

Appendix I:

**Research Directions of the 2019 Tencent Rhino-Bird
Elite Training Program**

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Direction 1: Robotics

Subject 1.1: Research on Perception and Motion Planning and Control Methods of Multi-Contact Complex Robotic Systems (Location: Shenzhen)

Many robotic systems perform complex motions and operations through physical interaction with the environment, including walking robots and multi-fingered hands. Realizing full perception of the environment and accurate planning and precise control of motion has been the key issue in the research of these robots. This subject will study localization, motion planning and control methods based on general sensor fusion for these complex robot systems.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent, IEEE senior member and has studied and worked at Shanghai Jiao Tong University (full-time undergraduate and Ph.D. programs), the University of North Carolina at Chapel Hill (Ph.D. program), National University of Singapore (postdoctoral fellow), Disney Research Pittsburgh (postdoctoral researcher), and University of Michigan-Dearborn (assistant professor). He is currently an Associate Editor for IEEE RAL. His main research focuses on motion planning and control for dexterous multi-fingered hands, walking robots and autonomous robots. He has published nearly 30 papers in international journals such as IEEE T-RO and IJRR as the first author and obtained 3 patents in the US.

Mentor 2: He is a senior research fellow at Tencent. He obtained his Ph.D. degree from Nanyang Technological University Singapore. His main research focus is navigation and control of unmanned aircraft systems (UAS). He worked as a postdoctoral fellow at the Air Traffic Management Institute of Nanyang Technological University. His current research includes the perception, planning and motion control of multi-legged robots.

Mentor 3: He is a senior research fellow at Tencent and obtained his bachelor's degree from the Wuhan University, master's degree from the Harbin Institute of Technology, and Ph.D. degree from the University of Genoa. He has published about 15 international papers and obtained a patent in the US. His main research includes robot mechanism and control, grasping and manipulation, and development of actuators.

Subject 1.2: Research on Robot Control and Strategy Transfer Based on Machine Learning Methods (Location: Shenzhen)

The subject will study deep reinforcement learning and model-based machine learning as well as optimal control algorithms for robots and aim to improve the robot learning efficiency with limited samples. At the same time, it will also study the capability of robot control strategy transfer using machine learning so that robots can automatically adapt to changing or unknown environments. The experimental platform includes quadruped robots, robotic arms and dexterous hands.

Mentor Profile: Mentor 1: He is a senior research fellow at Tencent and obtained the Ph.D. degree from the Hong Kong University of Science and Technology. His research interests include epigenetic robotics, joint learning of robot perception and decision-making, and robot control based on reinforcement learning and optimal control.

Mentor 2: He is a senior research fellow at Tencent and obtained the Ph.D. degree from the University of Tokyo. His main research focuses include computer vision, visual reasoning, and designing small laser sensors.

Mentor 3: He is a principal researcher at Tencent and obtained the Ph.D. degree from the University of Wisconsin–Madison. His main research focuses are deep reinforcement learning and computer vision and its application in game AI and robotics. He has published more than 10 papers in these fields (CVPR, ICCV, ICML and AAAI).

Mentor 4: He is a principal researcher at Tencent, IEEE senior member and has studied and worked at Shanghai Jiao Tong University (full-time undergraduate and Ph.D. programs), the University of North Carolina at Chapel Hill (Ph.D. program), National University of Singapore (postdoctoral fellow), Disney Research Pittsburgh (postdoctoral researcher), and University of Michigan-Dearborn (assistant professor). He is currently an Associate Editor for IEEE RAL. His main research focuses on motion planning and control for dexterous multi-fingered hands, walking robots and autonomous robots. He has published nearly 30 papers in international journals such as IEEE T-RO and IJRR as the first author and obtained 3 patents in the US.

Subject 1.3: Research and Application of Advanced Control Algorithms in Robotic Systems (Location: Shenzhen)

This subject will focus on the following research topics: 1. Static and dynamic balance control algorithms for biped/multi-legged/wheeled robots in different environments; 2. Application of self-adaptive, optimal control and robust control algorithms in complex robotic systems; 3. Hybrid position and force control and highly-adaptive compliance control algorithms; and 4. Research and optimization of dynamic control algorithms for multi-body, flexible and rigid-flexible hybrid systems.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent and obtained the Ph.D. degree in mechanical engineering from the University of Cassino, Italy. He has published more than 30 papers on international journals and conferences and obtained 8 patents.

Mentor 2: He is a senior research fellow at Tencent and obtained the Ph.D. degree in EEE from the University of Manchester. He has published more than 10 papers on IEEE TAC and other journals and conferences such as the IEEE CDC, and has obtained more than 10 patents.

Mentor 3: He is a senior research fellow at Tencent. He graduated from the Central South University with a major in mechanical design and automation and finished a master's study of the European Erasmus Mundus program. He graduated from the University of Genoa in Italy, completed advanced robotics study at the Centrale Nantes in France, and received a doctoral degree from the University of Quebec. He has published several papers on journals such as IJARS and TCSME, focusing on robot kinematics and dynamics, robot control systems, and human-robot interaction.

Subject 1.4: Research on Key Human-Robot Interaction Techniques and System Development (Location: Shenzhen)

This subject will focus on: 1. EEG control: low-microvolt EEG signal processing under high noise and internal resistance, and its application in tele-robots; 2. Development of exoskeleton systems that can assist and strengthen the physical potential of human body; 3. 3D human skeleton algorithms for mixed reality human-robot interaction; 4. New

human-robot interaction modes capable of real-time observation of human activities, understanding human intentions and collaborative content, predicting and responding to human behavior, and data collection.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent and obtained the Ph.D. degree in mechanical engineering from the University of Cassino, Italy. He has published more than 30 papers on international journals and conferences and obtained 8 patents.

Mentor 2: He is a principal researcher at Tencent, IEEE senior member and has studied and worked at Shanghai Jiao Tong University (full-time undergraduate and Ph.D. programs), the University of North Carolina at Chapel Hill (Ph.D. program), National University of Singapore (postdoctoral fellow), Disney Research Pittsburgh (postdoctoral researcher), and University of Michigan-Dearborn (assistant professor). He is currently an Associate Editor for IEEE RAL. His main research focuses on motion planning and control for dexterous multi-fingered hands, walking robots and autonomous robots. He has published nearly 30 papers in international journals such as IEEE T-RO and IJRR as the first author and obtained 3 patents in the US.

Mentor 3: He is a senior research fellow at Tencent and obtained the Ph.D. degree from the Hong Kong University of Science and Technology. His research interests include epigenetic robotics, joint learning of robot perception and decision-making, and robot control based on reinforcement learning and optimal control.

Mentor 4: He is a senior research fellow at Tencent and obtained his bachelor's degree from the Wuhan University, master's degree from the Harbin Institute of Technology, and Ph.D. degree from the University of Genoa. He has published about 15 international papers and obtained a patent in the US. His main research includes robot mechanism and control, grasping and manipulation, and development of actuators.

Direction 2: AI in Medicine and Healthcare

Subject 2.1: Virtual See-Through Surgical Navigation (Location: Shenzhen)

Using medical image processing, computer vision and machine learning techniques, the

subject seeks to implement accurate rendering of 3D anatomical structures of human body and spatial coordinate transformation in real time and apply it in surgical navigation to achieve virtual human perspective through AR glasses. Algorithm testing will be performed on the mobile computing platform under the setting of the operating theater, using accuracy, human-machine interface and real-time response as the evaluation metrics.

Mentor Profile: He is a principal researcher at Tencent with the biomedical engineering master degree from the Fudan University and computer science doctoral degree from the College of William & Mary. He worked as a postdoctoral fellow at the National Institutes of Health (NIH). He is a contributing reviewer of a series of top tier journals and conferences and a contributing developer of ITK and 3DSlicer. He has published 25 papers on journals, 16 papers on conferences, 4 book chapters, 6 patents and one software license. He is now engaged in AI medical research and development.

Subject 2.2: Real-Time Medical Image Deep Learning Algorithm (Location: Shenzhen)

The subject seeks to study and develop the real-time deep learning algorithm on large-size images in intelligent medical diagnosis scenarios. Clinical medical images are usually large-sized, often taking several minutes or longer to perform the calculation via a neural network. This subject aims to explore the data characteristics of specific problems and develop deep learning algorithms for real-time calculation in actual medical diagnosis scenarios.

Mentor Profile: He is a senior researcher at Tencent and received the Ph.D. on computer science from the University of Georgia. His main focuses include biomedical imaging, brain neural networks, and machine learning algorithms. Currently, he mainly focuses on the development of medical AI systems and algorithms. He has published 11 papers as the first author, 3 as the co-first author, and 20 as a co-author on leading medical imaging conferences such as MICCAI and ISBI. In addition, he has published 6 papers as the first author, 7 as the co-first author, and 20 as a co-author on core journals in related fields. Google scholar citation has reached more than 1,000. He has

also applied for several patents.

Subject 2.3: Medical Big Data Fusion and Artificial Intelligence (Location: Shenzhen)

The subject seeks to use medical big data to build artificial intelligence systems that integrate radiological medical imaging, digital pathology and gene expression to aid tumor diagnosis, tumor progression prediction, prognosis analysis, treatment planning and precision medicine. This research will introduce deep learning and multi-omics methods to create new research ideas and apply them to actual clinical practice.

