Spring/Summer 2023 | Issue 27 澳大リハagazine 新語UNagazine

物聯網核心技術 助構建智慧城市 Core Technologies for IoT-based Smart Cities





出版: 澳門大學	Publisher: University of Macau
總編輯:張惠琴	Chief Editor: Katrina Cheong
副總編輯:張愛華	Deputy Chief Editor: Ella Cheong
編輯: 葉浩男、盛惠怡	Editors: Davis Ip, Debby Seng
翻譯:蘇恩霆、關詠琪	Translators: Anthony Sou, Winky Kuan
顧問: 記副院長、翻譯傳譯認知研究中心主任李德鳳教授 社會科學學院藝術設計中心主任梁藍波特聘教授 社會科學學院傳播系副教授Timothy Simpson 人文學院中國語言文學系榮休教授鄧景濱	Advisors: Li Defeng, Professor and Director, Centre for Studies of Translation, Interpreting and Cognition / Associate Dean, Faculty of Arts and Humanities Lampo Leong, Distinguished Professor and Director, Centre for Arts and Design, Faculty of Social Sciences Timothy Simpson, Associate Professor, Department of Communication, Faculty of Social Sciences Tang Keng Pan, Professor Emeritus, Department of Chinese Language and Literature, Faculty of Arts and Humanities
排版: 何杰平	Design: Jack Ho
地址: 奧門氹仔大學大馬路澳門大學行政樓(N6) G012 室	Address: Room G012, Administration Building (N6), University of Macau, Avenida da Universidade, Taipa, Macau, China
聯絡: 電話: (853) 8822 8833 傳真: (853) 8822 8822 電郵: prs.publication@um.edu.mo	Contact: Tel: (853) 8822 8833 Fax: (853) 8822 8822 Email: prs.publication@um.edu.mo
製版印刷: 澳門豪邁實業有限公司	Printing: Hamah (Macau), Limitada
國際刊號: 2077-2491	ISSN: 2077-2491
奥大新語》創於2009年,為澳門大學官方刊物之一,	Published biannually since 2009, UMagazine is one of the University of Macau's

«

每年出版兩期,旨在展示澳門大學的創見和突破, official publications and aims to report innovative ideas and research breakthroughs 報導教研和社會服務的最新發展和成果。 of the University of Macau. It also showcases the latest developments and achievements of the university in teaching, research, and community services.



人文學院

中國》







全球先進城市紛紛借助數字科技力量引領城 市往智慧化轉型,解決因發展而衍生的能 源、環境和交通問題。澳門大學對此發揮所 長,對物聯網、大數據和人工智能等新一代 資訊科技開展前沿探索,建設以人為本、宜 居、綠色、韌性、可持續發展的智慧城市。

今期「封面專題」探討澳大智慧城市物聯網 國家重點實驗室成立以來,如何在智能傳感 與網路通信、大數據與智能技術這兩大基礎 領域,以及支撐智慧能源、智能交通、城市 公共安全與災害防治等智慧城市應用領域的 研究,有些項目已跟業界緊密融合,推動城 市智慧化發展。

澳大辦學特色之一是書院與學院協同育人。 書院是實踐社群教育及知識整合的學習平 台,通過體驗式教學幫助學生在本科階段獲 得全方位和多元栽培。「專題探討」全面展 示書院如何潛移默化地诵過五大教育舉措培 養學生的軟實力,同時介紹中華醫藥研究院 副教授王瑞兵的團隊用於改良癌症治療的超 分子技術研究。此外,人文社科高等研究院 院長於興中教授分享法理學和社會理論等方 面的洞見,中國語言文學系主任袁毓林教授 則暢談其研究語言學的經歷和視野。

「學術研究」欄目探究腸炎弧菌產生的 RhsP毒素與海鮮食物中毒的關係,並且介 紹極子研究如何開拓二維材料的應用潛 能。「書院發展」欄目則帶領讀者了解紹邦 書院怎樣培養心懷天下的學生,以及曹光 彪書院「Me to We戶外領袖冒險計劃」的 理念和成效。

The issue's Cover Story focuses on research at the State Key Laboratory of Internet of Things for Smart City at UM. It showcases the innovative studies conducted by researchers in the laboratory in two fundamental areas, namely intelligent sensing and network communication, and urban big data and intelligent technology, as well as those that aim to support smart city applications in smart energy, intelligent transportation, and urban public safety and disaster prevention. The results of some of these projects have been used by industry partners to promote smart city development.

The Academic Research column examines the link between RhsP toxin produced by Vibrio parahaemolyticus and seafood poisoning and explores the potential applications of two-dimensional materials through research on polarons. Lastly, the RC Development column presents Shiu Pong College's approach to nurturing worldly-minded students and Chao Kuang Piu College's 'Me to We' outdoor leadership programme.

Leading cities across the globe are embracing digital technologies to transform into smart cities in order to tackle imminent issues in energy, environment, and transportation brought by urban development. The University of Macau (UM) strives to contribute to this transformation and has been at the forefront of exploring next-generation information technologies, such as the Internet of Things, big data, and artificial intelligence, with the aim of building people-oriented, livable, green, resilient, and sustainable smart cities.

Joining forces with the university's faculties, UM's residential colleges (RCs) act as a platform for community and peer education and knowledge integration, assisting the development of undergraduate students through experiential learning. The Topic Insight column explores how the residential colleges cultivate students' soft skills through five major educational measures. The magazine also highlights a research study led by Wang Ruibing, associate professor in the Institute of Chinese Medical Sciences, on using supramolecular technology to enhance cancer treatment. Furthermore, Yu Xingzhong, director of the Institute of Advanced Studies in Humanities and Social Sciences, shares his insights on jurisprudence and social theory, while Yuan Yulin, head of the Department of Chinese Language and Literature, discusses his experiences and perspectives on linguistics.

