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1-14-2026

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PhD degrees @ CU

You can pursue your PhD in more than 30 fields, depending on the scope of your PhD project and the experts involved in your PhD committee.

Below you will find an overview of the fields the Professors active in this call are working in.

Click on the name to jump directly to the respective Professor's entry.

Applied Mathematics / Mathematics

Prof. Igors Gorbovickis, Prof. Sören Petrat, Prof. Petr Popov, Prof. Marc-Thorsten Hütt, Dr. Keivan Mallahi Karai

Biochemical Engineering / Biotechnology, Biochemistry

Prof. Matthias Ullrich, Prof. Björn Windshügel

Bioinformatics

Prof. Marc-Thorsten Hütt, Prof. Petr Popov,

Business Administration

Dr. Stanislav Chankov, Prof. Andreas Seebeck, Prof. Lennart Ante

Cell Biology

Prof. Maren Schenke

Chemistry

Prof. Torsten John, Prof. Ulrich Kortz, Prof. Nikolai Kuhnert, Prof. Werner Nau

Computer Science

Prof. Markus Wenzel, Prof. Francesco Maurelli, Prof. Andreas Birk, Prof. Petr Popov, Dr. Samaneh Rashidibajgan, Prof. Jürgen Schönwälder, Prof. Jakob Suchan

Data Engineering

Prof. Marc-Thorsten Hütt

Economics

Prof. Fabian Dehos

Electrical Engineering

Prof. Mojtaba Joodaki, Prof. Francesco Maurelli

Geosciences

Prof. Michael Bau, Prof. Andrea Koschinsky, Prof. Vikram Unnithan

History

Dr. Julia Timpe

History and Theory of Art

Prof. Isabel Wünsche

Industrial Engineering and Management / International Logistics

Dr. Stanislav Chankov, Dr. Mahdi Homayouni, Prof. Omid Fatahi Valilai

Information Science / Information Systems and Management

Prof. Hendro Wicaksono, Prof. O. Fatahi Valilai

Marine Microbiology / Biology

Prof. Matthias Ullrich

Neuroscience

Prof. Ben Godde

Philosophy

Dr. Eoin Ryan

Physics

Prof. Kettemann, Prof. Ulrich Kleinekathöfer, Prof. Hildegard Meyer-Ortmanns

Political Science

Prof. Tobias ten Brink, Prof. Marco Verweij, Prof. Karen Smith Stegen

Psychology

Prof. Sonia Lippke, Prof. Ulrich Kühnen

Sociology

Prof. Klaus Boehnke, Prof. Hilke Brockmann, Prof. Isak Frumin, Prof. Jan Lorenz

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Overview of potential hosts and research fields

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Prof. Dr. Lennart Ante (Entrepreneurial Finance)

Topics:

"Blockchain and Digital Markets"

This theme examines blockchain as a general-purpose digital infrastructure for coordination, exchange, and ownership—and the economic systems that form around it. Blockchains enable programmable rules (smart contracts), shared verification across organizations, and new governance and incentive structures in open networks. A central interest is when these features create real economic value by reducing frictions (trust, verification, contracting, coordination costs), and when conventional digital infrastructures and institutions remain more effective.

A second focus is how digital markets emerge and evolve on blockchain rails. Protocols change frequently, activity is observable at fine granularity, and shocks or design changes (upgrades, incidents, rule changes, regulatory developments) create natural variation for studying adoption and behavior. The theme spans technological design (governance mechanisms, incentives, interoperability), socio-technical dynamics (community coordination, legitimacy, standards), and market formation (how participation, liquidity, and information flows arise). The overarching goal is to understand mechanisms: how rules and incentives shape behavior, how trust is produced, and how digital market institutions form, compete, and change.

Examples of directions:

- Smart contracts as "institutional technology" (automation, enforcement, redesign of processes)
- Governance in open networks (participation, voting power, legitimacy, decision quality)
- Interoperability and fragmentation (bridges, L2s, multi-chain ecosystems, liquidity migration)
- Stablecoins as digital money infrastructure (payments, settlement, remittances, market quality and spillovers)
- Tokenization, crypto assets and digital ownership systems (Bitcoin, property rights, secondary markets, user participation)

"Generative AI and Agentic Systems in the Digital Economy"

This theme focuses on how generative AI changes economic activity when it becomes embedded in workflows, organizations, and markets—especially as systems shift from "tools" to agentic systems that can plan, decide, and act. The core interest is in mechanisms: how GenAI reshapes creativity and problem-solving, alters experimentation and execution, changes how information is produced and interpreted, and influences coordination among individuals, teams, firms, and market participants.

The theme naturally spans entrepreneurship and finance without being limited to either. It includes how GenAI affects opportunity recognition, iteration cycles, capability building, and competitive dynamics—alongside how it changes screening, due diligence, disclosure practices, and the speed of learning in markets. A complementary concern is the risk side: agentic systems can amplify herding, create feedback loops, and increase fragility through synchronized behavior or misinformation. Overall, the theme aims to move beyond hype toward rigorous evidence on where GenAI creates value, where it changes incentives, and where it introduces new failure modes and governance challenges.

Examples of directions:

- GenAI and creativity/novelty (diversification of ideas vs convergence/homogenization)
- AI-mediated persuasion and screening (pitches, investor memos, disclosures, due diligence)
- Agentic systems in markets (faster incorporation of information vs synchronized errors)
- Organizational redesign (new roles, new bottlenecks, control and accountability questions)
- Integrity and risk (manipulation, hallucinated "evidence," feedback loops, governance responses)

"Financial Economics and Information in Markets"

This theme is anchored in core financial economics: how information is produced, diffuses, and becomes reflected in prices and capital allocation. The central interest is market efficiency in a broad sense—when markets incorporate information quickly and accurately, when they underreact or overreact, and which frictions (limits to arbitrage, attention constraints, institutional incentives, trading mechanisms, disclosure quality) shape outcomes. It also includes how risk is priced and managed, and how changes in the information environment—new data sources, evolving disclosure practices, new intermediaries, and regulation—alter beliefs and market dynamics.

A defining feature of modern markets is that "information" is no longer limited to standardized financial reporting. Investors process narratives, text-heavy disclosures, alternative datasets, and real-time signals, creating scope to study credibility, strategic communication, and learning. The theme is intentionally broad and can be applied to equities, fixed income, funds/ETFs, corporate finance outcomes, or cross-asset spillovers. Application areas can range widely; sustainability (including climate or biodiversity finance) is one possible setting among many where measurement and credibility challenges are particularly salient.

Examples of directions:

- Market efficiency and attention (underreaction/overreaction to news, narratives, uncertainty)
- Information quality and disclosure (credibility, strategic communication, investor learning)
- Asset pricing and risk (risk premia, tail risk, liquidity and volatility dynamics)
- Institutional frictions (limits to arbitrage, intermediary incentives, fund constraints)
- One specific application area among many: sustainable finance (incl. Climate, green or biodiversity finance)

Find out more:

https://constructor.university/faculty-member/lennart-ante

https://scholar.google.com/citations?user=689-i20AAAAJ&hl=en

Prof. Dr. Michael Bau (Geochemistry, Geoscience)

Topics:

"Rare Earth Elements and other Critical Metals in South African rivers and lakes: Defining geogenic baselines for the exploration and mining industry"

Field of study: Geochemistry, Economic Geology, Environmental Science

Critical Raw Materials/Metals (CRMs) are the backbones of high-tech products and processes and are hence in dire need for enabling technologies such as electromobility and renewable energy as well as for the aviation, aerospace and defence industries. The exploration and mining of these CRMs as well as their various applications also leave an imprint on the environment and particularly on natural waters of all kind. This need not necessarily be a potential environmental concern to be dealt with in Environmental Impact Studies, but may also be utilised for geochemical exploration. However, while some of these metals are rather easy to analyse in natural waters (e.g., U, Li, Sr), others are considerably more challenging (e.g., REE, Y, Sc, Ga, Ge, Zr, Hf, Ta) and even natural geogenic background concentrations are often not known.
The PhD project offered sets out to determine and evaluate baselines for such elements (with emphasis on REE) in rivers and lakes (and, if possible, groundwaters) in South Africa, with the objective to inform both the mining industry and regulatory bodies. This will require water sampling and on-site measurements in South Africa and subsequent analytical work mostly in Germany and South Africa, and characterization of ambient river and lake sediments. The project, therefore, combines (geo-hydro-)chemistry and geology, and is suited for ambitious students interested to work at the interface between geochemistry, hydrochemistry and geology related to the mining and environmental behavior of CRMs.

Project in cooperation with Bertus Smith (University Johannesburg, South Africa), Dennis Kraemer (Constructor University & BGR, Germany), Andrea Koschinsky (Constructor University, Germany)

"Magneto- and chemostratigraphy of the terrestrial Olenekian to Anisian Burgersdorp Formation (Karoo Supergroup): Documenting environmental recovery following the Permian-Triassic biotic crisis"

Field of study: Geochemistry, Geophysics, Geology

The Burgersdorp Formation of the Karoo Supergroup in South Africa contains a diverse vertebrate assemblage and one of the richest late Early to early Middle Triassic continental biotas globally. It forms part of the global biostratigraphic standard of the continental Triassic and represents a cornerstone of long-range biostratigraphic correlations. It further records the environmental recovery of ecosystems in the wake of the Permian-Triassic mass extinction, possibly including the Smithian-Spathian boundary event, the full recovery of woody trees and the return of coals in the terrestrial stratigraphic record. The Burgersdorp Formation is characterized by Cynognathus Assembladge Zone fauna, which has been divided into three subzones (i.e., A to C) that likely correspond to the late Olenekian, early Anisian and late Anisian, respectively. However, unlike the other biozones of the Beaufort Group, the Cynognathus Assemblage Zone is unconstrained by precise U-Pb zircon ages. The lack of chronostratigraphic control has left the Burgersdorp Formation largely unexplored in terms of its chemostratigraphy despite its rich fossil assemblage. Such a record may document terrestrial paleoclimate variations during the environmental recovery between the extreme climatic pertubations of the Smithian-Spathian boundary event of the Early Triassic and the Carnian pluvial episode of the early Late Triassic. Here we propose to make use of magnetostratigraphy to calibrate the timing of the Burgersdorp Formation and to establish a correlation framework for its bio-, litho- and chemostratigraphic correlation within the Karoo

Basin and beyond. Magnetostratigraphy has successfully been utilized elsewhere within the Karoo Basin to provide higher resolution stratigraphic control for intra-basinal and global correlation of well-established biostratigraphic units. Previosuly investigated units include the early Permian Ecca Group, the Permian-Triassic boundary interval of the Beaufort Group, and the Late Triassic/Early Jurassic Stormberg Group. A preliminary study has confirmed that the red-maroon to red-purple-grey massive mudstones that dominate the Burgersdorp Formation are suitable magnetic recorders that retain a Triassic magnetic polarity record. This preliminary study is also an important control that show that the mudstones were not readily affected by thermal alteration during the widespread emplacement of the Jurassic Karoo Large Igneous Province. The mudstones of the Burgersfort Formation furthermore often contain pedogenic alteration features such as calcretes, calcified rootlets and calcareous nodules that has not yet been systematically targeted for chemostratigraphic studies (i.e., δ13Ccarb). Other important geochemical proxies (e.g., CIA, Ti/Al, K/Al, P/Al, REE anomalies, Sc/Yb) may track changes in weathering processes and terrestrial flux associated with increased humidity or long-term cooling cycles, while mercury (Hg) is a potential proxy for volcanic-driven environmental change during this period.

Project in cooperation with Michiel de Kock (University Johannesburg, South Africa), Dennis Kraemer (Constructor University & BGR, Germany), John Hancox (University Witwatersrand, South Africa), Joachim Vogt (Constructor University, Germany)

Find out more:

Geochemistry — Geosciences | Constructor University

Michael Bau | Constructor University

Prof. Dr. Andreas Birk (Electrical Engineering & Computer Science)

Topic:

“Machine perception in unstructured environments”

Find out more:

https://robotics.constructor.university/
https://scholar.google.de/citations?user=CR5fEFYAAAAJ)

Prof. Dr. Klaus Boehnke (Social Science Methodology)

Topics:

“Social Cohesion”

“Values and Wellbeing”

In both topical fields, Prof. Boehnke has established long-term collaborations with South African partners. Currently, he is leading the South African Social Cohesion Index study for the Inclusive Society Institute in Cape Town and a study on Values and Wellbeing with North West University @ Mafikeng.