Mentor Profile: He is a principal researcher at Tencent and is in charge of cutting-edge research and product development in the field of AI +medicine. He has made outstanding achievements in spinal imaging analysis, tumor growth prediction, colon cancer detection and image-guided robotic surgery. He has been the editor of several special journals and monographs and has organized several international workshops. He has published more than 350 papers in journals and conferences and has been cited more than 6,000 times. His Google h-index reaches 39.

Subject 2.4: AI Digital Pathology (Location: Shenzhen)

Pathology is the gold standard for disease diagnosis. However, human diagnosis faces problems such as high subjectivity, low repeatability, and difficulty in quantification. This subject aims to apply AI techniques in digital pathological image analysis in order to improve the consistency and accuracy of pathological diagnosis, and to implement the diagnosis method for precise and quantitative analysis. The research focuses on the development and application of computer vision algorithms (such target recognition, object detection and semantic segmentation) and deep learning algorithms (weak-supervision learning, transfer learning and adversarial networks) in pathological image analysis. Specific issues include automatic segmentation of cells or tissues, automatic detection and classification of lesions, and quantitative analysis of immunohistochemistry.

Mentor Profile: He is a principal researcher at Tencent and was graduated from the University of Science and Technology of China with the undergraduate degree and the Johns Hopkins University with the master and doctoral degrees. He has extensive research and development experience in medical image processing, machine learning and deep learning. He has published more than 60 papers, which have been cited more than 3,500 times. He has been granted 14 patents. His current research direction is the development of medical imaging algorithms based on deep learning and applications in disease screening and diagnosis.

Subject 2.5: Lesion Detection and Benign-and-Malignant Judgment in Medical Imaging (Location: Shenzhen)

In November 2017, Tencent was selected to join the National Artificial Intelligence Open Innovation Platform, emerging as a member of the "national team" of Medical Artificial Intelligence. This project will research and develop a deep learning-based method for lesion detection, benignity-malignancy classification by using the mass medical image and labels obtained by Tencent from its partner hospitals. Possible focusing diseases include cancer, cardiovascular and neurological diseases.

Subject 2.6: Medical Image Segmentation (Location: Shenzhen)

Recently, medical image segmentation algorithms based on deep learning have made tremendous progresses. The objective of this project is to improve the accuracy and efficiency of the existing algorithms, and to expand the application scenarios of the segmentation algorithms, such as multi-mode image segmentation, weak-supervision segmentation, and organ segmentation in video sequences.

Mentor Profile of Subject 2.5~2.6: He is a principal researcher at Tencent and received bachelor's and master's degrees from the Tsinghua University and a Ph.D. from the University of Maryland. He has published 3 academic monographs and more than 100 papers, which have been cited more than 4,800 times and have obtained nearly 70 U.S. patents. His research has won the Second Class Prize for Chinese National Science and Technology Progress Award, the Thomas Alva Edison Patent Award and the Technology Innovation Award from the European Association for Cardio-Thoracic Surgery.

Direction 3: Automatic Driving Technology

Subject 3.1: Sensor Fusion for Location Identification (Location: Beijing)

This research uses multi-channel sensor signals to solve classical location recognition problems. Technical fields involved include cutting-edge technologies such as sensor fusion, computer vision, and machine learning. Sensors that can be used include cameras, lidar and radar. Research directions include (but are not limited to):

1. Extraction and embedded mapping of visual and structural features;
2. Machine learning and featureless location identification;
3. Location identification based on use of time and space information;
4. Efficient location data management and location queries.

Subject 3.2: Sensor Fusion for Object Detection and Recognition (Location: Beijing)

This subject studies the fusion of multi-sensor signals to solve object detection and recognition problems. Technical fields involved include cutting-edge technologies such as sensor fusion, computer vision, depth perception and machine learning. Sensors that may be used include cameras, lidar, and radar. Research directions include (but are not limited to):

1. Early fusion or tight-coupling fusion models;
2. Pedestrian detection;
3. Vehicle detection and type identification;
4. Detection and recognition of specific fixed scene elements.

Mentor Profile of Subject 3.1~3.2: He is a principal researcher at Tencent. He received the Ph.D. from the Department of Computer Science of the Texas A&M University. His research focuses include sensor fusion, SLAM, computer vision and robotics. He has more than 20 academic papers published on leading conferences and periodicals and received 3 US patents. He has served as the associate editor of leading robotics conferences such as ICRA and IROS for many years, and is a reviewer for leading

conferences and periodicals such as T-RO, T-IP and AAAI.

Direction 4: Quantum Computing

Subject 4.1: Application of Reinforcement Learning in Quantum Systems (Location: Shenzhen)

In recent years, the application of reinforcement learning in games has had many breakthroughs. This technology has attracted great attention from academia and industry. In this study, we plan to use reinforcement learning to solve scientific problems in physical and chemical systems, including quantum error correction and predictions for chemical reaction paths. At the same time, we also focus on the theoretical research of reinforcement learning and seek to apply reinforcement learning to Tencent's recommendation systems and game services.

Mentor Profile: He holds the position of Distinguished Scientist at Tencent. He received his bachelor's degree from Fudan University, master's degree from Tsinghua University and PhD from the Department of Computer Science, Princeton University, and conducted his postdoctoral research at the California Institute of Technology. His main research directions are quantum and classical algorithms, complexity analysis, distributed protocol design and their applications in large-scale data processing, machine learning and fundamental research in artificial intelligence.

Subject 4.2: Cloud Computing Framework for Scientific Computing (Location: Shenzhen)

Modern artificial intelligence can require tremendous computing resources. Cloud computing can be an effective tool to deliver the required computational power. However, cloud computing resources are not effectively utilized for scientific computing. The objective of this study is to optimize the framework of high-performance cloud computing and make cloud computing more effective for scientific computing. We hope to use machine learning, quantum computing, and quantum

chemistry computing tools as a carrier to improve the deployment of computing technologies on the cloud, and lead to better resource allocation, data management, and user experience. It will provide powerful computing resources for the latest research fields such as artificial intelligence, quantum computing, drug development, and material simulation.

Mentor Profile: He is a principal researcher at Tencent. He received his PhD from Peking University. During his studies at Princeton University as a postdoctoral fellow and at the California Institute of Technology as a research fellow, he led the development of the Python quantum chemistry package which was used by the Google Quantum AI team to study quantum computing algorithms. His main research directions include quantum chemistry algorithms, quantum computing algorithms, and high-performance computing programs.

Subject 4.3: Accelerating Quantum Chemistry Simulation Using Machine Learning (Location: Shenzhen)

Computer simulation has the potential to be an affordable and convenient way to discover new materials. However, it is difficult to calculate the quantum mechanical properties of materials by simulation. In this subject, we plan to build machine learning models to accelerate the prediction of quantum mechanical properties of materials or molecules based on atomic composition and structures. We are also interested in the design and recommendation of new materials based on generative adversarial networks.

Mentor Profile: He is a senior research fellow at Tencent. He studied and worked at the Department of Physics at the University of Singapore (undergraduate), the Department of Chemistry at the Massachusetts Institute of Technology (PhD), and the Centre for Quantum Technologies at the National University of Singapore (research fellow). His research focuses include quantum dynamics, organic materials, the application of machine learning in chemical physics, and quantum simulation algorithms.

Subject 4.4: Quantum Machine Learning (Location: Hong Kong / Shenzhen)

In this research, we hope to improve the performance of traditional machine learning and artificial intelligence algorithms by studying quantum algorithms, and gain a deeper understanding of how neural networks operate. We also aim to develop new quantum algorithms based on concepts in classical machine learning. Through numerical simulation we also aim to verify the performance of classical and quantum algorithms.

Mentor Profile: He is a senior research fellow at Tencent and studied at the Department of Computer Science and Engineering at the Chinese University of Hong Kong (postdoctoral), Department of Mathematics of the University of Bristol in UK (PhD), and the University of Cambridge (undergraduate in physics). His main research interests are in quantum algorithms for machine learning and optimization, and applications of quantum computing to chemical and materials simulation.

Direction 5: Machine Learning and Related Applications

Subject 5.1: Research on Key Technologies of Neural Architecture Search (Location: Shenzhen)

Neural Architecture Search (NAS) is an important research direction in the field of machine learning. This subject aims to explore the theory and practice of NAS and explore feasible solutions and the theoretical boundaries of NAS technology in specific application problems such as model compression, object detection, and image segmentation to promote research progress in the NAS field.

Mentor Profile: Mentor 1: He is a senior research fellow at Tencent and received his Ph.D. from the Department of Electronic Engineering of the Tsinghua University. His research direction is automated machine learning and recommendation system algorithms. He has published works on leading journals and conferences including JMLR, TPAMI, IJCV, ICML, CVPR, IJCAI and AAAI, and has served as a reviewer for conferences including NeurIPS, ICML, ICLR, CVPR, ICCV, ECCV, AAAI and

AISTATS.

Mentor 2: He is a senior research fellow at Tencent and received his Ph.D. from the Institute of Automation, Chinese Academy of Sciences. His main research direction is deep learning model compression and large-scale distributed learning. He has published papers on journals and conferences such as JMLR, ICML, CVPR and AAAI.

