Nordic Encounters for Advancing Mathematics in Industry

Organizers: A. Muntean, Gr. Nika
Karlstad University
Karlstad, Sweden

May 26, 2025

KK-stiftelsen

SOLVE

Acknowledgments

This workshop is currently sponsored by the Knowledge Foundation (KK-stiftelsen) under grants, project nr. KK 2020-0152 and project nr. KK-NU 20230010-H-01. *The mission of the Knowledge Foundation is to support the exchange of knowledge and skills between academia and industry, as well as to fund profile research at Sweden's university colleges and new universities. They support the development of strong research and education environments that create value for academia, the business sector and society.* Additionally, the workshop is supported by Swedish Energy Agency's project Solar Electricity Research Centre (SOLVE) under grant number 52693-1.

The organizers wish to extend their heartfelt gratitude for their invaluable support.

Welcome Address

Mathematics, perhaps now more than ever, has the chance to firmly insert itself in the quantitative understanding of large scale industrial strategy and processes across all sectors of commerce. Enterprises that fully exploit of this opportunity will gain a significant competitive advantage. We, as academic mathematicians, firmly believe that mathematics gives the edge.
On the other, we believe that academic mathematicians are not sufficiently well connected outside the university community. Indeed, the greatest challenge / opportunity is how to build closer relations to industry. It is our aim that this workshop is a modest step to strike a better balance between theory and application as well as to make sure that that the inward-looking mathematical community does not miss opportunities that arise outside mathematical sciences and any opportunities that are part of the scientific and technological developments.
Given that problems never come formulated as mathematical question, it is our jobs as mathematicians to state the right question.

In der Mathematik ist die Kunst Fragen zu stellen wertvoller als Probleme zu lösen. — Georg Cantor

Scope: The goal of this workshop is to bring together industry professionals and researchers in academic institutions in order to foster the exchange of ideas and to better align the collaboration opportunities among the two communities. The workshop includes a wide span of cutting edge topics ranging from data encryption, medical implant technology, machine learning aspects, electrochemistry, energy storage, and semiconductor modelling and simulation, among others.

Contents

Abstracts

A MATHEMATICIAN IN THE SEMICONDUCTOR INDUSTRY

Joep Evers
ASML

ASML is the world's leading supplier for the semiconductor industry. We provide hardware, software and services to chip-makers around the world. The company employs people from a wide range of academic disciplines. Mathematics is one of them. In this presentation, I will talk mainly about the department I work in: Metrology. I will address what the goal of our department is, what kind of projects we do, and how my background as a mathematician plays a role in my (daily) work.

PREDICTING INFRARED SIGNATURES AND TRANSMISSION THROUGH THE ATMOSPHERE

Kristos Qiqi
Swedish Defense Agency (FOI)

An infrared (IR) signature is the contrast between the appearance of an object and its background to an IR sensor. Mathematical modeling of IR signatures is an important part in military applications, aiding in reducing IR signatures. The IR signature of an object depends on many parameters, such as its shape, emissivity, air temperature, pressure, water vapor, wind speed. This strong weather dependence makes the model very complicated and computationally expensive. The question is then how to reduce the computation time without loosing a lot of spatial or temporal resolution. It is beneficial to be able to predict an IR signature based on weather forecasts. To achieve this we use Numerical Weather Predictions (NWP). However, this introduces additional errors in the model and raises the question of the accuracy in the output. Using NWPs is computational heavy and requires many simplifications. To validate the results, the thermal model is compared to measurements.

TBA

Ola Hammarlid
Vattenfall

TBA

R & D CONSULTANCY AND CONTRACT RESEARCH AT SIMULA

Omar Richardson
Simula Research Laboratory

Simula is a Norwegian research institute conducting high-quality basic and applied research within information and communication technology, applied mathematics, and artificial intelligence. Simula's mission is to benefit society by solving relevant problems in science, educating the next generation, and aiding Norwegian industry in innovation. As part of this mission, Simula's Department of Applied AI is an R&D-focused group that works with industry to implement data and AI-driven solutions, provides technical advice and strategy.

The main focus of our group is data science and AI-driven technologies; computer vision, natural language processing and recommendation systems. Our project portfolio has a focus on the energy-sector, healthcare and aquaculture.

