Norwegian Workshop on Mathematical Optimization, Nonlinear and Variational Analysis 2023, Trondheim, April 26-28

Photo: Mentz Indergaard/NTNU

Contents

About

The aim of this workshop is to bring together experts from different countries with researchers in Norway to exchange the latest contributions and present the state of the art in the fields of nonlinear and variational analysis, set and vector optimization, and operations research. These theories have burgeoned tremendously due to rich applications in economics, management science, engineering, mechanics, and behavioral and life sciences. Due to such important applications from practice, these topics are vibrant research areas and expanding branches of applied mathematics.

More information can be found at `https://wiki.math.ntnu.no/monva2023/start`.

Special Issue

Novel results developed during the workshop will be published in a Special Issue of the international journal Optimization: A Journal of Mathematical Programming and Operations Research (Taylor & Francis). The Call for Papers is available at `https://wiki.math.ntnu.no/_media/monva2023/call_for_papers_si_monva.pdf`.

Best Poster Award

The workshop includes a one-hour poster session on **Friday, April 28th**, from **15:15-16:15**. The poster contributors will have the opportunity to present their research and get into discussions with the participants.

We are happy to announce that a best poster award will be sponsored in the form of a book voucher from CRC Press (Taylor & Francis Group).

Scientific Committee

Elisabeth Köbis (NTNU)
Markus Köbis (NTNU)
Christiane Tammer (Martin Luther University Halle-Wittenberg, Germany)
Jan-Joachim Rückmann (UIB)

Timetable

IT: Invited Talk, CT: Contributed Talk.

All talks will take place at NTNU, Valgrinda, room VG1, which is in walking distance from the Scandic Lerkendal hotel. The poster session will be held on the 13th floor in Sentralbygg 2 on Gløshaugen campus (we will walk there from the conference).

Wednesday, 26th of April

8:30–9:00	**Registration**		
9:00–9:10	**Welcome Remarks**		
9:10–9:55 Chair: M. Köbis	IT	**Christiane Tammer** Halle, Germany	Optimality conditions and algorithms for vector optimization problems with variable domination structure
9:55–10:40 Chair: M. Köbis	IT	**Basca Jadamba** Rochester, USA	A stochastic approximation approach for a coefficient identification problem in elliptic PDEs
10:40–11:15	**Coffee**		
11:15-12:00 Chair: M. Köbis	IT	**Jan-Joachim Rückmann** Bergen, Norway	Strongly stable C-stationary points for mathematical programs with complementarity constraints
12:00-12:45 Chair: M. Köbis	IT	**Boris Mordukhovich** Detroit, USA	Variational Convexity In Nonsmooth Optimization
13:00–14:15	**Lunch**		
14:15–14:50 Chair: C. Tammer	CT	**Constantin Zalinescu** Iasi, Romania	On normal and regular convex cones in topological vector spaces
14:50-15:25 Chair: C. Tammer	CT	**Radu Strugariu** Iasi, Romania	Directional derivatives and subdifferentials for set-valued maps with applications in set optimization
15:25–15:45	**Coffee**		
15:45-16:20 Chair: C. Tammer	CT	**Marius Durea** Iasi, Romania	Dilating cones and applications to vector and set-valued optimization problems
16:20-16:55 Chair: C. Tammer	CT	**Marcel Marohn** Jena, Germany	On modern portfolio optimization problems
16:55–18:00	**Finger Food & Mingling**		

