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Research Interests and Short Bio

My current research focus at PNNL falls in the intersection of deep learning, optimization, and model-based optimal control with applications in various domains of cyber-physical systems, energy sector in particular. Before joining PNNL, I was a postdoc at KU Leuven, Belgium, working on the cloud-based implementation of model predictive control (MPC) in a real-world office building. I have a PhD in Control Engineering from Slovak University of Technology in Bratislava, Slovakia. My PhD thesis was on *Model Predictive Control with Applications in Building Thermal Comfort Control* with the focus on learning-based approaches towards solution of MPC. My MSc thesis was on the *Efficient Modeling of Hybrid Systems*, finalized during my research visit at Linköping University, Sweden.

Professional Experience

Pacific Northwest National Laboratory

Data Scientist

Physics and Computational Sciences Directorate

Topic: Domain-aware Deep Learning

Team Lead: Malachi Schram

Supervisor: Draguna Vrabie

Richland, WA, USA

April 2020 – Present

Pacific Northwest National Laboratory

Postdoctoral Researcher

Optimization and Control Group

Energy and Environment Directorate

<https://eib.pnnl.gov/optimizationcontrol/default.asp>

Topic: Physics-informed Deep Learning for Modeling and Control

Supervisor: Draguna Vrabie

Richland, WA, USA

July 2019 – April 2020

KU Leuven

Postdoctoral Researcher

Thermal Systems Simulation Group

Department of Mechanical Engineering

https://www.mech.kuleuven.be/en/tme/research/thermal_systems

Topic: Cloud-based Implementation of MPC in a Real-world Office Building

Supervisor: Lieve Helsen

Leuven, Belgium

September 2017 – April 2019

Education

Slovak University of Technology in Bratislava

PhD

Institute of Information Engineering, Automation, and Mathematics

Thesis: Model Predictive Control with Applications in Building Thermal Comfort Control

Supervisor: Michal Kvasnica

<https://www.uiam.sk/index.php>

Bratislava, Slovakia

2012 – 2017

KU Leuven

Visiting PhD student

Thermal Systems Simulation Group

Department of Mechanical Engineering

Topic: Approximate Model Predictive Control via Machine Learning

Supervisor: Lieve Helsen

Leuven, Belgium

2016 – 2017

Linköping University

Visiting MSc student

Automatic Control

Department of Electrical Engineering (ISY)

Supervisor: Johan Löfberg

Linköping, Sweden

Spring 2012

Slovak University of Technology in Bratislava

MSc

Institute of Information Engineering, Automation, and Mathematics

Thesis: Efficient Modeling of Hybrid Systems

Supervisor: Michal Kvasnica

Bratislava, Slovakia

2007 – 2012

Theoretical Background

- **Machine Learning:** physics-informed ML, deep learning, classification and regression trees, SVM, dimensionality reduction, clustering
- **Systems Modeling:** differential equations, linear, nonlinear, hybrid systems, data-driven
- **Control Design:** model predictive control (MPC), stochastic control, learning-based control
- **Parameter Estimation:** moving horizon estimation (MHE), Kalman filtering (KF)
- **Optimisation:** linear (LP), quadratic (QP), mixed-integer (MIP), nonlinear programming (NLP)

Technical Skills

- **Languages:** Python, Matlab, Modelica, \LaTeX
- **Data Science Tools:** PyTorch, TensorFlow, NumPy, Pandas, SciPy, Matplotlib, Scikit-learn, Matlab Statistics and Machine Learning Toolbox
- **Control Tools:** Matlab toolboxes (Simulink, Stateflow, System Identification, MPT3, MPC, Control Systems, Fuzzy Logic), CasADi, HYSDEL
- **Optimisation Tools:** Solvers (Gurobi, CPLEX, etc.), YALMIP, CVXPY
- **Version Control and Code Management:** Git, Mercurial, Google Colab, Jupyter notebooks
- **Industrial Control:** Building management systems (BMS), communication protocols (Modbus, BACnet), industrial control systems and PLCs (Siemens Simatic, Foxboro, B&R)

