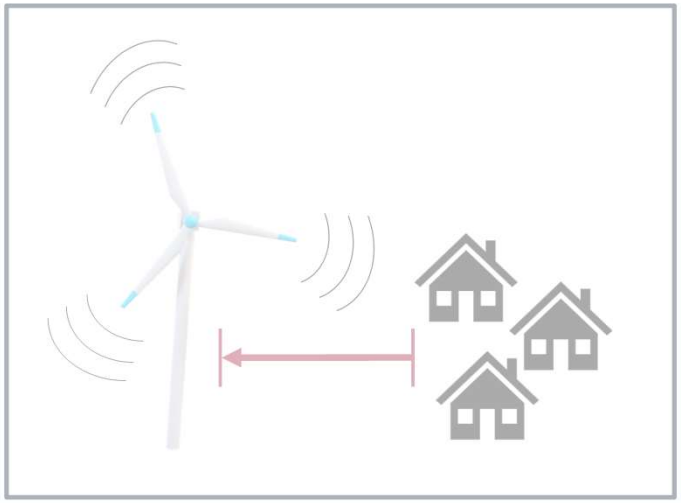
[1] Vestas V16 https://de.wikipedia.org/wiki/Vestas_Wind_Systems
[2] Vestas V52 https://de.wikipedia.org/wiki/Vestas_Wind_Systems)
[3] Vestas V136 https://www.indiamart.com/proddetail/v136-3-45-mw-21497927033.html
[4] Vestas V162https://www.reddit.com/r/windturbine/comments/rzvg23/vestas_enventus_v16256mw_on_169_m_hub_height_in/

