Aalto Science Institute (AScI) internship programme Summer 2021 project list

For more information on the program and how to apply, see https://www.aalto.fi/en/aalto-science-institute/aalto-science-institute-asci-internship-programme

School of Science

Department of Computer Science

1101 - Developing a DNA nanostructure design platform		
Field of study:	Computer Science / Computational Biology	
School:	School of Science	
Department:	Computer Science	
Professor:	Pekka Orponen	pekka.orponen@aalto.fi
Academic contact person:	Pekka Orponen	pekka.orponen@aalto.fi

The area of DNA nanotechnology [1] employs DNA as generic building material for assembling nanoscale objects with dimensions in the order of 10-100 nanometres. Our group has been contributing, in collaboration with a biochemistry team from Karolinska Institutet in Stockholm, to the design of a general-purpose design platform "vHelix" for producing in particular 3D wireframe designs folded from a single long DNA strand [2]. A new, user-friendly and extendible version of the vHelix platform was developed as a summer internship project in 2020 (not yet launched for public distribution). Following the publication of the DNA strand-routing algorithm implemented in the current vHelix version in 2015 [3], several alternative methods have emerged, and the goal of the present project is to implement some of these more recent algorithms as plugins to the new extendible vHelix version.

The project requires familiarity with basic algorithm design techniques, facility with combinatorial thinking, and good programming skills. Previous knowledge of biomolecules is not necessary, although it is an asset.

The work is performed in the context of research project "Algorithmic designs for biomolecular nanostructures (ALBION)", funded by the Academy of Finland. For further information, please see the research group webpage at http://research.cs.aalto.fi/nc/.

[1] https://en.wikipedia.org/wiki/DNA_nanotechnology
[2] http://vhelix.net/
[3] Benson et al., Nature 2015, https://doi.org/10.1038/nature14586

1102 - Efficient visualisation and simulation of DNA strand-displacement systems

Field of study:	Computer Science / Computational Biology	
School:	School of Science	
Department:	Computer Science	
Professor:	Pekka Orponen	pekka.orponen@aalto.fi
Academic contact person:	Pekka Orponen	pekka.orponen@aalto.fi

DNA strand-displacement (DSD) systems are a fundamental technique in the research area of dynamic DNA nanotechnology [1], whose general goal is to implement dynamical behaviours, including computation, in biomolecular systems. The basic biochemical DSD mechanism, which comprises the controlled binding and release of short segments of single-stranded DNA, is quite simple, yet rich enough to support the design of general-purpose computational devices [2].

The molecular-level details of DSD systems can get quite complicated and the eventual chemical interactions rather intricate, and so high-level design, simulation and visualisation tools to support the design of complex DSD systems are in demand. For this purpose, our group recently developed a flexible rule-based modelling package RuleDSD, which at the simulation level integrates to the widely-used BioNetGen framework [3]. A graphical user interface to the RuleDSD package, including a simulated annealing -based strand network visualisation method, was developed as a summer internship project in 2020.

The first goal of the present project is to improve the efficiency and reliability of the RuleDSD strand network visualisation tool, by replacing its general-purpose simulated annealing engine by an algorithmic method designed specifically for this task. A second goal is to address the methodological and efficiency challenges that arise in the current RuleDSD version when dealing with large, or even potentially infinite, strand networks.

The project requires familiarity with basic algorithm design techniques, facility with combinatorial thinking, and good programming skills. Previous knowledge of biomolecules is not necessary, although it is an asset. The work is performed in the context of research project "Algorithmic designs for biomolecular nanostructures (ALBION)", funded by the Academy of Finland. For further information, please see the research group webpage at http://research.cs.aalto.fi/nc.

[1] https://en.wikipedia.org/wiki/DNA_nanotechnology

[2] https://www.microsoft.com/en-us/research/project/programming-dna-circuits/

[3] Gautam et al., BIOSTEC 2020, https://doi.org/10.5220/0008979101580167

1103 - Statistical or psychological theories for combatting computer fatigue and multitasking

Field of study:	Computer science, psychological science, social science, behavioral science	
School:	School of Science	
Department:	Computer Science	
Professor:	Janne Lindqvist	janne.lindqvist@aalto.fi
Academic contact person:	Janne Lindqvist	janne.lindqvist@aalto.fi

Aalto Human-Computer Interaction and Security Engineering Lab http://lindqvistlab.org at the Aalto Department of Computer Science is recruiting a summer intern. We will be recruiting a student to contribute to our research on the application of statistical theory or psychological theory to the study of combatting computer fatigue and issues with multitasking. For example, we will study the cognitive mechanisms responsible for computer fatigue and psychological principles related to issues with multitasking. Our project will engage the summer intern in every step of the research process including research design, statistical analysis and provide the intern with a unique exposure to the application of psychology and statistics in human-computer interaction. Projects may also include Bayesian data analysis.

1104 - Statistical or psychological theories for user security

Field of study:	Computer science, psychological science, social science, behavioral science	
School:	School of Science	
Department:	Computer Science	
Professor:	Janne Lindqvist	janne.lindqvist@aalto.fi
Academic contact person:	Janne Lindqvist	janne.lindqvist@aalto.fi

Aalto Human-Computer Interaction and Security Engineering Lab http://lindqvistlab.org at the Aalto Department of Computer Science is recruiting a summer intern. We will be recruiting a student to contribute to our research on the application of statistical theory or psychological theory to the study of user security. For example, we will study the cognitive mechanisms responsible for password usability and the psychological principles driving security decisions. Our project will engage the summer intern in every step of the research process including research design, statistical analysis and provide the intern with a unique exposure to the application of psychology and statistics in human-computer interaction and usable security. Projects may also include Bayesian data analysis. Accepted student also has the opportunity to participate to activities of Helsinki-Aalto Institute for Cybersecurity (HAIC).

1105 - Active learning for interactive AI

Field of study:	Machine learning	
School:	School of Science	
Department:	Computer Science	
Professor:	Samuel Kaski	samuel.kaski@aalto.fi
Academic contact person:	Samuel Kaski	samuel.kaski@aalto.fi

Most machine learning systems operate with us humans, to augment our skills and assist us in our tasks. In environments containing human users, or, more generally, intelligent agents with specific goals and plans, the system can only help them reach those goals if it understands them. Since the goals can be tacit and changing, they need to be inferred from observations and interaction. We develop the probabilistic interactive user models and inference techniques needed to understand other agents and how to assist them more efficiently.

We are looking for a student to join us in developing these techniques. Additional keywords: active learning, experimental design, knowledge elicitation, multiagent learning, machine teaching.