The successful candidate will have the opportunity to become affiliated with BIGSSS (Bremen Integrates Graduate School of Social Science and the Research Training Group "Social Dynamics of the Self"
The projects will be co-supervised by Dr. Georgi Dragolov

Find out more:

https://constructor.university/sites/default/files/2024-04/CU%20Research%20Report%202024.pdf

https://constructor.university/faculty-member/klaus-boehnke

Prof. Dr. Hilke Brockmann (Sociology)

Topics:

"Happiness at the End of Life – Learning from Life-Course Data and Digitial Traces"

This project focuses on one of the most profound and least understood questions in social science: What does happiness mean at the end of life, and how can societies support it? While subjective well-being has been studied extensively across adulthood, happiness in the final phase of life remains empirically underexplored, despite its immense ethical, medical, and policy relevance.

The project combines life-course theory with cutting-edge data science to analyze happiness trajectories as individuals approach the end of life. It asks: *How do emotional well-being, meaning, and life satisfaction evolve in the final years and months? What social, relational, and institutional conditions help people experience dignity and peace rather than fear and distress?*

Methodologically, the project is distinctively innovative. It integrates longitudinal survey and panel data, administrative health records, and—crucially—social media and digital trace data. Using natural language processing and machine-learning techniques, the project analyzes how individuals articulate hopes, fears, and wishes related to dying, care, autonomy, and relationships in online spaces. These digital expressions provide rare insights into what people truly want at the end of life, often beyond what is captured in formal surveys or clinical settings.

Advanced econometric techniques (e.g., joint modeling of health decline and well-being, causal inference designs, latent trajectory analysis) are combined with AI-based text analytics to detect patterns of adaptation, inequality, and resilience. This multi-source approach allows for unprecedented triangulation between lived experience, medical reality, and subjective meaning.

A core pillar of the project is its close collaboration with medical experts, including clinicians and palliative-care researchers. This ensures ethically responsible research design, access to high-quality medical data, and direct relevance for end-of-life care practices.

Societal relevance is profound. Aging populations and rising chronic illness make happiness at the end of life a central concern for health systems and welfare states. The project produces evidence that can inform palliative care, communication strategies, and social support policies—helping societies move beyond merely prolonging life toward maximizing well-being at life's end.

For PhD students, this project offers rare interdisciplinary training at the intersection of sociology, medicine, and AI-based social research, with strong publication and career prospects.

"Artificial Intelligence for Good — Gender-Inclusive Design and Female Principles in AI Development and Use"

This project contributes to the field of Artificial Intelligence for Good by addressing a central yet insufficiently studied challenge: the systematic underrepresentation of women in both the development and use of AI—and the consequences this has for AI design, ethics, and social impact.

Rather than focusing on AI as a neutral technology, the project treats it as a social system shaped by power, norms, and gendered knowledge structures. It asks: *How does male dominance in AI development affect design choices, interaction styles, and use cases? How can incorporating female perspectives and care and support-oriented principles lead to more inclusive, ethical, and socially beneficial AI systems?*

Empirically, the project combines state-of-the-art AI methods (e.g., natural language processing, human-in-the-loop learning, algorithmic auditing) with experimental sociology, survey experiments, and behavioral data. One research strand systematically tests how AI systems that integrate relational, empathetic, and context-sensitive interaction principles—often undervalued in male-dominated tech cultures—are perceived and used, particularly by women.

While one dimension of this work may involve nurturing or supportive interaction styles, the project is deliberately broader: it focuses on trust, responsibility, inclusivity, and ethical alignment rather than any single metaphor. The goal is to empirically evaluate whether gender-inclusive design improves AI outcomes for everyone, especially in domains such as health, education, and social services.

The project is embedded in a strong international collaboration with colleagues from Estonia, France and Sweden.

The social and professional relevance is substantial. As AI increasingly shapes everyday life, ensuring that it reflects diverse values is essential for legitimacy and effectiveness. For PhD students, the project offers high-level training in AI-based methods, gender theory, and international collaboration—skills that are highly sought after in academia, policy, and industry.

"Innovate Immigration — Technological Pathways to Faster Integration, Higher Productivity, and Immigrant Well-Being"

This project rethinks immigration and integration through a technological lens, asking how digital infrastructures, AI-based tools, and platform technologies can accelerate immigrants' integration into host societies while increasing productivity, innovation, and subjective well-being. Moving beyond traditional explanations centered on skills, legal status, or language alone, the project conceptualizes integration as a tech-enabled social process shaped by access to information, digital public services, and data-driven matching mechanisms.

The core research questions are: *Which technological conditions help immigrants integrate more quickly into labor markets and social life? How do digital tools affect migrants' productivity, earnings trajectories, and happiness? Under what institutional settings does technology reduce—rather than reproduce—inequality?* By addressing these questions, the project positions technology as a complementary integration resource, alongside education, legal frameworks, and social networks.

Empirically, the project uses large-scale administrative data, linked employer–employee datasets, surveys, and digital trace data, combined with state-of-the-art econometric and AI-based methods. Key technologies under study include AI-driven job-matching platforms, digital credential recognition systems, language-learning apps, wearables, e-government services, and online professional networks. Machine-learning models are used to identify causal pathways linking technology use to employment speed, occupational mobility, innovation outcomes (e.g., patents, start-ups), and well-being indicators.

A distinctive feature of the project is its international comparative design. In addition to European cases, the project includes a collaboration with researchers in Australia, a country with extensive experience in digital migration governance and skill-based immigration systems. This comparison enables analysis of how different technological ecosystems and policy regimes shape integration outcomes and immigrant happiness.

Institutionally, the project is embedded in close cooperation with the Bremen Graduate School of Social Sciences, offering PhD students an outstanding interdisciplinary training environment. This includes advanced methods courses in econometrics and AI, strong links to policy research, and an international academic network.

The societal relevance of the project is immediate. As societies face demographic aging, labor shortages, and political polarization around migration, evidence on how technology can make integration faster, fairer, and more humane is urgently needed. By identifying technological conditions that enhance productivity *and* well-being, the project contributes to more effective immigration policies and inclusive digital welfare states.

Find out more:

https://constructor.university/faculty-member/hilke-brockmann

https://scholar.google.com/citations?hl=en&user=PS_BqiEAAAAJ

https://www.bigsss-bremen.de/

Dr. Stanislav Chankov (Industrial Engineering and Management)

Topic:

"Sustainable Consumer Behavior"

Find out more:

CU Research Report 2024.pdf (constructor.university)

Prof. Dr. Fabian Dehos (Economics)

Research topics are centered on health, labor, and family economics, with a particular focus on risky behavior and causal mediation analysis.

Topics:

"Causal effects and interdependencies of education and addictive behavior during adolescence and young adulthood on health later in life."

"Peer effects among teenagers and their impact on alcohol consumption, using quasi-experimental research designs."

"Early childhood exposure to animals and its long-term effects on immune function, using quasi-experimental research designs."

Students may also propose their own project ideas and research questions if they fall within the specified thematic scope, and if they are willing to apply quasi-experimental research designs.

Find out more:

Fabian T. Dehos | Constructor University

Prof. Dr. Omid Fatahi Valilai (Industrial Engineering and Management/ Information Science / Information Systems and Management)

Topics:

"AI- and Blockchain-Enabled Extended Producer Responsibility: Digital Product Passports, Incentives, and Auditable Compliance"

""Live" Customer Requirement Digital Twins via Multimodal Social Media Analytics for Sustainable Product Design and Additive Manufacturing"

"Autonomous Drone–Ground Cooperative Logistics with Moving Charging Infrastructure: Optimization, Simulation, and Governance"

"Digital-Twin-Driven Smart Energy Management in Factories: Web3-Enabled Data Sharing and Reinforcement Learning for Demand Flexibility"

"Interoperable Supply Chain Data Spaces: Ontology- and Knowledge-Graph-Based Traceability for Circular Manufacturing"

Find out more:

https://sites.google.com/view/fatahivalilai-omid/home
https://scholar.google.com/citations?hl=en&user=mgmtS-4AAAAJ
https://eitie.tech/

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Prof. Dr. Giuseppe Thadeu Freitas de Abreu (Wireless Communications and Signal Processing)

Topics:

"Quantum Technologies for Wireless Systems: Receivers, Algorithms and Coding"

Over the last several decades, the Information and Communications Technologies (ICT) sector has given the world innovations ranging from airplanes and satellites to computers and smartphones, and most recently to autonomous vehicles and artificial intelligence. All such significant tools rely on wireless communications and signal processing technologies, which enable information to be transmitted efficiently, received reliably, stored safely, and utilized effectively by the various components of systems of highly complex designs. In turn, all these tools and technologies build fundamentally on digital architectures, whereby information is exchanged and manipulated in the form bits, which in electronic chips ultimately translate to charges, each in a mutually-exclusively state of 0 (lower or negative) or 1 (higher or positive), captured in semiconducting material. All this is about to change substantially with the imminent switch to quantum architectures, whereby quantum effects are exploited to enable the storage and manipulation of information in the form of quantum bits (qbits), which are kept in a superimposition of 0 and 1 states, until observed [1]. This project is about the study of quantum technologies applied to the design of receivers, optimization algorithms and coding schemes.

[1] N. Ishikawa, G. Abreu, P. Popovski, and R. Heath Jr, "Quantum-Accelerated Wireless Communications: Concepts, Connections, and Implications" https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=11278576

"Continuous Aperture Arrays (CAPA) and Wireless Metasurfaces: Models and Optimization"

Devices operating any of the current wireless communications systems, from Bluetooth to WiFi, to cellular, to TV and radio, to satellite systems, utilize antennas that are in the form of either a single element (think of a parabolic satellite antenna, or old telescopic antenna of old radios) or a discrete set (known as an array) of such elements (think of the set of two antennas of typical WiFi routers). Under the paradigm of such discrete radiation structures, each element of the antenna array is connected to its own cascade of circuitry referred to as a radio frequency (RF) chain, which includes filters, amplifiers, frequency converters, etc. and are used either to excite the element for transmission, or to detect incoming signals for reception, typically integrated (at the expense of additional circuitry) to enable a coordinated operation of the entire array as a single system. Motivated by the need for higher data rates, as well as emerging sensing applications, there is a trend in future wireless systems towards the utilization of higher frequencies, which offer not only wider bandwidths for data, but also finer spatial resolution that yields more accurate sensing. Due to the resulting smaller size of individual elements and the harsher propagation environment at high frequency bands, however, this trend is concomitant with the consequent massification of the number of antennas in each device, towards the vision of massive and gigantic Multiple Input Multiple Output (MIMO) systems, which in turn implicate in larger hardware costs, under the current discrete paradigm. In order to mitigate the latter challenge, much effort has been made to develop an entirely new concept of radiating structures for wireless systems, based on the utilization of meta-materials that enable the construction of continuous aperture arrays (CAPA) [2,3]. This project is about the development of theoretical models and the design optimization of such modern radiating structures for future wireless systems.

[2] Z. Wang, K. Ranasinghe, G. Abreu, and Y. Liu, "Mutual Coupling in Continuous Aperture Arrays: Physical Modeling and Beamforming Design" https://arxiv.org/pdf/2511.11225

[3] K. Ranasinghe, J. An, I. Morales, H. Rou, G. Abreu, C. Yuen and M. Debbah, "Flexible Intelligent Metasurfaces in High-Mobility MIMO Integrated Sensing and Communications" https://arxiv.org/pdf/2507.18793

"Intelligent Sparse Array Design for Massive and Gigantic MIMO (mMIMO/gMIMO) Systems"

As an earlier alternative means to also lower the hardware costs of mMIMO and gMIMO systems, prior to the introduction of metamaterials and the development of CAPA systems, it is also possible to consider the optimized sparsification of discrete array structures, for example, based on a site-specific coverage, requirements and user distributions [4]. Due to the discrete nature of conventional arrays, however, this alternative is challenged by the consequently combinatorial nature of the underlying optimal design problem. This project is about the formulation and solution of discrete optimization problems aimed at the design of sparse arrays for mMIMO and gMIMO systems.

