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/Dual PhD Programmes | Graduate College | NTU Singapore.

Name of Partner University	KTH
Country	Sweden
Year of Establishment	2015
Program	☒ Joint Degree ☐ Joint Supervision
Description of the Program	The NTU-KTH Joint PhD Program was established in 2015, aiming for cutting-edge research on smart transportation, in response to worldwide mobility needs. Built upon the success of Phase 1 Program, the second phase is expected to start in January 2023, with a significantly extended scope that includes all exciting fields related to smart cities and sustainability. Candidates in this program are expected to fulfil standard coursework requirements at the host institution and complete a PhD dissertation in relevant areas in four years. In addition, candidates are also expected to fulfil a residency requirement at the partner institution for 12-13 months during the candidature period. Candidates will have opportunities to work with renowned scholars in relevant fields and enjoy world-class research facilities of both institutions. In addition, there are opportunities for candidates to interact with big companies that have established collaboration relationships with the program to understand real industrial needs and the state-of-art technologies. There will be hackathons organized by the program to allow candidates to demonstrate their cutting-edge technologies and most innovative ideas.
Disciplines	All disciplines that are related to smart cities and sustainability, e.g., electrical engineering, mechanical engineering, civil engineering, computer engineering, computer science, material science, biochemical engineering, social science and psychology.
PMC Names	NTU: Su Rong, Wang Zhiwei, Timothy John White KTH: Stefan Ostlund, Bo Wahlberg, Bjorn Berggren
PMC Emails	NTU: rsu@ntu.edu.sg, WangZhiwei@ntu.edu.sg, tjwhite@ntu.edu.sg KTH: stefano@kth.se, bo@kth.se, bjorn.berggren@abe.kth.se

Joint Projects

Home University	Nanyang Technological University	
Supervisors	**Home**	**Partner**
Name	Tang Yi	Wang Xiongfei
School	School of Electrical and Electronic Engineering	Division of Electric Power and Energy Systems
Email	yitang@ntu.edu.sg	xiongfei@kth.se
Website	https://dr.ntu.edu.sg/cris/rp/rp00875	https://www.kth.se/profile/xiongfei
Project Title	**Next Generation Grid-Forming Converters for Grid Integration of Renewable Energy**	
Project Description (200-300 words)	Modern power systems are evolving from fossil fuel-dominated carbon-intensive energy systems into renewable energy-dominated low-carbon energy systems. Power electronic converters, as the grid interface of renewable energy, play a pivotal role in underpinning the transformation and decarbonization of modern power systems. Conventionally, grid-tied converters apply grid-following (GFL) control and operate as AC current sources that passively follow the power grid frequency. However, the large-scale integration of power electronic converters in utility grids with GFL control may introduce a number of new scientific challenges. On one hand, power systems need to establish voltage and frequency first for GFL converters to connect, which cannot be achieved by GFL converters themselves. On the other hand, GFL converters may face instability issues under weak grid conditions. These concerns stimulate the demand for a novel grid-forming (GFM) control, with which power converters can establish their own voltage and frequency and synchronize with other power sources autonomously. This PhD project aims to study the modelling and control of grid-tied GFM converters and understand their behaviours under different operating scenarios such as small/large signal stability, synchronization stability, transient stability, fault ride through, etc. The goal is to develop innovative next-generation grid integration technologies for renewable energy, thereby paving the way for the clean energy transition in the power sector.	
Program/Center Website(s)	Centre for System Intelligence and Efficiency https://www.ntu.edu.sg/csie	
Additional Information (e.g., files with project details)	Nil	

