

Save the Earth: Accelerate Climate Science and Electrify Everything

Dr Tanya Morton
Global Director Customer Success Engineering, MathWorks
8 November 2024

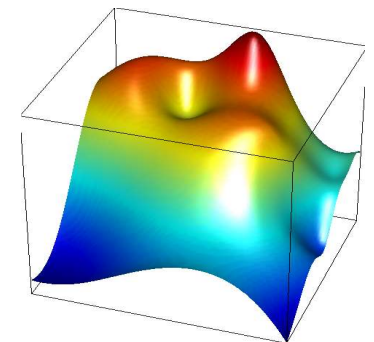
Tanya Morton – Education



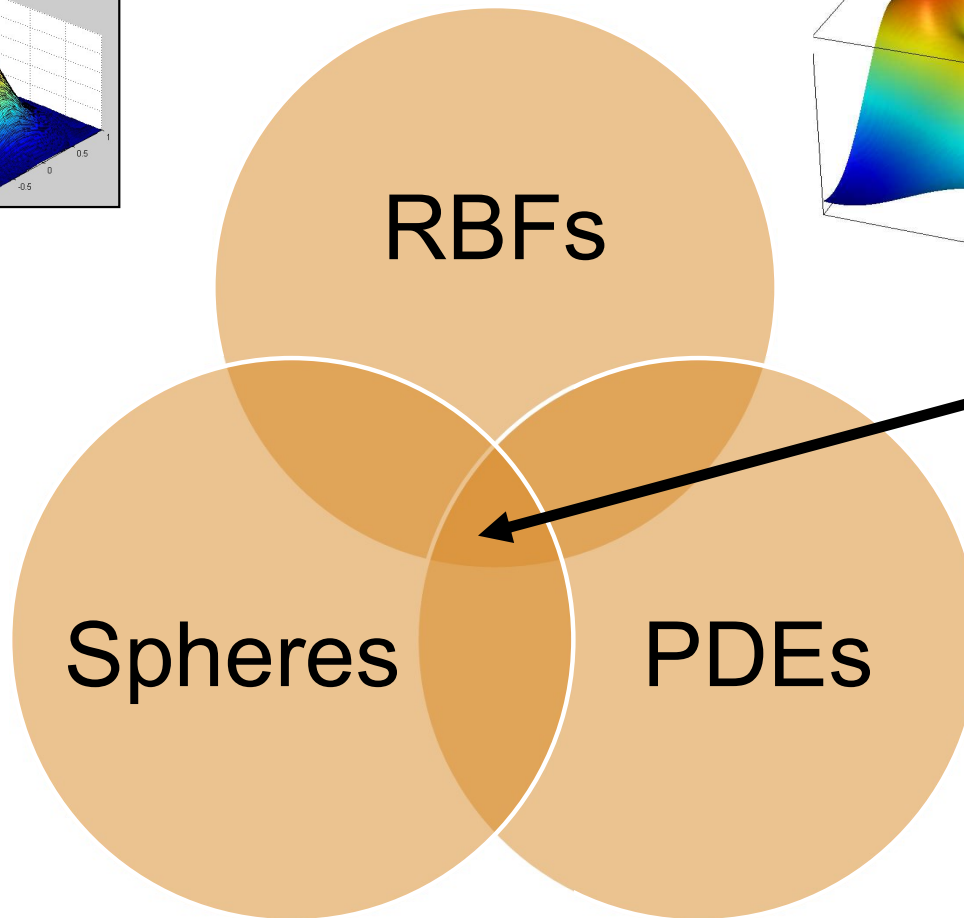
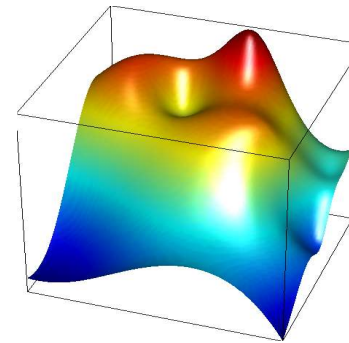
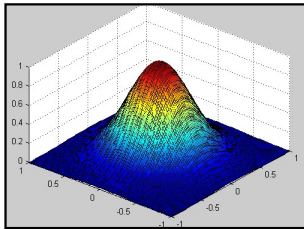
1995
BA Mathematics
Oxford University
UK



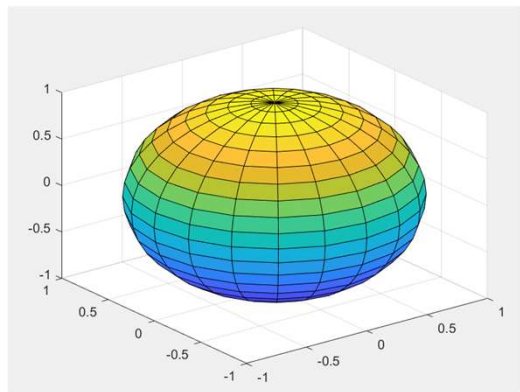
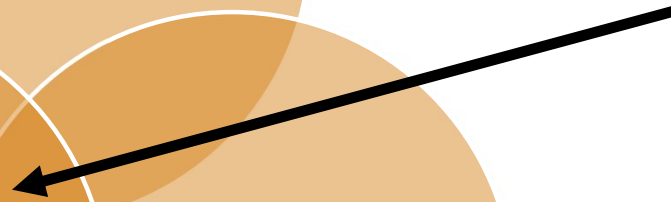
2000
PhD Mathematics & Computer Science,
Vanderbilt University,
USA



Thesis: Error Bounds for Solving Pseudodifferential
Equations on Spheres by Collocation with Zonal Kernels



My PhD



$$\nabla^2 f = h$$

Spherical Interpolation Convergence Order Result

- ψ is a conditionally positive definite function of order m on the unit sphere S^{d-1} whose Legendre coefficients decay like $(1 + k)^{-(1+\alpha)}$ for some $\alpha > 0$
- Ξ denotes a set of distinct data points on S^{d-1} with geodesic mesh-norm h
- There exists a positive number h_0 such that, if $h \in (0, h_0)$ then the ψ -based Spherical Basis Function interpolant sf to target function $f \in W^{2s}(S^{d-1})$ satisfies

$$\|f - sf\|_{W^s(S^{d-1})} \leq C h^s \|f\|_{W^{2s}(S^{d-1})}$$

where $2s = \alpha + d - 1$ and the generic constant C is independent of h

Tanya Morton - MathWorks Experience

Toyota Uses MathWorks Tools to Increase Quality, Reduce Costs, and Speed Time to Market of New Vehicles



Challenge
Speed up design, increase quality, and reduce R&D costs by finding an alternative to traditional design methods

Solution
Use MathWorks tools for control design to prototype, model, test, and refine control strategies in an integrated design environment

Results

- Deliver a better product to market faster — and at a lower cost
- Reduce time to embedded code
- Forge a pathway to innovation

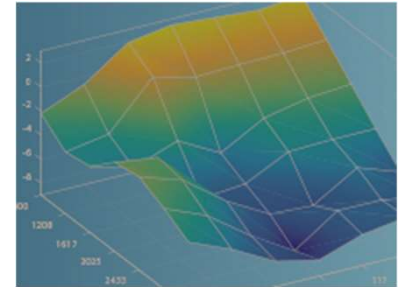
"MATLAB, Simulink, and Stateflow... have become the de facto standard at Toyota for simulation, data processing, and controls design. It would be impossible to list all of the applications for these tools at Toyota."

Akira Ohata
Toyota

[Link to user story](#)



- 2000 – 2005 Consultant
 - Developed AI and Optimization capability for the Model-Based Calibration (MBC) Toolbox
 - Worked with global automotive companies
- 2005 – 2015 Application Engineering Manager
 - Supported aerospace, automotive, energy companies, plus universities
- 2019 – 2024 Director Customer Success Engineering
 - Supporting students, educators and researchers, team based in 16 countries and 30+ cities



The logo for MATLAB EXPO, with "MATLAB" in orange and "EXPO" in blue. The background features dark blue geometric shapes in the corners.

MATLAB EXPO

SAVE THE EARTH
ACCELERATE CLIMATE SCIENCE
AND
ELECTRIFY EVERYTHING

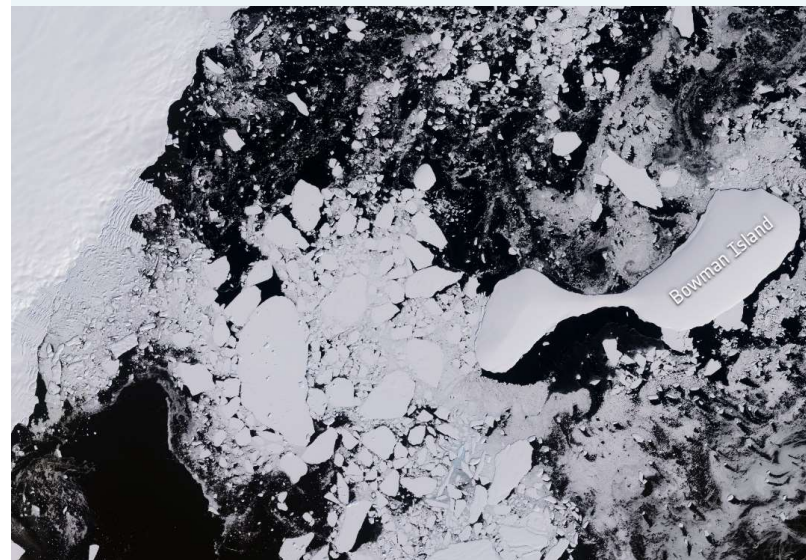
Dr. Tanya Morton

Director, MathWorks

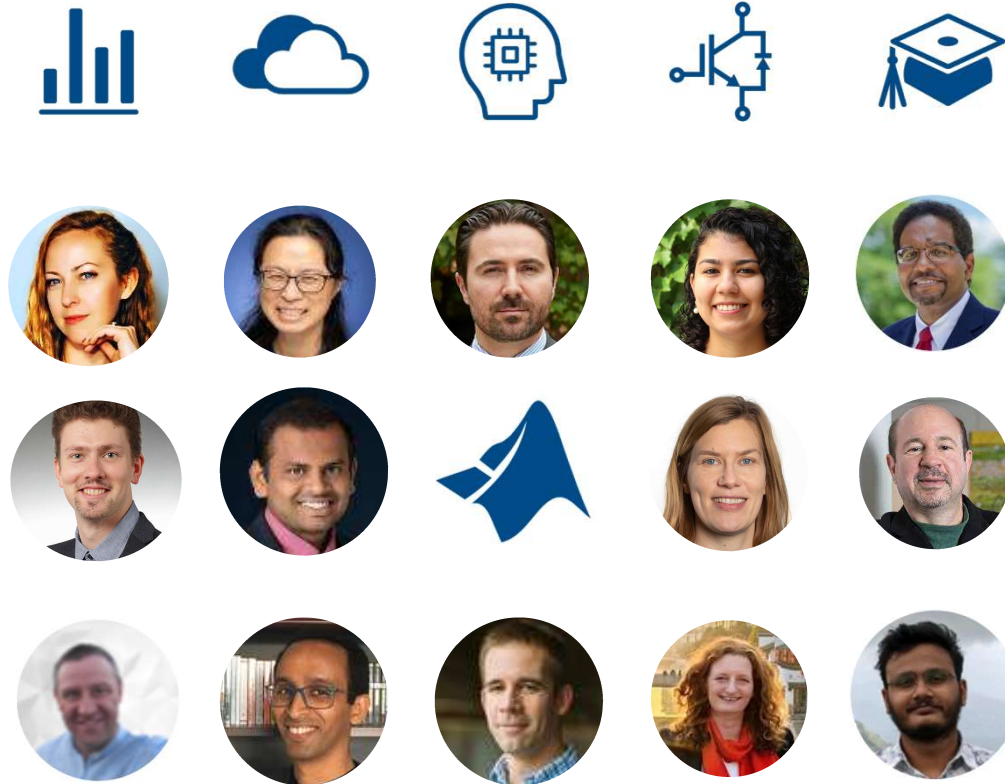
Ice shelf bigger than New York City breaks off eastern Antarctica

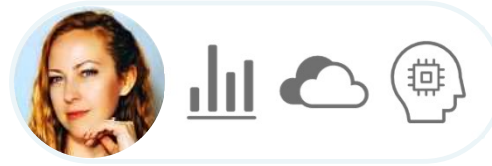
The Conger Ice Shelf is the first to break off eastern Antarctica in four decades of satellite observations.

