UNNC – SZU Joint PhD Program (Computer Science)

Available PhD topics

Formal applications should follow the instructions in 'How to apply' section.

PhD topic 1	Deep-learning-based Image/Video Detection/Recognition/Generation
SZU Supervisor	Prof Dylan Shen
UNNC Supervisor(s)	Dr Jianfeng Ren
Short introduction & description of PhD	With the rapid development of deep-learning techniques, research on computer vision has recently advanced significantly. Various deep neural networks have been developed for tackling problems in real world. The project aims to develop a suite of deep-learning-based approaches in solving one of the real-world problems in computer vision, including but not limited to the following tasks: • Facial analysis such as face anti-spoofing, face morphing, micro-expression analysis and GAN (Generative Adversarial Networks) based face generation & manipulation. • Biometric recognition such as face recognition, gait recognition, re-ID. • Object detection, tracking and segmentation. • Medical image analysis such as neuron segmentation, retinal classification. • Image/video understanding/reasoning. The candidate is expected to conduct pioneer research in one of the chosen fields, e.g., conduct a comprehensive literature review, implement a few state-of-the-art methods, identify the pros and cons of existing methods, propose a few feasible ways to improve the current methods, validate them through comprehensive empirical studies and finally publish the research outcome in top conferences such as CVPR, ICCV and ECCV, or top journals such as TIP, TMM, PR and other IEEE Trans. The candidates are expected to process the following knowledge and skills: • A good bachelor degree or master degree in Computer Science or related disciplines. • IELTS ≥ 6.5. • Good knowledge and understanding on computer vision or image processing. • Good problem-solving skills. • Hands-on programming experience using various deep learning architectures. • Most importantly, passion for research. • Candidates with previous research experience, e.g., with publications in top conferences or journals, are preferred. • Candidates with good writing skills are preferred.
Contact points	Informal inquiries may be addressed to Prof Dylan Shen (llshen@szu.edu.cn); Dr Jianfeng Ren (Jianfeng.ren@nottingham.edu.cn).

PhD topic 2	Deep learning-based Image and Language Models for Real World Applications
SZU Supervisor	Prof Linlin Shen
UNNC Supervisor(s)	Dr Zheng Lu
Short introduction & description of PhD	With the rapid development of deep-learning techniques, research on computer vision and natural language processing have recently advanced significantly. More and more research have focused on developing deep neural networks that combining both text and image data to solve real world tasks. The project aims to develop a suite of deep-learning-based approaches solving real-world problems with multi-modal data, including but not limited to the following tasks: • Image captioning that generates text description from a given image using techniques such as CLIP, GPT, Transformer, etc. • Visual question answering that answers text questions regarding images or videos. • Object detection, tracking and segmentation. • Medical image analysis such as neuron segmentation, retinal classification. • Image/video understanding/reasoning. The candidate is expected to conduct pioneer research in one of the chosen fields, e.g., conduct a comprehensive literature review, implement a few state-of-the-art methods, identify the pros and cons of existing methods, propose a few feasible ways to improve the current methods, validate them through comprehensive empirical studies and finally publish the research outcome in top conferences such as CVPR, ICCV and ECCV, or top journals such as TIP, TMM, PR and other IEEE Trans. The candidates are expected to process the following knowledge and skills. • A good bachelor degree or master degree in Computer Science or related disciplines. • IELTS $\geqslant$ 6.5. • Good knowledge and understanding on computer vision or image processing. • Good problem-solving skills. • Hands-on programming experience using various deep learning architectures. • Most importantly, passion for research. • Candidates with previous research experience, e.g., with publications in top conferences or journals, are preferred. • Candidates with good writing skills are preferred.
Contact points	Informal inquiries may be addressed to Prof Linlin Shen (llshen@szu.edu.cn) and Dr Zheng Lu (zheng.lu@nottingham.edu.cn), but formal applications should follow the instructions in 'How to apply' section.
PhD topic 3	Emerging Computational Intelligence and Applications
SZU Supervisor	Prof Zexuan Zhu
UNNC Supervisor(s)	Prof Ruibin Bai
Short introduction & description of PhD	Computational intelligence (CI) refers to the ability of a computer to learn a specific task from experimental observation. CI has exhibited great potential in addressing complex optimization problems, and attracted much attention from both academia and industry. For example, recently, an emerging CI technique named AlphaFold achieved near-perfect protein fold predictions. As one of the grand challenges in biology, it had been considered impossible. AlphaFold combines numerous deep learning innovations to leverage the combined knowledge from 50 years of