Joint Projects

Home University	Nanyang Technological University	
Supervisors	**Home**	**Partner**
Name	Su Rong	Vladimir Cvetkovic
School	School of Electrical & Electronic Engineering	School of Architecture and the Built Environment
Email	rsu@ntu.edu.sg	vdc@kth.se
Website	https://personal.ntu.edu.sg/rsu	https://www.digitalfutures.kth.se/person/vladimir-cvetkovic/
Project Title	Game-Theoretical Approach for Control of Multi-level Systems with Social Influence	
Project Description (200-300 words)	To ensure sustainability of a smart city, it is vital to achieve social optimality, whenever possible. For example, in intelligent transportation systems, good driving behaviors of individual drivers can significantly increase network throughput and reduce inroad fuel consumptions. In smart buildings, good energy usage habits of occupants can significantly reduce the overall building energy consumptions. All these will eventually contribute to zero carbon emission efforts. However, how to effectively influence individual persons' behaviors towards socially desirable ones is one challenge faced by the scientific community. In this PhD project, the student will explore game-theoretical approaches, which aim to embed the social optimality goals in daily social interactions at different levels of a hierarchical system, modelled by suitable game-theoretical models, and by using social influence and minimum incentive/penalty means to reshape certain behavior patterns to enhance long-term sustainability goals, in particular, in terms of energy sustainability. This research will require substantial knowledge of game theory and systems and control, and some relevant knowledge of psychological modelling. The student is expected to develop theoretical works such as modeling, analysis and controller design, and illustrate them in a realistic testbed, which could leverage on an existing smart building testbed on the campus of KTH. The candidate may rely on a simulated testbed to carry out theoretical development at NTU, and then carry out an onsite testbed development during his/her residency at KTH, which typically takes place in Year 4.	
Program/Center Website(s)	- KTH-NTU Joint PhD Program - Centre for System Intelligence and Efficiency (CSIE): https://www.ntu.edu.sg/csie - Cyber Physical Intelligent Systems Group: https://intelligentsystemseee.ntu.edu.sg/cpisrg/index.html	
Additional Information (e.g., files with project details)	None	

Joint Projects

Home University	NTU	
Supervisors	**Home**	**Partner**
Name	Yong Liang GUAN	Ming XIAO
School	EEE	KTH EECS
Email	eylguan@ntu.edu.sg	mingx@kth.se
Website	https://dr.ntu.edu.sg/cris/rp/rp00129	https://www.kth.se/profile/mingx
Project Title	Intelligent Joint Radar Communications with Millimeter Wave	
Project Description (200-300 words)	The PhD research project aims to design and optimize JRC (joint radio and communication) waveforms/sequences and network resources for improved sensing and communication capabilities in beyond 5G (6G) mobile networks. Traditionally, the functionalities of sensing and communications are separate technologies, which lead to low efficiency, long latency, and substantial waste of resources. JRC can simultaneously sense around environments and transmit information messages. However, in existed JRC schemes, sub-6GHz frequency bands are normally used, which often lead to low resolution sensing (in radio tomography), high interference and limited communication rates. To address the problem, in the project, we will exploit mmWave (millimeter wave) for JRC, which has the frequency of about 20GHz to 100GHz. The advantages of mmWave for JRC are multi-folded, e.g., higher-resolution sensing results and high data rates. However, there are also severe challenges for mmWave JRC. (1), Limited transmission distance and low peak-to average power ration; (2), Difficulty in channel estimation, mainly due to complexity and high wide band of mmWave signals, and especially pronounced in moving environments; (3), High processing complexity, which increases with frequency nonlinearly; (4) Due to high directional signals of mmWave, it is hard to support multi-user multi-objective systems for mmWave JRC. Thus, in our project, the main objectives are to design and optimize mmWave JRC with long range and high resolution for radar detection, accurate channel estimation capability, high spectrum and power efficiency, and supporting for multi-user operation and with limited complexity. For the purpose, the project shall join forces of researchers of KTH and NTU with complementary strength. KTH researcher (Ming Xiao and his student) has long-term studied and solid achievements in mmWave communications and resource allocation. NTU researchers (Yong-Liang Guan and his student) has very solid achievements in signal processing, especially in waveform design and radio detection. The project will have two work packages (WPs). (1) WP1, Radar and communication waveform optimization, leaded by NTU. To reduce complexity and to support multi-user JRC, communication waveforms will be optimized and sequence property bounds and performance limits for radar signals will be analyzed. Mathematical tools including but not limited to number theory, group theory, and coding theory will be used to address the challenges of complexity and multi-user access; (2) WP2, resource optimization, leaded by KTH. Power and spectrum resources will be optimized to improve the sensing/transmission distance and channel estimation. Optimization theory and machine learning approaches will be used. We should note the project is a true	

	collaboration one. Both KTH and NTU partners will participate in two WPs. At least two Ph.D. students respectively at KTH (Ph.D1) and NTU (Ph.D2) will work for the project in full time during the project period. The project teams will meet regularly online, at least once per month. The mobility plan is as follows: Month 6-12, Ph.D1 will visit NTU. Month13-18, Ph.D2 will visit KTH. As such, Ph.D1 and Ph.D2 will continue to visit partner universities 3 times of 6-month period. Meanwhile, Xiao and Guan will also visit each other 1 month per year.
Program/Center Website(s)	NTU, EEE, CISS, COSMO Lab
Additional Information (e.g., files with project details)	Nil