[4] E. Björnson, A. Irshad, Ö. Demir, A. Kosasih, G. Abreu and V. Petrov, "From Antenna Abundance to Antenna Intelligence in 6G Gigantic MIMO Systems"

"Waveform Design for Integrated Sensing and Communications (ISAC) Systems"

One of the key innovations introduced with the fourth generation (4G) of cellular systems was to enable the location of smartphones to be estimated, mimicking the functionality of the global navigation satellite network (GNSS), but with basis on the wireless signals of the public telephone network itself. That functionality, later improved with the deployment of the fifth generation (5G) of cellular systems, quickly became one of the most used features of smartphones, with location-based services (LBS) amassing a market of USD 31.17 billion in 2024. The next (sixth) generation (6G) of cellular systems, will continue this trend of adding new functionalities via the introduction of sensing capabilities to the cellular platform, giving raise to the paradigm of integrated sensing and communications (ISAC) systems. This notion requires, however, that the signals transmitted both by user devices and base stations have waveforms designed to enable the harmonious coexistence of both functionalities, under the distinct performance criteria and environmental conditions of the sensing and communications objectives. This project is about the design of such 6G ISAC-enabling waveforms, examples of which are Affine Frequency Division Multiplexing (AFDM) [5] and Affine Filter Bank Modulation (AFBM) [6].

[5] H. Rou, K. Ranasinghe, V. Savaux, G. Abreu, D. González, and C. Masouros, "Affine Frequency Division Multiplexing (AFDM) for 6G: Properties, Features, and Challenges" https://arxiv.org/pdf/2507.21704

[6] K. Ranasinghe, H. Senger, G. Gonçalves, H. Rou, B. Chang, G. Abreu, and D. Le Ruyet, "Affine Filter Bank Modulation (AFBM): A Novel 6G ISAC Waveform with Low PAPR and OOB" https://arxiv.org/pdf/2509.05683

"Integrated Communications, Sensing and Computing (ISCC): Transceiver Design"

Besides the integration of sensing yielding ISAC as described above, another trend for future wireless systems is the integration of computing functionality, yielding ISCC systems [7], which aim in particular to support the advancement of networked artificial intelligence (Net-AI). Indeed, unlike human users, machines can take advantage of the additive nature of the wireless channel, where electromagnetic waves at the same frequency are combined at the receiver. Exploiting this feature, nomographic functions of multiple variables can be computed "over the air" merely by the simultaneous transmission of signals from various sources, received by a common station. When integrated with communications and sensing functionalities, however, over-the-air computing (OTAC) must deal with interference from the corresponding

information-carrying and sensing-enabling signals. This project is about the design of transceivers that achieve Pareto optimality among the three competing functionalities of ISCC systems.

[7] K. Ranasinghe, K. Ando, H. Rou, G. Abreu, T. Takahashi and Marco Di Renzo "A Flexible Design Framework for Integrated Communication and Computing Receivers" https://arxiv.org/pdf/2506.05944

Find out more:

https://scholar.google.com/citationshl=en&user=_TUWOm-YAAAAJ&view_op=list_works&sortby=pubdate

https://pages.constructor.university/abreugroup/

Prof. Dr. Isak Frumin (Higher Education)

Topics:

"Role of universities in responding to global challenges in area of environmental sustainability"

"Adoption of Generative Artificial Intelligence in higher education and research"

"Innovations in higher education"

The projects will be co-supervised by Prof. Dr. Lattemann

Find out more:

https://constructor.university/research/school-business-social-decision-sciences/observatory-higher-education-innovations

Prof. Dr. Ben Godde (Neuroscience)

Topics:

"Investigations on the neural mechanisms underlying the associations between creative and cognitive functions in older adults and development of interventions for healthy and productive aging."

Cognition and creative divergent thinking share some executive control functions, such as inhibition control. This project aims at gaining a better understanding of the underlying neural mechanisms. It is further proposed that, based on these associations, training in either dimension – cognition or creativity – could facilitate performance also in the other dimension. The development of respective training interventions would be particularly relevant for older adults with age-related decline in executive functions.

"Embodiment of golf clubs in novice and expert golfers: Plasticity of the body schema and the emergence of ownership and agency"

Our ability to effectively use tools is crucial for interacting with the environment. Research has consistently shown that expertise in tool use is associated with a phenomenon known as tool embodiment. The embodiment phenomenon implies that when individuals can effectively manipulate tools, the body representation is adapted in a way that these tools are perceived as extensions of their own bodies, thus fostering enhanced senses of ownership and agency over them. While there is a vast amount of evidence for tool embodiment from simplistic reaching, grasping or raking tasks, it is unclear whether these effects generalize to more complex, naturalistic tool-use scenarios. With this project we aim at contributing to the research on neural and behavioral correlates of tool embodiment and how it is related to performance in the demanding and highly skilled domain of sports. In sports like tennis, hockey, or baseball, a tool, i.e., the racket, is used to manipulate an object, i.e., to hit a ball so that the ball moves with a certain velocity and trajectory to an intended target. We will particularly focus on the embodiment of golf clubs in golfers. The results of this project will contribute significantly to a more comprehensive understanding of how humans interact with tools, particularly in the domain of racket sports. This knowledge can have implications for training methodologies, rehabilitation strategies, and, more generally, the design of tools to enhance human performance and tool interaction.

“Prediction of online and offline effects of transcranial direct current stimulation on tactile learning by individual differences in EEG activity and tactile performance”

Tactile perceptual learning—the improvement of tactile discrimination abilities through experience or training—is fundamental to sensory rehabilitation and skill acquisition. Non-invasive brain stimulation (NIBS) techniques, such as transcranial direct (tDCS) or alternating (tACS) current stimulation, have emerged as promising tools to modulate cortical excitability and plasticity in the somatosensory cortex (SI), thereby enhancing tactile perceptual learning. The combination of NIBS techniques with behavioral interventions has revealed potential in promoting neuroplasticity and learning (Karim, ..., Godde, J Cogn. Neurosci. 2006). In a meta-analysis, we confirmed considerable effects of tDCS on tactile perception by targeted enhancement or attenuation of excitability in the cortical areas involved in somatosensation, however, the results of these studies are inconclusive and divergent results have been found for a number of different tactile tests, for example, detection and spatial, temporal, or amplitude discrimination tasks (Khalil, Karim, Godde, 2023). Besides differences in experimental protocols or different target regions, individual variations might also contribute to the variability observed in studies utilizing tDCS for enhancing tactile perception. Contributing to this ongoing discussion, in this study we will further examine the effectiveness of tDCS and tACS in operant tactile learning. In particular, we will compare the effects of tACS and tDCS on tactile perception and learning. As it seems plausible that reported inconsistencies in the effects of transcranial electrical stimulation on tactile performance and learning might be related to individual differences in baseline brain activity and learning thresholds, we will further investigate the predictive role of individual brain oscillation patterns for effects of tDCS and tACS on tactile learning.

Find out more:

https://constructor.university/faculty-member/benjamin-godde

https://www.researchgate.net/profile/Ben-Godde

Prof. Dr. Igors Gorbovickis (Mathematics)

Topics:

“Holomorphic Dynamics: renormalization of circle maps or Lorenz maps.”

“Rigorous numerical estimates of the Hausdorff dimension of Julia sets.”

Find out more:

Igors Gorbovickis | Constructor University

Complex Dynamical Systems | Constructor University

Dr. Mahdi Homayouni (Industrial Engineering and Management)

In the Sustainable and Resilient Operations Management (SROM) group, we work at the intersection of Advanced Optimization and Artificial Intelligence to design the next generation of industrial and service systems that are not only efficient but fundamentally sustainable and resilient. By combining the mathematical rigor of Operations Research with modern data-driven AI tools, we develop decision-support methods to solve complex operational challenges in manufacturing and logistics. We turn real-world complexity into actionable, sustainable strategies.

Research topics are motivated by real-world challenges in manufacturing, logistics, and service operations, with a strong emphasis on methodological rigor and practical relevance. PhD candidates are expected to work at the intersection of theory and application, contributing novel methodological insights while addressing relevant industrial problems.

Topics:

“Sustainable Operations Scheduling“

Design of multi-objective optimization models that balance economic performance with environmental and social sustainability metrics in production and logistics systems.

“Resilient Operations and Disruption Management“

Modeling and optimization of operations systems that can anticipate, absorb, and recover from disruptions, with applications in supply chains and industrial operations.

“AI-Enhanced Scheduling and Planning under Uncertainty”

Development of hybrid optimization frameworks that integrate metaheuristics with machine learning to improve robustness and adaptability in dynamic and uncertain operational environments.

“Learning-Guided Metaheuristics”

Development of learning-based methods to decompose large-scale combinatorial optimization problems and steer the search process toward promising regions of the solution space.

Typically, one will adjust things towards the interest of the candidates, too.

Find out more:

https://www.linkedin.com/in/mahdi-homayouni-96338244/

https://sites.google.com/view/srom-research-group/home?authuser=0

Prof. Dr. Marc-Thorsten Hütt (Computational Systems Biology)

Topics:

"Network-based interpretations of high-throughput data in human diseases"

Network medicine, a research field where networks are used to analyze medical high-throughput data, is based on the idea that the mapping of (e.g., gene expression) data onto a biological network can reveal the underlying biological mechanisms of the disease at hand.

In this project we want to establish a quantitative, reliable and well-calibrated method for evaluating the agreement between a set of genes and a given biological network. The gene sets can be obtained, for example, as the differentially expressed genes in a transcriptomics experiment or as disease-associated genes derived from GWAS data.

Relevant biological networks to be investigated here are metabolic networks and protein-interaction networks.

Further reading:

Jablonski, K.P., Carron, L., Mozziconacci, J., Forné, T., Hütt, M.-Th. and Lesne, A. (2022) Contribution of 3D genome topological domains to genetic risk of cancers: a genome-wide computational study. Human Genomics 16(1), 1–15.

Knecht, C., Fretter, C., Rosenstiel, P., Krawczak, M., and Hütt, M. T. (2016). Distinct metabolic network states manifest in the gene expression profiles of pediatric inflammatory bowel disease patients and controls. Scientific Reports, 6(1), 32584.

Sonnenschein, N., Golib Dzib, J.F., Lesne, A., Eilebrecht, S., Boulkroun, S., Zennaro, M.C., Benecke, A., and Hütt, M.-Th. (2012) A network perspective on metabolic inconsistency. BMC Syst Biol 6, 41.

"Development and analysis of stylized models of the human microbiome"

With an increasing understanding of the relevance of microbial communities, not only in the human body, but in many ecosystems, there is a high demand for algorithms capable of inferring interaction networks from microbial abundance patterns. An interesting conceptual aspect in this field is, whether network information is rather contained in the presences and absences observed in microbial abundance data (binary view) or in the population sizes and microbial counts (quantitative view). My group has pioneered the binary (presence-absence) approach to the inference of microbial interaction networks and its application to the human microbiome. In this project our main tools, ESABO and EDAME, are to be further developed and applied to data from the Human Microbiome Project.

An important modeling tool for the method development are Random Boolean Networks and their attractors. These models will be used to generate data with a 'ground truth' (the underlying network) to evaluate the performance of new inference methods.

Further reading:

Claussen, J. C., Skieceviciene, J., Wang, J., Rausch, P., Karlsen, T. H., Lieb, W., Baines, J. F., Franke, A., and Hütt, M.-T. (2017). Boolean analysis reveals systematic interactions among low-abundance species in the human gut microbiome. PLoS Computational Biology, 13(6):e1005361.

Mendler, I. H., Drossel, B., and Hütt, M. T. (2024). Microbiome abundance patterns as attractors and the implications for the inference of microbial interaction networks. Physica A 639, 129658.

Jyoti, J. and Hütt, M.-Th. (2025). Evaluating changes in attractor sets under small network perturbations to infer reliable microbial interaction networks from abundance patterns. Bioinformatics, 41(4), btaf095.

"Simultaneous analysis of disease transcriptomes via machine learning and network science: A case study for Crohn's disease"

Using artificial intelligence (AI) or machine learning to interpret high-throughput data (e.g., gene expression or 'transcriptomics' data) has yet to yield dramatic insight in disease mechanisms and diagnosis. A drastically different approach is to map the data onto a biological network and interpret the distribution characteristics. In this project the two approaches will be compared in detail for one disease, an inflammatory bowel disease called Crohn's disease, for which a range of gene expression data are available. Beyond better understanding this disease, the bigger goal of this case study is to explore, whether the joint application of AI and network analysis can provide insight in the disease mechanisms, which each individual approach cannot achieve.

As an example of a joint application, features selected by machine learning devices during training, e.g., to successfully discriminate patients and healthy controls, will be interpreted by mapping them onto existing biological networks. At the same time data preprocessing via network clustering and network propagation will enhance the performance of machine learning in spite of the typically very small size of the data sets.

