CaCTüS Internship Projects 2025

The projects are thematically sorted by their main focus on:

- Data Analysis
- Human Experiments
- Machine Learning
- Neuroscience

However, most projects span several methods and areas of research, so you are advised to read through all projects and their specific requirements.

Data Analysis

Project: Optimizing ultra-high-resolution fMRI for layer-specific analysis of the human prefrontal cortex
Project ID: DA-01
Lab: Cognitive Neuroscience & Neurotechnology
Area: Data Analysis, Neuroscience, Human Experiment

The Cognitive Neuroscience & Neurotechnology Lab focuses on advancing our understanding of the frontoparietal brain network mechanisms that underpin high-level cognition and adaptive behaviour in humans. For this, we pursue an interdisciplinary research programme that allows studying this brain system at multiple levels of granularity. Our methodology involves subject-specific brain-computer interface technology, fMRI at 3T and ultra-high (i.e., 7T and 9.4T) magnetic field strengths (for resolving cortical layers), EEG, non-invasive brain stimulation as well as computational modelling and machine learning.

As an intern, you will contribute to cutting-edge research in ultra-high-resolution fMRI, which allows for the investigation of the human cortex at the level of cortical layers and columns. You will explore the strengths and limitations of different MR acquisition sequences in localizing layer-specific activity in the human prefrontal cortex. Using existing datasets acquired at 7T, your work will focus on optimizing data analysis techniques, with an emphasis on improving cortical surface registration or addressing signal biases between cortical layers. Through this project, you will gain hands-on experience with advanced data analysis as well as insights into how these techniques can enhance the precision of fMRI research. Moreover, you will be invited to participate in ongoing studies, including the opportunity to attend scanning sessions and gain direct experience with MRI data acquisition at 9.4T. This will provide a comprehensive understanding of both the experimental and analytical aspects of fMRI research.

Required technical skills

- Good coding skills in Bash on Linux and Python
- Prior experience with (f)MRI data and corresponding software packages is desirable but not necessary (e.g. Freesurfer, FSL, SPM)
- Experience with high-performance computing clusters and code sharing platforms (e.g. GitHub) is desirable but not necessary

Project: Multi-stage decision making, computational models and individual differences in mental health
Project ID: DA-02
Lab: Developmental Computational Psychiatry
Area: Data Analysis

In our lab, the Developmental Computational Psychiatry Lab, we focus on understanding the cognitive and neural processes that underlie mental illness. We combine neuroimaging, computational modelling and psychological experimentation to understand the neurocognitive mechanisms underlying mental illnesses and how we can change them.

As an intern, you will contribute to cutting-edge research at the intersection of cognitive science, computational neuroscience, and mental health. You will investigate individual differences and their relation to various mental health conditions in the general population. Specifically, you will build and apply computational models to existing large-scale dataset from a multi-stage decision making task. You will learn the entire computational modelling pipeline starting from the data down to model parameters and model evaluation. You will gain practical experience in methods in computational psychiatry and various hierarchical approaches to computational modelling specifically.

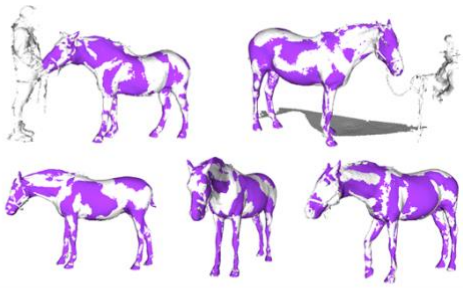
Required technical skills

- Proficiency in programming in Python
- Experience with data analysis
- Experience with behavioural tasks and assessments in humans
- Interest in the psychological foundations of behaviour, individual differences and/or computational psychiatry

Project: Trotting Data: AI based 3D Dynamic Horse Models
Project ID: DA-03
Lab: Optics and Sensing
Area: Point Cloud Analysis, 3D Model, 3D Scanning, Animal Anatomy, Deep Learning

In our lab we focus on the development of highly realistic human and animal avatars for use in research, film, virtual reality, biology and medicine using unique 3D & 4D capture facilities, machine learning, computer vision and advanced graphics. Our efforts in the previous years aimed at developing collaborative partnership and providing the veterinarian community with a 3D statistical model of quadrupedal large domestic animals with a focus on horses, which excels in anatomical accuracy.

3D template incorporating bones & muscles tissue



An example of a RAW scan (white) with the VAREN model overlaid (pink), shows how the model can explain 3D data with a small number of parameters.