Mentor 3: He is a principal researcher at Tencent and received his Ph.D. from Nanyang Technological University. He has published more than 90 papers on journals such as JMLR, ICML and KDD, which have been cited more than 2,700 times. In addition, he has been a reviewer or program member of journals such as JMLR, TPAMI, ICML and NeurIPS, and has served as the associate editor of Neurocomputing. His current research focuses are AutoML, including super-parameter optimization, network structure searches, and meta-learning.

Subject 5.2: Graph Convolutional Neural Network (Location: Shenzhen)

Traditional neural networks are limited to data in the Euclidean domain. The most prominent feature of traditional neural networks is the regular spatial structure. However, it is difficult to apply them to non-Euclidean domain data such as graph data. The main direction of the research is to design graph-based neural networks to utilize unstructured data.

Mentor Profile: He is a senior research fellow at Tencent. He graduated from the University of the Michigan - Shanghai Jiao Tong University Joint Institute and finished his master's and doctoral studies at the Computer Science Department of the University of Connecticut. He currently focuses on research in machine learning and medical big data analysis, especially for the analysis and processing of data containing complex structures, such as graph structures or time series structures, and survival analysis in the medical field. So far, he has published more than 10 academic papers in influential international journals and conferences. He has published papers on leading conferences such as ICML, SIGKDD, AAAI and BIBM.

Subject 5.3: The Application of Deep Learning in Heterogeneous Time Series Data (Location: Shenzhen)

In the medical field, much heterogeneous time series data can be collected. Using this data to predict patient status is a clinically valuable issue. The main purpose of the research is to design a predictive analysis of patient status based on no/weak supervision deep learning models for complex heterogeneous time series data.

Mentor Profile: He is a senior research fellow at Tencent and received the Ph.D. from the Department of Systems Engineering and Engineering Management of the Chinese University of Hong Kong. His main research directions include graph theory and data mining, graph-based large-scale distributed machine learning, social network analysis and recommendation systems. He has published papers on leading conferences of data mining/machine learning such as KDD, WWW, NeurIPS, CIKM and DASFAA. He was once a reviewer of conferences such as KDD, WWW, CIKM, WSDM, SDM and AAI, and journals such as VLDBJ and TKDE.

Subject 5.4: Reinforcement Learning for Real-time Strategy Games (Location: Shenzhen)

We will tackle core challenges of reinforcement learning in complex real-time strategy games (such as StarCraft II and Dota 2), including but not limited to: 1. implicit long-term planning with model-free and model-based methods under complex and unknown MDP, developing effective long-term gaming strategies for real-time strategy games (non-reactive); 2. modeling expert knowledge and common sense for reinforcement learning algorithms; 3. multi-agent collaboration in MOBA games.

Mentor Profile: He is senior researcher at Tencent and graduated from Peking University. He has published papers on leading conferences on multimedia and machine learning. His current research focuses on deep reinforcement learning.

Subject 5.5: Self-learning/self-play in MOBA Games (Location: Shenzhen)

We will investigate self-learning algorithms for MOBA games (such as StarCraft,

DOTA 2, and Doom): 1. design and development of large-scale distributed reinforcement learning systems, reward shaping in self-play training, temporal credit assignment, and effective sampling; 2. deep exploration and efficient self-learning with extremely complex action space, sparse rewards and partially observable MDP; and 3. application and research of game theory for learning by self-play.

Mentor Profile: Mentor 1: He is a senior researcher at Tencent, received a Ph.D. from Tsinghua University, and has worked as a postdoctoral researcher at Cornell University and Rutgers University before joining Tencent. He has published several papers at leading conferences, including ICML. His current research focuses are deep reinforcement learning and computer vision.

Mentor 2: He is a principal researcher at Tencent and obtained a Ph.D. from the University of Wisconsin–Madison. His main research focuses are deep reinforcement learning and computer vision, with applications in game AI and robotics. He has published more than 10 papers in these fields (CVPR, ICCV, ICML and AAAI).

Subject 5.6 Research on the Frontier of Game AI in the Development of Next Generation Games (Location: Shenzhen)

We will study what AI can do for next-generation game development: 1. high-quality game content generation, including high-fidelity animation (facial expression and body motion), maps, levels, rules, and 3D models; 2. automatic game testing and quality evaluation including balance, completeness and robustness; 3. modeling and learning human-like strategies and behavior from game data. This subject will focus on the application of deep reinforcement learning, graphic simulation, computer vision, deep learning and other fields in game AI.

Mentor Profile: He is a principal researcher at Tencent and obtained a Ph.D. from the University of Wisconsin–Madison. His main research focuses are deep reinforcement learning and computer vision, with applications in game AI and robotics. He has published more than 10 papers in these fields (CVPR, ICCV, ICML and AAAI).

Subject 5.7: Delayed Feedback Prediction (Location: Shenzhen)

The problem of delay in sample feedback often occurs in online learning scenes in the recommendation field. The subject will focus on how to consider the delay of the sample and how to use the delay feedback model to train jointly with the deep learning and online learning model.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. from the Computer Science Department of the University of Tokyo. After graduation, he was employed by the university as an assistant professor. His main research directions are computer vision, the optimization of the prediction of advertising click rate, and reinforcement learning and its applications. He has published papers on many international conferences and periodicals, such as ACCV and VAST, and has served as a reviewer of periodicals and conferences, such as PRL and IROS.

Subject 5.8: Quick Learning of Small Sample Orders (Location: Shenzhen)

In the online learning scenario of the recommendation field, some items have a small amount of data and click through rate estimation is unstable, causing poor convergence. The subject will explore, under the premise of ensuring the stability of the overall Bias, how to predict the click through rate of items with small sample data more accurately and control the complexity of the model and implement easily with the online learning algorithm.

Mentor Profile: He is a senior research fellow in Shenzhen and received his Ph.D. of the mathematics and applied mathematics, and biomedical engineering from Huazhong University of Science and Technology. During his Ph.D. study, he was mainly engaged in the research of regularization methods for medical image reconstruction algorithms and optimization algorithms and published 3 papers on class A periodicals as first author. Currently, he focuses on researching advertising click rate estimation and online learning algorithms.

Subject 5.9: Application of Deep Reinforcement Learning in Video Games (Location: Shenzhen)

When deep reinforcement learning is used to realize video game AI, there are problems such as large decision depth, sparse rewards, large action space and anthropomorphism. It is necessary to solve these problems by introducing ideas such as layered models, course learning, and expert knowledge to improve the model convergence performance.

Mentor Profile: He is a senior research fellow at Tencent. He graduated from the National University of Singapore and is currently engaged in fields such as game AI R&D and game data mining. He has participated in the development of more than 20 mobile games including League of Legends, King of Glory, CrossFire, and QQ Speed.

Subject 5.10: Research on Neural Network Lightweight Compression and Acceleration Technology (Location: Shanghai)

As deep learning has made significant progress in the fields of speech recognition and computer vision in recent years, there is a growing requirement for deploying deep neural network models on mobile platforms with limited resources. However, considering the huge computational complexity and model size of convolutional neural networks, it is extremely difficult to deploy these complex neural networks on embedded platforms. This subject mainly studies the basic ideas and methods of the neural network lightweight model, neural network quantitative training, model distillation, pruning and other common model compression and acceleration methods of neural network. The subject seeks to make breakthroughs in fields including sparse neural network model (Winograd domain and time domain), lightweight neural network architecture search and automatic model compression based on reinforcement learning and AutoML.

Mentor Profile: He is a senior research fellow at Tencent and graduated from Zhejiang University. He has worked on machine learning at Tencent for many years. His current main research fields include machine learning platform construction, large-scale distributed system design, deep model structure design, deep model quantitative

training and super-parameter learning.

Subject 5.11: Research on Deep Learning and High-performance Heterogeneous Computing Technology (Location: Shanghai)

This subject focuses on deep learning in the performance optimization of high-performance heterogeneous computing platforms: 1. explore the high-performance computing platform structure using thread-level, data-level and instruction-level parallel strategies, thus maximizing the performance of deep learning algorithms on the platform; 2. explore the performance of different depth model structures for different platform architecture characteristics and adjust the model to the platform characteristics to achieve the optimal tuning result of the software and hardware components of the algorithm.

Mentor Profile: Mentor 1: He is a senior research fellow at Tencent. He graduated from Beihang University and has worked at NVIDIA and Tencent for many years in high-performance computing, machine learning and autonomous driving. At present, his main research fields are high-performance computing, CPU/GPU/DSP platform architecture and deep learning.

Mentor 2: He is a senior research fellow at Tencent, graduated from Southeast University, and worked at Hikvision and Omnivision before joining Tencent on computer vision and high-performance computing. His main research directions include deep learning platforms, embedded systems, and edge computing.

Subject 5.12: Automatic Design and Parameter Adjustment of Neural Network (Location: Shenzhen)

With the release of the Google AutoML, the design of neural networks has evolved from manual to automatic. However, this technology remains far from actual application due to problems such as how to solve the long searching time, huge resource consumptions, and how to optimize the searched networks to different devices. The project will be based on the experimental exploration in labs to explore a set of neural networks which can be automatically designed that can be adjusted for different

application scenarios.