Link: https://aaltopml.github.io/machine-teaching-of-active-sequential-learners/

1106 - Bayesian deep learning

Field of study:	Machine learning	
School:	School of Science	
Department:	Computer Science	
Professor:	Samuel Kaski	samuel.kaski@aalto.fi
Academic contact person:	Markus Heinonen	markus.o.heinonen@aalto.fi

We are looking for a student to join the Aalto Probabilistic Machine Learning Group, to work on developing state-of-the-art Bayesian deep learning. Key research questions are about more useful neural parameterisations, process priors on function spaces and more efficient probabilistic inference methods for deep neural networks. Possible applications range from large-scale image classification to sample-efficient Bayesian reinforcement learning and robotics.

This work will build on top of existing research lines in the group on RL and BNNs, with a recent highlight work of implicit BNNs with state-of-the-art ImageNet performance while maintaining Bayesian principles. The group has excellent collaboration and application opportunities.

Background in machine learning, statistics or math is expected.

1107 - Deep learning with differential equations

Field of study:	Machine learning	
School:	School of Science	
Department:	Computer Science	
Professor:	Samuel Kaski	samuel.kaski@aalto.fi
Academic contact person:	Markus Heinonen	markus.o.heinonen@aalto.fi

We are looking for an exceptional and motivated phd student to push the boundaries of deep learning with differential equations. In conventional deep learning the inputs are transformed by a sequence of layers, while an alternative paradigm emerged recently interpreting learning tasks as continuous flows with ODEs or SDEs. We aim at developing new ways to perform machine learning by repurposing differential equations.

Possible topics include interpretable neural ODEs, to modelling data augmentations as flows, and to probabilistic neural ODEs. The work is supported by multiple active research lines at the department.

Background with machine learning, statistics or math learning will be useful.

1108 - Training probabilistic circuits on large scale datasets

Field of study:	Machine learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Arno Solin	arno.solin@aalto.fi
Academic contact person:	Martin Trapp	martin.trapp@aalto.fi

Probabilistic circuits, such as sum-product networks and probabilistic sentential decision diagrams, are a promising class of deep probabilistic models that unify ideas from classical AI and modern deep learning. In contrast to many other probabilistic modelling families, probabilistic circuits guarantee exact and efficient computation of many probabilistic inference tasks. However, training a circuit on massive datasets is a challenging task due to their sparse architecture. The aim of this project is to adopt work on coresets to enable efficient parameter learning in large scale settings.

The prospective candidates should be familiar with topics related to probabilistic machine learning and should ideally have experience with python deep learning frameworks.

References:
[1] Peharz et al. (2020). Einsum Networks: Fast and Scalable Learning of Tractable Probabilistic Circuits, in ICML. http://proceedings.mlr.press/v119/peharz20a/peharz20a.pdf
[2] Lucic et al. (2018). Training Gaussian Mixture Models at Scale via Coresets, in JMLR. https://www.jmlr.org/papers/volume18/15-506/15-506.pdf

1109 - Towards Integrable Continuous Normalizing Flows

Field of study:	Machine learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Arno Solin	arno.solin@aalto.fi
Academic contact person:	Martin Trapp	martin.trapp@aalto.fi

Normalizing flows use bijective, differentiable transformations to represent complex probability distributions. Recent work has focused on so-called continuous normalizing flows, which utilize a formulation in form of an ordinary differential equation (ODE) to represent more flexible flow architectures. However, even though flow type models allow tractable computation of densities by construction they lack the ability to compute more complex probabilistic inference tasks, e.g. marginals. In parallel, there has been an increasing interest in probabilistic circuits, which use a much more restricted family of neural network architectures to guarantee exact computation of arbitrary marginals, conditions and moments. The aim of this project is to explore ways to utilize ideas from probabilistic circuits to enable exact computation of marginals in continuous normalising flow models.

The prospective candidates should be familiar with topics related to probabilistic machine learning and should ideally have experience with the Julia programming language or alternatively experience with Python frameworks.

References:
[1] Pevny et al. (2020). Sum-Product-Transform Networks: Exploiting Symmetries using Invertible Transformations, in PGM. https://pgm2020.cs.aau.dk/wp-content/uploads/2020/09/pevny20.pdf
[2] Z. Kolter, D. Duvenaud, and M. Johnson (2020). Deep Implicit Layers Tutorial at NeurIPS. http://implicit-layers-tutorial.org

1110 - Non-stationary temporal priors for large-scale modelling

Field of study:	Machine learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Arno Solin	arno.solin@aalto.fi
Academic contact person:	William Wilkinson	william.wilkinson@aalto.fi

We are looking for motivated, skilled, and open-minded summer students with an interest in real-time inference and application of probabilistic machine learning methods to practical applications. This project is concerned with non-stationary Gaussian process models and stochastic differential equations for temporal and spatio-temporal data, with possible applications in air pollution modelling, sensor fusion, or computer vision, where the problems are inherently noisy and uncertainty quantification plays an important role. An important part of the project is implementing some of these models in JAX.

Successful applicants are expected to have an outstanding record in computer science, mathematics, statistics, or a related field, and familiarity with some of the topics mentioned above.

References:
[1] Arno Solin (2020). Machine Learning with Signal Processing. ICML tutorial. Link: https://youtu.be/vTRD03_yReI
[2] William J. Wilkinson, et al. (2020). State Space Expectation Propagation: Efficient Inference Schemes for Temporal Gaussian Processes. In ICML. Pre-print: https://arxiv.org/abs/2007.05994

1111 - Efficient Model-based Path Integral Stochastic Control

Field of study:	Machine learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Arno Solin	arno.solin@aalto.fi
Academic contact person:	Vincent Adam	vincent.adam@aalto.fi

Stochastic optimal control (SOC) is the problem of controlling a known noisy nonlinear dynamical system, modeled by a stochastic differential equation (SDE) [1]. SOC has applications in many domains including robotics and underlies many state-of-the-art reinforcement learning algorithms. When the system is unknown or non-stationary, its statistics and parameters can be learned from experience. Gaussian processes (GPs) can be used to incorporate a priori assumptions about the system (e.g., the drift of the SDE) into the problem, leading to sample-efficient algorithms, i.e. algorithms that can achieve good performance with a small number of interactions with the system. However, GPs suffer from poor computational scaling making such algorithms either prohibitively slow and unfit to real world settings or require approximations that impair their performance [2]. Recent advances in GP approximations now provide computationally efficient ways to learn and sample from GPs with guarantees [3].

The aim of this project would be to combine the sample based Path-integral formulation of SOC and these recent advances in GP inference and sampling to derive efficient model based SOC algorithms. The main aim of the project would be to derive, implement and evaluate the resulting algorithm. If time allows, a more theoretical analysis of the algorithm could be done.

The prospective candidates should be familiar with topics related to probabilistic machine learning and/or reinforcement learning and should ideally have experience with Python.