	experimental science, stored in sequence and structure databases. Traditionally, CI includes evolutionary algorithms, swarm intelligence algorithms, fuzzy system, learning based system, deep learning and hybrid system. These CI techniques have the capability to process imprecise information and search for approximate yet good enough solutions while ensuring robustness and computational tractability. They can achieve dramatic improvement in the tasks of classification, regression, pattern recognition, system modelling and decision-making. However, CI models are extremely reliant on the datasets as well as the labels connected with them. For instance, unavailability and inaccessibility of clinical data remain the most common hurdles in adapting CI in routine medical practices. The large-scale dataset must be manually created, retrieved and cleansed for CI techniques, while the process is laborious and inefficient in most cases. In this research, the students shall focus on breaking through the difficulties of adopting CI in practical applications, including but not limited to the domains of Synthetic biology, Drug discovery, Transportation and Logistics.
Contact points	Informal inquiries may be addressed to Prof Ruibin Bai (ruibin.bai@nottingham.edu.cn) and Prof Zexuan Zhu (zhuzx@szu.edu.cn).
PhD topic 4	**Learning-based methods for equipment scheduling in the automated container terminal**
SZU Supervisor	Prof Jiasong Zhu
UNNC Supervisor(s)	Dr Huan Jin
Short introduction & description of PhD	Automated container terminals (ACTs) have been vigorously developed in China due to the fact that they are more efficient and reliable than traditional container terminals, and can significantly reduce the operational costs associated with labour and equipment. However, the automated equipment provided for the ACTs have changed the layout of the terminals, which brings new complexity and difficulty to ACT operation management. How to schedule the automated equipment and make operation decisions efficiently according to the characteristics of automated equipment and the layout of ACTs have become urgent problems for the maritime transportation and logistics system. Learning-based combinatorial optimization is a promising method to solve the operation problems in ACTs. Combination optimization has successfully solved many problems in ACTs. However, complex characteristics such as the difference of containers, the randomness of vehicles arriving at ACTs and the uncertainty of joint scheduling are difficult to be described in mathematical programming and optimization algorithms. Fortunately, based on practical data, the training results of deep learning can assess the complex characteristics in ACTs. The PhD project will focus on the following major dimensions on (i) automated container terminal operation optimization problems (e.g. automated guided vehicle path planning, automated quay/yard crane scheduling, container handling and their joint optimization) and (ii) maritime and logistics system operation and planning optimization (considering the uncertainty and randomness of operations). (iii) Build a multi-agent simulation system to improve the efficiency of the ACT system, where each of the automated equipment can be viewed as a smart agent, which has the ability of learning from the environment and make autonomous decision with its own goal.
Contact points	Informal inquiries may be addressed to Dr Huan Jin (huan.jin@nottingham.edu.cn) and Prof Jiasong Zhu (zjsong@szu.edu.cn).
PhD topic 5	**Medical image segmentation**
SZU Supervisor	Prof Dylan Shen

UNNC Supervisor(s)	Prof Sean He
Short introduction & description of PhD	With the rapid development of deep-learning techniques, research on computer vision, multimedia, natural language processing, intelligent transportation etc. has recently advanced significantly. Various deep neural networks have been developed for tackling problems in real world. The project aims to develop a suite of deep-learning-based approaches in solving one of the real-world problems in the above fields, including but not limited to the following tasks: • Object detection and segmentation • Semantic segmentation • Biometric recognition • Medical image analysis • Image/video understanding/reasoning/classification • Audio recognition and classification • Text understanding/recognition/classification • Document understanding/analysis • Intelligent traffic control • Body networks The sample topics include but not limited to: **Medical image segmentation** Developing technologies that can help doctors carry out basic analysis of medical images can significantly improve disease diagnosis. For medical image segmentation based on a deep-learning model, labelling all data is time consuming and somehow impossible. Usually, when the amount of labelled data decreases, the accuracy of the model also decreases. Therefore, semi-supervised learning is a way to excavate as much information from the data as possible. This project aims to implement a semi-supervised approach for medical image segmentation. The candidate is expected to conduct pioneer research in one of the chosen fields, e.g., conduct a comprehensive literature review, implement a few state-of-the-art methods, identify the pros and cons of existing methods, propose a few feasible ways to improve the current methods, validate them through comprehensive empirical studies and finally publish the research outcome in top conferences such as ACL, AAAI, CVPR, ICCV, ECCV, etc., and top journals such as TPAMI, TIP, TMM, PR, IJCV etc. The candidates are expected to process the following knowledge and skills: • A good bachelor degree or master degree in Computer Science or related disciplines. • IELTS $\geqslant$ 6.5. • Good knowledge and understanding on machine learning, computer vision, multimedia, Internet of Things or image processing. • Good problem-solving skills. • Hands-on programming experience using various deep learning architectures. • Most importantly, passion for research. • Candidates with previous research experience, e.g., with publications in highly respected or top conferences or journals, are preferred. • Candidates with good writing skills are preferred.
Contact points	Informal inquiries may be addressed Prof Sean He (sean.he@nottingham.edu.cn) and Prof Dylan Shen (llshen@szu.edu.cn).
PhD topic 6	**Multimodal Object and Activity Sensing for Real-Time Robotic Systems**
SZU Supervisor	Prof Jianqiang Li