Further reading:

Knecht, C., Fretter, C., Rosenstiel, P., Krawczak, M., and Hütt, M. T. (2016). Distinct metabolic network states manifest in the gene expression profiles of pediatric inflammatory bowel disease patients and controls. Scientific Reports, 6(1), 32584.

Find out more:

https://sysbio.constructor.university/

https://constructor.university/faculty-member/marc-thorsten-hutt

Prof. Dr. Torsten John (Chemistry)

Topics:

"Nanomaterials to Inhibit Amyloid Self-Assembly (Biophysical Chemistry)"

The misfolding and self-assembly of peptides into amyloid fibrils is a hallmark of numerous neurodegenerative diseases, but amyloid formation is also increasingly exploited in functional biomaterials. Controlling peptide self-assembly therefore represents a central challenge at the interface of chemistry, biology, and materials science. This project aims to develop and characterize nanoscale and molecular tools that

modulate amyloid formation, with a particular focus on inhibiting or redirecting fibril growth. The PhD project will pursue an experimental strategy combining peptide chemistry, nanomaterials design, and biophysical characterization. The central hypothesis is that rationally designed nanoparticles or functionalized materials can interfere with key steps of amyloid nucleation, elongation, or secondary processes by exploiting multivalency, surface chemistry, and specific molecular interactions. Candidate materials may include functionalized nanoparticles, peptide-based inhibitors, or hybrid bio-nanomaterials.

The project will involve the functionalization of materials, followed by systematic studies of their interaction with amyloidogenic peptides. A range of biophysical techniques will be employed to monitor peptide aggregation kinetics and morphology, such as fluorescence assays and spectroscopy. Particular emphasis will be placed on quantitative analysis of aggregation pathways and on establishing structure-function relationships between material properties and inhibitory activity. Beyond inhibition, the project may explore how nanomaterials can redirect amyloid formation into non-toxic or structurally distinct assemblies, thereby contributing to a more fundamental understanding of peptide self-assembly landscapes. The work is embedded in a broader research program on biomolecular self-assembly and interfaces, offering opportunities to connect experimental findings with theoretical and computational models developed within the group and through collaborations.

The PhD candidate will receive interdisciplinary training in experimental physical chemistry and biophysical analysis. The project is well suited for motivated students with a background in chemistry, biochemistry, materials science, or related fields, and an interest in experimental laboratory work at the interface of chemistry and biochemistry. The results are expected to contribute both to fundamental insights into amyloid self-assembly and to the development of novel strategies for controlling pathogenic aggregation processes.

“Molecular Mechanisms of Amyloid Peptide Interactions with Membranes (Computational Chemistry)”

Amyloid peptides are widely studied for their role in neurodegenerative diseases, where their interaction with cellular membranes is believed to be a key determinant of toxicity. Despite extensive experimental evidence for membrane disruption, the molecular mechanisms underlying amyloid-membrane interactions remain incompletely understood. This PhD project aims to elucidate how amyloidogenic peptides interact with lipid bilayers at the molecular level, using state-of-the-art molecular simulation techniques. The project will employ atomistic and coarse-grained molecular dynamics simulations to study the structure, dynamics, and energetics of amyloid peptides at membrane interfaces. Key questions include how peptide sequence, aggregation state, and membrane composition influence binding, insertion, oligomerization, and membrane perturbation. The work will focus on model amyloid peptides but will be framed broadly to identify general principles governing peptide-membrane interactions.

Computationally, the student will construct and simulate peptide-membrane systems of increasing complexity, starting from single peptides and progressing to small oligomers and protofibrillar assemblies. Simulations will be complemented by advanced analysis methods to quantify peptide orientation, secondary structure, lipid perturbation, and free-energy profiles. Where appropriate, enhanced sampling techniques will be applied to access relevant timescales and rare events. A distinctive feature of the project is its strong connection to experimental biophysical chemistry. Simulation results will be interpreted in the context of experimental data from the literature and from ongoing work, enabling cross-validation and hypothesis generation. The ultimate goal is to develop a mechanistic framework that links peptide self-assembly in solution with membrane activity and toxicity.

The PhD candidate will receive thorough training in molecular dynamics simulations, Linux-based high-performance computing, and data analysis, as well as in the physical chemistry of biomolecular interfaces. The project is particularly suited for students with a background in chemistry, physics, computational science, or related disciplines, who are interested in biomolecular modeling and interdisciplinary research. By providing molecular-level insight into amyloid-membrane interactions, this work will contribute to a deeper understanding of amyloid toxicity and may inform the rational design of strategies to mitigate harmful peptide-membrane interactions.

Find out more:

https://johnlab.de/

https://constructor.university/faculty-member/torsten-john

https://scholar.google.com/citations?user=hImRPqoAAAAJ&hl=en

Prof. Dr.-Ing habil. Mojtaba Joodaki (Electrical Engineering)

Cutting-edge research in flexible/additive electronics, high-frequency circuits, sensors, semiconductor memories, metasurface antennas, solar cells and energy harvesting

Overview

Nanoelectronics is a major technology boomer in the 21st Century, with many current applications and enormous potential to alter humanity's future in areas such as electronics, computers, information technology, aerospace defence, and consumer goods. Our research interests lie at the interface of applied electromagnetics, high-frequency engineering and nanoelectronics (materials & devices). We focus on developing devices, circuits and systems for memories, sensors, energy harvesting, communications and biomedical applications.

Specific themes and goals

Organic solar cells characterization and modelling — In recent years, there have been impressive breakthroughs to enhance the structure of organic solar cells (OSCs) in order to improve the performance. The power conversion efficiency of polymer solar cells has increased from 3% in 2001 to 18.2% in 2021, and these thin, flexible, eco-friendly and low-cost photovoltaic devices are promising for a wide range of applications, such as the Internet of Things, sensors and wearable electronics. Theoretical analyses and characterizations of OSCs are of great scientific and economic value. We have undertaken valuable work in this area, with our results published in several high-impact journals.

Thin-film microwave, mm-wave and THz devices — Flexible and non-flexible thin-film electronic components are key to improving people's quality of life. Such devices can be used on infrastructure, vehicles and the human body for control, monitoring and energy harvesting purposes. They can also be cheap to make. For example, flexible substrates, such as plastic, are cheaper compared to crystal wafers like silicon wafers. Thin-film sensors and energy harvesters are two important building blocks of electronic circuits and systems, and these are interesting topics of future research, complementing our expertise. In addition, we are very eager to work on low-cost wireless sensors or antennas for medical and Internet of Things (IoT) applications.

Electromagnetic shielding — In the field of electromagnetic compatibility (EMC), shielding is becoming an increasingly important topic, as our technology and circuitry becomes more sensitive and

sophisticated. However, shielding requires air ventilation, input/outputs and other means of connections between either side of the shields, and these gaps cause emission leakage and degraded shields. Recently, our research group has undertaken successful shielding analyses and measurement of metal enclosures with apertures on different walls. We developed a method of calculating shielding effectiveness (SE) with respect to a metallic enclosure with arbitrary shape apertures on different walls. With our method, there is no need for antennas and reverberation chambers.

Hetero-integration and packaging of microwave and optical devices — This area of research consists of three parts. The first technological part focuses on implementing techniques in micro and nano electromechanical systems techniques. The goal is to integrate high power μ-wave or optical devices based on different materials into a single substrate. The second part deals with the electrical, optical, electro-thermal, and electro-thermo-mechanical characterising and measuring integrated devices, as well as an investigation of packaging environmental effects on their electrical and optical behaviours.

Flexible electronics especially high frequency flexible devices and circuits: Although electronic circuits are often firm and rigid, some may need to be bent to fit into a particular product while some others may need to undergo continuous flexing if they are moving parts. Specifying the flexible circuit materials and characterising them for microwave and mm-wave applications are vital for their development. Therefore, we are investigating the flexibility and mechanical properties of circuit materials to determine the extent to which a circuit board can tolerate bending and flexing.

Metasurface antennas and reconfigurable intelligent surfaces: In order to control the amplitude, phase, and polarization of the electromagnetic (EM) wave, specific materials are often employed. The EM properties of the materials derived from the periodic table of elements are in a certain range of values, which is in association with various factors e.g., the operation frequency. This limitation of the ordinary material leads to the limitation of wave-matter interaction. However, the artificially engineered materials, often named metamaterials, generate opportunities for researchers in both physic and engineering communities to extend the range of values beyond what Nature has provided for us. The subwavelength meta-atoms, scattering particles of the metamaterial, embedded in a host medium can be designed in desired ways, leading to extreme wave manipulation performance. Due to the decrease in the loss, profile size and several fabrication challenges of voluminal metamaterials, the two-dimensional counterparts of the metamaterials, termed metasurface, are mostly employed and provided with an unprecedented opportunity in manipulating the phase, amplitude and polarization of the EM wave. The metasurface has garnered special attention as it can engineer the wireless communication channel with advances in low-weight, low-size and low-power consumption equipment, etc. Recently, metasurfaces have been used to affect the classic antennas in many ways to miniaturize the antenna size. Also, they can enhance the radiation performance of the antenna. Besides, metasurfaces as an effective medium can be employed to increase the antennas' gain.

RRAM (resistive random-access memories) cell for in-memory computation: Traditional von Neumann architecture suffers from two major bottlenecks: the gap between CPU performance and memory speed, i.e. "memory wall'' and the power consumption due to the data transmission on the bus that has far exceeded the power needed for the calculation itself. A realistic answer to these bottlenecks is computing-in-memory architecture that is advantageous in speed matching and multifunctional logic operations. However, although this architecture significantly reduces the data transferring between the memory unit and CPU, technological integration of memory and processing poses new challenges. For example, the use of computing-in-memory enables neuromorphic systems to operate with low power consumption and high parallelism, making them well-suited for many applications. A hybrid memory cell can combine the properties of volatile, nonvolatile and WORM (write once read many times) memory cells offering more

advantages including data integrity and versatility. For example, volatile RRAM (resistive random-access memories) can emulate short-term memory (STM) function of human nervous system and nonvolatile RRAM can emulate long-term memory (LTM) function. Therefore, possibility of integrating different types of RRAM in a single cell is a critical step for development of neuromorphic systems.

Find out more:

Mojtaba Joodaki | Constructor University
Nanoelectronics | Constructor University

Prof. Dr. Arvid Kappas (Psychology)

Topics:

"Human-Robot Interaction"

I am very much interested in how humans and robots may interact – this refers to how the technology can be made more fitting to human needs and expectations, and how robots might act more flexibly to different contexts and user states. Humans tend to interpret the behavior of robots as a result of internal states resembling humans or animals. There are cultural differences in these processes. Very little is known regarding how robots are perceived in African cultures

"The function of facial expressions in interaction"

In the US and Europe there is great interest in the nonverbal expression of emotional states, particularly in the face. However, certain recent studies suggest that a) expressions are less a readout of how people feel, and more related to social goals, b) the expressions of so-called basic emotions are less universal than the most well-known theories predict, non-western cultures interpret expressions, such as the smile in different ways. The goal of this research is to follow up on these recent studies regarding facial expression and interpretation of interpretations in different cultures.

"Regulation of emotion"

While emotions in many cultures are seen as something that happens to someone, individuals have considerable influence over their emotions. In fact, they actively regulate how they feel and react through various strategies. Little is known about how universal these strategies are. (no clinical psychology)

Find out more:

Arvid Kappas |Constructor University
Social Psychology Network

Prof. Dr. Stefan Kettemann (Complex Systems)

Complex Systems are composed of many constituents which interact with each other, such as technical systems like power grids or quantum computers, physical systems like quantum spin systems or quantum glasses and natural systems like ecosystems. The interactions between the constituents can give rise to new, emergent phenomena with properties very distinct from their individual constituents. Complex systems can be modeled by networks where nodes represent the constituents and links the interactions. This network perspective on complex systems often reveals transfer insights between different disciplines. In

our research group we focus on Complex Quantum Systems, where the constituents of the networks are quantum objects, like spins, tunneling systems or quantum devices, and novel phenomena emerge, like heavy fermion physics, many body localization or exotic superconductivity.