References:
[1] Kappen (2008). Stochastic optimal control theory, ICML tutorial
[2] Pan et al. (2014). Model-based Path Integral Stochastic Control: A Bayesian Nonparametric Approach, https://arxiv.org/abs/1412.3038
[3] Wilson et al. (2020). Pathwise Conditioning of Gaussian Processes, https://arxiv.org/abs/2011.04026

1112 - Incorporating Physics into Deep Learning with Uncertainty

Field of study:	Machine learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Arno Solin	arno.solin@aalto.fi
Academic contact person:	Vincent Adam	vincent.adam@aalto.fi

Dynamical systems are governed by the laws of physics. Learning a dynamical system supporting accurate long-term predictions from observations of trajectories can be greatly enhanced by incorporating the right inductive biases from physics (e.g., in the form of constraints and conservation laws). Recent work has successfully incorporated laws of physics into deep learning [1, 2]. For example, neural networks were used to parameterize the parameters of the Hamiltonian of a system and learning was achieved through back propagating through the solution of the equations of motion derived from this Hamiltonian [3]. The purpose of this project would be to investigate how to best incorporate uncertainty about parameters in such models. Parameter uncertainty leads to uncertain future predictions which are crucial in control scenarios where driving the system in some particular configurations is very costly.

The prospective candidates should be familiar with topics related to classical physics, probabilistic machine learning or deep learning and should ideally have experience with deep learning frameworks such as TensorFlow.

References:
[1] Lutter et al. (2020). Deep Lagrangian Networks: Using Physics as Model Prior for Deep Learning, https://arxiv.org/abs/1907.04490
[2] Steindor Saemundsson et al. (2020). Variational Integrator Networks for Physically Structured Embeddings, ICML.
[3] Chen et al. (2018). Neural Ordinary Differential Equations, NeurIPS.

1113 - Deep Learning methods for Extreme Scale Classification

Field of study:	Machine Learning	
School:	School of Science	
Department:	Department of Computer Science	
Professor:	Rohit Babbar	rohit.babbar@aalto.fi
Academic contact person:	Rohit Babbar	rohit.babbar@aalto.fi

Large output spaces with hundreds of thousand labels are common in Machine learning problems such as ranking, recommendation systems and next word prediction. Apart from the computational problem of scalability, data scarcity for individual labels poses a statistical challenge and especially so for data hungry deep methods. The goal of the project is to investigate deep learning based architectures and adapting the well known techniques such as Attention mechanism for simultaneously addressing the computational and statistical challenge in learning with large output spaces. As the target domain is textual data, the project also involves exploring recent advances in NLP, such as Bert and TransformerXL, towards exploring the common grounds for further research in this area.

1301 - Neuroimaging with naturalistic stimuli		
Field of study:	Neuroimaging, naturalistic stimuli, data analysis	
School:	School of Science	
Department:	Department of Neuroscience and Biomedical Engineering	
Professor:	Iiro Jääskeläinen	Iiro.jaaskelainen@aalto.fi
Academic contact person:	Iiro Jääskeläinen	Iiro.jaaskelainen@aalto.fi

The topic of the position is functional magnetic resonance imaging (fMRI) using naturalistic stimuli such as movies and narratives. Using naturalistic stimuli has opened possibilities especially to address questions on, e.g., the neural basis of emotions and social cognition, that would have been difficult to tackle well with a more traditional experimental approach. This approach has especially flourished with advances in data analysis methods, such as intersubject correlation and machine learning approaches. The summer internship would involve the prospective student with aspects of experimental design with naturalistic stimuli, acquisition of data, and data analysis methods.

Prerequisites to the position include keen interest in the area, basic knowledge of cognitive neuroscience (e.g., some courses completed), and general skills in data analysis (e.g., basics of statistics, machine learning). Familiarity with Matlab and/or Python environments is a considered advantageous.

1401 - Magnetic foams

Field of study:	Physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mikko Alava	mikko.alava@aalto.fi
Academic contact person:	Mikko Alava	mikko.alava@aalto.fi

Here we study complex systems in the shape of magnetic foams. These are made of foams where magnetic nanoparticles have been mixed in. The intern is supposed to be interested in the physics of soft matter, and have skills or be interested in learning experimental physics and data analysis. The project is a collaboration between two groups at the department (Alava and ERC Grant winner Jaakko Timonen) and involves experimental studies of such foams. The project continues the successful topic of self-propelled particles in foams from summer 2019.

1402 - Coarsening and flow of foams

Field of study:	Physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mikko Alava	mikko.alava@aalto.fi
Academic contact person:	Antti Puisto	antti.puisto@aalto.fi

Foams coarsen i.e. change their structure with time. This is a complex process involving several microscopic mechanisms forcing the topology of the foam to change accordingly. Since, external forcing influences the foam structure, the coarsening in flowing foam systems is expected to deviate heavily from that in static foams. Here, we attack this problem by 3D simulations of foams using a novel GPU- based simulation code. The candidates should have an interest in soft matter physics and/or computational physics.

1403 - Machine learning in statistical physics

Field of study:	Physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mikko Alava	mikko.alava@aalto.fi
Academic contact person:	Mikko Alava	mikko.alava@aalto.fi

The task is to utilize the recently developed machine learning and artificial intelligence algorithms in statistical physics problems. The previous topics include predicting catastrophic events and local yielding or automatically classifying the material properties. Here, the algorithms are adapted to similar existing experimental and numerical datasets. The candidate is expected to have some programming experience and keen interest in computational physics.

1404 - Modeling and characterization of colored tandem solar cells

Field of study:	Applied physics, Photonics, Photovoltaics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Janne Halme	janne.halme@aalto.fi
Academic contact person:	Janne Halme Farid Elsehrawy	janne.halme@aalto.fi farid.elsehrawy@aalto.fi

Description: Building-integrated photovoltaics allow using a larger area for integration of solar panels into building façades – the visible part of the building envelope. However, conventional black solar panels do not appeal to architects and users, who prefer lighter colors for building façades [1]. Traditional colored solar cells have limited power that can be harvested due to the optical losses associated with colors [2]. Accordingly, colored solar cells can be implemented using tandem solar cells, which are less sensitive to color-induced optical losses than conventional silicon solar cells due to their efficient utilization of the sunlight spectrum. Tandem solar cells increase the efficiency by stacking multiple junctions to harvest light from a wider solar spectral range. The optical/electronic modeling and optimization of colored tandem solar cells requires a comprehensive approach involving the dependence of the optimal tandem solar cell bandgaps on the color spectrum. In this project, we develop colored solar panels that are visually aesthetic and efficient. To maximize efficiency, we search for the optimal coloration process for tandem solar cells.

References
[1] Bao et al., Renew. Energy, 113 (2017).
[2] Halme et al., Energy Environ. Sci., 12, 4 (2019).