This Presentation Focuses on AI-Enhanced Model Predictive Wind Turbine Control



Control Design

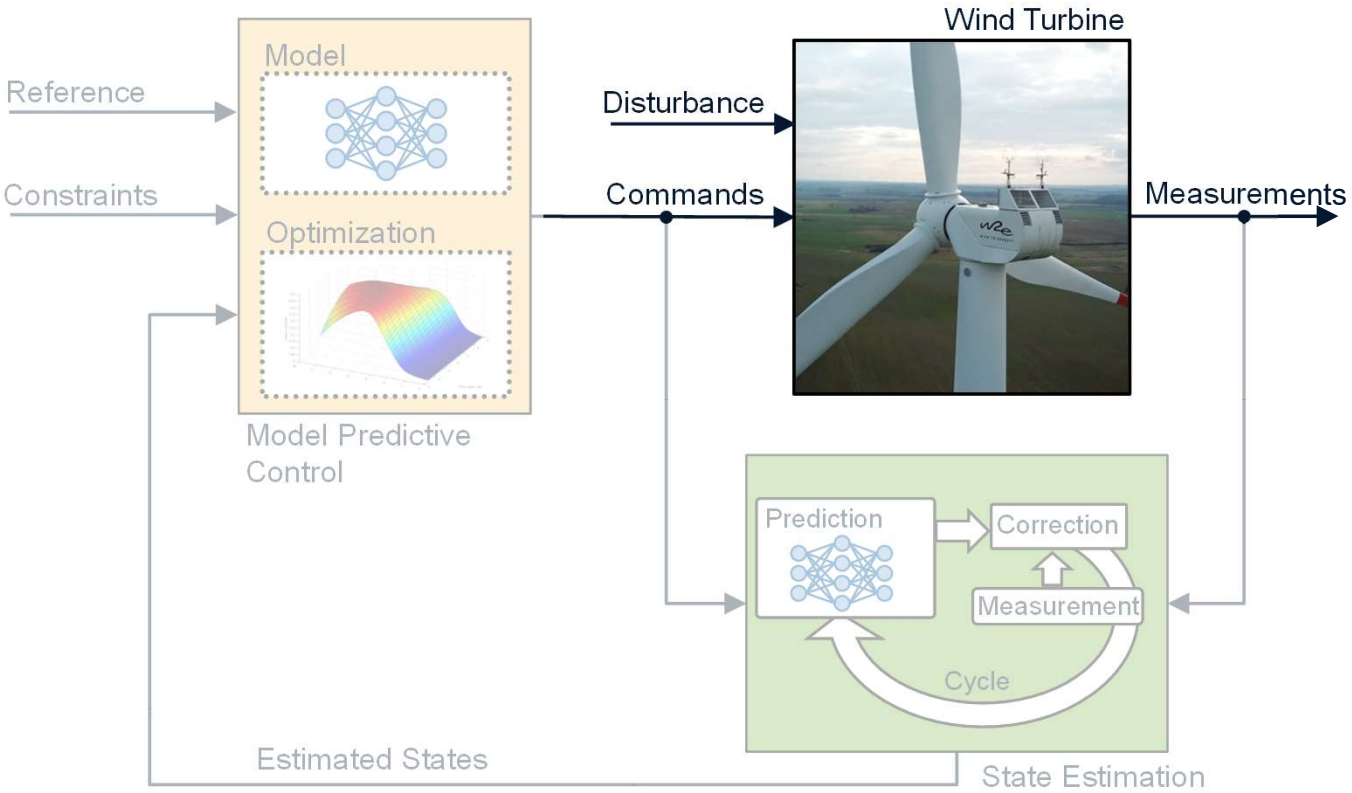
Practical Evaluation



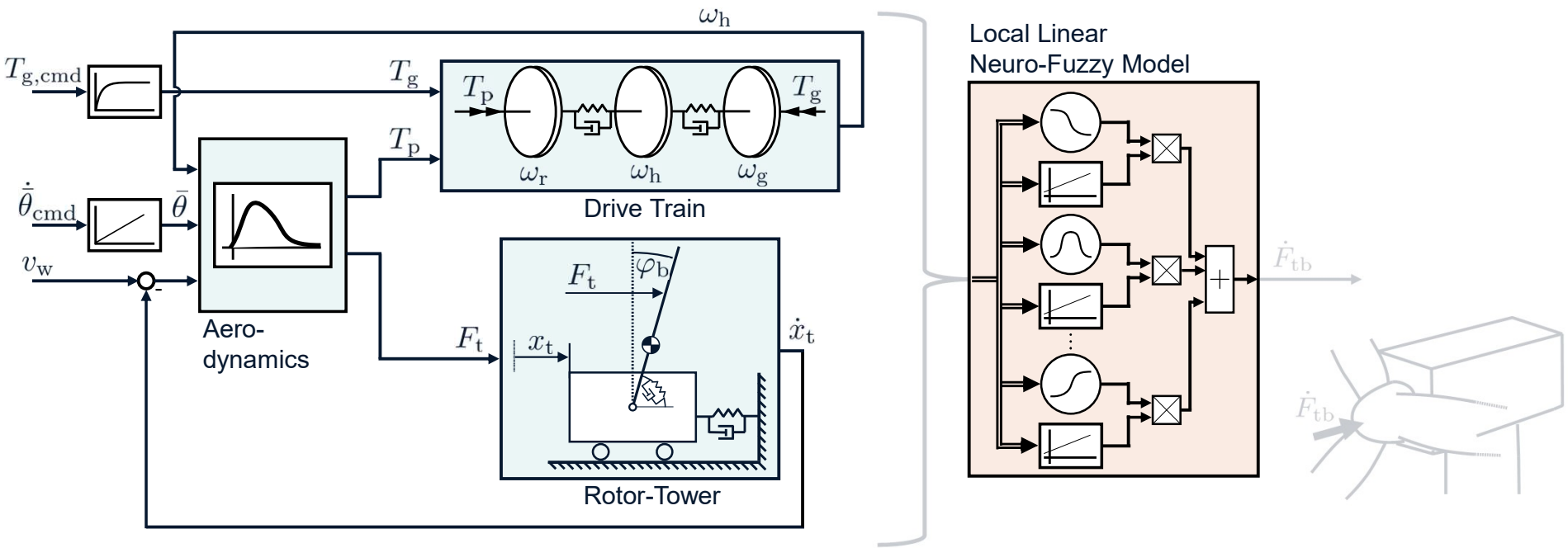
Future Trends

Wind Turbine Control is Speed and Power Control, and Load Reduction

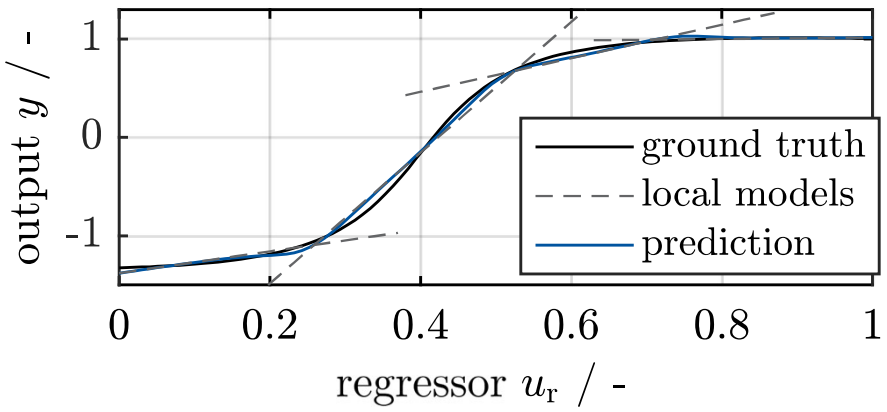
Model-Based Control May Incorporate Nonlinear Regression Models