— *The Washington Post*



Credit: Copernicus Sentinel data (2022), processed by ESA, [CC BY-SA 3.0 IGO](#)





Research

Accelerate Climate Science



Education

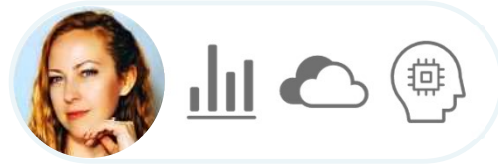
Train the Next Generation



Industry

Electrify Everything





Research

Accelerate Climate Science



Education

Train the Next Generation



Industry

Electrify Everything

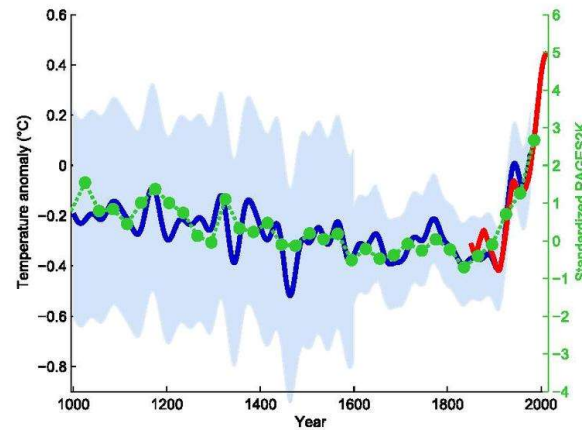




Climate Science Trends



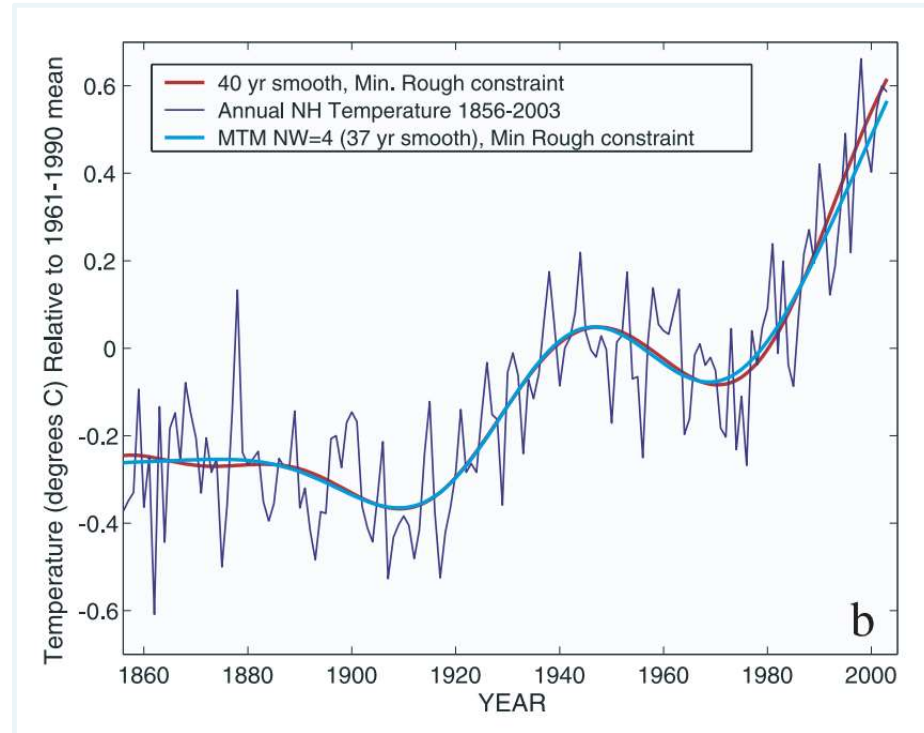
Prof. Michael E. Mann



Credit: Klaus Bittermann (2013), [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)



Uncovering Climate Change Signals in Noisy Data





Data availability

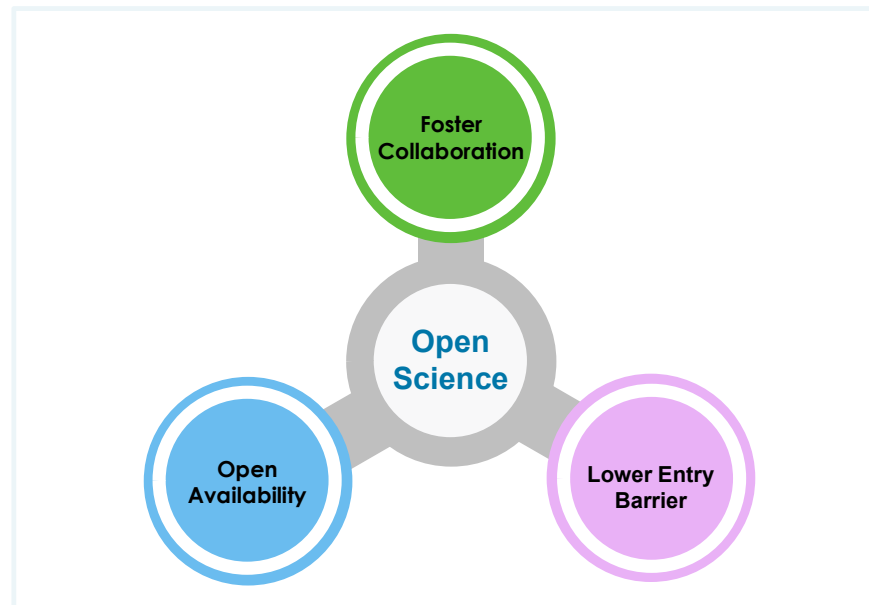
All raw data and results are available at the supplementary website:

[http://www.meteo.psu.edu/~mann/supplements/Mann MTMSVD 2019/Data](http://www.meteo.psu.edu/~mann/supplements/Mann_MTMSVD_2019/Data).

Code availability

All ©Matlab code is available at the supplementary website:

[http://www.meteo.psu.edu/~mann/supplements/Mann MTMSVD 2019/Code](http://www.meteo.psu.edu/~mann/supplements/Mann_MTMSVD_2019/Code).



MATLAB EXPO

November 13–14, 2024 | Online

[Register](#)

The event is free, but registration is required.