Thursday, 27th of April

9:00-9:45 Chair: M. Köbis	IT	**Akhtar Khan** Rochester, USA	A Stochastic Optimization Framework for Inverse Problems in Stochastic Variational Problems
9:45–10:30 Chair: M. Köbis	IT	**Torkel Haufmann** Oslo, Norway	Practical optimization in the construction industry
10:30–10:45	**Coffee**		
10:45–11:30 Chair: M. Köbis	IT	**Alexander Bockmayr** Berlin, Germany	Understanding cellular behaviors through mathematical optimization
11:30–12:15 Chair: M. Köbis	IT	**Iain Johnston** Bergen, Norway	Optimal behaviour of cellular societies: fulfilling multiple competing objectives in stochastic cell biology
12:15–13:15	**Lunch**		
13:15-14:00 Chair: C. Tammer	IT	**Dietmar Hömberg** Trondheim, Norway and Berlin, Germany	Phase-field based Topology Optimization
14:00-14:35 Chair: C. Tammer	CT	**Sjur Didrik Flåm** Bergen, Norway	On Steady States in Commons
14:35-15:10 Chair: C. Tammer	CT	**Markus Köbis** Trondheim, Norway	Time-optimal control for simulating cellular processes: A case-study from metabolic network simulation
15:30–16:00	**Group Picture at the Main Building of NTNU (we will walk there together)**		
16:00–17:00	**Excursion to the Nidaros Cathedral (we will walk there together)**		
18:00	**Conference Dinner (we will walk there together)**		

Friday, 28th of April

~~9:00–9:45~~ CANCELED	IT	~~**Vu Trung Hieu**~~ Trondheim, Norway	~~Certified Polynomial Optimization based on Exact Sum of Squares Decompositions~~
9:45–10:30 Chair: E. Köbis	IT	**Paul Schmölling** Trondheim, Norway	Vectorial penalisation for general vector optimisation problems
10:30–10:45	**Coffee**		
10:45–11:30 Chair: E. Köbis	IT	**Shipra Singh** Trondheim, Norway	Multi-Time Generalized Nash Equilibrium Problem
11:30–12:15 Chair: E. Köbis	IT	**Christian Günther** Hannover, Germany	Nonlinear Cone Separation Theorems in Real Reflexive Banach Spaces
12:15–13:15	**Lunch**		
13:15–13:50 Chair: J.-J. Rückmann	CT	**Elena Andreea Florea** Iasi, Romania	Cone-compactness of a set and applications to set-optimization problems
13:50–14:25 Chair: J.-J. Rückmann	CT	**Daniel Hernandez Escobar** Bergen, Norway	Strongly stable stationary points for a class of generalized equations

14:25–15:00 Chair: J.-J. Rückmann	CT	**Pankaj Gautam** Trondheim, Norway	Degenerate preconditioned backward-backward splitting for monotone inclusion problem
15:15–16:15	**Poster Session, Poster Prize, Finger Food & Conclusion (we will walk there)**		

List of Abstracts – Talks

Wednesday 26th of April

Optimality conditions and algorithms for vector optimization problems with variable domination structure

Christiane Tammer

Martin Luther University Halle-Wittenberg, Germany

In many real world problems, the simultaneous minimization of certain goals is needed. Such problems lead to vector optimization problems with variable domination structure, where the domination structure is given by a set-valued map. In this talk, we discuss corresponding solution concepts and derive optimality conditions. Furthermore, we propose a steepest descent-like method for computing nondominated solutions of smooth unconstrained vector optimization problems with variable domination structure.

The talk is based on joint work with Gemayqzel Bouza.

A stochastic approximation approach for a coefficient identification problem in elliptic PDEs

Basca Jadamba

Rochester Institute of Technology, USA

This talk will focus on issues surrounding the development of a computational framework for the problem of identifying a distributed parameter in certain elliptic PDEs. One particular example is the problem of recovering the tissue stiffness parameter in a linear elasticity system whose application is in identifying tumors in soft tissues from tissue displacement data. We present an optimization formulation, stochastic approximation approach, and the development of a finite element solution framework using adaptively refined meshes that provide the resolution needed for accurate recovery.

Strongly stable C-stationary points for mathematical programs with complementarity constraints

Jan-J. Rückmann

Bergen University, Norway

In this talk we consider the class of mathematical programs with complementarity constraints (MPCC). Under an appropriate constraint qualification of Mangasarian-Fromovitz type we present a topological and an equivalent algebraic characterization of a strongly stable C-stationary point of MPCC. Strong stability refers to the local uniqueness, existence and continuous dependence of a solution for each sufficiently small perturbed problem where perturbations up to second order are allowed. This concept of strong stability was originally introduced by Kojima for standard nonlinear optimization problems; here, its generalization to MPCC demands a sophisticated technique which takes the combinatorial properties of the solution set of MPCC into account.

