NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Graduate College

Joint PhD Program Description

The description for the Joint PhD program will be posted online as a sub-page to

Joint PhD Programmes | Graduate College | NTU Singapore.

Name of Partner University	Technische Universität Graz
Country	Austria
Year of JPP Establishment	2011
Program	☒ Joint Degree ☐ Joint Supervision
Description of the Program (150-250 words)	The joint PhD programm between Nanyang Technological University and Technische Universität Graz covers the following main areas of focus (not limited to): Human-Computer Interaction, Brain-Computer Interfaces, Computer Vision, Visual Analytics, Medical Computing, Artificial Intelligence, etc.
Disciplines	College of Computing and Data Science
PMC Names and Emails	NTU: • Prof Lin Weisi (wslin@ntu.edu.sg) • Prof Guan Cuntai (CTGuan@ntu.edu.sg) TU Graz: • Prof Dieter Fellner (dieter.fellner@igd.fraunhofer.de) • Prof Gernot Mueller-Putz (gernot-mueller@tugraz.at)

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Graduate College

Joint Projects

1. Enhancing Practical Quantum Key Distribution with Advanced Numerical Techniques for Finite-Key Analysis

Date Posted	5 July 2024	
Home University	Nanyang Technological University	
Partner University	Technische Universität Graz	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	Quantum Key Distribution (QKD) is pivotal for future-proof secure communications, particularly against the potential of quantum computing to break traditional cryptographic schemes. The secure implementation of QKD in realistic scenarios where only a finite number of signals can be exchanged remains a major challenge. Current methods often rely on asymptotic security analyses, which do not hold under practical conditions with finite resources. The objective of this project is to develop a robust numerical approach for analyzing the security of various QKD protocols in the finite-key regime. This involves extending the semi-definite programming (SDP) methods to provide more accurate estimates of the key rates achievable in practical settings. The project includes the following four tasks: 1) Model Development, 2) Protocol Analysis, 3) Optimization Techniques, and 4) Security Parameter Evaluation, which are elaborated below: • Task 1 in Year 1: Model Development. The project will develop numerical models using two types of SDPs for QKD finite-key analysis. The first SDP will utilize the relation between conditional smooth min-entropy and quantum relative entropy, and the second will use the relation between the smooth min-entropy and quantum fidelity. • Task 2 in Year 2: Protocol Analysis. The developed SDPs will be implemented to analyze several QKD protocols under practical conditions, focusing on protocols like BB84 with unequal detector efficiencies and B92, which are challenging to analyze	

	analytically. • Task 3 in Year 3: Optimization Techniques. Convex optimization solvers like Mosek and SDPT3 will be used to solve the SDPs. The project will explore the feasibility of applying these numerical methods to less symmetric, more practical QKD setups, including potential asymmetric configurations. • Task 4 in Year 4: Security Parameter Evaluation. The project will evaluate the impact of varying security parameters such as key reconciliation failure probability and quantum bit error rates on the estimated secure key rates.
Program/Center Website(s)	N.A.
Additional Information (e.g., files with project details)	N.A.

2. Conceptual Metaphor Understanding

Date Posted	5 July 2024	
Home University	Nanyang Technological University	
Partner University	Technische Universität Graz	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	Metaphors are not just linguistic phenomena but also reflections of cognitive processes. When we use a source concept to illustrate a target concept metaphorically, we establish a mapping relationship between these two concepts within our cognitive systems. For example, by metaphorically expressing "time is money", we imbue the target concept of "time" with attributes associated with the source concept of "money", such as scarcity and preciousness. This project aims to develop a state-of-the-art AI system designed to comprehend the concept mappings inherent in metaphors, thereby providing valuable cognitive insights across significant scientific domains. The project objectives encompass the following research directions: 1. Exploration of concept representations and perceptions with neurosymbolic methods: The successful candidate will investigate how metaphors are represented and perceived by integrating symbolic reasoning with neural network models. This neurosymbolic approach aims to capture the abstract and nuanced nature of metaphorical thinking, enabling a more profound understanding of cognitive processes. 2. Development of NLP or multimodal systems for metaphor processing: The candidate will focus on creating AI systems capable of identifying, interpreting, and generating concept mappings for metaphors. This involves leveraging advanced machine learning techniques, such as language modelling, commmonsense reasoning and analogical reasoning, to automatically process metaphorical language in text and multimodal data. 3. Application of developed systems to cognitive analysis from large-scale data: Utilizing the developed systems, the	

	candidate will analyse large-scale datasets to uncover patterns and insights related to human cognition. This big data approach will enable the examination of metaphor usage across diverse contexts and science domains, revealing how metaphors shape and reflect cognitive processes. Candidates with a strong background in natural language processing, cognitive science, and mathematics are encouraged to apply. Ideal applicants should possess experience with machine learning frameworks, a solid understanding of cognitive theories, and a passion for interdisciplinary research.
Program/Center Website(s)	https://sentic.net/
Additional Information (e.g., files with project details)	NA

3. Brain-Computer Interface Algorithms and Applications

Date Posted	31 May 2023	
Home University	Nanyang Technological University	
Partner University	Technische Universität Graz	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	The research topics will be centred around Brain-Computer Interfaces, algorithms and/or clinical applications in spinal cord injury or stroke. Following research topics are suggested (but not limited to): foundation models for BCI, deep learning algorithms in BCI, transfer from healthy to patients, motor decoding, BCI systems for stroke/brain injury, etc.	
Program/Center Website(s)	https://ntu-cbcr.org/ https://www.tugraz.at/institute/ine/home	
Additional Information (e.g., files with project details)	NA	

4. Generative AI for Adaptive AIoT

Date Posted	31 May 2023	
Home University	Nanyang Technological University	
Partner University	Technische Universität Graz	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	Generative artificial intelligence (AI) has attracted much attention and showed great potentials for applications involving human-perceptible multimedia data (e.g., text and images). Its adaptability to the prompts sheds new lights on addressing various adaptation problems faced by artificial intelligence of things (AIoT). For instance, the perception functions of AIoT should adapt to the context. This project will study building generative AI that produce AIoT perception functions based on the sensed meta information, in specific applications like acoustic localization, continuous human activity recognition, etc.	
Program/Center Website(s)	NA	
Additional Information (e.g., files with project details)	NA	

5. AI Meets Geometry

Date Posted	31 May 2023	
Home University	Nanyang Technological University	
Partner University	Technische Universität Graz	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	Artificial Intelligence and deep learning have achieved remarkable success in various domains including computer vision and natural language processing. They have also proven to be highly valuable in other fields such as 3D graphics and geometric modelling. This project investigates relationship between AI and geometric modelling & processing. The study delves into examples of new geometric processing algorithms and how deep learning algorithms can be incorporated to generate, analyze and process 3D digital models. To better understand the present dynamics between geometric modelling and AI, the research will analyze typical deep learning models from a geometric perspective, while also examining traditional geometry algorithms through the lens of learning. The project then focuses on specific geometric processing problems, selecting one or two for in-depth exploration. The objective is to develop intelligent geometric processing algorithms, leveraging principles of artificial intelligence or frameworks of deep learning. Examples of potential geometric processing problems include surface reconstruction, remeshing, point cloud segmentation, subdivision surfaces, and 3D shape parsing, among others. The overarching goal is to enhance the intelligence of geometric processes, empowering them to adeptly handle more intricate scenarios.	
Program/Center Website(s)	NA	
Additional Information (e.g., files with project details)	NA	