Graduate College

Joint Projects

Home University	NTU Singapore	
Supervisors	**Home**	**Partner**
Name	Chen Yu-Cheng	Kristinn Gylfason
School	School of Electrical & Electronic Engineering	Department of Intelligent Systems, Division of Micro and Nano Systems
Email	yucchen@ntu.edu.sg	gylfason@kth.se
Website	https://www.ntubimp.com/	https://www.kth.se/profile/gylfason
Project Title	**Development of Micro-Lasers on Chip for Biomedical Applications**	
Project Description (200-300 words)	Cells are key building block for all lives. Sensitive analysis of cellular activities and inhomogeneities is critical in biology and industries. Characterization of multicellular models, which consists of a collection of cells embedded in a complex microenvironment, has become an important area for tumor analysis, drug screening, and diseases modeling. However, optical sensing signal is oftentimes weak and masked by strong background noise from scattering and auto-fluorescence of cells, which makes it challenging or even unable to detect small but biologically critical dynamics in complex cell environment. To address the challenges, optofluidic lasers has come into the spotlight recent year for its potential to amplify subtle biological signals. However, current state-of-art biolasers remain at the proof-of-concept stage, without being able to carry into real world device. Hence, this collaborative PhD project aims to develop an on-chip integrated optofluidic laser system for multicellular screening and analysis. This includes the development of on-chip optofluidic cellular laser for medical analysis (NTU side) as well as integrated system on-chip (KTH side). Focus will be put on the design and implementation of different optofluidic photonic chips for cellular detection and analysis. The proposed project is envisioned as a new technology which aims to complement current state-of-art assays and readers. The significantly enhanced sensitivity and multi-parameter analysis enabled by laser emission allows us to analyze minute quantum effects in biomolecules, which may otherwise remain undetectable with classical light. Beyond biology and biomedicine, this project will provide in-depth understanding of how light interacts with living organisms and biological materials, which will be significant for the development of novel bio-control photonic devices.	
Program/Center Website(s)	https://www.kth.se/is	
Additional Information (e.g., files with project details)		

Joint Projects

Home University	NTU Singapore	
Supervisors	**Home**	**Partner**
Name	Chen Yu-Cheng	Wouter Metsola van der Wijngaart
School	School of Electrical & Electronic Engineering	Department of Intelligent Systems, Division of Micro and Nano Systems
Email	yucchen@ntu.edu.sg	wouter@kth.se
Website	https://www.ntubimp.com/	https://www.kth.se/profile/wouter
Project Title	**Smart Living Laser Systems- From Biosensors to Bioinformation Systems**	
Project Description (200-300 words)	Since the outbreak of global pandemic, drug screening has become one of the most critical processes in curing and understanding many infectious diseases nowadays. However, conventional tools usually suffer from low dynamic range and signal-noise ratio, making it very challenging to accurately quantify the efficacy of drugs and outcomes. An important technological bottleneck in the detection and readout analysis of these 3D complex cellular systems. To address the current challenges, a new screening modality is needed for high-throughput 3D cellular analysis and drug screening. This includes the development of new image sensor (NTU side) as well as integrated system (KTH side). Hence, this collaborative PhD project aims to overcome the current challenges by developing intelligent living lasers. Through the strong light-matter interactions between multiple cells and resonators, the intrinsic biological features will be converted into complex laser signals, delivering biochemical and structural information. Investigations of different physical mechanism and materials will be studied. In the third year, laser fingerprints will be collected and investigated on this platform due to the high heterogeneity of 3D cellular organoids. Organoid function can also be profiled for the investigation of specific bioactivities or drug screening. Laser wavelengths will be used as barcodes to investigate the relation among various biofunctions. Eventually an integrated lasing system will be built and scaled up to extend to downstream applications for high-content drug screening. The implementation of highly sensitive 3D cellular living laser will lead to rapid screening of large compound libraries to extract high-throughput digital sensing information and novel drug candidates. Developing living lasers with intelligent functions offers the potential to unlock new avenues of discovery in health sciences and health informatics.	
Program/Center Website(s)	https://www.kth.se/is	
Additional Information (e.g., files with project details)		