張惠琴 Katrina Cheong



CONTENT

2023年|總第27期 Spring/Summer 2023 | Issue 27



封面專題 COVER STORY 物聯網核心技術 助構建智慧城市 Core Technologies for IoT-based Smart Cities

- 05 開拓與創新:澳大智慧城市物聯網國家重點實驗室 Exploration and Innovation: UM State Key Laboratory of Internet of Things for Smart City
- 11 支撐智慧城市建設——智能傳感與網路通信技術 Supporting Smart City Development - Intelligent Sensing and Network Communication
- 15 驅動智慧應用——城市大數據與智能技術 Driving Smart Applications – Urban Big Data and Intelligent Technology
- 19 構建低碳高效智慧能源體系 Creating a Low-Carbon Smart Energy System with High Efficiency
- 23 開發安全高效自動駕駛技術 Developing Safe and Efficient Autonomous Driving Technologies

27 提升城市結構監測及防災力 Enhancing Structural Health Monitoring and Disaster **Response Capabilities**

專題探討 TOPIC INSIGHT

- 31 潤物細無聲: 澳大書院教育的探索與變革 Subtle Nourishment: UM's Exploration and Reform of Residential College Education
- 41 超分子技術提升癌症靶向治療 Enhancing Targeted Cancer Therapy with Supramolecular Technology

人物專訪 EXCLUSIVE INTERVIEW

- 47 心靈重於科技:於興中探求理想社會框架 Mind over Machines: Yu Xingzhong's Pursuit for an Ideal Social Framework
- 53 袁毓林:研究語言學的終極性走向是人文關懷 Yuan Yulin: The Ultimate Goal of Linguistics Research is to Benefit Humanity

學術研究 ACADEMIC RESEARCH

- 59 腸道菌群戰:RhsP毒素在海鮮食物中毒的角色 Exploring the Gut Microbial Warfare: RhsP Toxin in Seafood-Induced Food Poisoning
- 63 極子研究開拓二維材料潛能 Polarons: A Key to Unlocking the Potential of 2D Materials

書院發展 RC DEVELOPMENT

- 67 以書院為家 心懷天下 Residential College - A Home for Worldly-Minded Students
- 71 「給生命・生命」——體驗與生命之連結 曹光彪書院Me to We戶外領袖冒險計劃 Giving Life to Life – The Meaning of Experiential Learning Chao Kuang Piu College's 'Me to We' Outdoor Leadership Programme

開拓與創新: 澳大智慧城市物聯網國家重點實驗室 Exploration and Innovation: UM State Key Laboratory of Internet of Things for Smart City

文 / 余偉業・圖 / 何杰平,部分由受訪者提供・英文翻譯 / 關詠琪

Text / Kelvin U · Photo / Jack Ho, with some provided by the interviewee · English Translation / Winky Kuan

物聯網、大數據與人工智能等新技術不斷向前,正在 重塑世界格局。城市如何借助科技提升資源配置和 增強建設的創新能力是全球關注的議題。澳門大學智 慧城市物聯網國家重點實驗室以「立足澳門、面向世 界」的定位和學科交叉的研究團隊,精準提煉智慧城 市的科學問題,攻關物聯網領域的核心科研任務,為 構建智慧城市產業生態系統貢獻澳門的力量。

建設智慧城市科技創新高地

國家科技部依托大學和研究院所,在關鍵領域設立 國家重點實驗室,聚集和培養科技人才,組織開創 性研究,是攻克前沿科學問題的重要基地。在澳門 特區政府和科學技術發展基金支持下,澳大於2018 年獲國家科技部批准設立智慧城市物聯網國家重點 實驗室(以下簡稱實驗室),是全國第一個智慧城 市物聯網領域的國家重點實驗室,也是澳大第三個 國家重點實驗室。實驗室致力以雙碳戰略和打造宜 居韌性的智慧城市為導向,通過跨學科交叉合作, 聯合不同領域的學者解決重大科學問題、攻關關鍵 核心技術,持續開展戰略性基礎與應用研究,為構 建智慧城市的科技創新共同體而服務。

實驗室匯聚一批實力雄厚、跨學科的學術大師,在澳大校長、實驗室主任宋永華講座教授領軍下,以「立足澳門、融入國家、面向世界」的定位,聚焦先進的物聯網技術研究,培養理論研究與應用實踐能力俱備的複合型人才,通過國家級重大項目及平台,以原創性科學研究探索城市智慧化的顛覆性技術創新及創新實踐,為澳門構建智慧城市及粵港澳大灣區發展注入新動力。

宋永華教授表示,實驗室秉持「綠色、智慧、韌性、 可持續發展」的原則,以具影響力的戰略性基礎研 究,積極推動可持續智慧城市的科技攻關和研發成果

推廣應用,並與社會各界共同譜寫「澳門方案」,支 撐「雙碳」目標及國家智慧城市建設,發揮好實驗室 的示範性引領作用。

實驗室聚焦國家智慧城市建設的重大戰略需求和物聯 網產業發展中的關鍵瓶頸,不斷完善無線通信、大數 據及能源管理等基礎技術供給體系,開發具代表性的 自動駕駛及城市防災應急等應用,促進學術、工程和 產業全方位協同,為智慧城市的發展及應用提供科學 依據和技術支撐。