Topics:

"Quantum Entanglement Dynamics of long range interacting QBit systems: Machine Learning Enhanced Renormalization Group Methods "

"Complex Dynamics of Power Systems: Geometric Frequency Models "

"Majorana Fermions at the BCS- BEC Crossover: From analytical to numerical theory"

"Quantum Phase Diagram of dilute Kondo lattice systems"

Find out more

https://www.pks.mpg.de/heraeus26 (slides of invited talk at South African-German Workshop on Quantum Dynamics)

https://constructor.university/faculty-member/stefan-kettemann

Prof. Dr. Ulrich Kleinekathöfer (Computational Biophysics)

Topics:

"Studying the excitation energy transfer in the light harvesting of plants and diatoms"

Photosynthesis is a natural process that relies on the harvesting of solar energy and its transformation into chemical energy to sustain life. Common design principles exist in the organization of the photosynthetic apparatus especially in green plants and algae, like the diatoms. Solar energy is first captured by pigments such as chlorophylls and carotenoids that are bound to light-harvesting complexes. The aim of this project is to apply state-of-the-art computational approaches to simulate the photo-initiated excitation energy transfer in light-harvesting systems, purely based on atomistic grounds.

"Molecular dynamics simulations of transport through nanopores"

Due to their role in many biological processes as well as their (prospective) technological applications, biological nanopores have been the focus of numerous studies. Recent studies on nanopores have addressed two key areas: antibiotic permeation through bacterial channels and analyte sensing. Aim of this project is to simulate the permeation through bacterial pores which are interesting for both of these areas using molecular dynamics and machine learning techniques.

"Computational Approaches for the Development of Drugs Targeting Antimicrobial Resistance"

The offered project, supervised by Profs. Windshügel and Kleinekathöfer is for a student interested in applying computational techniques (molecular docking, molecular dynamics simulations) for the identification and characterization of novel compounds targeting efflux pumps that fastly remove antibiotics from the bacterium, representing an important mechanism of antimicrobial resistance. Our aim is to develop compounds that switch off these pumps which results in improved efficacy of antibiotics. This project is a

continuation of recently finished work (https://www.jpiamr.eu/projects/reset-me/) and is done in close co-operation with Fraunhofer ITMP in Hamburg. The institute will provide comprehensive experimental support (e.g., https://pubmed.ncbi.nlm.nih.gov/37371580/), thereby enabling validation of the compounds identified by the student. Based on the experimental data, the student can improve his/her models that may result in the identification of more potent inhibitors.

Prof. Björn Windshügel applies computational techniques for the identification of substances that serve as starting points for the development of novel drugs. Prof. Ulrich Kleinekathöfer (https://constructor.university/comp_phys) uses computational simulations to understand molecular processes on an atomic scale.

Joint project with and Professor Dr. Björn Windshügel (Computational Drug Discovery)

Find out more:

Ulrich Kleinekathöfer | Constructor University

https://constructor.university/comp_phys

Prof. Dr. Ulrich Kortz (Chemistry)

Topics:

"Synthesis of noble metal-oxo clusters and study of their catalytic properties"

This research project will encompass the synthesis of novel palladium-oxo and platinum-oxo clusters, their complete structural characterization in the solid state, solution and gas phase, followed by catalytic studies in the areas of hydrogenation and oxidation of suitable organic substrates. Such project has academic, but also applied impact, as we have been sponsored by the German Research Council (DFG) and the chemical industry over the years.

Find out more:

https://thepomlab.de/

Ulrich Kortz | Constructor University

Functional Inorganic Materials: Synthesis, Characterization, and Catalysis | Constructor University

research report

Prof. Dr. Andrea Koschinsky (Geosciences)

Topics:

"The role of physical and chemical speciation on the biogeochemical cycles of the key trace metals iron and copper in different marine environments"

Trace metals such as iron and copper play a fundamental role in the biochemical cycles including bioproductivity in the ocean; they can be essential micronutrients, such as iron, manganese, zinc, cobalt and copper, but some of them can also be toxins above a certain threshold value, such as copper. These functions do not only depend on the concentrations, but also on the physical (dissolved, colloidal or particulate) and chemical (free or complexed ion) forms (i.e., their speciation) at which they are present in the

marine environment. Organic molecules binding to the metals, thus forming stable organic metal complexes, play a fundamental role in trace metal speciation, and microorganisms can even produce such molecules to mitigate metal availability. However, the knowledge on marine trace metal speciation is still limited and it deserves more attention to understand the implications of global changes on the health and productivity of our oceans.

Through a large number of research cruises as part of the international GEOTRACES program and other cruises, we have acquired unique trace-metal clean samples (preserved in frozen state) to study the speciation of iron and copper in the open ocean and at various marine interfaces, such as estuaries, the sediment - seawater boundary, and hydrothermal plumes. Our lab is well equipped with several voltametric devices to investigate the role of organic complexation for iron and copper in the various marine settings, and the relevant methods are established. We suggest a PhD project to study the role of physical and chemical speciation of copper and iron on their bioavailability and toxicity, respectively (for copper) in estuaries, in coastal regions influenced by terrestrial dust input, and in hydrothermal plumes as interfaces between hot metal-rich hydrothermal fluids and ambient seawater. The PhD student may also be offered the opportunity to participate in one of the future research expeditions to collect more samples for the project.

Here are some example publications to this topic:

Zitoun, R., Achterberg, E. P., Browning, T. J., Hoffmann, L. J., Krisch, S., Sander, S. G., & **Koschinsky, A. (2021)**. The complex provenance of Cu-binding ligands in the South-East Atlantic. *Marine Chemistry*, *237*, 104047. https://doi.org/10.1016/J.MARCHEM.2021.104047

Hollister, A. P.; Whitby, H.; Seidel, M.; Lodeiro, P.; Gledhill, M.; **Koschinsky, A. (2021)** Dissolved concentrations and organic speciation of copper in the Amazone estuary and mixing plume. *Marine Chemistry 234: 104005.* doi: 10.1016/j.marchem.2021.104005

Kleint, C., Hawkes, J. A., Sander, S. G. and **Koschinsky, A**. (**2016**): Voltammetric investigation of hydrothermal iron speciation. *Frontiers in Marine Science 3, article 75*. https://doi.org/10.3389/fmars.2016.00075

"Platinum and other emerging critical metal contaminants - natural background in the world oceans and anthropogenic input. A contribution to the international GEOTRACES program"

The project will be conducted in the framwork of the GEOTRACES program and co-supervised by a South-African/Namibian postdoc

Here are some example publications to this topic:

Hollister, A., Marcinek, S., Schmidt, K., Omanović, D., **Schulte, M.**, & **Koschinsky, A.** (2024). First indication of platinum input into the southern North Sea via German Rivers. *Marine Chemistry, 104439*. https://doi.org/10.1016/j.marchem.2024.104439

Find out more:

https://andrea-koschinsky.org/

Andrea Koschinsky-Fritsche | Constructor University

Geochemistry of Trace Metals in the Ocean | Constructor University

https://www.geotraces.org/

Prof. Dr. Ulrich Kühnen (Socio-cultural Psychology)

Topics:

"Variants of interdependence in Africa"

"Who am I, where do I belong, and how should I relate to others?" The answers to such questions are core concepts of the self. While each and every person has a unique sense of the self, most of the potential answers to these kinds of question fall into one of two categories: The self can either be defined by stressing one's uniqueness and independence from others, or by relating the self to others and to social groups, thus by stressing the interdependence with them. Whenever a cognitive, motivational, or emotional process implicates the self, the degree of independence-interdependence is likely to affect the outcome. People from most cultures of the world emphasize interdependence with others more than independence from them. This can also be expected for many people in Africa. Yet, the way in which interdependence with others is achieved varies between cultures: In some cultures modesty, in fact self-effacement is appreciated, while in others self-assertiveness is the typical way to gain respect by others. In some cultures emotional expressiveness is appreciated, in others not, etc. However, little is known about African people in this regard. Therefore, the central question of this proposed PhD project is this: How do people in Africa achieve interdependence with others?

"Mutual stereotypes of atheists and people of faith"

Most people worldwide are religious. Yet, at least in some parts of the world (such as in most European countries), religion is strongly declining. Previous research suggests that atheists are among the most strongly stereotyped social groups: People of faith tend to distrust atheists. Why is this so? How are atheists perceived in African countries? And what about reversed stereotypes: Do atheists devalue people of faith and why? Are there different patterns of mutual stereotypes in Africa than in Europe? How do these stereotypes translate into action?

"Honor and dignity in an African context"

Previous research has revealed marked cultural differences in the understanding of the value of a person. In dignity cultures, (e.g., Western Europe, North America) the worth of a person is seen as inherent, internal, and equal for all individuals, emphasizing autonomy. In honor cultures, personal worth is earned externally through reputation, often pertaining to the whole family. Since one can lose one's reputation in the eyes of others, honor has been found to be a more vulnerable basis of self-evaluations than dignity. Yet, little is known about how honor and dignity are perceived in an African context.

The successful candidates will have the opportunity to become affiliated with BIGSSS (Bremen Integrates Graduate School of Social Science)

Find out more:
https://www.bigsss-bremen.de/academic-program/self-phd-program-rtg.

https://constructor.university/faculty-member/ulrich-kuhnen

https://scholar.google.com/citations?user=SeT9EeQAAAAJ&hl=en&oi=ao

Prof. Dr. Nikolai Kuhnert (Analytical Chemistry)

Topics:

"Mass spectrometry-based wine metabolomics"

Using state of the art mass spectrometry techniques we like to study in depth the metabolomics of wine. The project will be split in two parts. In part one we collaborate with Prof Bauer at the University of Stellenbosch investigating climate influence on wine constituents including temperature, soil, irrigation, wind rain and extreme climates. In a second part we aim to identify biomarkers allowing authentication of South African wines if compared to European or American wines.

"AI assisted and data science driven interpretation of mass spectrometry data"

Mass spectrometeters are highly powerful instruments combining ultimate resolution with excellent selectivity. As a consequence we generate datasets from plant or human body fluid metabolomes that contain tens of thousands of mass spectra containing structural information of metabolites. Unfortunately current library or AI trained models are only able to account for and assign less than 10 % of the experimental data requiring a radical rethinking and novel approaches to solve the challenge at hand. The thesis work aims at creating some test data sets (eg food or dietary plant metabolomics eg Rooibush, Wine or else or human body fluid samples) followed by applying network science based algorithms to such data sets for improvement of compound identification.

Find out more:

https://constructor.university/nikolai-kuhnert

Prof. Dr. Sonia Lippke (Health Psychology and Behavioral Medicine)

General research interests

Dr. Sonia Lippke's research centers on loneliness, well-being and health behaviors across the lifespan and intercultural background, with a particular focus on workplace and study contexts as well as self-regulation processes, climate change and digitalization. Her work spans theories and models, university health promotion and health service provision, lifelong health and risk behavior change, and multiple behavior change, integrating interdisciplinary perspectives from medicine, gerontology, sociology, and psychology. Through international collaborations, she aims to develop evidence-based strategies for promoting health and preventing disease throughout different life stages and from / in different cultures including in Europe, Africa, Americas and Asia.

Topics:

“Health, well-being and loneliness in students from Africa at constructor university campus”

see Study Details | NCT06899308 | Health Surveillance at Constructor University Bremen (CUB) and Among HAW-Hamburg Employees | ClinicalTrials.gov

“Comparison of perceived acceptance and perceived benefits of digitalization in Europe and Africa including trust in A”

see Study Details | NCT07265427 | Trust in AI and Digitalization in Healthcare Across Generational Groups: A Comparative Study of Barriers and Facilitators Toward Equitable Adoption. | ClinicalTrials.gov

Perception of climate change and loneliness in Europe and Africa, see former data collection in Germany

Study Details | NCT06004531 | Planetary Health and Loneliness | ClinicalTrials.gov

All projects will be co-supervised by Prof. Dr. Ulrich Kühnen and Prof. Dr. Ben Godde.

Find out more:

Sonia Lippke | Constructor University

CU Research Report 2024.pdf

The successful candidates will have the opportunity to become affiliated with BIGSSS (Bremen Integrated Graduate School of Social Science)

Prof. Dr. Jan Lorenz (Social Data Science)

General research interests:

"Social Data Science and Computational Social Science on the emergence and evolution of wealth inequality, ethnic segregation, political polarization and their interplay using data-driven agent-based modeling and computer simulation and innovative data analysis."

Find out more:

About me - Jan Lorenz

CU Research Report 2024.pdf (constructor.university)

Dr. Keivan Mallahi Karai (Mathematics)

Topic:

"Mathematical Models of Decision Making”

Find out more:

Keivan Mallahi-Karai - Research (google.com)

Particularly relevant to this project is the section on applied probability theory in the Research Section

Prof. Dr. Francesco Maurelli (Robotics & Intelligent Systems)

General research interests:

"Autonomy in robotics and intelligent systems: intelligent navigation (SLAM / active SLAM), fault management, planning, applied to marine robotics, mobile robots, robotics arms, autonomous driving."