Joint Projects

Home University	Nanyang Technological University	
Supervisors	**Home**	**Partner**
Name	Cesare Soci	Val Zwiller
School	SPMS/EEE	School of Science, Department of Applied Physics
Email	csoci@ntu.edu.sg	zwiller@kth.se
Website	http://www1.spms.ntu.edu.sg/~oson/	https://www.kth.se/profile/zwiller?l=en
Project Title	**Time-tagging camera** based on **Superconducting Nanowire Single Photon Detectors** (SNSPD)	
Project Description	Future communications and imaging systems will rely on quantum photonics to push beyond the limits achievable by classical systems and realize the next generation of communication networks. Detection of light at the single photon level is therefore essential for the implementation of all of these systems as more and more fields require large arrays of time-resolved single photon detectors. In addition to allowing the development of new technologies, time-resolved single photon sensors allow a significant improvement in quantum vision techniques such as: - Ghost imaging - Time-resolved Raman spectroscopy, - Sub-shot-noise imaging - Fluorescence lifetime imaging microscopy, - Quantum LiDAR - Quantum astronomy - Time-of-flight (ToF) imaging All these techniques require single photon detection and high temporal resolution with low noise and high sensitivity. To date, superconducting nanowire single photon detectors (SNSPDs) are the best single photon detectors in terms of efficiency, time resolution, dark count rate, and wavelength sensitivity range. They appear to be the most promising candidates to build large-scale devices in which high temporal resolution is a crucial parameter. This PhD project will focus on the design, realization and testing of SNSPD arrays and builds on the existing multidisciplinary expertise available at KTH and NTU. The first part of the work will be to build a multipixel detector interfacing and multiplexing SNSPDs with each other. This detector would include a hundred pixels, the goal being to achieve very high temporal resolution and a sensitivity range extending in the infrared for each pixel rather than to match the pixel number of classical CCD/CMOS cameras. The most critical performance criteria for our application being the temporal resolution and the ability to extend the structure to several hundred pixels, the use	

of amorphous materials such as molybdenum silicide (MoSi) for the fabrication of the superconducting film seems to be the most appropriate choice. Indeed, since this type of material does not have a crystalline structure, it is less sensitive to film imperfections and structural defects, and is therefore the ideal candidate for integration on a larger scale.

The second part of the work will be to use the SNSPD arrays to image, measure and retrieve the arrival time of each photon hitting each pixel. At this stage, by means of post-processing, we will be able to measure correlations between photon pairs by realizing a large number of entangled states between each pixel. Because quantum light sources emit photons as correlated photon pairs, extracting temporal and spatial correlations between photons can lead to significant improvements beyond classically achievable limits in imaging systems. For instance, the availability of SNSPD arrays would greatly benefit the field of astrophysics, where measuring coherence through the second order autocorrelation function allows to gain information on location, size and composition of the sources. Through temporal correlation spectroscopy one could also detect non-classical light (photon bunching) emitted by celestial light sources.

The multi-pixel camera we envision is also very interesting in the context of quantum communications. Indeed, with detector bandwidth of the order of 10 MHz, the interfacing and simultaneous operation of 1000 detectors allows for the detection of single photons with 10 GHz of bandwidth.

Building such an imaging system would greatly increase the possibility for quantum imaging technologies to take hold in real-world applications, but also would make it possible to meet the current environmental challenges by considerably reducing the operating power of a superconducting single photon detector. Indeed today the power required for the operation of the cryostat is the main source of power consumption. By co-locating a large number of detectors in the same cryostat, the energy footprint of each detector will be considerably reduced.

This project is truly interdisciplinary as it requires several fields of complementary expertise, from photonics to quantum optics, from systems engineering to nanofabrication and materials engineering. The two groups that will co-host the PhD project have complementary areas of expertise in nanofabrication and spectrometry (NTU) and superconducting detectors design and quantum optics characterization (KTH). This exchange would be an exceptional opportunity to carry out this project and initiate a collaboration on large-size integrated superconducting detector arrays, which none of the two groups is currently pursuing.