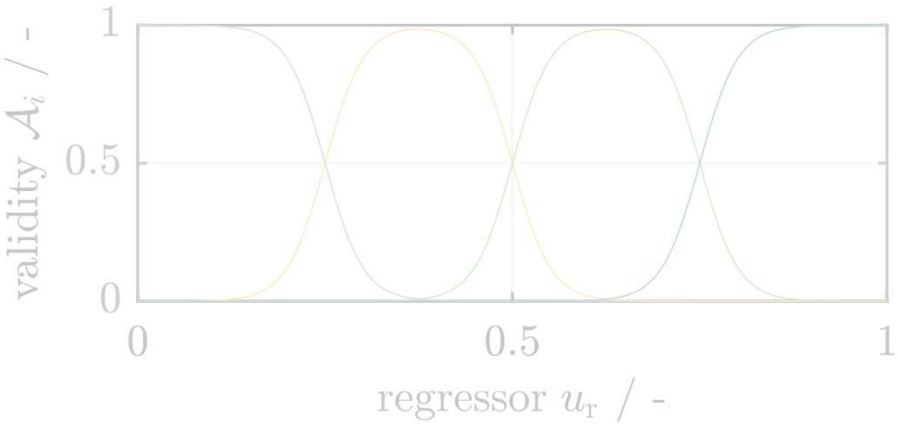


The Machine Learning Extension Allows Mapping to Non-Measurable Outputs



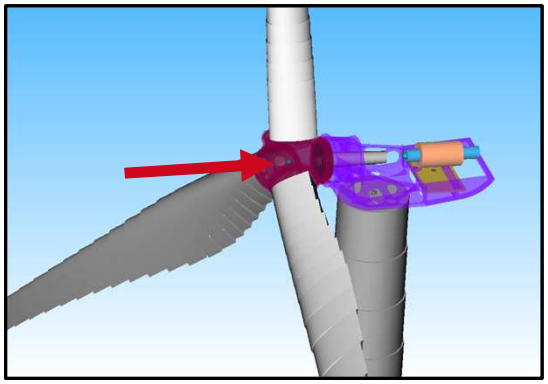
Local Linear Neuro-Fuzzy Models Offer Nonlinear Identification With Good Interpretability



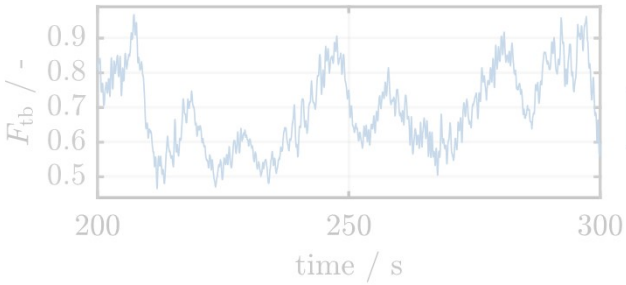


Low-Pass Filtering Only Retains Low Frequency Components That Can Be Used for Training

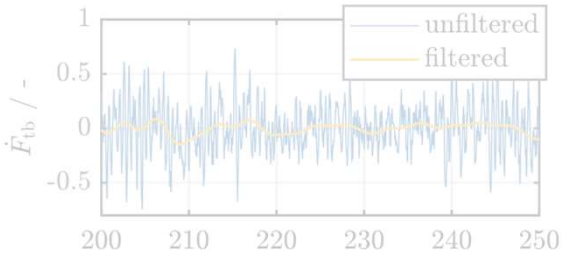
Generating Data

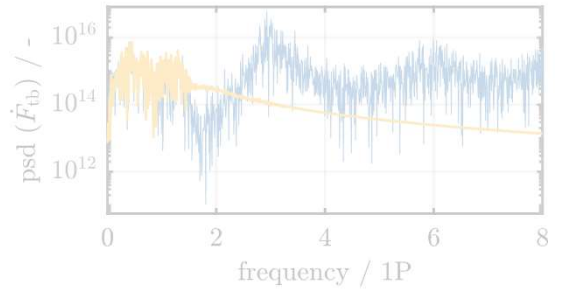


[1]