Mentor Profile: He is a senior research fellow at Tencent and holds undergraduate and master's degrees from the Zhejiang University and a Ph.D. from the Chinese University of Hong Kong. He has been engaged in computer vision research, and has published more than 20 papers on international leading conferences and periodicals such as CVPR, NeurIPS, ICCV, ECCV, SIGGRAPH, TPAMI and IJCV as a reviewer. He has won championships in a series of prestigious international competitions. At present, he is mainly engaged in research and development of image and video understanding and autonomous driving.

Subject 5.13: Cluster Analysis of WeChat Users' reading behavior (Location: Guangzhou)

The research will conduct clustering analysis based on more than 1 billion users' reading behavior data, with the direction of optimization the large-scale clustering algorithms. Another focus of the research is embedding the users' reading behavior. Rapid clustering algorithm and transfer learning will be applied to this research.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. from the Stevens Institute of Technology (machine learning). He worked as a postdoctoral fellow for one year on intelligent recommendation at Upenn, and published more than 15 academic papers. With his instruction, an intern student in WeChat published an article at a leading AI conference (AAAI) during a 2-month summer internship.

Subject 5.14: Study of Personalized Search Based on Social Networks and Click Offset Model Based on Multidimensional Information (Location: Beijing)

The subject will use users' social relationship diagrams and their behavior in the social network (public data) to develop users' personalized models and combine them with the existing search relevance model to provide users with more accurate sorting results.

The subject uses user's post-click behavior and the multi-dimensional click bias of the location and style brought by our different search business scenarios to learn the relevance scores of each sorting result and explore how to evaluate and improve the

existing search engine sorting quality with rich user behavior.

Mentor Profile: He is a principal researcher at Tencent and graduated from Xidian University. He is now working on research related to WeChat search and has published papers on leading conferences such as ACL and AAAI. He has more than 10 related technology patents and published the technical book *Text Algorithms*.

Subject 5.15: Recommendation System Ranking Algorithm (Location: Beijing)

This subject studies the ranking algorithm in Top Stories, which is the personalized feeds recommendation system in WeChat. Based upon the state-of-the-art deep reinforcement learning technology and the data both inside and outside of the WeChat ecosystem, we explore various ranking methods, as well as the exploitation and exploration algorithms for new users and coldstart users. Our goal is to improve core metrics such as user-experience, ctr, duration, and diversity.

Mentor Profile: He is a senior research fellow at Tencent, responsible for the research, development and application of recommendation system in Wechat. He graduated from the Institute of Computing Technology of the Chinese Academy of Sciences. In the field of recommendation system, he has filed a series of patents and published several papers in prestigious conferences, such as ACL and AAAI.

Direction 6: Speech Technology

Subject 6.1: Research on Voiceprint Recognition Algorithms (Location: Shenzhen)

This subject will study algorithms by focusing on the difficulties in voiceprint recognition technology, such as phrase voiceprint recognition, scene mismatch and noise conditions. During the joint training, the applicant will have access to the latest voiceprint recognition technologies such as voiceprint recognition based on deep speaker embedding, end-to-end metric learning and more efficient loss function construction for optimizing network training. The research will seek to improve the existing methods or put forward new ones during the joint training.

Mentor Profile: He is a senior research fellow at Tencent and received Ph.D. from the Northwestern Polytechnical University. He has six years' research experience in voiceprint recognition and has published more than 10 papers on leading periodicals and conferences on phonetics such as TASLP, CSL, ICASSP, Interspeech and SLT and served as a reviewer of many periodicals or conferences such as TASLP, Interspeech and ICASSP. He once worked as a postdoctoral research fellow at Hong Kong Polytechnic University. After joining Tencent, he continued researching and developing voiceprint recognition technologies.

Subject 6.2: Research on Speaker and Domain Adaptation in ASR System Based on Neural Network (Location: Shenzhen)

The acoustic model based on deep neural networks has made great progress in many fields. However, this model has disadvantages including huge data demand, large training quantity, and the limitation of fields. Adaptation can be a solution to each of the above problems, including speaker adaptation and domain adaptation, using a small amount of data to quickly update an existing model to realize considerable recognition accuracy on specific speakers and scenes. During the joint training period, the adaptation of various neural networks based on the Kaldi Chain model will be investigated, implemented and explored, including but not limited to learning hidden unit contribution (LHUC) and factorized hidden layer (FHL). The study will also explore the adaptation of listen attend spell.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. from the National University of Singapore. The doctoral thesis topic is acoustic modeling based on neural networks. He has 8 years' experience in acoustic model research and development. He has published more than 10 papers on leading conferences and 1 paper on 1 top tier journal paper in this field. At present, he is working on acoustic modeling based on Kaldi Chain LFMMI and the end-to-end acoustic model based on Listen Attend Spell (LAS).

Subject 6.3: Research on Audio-visual Fusion of Multi-speaker Voice Tracking (Location: Beijing / Shenzhen)

Multi-speaker voice tracking plays a key role for many applications such as human-computer interaction and surveillance and monitoring systems. This subject will seek to track multiple mobile speakers using auditory and visual information. To better process audio and visual data or the data under interference, it is necessary to properly fuse the multi-modal information, so that the complementary information can be correctly processed and fused.

Subject 6.4: Multi-modal Emotion Analysis and Recognition (Location: Shenzhen)

The research is to perceive emotions of the audience and recommend content that matches their emotions. The research's focus is multi-modal sentiment analysis and identification. The specific research includes:

1. Analyze emotions in voice, music, text, image and video.
2. Understand emotions in multi-modal fusion;
3. Multi-modal event detection based on emotions;
4. Explore, dig, search for and recommend music, news and information streams based on emotions;
5. Set up the emotion evaluation benchmark.

Mentor Profile of Subject 6.3-6.4: He is a principal researcher at Tencent and has focused on the signal processing of speech and sound (enhancement, suppression and separation) and acoustic model research for speech recognition. His current research focuses include audio signal processing, keyword wake-up, multi-speaker separation and multi-modal speech recognition.

Subject 6.5: Acoustics Detection Technology for Songs in Short Videos and Live Broadcast Scenes (Location: Beijing)

Short video and live broadcast are the most popular fields of Internet products. The biggest technical difficulty facing the scenes is the complexity of acoustic scenes. The focus of the subject is how to recognize content, language and speaker information in humming in a complex music background with a low signal-to-noise ratio and the separation of signal processing in such scenes.

Specific research includes:

1. Speaker recognition, language recognition and other audio classification in complex song scenes;
2. Song and music removing technology in complex scenes;
3. Keyword wake-up system and music and lyrics transfer system;
4. Explore the single channel enhancement algorithm (Noise Cancellation, De-reverberation and Automatic Gain Control) in online live music broadcasts.

Mentor Profile: He is a senior research fellow at Tencent. He received his bachelor's degree from the Department of Automation of the University of Science and Technology of China and his master's and doctor's degrees from the Institute of Automation, Chinese Academy of Sciences. His research direction is speech recognition. He has published 5 papers on conferences such as INTERSPEECH and ICASSP. Currently, he has focused on the identification of pornography and speakers and study on audio subjects such as pornography audio identification, general audio classification and speaker identification. Some technical achievements have been outputted through Tencent Cloud.

Subject 6.6: Key Technologies of Scene-awareness Speech Enhancement and Audio Separation (Location: Shenzhen)

The project is to seek innovative signal processing and deep learning methodologies to improve the performance of speech enhancement and audio separation in diverse conditions.

It is highly expected that the new method enables effective sensing of different acoustic scenes to set up optimized and flexible signal processing and learning strategies in feature extraction, enhancement/separations (denoising, intelligibility improvement, speech separation, music separation, prosody recognitions) for different noise and acoustic interference conditions.

Mentor Profile: He is a principal researcher with more than 12-year experiences in speech and audio processing. He ever contributed to multiple international standards in ITU-T, 3GPP, MPEG and AVS, covering speech and audio compression and speech

quality assessment with more than 50 technical contributions. He has more than 30 pending/granted patents. His current research includes voice communication, speech enhancement, psychoacoustic modeling and speech quality assessment.

Subject 6.7: Conversion of Highly Expressive Speech Speaker and Speech Style Conversion (Location: Shenzhen)

Speech synthesis technology is an important output module for speech and multi-modal intelligent human-computer interaction. The current speech synthesis technology performs well with sufficient speaker training data. However, using limited training sentences to create a synthesis system for new speakers or speaking styles remains a great challenge. Making the model or system after speech conversion robust and ensuring the consistency of the speaker or style conversion are also very challenging. Therefore, students need to learn the basic methods of machine learning during their studies and improve their mathematical modeling and deep learning. Mathematics and programming capabilities are also required.

Mentor Profile: He is currently a principal researcher at Tencent, responsible for research and product development of speech synthesis and speech style conversion. He has won the first prize in Blizzard Challenge, an international speech synthesis competition, several times during the doctoral study. After finishing his doctoral studies, he worked at the University of Edinburgh in the UK for two years on postdoctoral research. He has published more than 20 academic papers including papers published on leading conferences such as INTERSPEECH and ICASSP and is a reviewer and excellent reviewer of several conferences. He has also obtained several patents in China and the U.S.

Subject 6.8: Multi-modal Speaker Diarisation (Location: Shenzhen / Beijing)

In a multi-speaker scenario, It is often necessary to identify who has spoken, but also who spoke when (Speaker Diarisation). The microphone array and the DOA (Direction of Arrival) technology can identify the source of sound, while facial recognition can provide us with the orientation information of the speaker. Voice

recognition alone may distinguish between different speakers, but combining multi-modal information allows for more robust Speaker Diarisation. The subject will explore how to combine multi-modal information to realize robust Speaker Diarisation.