Find out more:

https://www.linkedin.com/in/francescomaurelli

https://scholar.google.com/citations?user=t1hnyyAAAAAJ&hl=en

CU Research Report 2024.pdf (constructor.university)

Prof. Dr. Hildegard Meyer-Ortmanns (Complex Systems)

Field of Study:

Theoretical physics, in particular statistical physics and nonlinear dynamics, applied to complex systems

Topics:

"Effects of Nonreciprocity in Complex Networks"

Typical complex systems are neuronal networks, the brain, genetic networks, but also artificial systems like power grids or the World Wide Web. Among complex networks, adaptive networks have attracted much attention over the last years. In adaptive networks, the connectivity changes in time. For example, in neural networks, synaptic connections between neurons change according to certain rules or as a function of the relative timing of spiking. This way, neuronal synaptic plasticity is modeled, which is relevant for learning and memory. In chemical networks, the reaction rates may dynamically adapt. In social systems agents can adapt the strategies they pursue. As example from technical applications, adaptive couplings are used in power grids to account for transmission line failures, or to include voltage dynamics.

At another frontier, the discussion of nonreciprocity is currently quite topical. Newton's third law (for every action is an equal and opposite reaction) is the exception rather than the rule in out-of-equilibrium systems, more specifically in neuronal networks, active matter, metamaterials, social systems, or ecological systems governed by predator-prey relations. Obviously, friendship and enmity relations need not be symmetric. This means that there are many and very versatile applications.

A number of results exist which already account for the nonreciprocity and show very interesting effects, for example in nonreciprocal phase transitions. In nonreciprocal transitions, nonreciprocity leads to time-dependent phases, going along with critical phenomena here in systems, whose dynamics cannot be derived from an optimization principle. Just as result of nonreciprocity, groups of oscillators may start rotating or switching their affiliation to a group with which they synchronize. From a mathematical point of view, in particular from linear stability analysis it becomes obvious that nonreciprocity leads to a linear operator that is non-Hermitian, allowing for exceptional points. Here one may profit from insights from another frontier, non-Hermitian quantum mechanics. In view of manifestations of nonreciprocity, a prototypical form of self-organization in many-body systems out-of-equilibrium is synchronization.

Generalizations of nonreciprocal synchronization will be the focus of this project. More specifically, the project will be on nonreciprocity in adaptive networks and its impact on synchronization patterns.

First results in this direction can be found under arXiv:2512.20410v1 (2025). In general, the dynamics of adaptation may be realized in various ways, via the type of favored interaction (alignment or anti-alignment in the extreme cases), via the choice of time scales, via feedback, or via frequency adaptation to name just a few. Our systems will be described by classical nonlinear oscillators with nonreciprocal adaptive couplings. Here, a modified Kuramoto model will be a good starting point for the student to get familiar first with reciprocal adaptation, and next with nonreciprocal versions. One expects different transients towards the stationary states, different stationary states, different system's phases, dynamical restoration of spontaneously broken continuous symmetries. Besides

the numerical implementations, the student should get acquainted with linear stability analyses, bifurcation theory, and dynamical mean field theory where possible. Earlier results from reciprocal adaptive networks show already interesting reorganization of networks, generated hierarchies and modular structure, or effects like excitability, emerging rather than being implemented in the basic dynamical units. Therefore, when nonreciprocity adds upon adaptive coupling, we expect very rich behavior as result of combining nonlinear dynamics with collective effects in stochastic many-body systems out-of-equilibrium.

The project will be co-supervised by Prof. Sören Petrat.

Required background of the student:

The student should have strong background in theoretical physics, in particular statistical physics or nonlinear dynamics. Beside numerical simulations the candidate should be interested in learning analytical approaches.

Find out more:

https://constructor.university/faculty-member/hildegard-meyer-ortmanns

https://csh.ac.at/hildegard-meyer-ortmanns/

Prof. Dr. Werner Nau (Chemistry)

Topic:

"Next-generation drugs and drug delivery"

Find out more:

Werner Nau | Constructor University

Supramolecular Chemistry | Constructor University

Prof. Dr. Sören Petrat (Mathematics)

Topic:

"The Mathematics of the Hubbard Model"

The Hubbard model described cold atoms in optical lattices. It is known to exhibit a quantum phase transition from a Mott insulating phase to a superfluid phase. The project's goal is to study various aspects of this model in a mathematically rigorous way. The project connects theoretical physics and rigorous mathematics and is thus perfect for students interested in both fields.

"Bosonic gases near the critical temperature"

At low temperatures, bosons exhibit Bose-Einstein condensation, which is a state of matter where quantum effects become macroscopically visible. These can often be described in a simplified mean-field theory. This project explores what happens near (or just above) this critical temperature. Here, in some cases it is known that the system is described by a classical Gibbs measure. This project aims to explore this further, and for example derive higher order expansions around such Gibbs measures. The project connects theoretical physics and rigorous mathematics and is thus perfect for students interested in both fields.

Find out more:

CU Research Report 2024.pdf (constructor.university)

Sören Petrat | Constructor University

Mathematical Physics | Constructor University

Prof. Dr. Petr Popov (Applied Mathematics)

Topics:

"Deep Learning for Robust QSAR Models for Antimicrobial Discovery"

The rapid emergence of antimicrobial resistance (AMR) represents a critical global health challenge, necessitating the discovery of novel antimicrobial agents with new mechanisms of action. Quantitative Structure–Activity Relationship (QSAR) modeling has long been used to relate molecular structure to biological activity; however, conventional QSAR approaches often suffer from limited generalizability, dataset bias, and poor performance on chemically novel compounds. Recent advances in deep learning offer unprecedented opportunities to build more robust, scalable, and predictive QSAR models for antimicrobial discovery.

This PhD project will focus on the development of next-generation deep learning–based QSAR frameworks tailored to antimicrobial activity prediction. The research will integrate modern molecular representations—including graph neural networks, message-passing architectures, and transformer-based models—with curated antimicrobial datasets spanning diverse chemical spaces and pathogen targets. Particular emphasis will be placed on addressing key challenges in antimicrobial QSAR modeling, such as data sparsity, class imbalance, noisy biological measurements, and activity cliffs.

The student will investigate strategies for improving robustness and generalization, including self-supervised pretraining on large unlabeled chemical libraries, multi-task and transfer learning across different microbial species, and uncertainty-aware modeling to identify high-confidence predictions. Model interpretability will also be a core component of the project, enabling the extraction of chemically meaningful insights that can guide rational compound optimization and hypothesis-driven experimental validation.

A significant methodological focus will be on benchmarking deep learning models against classical QSAR approaches, establishing best practices for dataset splitting, validation on truly novel chemical scaffolds, and assessment of model extrapolation capabilities. The project may further explore integration of physicochemical descriptors, molecular docking scores, or predicted ADMET properties to improve real-world applicability.

The expected outcomes include novel deep learning architectures and training paradigms for antimicrobial QSAR, open and reproducible benchmarking pipelines, and predictive models capable of prioritizing candidate molecules for experimental screening. This research will contribute both methodologically to cheminformatics and practically to antimicrobial drug discovery.

The project is well suited for candidates with strong backgrounds in machine learning, chemistry, bioinformatics, or related fields, and an interest in interdisciplinary research at the interface of artificial intelligence and biomedical science.

The project will be co-supervised by Prof. Dr. Ulrich Kleinekathöfer.

"Deep Learning for Structure-Based Analysis of the Effects of Point Mutations in Proteins"

Point mutations can profoundly alter protein structure, stability, dynamics, and function, playing critical roles in disease, drug resistance, and protein engineering. Despite advances in structural biology and computational modeling, accurately predicting the effects of single amino acid substitutions remains a fundamental challenge. Recent breakthroughs in deep learning for protein structure and representation learning provide a powerful foundation for addressing this problem in a data-driven yet physically informed manner.

This PhD project aims to develop deep learning models for structure-based prediction and analysis of the functional and biophysical consequences of point mutations in proteins. The research will leverage high-resolution protein structures, predicted structures, and large-scale mutational datasets to model how local and global structural perturbations arise from sequence changes. Emphasis will be placed on integrating three-dimensional geometric information, residue–residue interactions, and evolutionary context into neural network architectures.

The student will explore state-of-the-art approaches such as graph neural networks on protein structures, equivariant neural networks that respect physical symmetries, and transformer-based protein language models augmented with structural features. Key prediction targets may include changes in protein stability, binding affinity, enzymatic activity, or conformational flexibility. Particular attention will be given to mutations relevant to disease mechanisms and drug resistance.

A central goal of the project is to move beyond black-box prediction toward mechanistic interpretability. The student will develop methods to localize structural regions most affected by mutations, identify disrupted interaction networks, and quantify uncertainty in predictions. Comparative evaluation against physics-based approaches such as molecular dynamics and free-energy calculations will be used to assess strengths, limitations, and complementarities.

The project may also involve developing scalable pipelines for in silico mutational scanning, enabling systematic exploration of protein fitness landscapes. Such tools have direct applications in variant interpretation, protein design, and personalized medicine.

Expected outcomes include novel deep learning models for mutation effect prediction, interpretable structure-based analysis tools, and insights into the structural determinants of protein robustness and

function. The research will contribute to both fundamental protein science and applied biomedical research.

This project is ideal for students with backgrounds in computational biology, structural bioinformatics, physics, or machine learning, and a strong interest in protein structure–function relationships.

The project will be co-supervised by Prof. Dr. Ulrich Kleinekathöfer.

"Physics-Based Machine Learning Models for Molecular Property Prediction"

Accurate prediction of molecular properties is central to computational chemistry, materials science, and drug discovery. While machine learning models have achieved impressive performance, many purely data-driven approaches struggle with transferability, physical consistency, and extrapolation beyond training distributions. Physics-based machine learning seeks to overcome these limitations by embedding fundamental physical principles directly into model architectures and learning objectives.

This PhD project focuses on the development of physics-informed machine learning models for molecular property prediction. The goal is to combine the efficiency and flexibility of modern deep learning with constraints derived from quantum mechanics, statistical physics, and molecular symmetry. The student will investigate how incorporating physical priors can improve accuracy, data efficiency, and generalization across chemical space.

Key research directions include the use of symmetry-preserving neural networks (e.g., rotationally and translationally equivariant models), energy-conserving architectures, and force-matching approaches for learning molecular potentials. The project will explore prediction of diverse properties such as energies, forces, dipole moments, reaction barriers, and spectroscopic observables, with applications ranging from small molecules to complex molecular assemblies.

A major component of the work will involve systematic comparison between purely data-driven models and physics-informed alternatives, analyzing performance under limited data regimes and in out-of-distribution scenarios. The student will also investigate hybrid approaches that integrate machine learning with traditional electronic structure or molecular simulation methods, aiming to achieve near ab initio accuracy at a fraction of the computational cost.

Methodological rigor and reproducibility will be emphasized, including careful dataset construction, uncertainty quantification, and benchmarking against established quantum chemistry methods. Where appropriate, the project may extend to active learning strategies that adaptively select new training data to maximize model improvement.

The expected outcomes include novel physics-based machine learning architectures, improved molecular property predictors, and general design principles for combining physical knowledge with data-driven models. This research will advance the reliability and applicability of machine learning in the molecular sciences.

The project is suitable for candidates with strong quantitative backgrounds in physics, chemistry, materials science, or machine learning, and an interest in developing principled computational methods.

The project will be co-supervised by Prof. Dr. Ulrich Kleinekathöfer.