基礎領域研究方面,由於網路的智能傳感與通信技術是 城市互聯的核心和基礎,研究團隊圍繞未來網路的智能 傳感與通信基礎理論與關鍵技術深入研究,在可重構智 能反射面輔助的高效節能通信、高能效通信感知一體化 的無線物理層、智能感知與傳輸計算一體化等方面取得 進展及突破,助力城市萬物互聯。

大數據對智慧城市建設起著重要支撐作用。研究團隊 圍繞城市智慧化過程中的大數據與智能技術基礎理論 與關鍵技術深入研究,在時空數據表徵學習、時空數 據建模、大規模複雜結構知識圖譜推理、跨城市多粒 度知識遷移、算法博弈論、多媒體大數據信息取證與 安全等方面取得諸多成果,助力城市決策及治理。

應用基礎研究方面,研究團隊圍繞「雙碳」目標下城 市能源系統面臨的機遇與挑戰,深入研究綜合能源系 統運行優化與柔性配電的理論與方法,在能源大數據 挖掘與利用、需求側資源靈活調控、綜合能源系統安 全與防護、柔性配電關鍵裝備研發與應用等方面取得 了諸多成果。面對灣區城市群一體化建設的智能交通 問題,研究團隊開發協同智能駕駛的感知技術,通過

封面專題・COVER STORY

大規模交通數據處理及融合智能交通調度等手段,探 索適合城市的新型智能交通解決方案。此外,城市公 共安全與災害防治領域的研究團隊探究海洋災害及極 端天氣對城市空間節點及重大設施的影響,研究結構 健康監測和智慧運維等防災前沿性研究。

實驗室牽頭或承擔了多項國家科技部、國家自然科學 基金委員會及澳門科學技術發展基金項目,獲批多個 粵港澳聯合實驗室,並穩步前進,獲得多項國家級的 科技成果獎項,包括國家科技進步獎二等獎、廣東省 科技進步獎一等獎、光華工程科技獎,何梁何利基金 科學與技術進步獎,以及多項澳門科學技術獎等,受 到國家和澳門各界充分肯定。

設計澳門首個智慧城市仿真決策平台

實驗室搭建澳門首個「智慧城市混合現實仿真與智能 決策平台」,涵蓋城市基礎大數據、智慧綜合能源



宋永華教授 Prof Yonghua Song



管理、虛實結合混合駕駛測試、城市基礎設施健康監 測、城市水災害仿真模擬等多個模塊。平台以澳門城 市三維模型為基礎,利用數字孿生技術,搭建數字澳 門模型,以可追溯的實時數據記錄構建模擬與試驗驗 證平台,鼓勵學科交叉融合和跨學科研究,建設可持 續發展的智慧城市。

研究團隊通過此平台實現城市建模及互動模擬,在不 同城市場景下顯示了良好的應用效果,其中城市基礎 大數據模塊,基於時空大數據及知識圖譜技術科研成 果,於2022年6月結合澳門實際情況,構建實時高效的 「新冠疫情熱點分析系統」,為澳門抗疫貢獻科學力 量。團隊將繼續透過物聯網、混合現實與數字孿生技 術,提升數字城市與物理系統的耦合互動模擬,為城 市的智慧監管與分析決策提供科學理論和應用支撐。

培育複合型的高端科技人才

響應教育、科技和人才「三位一體」的國家戰略,實 驗室針對物聯網、人工智慧、大數據等新科技的廣泛 應用,加快高質量複合型科技人才的選拔和培養。實 驗室透過組建科研團隊,重點培育複合型科技人才, 有序推動澳門發展高新技術產業。實驗室自成立以 來,透過澳大各類學術項目積極引智,培養了逾百名 碩士及博士,並積極吸引海內外的優秀年輕學者及本 地畢業生從事科研實踐,以優質人才儲備支撐國家自 主創新和整體科技實力快速發展,將研究成果本地市 場化和產業化。

為增強澳門青少年的科技素養,充分激發中學生心中 科技火花,助力本澳科技產業發展,實驗室每年定 期面向澳門中學生,舉辦各類科普活動,以大學開放 日、科普講座、師生座談、科技競賽、參觀實驗室及 科研設備等形式,向澳門中學生普及智慧城市和物聯 網的基礎知識。實驗室期望學生通過與一線科研團隊 及資深學長交流,從實踐中加深對智慧城市的理解, 為學術傳播及本地人才儲備打穩根基。

推動國際化的科技創新

展望未來,實驗室將繼續以教學和科研並重的發展路徑加強資源整合,堅持以立足澳門、全球視野、國際標準推動科技創新,為澳門、國家和全球共同關注的智慧城市物聯網研究議題貢獻澳大力量。

宋永華教授說:「歷史上,每一場工業革命都顛覆了 全球經濟格局。如今數字科技正掀起新一輪變革,而 澳大在此關鍵的歷史節點上,藉著實驗室的教研力量 抓緊發展機遇,發揮好澳大擔當,以開創性的研究成 果助力構建城市新型的數字基礎設施,提出具世界領 先性的澳門方案,並與領軍企業合作,共同支撐智慧 城市建設不斷向前。」



智慧城市混合現實仿真與智能決策平台 The Smart City Virtual Reality Simulation and Decision-making Platform

The new global landscape brought about by the evolution of the Internet of Things (IoT), big data and artificial intelligence has prompted urban decision-makers to harness the power of digital technologies to enhance urban resource allocation and innovations. As an institution rooted in Macao with a global perspective, the State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) at the University of Macau (UM) brings together a team of interdisciplinary researchers to address core scientific problems facing smart city development and IoT research, with the aim of generating innovative technologies and sustainable solutions for smart cities.