Mentor Profile: He is a principal researcher at Tencent and received a Ph.D. from the University of Cambridge. He mainly focuses on speech recognition research and the research directions include deep learning, structural prediction, kernel method, Bayesian nonparametric estimation, graph models, speech recognition, speaker recognition and keyword wake-up. He was awarded the Best Student Paper by Interspeech and IEEE Hong Kong Chapter of Signal Processing and the first prize of the American Mathematical Contest in Modeling.

Subject 6.9: End-to-end Speech Recognition (Location: Beijing)

Speech recognition is one of the most popular AI research subjects. Based on the deep learning framework, the recognition rate of speech recognition systems has been greatly improved. However, the speech recognition rate drops significantly in certain practical scenarios such as Code-mixing. A multilingual pronunciation dictionary with manual marks is needed to construct a traditional speech recognition system. The work requires a lot of human resources, and each module of the recognition system needs to be optimized independently. This subject will study the end-to-end speech recognition system and improve the speech recognition effect in the Code-mixing scene through the optimization of data, features and models.

Mentor Profile: He is a principal researcher at Tencent and received his master's degree in pattern recognition and intelligent system from the Institute of Automation, Chinese Academy of Sciences. He has many years' experience in the speech recognition R&D.

Direction 7: Natural Language Processing

Subject 7.1: Text Understanding (Location: Shenzhen)

The subject will study and explore deep text understanding techniques based on semantic analysis and knowledge reasoning, including but not limited to: 1. new text understanding model architecture; 2. language understanding technique for social text; 3. language understanding model by introducing common sense and external background knowledge; 4. representation and reasoning of knowledge graph; and 5. the application of the above understanding techniques in open-domain chatting and other scenarios.

Mentor Profile: He is a principal researcher at Tencent and received Ph.D. from the Department of Computer Science and Technology, Tsinghua University. At present, his research focuses on text understanding and intelligent human-computer interaction. He has published more than 20 papers on top-tier conferences such as ACL, EMNLP, WWW, SIGIR, CIKM and AAI. He served as a program committee member of conferences such as ACL, EMNLP, WWW, and AAI, and reviewer of journals such as TOIS and TKDE.

Subject 7.2: Dialogue System and Text Generation (Location: Shenzhen)

The research of the dialogue systems aims to develop new algorithms to improve the response performance of the social-chat dialogue system, including but not limited to: 1. combining the retrieval-based model and the generation-based model to improve the information diversity of the response; 2. dialogue logic management and topic expansion in multi-turn dialogue scenario, etc.

The study on text generation will develop new algorithms to improve the response performance of the social-chat dialogue system, including but not limited to: 1. long text generation such as stories and news; 2. controllable text generation: generating text that can objectively obey the given conditions such as the emotions and characters as well as some other specific styles; and 3. abstractive long text summarization: long text modeling and multi-sentence summaries generation.

Mentor Profile: He is a principal researcher at Tencent and received Ph.D. from the University of Science and Technology of China. At present, his research focuses on dialogue and text generation. He has published several papers at top-tier conferences such as EMNLP, WWW, and KDD.

Subject 7.3: Machine Translation (Location: Shenzhen)

This project aims at alleviating the key problem of neural machine translation (NMT) – inadequate translation, including but not limited to designing advanced architectures and learning strategies, building high-performance NMT models on large-scale data (possibly noisy and multi-domain), improving translation of entities and low-frequency words. This project also investigates iterative translation to bridge the gap between machine translation systems and human translators.

Mentor Profile: He is a principal researcher at Tencent and received Ph.D. from the Institute of Computing Technology, Chinese Academy of Sciences. His research focuses on machine translation and deep learning for natural language processing. He has published more than 40 papers on top-tier conferences and journals, such as ACL, TACL, EMNLP, AACL, and IJCAI. He served as ACL2019, EMNLP2018, NAACL2019 machine translation area co-chair, and AACL2019 senior PC member.

Subject 7.4: Research on Neural Machine Translation System for Minorities with Limited Resources and Cross-disciplinary Text (Location: Beijing)

Most languages other than Chinese and English lack adequate parallel language data. Therefore, making full use of existing data to solve the resource shortage has become an important research direction of neural machine translation. Most machine translation application scenarios are in minority languages of countries in the Belt and Road Initiative, facing a shortage of language data.

Cross-disciplinary translation is another challenge, which requires domain adaptation techniques. In the To B scenario, machine translation may need to provide services in vertical fields such as courts, procuratorates, national security, games and short videos. Therefore, a common model needs to be used for cross-domain adaption research.

Specific research includes:

1. Use monolingual language data to learn in a semi-supervised manner with limited parallel language data;
2. Use intermediate language and monolingual language data to learn through multi-task learning in a completely unsupervised manner;
3. NMT system that utilizes bilingual data with adequate resources to learn low or zero resources through transfer learning.

Mentor Profile: He is a principal researcher at Tencent and received a Ph.D. from the Institute of Automation, Chinese Academy of Sciences. He has published 17 papers on various international audio conferences and periodicals and has obtained more than 10 US patents. He won second place in a Chinese-English translation contest of the Workshop on Machine Translation and the first place in the CWMT Chinese-Minority machine translation contest.

Subject 7.5: Chinese General Language Representation (Location: Beijing/Shenzhen)

Chinese characters are highly expressive and change in form, bringing great challenges to Chinese NLP. Varied and adversarial Chinese texts are often seen in business scenarios. Processing these texts effectively is an important goal.

Specific research includes:

Low-level pre-training + high-level task tuning is a current mainstream research direction of NLP. The subject will include the following research:

1. Modeling variations and adversarial texts from the levels of words, shapes and sounds;
2. Constructing a general and effective low-level model for variation and adversarial texts based on underlying features;
3. Optimizing the task-driven high-level model based on a low-level general representation model.

Mentor Profile: Mentor 1: He is an expert engineer at Tencent and received a Ph.D. in machine learning in Italy. His doctoral thesis was published on ACL2012 (Long Paper). He has been devoted to the application of machine learning in real business scenarios,

including e-commerce, information, O2O and information security.

Mentor 2: He is a senior research fellow at Tencent and received a Ph.D. from the College of Computer Science and Technology, Zhejiang University, majoring in computer science and technology. During his doctoral studies, he mainly worked on physical links and published several papers on various publications and conferences. At present, he is mainly working on representation of Chinese common language models.

Mentor 3: He is a senior research fellow at Tencent and received a Ph.D. from the Institute of Automation, Chinese Academy of Sciences, majoring in natural language processing. His main focuses during the doctoral study were text categorization, entity extraction and relationship extraction. He has published several papers on conferences and journals related to natural language processing. Currently, he is mainly working on text classification.

Subject 7.6: Research on Open-domain Question Answering Technology (Location: Beijing)

Open-domain question answering technology has attracted intense interest from both academics and industry, and is one of the most popular research directions in recent years. In this project, we will focus on the research on open-domain question answering technology include but not limited to knowledge representation and acquisition, evidence retrieval, answer prediction, confidence assessment and complex interaction based on reinforcement learning.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent and received a Ph.D. of statistical physics from the Institute of Theoretical Physics, Chinese Academy of Sciences. Currently, he is working on technologies and product applications related to machine learning and natural language understanding, including dialogue systems, reading comprehension, and machine translation. He has published many papers in top conferences such as ACL and NeurIPS.

Mentor 2: He is a senior research fellow at Tencent and received a Ph.D. from the Department of Computer Science and Technology, Tsinghua University. Currently, he is working on technologies and applications related to natural language processing. His

major research interests include question answering, dialogue system and machine translation. He has published a few papers in top NLP conferences and served as a reviewer for several conferences.

Subject 7.7: Research on Application of Reinforcement Learning in Natural Language Processing (Location: Beijing)

Reinforcement learning has great potential for improving the performance of natural language processing tasks involving complex machine-environment interaction or dependencies. We will explore the application of reinforcement learning in dialogue systems, question answering, and text generation based on real product scenarios and data.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent and received a Ph.D. of statistical physics from the Institute of Theoretical Physics, Chinese Academy of Sciences. Currently, he is working on technologies and product applications related to machine learning and natural language understanding, including dialogue systems, reading comprehension, and machine translation. He has published many papers in top conferences such as ACL and NeurIPS.

Mentor 2: He is a senior research fellow at Tencent and received a Ph.D. from the Institute of Computing Technology, Chinese Academy of Sciences. He is currently working on research and application of the latest natural language technologies. His major research interests include machine translation, natural language processing and deep learning models. He has published papers in top conferences including ACL, IJCAI and AACL, and the translation of book *Python Natural Language Processing*.

Subject 7.8: Study of Humanoid Dialogue System (Location: Beijing)

End-to-end dialog system is a popular NLP research direction. In this project, we will focus on the research of generating meaningful dialogs with subject, theme and sentiment constraints by leveraging both structured and unstructured knowledge.

Mentor Profile: He is a principal researcher at Tencent and received a Ph.D. from the University at Buffalo, the State University of New York. Currently, he is working on

technologies and products related to dialogue robots and open semantic platforms. His team won the first place and second place in 2018 DSTC7 (Dialogue System Technology Competition). In addition, he has published many papers in top conferences such as ACL.