Role and duties: The candidate's role will be to develop a modeling tool for colored tandem solar cells that enables optical simulations of the color coatings in addition to optical/electronic simulations of tandem solar cells. Next, the candidate will validate the functionality of the tool by performing optical and electrical characterization of colored tandem solar cells.

Team: The work will be performed within the New Energy Technologies research group at the Department of Applied Physics, Aalto University. The colored photovoltaics research area is led by Dr. Janne Halme, University Lecturer. The candidate will work within a team of experts on colored photovoltaics and opto-electronic solar cell modeling and characterization.

Necessary skills: Strong background in optics, numerical modeling, and solid understanding of solar cells operation. Experience in programming using Matlab and/or Python.

1405 - MBE growth of transition metal dichalcogenide heterostructures

Field of study:	Phyics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Peter Liljeroth	peter.liljeroth@aalto.fi
Academic contact person:	Xin Huang	xin.huang@aalto.fi

This project involves growing heterostructures of transition metal dichalcogenides using molecular-beam epitaxy (MBE) and characterizing them using surface science methods (XPS, STM, AFM) and optical techniques (e.g. micro-Raman). The main part of the work is to optimize the MBE growth parameters for obtaining well-defined heterostructures.

The applicant should have some experience on working a lab, prior experience on MBE or surface science tools is a plus.

1406 - Interaction-stabilized colossal topological Chern superconductors

Field of study:	Theoretical physics, Topological physics Interplay between magnetism and superconductivityics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Jose Lado	jose.lado@aalto.fi
Academic contact person:	Jose Lado Timo Hyart Teemu Ojanen	jose.lado@aalto.fi timo.hyart@aalto.fi teemu.ojanen@tuni.fi

Topological Chern superconductors are one of the paradigmatic milestones in quantum materials, due to the emergence of Majorana modes associated with their topological electronic structure. Ultimately, topological superconductors represent one of the critical materials for potential future topological quantum computers, stemming from the non-abelian braiding properties of their topological excitations. Topological superconductors are extremely rare in nature, which has motivated intense theoretical and experimental efforts for their design in artificial materials. Remarkably, recent breakthrough experiments have demonstrated the emergence of Majorana modes in these compounds. Theoretically, these systems can support an arbitrarily large number of topological modes. However, experiments up to date only have realized topological superconducting states with a limited number of Majorana modes.

The objective of this project is to theoretically study a model for topological superconductor including collective many-body reconstructions driven by electronic interactions. In particular, the student will demonstrate how electronic interactions can dramatically enhance topological gaps of interacting Chern superconductors, stabilizing phases displaying a large unprecedented number of Majorana modes. During the internship, the student will gain in-depth knowledge of topological physics, superconductivity, and magnetism, providing him/her with an outstanding experience for future studies in theoretical physics and quantum materials.

Necessary skills:
We look for a highly motivated BSc/MSc student in Physics, with a strong background in condensed matter physics, theoretical physics, and computational physics. The project will combine several analytic and computational skills, and as a result, we look for a student with experience in programming, ideally with Python.

1407 - Machine learning multipartite quantum entanglement

Field of study:	Theoretical physics Many-body quantum physics Machine learning	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Jose Lado	jose.lado@aalto.fi
Academic contact person:	Jose Lado	jose.lado@aalto.fi

Quantum many-body systems represent one of the cornerstones of modern physics, providing platforms to explore radical new forms of exotic physical phenomena. This genuine emergent phenomena in many-body systems stems from the existence of quantum entanglement, non-local forms of correlation that are forbidden in classical systems. However, experimentally detecting generic forms of quantum entanglement has remained an open problem, as only partial information of a quantum state can be accessed in experiments. Machine learning raised in the last years as a compelling framework for extracting highly-non trivial information from physical systems. Ultimately, machine learning algorithms have demonstrated to provide a powerful formalism to solve complex physical problems that lack a conventional solution, and even in the presence of incomplete and noisy information.

The objective of this project is to demonstrate that a machine-learning algorithm to infer multipartite entanglement from measured correlation functions. In particular, the student will demonstrate how supervised machine learning with deep neural networks predicts entanglement properties of quantum-many body systems solved with tensor networks. During the internship, the student will gain in-depth knowledge of machine learning, quantum entanglement, and many-body physics, providing him/her with an outstanding experience for future studies in theoretical physics, quantum technologies, and quantum materials.

Necessary skills:
We look for a highly motivated BSc/MSc student in Physics, with a strong background in condensed matter physics, theoretical physics, and computational physics. The project will combine analytic and computational skills, and so we look for a student with experience in programming, ideally with Python.

1408 - Quasiperiodic many-body criticality in quantum entangled magnets

Field of study:	Theoretical physics Many-body quantum physics Quasiperiodic criticality	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Jose Lado	jose.lado@aalto.fi
Academic contact person:	Jose Lado	jose.lado@aalto.fi

Interacting quantum systems represent one of the paradigmatic open problems in modern condensed matter physics. In particular, these systems are known to display remarkable emergent phenomena, including macroscopic quantum entanglement and exotic fractionalized excitations. Besides the conventional periodic quantum systems that are realized in natural materials, the rise of metamaterials and moire heterostructures has put forward a whole new class of systems lacking conventional translational symmetry but rather realizing quasiperiodic order. Quasiperiodicity is known to give rise to a whole new family of unconventional phenomena, and in particular, leading to the realization of tunable quantum criticality and high dimensional topological phenomena.

The objective of this project is to theoretically study a model for a quasiperiodic many-body one-dimensional quantum magnet using the many-body tensor network formalism. In particular, the student will demonstrate how the coexistence of quantum entanglement and quasiperiodicity leads to the emergence of critical fractionalized spinon excitations. During the internship, the student will gain in-depth knowledge of quasiperiodic physics, fractionalization, and quantum magnetism, providing him/her with an outstanding experience for future studies in theoretical physics, quantum technologies, and quantum materials.

Necessary skills
We look for a highly motivated BSc/MSc student in Physics, with a strong background in condensed matter physics, theoretical physics, and computational physics. The project will combine analytic and computational skills, and so we look for a student with experience in programming, ideally with Python.

1409 - Detection of entanglement in Cooper pair splitters

Field of study:	Theoretical physics, Quantum transport, Quantum information	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Christian Flindt	christian.flindt@aalto.fi
Academic contact person:	Fredrik Brange	fredrik.brange@aalto.fi

Summary

Entanglement lies at the heart of quantum mechanics and constitutes a key ingredient for many quantum information applications, such as quantum teleportation, superdense coding, and quantum cryptography. Over the last two decades, Cooper pair splitters have emerged as a promising way of generating entangled electrons in nanoscale systems. In these systems, entangled pairs of electrons are extracted from a superconductor and spatially separated to, e.g., two quantum dots. In this project, we will investigate how entanglement can be detected in a quantum dot-based Cooper pair splitter, and devise an experimental scheme to verify (and quantify) the entanglement of the emitted electrons by using entanglement witnesses, a general method for detecting entanglement. The student will gain in-depth knowledge in how to describe transport and entanglement in quantum systems, providing him/her with a solid background for future studies and research in theoretical physics, quantum transport and quantum information.