Certificates

Practical Deep Learning with PyTorch

- Institution: Udemy
- Credential-ID: UC-9dec7d20-3602-45e2-8a13-8a7e5d48939a

PyTorch for Deep Learning and Computer Vision

- Institution: Udemy
- Credential-ID: UC-8CJQVJQ3

Reinforcement Learning with PyTorch

- Institution: Udemy
- Credential-ID: UC-SUYYUJO9

PyTorch for Deep Learning with Python Bootcamp

- Institution: Udemy
- Credential-ID: UC-QCB1ITNG

Complete Python Bootcamp: Go from zero to hero in Python 3

- Institution: Udemy
- Credential-ID: UC-2XD8WD5E

Deep Learning Prerequisites: The Numpy Stack in Python

- Institution: Udemy
- Credential-ID: UC-IXKWH5A6

Introduction to TensorFlow for Artificial Intelligence, Machine Learning, and Deep Learning

- Institution: Coursera
- Credential-ID: LNS44XXKD24N

Mini-course on optimal control with CasADi

- Institution: Yacoda
- Credential-URL: <https://web.casadi.org/leuven2018/>

Data Analysis with Python

- Institution: KU Leuven
- Credential-URL: <https://www.flames-statistics.com/courses-seminars/data-analysis-with-python/>

The Supervisor as a Manager

- Institution: KU Leuven
- Credential-ID: u0107194


Machine Learning

- Institution: Coursera
- Credential-ID: KPJ3KJPFNR4U

TEMPO Spring School on Theory and Numerics for Nonlinear Model Predictive Control

- Institution: IMTEK, University of Freiburg
- Credential-URL: <https://www.imtek.de/professuren/systemtheorie/events/tempospringschool/>

Publications

- **Journal Papers:** 6
- **Conference Papers:** 18
- **Citations:** 207
- **Full list:**  <https://scholar.google.com/citations?user=A-EA2KsAAAAJ>

Media Appearance

- **PNNL web:** Deep Learning Cuts Costs in Building Control
🔗 <https://www.pnnl.gov/news-media/deep-learning-cuts-costs-building-control>
- **PNNL web:** New Method for Automated Control Leverages Advances in AI
🔗 <https://www.pnnl.gov/news-media/new-method-automated-control-leverages-advances-ai>

Reviewer

- **Journals:** Control Engineering Practice, IEEE Transactions on Industrial Informatics, Energy and Buildings, Applied Energy, Energies, Applied Sciences, Indoor Air, Journal of Control Automation and Electrical Systems (JCAE)
- **Conferences:** International Conference on Learning Representations (ICLR), Conference on Decision and Control (CDC), American Control Conference (ACC), European Control Conference (ECC), IFAC World Congress, IEEE Conference on Control Technology and Applications (CCTA), International Conference on Process Control (PC), International Conference on Control and Fault-Tolerant Systems (SYSTOL), International Conference on Control, Decision and Information Technologies (CoDIT)

Open-Source Code Development

- **Neural ODE:** Pytorch implementation of constrained neural ODE for ICLR 2020 paper.
https://github.com/pnnl/neural_ODE_ICLR2020
- **DEPS:** Pytorch implementation of constrained differentiable control for unknown linear systems.
https://github.com/pnnl/deps_arXiv2020
- **BeSim Toolbox:** Matlab toolbox for fast development, simulation, and deployment of advanced building climate controllers.
<https://github.com/drgona/BeSim>
- **Observers for Buildings:** Matlab simulation framework for evaluation and comparison of state observers for buildings. Code for Building Simulation Conference 2019.
https://bitbucket.org/Drgona/observers_for_buildings/src/master/ https://bitbucket.org/Drgona/cdc13_stochastic_mpc/src/default/
- **Real-time MPC Laboratory Distillation Column:** Code for International Conference on Process Control 2015.
https://bitbucket.org/Drgona/distillation_column_rt_mpc/src/default/
- **Reference Governor MPC :** Code for Conference on Decision and Control 2015.
https://bitbucket.org/Drgona/cdc15_ref_gov/src/default/
- **Explicit Stochastic MPC :** Code for Conference on Decision and Control 2013.
https://bitbucket.org/Drgona/cdc13_stochastic_mpc/src/default/
- **Control Examples:** Matlab tutorial on MPC, LQR, LQI, PID, RBC, on-off.
https://bitbucket.org/Drgona/matlab_control_examples/src/master/