Algorithm Development and Data Analysis

FIND OUT MORE

**OPEN SOURCE SOFTWARE
AND MATLAB: PRINCIPLES,
PRACTICES, AND PYTHON**



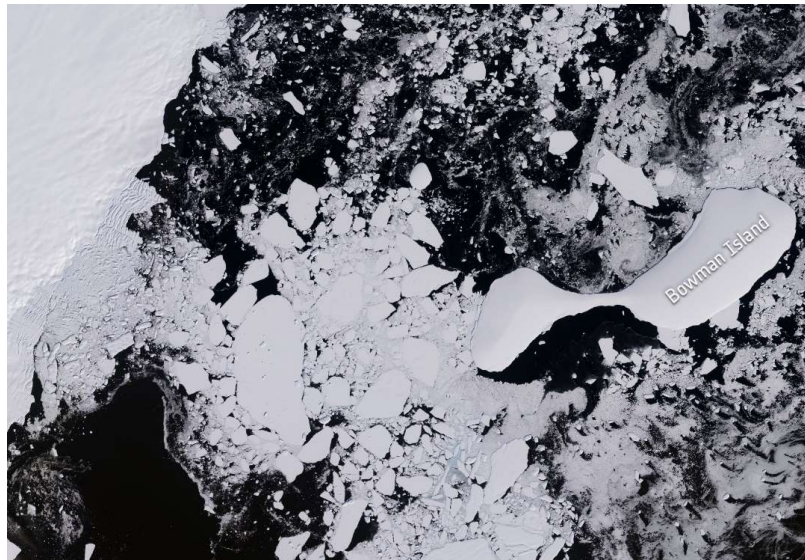
Dr. Heather Gorr, MathWorks



Dr. Mike Croucher, MathWorks



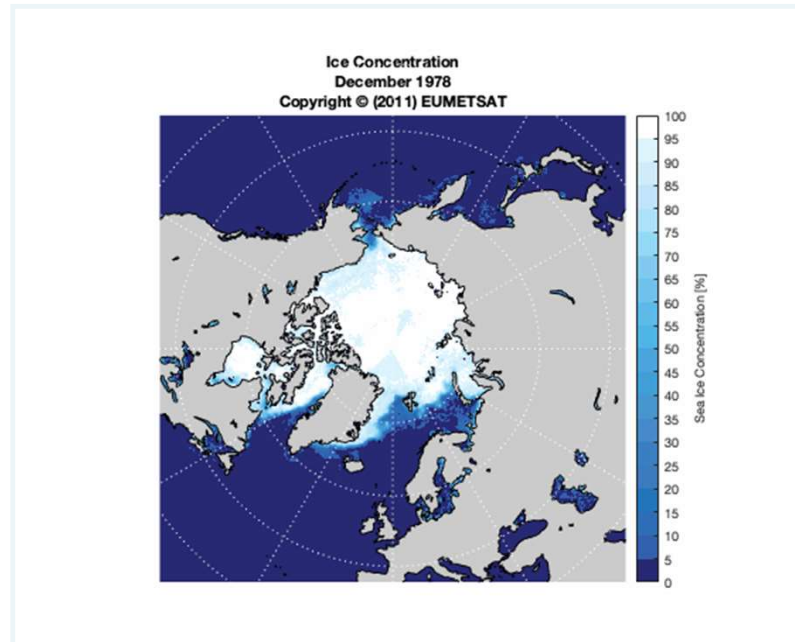
Climate Science Cloud Portals



Copernicus



Climate Science Cloud Portals





Predict Droughts with AI



Dr. Jan Adamowski, McGill University



Anteneh Belayneh, Carleton University



Dr. John Quilty, University of Waterloo



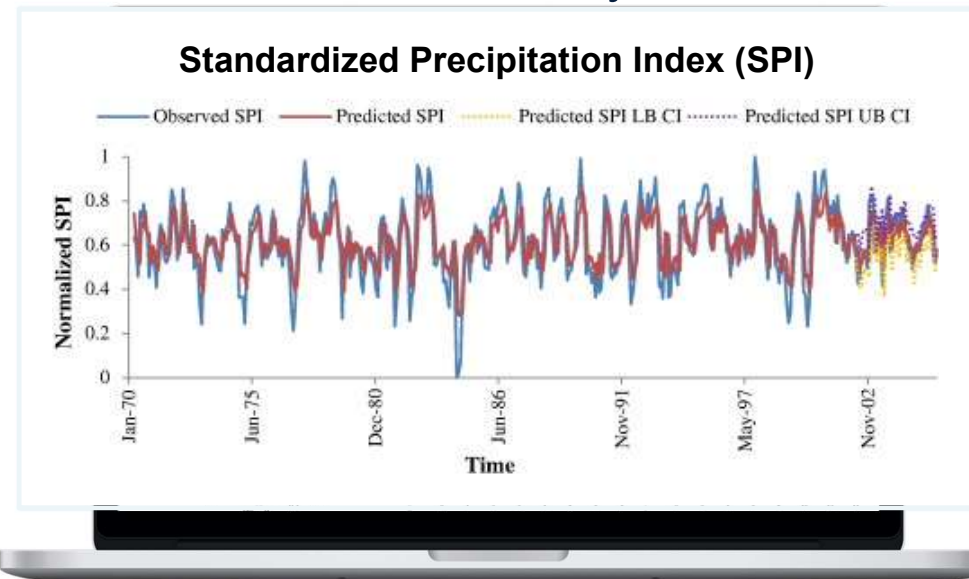
Bousnobra Khalil, University of Guelma



Awash Basin, Ethiopia



Artificial Neural Networks





Hands-On Workshop

FIND OUT MORE

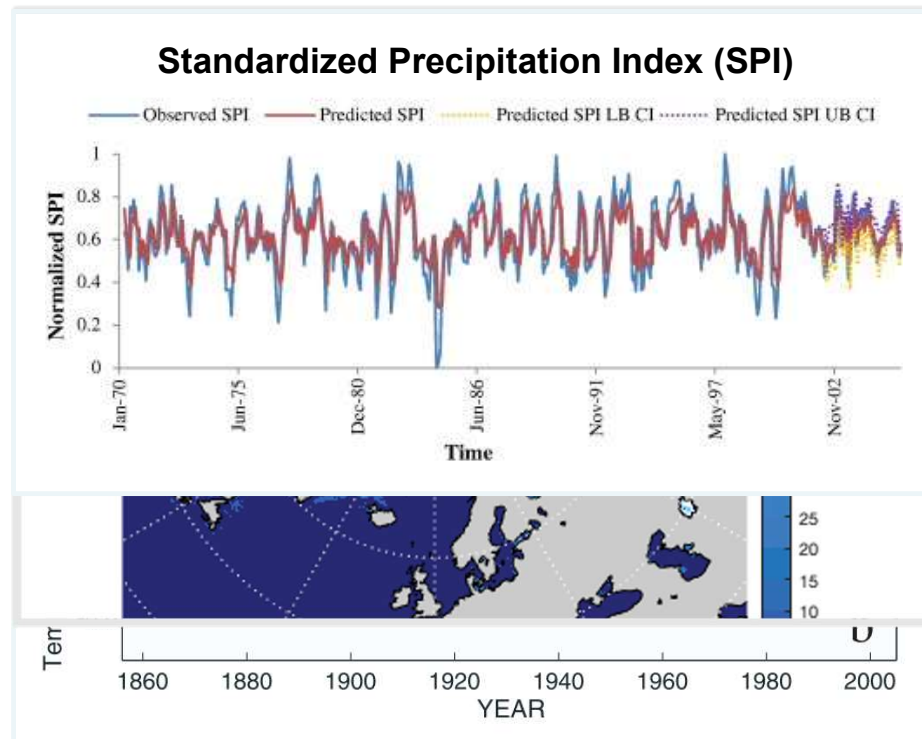
OPTIMIZING AI-ENABLED
BIOMEDICAL SIGNAL
PROCESSING ALGORITHMS

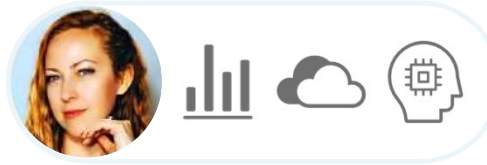


Dr. Brenda Zhuang, MathWorks



Akhilesh Mishra, MathWorks





Research

Accelerate Climate Science



Education

Train the Next Generation



Industry

Electrify Everything



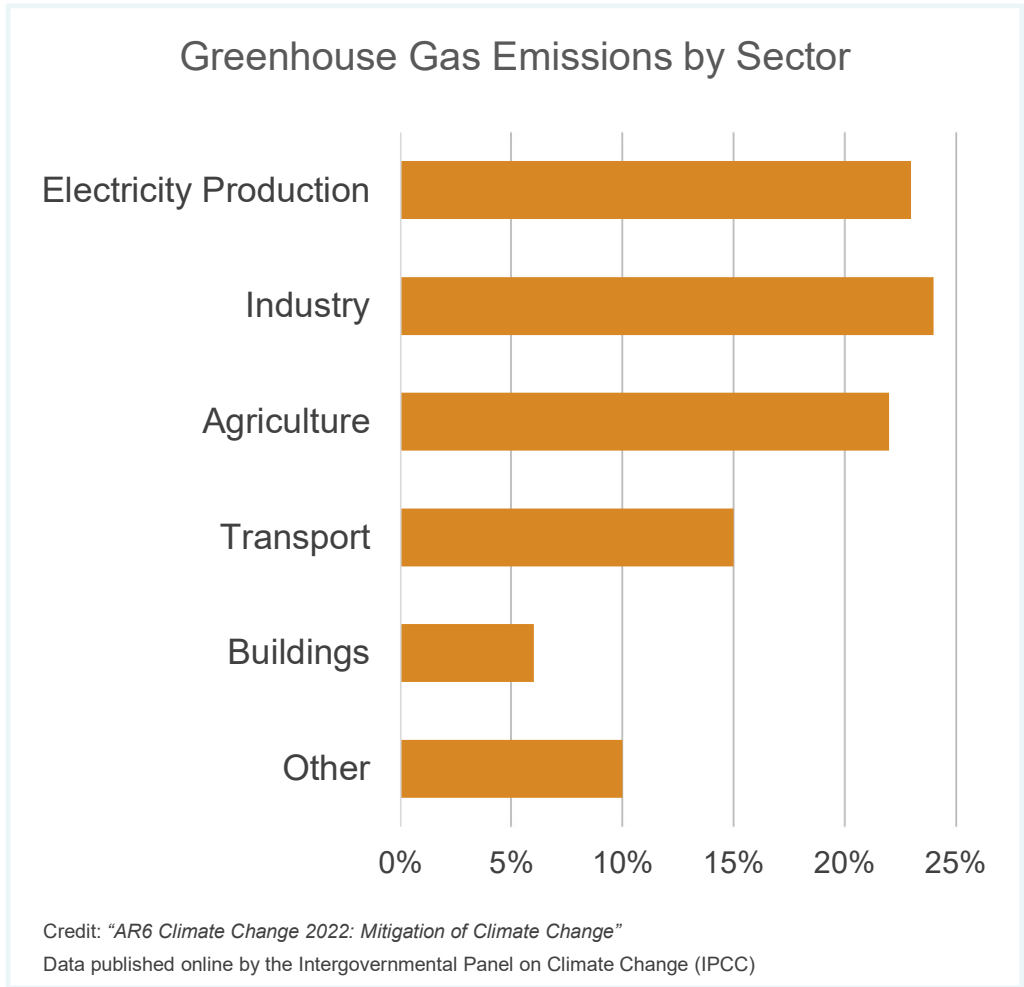
*Circumstances Affecting the Heat
of the Sun's Rays*

American Journal of Science and Arts

Series 2: Volume 2 (1856)



Eunice Newton Foote





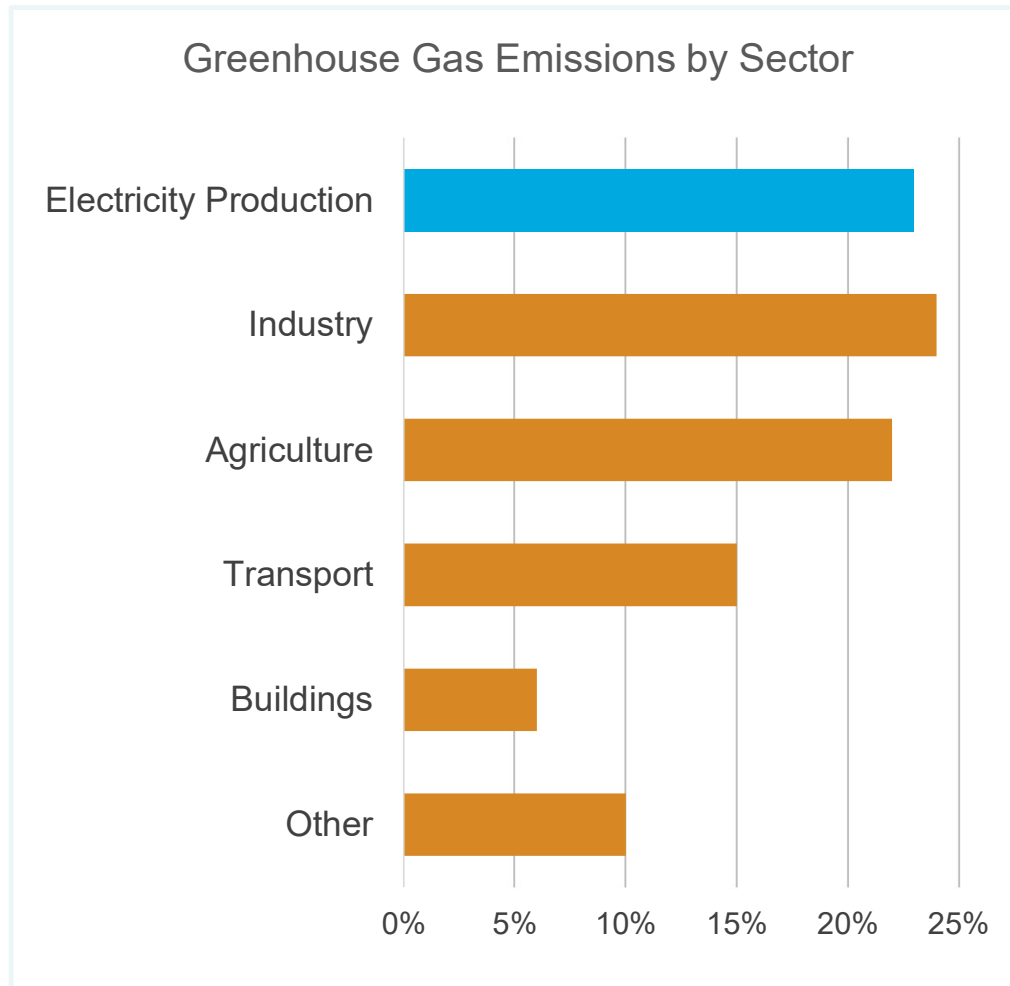
Generate electricity from
renewable sources

+

Use electricity as our primary
energy source

=

Electrify everything!