Necessary skills

We look for a highly motivated student in theoretical physics (or related areas), with a strong academic background in quantum physics and/or mathematics. The project will mainly deal with analytic derivations and calculations.

1410 - Quantum computing online

Field of study:	Theoretical physics, Quantum information, Quantum computing	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Christian Flindt	christian.flindt@aalto.fi
Academic contact person:	Fredrik Brange	fredrik.brange@aalto.fi

Summary

The field of quantum information and quantum computing is currently undergoing a tremendous development. Not long ago, only very few qubits had been realized experimentally in the lab. Now, small versions of real quantum computers are being developed and, in some cases, made accessible online by a few different companies. In this project, we will implement quantum computing algorithms remotely on one of these real quantum computers. You will have the chance to get familiar with both the theory of quantum information and quantum computing as well as the practical aspects of using quantum computers remotely. After the project, you will have gained a solid background for future studies and research in theoretical physics, quantum information and quantum computing.

Necessary skills

We look for a highly motivated student in theoretical physics (or related areas), with a strong academic background in quantum physics and programming.

1411 - Single photon generation in electron quantum optics

Field of study:	Theoretical physics, quantum mechanics, quantum optics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Christian Flindt	christian.flindt@aalto.fi
Academic contact person:	Benjamin Roussel	benjamin.roussel@aalto.fi

Summary
Recent experiments have demonstrated the ability to generate, manipulate, and probe electrical currents at the level of the individual electrons. This progress has led to a novel research field in condensed matter physics called *electron quantum optics*, where electrons are manipulated in a similar way as photons in quantum optics. However, there are major differences between photons in a waveguide and electrons in a quantum conductor: Electrons, being charged particles, are always surrounded by electromagnetic radiation. Notably, this means that it is possible to use electron quantum optics to engineering interesting states of the electromagnetic field by controlling the electronic states with time-dependent voltages. In this theoretical project, the student will explore the implementation of a single-photon source based on the decay of electron-hole pairs in a quantum conductor. The student will gain in-depth knowledge of quantum optics and interactions in many-body electronic systems, providing her/him with a solid expertise for further studies in theoretical physics and quantum technologies.

Necessary skills
We are looking for a highly motivated student in theoretical physics (or related areas), with a strong knowledge of quantum mechanics. This project will mainly deal with analytical derivations and simple numerical calculations.

1412 - Lee-Yang theory of Bose-Einstein condensation

Field of study:	Theoretical physics, quantum mechanics, statistical physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Christian Flindt	christian.flindt@aalto.fi
Academic contact person:	Christian Flindt	christian.flindt@aalto.fi

Summary:
Bose-Einstein condensation occurs when a gas of bosons is cooled below its critical temperature, and a large fraction of the particles suddenly occupy the ground state of the system. Bose-Einstein condensation is an example of a phase transition, where the macroscopic properties of a many-body system abruptly changes as an external control parameter is varied. In two seminal papers, Lee and Yang showed that phase transitions can be understood by considering the zeros of the partition function in the complex plane of the control parameter: In the thermodynamic limit of large system sizes, the zeros will approach the real value of the control parameter for which a phase transition occurs, and the associated free energy as well as other thermodynamic observables become nonanalytic. For a long time, these Lee-Yang zeros were considered a purely theoretical concept. Recently, however, it has been realized that they can also be experimentally determined, leading to a renewed interest in Lee-Yang theories.

In this project, the student will make use of recent advances in the theoretical understanding of phase transitions in many-body systems and employ a cumulant method to determine the Lee-Yang zeros of Bose-Einstein condensation from the energy fluctuations in small Bose gases. Using a finite-size scaling analysis, it is possible to extrapolate the convergence points of the Lee-Yang zeros in the thermodynamic limit and thereby determine the condensation temperature, for instance, depending on the dimensionality and the shape of the trapping potential. The project is theoretical but will lead to specific suggestions for future experiments on Bose gases. The student will become acquainted with recent theories of phase transitions in quantum many-body systems, which will provide him/her with a solid background for future studies and research in theoretical quantum and statistical physics.

Necessary skills:
We are looking for a highly motivated student in theoretical physics (or related areas), with a strong academic background in quantum physics, statistical mechanics and/or mathematics. The project will mainly deal with analytic derivations and calculations as well as some numerics. Experience with Mathematica, for instance, is an advantage.

1413 - Tunable couplers for superconducting qubits

Field of study:	Experimental quantum physics Superconducting qubit - mechanical hybrid quantum systems	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi
Academic contact person:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi

In the Quantum Nanomechanics research group
https://www.aalto.fi/en/department-of-applied-physics/quantum-nanomechanics
we work on nanomechanical systems in the quantum regime, and on superconducting quantum hybrid systems. Experimental work is carried out in the premises of Low Temperature Laboratory.

The summer projects involve design, fabrication and measurement of devices, and give an excellent overview of cutting-edge experimental research on an exciting topic with a strong relevance to quantum technologies. Quantum bits made with Josephson junctions are considered the most promising platform for realization of quantum computer. Besides this distant goal, superconducting qubits can be useful for exploring hybrid quantum systems, and testing quantum mechanics in nearly macroscopic systems. To this end, we offer three summer projects:

1. Tunable couplers for superconducting qubits.
In a quantum computation architecture, one has to be able to switch on or off the interaction between adjacent qubits. In this project, you will design a fast switchable coupling circuit for two transmon qubits. You will first run electromagnetic simulations to design the structure, then realize the device using cleanroom microfabrication, and finally test the device in a dilution refrigerator.

1414 - FPGA programming of real-time feedback for quantum circuits

Field of study:	Experimental quantum physics Superconducting qubit - mechanical hybrid quantum systems	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi
Academic contact person:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi

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2. FPGA programming of real-time feedback for quantum circuits
Superconducting qubits, or quantum micromechanical experiments, often require real-time feedback, built upon the measurement record, in order to apply delicate corrections to the quantum state. In this project you will program a FPGA (Field Programmable Gate Array) data processing architecture for creating such feedback. The system is tested with simulated data, and depending on the progress, also tests using real samples can be foreseen.