As an intern, you will be learning existing code base for data pre-processing based on previous publication, i.e. VAREN [1]. You will be working on data of dynamic 3D horse scans for pre-processing, automating the steps and on assessing scanning quality of the 3D horse scans.

[1] Zuffi S, Mellbin Y, Li C, Hoeschle M, Kjellström H, Polikovsky S, Hernlund E, Black MJ. VAREN: Very Accurate and Realistic Equine Network. InProceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition 2024 (pp. 5374-5383).

Required technical skills

- Experience in one of the following: Point-cloud libraries, OpenCV, 3D rendering pipelines and deep-learning frameworks
- Strong academic performance in relevant bachelor's or master's courses
- Good programming skills in Python or C++; PyTorch experience is a plus
- Good oral and written communication skills in English

Human Experiments

Project: Diurnal rhythms of human ocular physiology
Project ID: HE-01
Lab: Translational & Circadian Neuroscience
Area: Human Experiment

In our lab we study the effects of light on human physiology and behaviour. We aim to understand how light is processed by non-image-forming visual pathways in the brain and how this impacts the human circadian clock.
Every tissue and organ in the human body that has been investigated have shown circadian rhythms, displaying changes in their physiology throughout the 24-hour cycle of day and night. However, the circadian rhythms of the human visual system remain minimally investigated to date.

The aim of this project is to collect exploratory data on the physiological changes the eye undergoes throughout the day. This is an experimental project on a novel topic where you will have the chance to learn new techniques, use several instruments that evaluate ocular anatomy and physiology and gain experience doing research with human subjects.

Required technical skills

- Basic knowledge of neuroscience or chronobiology
- Basic programming (e.g. Python, MATLAB)

Machine Learning

Project: Data-driven multispectral calibration of wide-angle GoPro cameras
Project ID: ML-01
Lab: Translational & Circadian Neuroscience
Area: Machine Learning

In our lab, we focus on understanding light has role in controlling our physiology and behaviour. To understand how light changes in the real-world, we recently collected a large amount of images of natural scenes (>700) using a high-dynamic range multispectral 5-channel radiance camera, along with RGB images collected using a GoPro camera. We want to understand how to augment the GoPro RGB

images to indicate multispectral information, thereby obviating the need for more expensive radiance image capture.

As an intern, you will be working on developing approaches for fusing image data of different resolutions and channels. You will learn about processing images from different sources, finding ways to transform between image types, and characterizing the spectral response of different cameras using data-driven and analytic, measurement-based approaches.

Our mission statement: https://www.tscnlab.org/mission-statement

Required technical skills

- Good coding skills in Python
- Experience in handling, processing and analysing image data
- Experience in image registration
- Proactive, solution-oriented communication and reporting skills

Project: Emotion Drift in Long-context Conversational AI
Project ID: ML-02
Lab: Safety- and Efficiency-aligned Learning and Deep Models and Optimization
Area: Machine Learning

Our labs are interested broadly in both efficiency considerations (DMO group, Antonio Orvieto) and safety considerations (SEAL group, Jonas Geiping) in modern machine learning, and we hence are interested not only in understanding and improving state-of-the art deep learning models, such as large language model, but also in methods to reduce harm arising from the use of these models.

In this project, we are interested in studying the internal representation of large language models over the course of long conversations. We are interested especially in feature vectors, developed, for example, through representation engineering, that encode "emotion" in the model's internal processing. In practice, the first step in this project will be learning to set up inference for a large open-source language model with support for long contexts. The second step will be to analyze internal representations and track them over the course of long conversations. The third step will be evaluating and analyzing the drift of representations over time and to consider the safety implications of these drifts.

Required technical skills

- Good coding skills in Python
- Great command of the English language, necessary to improve and analyze text model outputs
- Basic Understanding of Nature Language Processing with Large Language Models

Project: Efficient Finetuning of Language Models
Project ID: ML-03
Lab: Deep Models and Optimization and Safety- and Efficiency-aligned Learning
Area: Deep Learning, Optimization

In the Deep Models and Optimization Group, our research focuses on developing theoretical insights to address the challenges of training modern deep learning models by leveraging tools from optimization theory and statistics. In collaboration with the Safety- and Efficiency-aligned Learning Group of Jonas Geiping, we propose here a project aimed at improving efficiency when fine-tuning language models, with an emphasis both on theoretical aspects and practical performance. This topic is highly relevant for applications where large pretrained models (e.g., Llama, Gemma) need to be fine-tuned on new data by users with limited GPU resources (such as 24GB memory cards, which are

commonly available at lower prices). Modern techniques, like adapters such as LoRA and its variants (e.g., GaLore), demonstrate significant potential for improvement, with innovative and exciting research released regularly.