Based on joint work with Daniel Hernandez Escobar.

Variational Convexity in Nonsmooth Optimization

Boris Mordukhovich

Wayne State University, USA

The talk is devoted to the study, characterizations, and applications of variational convexity of nonsmooth functions, the property that has been recently introduced by Rockafellar together with its strong counterpart. First we show that these variational properties of an extended-real-valued function are equivalent to, respectively, the conventional (local) convexity and strong convexity of its Moreau envelope. Then we present new characterizations of both variational convexity and variational strong convexity of general functions via their second-order subdifferentials (generalized Hessians), which are coderivatives of subgradient mappings. We also study relationships of these notions with local minimizers and tilt-stable local minimizers. The obtained results are used for characterizing related notions of variational and strong variational sufficiency in composite optimization with applications to nonlinear programming.

Based on joint work with P. D. Khanh and V. T. Phat.

On normal and regular convex cones in topological vector spaces

Constantin Zalinescu

Octav Mayer Institute of Mathematics, Iasi Branch of Romanian Academy, Iasi, Romania

As well known, the order relation of an ordered topological vector space X is induced by a convex cone X_+; a very important topological property of X_+ is to be normal, that is, the origin of X has a neighborhood base formed by full sets. Other related topological properties of X_+ are those of being (fully) regular, Daniell, supernormal. It is our aim to present some refinements of results concerning these notions.

Directional derivatives and subdifferentials for set-valued maps with applications in set optimization

Radu Strugariu

Octav Mayer Institute of Mathematics, Iasi Branch of Romanian Academy, Iasi, Romania

We present a general method to devise directional derivatives and subdifferentials for set-valued maps that generalize the corresponding constructions from the classical situation of real-valued functions. We show that these generalized differentiation objects enjoy some properties that, on the one hand, meaningfully extend the aforementioned case and, on the other hand, are useful to deal with the so-called $\ell-$ minimality in set optimization problems.

Dilating cones and applications to vector and set-valued optimization problems

Marius Durea

Octav Mayer Institute of Mathematics, Iasi Branch of Romanian Academy, Iasi, Romania

Motivated by the study of some directional properties in vector optimization and by some cone separation results, we study four types of enlargements for cones (or dilating cones) in normed vector spaces. We identify some commune features and mutual inclusions that these enlargements enjoy under different classical properties of cones such as normality or well-basedness. Then, by the use of these constructions, under appropriate topological conditions, we study the properness of several types of solutions in different kinds of vector and set-valued optimization problems.

On modern portfolio optimization problems

Marcel Marohn

Friedrich-Schiller-University Jena, Faculty of Economics and Business Administrations, Chair of Finance, Germany

Portfolio optimization problems arise in many practical situations. The origin of modern portfolio theory can be seen in the mean-variance-portfolio model by Markowitz. Since then, many extensions like, e.g., models including monetary risk measures in the sense of Artzner et al. have been studied. In this talk, we present some insights in several modern portfolio vector optimization problems being motivated by present practical trends and challenges. These problems refer to regulatory capital adequacy tests and the integration of environmental, social and organizational criteria into optimization.

Thursday 27th of April

A Stochastic Optimization Framework for Inverse Problems in Stochastic Variational Problems

Akhtar Khan

Rochester Institute of Technology, USA

Motivated by the necessity to identify stochastic parameters in a wide range of stochastic partial differential equations, an abstract inversion framework will be presented. We will study the stochastic inverse problem in a stochastic optimization framework. The essential properties of the solution map and the solvability of the stochastic optimization problems will be presented. Novel convergence rates for the stochastic inverse problem will be given in the abstract formulation without requiring the so-called smallness condition. Under the assumption of finite-dimensional noise, the stochastic inverse problem will be parametrized and solved by using the Stochastic Galerkin discretization scheme. Applications to estimating stochastic Lamé parameters in the system of linear elasticity will be discussed. We will present numerical results to show the feasibility and efficacy of the developed framework.