1415 - Open superconducting microwave cavity

Field of study:	Experimental quantum physics Superconducting qubit - mechanical hybrid quantum systems	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi
Academic contact person:	Mika A. Sillanpää	Mika.Sillanpaa@aalto.fi

In the Quantum Nanomechanics research group
https://www.aalto.fi/en/department-of-applied-physics/quantum-nanomechanics
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The summer projects involve design, fabrication and measurement of devices, and give an excellent overview of cutting-edge experimental research on an exciting topic with a strong relevance to quantum technologies. Quantum bits made with Josephson junctions are considered the most promising platform for realization of quantum computer. Besides this distant goal, superconducting qubits can be useful for exploring hybrid quantum systems, and testing quantum mechanics in nearly macroscopic systems. To this end, we offer three summer projects:

3. Open superconducting microwave cavity
Three-dimensional (3D) microwave cavity resonators offer an attractive platform for implementing the best superconducting qubit circuits. Additionally, 3D cavities can be used to carry out quantum experiments with large vibrating membranes used as mechanical oscillators. In this project, you will investigate a possibility to realize an open 3D cavity that consists of two separate blocks. The motivation is that the scheme allows for introducing voltage to one of the blocks. The work involves running electromagnetic simulations, realizing the physical structure, and carrying out basic measurements.

1416 - Radiation damage in structural materials

Field of study:	Physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Andrea Sand	andrea.sand@aalto.fi
Academic contact person:	Andrea Sand	andrea.sand@aalto.fi

Description: Particle irradiation modifies the physical and mechanical properties of materials, and plays an increasing role in modern technological developments. For example, climate change is driving the need for green energy, with nuclear fusion and next generation fission standing as two of the strongest candidates for efficient and reliable energy production of the future, yet the challenges posed to reactor materials in the high radiation environments are significant. Modelling provides an essential tool for predicting the response of reactor components in future nuclear devices. The damage in materials created by energetic impacting particles is highly sensitive to the mechanisms of dissipation of the impinging particle's kinetic energy. This summer project involves performing simulations employing a recently developed atomistic model, which accounts for energy dissipation in unprecedented detail, to predict the primary radiation damage in metals and model alloy systems under different incident neutron and ion energy spectra. The work will support the further development and validation of the model. The student will gain knowledge of the processes of radiation damage formation in materials, learn the basics of performing molecular dynamics simulations of highly non-equilibrium events, and develop a familiarity with high performance computing environments.

Necessary skills: Experience in programming is highly desirable. The candidate should also have basic knowledge of solid state physics and computational physics. Previous experience of molecular dynamics or high performance computing is considered a plus.

1417 - Machine Learning Strategies for Scientific Data Analysis

Field of study:	Physics	
School:	School of Science	
Department:	Department of Applied Physics	
Professor:	Adam Foster	adam.foster@aalto.fi
Academic contact person:	Adam Foster	adam.foster@aalto.fi

Scientific data can be generated through physical simulations, experimental laboratories and observations from real-world problems. Compared to just a few years ago, the advancement of scientific instruments, digital sensors and computational resources as well as storage devices have created huge collections of scientific data. Unlike traditional statistical analysis, Machine Learning (ML) thrives on growing data sets. The more data fed into an ML system, the more it can learn and apply the results to higher quality predictions and new insights. In this project, we will investigate and implement ML methods (e.g., kernel regression, autoencoders, deep learning) for finding key variables influencing physical phenomena and materials properties. In particular, we will develop and exploit the wealth of materials data available (most of it generated in our research group), and use ML to discover new materials and phenomena linked to them. Examples within the SIN group (http://www.aalto.fi/physics-sin) include interpreting microscopy imaging, identifying exotic quantum phenomena and predicting hydration structures.

The detailed applications and tasks will be tailored according to the background of successful candidates. Applicants should have a basic knowledge of physics, data analysis and statistics. Knowledge of Python would be highly beneficial.

School of Electrical Engineering

Department of Communications and Networking

2101 - Interactive prior elicitation		
Field of study:	Computer Science - HCI, Probabilistic Machine Learning, Cognitive Science, Bayesian Methods	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Suyog Chandramouli	suyog.chandramouli@aalto.fi

Description: Prior elicitation, during which subjective knowledge and beliefs of experts are elicited is an important part of the Bayesian methodology which is used very widely in artificial intelligence and computational modeling. However, there are many sources of variance in elicited beliefs due to (i) actual differences in experts' beliefs, (ii) cognitive biases of the experts in uncertain settings, (iii) measurement noise in prior elicitation methods, (iv) elicitor induced biases, and (v) methodological flexibility in the elicitation procedure. The goal of any good prior elicitation method is to capture to the extent possible, the true unbiased beliefs of an expert while making sensitive measurements.
Prior elicitation methods are often developed independently, and seldom comprehensively tested for validity. Additionally, variance in elicited beliefs are often assumed to be only due to differing views of experts. In this project we will develop a new interactive prior elicitation procedure which views human judgments as a result of sampling from subjective mental representations, after a training phase using data generating distributions that are known to us. This procedure which collects many such samples from participants will then be used as a gold standard along with the true generating distributions, against which existing elicitation methods (which we believe may be quicker but less accurate) would also be compared. [This work is associated with the Finnish Center for AI (fcai.fi).]

Preferred Skills/qualification
Experience with one or more of the following:
a) Bayesian statistical methods, e.g. MCMC sampling
b) Programming HCI or Psychology experiments, e.g. using PsychoPy
c) Cognitive modeling
d) R, Python

2102 - Bayesian Inference for Computational Cognitive Models

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning, and Cognitive Science	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Antti Oulasvirta	antti.oulasvirta@aalto.fi

Description: Computational cognitive models are simulators that make predictions of behaviour in various tasks. They can be very useful in creating intelligent interactive systems that understand their users, but only if the models are correctly specified and their parameters set according to the preferences and abilities of individual users. Correctly parametrised user models can predict behaviour under various conditions, permitting optimisation of user interfaces and anticipation of user responses to task events. Recent advances in reinforcement learning (RL) based cognitive modelling have extended the range of possibilities for simulating task behaviour, as they can predict how adaptive strategies emerge in various task conditions.

The project presents an opportunity to learn about RL based computational modelling and Bayesian parameter inference. It utilises an existing RL based computational model and task data, and utilises an engine for inferring the parameters of the model from different individuals in the data. The project implements the inference framework required to create predictions of users given observed interactive behaviour. [This work is associated with the Finnish Center for AI (fcai.fi).]

Requirements: The applicants are expected to have strong programming skills (Python) and studies in human-computer interaction. In addition, skills in following are preferred but not required: reinforcement learning, Bayesian parameter inference, computational cognitive modelling.