Preprocessing



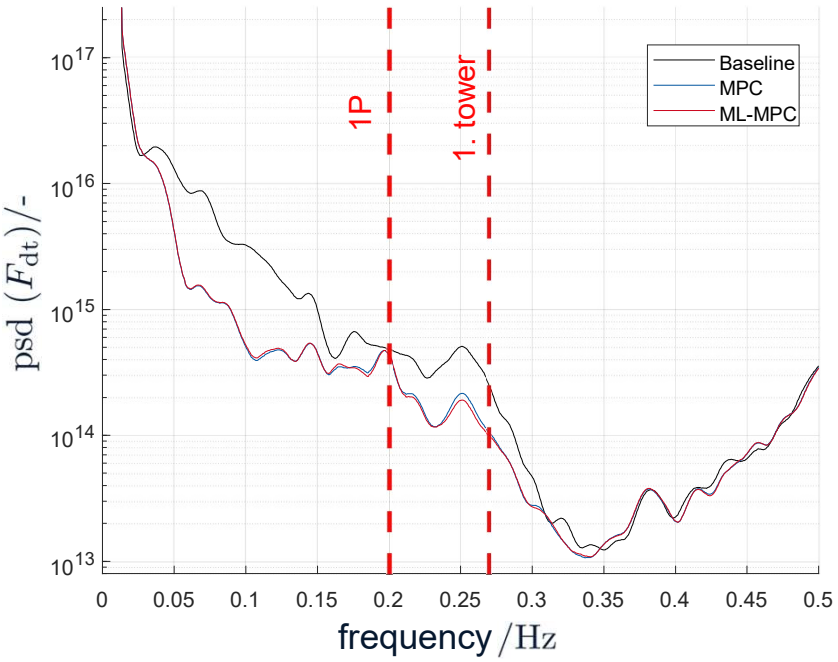


Training

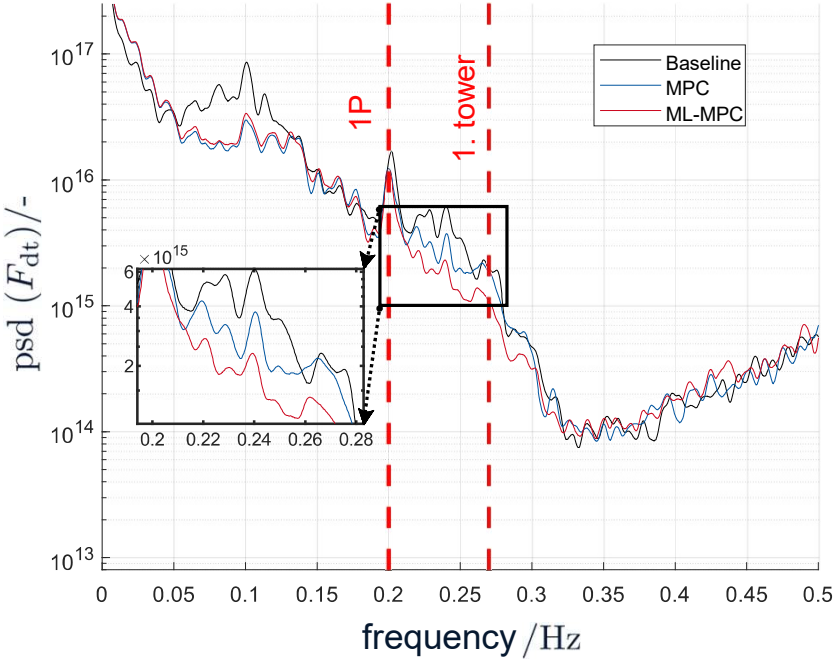
[1] Freudenberg H. Der Einsatz von alaska bei der Entwicklung von Windkraftanlagen. 2016.
[2] Hartmann B., Ebert T., Fischer T., Belz J., Kampmann G., Nelles O.: "LMNtool - Toolbox zum automatischen Trainieren lokaler Modellnetze", 22. Workshop Computational Intelligence, Dortmund, Dezember 2012.

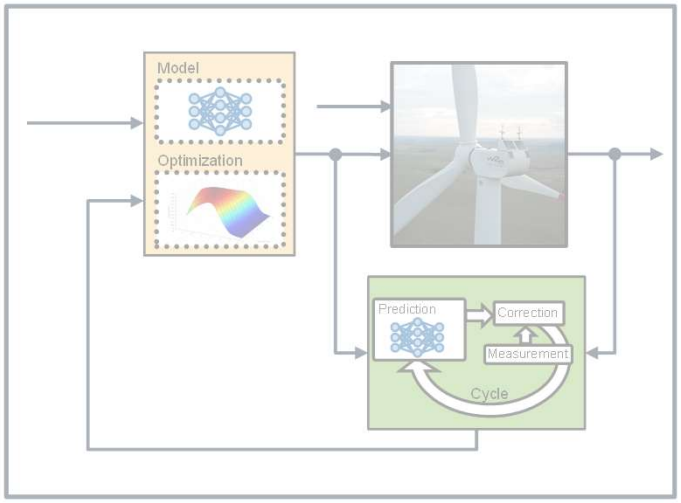
Data-Enhancement Reduces the Dynamics of the Thrust Force in the Full Load Regime

Partial Load Regime
(Wind Power < Rated Power)



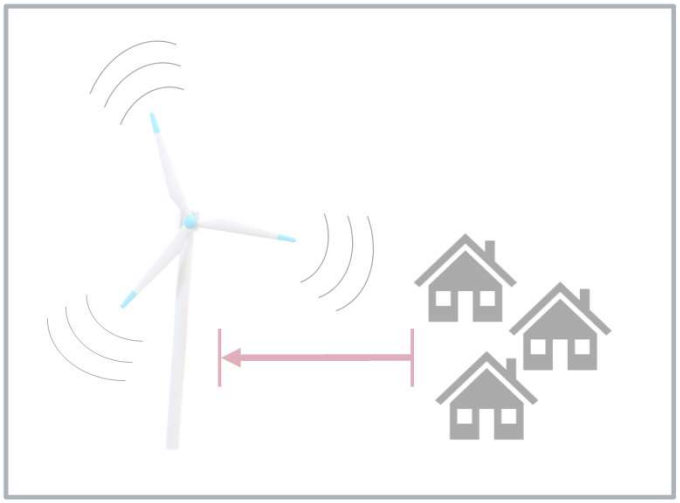
Full Load Regime
(Wind Power > Rated Power)