Practical optimization in the construction industry

Torkel Haufmann

Sintef Oslo, Norway

The construction industry is of great economic importance and obviously has an important role in society. It is however also a major contributor to emissions and known for being "under-digitized". Among other things there is a need for better decision support, which in essence means solving optimization problems - although the actual optimum is usually both hard to define and impractical to compute. In this talk I will discuss some of our work in applying heuristics in practice in the construction industry, with an emphasis on the challenges involved with real-world data and constraints, and the difficulties involved in making these tools practically useful to non-experts.

Understanding cellular behaviors through mathematical optimization

Alexander Bockmayr

Freie Universität Berlin, Germany

Integrated modeling of metabolism and gene regulation continues to be a major challenge in computational systems biology. Starting from flux balance analysis (FBA) for genome-scale metabolic network reconstructions, various optimization-based modeling approaches have been developed over the years. In this talk, I will present regulatory dynamic enzyme-cost flux balance analysis (r-deFBA), which unifies dynamic modeling of metabolism, cellular resource allocation and transcriptional regulation in a hybrid discrete-continuous modeling framework. Using r-deFBA, one can predict Boolean regulatory states together with the continuous dynamics of metabolic fluxes, external substrates, enzymes, and regulatory proteins, which allows optimizing a cellular objective such as biomass production over a given time interval. The dynamic optimization problem underlying r-deFBA can be reformulated as a mixed 0-1 linear optimization problem, for which there exist efficient solving methods.

Optimal behaviour of cellular societies: fulfilling multiple competing objectives in stochastic cell biology

Iain Johnston

University of Bergen, Norway

Biology is messy, and lacks the clean "laws" of physics (and maths). But there are two general principles – noise and optimisation – which are found across all life. Noise – because the biological cell is a bag of molecules subject to constant thermal, and external, fluctuations. Life's essential processes must take place on this background of effectively random dynamics. And optimisation – because all biology is shaped by evolution. Natural selection is not a perfect optimiser, but it will generally lead to good solutions to a given problem being favoured over bad ones.

This already places us in the field of stochastic optimisation. But there's another feature of cell biology that I hope aligns even more with this meeting. The thousands of cellular processes that are essential for life are often in conflict, meaning that evolution cannot optimise all of them simultaneously. Instead, life must identify reasonable tradeoffs between conflicting objectives in the noisy environment of the cell. I think this means that tools from optimisation, stochastic optimal control, and operations research, have the potential to shed a great deal of light on how life adopts these tradeoffs – and how we might adapt them for our own purposes.

I'll aim to make these rather abstract claims more concrete with some specific examples about "organelles" – cellular subcompartments whose physical structure and dynamics are essential for their biological function. For example, we have identified unavoidable tradeoffs in the populations of mitochondria within cells – which need to colocalise to exchange contents but also remain evenly spread through the cell to ensure uniform chemical profiles. I'll talk about our work experimentally characterising their behaviour and developing some theoretical ideas about the evolved principles controlling them in the cell. I'll also expand on other examples from biology where I think modelling approaches have real potential to make exciting new discoveries.

Phase-field based Topology Optimization

Dietmar Hömberg

WIAS Berlin and NTNU Trondheim

Subject of my presentation is a novel approach for optimizing both the macroscopic shape and the porous mesoscopic structure of components. In the first part of my presentation I will introduce the concept of phasefield based topology optimization.

The second part of my presentation is devoted to two-scale topology optimization. The key feature here is the introduction of an additional local volume control (LVC), which allows to adjust the desired spatial scales.

The main novelty is that the radius of the LVC may depend both on space and a local stress measure. This allows for creating optimal topologies with heterogeneous mesostructures enforcing any desired spatial grading and accommodating stress concentrations by stress dependent pore size.