Growth of the Electric Power Grid



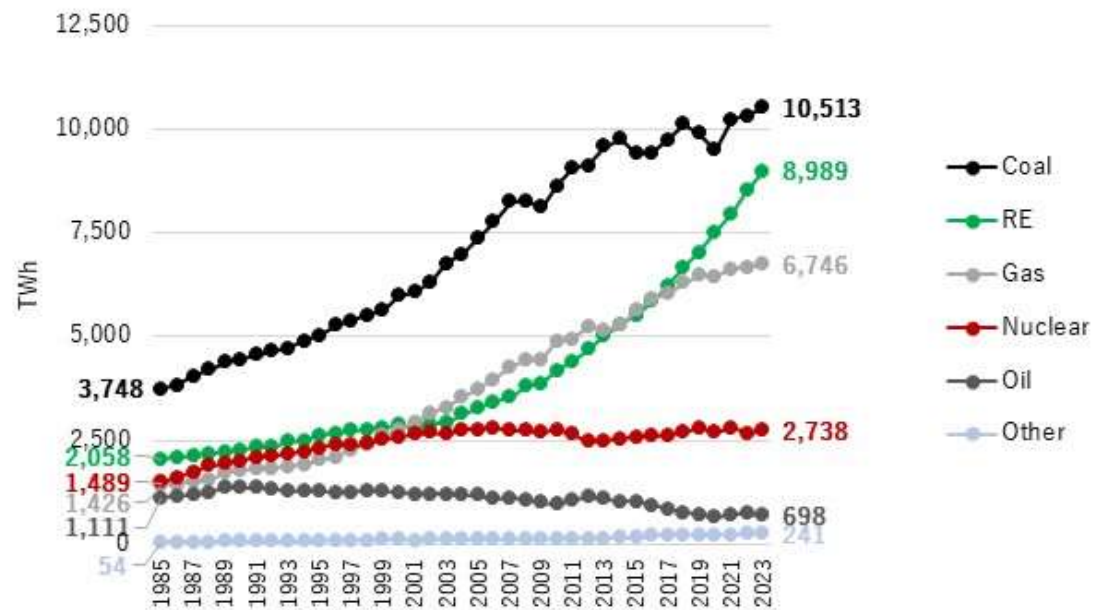
Growth of the Electric Power Grid



Worldwide Electricity Production by Source

< 1985-2023 >

Updated: 25 June 2024



Notes: "RE" (renewable energy) includes hydro, wind, solar, bioenergy and geothermal. "Other" includes pumped hydro, other fossil generation, and statistical differences. Based on "gross" generation.

Source: Energy Institute, Statistical Review of World Energy 2024 (June 2024) (downloaded 21 June 2024).



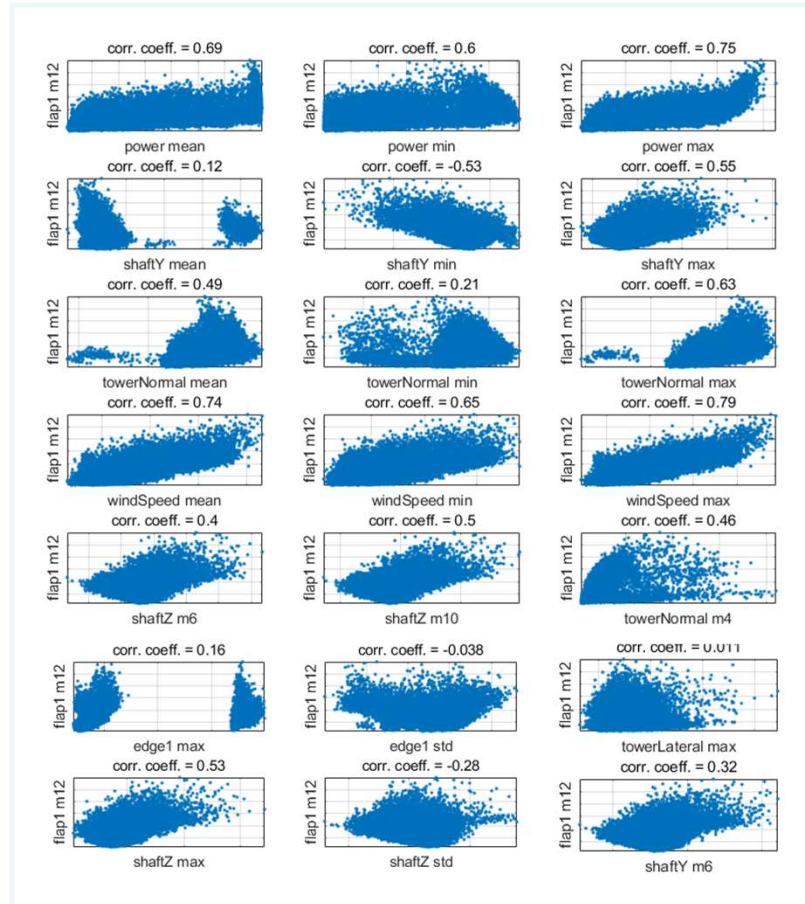


8,000+ Components

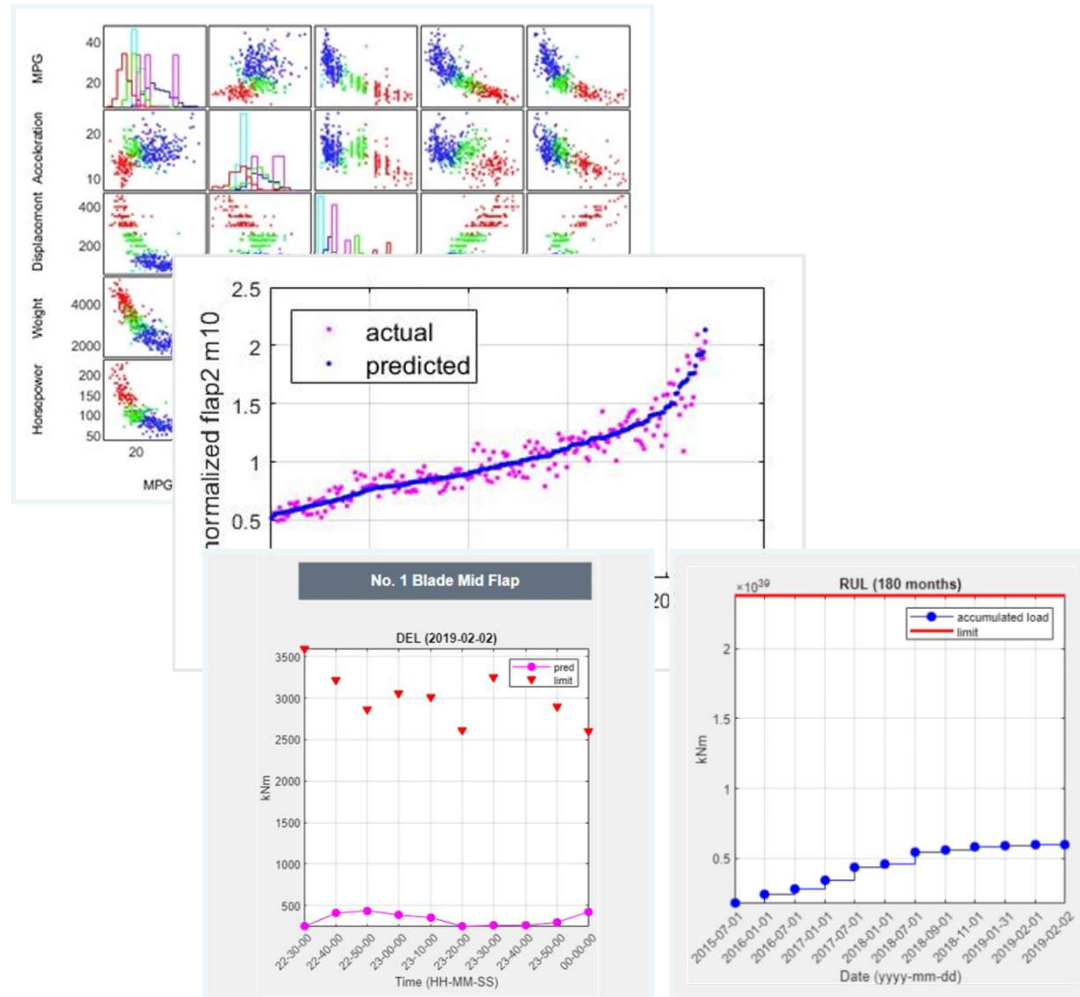
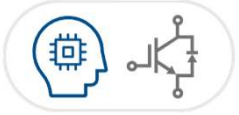




3,000+ Signals



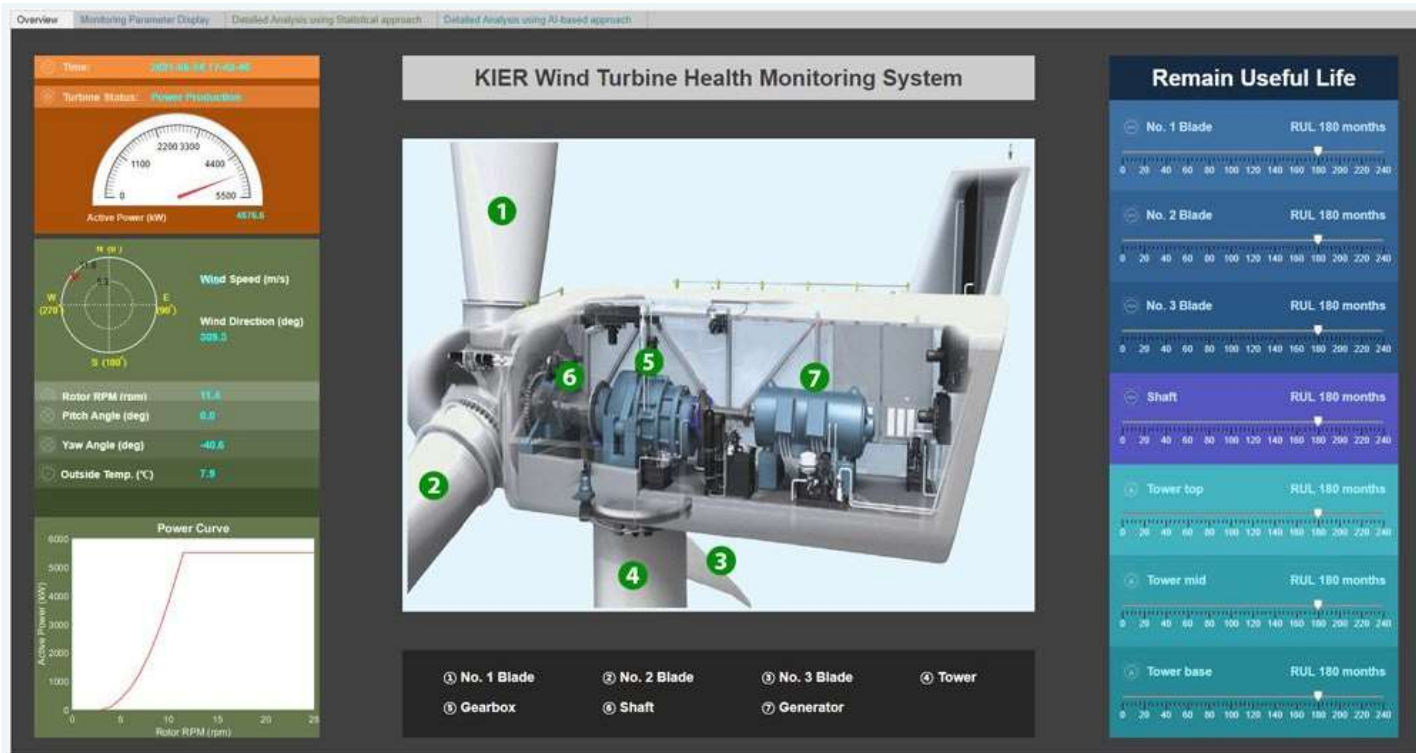
Courtesy of Korea Institute of Energy Research (KIER)





“Despite having little previous experience with AI... we completed a diagnostics model in MATLAB capable of detecting wind turbine component failure with over 90% accuracy.”