As an intern, you will be able to develop on this exciting literature and design your new efficient fine-tuning. The project will crucially allow you to develop your practical understanding of large language models, understand the details and benchmark existing techniques, and identify the limitations of the currently available solutions. Informed by recent literature, we believe that much focus has to be placed on the initialization of modern adapters and optimization techniques (e.g., learning rate schedulers) to be designed specifically in this setting.

Required technical skills

- Good coding skills in Python and knowledge of libraries such as Torch or Jax
- Basic knowledge of machine learning concepts
- Working knowledge of the structure of transformer models
- Interest in the mission of finetuning
- Experience in training language models is a plus

Project: Building tactile representations through self-exploration
Project ID: ML-04
Lab: Haptic Intelligence and Autonomous Learning
Area: Machine Learning

The Autonomous Learning Lab focuses on building artificial systems that learn from experience. Artificial intrinsic motivations are a central component that we develop using information theory and dynamical systems theory. We work on reinforcement learning, representation learning, and internal model learning.
The Haptic Intelligence Department believes that a sense of touch is essential for a robotic system to efficiently collect information about the physical interactions it has with its environment. Endowing robots with touch capabilities that are sensitive, useful, and robust is still an ongoing research field. Many touch sensors have been proposed; however, they often output high-bandwidth information, and processing this information efficiently is essential to being able to react to changes in the environment quickly enough.

As an intern, you will be working on using self-organizing maps or other machine-learning methods to learn an efficient representation of tactile input collected with a robot platform using vision-based tactile sensors (our previously published sensor, Minsight). The internship will include collecting data on the robotic platform and afterward processing the data using the selected methods. You will learn about tactile sensing in robotics and deepen your knowledge of representation learning, as well as get into contact with real robots and meet many fun people.

Required technical skills

- Good coding skills in Python
- Experience with machine-learning methods

(Theoretical) Neuroscience

Project: Organisation of individual behaviour in group settings
Project ID: TN-01
Lab: Computational Neuroscience
Area: Theoretical Neuroscience, Human Experiments, Reinforcement Learning

In our lab, we focus on building and testing theories and computational models of neural processing, with a particular emphasis on decision-making, learning and representation. One of our research directions explores social decision-making, where two or more agents — human or artificial— try to infer each other's intentions and leverage this understanding for both collaboration and competition. An intriguing but underexplored question involves determining which hierarchical organisation structures are best suited — or emerge naturally — when multiple agents interact in different environments and tasks.

As an intern, you will be working on a novel project investigating how agents exchange information when faced with a shared challenge that each individual only receives limited information about. Depending on your interests, you will be focusing more on developing algorithms for optimal agent behaviour or conducting and analysing human experiments. You will learn about (multi-agent) reinforcement learning, social decision making, and working with simulated and/or empirical data.

Required technical skills

- Good coding skills (e.g. Python, Matlab, R)
- Statistics

Project: Impact of learning algorithm on learned representations across cognitive tasks
Project ID: TN-02
Lab: Computational Neuroscience
Area: Theoretical Neuroscience, Machine Learning

Our lab focuses on developing and testing theories and computational models of neural processing and representations across cognitive processes such as decision-making and learning. One of the directions we are interested in is neural reinforcement learning, which allows us to gain a deeper understanding of how humans and animals learn to perform adaptive behavior (e.g., decision-making, foraging, etc.) in dynamic and complex environments and uncover the underlying neural machinery.

As an intern, you will be working on a research project that investigates how distinct learning algorithms impact the learned neural dynamics and representations relevant to performing various cognitive tasks. Recently, there has been a growing interest in using task-optimized recurrent neural networks (RNNs) to uncover the neural mechanisms underlying cognitive processes (e.g., decision-making). However, these studies usually apply supervised training algorithms that are unrealistic concerning animal behavior and learning. Reinforcement learning can serve as an alternative learning algorithm capable of capturing complex animal behavior. In this project, you will learn to use both supervised and reinforcement learning algorithms to train RNNs on a variety of cognitive tasks (e.g., using NeuroGym library) and compare how the learning algorithm affects the neural representations and dynamics in the trained RNNs.

Required technical skills

- Good coding skills in Python
- Basic familiarity with neural networks