Subject 7.9: Automatic Question-Answering System in the Game Domain Based on Game Knowledge Graph (Location: Shenzhen)

The automatic question-answering system based on knowledge graph is a popular research subject. Its challenges include: 1. Understanding questions and converting to specific forms; 2. mapping questions to structured queries; and 3. answering in natural languages. Technologies involved in this research include natural language processing, knowledge graph, and machine learning.

Mentor Profile: He is a senior research fellow at Tencent and received his Ph.D. in mathematics at USTC. At present, he is working on the study and application of data mining technology in games, which will improve user experience through user profile and personalized services, and provide valuable operational support for businesses.

Subject 7.10: Article Quality Understanding Based on Deep Learning (Location: Guangzhou)

The students will have access to billions of articles in the WeChat ecology, starting from the direction of Word2vector and using the deep learning method to generate the vector of the articles, which can clearly evaluate the quality of the articles. Main tools to be used include Tensorflow and Pytorch.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. in machine learning from the Stevens Institute of Technology. He worked on intelligent recommendation as a post-doctoral fellow at Upenn for one year. He has published over 15 academic papers. With his instruction, an intern student in WeChat published an article on a leading AI conference (AAAI) during a 2-month summer internship.

Subject 7.11: Research on Machine Translation Methods with Low Resources (Location: Beijing)

Bilingual parallel corpus is fundamental for machine translation, especially for neural machine translation. However, for many language pairs there are insufficient corpus required for building high-quality neural machine translation systems. This research aims to improve neural machine translation quality under the circumstance of limited resources, including better exploiting in-hand bilingual resources, exploring more effective use monolingual data, pivotal languages and other data resources.

Mentor Profile: He worked as a principal researcher at Tencent and received his Ph.D. from the Institute of Computing Technology, Chinese Academy of Sciences. His main research interests include machine translation, natural language processing and dialogue systems. He has published more than 10 papers on leading proceedings including ACL, COLING, EMNLP and AACL. Besides he has participated several projects sponsored by National Key Basic Research Development Program (also known as the 973 Program), National High Technology Research and Development Program (also known as the 863 Program) and National Natural Science Foundation of China.

Subject 7.12: Research on the Multi-task Learning Algorithms for Natural Language Understanding in Dialogue Systems (Location: Beijing)

In dialogue systems, conversations between users and systems can be of different types, typically including task-oriented, question-answering and chitchat. The language understandings for different types of conversation can be related to each other although they are usually carried on independently. This project is concerned with the multi-task learning problem for the language understanding in dialogue systems. The multi-task learning will try to make use of the dependencies between the tasks of intent detection, slot filling and answer matching. In addition, this project will also try to address the cold-start problem by leveraging data-sufficient tasks to assist data-insufficient tasks.

Subject 7.13: Research on Conversational Question--Answering Algorithms (Location: Beijing)

Multi-turn question answering is one of the main ways for people to access information in daily dialogues. Task-oriented dialogue systems and question-answering systems, however, are usually treated as two separated systems in previous research. Meanwhile, voice-enabled intelligent assistant presents the increasing need of conversational question-answering, in which question answering dialogues are required to interact with task-oriented dialogues. This project is concerned with designing new algorithms for conversational question answering, covering the aspects such as coreference resolutions, long-distance context utilization and logical reasoning.

Mentor Profile of Subject 7.12~7.13: Principal researcher at Tencent and Ph.D. from Shanghai Jiaotong University. His research interest includes natural language processing, dialogue systems and knowledge mining. He has published more than 30 papers on leading international academic conferences and journals such as ACL, EMNLP, and AACL, and filed more than 20 US patents. Currently he is responsible for the research and innovation around the dialogue system of Tencent's Dingdang (an AI Voice Assistant).

Subject 7.14: Research on Semantic Matching and Personalized Query Rewriting (Location: Beijing)

This subject studies the accurate Question and Answer(Q&A), and Query Understanding technology of WeChat. Based upon the state-of-the-art deep learning technology, we explore the idea of integrating knowledge graph information into accurate Q&A task, and integrating personalized information into Query Rewriting task. The technology effectiveness has been demonstrated on WeChat search platform.

Mentor Profile: He is a principal researcher at Tencent. Before, he received his Ph.D. from the Institute of Computing Technology, Chinese Academy of Sciences (ICT, CAS). His research interests include Information Retrieval (IR), Natural Language Processing (NLP), Question and Answer systems (QA system) and Data Mining.

Recently, he has published many high-quality papers on leading AI and NLP conferences such as AAAI, IJCAI and ACL, and obtained multiple technological patents in relative fields.

Direction 8: Computer Vision and Multimedia Computing

Subject 8.1: Image / Video Generation (Location: Shenzhen)

This subject studies the image/video processing, editing, and generation, mainly focusing on image/video generation models, such as GAN, VAE, to model spatio-temporal characteristics and generate the desired image/video.

Mentor Profile: He is a distinguished scientist at Tencent and received his Ph.D. degree from the Columbia University in the United States. He has a long history of fundamental research and product development in the fields of computer vision, machine learning, big data, and information retrieval. He has published over 180 papers and got more than 7,000 citations according to Google Scholar.

Subject 8.2: Human Perceptual Video Color Enhancement and Noise Reduction, and the Associated Evaluation Methodology (Location: Shenzhen)

The human perceptual color enhancement topic focuses on various applications and challenges in the video processing domain, including SDR-to-HDR conversion, hue and saturation enhancement, video color temporal consistency and adaptivity to various scenes, and non-reference quality assessment.

The human perceptual noise reduction topic focuses on advanced technologies of video noise reduction, and pleasant noise level evaluation based on human perception. Combined with motion aligned transform domain thresholding and deep learning network, we target at developing an advanced and fine-granularity controllable AI video de-noiser.

Mentor Profile: He is a principal researcher at Tencent and received his Ph.D. in Electrical and Computer Engineering from the University of California, San Diego.

After joining Tencent, he is dedicated to improving high-quality multimedia services and advocating the next generation of multimedia innovation with the help of artificial intelligence and cloud data.

Subject 8.3: Research on Image and Video Aesthetics Assessment and No-Reference Video Quality Assessment Based on Deep Learning (Location: Shenzhen)

Image and video aesthetic assessment is to use the computational method to measure the beauty of the visual content, which simulates the perception process of Human Visual System (HVS) for different content. This topic mainly investigates the basic low-level information such as composition, colors and sharpness, and high-level semantic information such as themes and emotions in the visual content.

Video Quality Assessment (VQA) is essential to many computer vision technologies, such as video compression, enhancement, stabilization and other pre- or post-processing methods. This topic aims to exploiting deep learning-based approaches to model the HVS characteristics. We will conduct large-scale subjective tests and study VQA in a supervised and No-Reference manner.

Mentor Profile: He is a senior research fellow at Tencent and received the Ph.D. from the School of Computer Science and Engineering, Nanyang Technological University, Singapore. His research interests include video coding, image/video processing, image quality assessment and computer vision. Four conference and journal papers such as Transaction on Image Processing (TIP) have been published in related fields. Currently, he is working on no-reference video quality assessment algorithm and application for video enhancement.

Subject 8.4: Research on Design & Implementation of High-performance & Low-latency Real-time Media Streaming Service (Location: Shenzhen)

This project will study on high-performance & low-latency service for real-time media streaming. Specifically, the project focuses on: 1. High-performance and parallel audio and video transcoding solutions; and 2. The design and implementation of high-

bandwidth and low-overhead network stacks.

From the perspective of joint optimization, in this project we will: (1) conduct a large-scale measurement study on massive audio and video data, (2) identify the dynamic adaptation among coder/decoder, audio and video processing, and congestion control, and (3) design novel mechanisms to reduce the end-to-end user-perceived latency through joint optimization.

Mentor Profile: He is currently a senior researcher at Tencent Media Lab. He received the Ph.D. degree from the Department of Computer Science and Technology, Tsinghua University in 2018. During his doctoral studies, his main research interest was wireless networks and mobile cloud computing. He was awarded the national scholarship in 2015&2017, Microsoft scholar scholarship nomination in 2016, and the Tsinghua University outstanding graduate award in 2018. His research results have been published on CCF class A conferences and journals such as ACM Mobicom, Transaction on Mobile Computing (TMC) and IEEE INFOCOM with more than 10 related patents. Currently, he is working on low-latency networked system for next generation real-time media streaming.

Subject 8.5: Video Understanding (Location: Shenzhen)

Video understanding requires not only the representation of single-frame images, but also modeling of the temporal relationships between video frames. The research topics include but not limited to video classification, action recognition, action proposal, action localization, and video captioning.

Mentor Profile: He is a principal researcher at Tencent and received his Ph.D. degree from the Department of Electronic Engineering, the Chinese University of Hong Kong, and the master and bachelor degrees from the School of Computer Science and Technology, Harbin Institute of Technology. Currently, he is working on image/video understanding and has published many papers on leading international conferences and journals.

