

# SAKET ADHAU

## Machine Learning and Optimization

✉ Department of Chemical Engineering (IKP),  
NTNU, Trondheim, Norway

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## RESEARCH INTERESTS

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1. Machine learning for MPC
2. Nonlinear model predictive control
3. Embedded systems
4. Optimization

## EDUCATION

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### Researcher

*Sep'19–Ongoing*

- Norwegian University of Science and Technology (NTNU), Norway
  - Part of the project “*Intelligent use of data to build optimization tools for cyber-physical systems in the process industry*” funded by the Research Council of Norway.
  - By leveraging big data and machine-learning algorithms, task is to utilize process data to develop machine-learning based models (also known as digital-twins), that can be used for developing optimization tools. This will enable to address the challenges with respect to developing models for optimization.

### Master of Technology, Instrumentation and Control

*Aug'17–June'19*

- College of Engineering Pune, India
  - Thesis Title: *Learning Based Model Predictive Control*
  - Supervisor: Prof. Dayaram Sonawane
  - CGPA: 8.16

### Bachelor of Engineering, Instrumentation and Control

*Aug'13–June'17*

- University of Pune, India
  - Project Title: *System Identification and PID Control of PMDC Motor using MATLAB and LabVIEW*
  - Supervisor: Dr. Milind Bongulwar
  - Mention: First Class with Distinction | Percentage: 69.67

## WORK EXPERIENCE

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### Trainee Engineer

*June'19–August'19*

- Aker Solution, Pune, India.
  - Post Graduate Trainee Engineer in the Application Engineering department.
  - Developed automated method for testing of the subsea module used in offshore oil fields.

## PUBLICATIONS

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### Articles in international conferences

#### 2021

- **Adhau S.**, Naik Vihang, and Skogestad S., “Constrained Neural Networks for Approximate Nonlinear Model Predictive Control”, *submitted to 60<sup>th</sup> IEEE conference on Decision and Control (CDC)*.
- Mohanty N. R., **Adhau S.**, Ingole D., and Sonawane D., “Hardware Implementation of Low-complexity Deep Learning-based Model Predictive Controller”, *accepted for presentation and publication in the proceedings of the 2021 European Control Conference (ECC)*.

#### 2019

- **Adhau S.**, Patil S., Ingole D., Sonawane D., “Embedded Implementation of Deep Learning-Based Linear Model Predictive Control”, *in Proceedings of 6<sup>th</sup> Indian Control Conference*, IEEE, Hyderabad, India, 2019.
- **Adhau S.**, Patil S., Ingole D., and Sonawane D., “Implementation and Analysis of Nonlinear Model Predictive Controller on Embedded Systems for Real-Time Applications”, *in Proceedings of the 17<sup>th</sup> European Control Conference (ECC’19)*, IFAC and IEEE, Naples, Italy, 2019.

#### 2018

- **Adhau S.**, Phalke K., Nalawade A., Ingole D., Patil S., Sonawane D., “Implementation and Analysis of Offset-Free Explicit Model Predictive Controller on FPGA”, *in Proceedings of 5<sup>th</sup> Indian Control Conference*, IEEE, Delhi, India, 2018.

## THEORETICAL BACKGROUND

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- **Machine Learning:** physics-informed ML, deep learning, classification and regression trees, clustering
- **Systems Modeling:** differential equations, linear, nonlinear, hybrid systems, data-driven
- **Control Design:** model predictive control (MPC), learning-based control
- **Optimisation:** linear (LP), quadratic (QP), nonlinear programming (NLP)

## INTERNSHIP EXPERIENCE

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**Bosch Chassis Systems India Pvt. Limited, Chakan, Pune.**

**June’15 - July’15**

- Worked with the TeF department towards maintenance and predictive safety standards.
- Carried out analysis of Mean Time To Repair (MTTR) and Mean Time Between Repair (MTBR) on the assembly lines (NOAH, Line 51, TMC line).