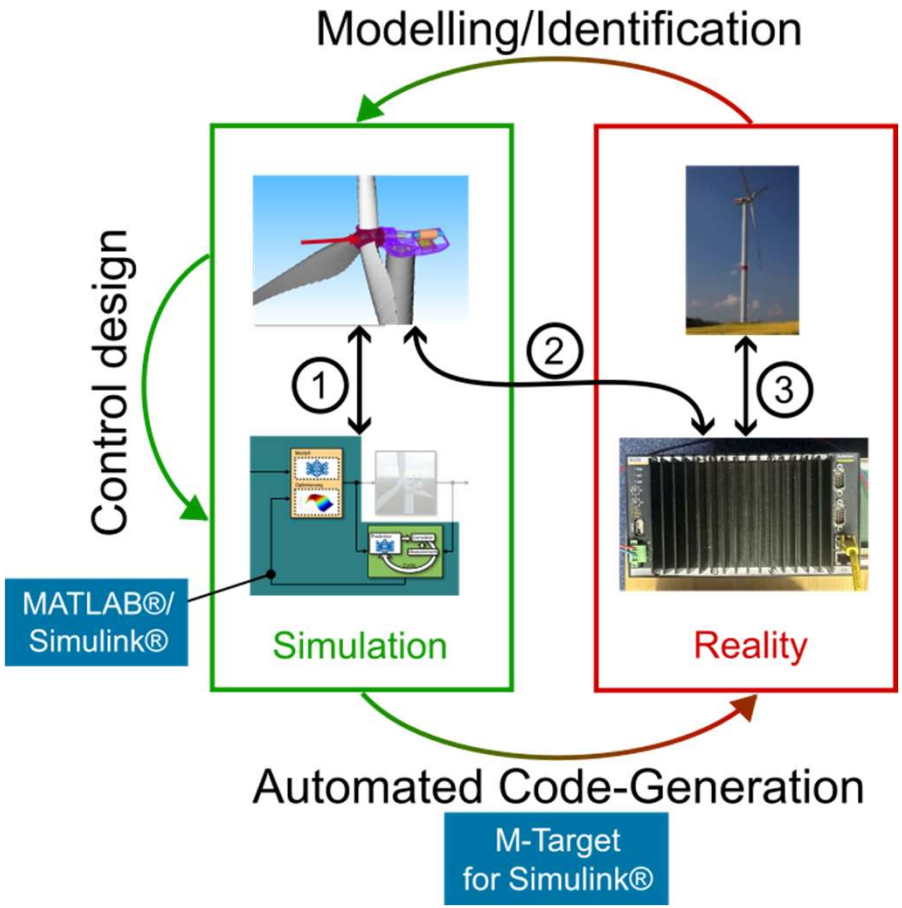
Control Design

Practical Evaluation



Future Trends

Validating the Controller with a Field Test on a Real Wind Turbine

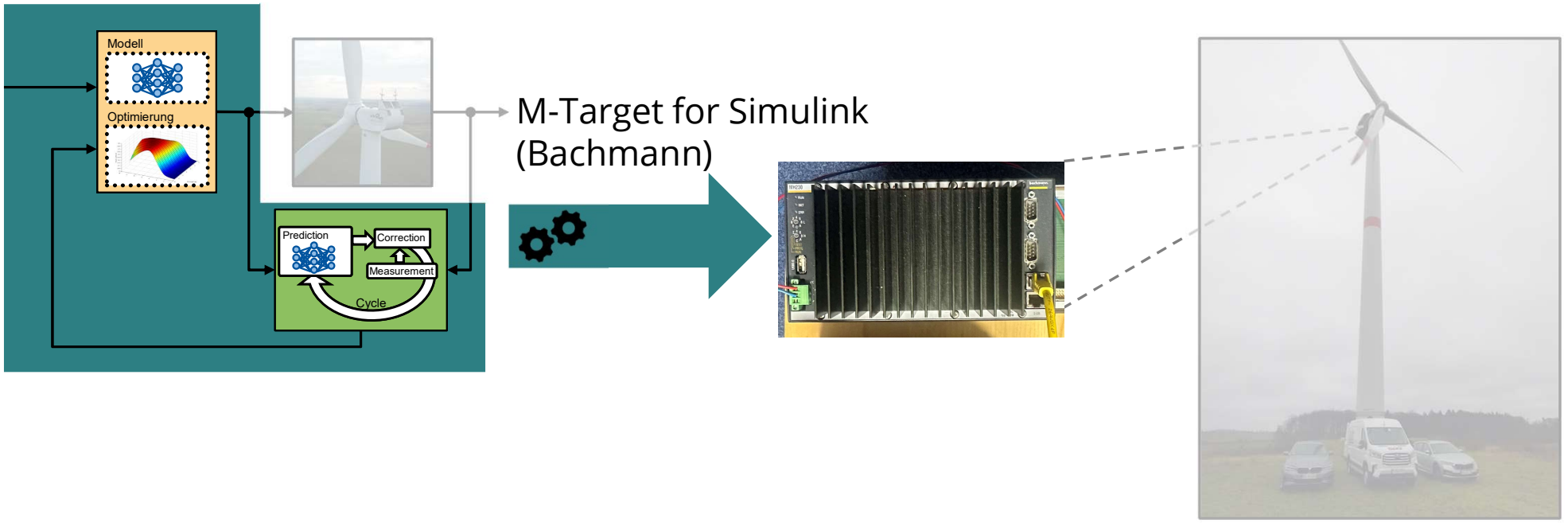


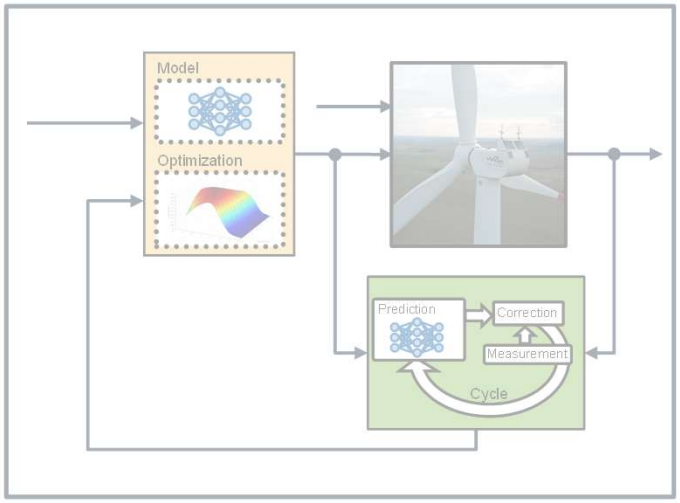
1: SiL (Software-in-the-Loop)

2: HiL (Hardware-in-the-Loop)

3: Fieldtest