"The robust molecular machine learning for anti-fungal drug discovery Learning for Structure-Based Analysis of Biomolecules"

It has been recognized that the emergence of antibiotic-resistant microbes represents a clear and present danger with a global impact, and, therefore, an effective response should be facilitated by adopting new methods for the discovery of new antibiotic candidates. With the advances in machine learning, more efforts are being made to develop molecular machine learning (MML) models to study quantitative-structure-activity-relationships (QSAR) for drug discovery. Despite its relevance, fewer MML models focused on identifying new hits against fungi and, particularly, against Candida albicans, which is one of the four pathogens categorized as having critical risk to human health according to the World Health Organization. In this project, we aim to make a step forward in anti-fungal drug discovery, particularly, against Candida albicans, using MML. We will develop robust MML models following the best practices of the QSAR modeling and rigorously investigate the predictive power and limitations of the developed models. Particularly, we will use applicability domain analysis, which will be integrated into the MML pipelines to estimate the feasibility of the predictive models applied to a given compound. The developed MML pipelines will be applied for the screening of commercially available chemical libraries as well as to the designed focused chemical libraries. We will perform large-scale characterization of the selected compounds experimentally. Thus, we will not only rigorously evaluate the developed method but generate new high-quality data for the community. The compound screening will be done in several rounds, such that we will iteratively test and improve the derived models using new data and feedback from experimental results, ensuring their reliability and applicability in real world scenarios. For the focused chemical libraries, we will prioritize novel scaffolds aiming to identify promising compounds as new generation anti-fungal agents. The subsequent analysis of the SAR data obtained will contribute to our understanding of how to combat Candida albicans and the development of effective anti-fungal therapies. Finally, to facilitate usage of the developed methods and the obtained results, we will implement the developed pipelines as a tool for the community, particularly for medicinal chemists with no prior knowledge of MML or computer science to be useful in the prospective research.

Further reading:

[1] Zaretckii, Mark, et al. "3D chemical structures allow robust deep learning models for retention time prediction." Digital Discovery 1.5 (2022): 711-718

[2] Mqawass, Ghaith, and Petr Popov. "GraphLambda: fusion graph neural networks for binding affinity prediction." Journal of Chemical Information and Modeling 64.7 (2024): 2323-2330.

[3] Tevyashova, Anna N., et al. "Discovery of amphamide, a drug candidate for the second generation of polyene antibiotics." ACS Infectious Diseases 6.8 (2020): 2029-2044. https://dx.doi.org/10.1021/acsinfecdis.0c00068

This project is a back-to-back project with a computational perspective (supervised by P. Popov) and a chemical perspective (supervised by A. Tevyashova)

Find out more:

https://scholar.google.com/citations?user=xMTbJLcAAAAJ&hl=en

Petr Popov | Constructor University

Dr. Eoin Ryan (Philosophy)

My main research interests lie in the area of (analytic) philosophy of mind and philosophical issues related to AI. Students who are interested in areas such as core philosophy of mind, introspection, self-knowledge, implications of AI for understanding minds and the nature of intelligence, AI ethics, etc would be welcome collaborators. I am also interested in social epistemology and social ontology, including practical aspects of these such as pressing issues around knowing how or what to believe in these days of "fake news", or so-called conceptual engineering around social issues, and would equally welcome PhD candidates interested in these sort of areas.

Find out more:

Eoin Ryan | Constructor University

Prof. Maren Schenke, PhD (Cell Biology)

Topic:

"Modeling Neurotoxicity in Human iPSC-Derived Brain Organoids"

This PhD project focuses on studying the effects of neurotoxicants on neuronal function and network development using human induced pluripotent stem cell (iPSC)-derived brain organoids. By generating human-relevant in vitro models that incorporate biological variables such as sex, we aim to enhance translational value. The research will combine cell culture techniques with electrophysiological recordings of neural activity and omics approaches to assess functional and molecular endpoints. The primary goal is to understand how neurotoxicants and disease-related factors influence neural development and connectivity. This work will contribute to developing more predictive models for neurotoxicity and inform strategies for personalized interventions in neurological conditions. Please see our most recent publication for reference: https://doi.org/10.64898/2025.12.03.692130

Find out more:

constructor.university/Maren Schenke

Prof. Dr. Andreas Seebeck (Accounting and Auditing)

Topic:

"Sustainability and Integrated Reporting Practices in South Africa: A Critical Analysis of Current Practices, Challenges, and Opportunities"

In recent years, sustainability and integrated reporting have gained significant prominence worldwide as companies and stakeholders recognize the importance of non-financial reporting in enhancing transparency, accountability, and corporate responsibility. In South Africa, the King Code on Corporate Governance (King IV) has played an important role in promoting integrated reporting, positioning the country as a leader in this field. However, challenges persist in the adoption, implementation, and effectiveness of sustainability and integrated reporting practices.

2. Research Objectives

The research conducted in this project aims to critically examine the current state of sustainability and integrated reporting in South Africa, identify key challenges and opportunities, and propose a framework to enhance reporting practices for improved corporate sustainability performance.

The research project seeks to achieve the following objectives:

- Assess the current state of sustainability and integrated reporting among publicly listed companies in South Africa, with a focus on the quality, completeness, and consistency of reporting practices.
- Identify key challenges and barriers to the adoption and effective implementation of sustainability and integrated reporting, including organizational, regulatory, and cultural factors.
- Evaluate the impact of sustainability and integrated reporting on corporate performance, stakeholder engagement, and/or decision-making processes.

Find out more:

research report

Prof. Dr. Jürgen Schönwälder (Computer Networks and Distributed Systems)

Topics:

“Security of hypervisors and unikernels”

“Security of Internet of Things devices”

“Security of Internet protocols”

“Declarative configuration management”

Find out more:

Computer Networks and Distributed Systems | Constructor University

Jürgen Schönwälder | Constructor University

Prof. Dr. Karen Smith Stegen (Political Science)

Topic:

“International Energy and Resource Governance, Sustainability and Transitions”

Find out more:

research report

Karen Smith Stegen | Constructor University

Political Science — International Energy and Resource Governance, Sustainability and Transitions | Constructor University

Prof. Dr. Jakob Suchan (Computer Science)

Topic:

"Artificial Visual Intelligence: Neurosymbolic learning and reasoning for visual sensemaking."

The PhD project is embedded within the area of **Cognitive Vision** (https://codesign-lab.org/cognitive-vision/). The primary objective is to develop general methods for processing and semantic interpretation of dynamic visuospatial imagery (e.g., videos, sensor data, human behavioral data, etc.), with a particular emphasis on the ability to abstract, learn, and reason with cognitively rooted structured characterisations of commonsense knowledge pertaining to space and motion. The general aim of this research is to integrate techniques from **AI** and **Knowledge Representation and Reasoning** with **Computer Vision** methods, to facilitate commonsense visual reasoning and sensemaking in diverse application domains, such as **autonomous driving**, **robotics**, or **visual perception and media studies**.

We are seeking motivated PhD candidates with a strong interest in **Artificial Intelligence**, **Computer Vision**, and **Human-Centred Computing**. The specific focus of the project may vary based on the individual's interest and the candidate's profile. Suitable candidates should be interested and (potentially) have prior experience in at least one of the following areas:

- **Knowledge Representation and Reasoning (KRR)**: Formal foundations for reasoning and relational concept learning with dynamic scenes, and implementation within declarative programming approaches such as Answer Set Programming (ASP).
- **Computer Vision and Machine Learning (CV & ML)**: General deep learning based methods for low-level visual processing, aiming at extracting scene elements and their properties from dynamic visual imagery (RGB, Point-Clouds, etc.).
- **AI and Human Cognition (HCC):** Human behavioural research driven analysis and development of interactive technology.

Find out more:

https://codesign-lab.org/cognitive-vision/

https://constructor.university/jakob-suchan

https://scholar.google.de/citations?user=cUEz_e8AAAAJ&hl=de

Prof. Dr. Tobias ten Brink (Chinese Economy and Society)

Topic:

“Learning Empire? Understanding and explaining emerging Chinese practices in Africa.“

Find out more:

Tobias ten Brink | Constructor University

Implications of the Rise of China and Non-Western Emerging Economies | Constructor University

Dr. Anna Tevyashova (Medicinal Chemistry)

Topics:

“Synthesis and Evaluation of Next-Generation Aminoglycosides”

The rise of bacterial strains resistant to diverse antibiotics, coupled with the stagnation in the development of new bactericidal agents, underscores antimicrobial resistance as a severe global health threat. In 2019, approximately 1.27 million deaths were directly linked to antibiotic-resistant bacteria, with an additional 5 million deaths associated with these infections. The 2024 update of the World Health Organization's Bacterial Priority Pathogens List continues to highlight Gram-negative bacteria as critical threats, alongside other significant pathogens such as Salmonella, Pseudomonas aeruginosa, and Staphylococcus aureus. Therapeutic options for infections caused by multidrug-resistant (MDR) Gram-negative bacteria remain very limited, and many existing treatments are burdened with severe side effects. The alarming rise in hospital-acquired MDR infections has spurred interest in developing new aminoglycoside antibiotics. Among these, apramycin has emerged as a particularly promising candidate due to its unique structural and functional features, which confer advantages in combating resistance. Apramycin avoids common resistance mechanisms, including aminoglycoside-modifying enzymes, and displays a unique interaction with bacterial ribosomes. Its chemical structure also supports modifications that can enhance its pharmacological properties. To exploit apramycin’s potential, targeted chemical modifications are essential to improve its antibacterial activity, minimize resistance, and ensure selective action against prokaryotic ribosomes, thereby reducing risks such as ototoxicity. Ideal derivatives would evade resistance mediated by AAC(3)-IV and ApmA enzymes while achieving superior antibacterial efficacy compared to the parent compound. This research aims to develop new approaches to the chemical modification of apramycin, synthesize series of new derivatives, and evaluated biological properties of these compounds, including their ability to act on resistant bacterial strains. The objective is to establish detailed structure-activity relationships (SARs) for apramycin derivatives, guiding the development of next-generation antibacterials and expanding the clinical utility of this aminoglycoside. Through these efforts, we seek to address the urgent need for effective therapies against MDR pathogens and contribute to global efforts to combat antimicrobial resistance.

“The robust molecular machine learning for anti-fungal drug discovery Learning for Structure-Based Analysis of Biomolecules”

It has been recognized that the emergence of antibiotic-resistant microbes represents a clear and present danger with a global impact, and, therefore, an effective response should be facilitated by adopting new methods for the discovery of new antibiotic candidates. With the advances in machine learning, more efforts are being made to develop molecular machine learning (MML) models to study quantitative-structure-activity-relationships (QSAR) for drug discovery. Despite its relevance, fewer MML models focused on identifying new hits against fungi and, particularly, against Candida albicans, which is one of the four pathogens categorized as having critical risk to human health according to the World Health Organization. In this project, we aim to make a step forward in anti-fungal drug discovery, particularly, against Candida

albicans, using MML. We will develop robust MML models following the best practices of the QSAR modeling and rigorously investigate the predictive power and limitations of the developed models. Particularly, we will use applicability domain analysis, which will be integrated into the MML pipelines to estimate the feasibility of the predictive models applied to a given compound. The developed MML pipelines will be applied for the screening of commercially available chemical libraries as well as to the designed focused chemical libraries. We will perform large-scale characterization of the selected compounds experimentally. Thus, we will not only rigorously evaluate the developed method but generate new high-quality data for the community. The compound screening will be done in several rounds, such that we will iteratively test and improve the derived models using new data and feedback from experimental results, ensuring their reliability and applicability in real world scenarios. For the focused chemical libraries, we will prioritize novel scaffolds aiming to identify promising compounds as new generation anti-fungal agents. The subsequent analysis of the SAR data obtained will contribute to our understanding of how to combat Candida albicans and the development of effective anti-fungal therapies. Finally, to facilitate usage of the developed methods and the obtained results, we will implement the developed pipelines as a tool for the community, particularly for medicinal chemists with no prior knowledge of MML or computer science to be useful in the prospective research.

Further reading:

[1] Zaretckii, Mark, et al. "3D chemical structures allow robust deep learning models for retention time prediction." Digital Discovery 1.5 (2022): 711-718

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[3] Tevyashova, Anna N., et al. "Discovery of amphamide, a drug candidate for the second generation of polyene antibiotics." ACS Infectious Diseases 6.8 (2020): 2029-2044. https://dx.doi.org/10.1021/acsinfecdis.0c00068

This project is a back-to-back project with a computational perspective (supervised by P. Popov) and a chemical perspective (supervised by A. Tevyashova)

Find out more:

Anna Tevyashova | Constructor University
https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

https://www.mdpi.com/1999-4923/15/4/1177

Dr. Julia Timpe (History)

Topics:

Open to supervise history PhD topics from fields including **Modern German History, Everyday** History, History of World War II and the Holocaust, and Modern European History.

Find out more:

CU Research Report 2024.pdf (constructor.university)

JULIA TIMPE - (personal website with list of publications and current research projects)

Prof. Dr. Matthias Ullrich (Microbiology)

Topic:

“Molecular analysis of marine bacteria attaching to microscopic surfaces”

We will develop a genetically accessible model system for marine bacteria-particle surface interaction to identify genes and gene products relevant for this process. This will help elucidate key factors contributing to the vertical transport of organic material in the Ocean.