## POSITIONS OF RESPONSIBILITY

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- **Co-supervisor for master's theses student at the Department of Chemical Engineering, NTNU.** *Autumn 2020*
- **Coordinator for 3<sup>rd</sup> Winter School.** *Dec'18*
  - Served as convener and co-ordinator of **3<sup>rd</sup> Winter School on Optimization and Optimal Control – A Data-based Approach** at Embedded Systems Lab, COEP.
- **Teaching Assistant.** *July'18–Dec'18*
  - Served as TA for **Microcontroller Techniques and Its Applications** and **Embedded System Design** which was a special course.

## AWARDS AND FUNDING

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- Project accepted for oral presentation in **MATLAB Expo'19.** *May'19*
- Student support program for Indian Control Conference – IIT Delhi. *Jan'19*
- Xilinx University Program for researchers – Pynq development board and software. *Sep'18*

## TECHNICAL SKILLS

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- **Programming languages:** Python, MATLAB, C, L<sup>A</sup>T<sub>E</sub>X.
- **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), CasADi.
- **Development:** Atmel Studio, Vivado, MPLAB X, HDL coder, LabView, Arduino IDE, Linux.
- **Toolboxes:** Protoip, MPT toolbox, ACADO Toolkit, CasADi, FORCES, GRAMPC.
- **Version Control and Code Management:** GitHub, GitLab, Google Colab, Jupyter notebooks.

## PROJECTS

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- **Deep Neural Networks based Linear MPC**
  - Trained highly nonlinear and linear models using neural networks, to mimic the original model.
  - Neural networks were trained to behave as Linear model predictive controller to reduce the online optimization and guarantee safety.
  - The designed neural network was also implemented on ARM Cortex-M3 to prove the usability in embedded devices.
- **Implementation of nonlinear MPC on ARM Cortex-M3 and FPGA**
  - Successfully implemented nonlinear MPC on for the first time ARM Cortex-M3 and FPGA using GRAMPC and ACADO toolkit

- The performance of NMPC controller was rigorously tested using HIL simulations in MATLAB
- Designed framework for easy implementation of NMPC on micro-controllers and FPGA.
- **Linear and explicit MPC on ARM Cortex-M3 and FPGA**
  - Implemented Interior Point Method, Active Set Method and KWIK Algorithm for linear MPC on Arm Cortex-M3
  - Validated the designed MPC on DC motor using HIL simulation for real-time using Simulink coder.
  - Implemented Explicit MPC using MPT toolbox, Hybrid toolbox and MATLAB based toolbox on micro-controllers and validated the same on actual plant
  - The same framework was also validated and detailed analysis were carried out on FPGA Zedboard.
- **Auto-tuning of PID controller using optimization method**
  - Evaluated optimization algorithm SQP for auto-tuning of PID controller
  - Verified values of  $K_p$ ,  $K_i$  and  $K_d$  parameters using run-time optimization in MATLAB/Simulink.
- **Parameter Estimation and Position control of PMDC motor**
  - Validated PMDC motor model using parameter estimation
  - Implemented SQP algorithm in MATLAB for parameter estimation
  - Implemented and tested PID controller for position and speed control on ARM Cortex-M3 micro-controller
- **System Identification and PID Control**
  - System identification for an unknown DC motor was done using System Identification toolbox of MATLAB
  - Verified the system by passing through various linear and non-linear signals for accurate system model
  - PID tuning using Zeigler Nicholas and Cohen-Coon methods for speed control of the DC motor using identified state-space model
  - Implemented PID controller on 8-bit micro-controller using plain C code, MATLAB based embedded coder and in LabVIEW using toolbox for VISA protocol.

## CERTIFICATES

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- Hands-on CasADi course on Optimal Control, Hasselt, Belgium [\[Link\]](#) *Nov'19*
- Winter School on Optimization and Optimal Control - A Data-based Approach. *Dec'18*

## PERSONAL DETAILS

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- Citizenship: Indian
- Current Residence: Trondheim, Norway
- Languages: English - Fluent, Norwegian - Level 1
- Date of Birth: 29 May 1995