Core Innovation Hub for Smart City Development

As crucial hubs for cutting-edge research, state key laboratories (SKLs) are institutions established with the approval of China's Ministry of Science and Technology (MOST) in top-notch universities and research institutes across the country. With the support of the Macao SAR government and the Macao Science and Technology Development Fund, UM established SKL-IOTSC upon the endorsement by MOST in 2018 and it is the first SKL of its kind in China. It is also the third SKL at UM. In line with the national 'dual carbon' strategy to build a salubrious and resilient smart city, the laboratory conducts fundamental and applied research through interdisciplinary collaboration to bring forth technological innovations dedicated to smart city development.

Led by Chair Professor Yonghua Song, rector of UM and director of the laboratory, and composed of interdisciplinary researchers with strong academic backgrounds, SKL-IOTSC focuses on research in advanced IoT technologies, undertaking large-scale national projects and nurturing talent with both theoretical knowledge and practical skills. This research will not only benefit smart city development in Macao, but also help to gain momentum for the growth of the Guangdong-Hong Kong-Macao Greater Bay Area (GBA).

Prof Song says that the laboratory is committed to achieving technological breakthroughs in strategic fundamental research that would accelerate progress towards building sustainable smart cities and applying research results. 'Working together

封面專題・COVER STORY



智慧城市物聯網國家重點實驗室於2018年在澳大設立,是全國第一個智慧城市物聯網領域的國家重點實驗室。

UM established SKL-IOTSC, the first State Kay Lab in its area of research, in 2018.

with professionals from various sectors, we will create a smart city blueprint tailored for Macao, stride towards China's "dual carbon" goals, and facilitate the development of smart cities across the country,' he says.

SKL-IOTSC devotes itself to strategically addressing the national needs for pilot smart city development and the bottlenecks facing the IoT industry. To this end, the laboratory has established fundamental technological synergies with technologies such as wireless communications, urban big data, and artificial intelligence (AI) to support smart city applications in smart energy, intelligent transport, and disaster prevention. All its efforts made in fundamental and applied research are essential for laying a solid foundation for smart city development and industry-academia collaboration.

In terms of fundamental research, considering intelligent sensing and network communication are at the core of urban interconnectivity, the researchers have conducted studies extensively on both theories and technologies in this field. Significant breakthroughs have been made in intelligent reconfigurable surface-empowered communications, integrated sensing and communication, and space-air-ground integrated network, strengthening the internet of everything for cities.

Urban big data and AI are also key domains of fundamental research which the laboratory has been exploring and where researchers have been generating new findings. Substantial progress has been made in spatiotemporal representation learning, spatiotemporal modelling, inference of large-scale and complex knowledge graphs, cross-city multi-granular knowledge transfer, algorithmic game theory, and multimedia big data forensics and security, and these research achievements will support urban decision-making and smart governance.

With respect to applied research, researchers have conducted in-depth studies on theories and methodologies for optimising the operation and flexible power distribution of integrated energy systems (IES) for the 'dual carbon' goals. Significant progress has been made in energy data mining and utilisation, flexible power demand side management, IES security and protection, and R&D and application of key components for flexible power distribution. In addition, the researchers have developed efficient sensing, control, and decision-making technologies for autonomous driving. They have also explored intelligent transportation innovations through large-scale traffic data processing and integrated traffic planning, which further reinforces the intelligence in future transportation systems. Moreover, the researchers have investigated the mechanism of coastal marine disasters, especially under extreme climate events, and proposed advanced methods for structural health monitoring and intelligent operation and maintenance, which are significant



科研佈局:兩大基礎研究領域+三大重點應用領域 Research layout: two fundamental fields and three typical application fields

in improving urban public safety and resilience.

SKL-IOTSC has led or undertaken various projects under MOST, the National Natural Science Foundation of China, and the Macao Science and Technology Development Fund, and has established several Guangdong-Hong Kong-Macao joint laboratories to foster research collaboration in the GBA. The laboratory has received a substantial number of national and regional awards for its scientific and technological achievements, including a second prize in the State Scientific and Technological Progress Award, a first prize in the Guangdong Science and Technology Progress Award, the Guanghua Engineering Science and Technology Prize, the Ho Leung Ho Lee Foundation Science and Technology Progress Award, as well as Macao Science and Technology Awards. These accolades are a testament to the laboratory's recognition in Macao and across the country.

Macao's First Smart City Simulation and **Decision-making Platform**

SKL-IOTSC has built the first smart city simulation and decision-making platform in and for Macao. The platform consists of various modules, including urban big data, smart energy, intelligent transportation, structural health monitoring of civil infrastructure, and urban flooding simulation, and it can further facilitate interdisciplinary collaboration for sustainable smart city development. Based on a 3D graphic model of Macao, the laboratory has also established a city-wide simulation system with digital twin technology, through which researchers can collect traceable real-time data, develop simulation models, and conduct pilot tests.

The researchers have implemented effective interactive simulation models of urban systems in various settings and obtained fruitful application results. For instance, they developed a COVID-19 hotspot map for Macao in June 2022 through the platform (urban big data module) with spatiotemporal big data and knowledge graph technologies. The real-time operating system enhanced the city's capability in epidemic prevention. The researchers will continue to contribute to the city's competence in coupling a physical replica with its digital twin model in order to provide theoretical and technological support for intelligent urban regulation and decision-making.