—*Jung Chul Choi, senior researcher at Korea Institute of Energy Research*



Courtesy of Korea Institute of Energy Research (KIER)

Access Data



Sensors



Files



Databases

Analyze Data



Data exploration



Preprocessing



Domain-specific algorithms

Develop



AI model



Algorithm development



Modeling & simulation

Deploy



Desktop apps



Enterprise systems



Embedded devices



AI and Electrification

FIND OUT MORE

ENHANCING MODEL PREDICTIVE
CONTROL OF A 3 MW WIND
TURBINE WITH MACHINE
LEARNING



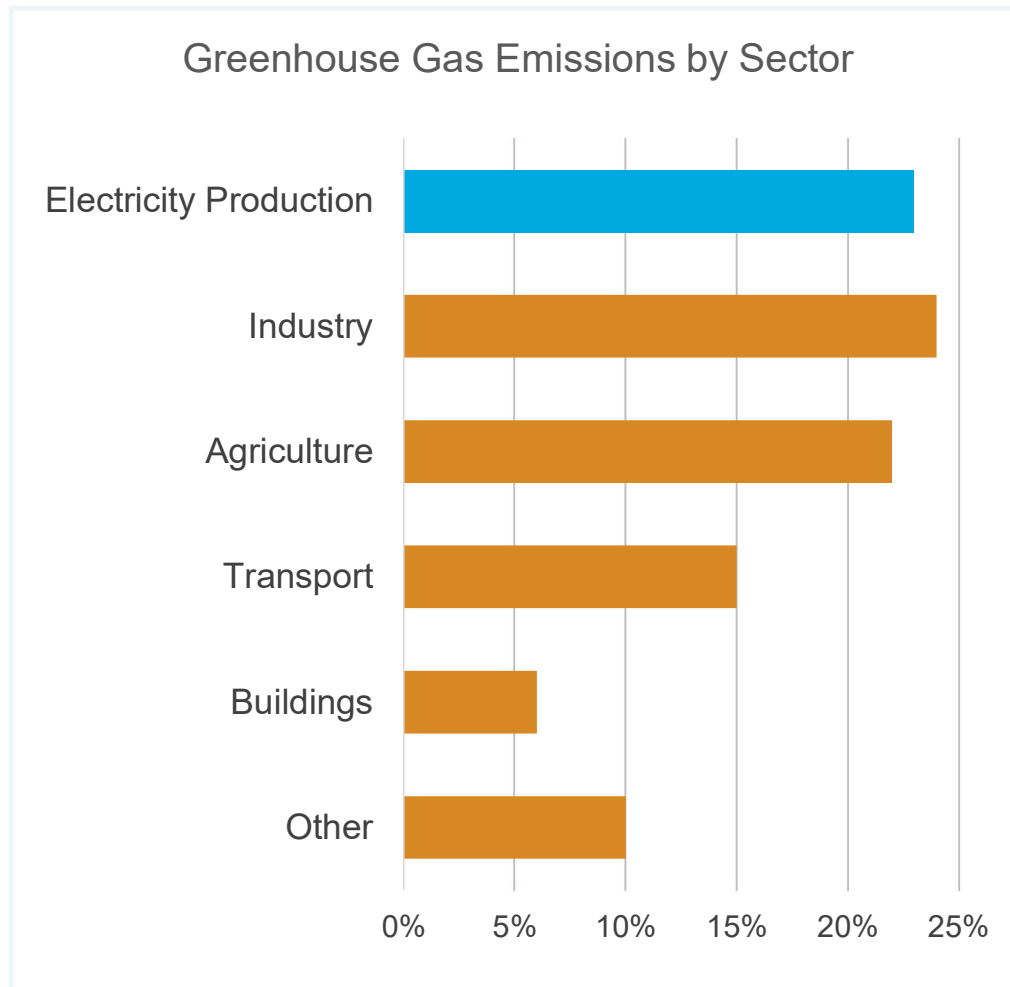
Paul Piechnick, RWTH Aachen University

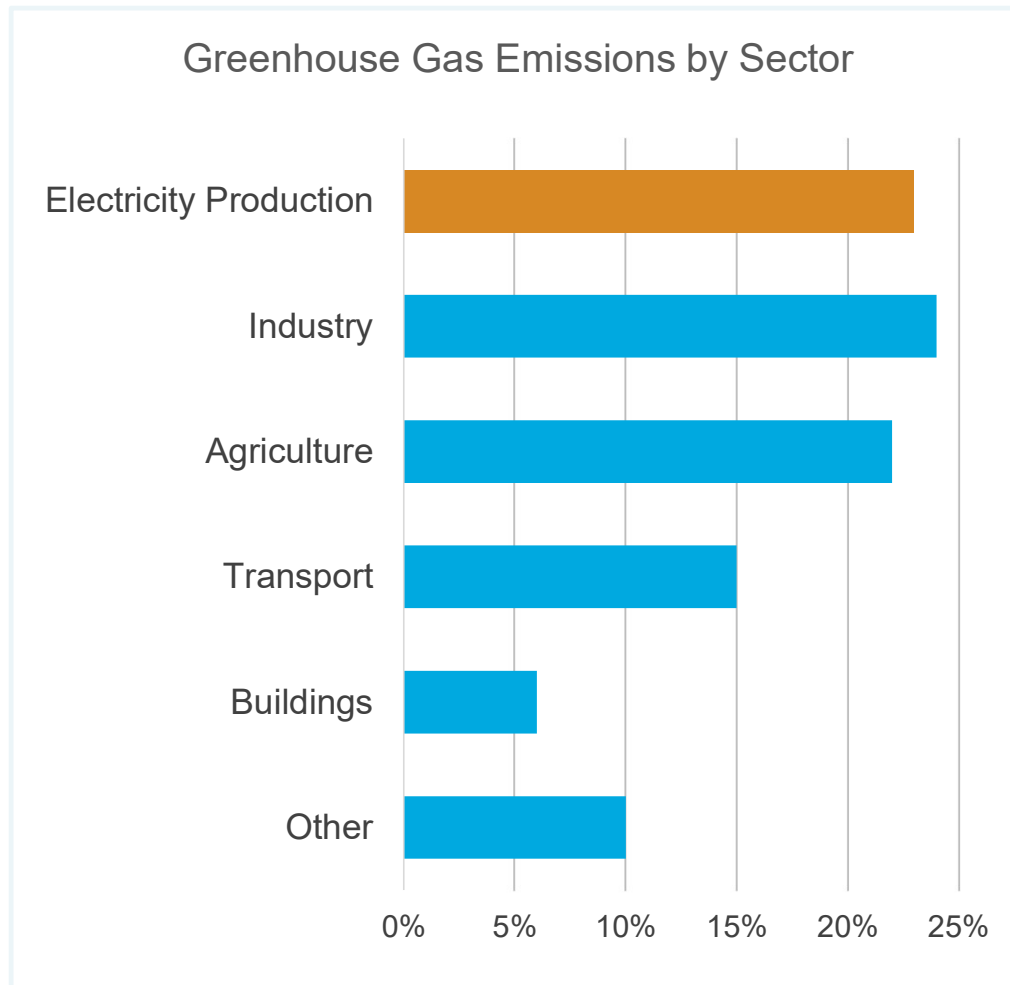


Andreas Klein, RWTH Aachen University



Jeffrey Stegink, W2E Wind to Energy GmbH









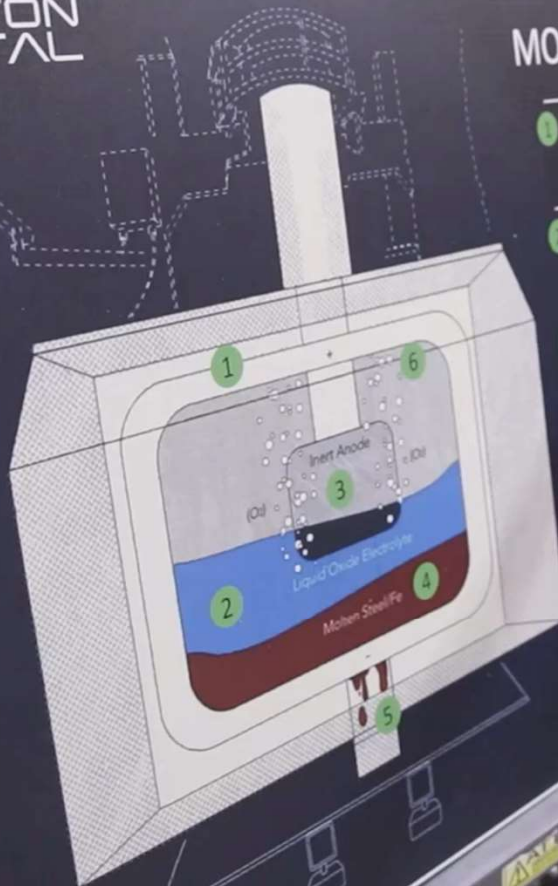


Transforming the Steel Industry



BOSTON
METAL

MOE Steel Production



- 1 Iron ore (iron oxide and trace elements) is fed into the cell and dissolves into a molten electrolyte.
- 2 The molten electrolyte is a tailored mixture of iron oxide and other more stable oxides.
- 3 Electricity passing through an inert metallic anode heats the cell interior to approximately 3000 °C / 2900 °F.
- 4 Electricity also reduces the iron oxide to form molten steel, which collects at the bottom of the cell.
- 5 Molten steel is removed from the cell and transported directly to slab metallurgy or casting.
- 6 Since no carbon is used in the process, oxygen from the splitting of iron oxide is the only emission.

Project Report System Engineering

1. Introduction

The purpose of this report is to provide a comprehensive overview of the system engineering process. It will cover the key phases of system engineering, from requirements gathering to system integration and testing. The report will also discuss the challenges and opportunities associated with system engineering in a complex, multi-disciplinary environment.

2. System Engineering Process

The system engineering process is a structured approach to the development of a system. It involves the identification of system requirements, the design of system architecture, the development of system components, and the integration and testing of the system. The process is iterative and collaborative, involving the participation of all stakeholders in the system development process.

3. System Requirements

System requirements are the foundation of any system. They define the functional and non-functional characteristics of the system. Requirements are typically gathered through a series of stakeholder interviews, workshops, and focus groups. The requirements are then documented in a system requirements specification (SRS), which serves as the primary reference for the system development process.

4. System Architecture

System architecture is the high-level design of the system. It defines the overall structure of the system, including the major components and their interactions. The architecture is typically represented by a block diagram or a similar graphical representation. The architecture is developed through a series of iterative design reviews and stakeholder consultations.

5. System Integration and Testing

System integration and testing are the final phases of the system engineering process. They involve the assembly of the system components and the verification of the system against the requirements. Integration testing is performed to ensure that the components work together as intended. System testing is performed to verify that the system meets the user requirements and is ready for deployment.