I will present some analytical results for the resulting optimal control problem and conclude with numerical results showing the versatility of our approach for creating optimal macroscopic designs with tailored mesostructures.

Joint work with Moritz Ebeling-Rump and Robert Lasarik, WIAS.

Reference:

Moritz Ebeling-Rump, Dietmar Hömberg, Robert Lasarzik, Two-scale topology optimization with heterogeneous mesostructures based on a local volume constraint. Computers & Mathematics with Applications, Volume 126, 2022, Pages 100-114, https://doi.org/10.1016/j.camwa.2022.09.004.

On Steady States in Commons

Sjur Didrik Flåm

Bergen University, Norway

The paper considers management of common property, renewable resources. It argues that good governance needs two levels - each with its own agency, purpose and time scale. At the lower level, market-like mechanisms should help allocate quotas within season. At the upper level, principal planning should decide quotas across seasons. In this optic, to simplify, focus is on steady states, and uncertainty is ignored. Main arguments revolve around existence and stability of fixed points.

Key words: commons, dynamic programming, fixed point, steady state.

Time-optimal control for simulating cellular processes: A case-study from metabolic network simulation

Markus Köbis

Norwegian University of Science and Technology, Gjøvik, Norway

Metabolic network simulation is a vibrant sub-field of computational systems biology where one aims at identifying the bio-chemical foundations of “life” as a complex, but mathematically describable, process. In recent years, the role of (dynamic) control techniques, mathematical robustness and – more broadly – analytical tools from operational research have been more and more acknowledged.

In this contribution, we exemplify how time-optimal control can be used to give a computational rational as to why microbes seemingly non-optimally allocate storage molecules by means of applying the technique to a small surrogate model of metabolism.

The framework itself is building upon dynamic enzyme-cost FBA and resource balance analysis but we will emphasis on how it fits into a broader class of frameworks and tightly connects to the incorporation of robustness, inverse-problem theory, and multi-objective optimization.

This is a joint work with A. Bockmayr and R. Steuer.

Friday 28th of April

~~Certified Polynomial Optimization based on Exact Sum of Squares Decompositions~~ This talk is unfortunately canceled

Vu Trung Hieu

Norwegian University of Science and Technology, Trondheim, Norway

It is well-known that computing the infimum of a multivariate polynomial optimization problem is NP-hard in general. To avoid this issue, there is a standard method using hierarchies of semi-definite relaxations and theory of sums of squares (SOS for short) of polynomials in which every semi-definite program can be solved in polynomial time. Within this method, non-negativity of polynomials is replaced by SOS property. Hence, assessing non-negativity of polynomials based on SOS decompositions is a topical issue in polynomial optimization.

Certificates of non-negativity are usually tackled through the computation of SOS decompositions which rely on efficient numerical solvers for semi-definite programming. Consequently, certificates obtained by this way are approximate and then non-exact. For some critical applications, it is important to actually compute exact certificates of non-negativity.

In this talk, we provide a symbolic algorithm to compute SOS decompositions modulo the gradient ideals of non-negative real multivariate polynomials with rational coefficients. The algorithm can tackle a large range of problems that are out of reach of state-of-the-art algorithms. Moreover, we analyze the bit complexity of the algorithm, implement it in the computer algebra systems MAPLE, and evaluate its performance on some standard benchmarks.

The talk is based on joint work with Victor Magron and Mohab Safey El Din.

Vectorial penalisation for general vector optimisation problems

Paul Schmölling

Norwegian University of Science and Technology, Trondheim, Norway

The solution set of a constrained vector optimisation problem is expressed in terms of two related unconstrained problems. For this purpose, algebraic concepts are used in general real linear spaces, with which the restricted admissible set is divided into an algebraic interior and an algebraic boundary. With the help of generalised cone convexity, the solution set of the constrained problem in the interior of the admissible set can be expressed by the solution set of the associated unconstrained problem. By means of vectorial penalisation, under various properties of the penalisation function, relations of the solution sets of the original restricted and the unrestricted penalised problem are derived and finally a representation of the solution set of the former on the boundary by the solution set of the latter is obtained. Overall, the desired representation is obtained.

