Muhammad Zakwan

Ph.D. in Machine Learning and Control

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Competences and Interests

— In-depth knowledge at the interplay of machine learning, system identification, and control theory with application to electromechanical systems
— Physics-consistent time-series forecasting of energy systems
— Hands-on experience with data-driven control, robust and LPV control, distributed, hybrid systems, and time delays
— Analytical mindset, Team player, Problem-solving

Education

2021 - Present **Ph.D. in Robotics, Control, and Intelligent Systems, Ecole Polytechnique Fédérale de Lausanne (EPFL)**, *Lausanne, Switzerland*
Thesis - Interplay of Machine Learning and Control from the lens of Dissipativity and Contraction

2017 - 2019 **M.S. in Electrical and Electronics Engineering (Systems and Control Theory), Bilkent University**, *Ankara, Turkey*
Thesis - Stability analysis of switched dynamical systems
GPA - 3.71/4.00

2010 - 2014 **B.S. in Electrical and Electronics Engineering, Pakistan Institute of Engineering and Applied Sciences**, *Islamabad, Pakistan*
Thesis - System Identification and Control of Magnetic Levitation Systems
GPA - 3.91/4.00 (2^{nd} position with distinction)

Experience

2019 – 2021 **Manager, Centre for Excellence in Sciences and Applied Technology (CESAT)**, Islamabad, Pakistan
Responsibilities - Supervising and managing undergraduate and graduate projects across universities under time and budget constraints.
Contributions
— Modelling and robust controllers design for LPV systems using MATLAB
— System identification and robust control of ECP models
— Discretization methods for LPV systems

2014 – 2017 **Assistant Manager, CESAT**, Islamabad, Pakistan
Responsibilities - Assisting manager in supervising projects in universities.
Contributions
— System identification of ECP models using MATLAB
— Discretization and implementation of LPV controllers in real-world applications

Projects

Ph.D. - Enhancing the robustness of deep neural networks (DNNs) against adversarial attacks using system theory with provable non-exploding gradients during training.

- Non-linear optimal control using NNs with stability guarantees and safety certificates with applications to robots, electromechanical systems, and Kuramoto oscillators.

- Physics-consistent time-series forecasting of the temperature of a real building by improving up to 40% over 72 hr prediction horizon compared to standard methods while compliant with the laws of thermodynamics by design.

- SIMBa - System Identification Methods leveraging Backpropagation that leverages Machine Learning tools to solve complex system identification problems while maintaining stability and introducing prior system knowledge, improving up to 25% compared to standard system identification methods.

Masters - Derived novel geometric conditions for stability analysis of hybrid dynamical systems using graph theory.

-Visual object recognition via multi-voxel pattern analysis to identify what a person was seeing based on functional MRI data.

GoogleScholar All the projects yielded over 15 peer-reviewed publications in conferences and journals.

Additional Experience

2021 – Present **Teaching Assistant, EPFL**, *Lausanne, Switzerland*
Courses - i) Control systems, ii) Networked control systems

2021 – Present **Graduate and undergraduate projects supervision, EPFL**, *Lausanne, Switzerland*
Supervised over 10 graduate and 3 undergraduate projects.

2017 – 2019 **Teaching Assistant, Bilkent University**, *Ankara, Turkey*
Course - Engineering Mathematics

Technical Skills

Python PyTorch, Pytorch-lightening, pandas, numpy, scipy, scikit-learn, wandb, matplotlib, seaborn

Machine Learning Deep learning, Computer vision, Time-forecasting, Adversarial robustness, DNNs, Learning-enabled control, Physics-informed NNs, Transformers

Control Systems MATLAB, SIMULINK, YALMIP, Robust control design, Signal processing, System identification, LMIs, Observer design, Frequency-response analysis

IT Prompt engineering, MS Office, Linux, Github/Gitlab, Website designing

Project Management Organization of symposium (The interplay of dynamical systems, neural networks, and control), workshops (Neural Network control with stability and performance guarantees), and NCCR Automation Junior retreat on Entrepreneurship. Collaboration in several projects during Ph.D.

Talks, Awards and Memberships

– Invited 1-hour talk on "Towards dependable machine learning - A Hamiltonian approach" at KIT, Karlsruhe, Germany.

– Invited 1-hour talk in Road2CDC and the Young Expert Seminar series titled "Physics-consistent machine learning - a neural ODE perspective " at CNR-IASI, Rome, Italy.

– Conference talks in Switzerland, Mexico, Japan, and Singapore.

– Fully funded Masters and Ph.D. scholarships.

– Active member of NCCR Automation, ETH Zurich, and EPFL, Switzerland.

Languages

English Fluent spoken (C1) and written (C1)

French Basic level spoken and written (A1), learning on weekly basis.

German Basic level spoken and written (A1), studied two semesters at CDL, EPFL, Lausanne.

Turkish Intermediate level spoken and written (B1), lived two years in Ankara, Turkey.

Urdu Native

Extra-Curricular Activities

– Travelling (Travelled to almost 20 countries for conferences, invited talks, and tourism)

– Group Hiking, and biking

– Sketching

– MOOCs (Completed several courses related to machine learning on Coursera)

Personal Details

31, Single, Swiss residence permit B, and Pakistani citizenship.