In this seminar, we discuss some of the projects our group is working on and how we engage in collaborations. The main point of this talk, however, is to share how we attempt to bridge the gap between academia and industry. The aim is to generate a discussion on which technical and non-technical guiding principles bring the best results in industrial/academic collaborations.

SEEING SIZE EFFECTS IN METAMATERIAL IMPLANTS

H.C.V. Megha Shyam Veluvali
Engineering and Technology Institute Groningen, Faculty of Science and Engineering, University of Groningen, Groningen, The Netherlands

This is a joint work with S. Beniwal[1], Prof. dr. J. Kraeima [2], Dr. G. Nika [3], Prof. dr. ir. P. R. Onck[4], Prof. dr. A.O. Krushynska[1]

1. Engineering and Technology Institute Groningen, Faculty of Science and Engineering, University of Groningen, Groningen, The Netherlands
2. University Medical Center Groningen, Groningen, The Netherlands
3. Department of Mathematics and Computer Science, Karlstad University, Karlstad, Sweden
4. Zernike Institute of Advanced Materials, Faculty of Science and Engineering, University of Groningen, Groningen, The Netherlands

Metamaterial implants – rationally designed cellular bone-reconstruction devices – have recently emerged as promising alternatives to common clinical solid implants [1]. While researchers can nowadays design personalized implants replicating patient's morphology [2], these bulky metal structures suffer from mechanical failure occurring mainly due to stress shielding - a mismatch in the mechanical properties of an implant and adjacent bones that leads to a loss in bone density followed by loosening of the implant. In contrast, the mechanical properties of metamaterial implants can be tuned to bone-like behavior that promises to minimize implant failure [1, 2]. For this, the solid parts of a metal implant are replaced with a porous microstructure optimally distributed for applied muscular-driven loads.

The dimensions of a metamaterial implant can be very limited, to ensure the implant's fit which leads to size effects – the dependence of the mechanical properties of a metamaterial on the number of constitutive building blocks (unit cells) under different types of loading. It occurs if the characteristic lengths of an implant and unit cells are comparable and results in the failure of classical approximation techniques, e.g. first-order homogenization, to provide adequate approximations for the mechanical behavior. Generalized continuum theories are helpful to model these complicated metamaterial implants as an effective continuum with size effects [3, 4]. In this talk, the problem of size effects for implants and the motivation behind using generalized continuum theories will be presented.

Bibliography

1. J.-I. Heins, B. B. Merema, J. Kraeima, M. J. Witjes, A. O. Krushynska, Mandibular Implants: A Metamaterial-Based Approach to Reducing Stress Shielding. Adv. Healthcare Mater. 2025; 2500405.

2. B.B.J. Merema , J. Kraeima, S.A.J.H. de Visscher, et al., Novel finite element-based plate design for bridging mandibular defects: Reducing mechanical failure. Oral Dis. 2020; 26(6): 1265–1274.

3. Nika G, Muntean A. Effective medium theory for second-gradient elasticity with chirality. Asymptotic Analysis. 2024;139(1-2):111-137

4. C. Tekoğlu, P. R. Onck, Size effects in two-dimensional Voronoi foams: A comparison between generalized continua and discrete models. Journal of the Mechanics and Physics of Solids. 2008, 56(12): 3541-3564

TRANSPARENT BY DESIGN: A WHITE-BOX SYNTHETIC DATA METHOD AND ITS REAL APPLICATION

Nicklas Jävergård, Jonas Forsman
Karlstad University, CGI

This is a joint work with Prof Adrian Muntean (Karlstad Univeristy) and PhD Rainey Lyons (Univeristy of Boulder, Colorado)

In this talk we present our work to construct a statistical approach for generating synthetic data with sound statistical properties. Our method is a white box approach that utilizes joint probability distribution and conditional distributions of the original data to attain two goals. Firstly, the empiric distributions of the synthetic data should approximate the empiric distributions of the original data. Secondly, the inter-feature correlations of the synthetic dataset should be sufficiently close to that of the original dataset. We finish with a short presentation of a real-world implementation, CGI DataEcho, where the generating synthetic data is a key factor. As organizations face challenges related to data privacy, availability, fairness, and quality, CGI DataEcho offers a strategic solution by enabling the on-demand generation of realistic, anonymized synthetic datasets — empowering innovation while ensuring compliance. CGI DataEcho is a secure, scalable, and high-performance synthetic data platform designed to meet the growing demand for privacy-compliant, high-quality test and training data in AI development and application testing.

Author Index