Multi-Time Generalized Nash Equilibrium Problem

Shipra Singh

Norwegian University of Science and Technology, Trondheim, Norway

The talk intends to give a concise view of a multi-time generalized Nash equilibrium problem and its application in traffic network and river basin pollution problems. We propose a multi-time generalized Nash equilibrium problem and prove its equivalence with a multi-time quasi-variational inequality problem. Then, we establish the existence of equilibria. Furthermore, we demonstrate that our multi-time generalized Nash equilibrium problem can be applied to solving traffic network problems, the aim of which is to minimize the traffic cost of each route and to solving a river basin pollution problem.

Nonlinear Cone Separation Theorems in Real Reflexive Banach Spaces

Christian Günther

Leibniz University Hannover, Germany

The separation of two sets (or more specific of two cones) plays an important role in different fields of mathematics (such as variational analysis, convex analysis, convex geometry, optimization). In the talk, we show some new results for the separation of two (not necessarily convex) cones by a (convex) cone / conical surface in real reflexive Banach spaces. We follow basically the separation approach by Kasimbeyli (2010, SIAM J. Optim. 20) based on augmented dual cones and Bishop-Phelps type (normlinear) separation functions. Classical separation theorems for convex sets will be the key tool for proving our main nonlinear cone separation theorems.

Cone-compactness of a set and applications to set-optimization problems

Elena Andreea Florea

Octav Mayer Institute of Mathematics, Iasi Branch of Romanian Academy, Iasi, Romania

The compactness with respect to a cone, understood in the most used sense, with coverings, naturally appears in set-valued optimization problems through various procedures of scalarization, in discussions concerning the existence of solutions, as well as in penalization results. In this talk, we propose a sequential characterization of the compactness of a set with respect to a cone, under an assumption of separability for the ordering cone, and we show how this characterization simplifies the proofs of several topological results concerning the cone-compactness. Then, we consider some set-equilibrium problems, whose formulations are inspired by set-optimization problems, and we show how the cone-compactness notion can be employed in a meaningful way in the study of the existence of solutions for these problems.

The talk is based on joint work with Marius Durea.

Strongly stable stationary points for a class of generalized equations

Daniel Hernandez Escobar*, Harald Günzel and Jan-J. Rückmann

Bergen University, Norway

We consider a generalized equation characterized by a cone-valued mapping. It is well-known that optimality conditions for different classes of optimization problems can be formulated as such a generalized equation. In this talk, we generalize Kojima's concept of strong stability and introduce appropriate constraint qualifications. Moreover, we discuss related properties between strong stability and these constraint qualifications. Finally, we apply these results to the particular class of mathematical programs with complementarity constraints and to that of mathematical programs with abstract constraints.

*speaker

Degenerate preconditioned backward-backward splitting for monotone inclusion problem

Pankaj Gautam

Norwegian University of Science and Technology, Trondheim, Norway

In this work, we introduce the notion of warped Yosida approximation and discuss its properties. We analyze an algorithm where the inclusion problem is first approximated by a regularized one, and the preconditioned regularization parameter is then reduced to converge to a solution of the original problem. We propose and investigate backward-backward splitting using degenerate preconditioning for monotone inclusion problems. The applications provide a tool for finding the minima of a preconditioned regularization of the sum of two convex functions.

List of Posters

Economic Principles in Cell Biology

Economic principles in Cell Physiology forum. Presenter: Markus Köbis, *NTNU*, *Gjøvik*, *Norway*

