LAND OF THE CURIOUS







LUT University

LUT University, Lahti

SUMEC LAB

Physics-Informed Robotics and AI for Tough Environments

SUSTAINABLE MECHATRONICS LAB

Grzegorz “Greg” Orzechowski

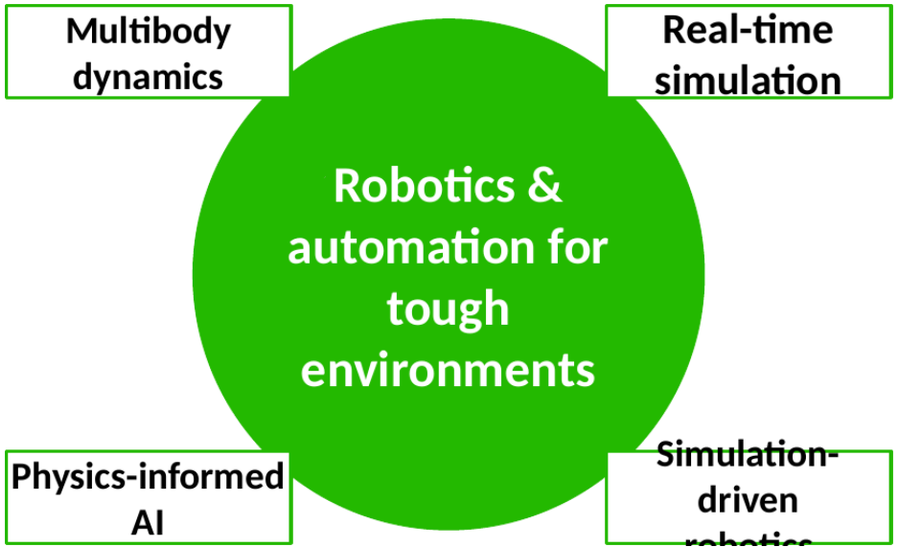
WHO WE ARE

Our core

Robotics and automation for tough environments

Why this combination

The machines our partners build are expensive to prototype and hard to control without good models. Our methods help to make design, autonomy and lifecycle decisions earlier and with more confidence.



WHAT WE DO

- **Model**: physics-based models of machines: multibody dynamics, flexible bodies, contacts, clearances, friction and hydraulics.
- **Simulate**: real-time simulation, hardware-in-the-loop testing and real-time fatigue assessment.
- **Understand**: physics-informed AI: virtual sensors, state estimation and remaining useful life. A model that runs in real time and is updated with measurements is a digital twin.
- **Act**: simulation-driven robotics: motion planning, control, reinforcement learning and sim-to-real transfer.

Safer, more autonomous, and more sustainable machinery.

RECENT RESEARCH TOPICS

1 MODEL

Physics-based modelling

- Projective geometric algebra
- Flexible multibody formulations
- Lie group integration

2 SIMULATE

Real-time simulation

- Real-time structural dynamics
- Reduced-order and sliding-beam models
- Valve control for hydraulic impedance

3 UNDERSTAND

Physics-informed intelligence

- Physics-informed friction models
- Clearance detection without feature extraction
- Fatigue and remaining useful life

4 ACT

Simulation-driven robotics

- Reliable reinforcement learning
- Excavation automation

WHAT WE DELIVER, AND WHERE

What we deliver

- Digital twins
- Virtual sensors
- Better designs and controllers

Where it is used

- Non-road mobile machinery: forestry, mining, lifting and heavy industry
- Hydraulically driven systems
- Robotics and automation solutions

WHO WE WORK WITH

Academic collaborators

- Johannes Gerstmayr, University of Innsbruck, Austria
- Francisco González, University of A Coruña, Spain
- Seongji Han, Chungnam National University, South Korea
- Marek Wojtyra and Paweł Malczyk, Warsaw University of Technology, Poland

We also work with companies in national and European projects.

CONTACT

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We are open to visits, talks, invitations and collaboration with companies.