2103 - Helping People to Learn with Artificial Teachers that Adapt to User's Cognitive Characteristics

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning, and Cognitive Science	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Aurélien Nioche	aurelien.nioche@aalto.fi

Description: How can we make better artificial teachers? We suggest splitting the problem into two parts: (i) inference of the cognitive features, (ii) sequence planning. Hence, on the one hand, we infer the cognitive traits of the user, by fitting the user data with a series of plausible psychological models. On the other hand, the schedule of review is optimized based on individualized predictions of performance. This generic framework allows answering a series of questions that would help to develop better self-teaching applications: How to take into account the cognitive particularities of the learner? How to take into account the time constraints of the learner? How to combine the information of several learners? How to maximize the information about the learner without penalizing his learning (i.e. how to deal with the exploitation-exploration tradeoff in this context)? How to select the 'teaching' trajectories worthy to simulate (i.e. identify the best sampling technique in this context)? This project includes in silico experiments (with artificial agents only) and lab experiments (with human embodied users). The intern will aim to improve user modeling and/or the algorithm that handles the sequence planning. The intern will be invited to also test his own hypothesis. [This work is associated with the Finnish Center for AI (fcai.fi).]

Requirements: The intern is expected to know to be proficient in Python. Having some background knowledge about data analysis, machine learning, and/or cognitive modeling will be appreciated.

2104 - AI-Assisted Indirect Input Design

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Julien Gori	julien.gori@aalto.fi

Description: Transfer functions in indirect input modalities operate a transformation from physical action to virtual movement (e.g. of a cursor on a screen), and are usually designed by trial-and-error.
The goal of this project is to propose a general methodology for designing transfer functions, that takes into account explicit objectives (e.g. minimizing fatigue of a user) and users own abilities (e.g. motor impaired user). We first look at this problem under the scope of a two agent paradigm. The first agent, the operator, provides physical actions (e.g. mouse movements), which are modulated by a second agent, the enhancer (e.g. applying a constant gain). The operator wants to reach a specific goal (e.g. a target on the screen): the enhancer will help him reach that goal in the best possible way i.e. accounting for the operators abilities and the stated objective.
The behavior of the two agents will be determined using the multi-agent reinforcement learning (MARL) framework, "in silico". A second step will be to deploy the enhancer with a human operator. The enhancer's performance will be validated with several devices and with different operators. The project thus presents the opportunity for the student 1) to develop his skills in reinforcement learning (RL), including MARL; 2) to implement a working solution on a chosen indirect input device. [This work is associated with the Finnish Center for AI (fcai.fi).]

Preferred Skills/qualification: Strong programming skills (Python, GUI) are expected.

2105 - Deep generative movement models for HCI

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Julien Gori	julien.gori@aalto.fi

Description: This project will be in collaboration with Prof. Luis Leiva (University of Luxemburg). Movements, from cursor trajectories, to strokes, gestures, and handwriting are ubiquitous in Human Computer Interaction (HCI). Artificially generating human-like movement data would allow to improve the design of HCI interfaces while reducing the need for time consuming experiments with participants in the laboratory.
The articulation and production of human movements is a complex problem grounded on motor control principles. Modern deep generative models can produce realistic human-like movements, exploiting non-linear and long-term dependencies within the observed human data. However, these models can make only limited inferences about the distribution of the observed data.
The project will focus on modeling the full representation of human handwriting, gestures and/or pointing, i.e. 2D trajectories with their associated timestamps. The intern will contribute techniques to sample realistic trajectories from deep generative models. [This work is associated with the Finnish Center for AI (fcai.fi).]

Preferred Skills/qualification: The intern is expected to be knowledgeable in Deep Learning (DL) methods for generative modeling and be familiarized with some popular DL library or framework, such as Tensorflow, Keras, Pytorch, Lightning, etc.

2106 - Computational methods in understanding decision-making processes in HCI

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning, and Cognitive Science	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Aini Putkonen	aini.putkonen@aalto.fi

Description: People make hundreds, if not thousands, of decisions a day. These decisions reflect individual preferences, resulting from latent cognitive and behavioural processes. Today, individuals make a number of these decisions when interacting with different technologies, clicking and tapping through content on their devices. Understanding the rationale behind each click and tap can be leveraged in various applications in human computer interaction, including personalising user interfaces. Drawing from existing research in decision theory and advances in computational cognitive modelling, we aim to discover novel ways of understanding decision-making using empirical data. The types of questions we aim to answer include: Which models best capture how individuals engage with content, e.g. news articles, on a website? How can we model users' scrolling behaviour? What kind of data can be used to test these models?
The intern will contribute to both model specification and practical implementation of the modelling workflow, with an emphasis depending on their specific interest. We invite candidates with a background in social/cognitive/computer science, and other applicable fields. An ideal candidate is expected to be proficient in Python and have an understanding of some model types used in HCI and cognitive science (e.g. POMDP, heuristics, models of decision-making under risk). [This work is associated with the Finnish Center for AI (fcai.fi).]

Requirements: Experience in handling and analysing large datasets is appreciated.

2107 - Interactive multi-objective optimization

Field of study:	Computer Science - Mathematics, Machine learning, Optimization Techniques	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Morteza Shiripour	shiripour.morteza@aalto.fi

Description: This project aims to develop an interactive multi-objective to graphical user interfaces. Graphical user interface is a visual way for the user to interact with a computer via several graphical elements (e.g. icons, menus, windows, and buttons) and its layout problem aims to find the best way to organize these graphical elements on a fixed canvas. Organizing these layouts is challenging because there are a huge number of different layout designs and the designers should also consider various limitations and criteria in their layout design process. Hence, we intend to present a model and algorithm in order to automatically generate layouts addressing different multiple tasks such as usability and aesthetic qualities. Moreover, we aim to guide the algorithm to find solutions according to a decision maker preferences. [This work is associated with the Finnish Center for AI (fcai.fi).]

Prerequisites: The successful intern should have a background in mathematical programming and evolutionary multi-objective optimization, a strong previous background in coding in Python and machine learning methods are beneficial (optional).

2108 - Inferring agent preferences from behaviour

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning, and Cognitive Science	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Andrew Howes	andrew.howes@aalto.fi

Description: The project will investigate reinforcement learning algorithms with which an observer can infer the preferences of agents that forage for care-packages in a type of grid world that has varying terrain. Agents differ in their preferences for different care-packages and in how costly they find different terrains to traverse. Agents also differ in their cognitive capacities (e.g. their awareness of the care-packages and terrain). The preferences and capacities of any particular agent are hidden from the observer but they do partly determine the agent's behaviour. The task is for the observer to infer the agent's preferences given only the agent's behaviour. [This work is associated with the Finnish Center for AI (fcai.fi).]

Paper: Jara-Ettinger, J., Schulz, L. E., & Tenenbaum, J. B. (2020). The naive utility calculus as a unified, quantitative framework for action understanding. Cognitive Psychology.