實驗室向澳門多所中學提供科普教育 SKL-IOTSC provides science education to a number of secondary schools in Macao

Cultivating High-Calibre and Interdisciplinary Talent

In line with the national strategy to build a global powerhouse in science and technology, SKL-IOTSC spares no effort to nurture high-calibre and interdisciplinary professionals in the fields of IoT, AI and big data to facilitate the extensive applications of these technologies. UM's academic capacity has encouraged many outstanding overseas young scholars and local graduates to pursue their dream as researchers at SKL-IOTSC. Since its inception, the laboratory has successfully trained more than 100 graduates with master's or doctorate degrees. Through its top-tier faculties and talent nurturing scheme, the laboratory not only strives to accelerate the transfer of its research results and the development of the high-tech industry in Macao, but also aims to strengthen the country's independent innovation capability and R&D in science and technology.

To enhance digital literacy among adolescents in Macao and inspire them to become high-tech professionals in the future, SKL-IOTSC organises various science promotion activities for local secondary school students on a regular basis to stimulate their interest in science and technology. Activities such as the UM Open Day, distinguished lectures, seminars, competitions, and visits to the laboratory enable local students to better understand the concept of a smart city and learn more about the latest developments in IoT. Furthermore, the

students can enjoy learning through hands-on experiments and interactions with researchers and students at SKL-IOTSC. All efforts made to enhance teenagers' digital literacy are crucial to the expansion of the local talent pool.

Advancing Technological Innovation in a Global Landscape

Looking ahead, SKL-IOTSC will continue to optimise resource integration by placing equal emphasis on teaching and research, and adhere to its position as an institution rooted in Macao with global perspectives. At the same time, the laboratory will uphold international standards to advance technological innovation in IoT for smart city development, making contributions to this research front that are not only important to Macao and China, but also to the world.

'Looking back in history, each industrial revolution led to radical changes to the global economic landscape. UM is now at a critical moment in history where digital technology is setting off a new round of reform. We will seize the opportunity to enhance the academic and research competence of SKL-IOTSC, in order to help UM leverage its promising innovative research results to accelerate the development of novel digital infrastructure, propose a world-leading smart city blueprint for Macao, and collaborate with leading enterprises to bring forth smart city initiatives,' says Prof Song.



大規模天線通信系統 Massive MIMO systems

支撐智慧城市建設—— 智能傳感與網路通信技術

Supporting Smart City Development — Intelligent Sensing and Network Communication

文 / 余偉業 ¹ 實習校園記者朱江舸 · 圖 / 何杰平 ¹ 部分由受訪者提供 · 英文翻譯 / 蘇恩霆 Text / Kelvin U, Trainee UM Reporter Zhu Jiangge · Photo / Jack Ho, with some provided by the interviewee English Translation / Anthony Sou

物聯網開啟了萬物互聯的時代,是物理世界與數字世界的橋樑,也是各國城市智慧化轉型的關鍵支撐技術。因此,解決物聯網的關鍵科學和技術問題成為了澳門大學智慧城市物聯網國家重點實驗室的研究重點。該實驗室的智能傳感與網路通信研究團隊肩負起 鋪設信息感知和傳遞管道的重任,為虛實世界融合發揮紐帶作用,亦為智能技術應用打下穩固基石。

創新技術驅動城市數字化轉型

城市感知、網路通信技術作為物聯網的主要手段,加 速全球先進城市智能升級。澳大智慧城市物聯網國家 重點實驗室(以下簡稱實驗室)的智能傳感與網路通 信研究團隊聚焦核心技術的攻關,以支撐全面感知、 泛在連接、低時延、安全可靠的物聯網新型基礎設施 建設,為智慧城市發展提供技術。

實驗室助理主任、電機及電腦工程系教授馬少丹是無 線通信專家,她表示,若把物聯網簡單理解為一棵大 樹,那麼智能傳感與網路通信這部分就是「根」,透 過接收與傳輸信息,為大樹提供成長所需的養分,而 城市大數據與智能技術就是「莖」,透過數據挖掘和 智能算法支撐「善解人意」的技術開發,才能「開花 結果」,應用到智慧能源、智能交通、城市公共安全 與災害防治等各大智慧城市發展的重要領域。「這也 反映了實驗室研究佈局的戰略思路。」

智能傳感與網路通信研究團隊以構建物聯網的有效感知 與傳輸體系為目標,面向未來萬物智聯時代的科技演 進,致力研發先進的傳感和通信技術,驅動城市數字化 轉型。馬教授是此研究團隊的學術領軍人物,她指城市 的「物」遍佈每個角落,遠至萬丈高樓、偏僻街道、橋 樑,廣至樓梯轉角、車輛,深至地下管網,對城市互聯 感知、網路通信體系建設有著更廣、更深的需求。

智能傳感如人之五感

研究團隊現聚焦智能傳感、網路通信兩大方向,進行 拓展物聯網技術的基礎研究,為城市互聯、萬物互 聯打牢地基。馬少丹教授表示,智能傳感有如人之 五感,透過採集物理世界四方八面的信息,如圖像、 溫度、路況、視頻、能耗等數據,感知城市運行的脈 搏;同時,利用網路通信技術,鋪設更寬敞的康莊大 道,使信息傳輸更流暢和迅速,從而向城市作出反饋 和控制,形成與物理世界的互動,最終實現以最低程 度的人為介入、智慧化的城市管理與運行。