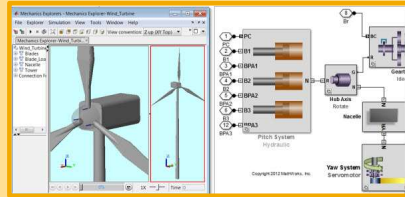
Transforming the Steel Industry

A screenshot of a MathWorks webpage. At the top is the MathWorks logo and a navigation menu with links for Products, Solutions, Academia, Support, Community, and Events. Below the navigation is a blue header with the text 'MATLAB and Simulink for Startups'. Underneath the header are two tabs: 'Overview' and 'EV Startups'. The main content area features a dark background image of people working at computers in an office. Overlaid on this image is the text 'Build Your Startup with MATLAB and Simulink' in large white font, followed by 'Develop products and reach early-stage milestones' in a smaller white font. At the bottom left of the image is a blue button with the text 'Apply now' in white.

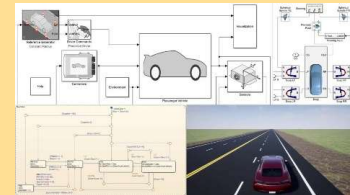


Design Solutions

Adjustable model with workflow tools to answer design questions

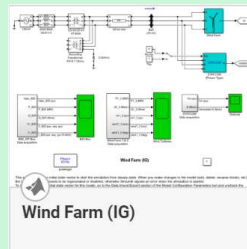


Simscape Battery R2022b

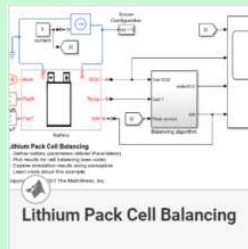


Reference Examples

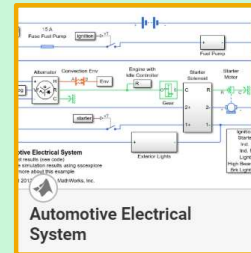
Full system model to illustrate possibilities



Wind Farm (IG)



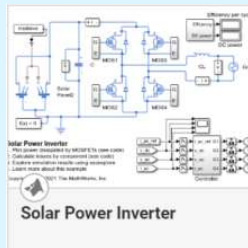
Lithium Pack Cell Balancing



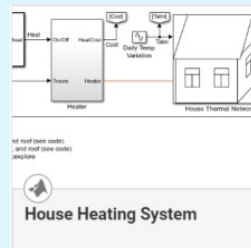
Automotive Electrical System

Component Examples

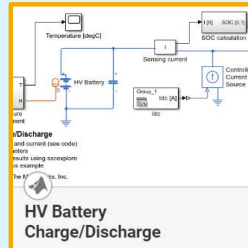
Demonstrate use of components in simulation



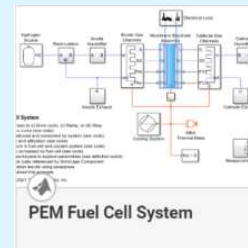
Solar Power Inverter



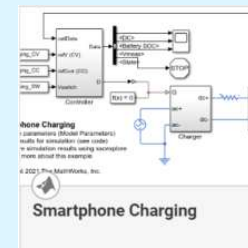
House Heating System



HV Battery Charge/Discharge



PEM Fuel Cell System

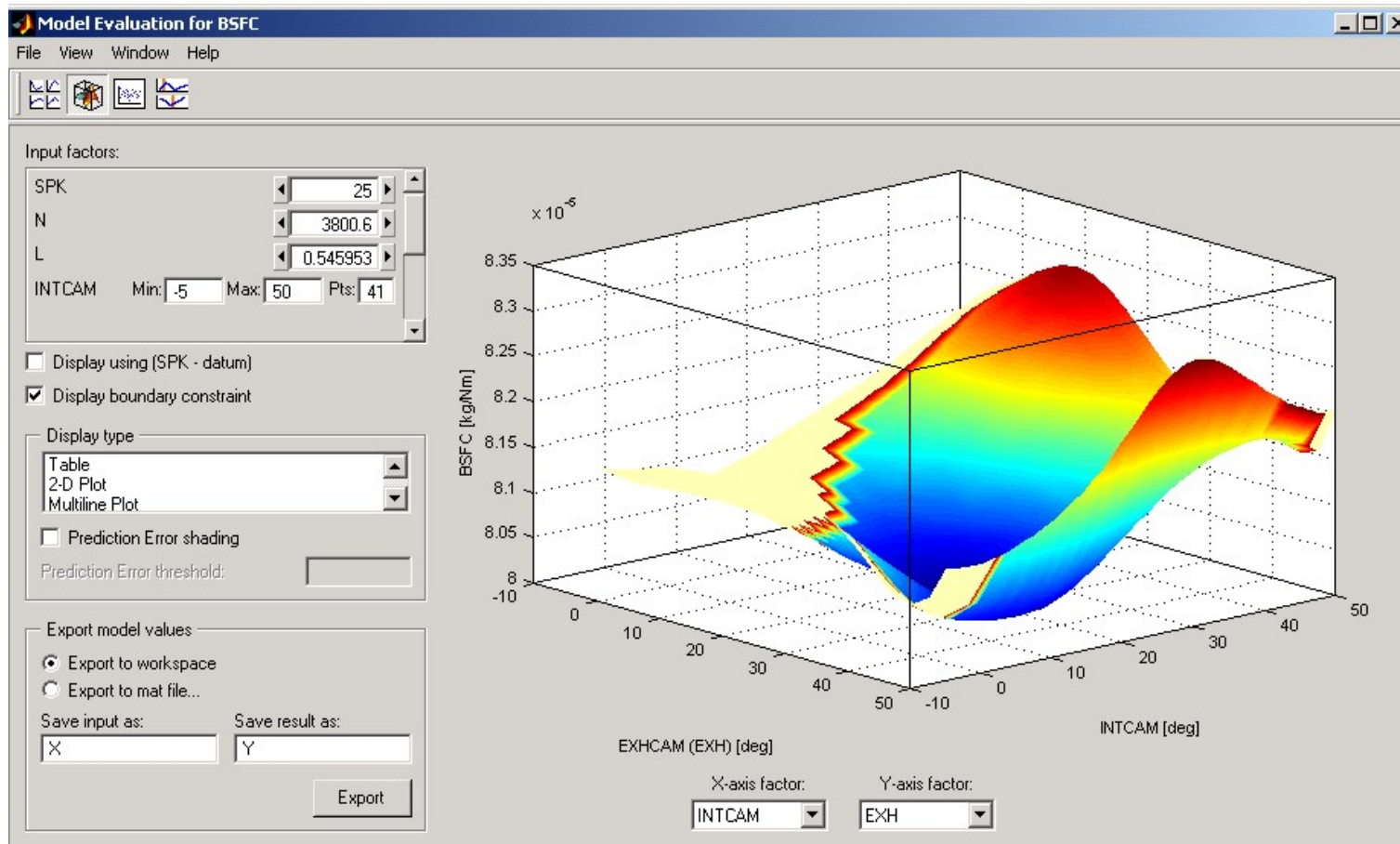


Smartphone Charging

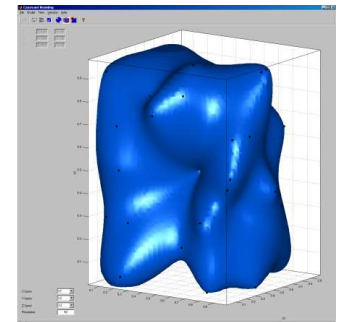
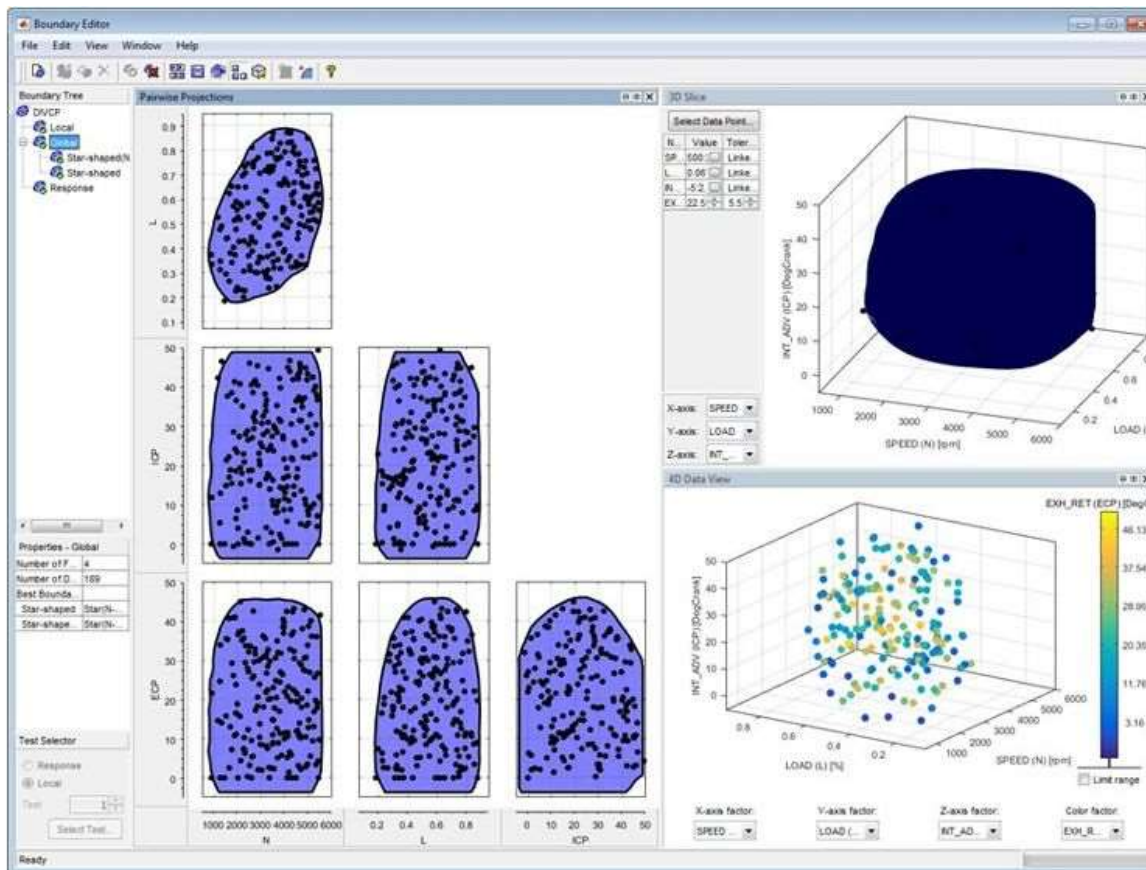