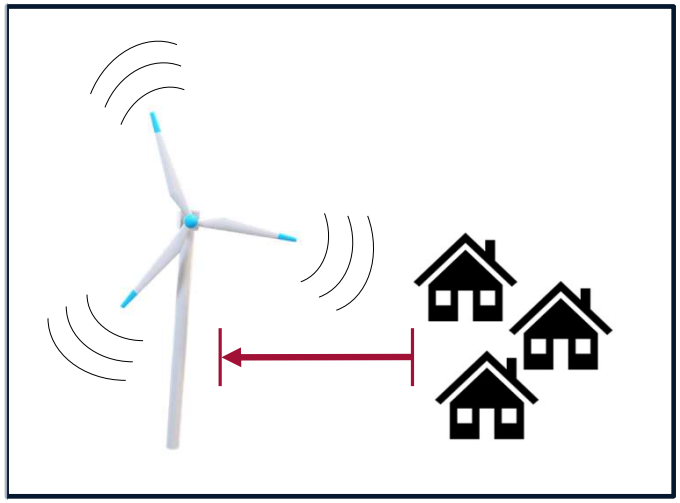
Automated Code-Generation Allows Transfer to the Full-Scale Wind Turbine





Control Design

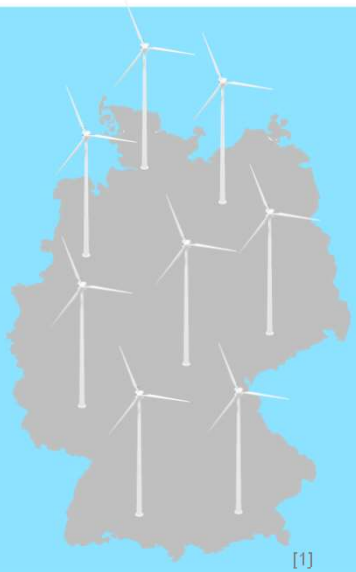
Practical Evaluation



Future Trends

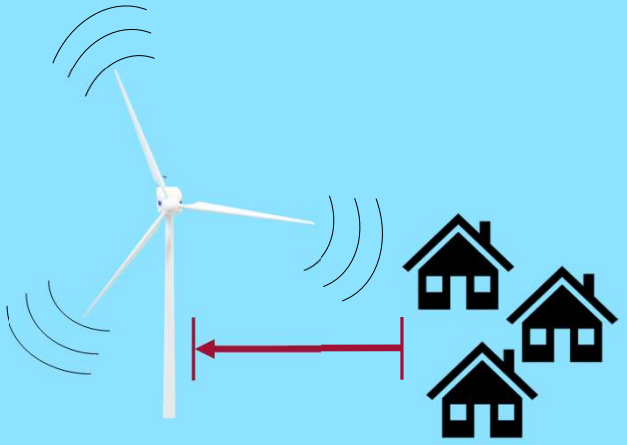
Targeted Control of Rotor Blade Noise as One Future Trend in Wind Turbine MPC