The student identified to carry out the IGP Collaborative Initiative project, Pierre Brosseau, is an ideal candidate with prior knowledge and experience in several areas relevant to the proposed research program. After training in a major engineering school in France in systems engineering as well as in photonics, Pierre conducted a master project related to the operation of superconducting detectors SNSPD in the Quantum NanoPhotonics group of Val Zwiller in the applied physics department of KTH in Stockholm. His prior knowledge and expertise will allow him to lead the effort on the development of SNSPD arrays and to work independently at both NTU and KTH from the very beginning of the project.

Graduate College

Joint Projects

Home University	Nanyang Technological University	
Supervisors	**Home**	**Partner**
Name	Zhao Ou	Zuheir Barsoum
School	CEE	School of Engineering Science
Email	ou.zhao@ntu.edu.sg	zuheir@kth.se
Website	https://zhaoou.weebly.com/	https://www.kth.se/profile/zuheir
Project Title	Fatigue and Fracture of High Strength Steel Structures	
Project Description (200-300 words)	Compared with normal strength mild steels (e.g., grades S235, S275 and S355), high strength steels possess superior mechanical strengths. The use of high strength steels in construction brings the possibility of designing and constructing structures with smaller sizes, lighter weight, higher storey and longer span, being in line with the concept of sustainable construction. However, on the other hand, high strength steels suffer from low ductility, which has negative influences on the fatigue and fracture behaviour of structures. This project aims at investigating the fatigue and fracture behaviour as well as design of high strength steel structures. Laboratory tests and numerical simulations will be conducted to generate an extensive data pool. Based on the test and FE data, the fatigue and fracture behaviour of high strength steel structures will be investigated, each key influencing parameter will be examined and quantified, and design guidelines will be proposed. Objective: (i) Investigate the fatigue and fracture behaviour of high strength steel structures at material, member, joint and structural levels, (ii) Examine and quantify each key influencing parameter, and (iii) Propose design guidelines. Timeline/plan: The PhD candidate will spend his first 2-2.5 years at NTU for conducting testing and numerical modelling, and then go to KTH for another set of testing as well as design analyses. The main supervisor, Asst Prof. Zhao Ou, is an expert in the field of high strength steel structures. The co-supervisor, Prof Zuheir Barsoum, is an expert in the field of fatigue and fracture of engineering materials and structures. The proposed project titled 'Fatigue and Fracture of High Strength Steel Structures' combines the expertise from both of them. The resources and knowledge from both faculty's labs and schools will certainly contribute to the success of the project.	
Program/Center Website(s)	https://zhaoou.weebly.com/	
Additional Information (e.g., files with project details)	NIL	

Joint Projects

Home University	Nanyang Technological University, Singapore	
Supervisors	**Home**	**Partner**
Name	Wei Wu	Stefan Larsson
School	Civil and Environmental Engineering	Architecture and the Built Environment
Email	wu.wei@ntu.edu.sg	stefan.larsson@byv.kth.se
Website	https://dr.ntu.edu.sg/cris/rp/rp00944	https://www.kth.se/profile/stelar
Project Title	**Understanding and mitigating rock burst in deep rock excavation**	
Project Description (200-300 words)	Creating urban underground space and extracting deep natural resources are the next frontiers for social development and environmental sustainability. However, these anthropogenic disturbances deep underground may perturb the initial equilibrium of rock masses and lead to the occurrence of unpredictable geohazards. At great depth, rocks are subjected to high in-situ stresses. Field observations indicate that rock failure under high in-situ stress conditions can be either conditionally stable, which is accompanied by the progressive formation of layered structure (e.g., spalling failure), or abruptly unstable, which occurs along with the violent release of strain energy (e.g., rock burst). The objective of this study is to investigate the mechanisms of rock bursts under extreme environments. Laboratory experiments and numerical simulations will be performed to study the occurrence of rock bursts in intact and fractured rocks under various high stress and temperature conditions. The study is expected to improve our capability to predict and mitigate the risks of rock bursts during deep underground projects.	
Program/Center Website(s)	NA	
Additional Information (e.g., files with project details)	NA	