Requirements: Cognitive modeling or reinforcement learning

2109 - Model-based eye tracking

Field of study:	Computer Science - Human-Computer Interaction, Machine Learning, and Cognitive Science	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Xiuli Chen Andrew Howes	xiuli.chen@aalto.fi andrew.howes@aalto.fi

Description: Eye tracking is a technology that allows a computer to estimate where on a computer screen a person is looking. It is used routinely in Human-Computer Interaction research, as well as in gaming and virtual/augmented reality. The project will investigate whether the accuracy of eye tracking (how well it determines what a person is looking at) can be improved with a model of how people use the eyes to gather information. [This work is associated with the Finnish Center for AI (fcai.fi).]

Requirements: Cognitive modeling or reinforcement learning

2110 - Computational Graphical User Interface Evaluation

Field of study:	Computer Science - Human-Computer Interaction (HCI)	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Markku Laine	markku.laine@aalto.fi

Description: Graphical user interfaces (GUI) are omnipresent in our everyday life and play an important role in how users interact with various electronic devices. Typically, evaluation of GUIs relies on personal experience (subjective) and empirical testing (timeconsuming), and less so on computational modeling. To address these concerns, we developed Aalto Interface Metrics (AIM), an online web service (https://interfacemetrics.aalto.fi/) and codebase for computational evaluation of GUI designs.

The intern will contribute to the further development of AIM, including (i) the study and implementation of new metrics and models and (ii) web development.
[This work is associated with the Finnish Center for AI (fcai.fi).]

Requirements: The intern is expected to have strong programming skills in Python and JavaScript, and background in human-computer interaction.

2111 - Combining optimization with Machine learning for UI design

Field of study:	Computer Science - Mathematics, Machine learning, Optimization Techniques	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Antti Oulasvirta	antti.oulasvirta@aalto.fi
Academic contact person:	Niraj Dayama	niraj.dayama@aalto.fi

Description: This project aims to integrate Machine learning with Optimization techniques for solving problems in User Interface design. Graphical user interface is the visual way for the user to interact with a computer via several graphical elements (e.g. icons, menus, windows, and buttons) and its layout problem aims to find the best way to organize these graphical elements on a fixed canvas. Organizing these layouts is challenging because there are a huge number of different layout designs and the designers should also consider various limitations and criteria in their layout design process. Hence, we intend to develop techniques to handle UI layouts addressing different multiple tasks such as usability and aesthetic qualities.

Prerequisites:
The successful intern should have a background in mathematical programming, optimization techniques and machine learning.

2112 - Interledger and Decentralised Identifiters for IoT Privacy

Field of study:	Information technology	
School:	School of Electrical Engineering	
Department:	Department of Communications and Networking	
Professor:	Raimo Kantola	raimo.kantola@aalto.fi
Academic contact person:	Yki Kortesniemi	yki.kortesniemi@aalto.fi

Are you a developer interested in Internet-of-Things (IoT), distributed ledgers and interledger technologies, and decentralised identifiers - in real-world applications?

We are now looking for summer interns to participate in the development work at Aalto University's IoT-NGIN project group in collaboration with experts around Europe. IoT-NGIN (https://iot-ngin.eu) is a large European Union H2020 project that applies multiple novel technologies to develop more efficient, secure and privacy preserving IoT solutions as part of the European Next Generation Internet.

Your work focuses on the development of privacy preserving solutions using interledger and decentralised identifier technologies to support Digital Twins and other IoT applications. We except applicants to have:

- At least a bachelor's degree in computer science or related field
- Good programming skills
- Solid experience with Python and Web service backend development
- Experience with distributed service design and API specification
- Good command of written and spoken English
- Ability to work effectively in an international environment

This position enables you to work on leading edge technologies with real-world applications in a fast-growing field.

2201 - Organic Materials and Devices

Field of study:	Physics, Materials Science, Chemistry	
School:	School of Electrical Engineering	
Department:	Department of Electronics and Nanoengineering	
Professor:	Caterina Soldano	caterina.soldano@aalto.fi
Academic contact person:	Caterina Soldano	caterina.soldano@aalto.fi

The Organic Electronics Group is looking for a curious and talented student, either at BSc or MSc level, for the Summer 2021, as part of the Aalto Science Institute internship program. You will contribute to the advance of a novel class of organic devices (organic light emitting transistors); in particular, your role will be to develop thin films, both dielectrics and organic materials, in order to study and improve device performances. Experimental work will include growth of materials, surface characterization and device fabrication.
Our group is international, thus a good command of English is required.

Further information: Prof. Caterina Soldano (please visit our website for more info www.organicelectronics.aalto.fi)

School of Chemical Engineering

Department of Chemistry and Material Science

3101 - Investigation Li-ion batteries electrode degradation processes		
Field of study:	Electrochemistry	
School:	School of Chemical Engineering	
Department:	Department of Chemistry and Material Science	
Professor:	Tanja Kallio	tanja.kallio@aalto.fi
Academic contact person:	Ekaterina Fedorovskaya	ekaterina.fedorovskaya@aalto.fi

Description: In this project, investigation of ageing of Li-ion batteries comprising of advanced materials is carried out using an accelerated aging test and related electrochemical and structural characterization methods. The positive and negative electrode materials are extracted and investigated before and after ageing using various structural and electrochemical characterization methods such as Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy, Scanning electron microscopy, Transmission electron microscopy, cyclic voltammetry, rate capability measurements, electrochemical impedance spectroscopy. The work includes carrying above-mentioned experiments and/or interpreting the obtained data.

Skills: Knowledge and experience on using of the above-mentioned characterization methods as well as knowledge and experience on inorganic synthesis and electrochemical characterization methods are appreciated. Furthermore, experience on using a glove box and assembling of electrochemical cells, such supercapacitors and Li-ion batteries, is valued.

Education: The appropriate candidate has background in Chemistry, Material Science or related fields. Completing courses on Analytical chemistry, Inorganic Chemistry, Organic Chemistry, Electrochemistry, Physical Chemistry, Chemical Kinetics, Chemical Thermodynamics, Chemistry of Solids, Materials Science, Materials for Electrochemical Engineering is beneficial.

School of Engineering

Department of Civil Engineering

4101 - Computational analysis of microarchitectural solids and structures		
Field of study:	Computational mechanics	
School:	School of Engineering	
Department:	Department of Civil Engineering	
Professor:	Jarkko Niiranen	jarkko.niiranen@aalto.fi
Academic contact person:	Jarkko Niiranen	jarkko.niiranen@aalto.fi

Description: The internship studies within the topic “Computational analysis of microarchitectural solids and structures” will focus on the modelling of solids and structures -- such as beams, plates and shells -- having a microarchitecture, typically a periodic lattice or cellular microarchitecture. The peculiarities of the thermomechanical behavior of these types of solids (e.g., the so-called size effects) can be captured via (computational) homogenization and generalized continuum theories.

Requirements: The topic requires solid understanding of continuum mechanics and engineering mathematics plus some experience in finite element analysis and Matlab-programming.