UNNC Supervisor(s)	Dr. David Chieng
Short introduction & description of PhD	With the rapid development of artificial intelligence techniques, research on robot systems has achieved significant advancements in recent years. The project aims to develop a suite of approaches for improving the robot's perception ability, including but not limited to the following tasks: • Adopt multimodal sensing and localisation techniques such as computer vision, RF, mmWave for object identification, activity recognition and SLAM in challenging environments i.e. poor lighting, visibility, non-light-of-sight and dynamic surroundings. • Optimisation of multimodal sensing with evolutionary learning algorithms to maximize the benefit for a specific index. • Design and test robot systems for target applications such as hazard inspection, fire rescue, elderly care, etc. The candidate is expected to conduct pioneer research in one of the chosen fields, e.g., conduct a comprehensive literature review, implement a few state-of-the-art methods, identify the pros and cons of existing methods, propose a few feasible ways to improve the current methods, validate them through comprehensive empirical studies and finally publish the research outcome in top conferences such as CVPR, ICCV and ECCV, or top journals such as TIP, TMM, PR and other IEEE Trans. The candidates are expected to process the following knowledge and skills. • A good bachelor's or master's degree in computer science, computer, robotics, EE, mechanical engineering or related disciplines. • IELTS ≥ 6.5. • Good knowledge and understanding of machine learning, robotics, SLAM, computer vision, sensors, IoT or related fields. • Good problem-solving skills. • Hands-on programming experience using various robotics architectures. • Most importantly, passion for research. • Candidates with previous research experience, e.g., publications in top conferences or journals, are preferred. • Candidates with good writing skills are preferred.
Contact points	Informal inquiries may be addressed to Dr David Chieng (David.Chieng@nottingham.edu.cn) and Prof Jianqiang Li (lijq@szu.edu.cn).
PhD topic 7	**Reinforcement Learning and Optimisation**
SZU Supervisor	Prof Zhong Ming
UNNC Supervisor(s)	Prof Ruibin Bai
Short introduction & description of PhD	Reinforcement learning (RL) is a hot spot in current research, and has gradually begun to be applied in the field of games, robot control, intelligent transportation, etc. RL methods can be divided into model-free RL and model-based RL methods according to whether the environment is modelled. Model-free RL methods do not need to construct an environmental model, and optimize the agent's policy through direct interaction between the agent and the environment. The advantage is that the collected interaction data is not biased, but the disadvantage is that there needs to be a suitable environment for the agent to interact. Model-free RL methods are particularly common in the gaming domain, where the cost of the agent interacting with the environment is almost negligible. In the field of robot control and intelligent transportation, model-free RL methods are not suitable. Mode-based RL methods reduce the interaction between the agent and the real environment, and improve the utilization of data by building an environmental

	model. However, there will be a bias between the constructed environment model and the real environment model. How to reduce the bias is a major difficulty in model-based RL. In this research, students will concentrate on breaking through the difficulties in RL, including but not limited to data utilization in RL, multi-agent RL, mathematical programming modelling. And the research can be combined with other domain problems such as game strategy, robot control, intelligent transportation, combination optimization, etc. Combinatorial optimisation problems (COP) have extensive real-life applications. However, most of them are NP-Hard and finding the optimal solutions is normally computationally prohibitive for large-size instances. The problems become even harder when uncertainties are taken into account to improve the practicality of the solutions. The existing approaches to tackle these types of problems can broadly be classified into analytical model driven methods (typified by mathematical programming methods) and data-driven methods (e.g. genetic programming and reinforcement learning. The former methods focus on the analytical properties of the mathematical model but may suffer from the robustness issues over uncertainties from the input data. The data driven methods often formulate the combinatorial problems as online optimisation problems and try to tackle the problem sequentially based on some policies or rules upon the realisation of random variables and the states of the partial solution at each decision point. One of the main drawbacks of these data driven methods is their inability to efficiently exploit the core structures and properties of the problem. More specifically, existing data driven methods primarily focus on the objectives to be optimised but often neglect various complex inter-dependencies among the decision variables (in the form of constraints) and their collective influence on the objective. In this research, the students shall investigate integrating linear/integer programming methods with the latest deep learning methods, including but not limited to reinforcement learning and graph neural network based learning.
Contact points	Informal inquiries may be addressed to Prof Ruibin Bai (ruibin.bai@nottingham.edu.cn) and Prof Zhong Ming (mingz@szu.edu.cn).