Motivation



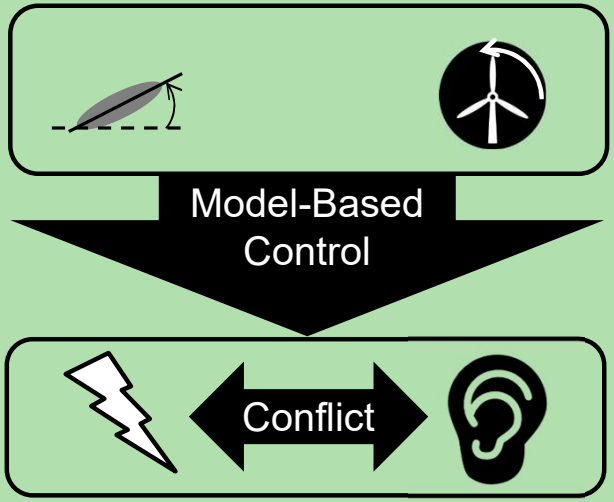
[1]

Energy Transition Relies on Onshore Wind Energy



Noise Emissions Require Minimum Distances to Residential Areas

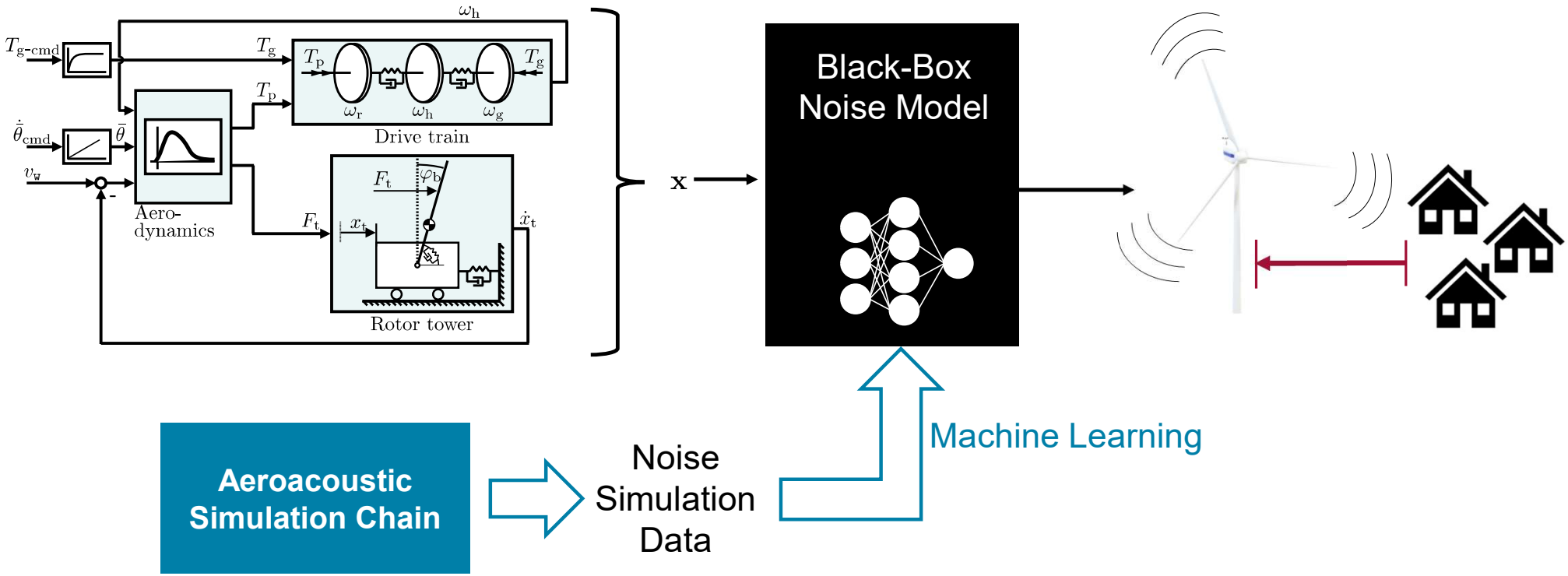
Approach



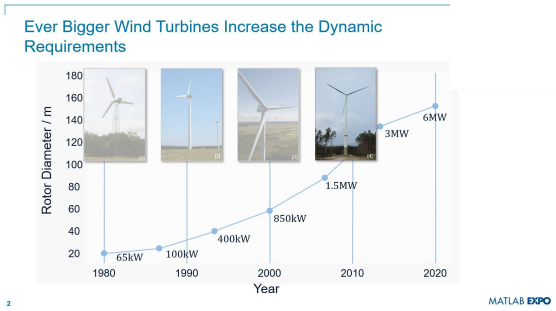
Main Challenge: Quieter and Still Efficient Operation

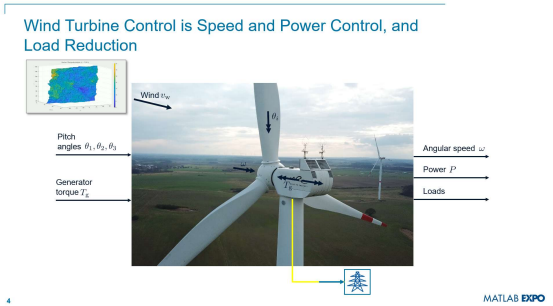
[1] Picture from Stefan Schweihofer on Pixabay