物聯網如今邁向下一階段變革,對智能傳感、網路通 信技術提出更高的發展要求。研究團隊面對海量接 入、動態複雜與資源受限的通信環境、多樣化感知與 通信需求、跨行業多領域應用場景,以及高效安全傳 輸等諸多挑戰,在可重構智能反射面輔助的高效節能 通信、高能效通信感知一體化的無線物理層、智能感 知與空天地一體化網絡,取得實質進展及突破,持續 為物聯網新型基建作有力支撐。



馬少丹教授 Prof Ma Shaodan

搭建大規模高效通信系統

沒有康莊的網路通信大道,就難以實現高效的信息感 知。5G網路作為數字世界新型基建,為城市大數據的 傳輸「打通經脈」,同時對無綫通信的速度、效率和 可靠性提出更高要求。研究團隊在馬教授帶領下,針 對5G系統低時延、大連結、高速率、超可靠等關鍵需 求,開展大規模天線通信系統研究,以構建高效的信 息傳輸體系。馬教授說,團隊積極構建更佳的網路通 信環境,也為智能感知提供新途徑。

團隊搭建了「大規模天線通信系統」:透過波束賦形 技術,善用豐富的空間資源,實現海量用戶於同一空 間、同一頻率、同時接入;同時可透過波束賦形,利 用大規模多天線將空間切塊細化,保證每個小區域均 可支持多路數據同時傳輸,提高網路容量,實現低時 延通信。

另外,團隊還就大規模天線通信系統與生俱來的技術 難題,如高維信道矩陣和複雜信道結構等挑戰,提供 了新的分析理論與優化方法,為5G及下一代移動通信 系統設計與實現奠定理論與技術基礎,成果獲頒澳門 科學技術獎自然科學獎三等獎。

探索適合澳門的智能傳感體系

城市大腦信息反饋的敏捷程度除了講究網路傳輸的效 能,亦取決於擔當城市「神經末梢」的智能傳感器能 否迅速、精準地掌握城市的脈搏;搭建城市的智能傳 感體系有賴學術、工程和產業全方位協同。近年,全 球先進城市陸續利用智慧街燈,建設智慧城市的感知 系統,因此澳大與澳門電力股份有限公司在2020年就 澳門構建智慧街燈系統開展研究,把工程應用與理論 研究相結合,探索適合澳門的方案。

團隊針對澳門發展智慧街燈的基礎條件開展調查,並 透過在澳大校園設置的智慧街燈試點,深入研究智慧 街燈系統各功能模塊的技術開拓和控制平台設計。

馬教授表示,智慧街燈集智慧照明、人流及車流管 理、環境監測、資訊交互多功能於一桿,是建設智慧 城市全面感知網路的載體。團隊將繼續完善無線通 訊、感知網路的技術供給體系,支撐澳門智慧城 市的發展。



澳大與澳門電力開展智慧街燈在澳應用研究 UM and CEM study the use of smart streetlights in Macao

The Internet of Things (IoT) has given rise to an era of interconnectivity, bridging the gap between the physical world and the virtual world. It is also the key technology in the development of smart cities around the world. The State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) of the University of Macau (UM) has tasked itself with solving important scientific and technological problems facing IoT. In particular, the laboratory's intelligent sensing and network communication group strives to enable information perception and transmission in a smart city to realise physical-virtual world integration and lay the ground for smart technology applications.

Digital Transformation of Cities Driven by Innovative Technologies

Urban sensing and network communication, two major IoT technologies, have accelerated the pace of smart upgrading of cities around the world. The group aims to tackle core problems and provide technical support for smart city development, especially in the development of new IoT-based infrastructure with comprehensive sensing capability, ubiquitous connectivity, low latency, and high safety standards.

Ma Shaodan, assistant director of SKL-IOTSC and professor in the Department of Electrical and Computer Engineering, is an expert in the field of wireless communication. She says that IoT may be conceived as a big tree, where intelligent sensing and network communication are the roots that provide the tree with the nutrients needed for growth by receiving and transmitting the information. Urban big data and smart technology are the tree trunk which tries to understand what people need through data mining and intelligent algorithms. The flowers of the tree will eventually blossom, and the fruits are data for use in major areas of smart city development, such as smart energy, intelligent transportation, as well as urban public safety and disaster prevention. 'This can reflect the strategic research layout of the laboratory,' says Prof Ma.

At present, the group aims to build an effective loT-based sensing and transmission system. Through the R&D of advanced sensing and communication technologies, the researchers hope to drive the digital transformation of cities to usher them into the era of smart interconnectivity. As the leader of the group, Prof Ma says, 'things' that can be connected to the network exist in every corner of a city, from buildings, streets, and bridges, to stairways, vehicles, and even underground pipes. To effectively connect various 'things' and achieve intelligent sensing, it is necessary to implement a far-reaching network that can cover all urban spaces.

Intelligent Sensing Comparable to the Five Senses

Focusing on intelligent sensing and network communication, the researchers conduct fundamental research to expand IoT technology and lay a solid foundation for the interconnection of all elements in an urban environment. According to Prof Ma, intelligent sensing operates like the five human senses, collecting information in the physical world, such as images, videos, temperature, road conditions, and energy consumption, in order to sense the pulse of the urban operation. At the same time, network communication technology paves the way for smooth and rapid information transmission in feedback channels to inform city control, realising interactions with the physical world and leading to smart city management and operation with minimal human intervention.

The new IoT development raises the demand for better intelligent sensing and network communication technologies. The existing challenges include massive connectivity, assessing the dynamic and complex communication environment with limited resources, the diverse sensing and communication needs, applying the technology across different industries and domains, and maintaining efficient and secure transmission. To overcome these challenges, the researchers carried out studies such as intelligent reconfigurable surface-empowered communications, integrated sensing and communication, and space-air-ground integrated network. They have made significant progress, offering solid support for new IoT-based infrastructure.