Subject 8.6: Research on the Algorithm of Human-Object Interactive Video Behavior Recognition (Location: Shanghai)

With the emergence of large-scale video behavior analysis data in recent years, such as ActivityNet, video comprehension research has received much academic attention. The establishment of human-object relationship (human-goods relationship) is very important in intelligent retail scenarios. This subject will focus on the following two aspects:

1. Research on high-performance models of motion behavior recognition based on the latest technologies of human attitude estimation and video motion recognition;
2. Expansion of the Human Object Interaction (HOI) algorithms based on two-dimensional images to three-dimensional time-series videos. The research on HOI in the video field will realize the analysis of human-object interaction from videos.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. from Tsinghua University. With years of experience in the research on machine learning and mainly engaged in the research of deep learning technology applications. In addition, who has published dozens of papers at leading conferences such as IJCAI, AAAI and ACL.

Subject 8.7: Few-shot learning for Image and Video Understanding (Location: Shenzhen)

Over the past few years, we have witnessed the success of deep learning in image recognition thanks to the availability of large-scale human-annotated datasets such as PASCAL VOC, ImageNet, and COCO. Although these datasets have covered a wide range of object categories, there are still significant number of objects that are not included. Can we perform the same task without a lot of human annotations? In this project, we hope to develop a new model for scene recognition, object classification, detection, segmentation, and human behavior understanding by using limited training data by exploring few shot learning. Such model is very useful in tackling real-world problems and would have large industrial and academic impacts.

Subject 8.8: Human Face and Body Gesture Recognition and Reconstruction (Location: Shenzhen)

With the popularity of smart phones and mobile computing devices, human faces and bodies have gradually become the most common targets on photos. Visual algorithms related to human faces and bodies recognition have significant research and utility value in both To C scenes such as human face retrieval, liveness identification, automated slimming, beauty and makeup and virtual socialization and also To B scenes, including security monitoring, human-computer interaction and motion detection. Based on Tencent's expertise in social entertainment, this topic relies on Tencent's platform capability and studies face and body images. The research mainly covers illumination calibration, 3D reconstruction, gesture estimation, apparent modeling and picture editing. This subject will not only explore the world's leading research fields, but also gathers the best young researchers in the industry and provides the opportunity to apply research results to Tencent's games, social entertainment and other related products, thus improving the social entertainment experience for millions of users.

Mentor Profile of Subject 8.7~8.8: He is a principal researcher at Tencent and received the bachelor's degree and master's degree from the Hong Kong University of Science and Technology and a Ph.D. from the National University of Singapore. He has published more than 100 papers, of which more than 40 have been published on CVPR, ICCV and ECCV, which have been cited more than 4,500 times on Google Scholar. He is the area chair for ICCV'15, ICCV'17 and ICCV'19.

Subject 8.9: 3D Vision (Location: Shenzhen)

This subject focuses on the reconstruction of 3D scenes, objects, human faces, and human bodies based on RGB or RGBD input, as well as the semantic understanding, editing, rendering, and animation of the reconstructed 3D representation (Point Cloud, 3D Volume and Mesh). The research also involves SLAM, sensor fusion, stereo vision matching and optical flow estimation, video object segmentation, and other related topics.

Mentor Profile: He is a principal researcher at Tencent and received his Ph.D. from

the Department of Computer Science, City University of Hong Kong. Currently, he is mainly working on topics related to 3D vision and video analysis. He has published over 20 papers on leading international conferences and journals.

Subject 8.10: Full-Stack AI Technologies on Human Faces (Location: Shenzhen)

Human faces are one of the most important visual information. Automatic facial detection and recognition research is a popular and challenging topic in the field of artificial intelligence and computer vision, receiving extensive academic and industrial attention. To satisfy the ever-increasing needs from the mobile Internet, video surveillance, government affairs, smart retail and other related fields, this subject is aimed at developing a full-stack of AI technologies on 2D and 3D for human faces. With key technologies based on deep learning, we specifically focus on most popular studies such as face detection and recognition in complex scenes, face liveness recognition and attack and defense in the adversarial face recognition.

Mentor Profile: He is a principal researcher at Tencent and an IEEE senior member. He received a Ph.D. degree from the Chinese University of Hong Kong. He was once a researcher (professor) and a Ph.D. supervisor of the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences. His research focuses include artificial intelligence, computer vision, and human face recognition. He has published a series of significant papers in relevant fields, among which the classical algorithm for face detection and key point localization based on deep learning (MTCNN, cited on Google 524 times since release in 2016) and the classical face recognition algorithm based on deep learning (Center Face, cited on Google 553 times since its release in 2016) have received wide academic and industrial attention. Moreover, he is an editorial board member of *Neurocomputing*.

Subject 8.11: Tibetan OCR Identification (Location: Beijing)

In addition to Chinese and English, Tibetan makes up the largest minority languages in the application field of identification of language on images, creating the demand for Tibetan image identification. At present, the research and application of this field lags far behind the demand in China. One reason is that there is very limited image data with

Tibetan texts, leading to the shortage of available data. Another reason is that little progress has been made in the application of the Tibetan image text identification.

Specific research includes:

1. Use existing text synthesis technology to synthesize a Tibetan image that can simulate the effect of social text images;
2. Model Tibetan characters, which requires full understanding and modeling of Tibetan characters to find the most effective technical solution;
3. Use the language model to optimize Tibetan OCR recognition.

Mentor Profile: He is a senior research fellow at Tencent and finished the Ph.D. study at the Model Identification Lab of the Beijing University of Posts and Telecommunications. His main research direction is the detection and identification sensitive texts, multilingual text, and keywords in massive social scenarios. He has made a major contribution to maintaining social stability, ensuring the security of content on billions of social OCR images every day.

Subject 8.12: Research on Face Recognition Challenges (Location: Shanghai)

This subject focuses on the most challenging issues of face recognition, including but not limited to low-quality face recognition in difficult scenarios (such as Surveillance environment), such as low resolution, large pose, cross-age, cross-region, cross-race and other variations. The technologies involved include those based on Generative Adversarial Networks (GAN). Based on the theories in deep learning and machine learning, and the cutting-edge novel models, this subject aims to make the models more robust and generalized, making unique academic contribution.

Subject 8.13: Research on Cutting-edge Technologies of Human Face Image (Location: Shanghai)

This subject explores the cutting-edge technologies for face image analysis, including but not limited to face alignment, face parsing, face restoration, face makeup, face detection and face liveness detection. Based on the cutting-edge technologies (such as GAN and Attention models), the focus is researching innovative/practical method in related fields.

Mentor Profile of Subject 8.12~8.13: He is a senior research fellow at Tencent and received a Ph.D. from the Institute of Computing Technology, Chinese Academy of Sciences. He is one of the first Chinese scholars working on deep learning and ImageNet. At present, based on the big data and cloud computing platform at Tencent, he is committed to constructing the world's best human face database in terms of the quantity and quality of identities, scenes and images, studying the performance of large-scale face recognition algorithms, and promoting the evolution of The Grandmother Model.

Subject 8.14: Fine-Grained products image classification (Location: Shanghai)

Using CV technology to achieve general product image classification is a great challenge: precise positioning of dense small objects with partially blocked-vision, identification of extreme product class under fine granularity, insufficient training samples, complex illumination and perspective impacts. These problems need to be solved through research on using multi-scale, multi-task, transfer learning and focus technologies. In addition, due to the large number of commodities, building a general product identification system to support the automatic expansion of unknown commodity categories is a research direction to be explored.

Mentor Profile: He is a senior research fellow at Tencent and received a Ph.D. from the Shanghai Jiao Tong University. He finished his postdoctoral study at the University of Texas in the US. He has many years of experience in deep learning in the fields of image, natural language processing and audio, and has published several papers on leading AI conferences including ACL, EMNLP and CIKM. His current research direction is product recognition and fine-grained classification.

Subject 8.15: Road Scene Understanding in Autonomous Driving (Location: Shenzhen)

Accurate and efficient perception of the environment is very important for automated driving. In addition, special scenes of automated driving put high requirements on the accuracy and efficiency of the algorithm and promote the continuous improvement of

related technologies. This project will involve image-based object detection, semantic segmentation and object detection based on lidar point cloud to continuously improve accuracy and efficiency on these tasks.

Mentor Profile: He is a senior research fellow at Tencent and received undergraduate's and master's degrees from the Zhejiang University and a Ph.D. from the Chinese University of Hong Kong. He has been engaged in computer vision related research. He has published more than 20 papers at international leading conferences and periodicals such as CVPR, NeurIPS, ICCV, ECCV, SIGGRAPH, TPAMI and IJCV as a reviewer. He has won championships in a series of prestigious international competitions. At present, he is mainly engaged in research and development of image and video understanding and automated driving.

Subject 8.16: Object Detection and Tracking in Natural Scenes on Mobile Devices (Location: Beijing)

Images and videos of natural scenes contain extremely rich information. Real-time and natural-scene object detection and tracking on mobile devices are challenging research problems and highly demanded capabilities in a wide range of real-world applications. This research project will research and develop automated approaches and technologies to the detection, recognition and tracking of objects in natural-scene videos and images, for the purpose of automated extraction of spatial data elements, rapid update of maps, and substantial improvement of LBS service quality.

Mentor Profile: Mentor 1: He is the Chief Scientist at Tencent Map, with B.S. degree in Urban and Environmental Sciences from Peking University, M.S. degree in Cartography and GIS from Chinese Academy of Sciences, and a Ph.D. degree from Pennsylvania State University. He has extensive experience in geographic information science, space-time big data mining, information visualization and spatial optimization. He was the recipient of the CAREER Award from the U.S. National Science Foundation (NSF).