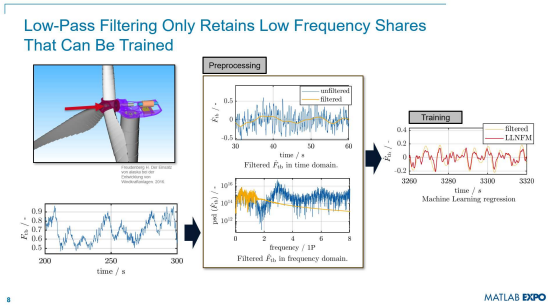
Starting Point: Extending the Controller's Prediction Model with a Control-Oriented Acoustic Submodel

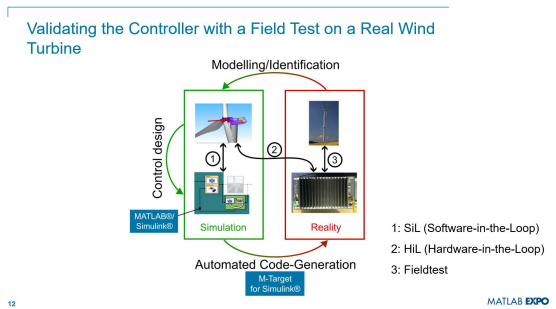


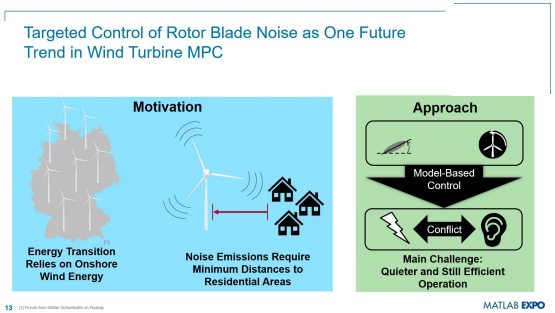
Data-Enhancement Provides a Valuable Addition to Model-Based Control











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Questions?

MATLAB EXPO

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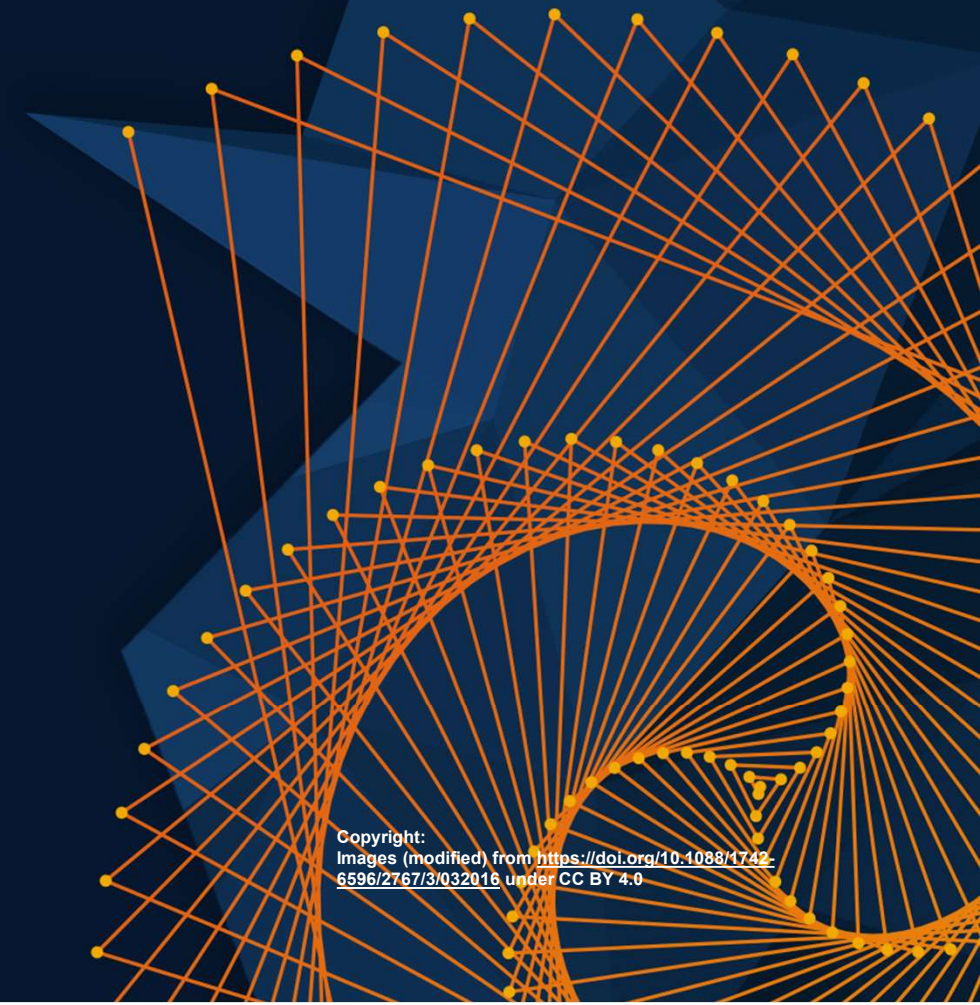
Thank you



MathWorks