Awards and Funding

MARS initiative: Deep Learning Control with Embedded Physical Structure

2020

- Funded amount: 100k \$
- Funding agency: PNNL LDRD
- Role: core team member, part of the project proposal writing

Moonshot: Control algorithms for flexibility in power-to-X and industrial processes

2019-2021

- Funded amount: 1.5M €
- Funding agency: Agency for Innovation and Entrepreneurship (VLAIO), Belgium
- Role: core team member, part of the project proposal writing
- Rector's Award (Summa cum laude)** 2017
- PhD in Control Engineering, Slovak University of Technology in Bratislava, Slovakia
- The National Scholarship Programme of the Slovak Republic** 2017
- Visiting PhD Student at KU Leuven, Belgium
- European Union's Erasmus Mundus Scholarship** 2016
- Visiting PhD Student at KU Leuven, Belgium
- European Union's Erasmus Mundus Scholarship** 2012
- Visiting MSc Student at Linköping University, Sweden

Projects

- Mathematics for Artificial Reasoning in Science (MARS) Initiative** 2019 - 2020
 - Description: development of Deep Learning Control with Embedded Physical Structure
 - Funding agency: PNNL LDRD
 - Role: code development, project proposal writing
 - Project website: <https://www.pnnl.gov/projects/mars>
- IBPSA Project 1** 2017 - 2022
 - Description: BIM/GIS and Modelica Framework for building and community energy system design and operation
 - Funding agency: U.S. DOE
 - Role: documentation and assessment of advanced optimal control strategies
 - Project website: <https://ibpsa.github.io/project1/schedule.html>
- Adaptive Control** 2019 - 2020
 - Description: Developing technology to help ensure that building systems automatically adapt and operate in an optimal manner
 - Funding agency: U.S. DOE
 - Role: development of deep-learning based optimal control methods
 - Project website: <https://www.energy.gov/eere/buildings/downloads/adaptive-control>
- Geothermal Technology for Economic Cooling and Heating** 2017 - 2019
 - Description: The optimisation of geothermal system operation
 - Funding agency: European Union, Horizon 2020 initiative
 - Role: development and real-time deployment of cloud-based optimal control strategy
 - Project website: <https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/geothermal/geotech>
- Robust Model Predictive Control Meets Robotics** 2016 - 2017
 - Description: Robust MPC design for uncertain dynamic systems
 - Funding agency: The Slovak Research and Development Agency
 - Role: development of MPC methods
 - Project website: https://www.uiam.sk/index.php?show_id=5&r_p_id=50
- Verifiably Safe Optimal Control** 2015 - 2017
 - Description: Design of optimal control methods with safety guarantees and economical operation
 - Funding agency: VEGA Scientific Grant Agency of the Slovak Republic
 - Role: development of learning-based optimal control methods
 - Project website: https://www.uiam.sk/index.php?show_id=5&r_p_id=47
- Complexity, Sensitivity and Robustness in Explicit Model Predictive Control** 2014 - 2015

- Description: Model predictive control with a specific emphasis on explicit solutions
- Funding agency: The Slovak Research and Development Agency
- Role: development of explicit MPC methods
- Project website: https://www.uiam.sk/index.php?show_id=5&r_p_id=45

Model Predictive Control on Platforms with Limited Computational Resources *2012 - 2014*

- Description: Real-time implementation of MPC using HW platforms with limited CPU power
- Funding agency: VEGA Scientific Grant Agency of the Slovak Republic
- Role: development of explicit MPC methods
- Project website: https://www.uiam.sk/index.php?show_id=5&r_p_id=32