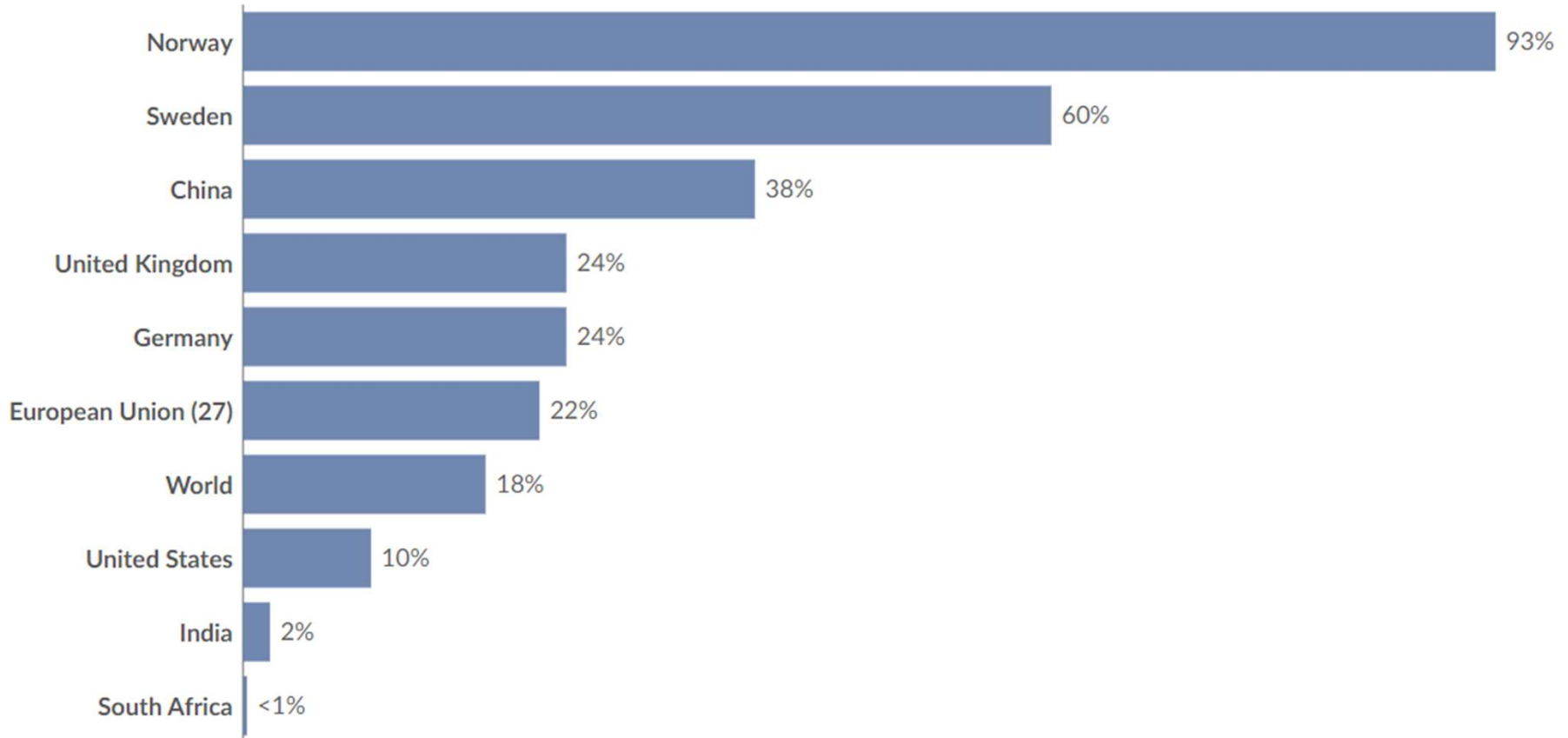
Application Example: Increasing fuel-efficiency of car engines with radial basis functions



Using Spherical Basis Functions to define and visualize the feasible testing region of engines



Share of new cars sold that are electric, 2023



Data source: International Energy Agency. Global EV Outlook 2024.
 OurWorldinData.org/energy | CC BY



Hands-On Workshop

FIND OUT MORE

WATT'S UP WITH ELECTRIC VEHICLES: MODELLING THE EV ECOSYSTEM



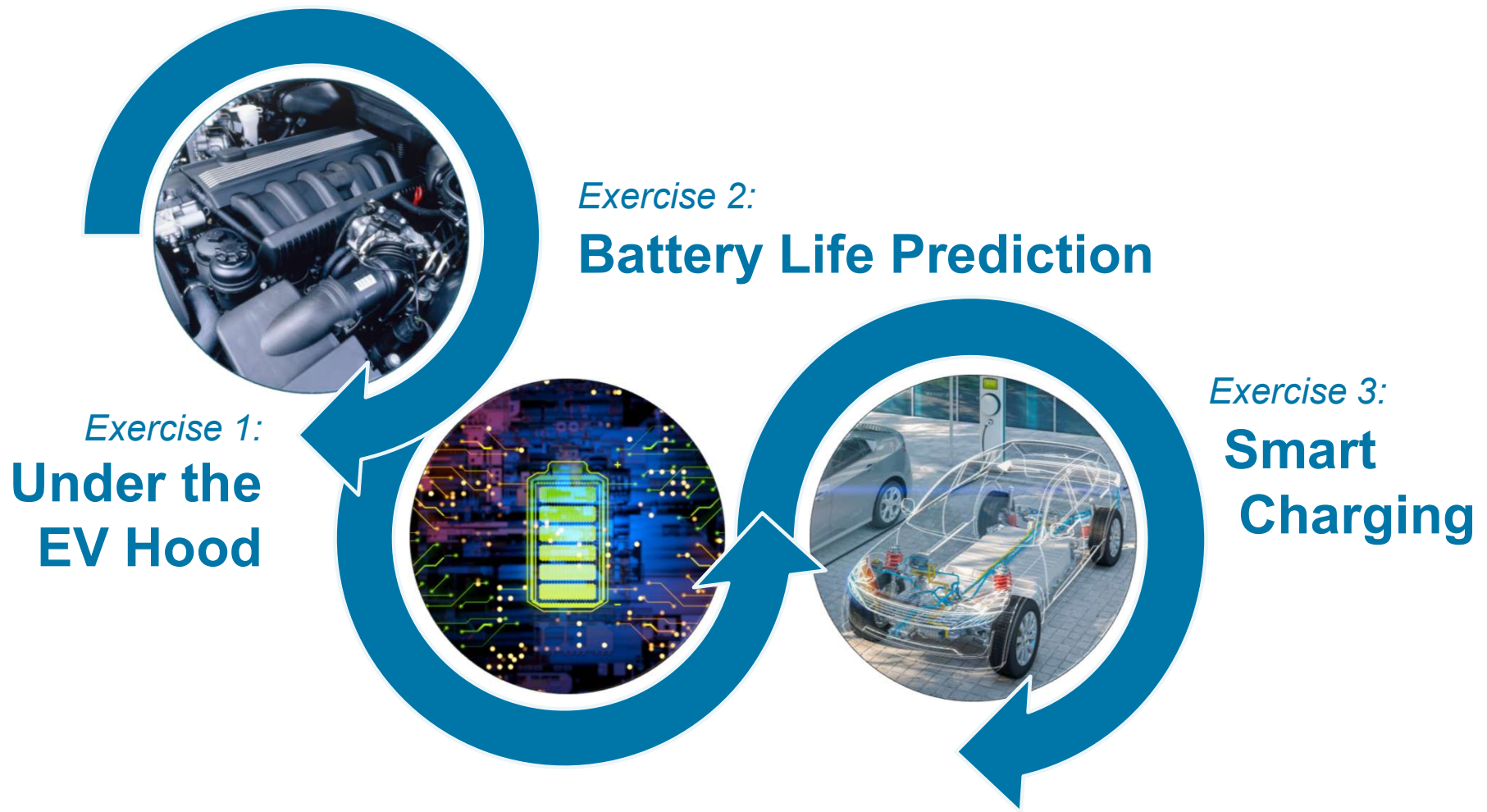
Eva Pelster, MathWorks



Nayara Aguiar, MathWorks



Tanya Morton, MathWorks





AI and Electrification

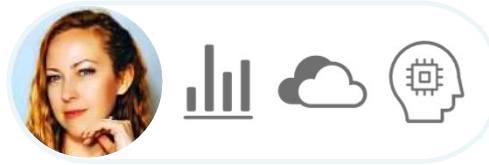
FIND OUT MORE
IMPLEMENTATION OF A
PROBABILISTIC POWER FLOW
SYSTEM



John Kreso III, Eversource Energy



Steffen Ziegler, Eversource Energy



Research

Accelerate Climate Science



Education

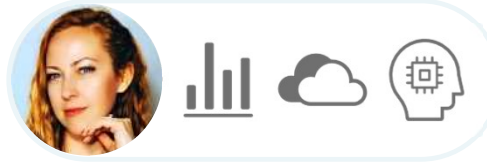
Train the Next Generation



Industry

Electrify Everything





Research

Accelerate Climate Science



Education

Train the Next Generation



Industry

Electrify Everything





BOSCH

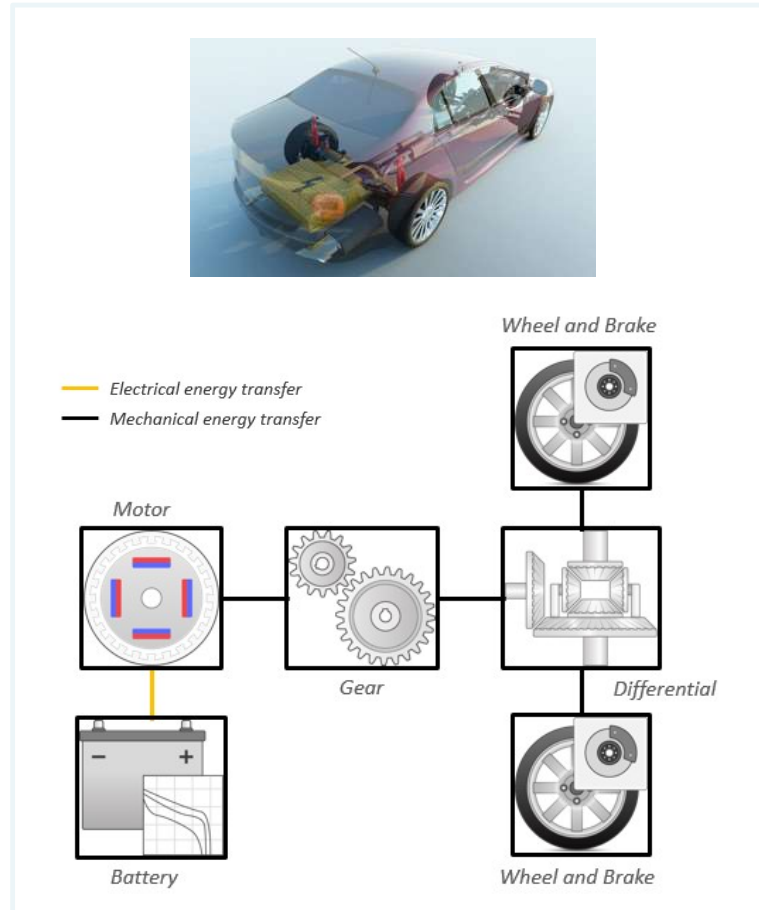


Curriculum Development





Electric Vehicle Fundamentals





“The EVSE course I took in my final year of BTech was a turning point in my understanding of the world of engineering.”



—Hari Bhaskar, Bosch Global Software Technologies and Graduate of NIT Calicut



Educators

Teach with MATLAB and Simulink | Curriculum Resources | Online Teaching | Campus-Wide License

Online

Whether you use virtual labs, or active learning ideas for providing student learning. Explore by course area:

MATLAB Courseware

Teach with MATLAB and Simulink | Curriculum Resources | Online Teaching | Campus-Wide License

MATLAB courseware consists of downloadable sets of curriculum resources based on MATLAB and Simulink. These materials enhance curriculum, facilitate lectures and classroom exams, and provide student learning. Explore by course area:

- | | |
|--|--------------------------------------|
| Introduction to Programming | Electrical and Computer Engineering |
| First-Year Engineering | Mathematics |
| Biology and Biomedical Engineering | Mechanical and Aerospace Engineering |
| Chemistry | Physics |
| Data Science | Psychology and Behavioral Science |
| Deep Learning | Quantitative Finance and Management |
| Earth, Ocean, and Atmospheric Sciences | Robotics and Mechatronics |
| Econometrics | |

MATLAB Courseware

```
molweight(species);
V = stoich(species);
V = disp_reaction(V,species);

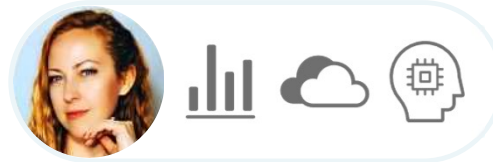
% Data Science Example
load('data.mat');
[edges,weights] = graphdist(primates);
% ...
plot(edges,weights);
```



Teaching Data Science with MATLAB

Data science is emerging as a field that is revolutionizing science and industries alike ... Undergraduate teaching, in particular, offers a critical link in offering more data science exposure to students and expanding the supply of data science talent.