The project will be conducted in cooperation with Max Planck Institute for Marine Microbiology in Bremen.

Find out more:

Matthias Ullrich | Constructor University

Molecular Plant Microbiology | Constructor University

https://pages.constructor.university/ullrichmatthiasmicrobiology

Prof. Dr. Vikram Unnithan (Geosciences / Geophysics)

Topic:

“Deep learning / AI driven resource exploration and assessment using (ENAM) hyperspectral data: From Critical Minerals to Water and Earth Resources”

(jointly with Prof. Vogt, and Prof. Bau)

“Gas Hydrate Controls on Submarine Mass Failures: Numerical Modeling and Comparative Analysis of the Nile and Amazon Deep-Sea Fan Systems”

(jointly with Dr. Daniel Praeg)

Find out more:

Vikram Unnithan | Constructor University

Vikram Unnithan

CONSTRUCTOR UNIVERSITY

Prof. Dr. Dr. Ing. Yilmaz Uygun (Industrial Engineering and Management / International Logistics or Information Science / Information Systems and Management)

Topic:

"Leveraging Large Language Models for Requirements Engineering in Logistics Systems"

Background

Logistics systems are increasingly complex, distributed, and data-intensive, requiring precise and adaptable requirements engineering (RE) processes. Traditional RE methods in logistics struggle with scalability, ambiguity in stakeholder communication, and rapid changes in operational constraints. Large Language Models (LLMs) have recently demonstrated strong capabilities in natural language understanding, synthesis, and reasoning, suggesting potential benefits for requirements elicitation, analysis, and validation. This research proposes to investigate how LLMs can be systematically integrated into logistics requirements engineering to improve requirement quality, traceability, and adaptability while addressing domain-specific risks such as hallucinations, bias, and safety constraints.

Problem Statement

Logistics systems involve diverse stakeholders, including operators, planners, IT architects, and regulatory bodies. Requirements are often expressed in unstructured natural language, leading to ambiguity, inconsistency, and costly rework during system development. Existing RE tools provide limited semantic understanding and rely heavily on manual effort. Meanwhile, logistics operations demand fast iteration due to fluctuating demand, disruptions, and regulatory changes. LLMs offer an opportunity to automate and augment RE tasks, but their application in safety- and reliability-critical logistics contexts remains underexplored. There is a lack of empirical evidence, methodological frameworks, and evaluation metrics for using LLMs in logistics RE.

Research Objectives and Questions

The main objective of this PhD is to develop and evaluate LLM-based methods that support requirements engineering in logistics systems. The research will address the following questions:

- How can LLMs support requirements elicitation and clarification from heterogeneous logistics stakeholders?
- To what extent can LLMs detect ambiguity, inconsistency, and incompleteness in logistics requirements?
- How can domain knowledge and constraints be incorporated to improve LLM reliability and reduce hallucinations?
- What are the measurable impacts of LLM-assisted RE on requirement quality, development effort, and stakeholder satisfaction?

Methodology

The research will adopt a mixed-methods approach. First, a systematic literature review will analyze existing work on RE in logistics and AI-assisted RE. Second, domain-specific datasets of logistics requirements

will be collected from industrial case studies or realistic benchmarks. Third, LLM-based prototypes will be developed for tasks such as requirement extraction, classification, ambiguity detection, and traceability generation. Techniques such as prompt engineering, retrieval-augmented generation, and fine-tuning with logistics ontologies will be explored. Finally, controlled experiments and expert evaluations will compare LLM-assisted RE with traditional approaches using established RE quality metrics.

Expected Contributions

This research is expected to contribute (1) a conceptual framework for applying LLMs in logistics requirements engineering, (2) empirically validated methods and tools for LLM-assisted RE, and (3) guidelines for safe and effective deployment of LLMs in logistics system development. The outcomes aim to bridge the gap between advances in language models and practical requirements engineering in complex logistics environments.

Find out more:

https://constructor.university/faculty-member/yilmaz-uygun

Prof. Dr. Marco Verweij (Political Science)

Topic:

"Making Democratic Governance More Polyrational"

Aims:

(1) Understand how 'wicked' (or, in Herbert Simon's words, 'ill-structured') environmental and social problems can be resolved through the combined forces of (inter)governmental action, entrepreneurship, technological innovation, as well as civil society engagement.

(2) Analyze which policy failures have fueled the global rise of (authoritarian) populism, how these could have been prevented, and how populism's support can be drained.

(3) Explore the possible synergies between social and political theory, brain research and the analysis of human complex systems.

Find out more:

https://constructor.university/faculty-member/marco-verweij

Prof. Dr. Markus Wenzel (Computer Science)

Topics:

"Extraction and use of structured knowledge in medical contexts"

In this area, the candidate will utilize LLMs (Large Language Models) together with state-of-the-art frameworks for the extraction of information and generation of semantically grounded knowledge from a variety of sources in the medical field, ranging from medical reports drafted by diagnosing doctors in residency

and in hospitals, from medical scientific literature, and from curated knowledge sources like clinical practice guidelines and controlled clinical trials.

Aims

The aims are different from source to source, and it will be up to your preferences to choose and focus on any or all of them, solving practical problems on real data and for real applications.

- Extracting knowledge from free-text medical reports contributes to the harvesting of massive amounts of unstructured medical and clinical information, potentially enabling new avenues of clinical research by allowing to structure and sort data sources of real-world data.
- Extracting the conditional knowledge from clinical practice guidelines aids in converting such guidelines into computer-readable formats, so that they can be used in clinical decision support systems.
- Extracting causal relationships from medical scientific publications can contribute to building up a knowledge database that can in turn be used to interpret textual sources like the two previous applications.

Such technologies are able to contribute to pressing, intricate clinical needs, so that more than just a basic understanding of the medical field is expected of a successful applicant. Since the field is moving fast, details are to be defined depending on mutual interests.

"Multi-Agent AI Systems in Real-World Clinical Contexts"

In this area, the candidate will focus on dynamic adaptive systems found in the clinical context. Among the examples are Emergency Rooms, Intensive Care Units, and other areas where demand and response are highly complex and dynamically changing, and resource restrictions apply.

This necessitates careful interventions which additionally have to deal with incomplete data. To tackle this, hybrid simulation approaches can provide test beds. Scaling them and validating them to conform to observed realities is one part of the proposed research, but the novel and challenging part concerns the use of Multi-Agent Systems (composed of tool-using LLMs) which partially autonomously interact with sensors and players in the setting to improve scheduling, safeguard decision making, and prevent medical errors.

Find out more:

Markus Wenzel | Constructor University

Prof. Dr. Hendro Wicaksono (Industrial Engineering)

Topics:

1. Causal AI for Carbon Footprint Attribution in Global Supply Chains
2. Integrating Causal AI and Life Cycle Assessment (LCA) for Comprehensive Sustainability Metrics
3. Leveraging Causal AI to Assess Social and Environmental Trade-offs in Sustainable Supply Chains: Case Study South Africa vs. Germany
4. Causal Discovery in Data-Scarce Supply Chains for Sustainability Enhancement

5. Comparative Analysis of Using Causal Inference and System Dynamics for Decarbonization Policy in South Africa
6. Causal AI for Decarbonization Pathways in Heavy Industries in South Africa and Germany
7. Explainable AI for Risk Management in Supply Chains
8. Explainable AI for or Decision-Making in Smart Cities
9. Transfer Learning for Predictive Maintenance in Industrial IoT Systems
10. Deep Reinforcement Learning for Emission Reduction in Industrial Processes
11. Deep Reinforcement Learning for Waste Management and Recycling Systems
12. Deep Reinforcement Learning for Personalization of Smart City Services
13. The Role of Digital Product Passports in Transforming Agricultural Supply Chains
14. Agentic AI for Closed-Loop LCA: Automated Data Collection → Quality Checks → LCA Updates → Management Recommendations
15. LLM-Assisted Causal Discovery: Using Domain Text and Expert Feedback to Constrain DAG Structure in Sparse Industrial Data
16. Trustworthy Agentic Workflows for Sustainability: Guardrails, Human-in-the-Loop Oversight, and Evaluation Metrics (hallucination, faithfulness, compliance)

Find out more:

Hendro Wicaksono | Constructor University

Data-Driven Collaborative Decision Making in Complex Industrial Systems | Constructor University

For detailed descriptions of the projects, contact juhligherr@constructor.university

Prof. Dr. Björn Windshügel (Computational Drug Discovery)

Topics:

"Computational Approaches for the Development of Drugs Targeting Antimicrobial Resistance"

The offered project, supervised by Profs. Windshügel and Kleinekathöfer is for a student interested in applying computational techniques (molecular docking, molecular dynamics simulations) for the identification and characterization of novel compounds targeting efflux pumps that fastly remove antibiotics from the bacterium, representing an important mechanism of antimicrobial resistance. Our aim is to develop compounds that switch off these pumps which results in improved efficacy of antibiotics. This project is a continuation of recently finished work (https://www.jpiamr.eu/projects/reset-me/) and is done in close cooperation with Fraunhofer ITMP in Hamburg. The institute will provide comprehensive experimental support (e.g., https://pubmed.ncbi.nlm.nih.gov/37371580/), thereby enabling validation of the compounds identified by the student. Based on the experimental data, the student can improve his/her models that may result in the identification of more potent inhibitors.

Prof. Björn Windshügel applies computational techniques for the identification of substances that serve as starting points for the development of novel drugs. Prof. Ulrich Kleinekathöfer

(https://constructor.university/faculty-member/ulrich-kleinekathoefer) uses computational simulations to understand molecular processes on an atomic scale.

Joint project with and Professor Dr. Ulrich Kleinekathöfer (Theoretical Physics)

Find out more:

Björn Windshügel | Constructor University

"Assessment of Molecular Docking and Scoring Algorithm Performance Using Substance Class-Specific Benchmark Data Sets"

The offered project, supervised by Prof. Windshügel (co-supervised by Prof. Anna Tevyashova) is for a student interested in applying computational techniques for assessing the performance of molecular docking algorithms and scoring functions.

Molecular docking is a frequently applied computational technique for structure-based virtual screening of large compound libraries in order to identify potentially bioactive molecules that may serve as starting structures for drug discovery or to predict the binding mode of a given bioactive compound for supporting further optimisation by means of synthetic chemistry. In addition, molecular docking is also utilized for predicting adverse effects of chemical substances as well as fishing and profiling of drug targets.

Moreover, developers of molecular docking programmes or scoring functions require high-quality data sets for testing and further improving their software.
A detailed understanding of the performance of docking algorithms and scoring functions for different protein and compound classes will facilitate molecular docking and virtual screening campaigns and therefore facilitate drug discovery projects worldwide. In addition, these data sets support the development of novel algorithms.
In this project, different computational tools will be used to generate molecular docking benchmark data sets for different substance classes, for example covalently binding compounds or fragments, using a sophisticated workflow for large-scale analysis of X-ray crystal structures containing bound ligands.
Subsequently, these data sets will be used to evaluate popular molecular docking programmes and scoring functions with respect to their docking and virtual screening performance.
This project extends the previous studies on the development of benchmark data sets for peptide and fragments (LEADS-PEP: https://pubmed.ncbi.nlm.nih.gov/26651532/ & LEADS-FREAG: https://pubmed.ncbi.nlm.nih.gov/33289563/). Up to four benchmark data sets will be generated, including updated and extended versions of LEADS-PEP and LEADS-FRAG.
All data sets will be used for assessing the performance of a diverse set of docking algorithms and scoring functions. The data sets and the results will be made publicly available.

An applicant should have a basic knowledge of protein structures (secondary structural elements, structure visualisation and analysis), protein-ligand interactions (van der Waals forces, hydrogen bonds, salt bridges) as well as the principles of programming. Expertise with Linux, KNIME, shell scripting, Python programming, and/or molecular docking software such as AutoDock Vina would be a plus.

Find out more:

Björn Windshügel | Constructor University

Prof. Dr. Isabel Wünsche (Art and Art History)

Topic:

The research group examines the production of art from the 19th to the 21st century. Particular focus is on the art movements and artistic networks that shaped the emergence of Modernism, including Expressionism, the avant-garde movements, and the Bauhaus, as well as the reception of these movements beyond Europe, in North and Latin America, Africa, and Australia.

Open to supervise art history PhD topics, including Global Modernism, Expressionism, Settler Primitivism, Decolonizing Modernism and the Avant-garde, Abstraction.

Find out more:

Isabel Wünsche / Constructor University