Mentor 2: He is a senior research fellow at Tencent with expertise in image analysis and deep learning. He received his Ph.D. degree from the Academy of Mathematics and

System Science, Chinese Academy of Sciences.

Subject 8.17: Analysis and Comprehension of Daily Scenes (Location: Shenzhen/Beijing)

Many new achievements have recently been made in the fusion of NLP and vision, including the generation of image and video titles and the mapping of natural language images or videos. Most of the research in this area follows the standard database, but ignores the analysis and comprehension of everyday scenes. People spend most of their time at work or at home, such as the office, kitchen and living room. These scenes are significantly different from those in standard databases by scene structures, object composition and human behavior. How to combine natural language with these everyday scenes? How to map natural language to the behavior of the corresponding object or person? How to describe these scenes?

Mentor Profile: He is a principal researcher at Tencent and received a Ph.D. from the University of Southern California. He is focusing on machine learning and computer vision. Nearly 20 papers have been published on leading conferences such as CVPR, ICCV, NeurIPSS, ICML and ICLR. In addition, he is the former or current area chair for IEEE ICCV, ICML, AISTATS and IEEE WACV.

Subject 8.18: Object Detection and Tracking & Person Re-identification (Location: Shanghai)

This subject studies the characteristics and commonality of target detection and body key point detection, aiming to combine the two tasks to develop a high-performance and high-accuracy model. Besides, person ReID is studied and improved by discovering techniques such as multi-task, multi-scale, cross-domain learning, etc. All these efforts lead to a robustness enhancement for person ReID to conquer high variance in people direction and scene, as well as similarity in clothing and posture.

Subject 8.19: Image Local Similarity Comparison based on Deep Convolutional Neural Network (Location: Shanghai)

Nowadays, deep learning and deep convolutional neural network can understand the

overall (global) semantic information of images effectively. However, in fields that require local similarity comparison, such as image content review, similar/repetitive image detection and image forensics, existing deep network technologies do not perform well. The integration of local similarity features and current deep framework remains a great challenge for the industry.

Mentor Profile of Subject 8.18~8.19: He is a senior researcher at Tencent and received a Ph.D. from the University of Hong Kong. He has years of experience in computer vision and machine learning research and focus on the application of deep learning in video surveillance. He has published a dozen of papers and patents in image processing and computer vision. His current research direction is deep model based person ReID.

Direction 9: Data Mining and Related Applications

Subject 9.1: Characterization of Massive Complex Dynamic Networks and Community Division (Location: Shenzhen)

The current credit degree divides the WeChat and QQ groups based on the static membership network. However, as the member number of a group changes, especially the rapid network changes due to the adversarial behavior of malicious groups, the traditional static network can hardly show the true picture. Therefore, the embedded representation based on massive complex dynamic networks is more realistic and the dynamic network with richer information can also solve the problem that applications such as community division frequently need full calculations.

Specific research includes:

1. Constructing a large-scale dynamic network embedding representation framework that can be used to solve the difficulty in training models in the real dynamic network.
2. Using the rich information of dynamic network representation and improving the precision of the community division to achieve 85% community purity and stable division results.

Mentor Profile: He is an expert engineer at Tencent and graduated from the Xidian University. He has focused on security strategy development and data modeling, and

has participated in projects including the crackdown on bots, login protection, QB consumption protection, and crackdown on account theft. At present, he is working on the combination of security strategies and machine learning to protect content safety for various businesses of Tencent.

Subject 9.2: Research on User Social Networks and Multivariate Data Learning (Location: Beijing)

The goal of this subject is to explore the characteristics of user portraits mainly using multivariate behavior in the social network of WeChat users and the various WeChat environments. The social field includes super-large-scale social network representation learning, user social level mining, user community detection and article social communication model, all of which will be studied taking social networking as the core and considering users' interest and other characteristics. Another area of multivariate data learning is based on various third-party behavior data in the WeChat environment to realize cross-learning use of the characteristics of various data sources, including but not limited to study on the social behavior relationship map comprising social relationships and multi-domain behavior, and the study of highly real-time lookalikes. Through this kind of study, we can effectively solve the problems of cold-start and interest prediction in recommendation systems.

Mentor Profile: Mentor 1: He is a principal researcher at Tencent and graduated from the Institute of Computing Technology, Chinese Academy of Sciences. He is currently working on the research and development of technologies and products relating to the search and recommendation and has published papers on leading conferences such as ACL and AAAI.

Mentor 2: He is a senior research fellow at Tencent and graduated from the Northeastern University. He has more than 10 years' experience in R&D of big data technologies and the application of products. Currently, he is working on the research and development of WeChat user portraits and social group mining and has obtained several patents.

Subject 9.3: Application of Transfer Learning Across Characteristic Domains in Sequence-Aware Recommendation (Location: Beijing)

Sequence-aware recommendations based on serial models is widely used for recommendations. Based on transfer learning and multi-task learning models, the subject combines text semantic information, video covers, video content features, and users' interest preference and use Memory Network and Sequence Modeling on the business scenes of WeChat Top Stories to model user attributes, clicking article sequence, viewing behavior and text content attributes, providing customized article recall and recommendation for users.

Mentor Profile: He is a senior research fellow at Tencent and graduated from Zhejiang University. His main research directions include advertising systems, natural language processing, knowledge graphs, co-recommendation technology, and data mining. He has obtained multiple patents and published many articles at leading conferences such as ACL and AAAI.

Subject 9.4: Large-scale Social Network Mining (Location: Shenzhen)

This project focuses on social network modeling. Using the high-dimensional heterogeneous data in the real-world large-scale social network, we will leverage representation learning to build portraits of nodes, relationships and communities. We will also build social recommendation systems according to the needs of our real business so that the research results could be applied in various services of WeChat in the future.

Mentor Profile: He is a principal researcher at Tencent. He received his master's degree in mathematics from the South China University of Technology. At present, he is mainly working on WeChat social data mining, WeChat social Lookalike and WeChat social communication analysis modeling. He has led projects such as social recommendations of apps and mining and building portraits friend circle. He was a invited speaker of many industry conferences such as InfoQ.

Subject 9.5: LBS Big Data Analytics, Learning, Modeling, Prediction and Visualization (Location: Beijing)

Tencent LBS big data covers billions of active users, real-time LBS points, population demographics, and detailed POI information. The objective of this project is to develop new models and methodologies to extract information and new knowledge from such big data. Research topics include but not limited to: (1) data-driven dynamic population modeling, estimation and prediction; (2) mobility and migration analysis, prediction, and visualization at different spatial and temporal scales; (3) methodologies and solutions for various application domains such as urban planning, transportation, retail, emergence response, and others. The research results will significantly expand the scope of LBS services and products, with broad applications in a wide range of domains.

Mentor Profile: Mentor 1: He is the Chief Scientist at Tencent Map, with B.S. degree in Urban and Environmental Sciences from Peking University, M.S. degree in Cartography and GIS from Chinese Academy of Sciences, and a Ph.D. degree from Pennsylvania State University. He has extensive experience in geographic information science, space-time big data mining, information visualization and spatial optimization. He was the recipient of the CAREER Award from the U.S. National Science Foundation (NSF).

Mentor 2: He is a principal researcher at Tencent, with M.S. degree in Computer Science and Engineering from Beihang University. He has extensive expertise in positioning technologies, platforms and services. He leads a R&D team on LBS big data collection, management, analysis, modeling, and application.

Subject 9.6: Causal Inference (Location: Shenzhen)

The focus of the joint training will be on causal inference. For example, we would like to identify and quantify causal effects and causal diagrams from the high-dimensional time-series user behavior data. The key research direction is to build a general and robust causal inference framework with the goal of lessen the reliance on substantive domain knowledge during the inference process.

Mentor Profile: He is a principal researcher at Tencent. He received his master's degree in mathematics from Xi'an Jiaotong University. Currently, he is mainly working on WeChat user behavior analysis and prediction and WeChat social data mining and modeling.

Direction 10: Database Technology

Subject 10.1: OLML (Online Machine Learning Database) System Architecture (Location: Beijing)

Tencent's financial services have accumulated massive business data in large-scale online transactional databases. Faced with such a distributed database, there is a strong demand for taking advantage of AI technologies to address problems in core application scenarios such as distributed transaction scheduling, workload prediction, cache optimization, anomaly detection, intelligent operation and maintenance, hot/cold separation and load balancing.

Subject 10.2: Transaction Processing and New Hardware Technologies in Distributed Database (Location: Beijing)

Tencent's distributed database serves crucial financial businesses. There are increasing requirements on utilizing new hardware technologies to improve the performance of the database and expand the database architecture, so that to enable the database to adapt to cloud platform and large-scale cross-domain deployment. There are emerging research efforts in the area. However, the combination of distributed transactions with new hardware remains a great challenge considering the absence of such a solution in mature production system.

Mentor Profile of Subject 10.1~10.2: He is a principal researcher at Tencent and received the master's degree in software engineering from the University of Science and Technology of China. Currently, he is mainly working on the development of the distributed database TDSQL. He has worked on database engine development, database architecture design and database technology management for 20 years. He has

published and applied for more than 20 papers and patents.