Building Efficient Massive MIMO Systems

It is difficult to achieve efficient information perception and transmission without a well-established communication network. As a new digital technology, 5G network enables big data transmission in cities, but at the same time requires enhanced speed, efficiency, and reliability of wireless communication. The researchers study communication systems based on massive antennas in order to build more efficient information transmission systems. The research focuses on the key requirements of 5G system, such as low latency, massive connectivity, high speed, and ultra-reliability. Prof Ma says that the researchers are building a better environment for network communication, and providing a new means for intelligent sensing.

The group has successfully built its own massive multiple-input multiple-output (MIMO) system. Using beamforming techniques, the system takes advantage of spatial resources to realise simultaneous connections to a massive number of users in the same space and at the same frequency. The system also uses massive antennas through beamforming to subdivide space into tiny areas and ensure that each area supports simultaneous transmission of data, thus increasing network capacity and realising low latency communications.

The group has also developed new theories and optimisation methods to overcome challenges posed by massive MIMO systems, such as high-dimension channel matrix and complex channel structure, laying the theoretical and technical foundation for 5G and the design and implementation of the next-generation mobile communication system. The research result received a third prize in the Natural Science Award category of the Macao Science and Technology Awards.

Developing an Intelligent Sensing System Suitable for Macao

In addition to a highly-efficient network, the speed of information feedback to the brain of a smart city also depends on smart sensors that act as 'nerve endings' to quickly and accurately grasp the pulse and dynamics of the city. Moreover, the collaboration between academia and industry is crucial to building an intelligent sensing system. In recent years, leading cities around the world have used smart streetlights as the building blocks of their smart city sensing systems. Macao is no exception. UM and Companhia de Electricidade de Macau conducted a collaborative project in 2020 to investigate the implementation of a smart streetlight system in Macao.

To understand the conditions required for implementing smart streetlights in Macao, the group set up a pilot site on the UM campus to explore the development of the various modules in the smart streetlight system and the design of the control platform.

According to Prof Ma, the poles of smart streetlights can perform various functions, including intelligent lighting, pedestrian and traffic flow management, environmental monitoring, and information interaction, and are therefore the cornerstones of a comprehensive sensing network in a smart city. The group will persist in bolstering its capacity to offer technical support in wireless communication and sensing networks for Macao, thereby facilitating the city's smart development.



澳大開發的「新冠疫情熱點分析系統」融合時空大數據和知識圖譜技術 The Macau COVID-19 HotSpot Map developed by UM integrates spatiotemporal big data and knowledge graph technologies

驅動智慧應用—— 城市大數據與智能技術

Driving Smart Applications – Urban Big Data and Intelligent Technology

文 / 余偉業、實習校園記者張嘉禾 · 圖 / 何杰平,部分由受訪者提供 · 英文翻譯 / 關詠琪

Text / Kelvin U, Trainee UM Reporter Zhang Jiahe · Photo / Jack Ho, with some provided by the interviewees English Translation / Winky Kuan

大數據、人工智能等新一代信息技術是開發城市大腦 的驅動力,更是全球先進城市推動智慧應用的關鍵技 術支撐。澳門大學智慧城市物聯網國家重點實驗室城 市大數據與智能技術研究團隊以應用為牽引,從基礎 研究入手,設計能滿足實際需求的高效基礎演算法, 著力提升智慧城市的計算思維,以萃取準確和有用的 數據,助力更明智的決策。

演算法支撐智慧城市應用

從政府決策與服務到衣食住行,再到城市的產業佈局 和規劃等,如今都在大數據支撐下逐步智慧化。城市 大數據與智能技術研究團隊聚焦解決大數據分析與處 理技術底層依賴的相關數學模型、分析原理與計算方 法等科學問題,對大數據加工處理,萃取準確和有用 資訊,使決策和產品更符合人的需求,助力城市落實 以人為本的建設理念。

如今,運算科學是國家科技核心競爭力的重要標誌, 也是澳大近年銳意發展的學科領域。解決許多重大科 學問題時都高度依賴基礎演算法與可計算建模的發展 水平。研究團隊積極開展多項高效能的基礎演算法研 究,深入探索智慧城市的多源數據融合技術。團隊已 在基於大數據驅動的知識圖譜(Knowledge Graph) 構建方法和基於深度學習的智能多媒體信息處理系統 的開發上取得突破。

構建城市知識圖譜

知識圖譜能將網路上的信息、數據等聚集為知識,使 信息資源更易於計算、理解,從而實現對知識的快速 回應和推理。研究團隊利用影響城市運行、不斷變化 的數據流,構建動態的信息系統,以形成城市知識圖 譜,為城市管理者提供「一張圖」的綜合監管。

長期研究大規模數據處理的數據科學中心代主任、實 驗室副教授余亮豪帶領團隊於2022年7月結合澳門實 際情況,融合時空大數據和知識圖譜技術,建立

實時 高效的「新冠疫情熱點分析系統」。該系統借助實驗 室的城市基礎大數據平台,針對疫情數據的多樣性及 數據量,利用知識圖譜分析病毒株的傳播鏈與時空之 間熱點關係圖,深入探索疫情的起源及趨勢,為澳門 抗疫貢獻力量。

在分析演示系統上,研究團隊提出的熱點算法較目 前的算法庫快10至100倍。另外,礙於時間複雜度, 分析工作的反響時間難以達至實時。因此,團隊 開發了一系列優化技術,降低搜索空間和計算複雜 度, 達至接近 實時 演示 需求。 多項 成果 已於 多 個 國 際數據工程會議發表。