Unboundedness of Solution Sets in Vector Optimization

Vu Trung Hieu, *NTNU*, *Trondheim*, *Norway*

Time-Optimal Adaptation in Metabolic Network Models

Markus Köbis, *NTNU*, *Gjøvik*, *Norway*

Non-cooperative Strategic Games with an Application to Spot Electricity Markets

Shipra Singh, *NTNU*, *Trondheim*, *Norway*

Vectorial Penalization for General Vector Optimisation Problems

Paul Schmölling, *NTNU*, *Trondheim*, *Norway*

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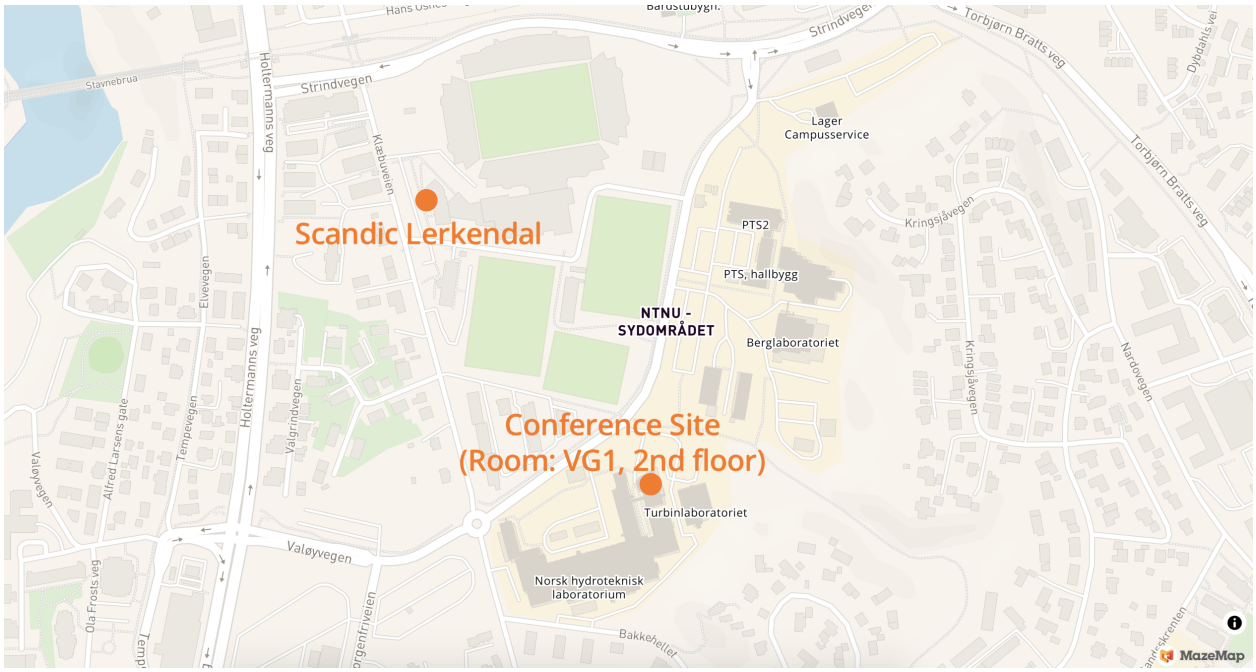
Useful Information

How to get to the conference site

Talks will be held at **NTNU, Valgrinda, room VG1, address: S. P. Andersens veg 3, 7031 Trondheim**, which is within a 5-minute walk from the Scandic Lerkendal hotel, see the link:

`https://doodle.mazemap.com/#!/doodle/3d64307cb13fbf25c840edcf739ab84a4b69b4bc0ca29604c3342e1c73f9c3fe`



You enter where the red arrow is pointing, and then the conference room is on the right.

Poster session

The **poster session** will be held on the 13th floor in Sentralbygg 2 on Gløshaugen campus (we will walk there together from the conference).

Wi-Fi

Wi-Fi will be available during the conference via eduroam. Moreover, you can use the network "ntnu guest" by simply typing in your email.

Conference dinner

The **conference dinner** will be held on April 27th, 18:00, at the restaurant "Rive Gauche" (`https://www.rivegauche.no`, Address: Øvre Bakklandet 66, 7016 Trondheim, it is located next to the old town bridge), see the link:

`https://doodle.mazemap.com/#!/doodle/8f926870c85b0439d4eb0ca203b4310db9ede4d0af649b7fcda2b6bf3ec0ccc2`

Sponsors

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Notes