— National Academies of Sciences, Engineering, and Medicine, 2018



Research

Accelerate Climate Science



Education

Train the Next Generation



Industry

Electrify Everything





Student Research



MATLAB and Simulink
Challenge Projects





[README](#)
[License](#)
[Security](#)



MATLAB and Simulink Challenge Projects

Contribute to the progress of engineering and science by solving key industry challenges!

Are you looking for a design or research project idea with real industry relevance and societal impact?

Explore this list of challenge projects to learn about technology trends, gain practical skills with MATLAB and Simulink, and make a contribution to science and engineering. Even more, you gain official recognition for your problem-solving skills from technology leaders at MathWorks and rewards upon project completion!



If you are new to MATLAB and Simulink [for students](#)

How to participate

Make the results of your work open and research leads. Let us know your intent to accessible from the project's description recognition awards.

For more information about the program

If you are industry or faculty and interest project, contact us [here](#).

Announcements

Sustainability and Renewable Energy Challenge 2024* 🏆

More details [here](#)



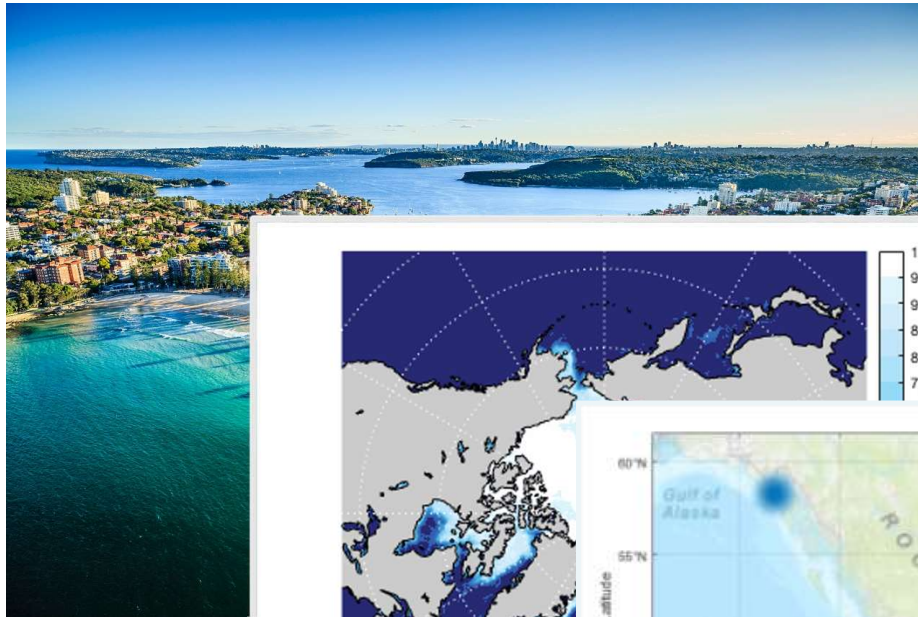
Sustainability and Renewable Energy Challenge



We are excited to announce the second edition of the MathWorks Sustainability and Renewable Energy Challenge! You're invited to submit innovative solutions to environmental challenges related to sustainability and renewable energy. Select a project from our list and submit a solution to be eligible to win up to \$1,000 (USD). Showcase your creativity and contribute to a more sustainable future.

[View the 2023 winners](#)

[Contact us with questions](#)



Copernicus

60°N
55°N
50°N
45°N

Gulf of Alaska

ROCKY MOUNT

140°W 130°W 120°W 110°W

Longitude

Latitude

500 mi
200 mi

Exp. HERE, Garmin, FAO, NOAA, EPA, AMF, NRCan

Create Maps Using Latitude and Longitude Data

A detailed map of the Gulf of Alaska and the Rocky Mountains region. The map shows a color gradient from light blue to dark blue, indicating a data distribution. A scale bar shows 500 miles and 200 miles. The map includes latitude and longitude coordinates. A navigation arrow icon is located at the bottom left of the map area.



Landslide Susceptibility Mapping using Machine Learning



Plenary

FIND OUT MORE

THE EMPATHETIC ENGINEERS OF
TOMORROW

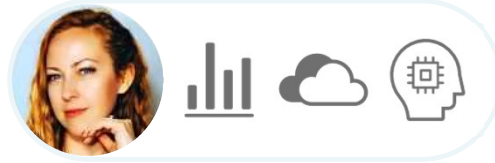


Dr. Darryll Pines, University of Maryland



MATLAB and Simulink Challenge Projects





Research

Accelerate Climate Science



Education

Train the Next Generation



Industry

Electrify Everything



Two-Hour Onramp Tutorials

Massive Open Online Courses



**Machine Learning
with MATLAB**

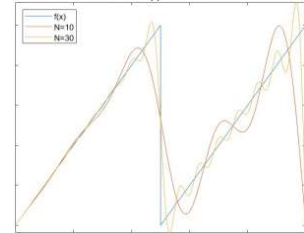
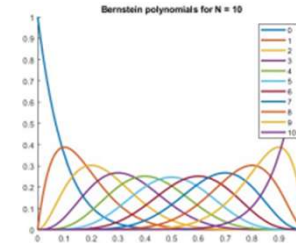
**Deep Learning with
MATLAB**

And more...

Approximation Techniques with MATLAB

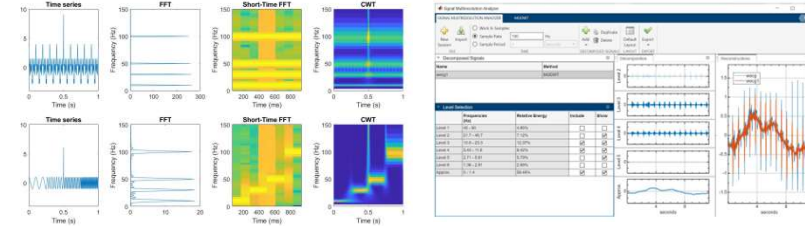
Function approximation

- Uniform approximation (Bernstein, Bezier)
- L^2 -approximation with orthogonal polynomials (Jacobi, Fourier)



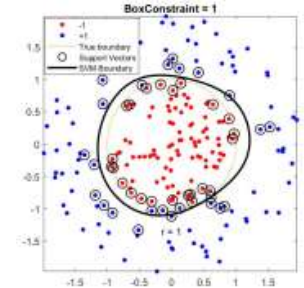
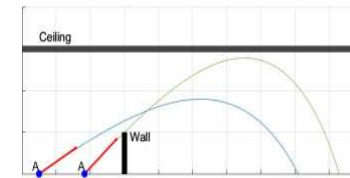
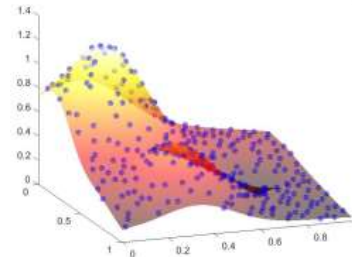
Wavelets Analysis in $L^2(\mathbb{R})$

- Wavelet Transform
- Multiresolution Analysis



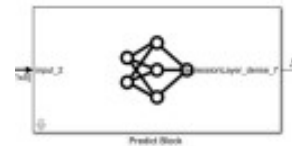
Radial Basis Functions

- Scattered data interpolation
- Surrogate Global Optimization
- Kernelized Support Vector Machines

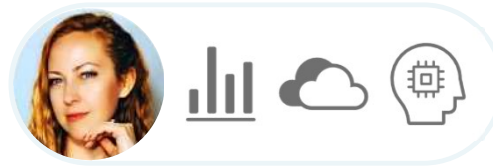


Neural Networks

- Universal approximators
- Approximation of an Extended Kalman Filter.



[Approximation Techniques with MATLAB® | Dolomites Research Notes on Approximation](#), Paolo Panarese, MathWorks



Accelerate Your Research



Train the Next Generation



Electrify Everything



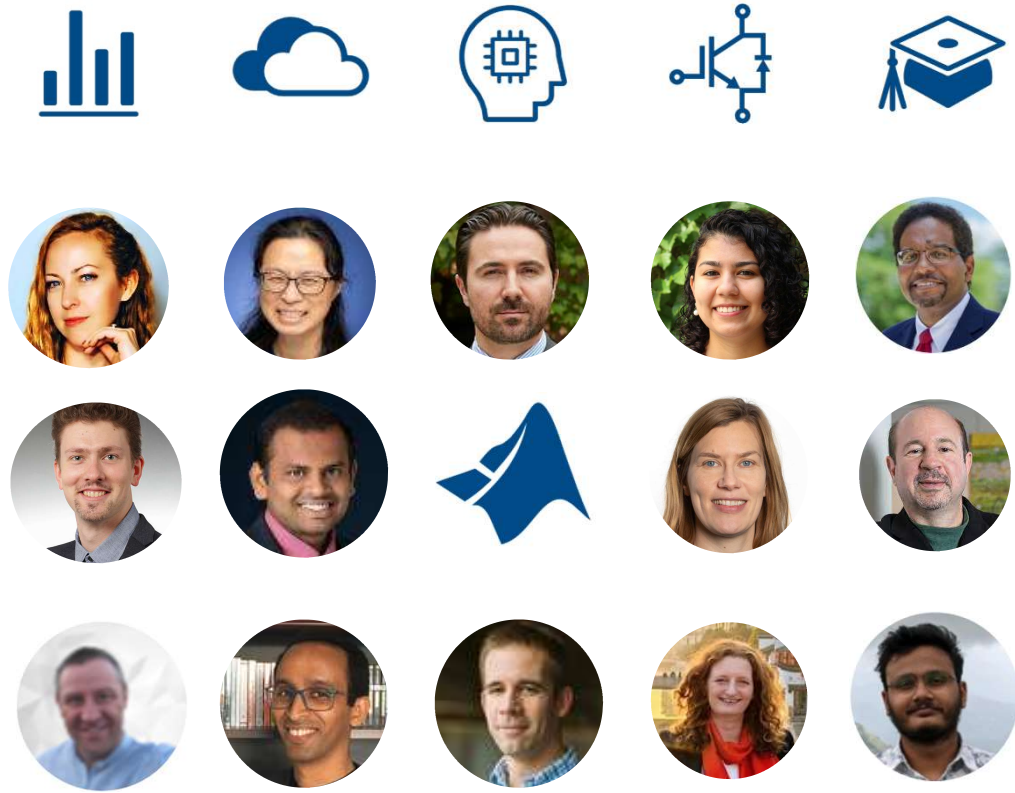
MATLAB EXPO

November 13–14, 2024 | Online

Register

The event is free, but registration is required.

<https://www.matlabexpo.com/online/>



Questions?