建全澳最大型智能超算中心

澳大的第三代高性能計算集群 (Coral) 由130台伺服器組 成,提供超過4.200個計算核心及37個圖形處理核心, 並配備八台超大記憶體計算節點,合共提供24TB記憶 體。大學同時建成全澳最大型的「智能超算中心」, 內含管理與計算伺服器群組、雲計算平台軟件、高速 網路設備、大容量存儲服務器、英偉達DGX-2,強大算 力滿足研究團隊面對龐大的海量數據流、參數量將達 萬億級的人工智能高強度運算時的需求。上述關鍵的 基礎設施能大幅度提升人工智能運算速度,有效支撐 智慧應用對於城市大數據分析和處理的需求。

圖像篡改檢測系統

智慧城市信息基礎設施以雲計算為中心的方式向集約化



固建渣教授 Prof Zhou Jiantao

「假圖粉碎機」 偵測工具 The detection e-tool Fake Pictures Crusher

封面專題 · COVER STORY

發展,其數據高度共用加大了安全風險。為破除網路信 息傳播的安全漏洞,電腦及資訊科學系、實驗室副教授 周建濤近年帶領團隊開發更敏銳的圖像篡改檢測系統, 與日新月異的反取證技術博弈。

團隊2021年提出新的人工智能偵測算法,能在0.5秒 內對被篡改圖像的偽造區域定位,於國際安全人工智 能挑戰賽擊敗1,500多支隊伍,分別在「篡改」與 「檢測」賽道奪得冠軍及季軍,其成果能供司法界辨 識篡改影像。團隊後獲阿里巴巴邀請和贊助開發更強 大的偵測工具「假圖粉碎機」,2022年開放予大眾試 用,以產學研合作助力解決智慧城市的安全問題

陈著雲計算汛速發展,各種資料獲取存放裝置廣泛使 用,這對多媒體工具技術與社交網路安全提出更高要 求。有見及此,團隊就社交網絡多媒體安全的關鍵技 術,包括受信道干擾性強、魯棒泛化性差、安全可信 性低等問題,率先建立了社交網絡信道分析機制,研 發出高魯棒多媒體取證技術,以及具數據隱私保護的 特徵學習算法。該項目成果獲澳門科學技術獎自然科 學獎三等獎,更獲海內外學者反複引用與應用。

探索新一代關鍵數字科技

基於澳大與中國科學院深圳先進技術研究院聯合實驗 室的優勢,團隊針對新一代關鍵數字科技,不斷探索 城市大型數據集的關聯性與模式,拓展人工智能領域 的創新性研究。團隊的基礎演算法研究,將對智慧城 市的應用領域,如智慧能源、智能交通、城市公共安 全與災害防治,起著關鍵技術支撐作用,促使城市實 現最合理的資源配置與自我調節。



澳大與中科院深圳先進技術研究院共建人工智能與機器人聯合實驗室 The Joint Laboratory of Artificial Intelligence and Robotics jointly established by UM and the Shenzhen Institute of Advanced Technology of the Chinese Academy of Sciences

余亮豪教授 Prof U Leong Hou

The new generation of information technologies, including big data and AI, is the driving force behind smart city development, promoting smart applications in advanced cities around the world. To facilitate such applications, a research group on urban big data and intelligent technology of the State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) at the University of Macau (UM) conducts fundamental research to design highly-efficient algorithms in order to enhance the computational thinking capabilities of smart cities and extract valuable information to assist decision-makers.

Developing Algorithms to Support Smart City Applications

With the support of big data, intelligent technologies are transforming all aspects of our lives, from government decision-making and services, to the way people live, to industrial layout and urban planning. The research group is committed to solving fundamental scientific problems facing big data analysis and processing by developing mathematical models, principles, and computational methodologies. Through big data analytics, the researchers can extract accurate and useful information to inform decision-making and improve products based on the practical needs of residents in order to develop more human-centred cities.

Computational science is not only an important symbol of China's competitiveness in science and technology, but also a discipline that UM developed in recent years. The solutions to many major scientific problems rely heavily on fundamental algorithms and computational models. Currently, the researchers are developing a number of high-performance fundamental algorithms and exploring multisource data fusion techniques for smart city development. They have made breakthroughs in creating methods for knowledge graph construction with big data and an intelligent multimedia information processing system based on deep learning.

Building Urban Knowledge Graphs

Knowledge graphs integrate information and data available on the network to make them easier to compute and understand, thereby enabling rapid responses and reasoning. The research group uses data streams that are constantly changing and affecting urban operations to build a dynamic information system. The system can generate knowledge graphs and provide city managers with comprehensive monitoring information.

In July 2022, a team led by U Leong Hou, interim head of the Centre for Data Science and associate professor in SKL-IOTSC, developed the Macau COVID-19 HotSpot Map, an efficient real-time system based on spatiotemporal big data and knowledge graph technology. With the large variety and volume of epidemic data in hand, the group used the laboratory's urban data platform and knowledge graph technology to analyse spatiotemporal data in relation to the transmission chains of different viral strains. The study shed light on the origin and development of the outbreak in Macao and was one of the group's major contributions to Macao against COVID-19.

To build an analysis and demonstration system, the research group proposed a hotspot algorithm that could run between 10 to 100 times faster than existing algorithms. However, the time complexity of the analysis made it difficult to achieve real-time responses. The group then developed a series of optimisation algorithms to reduce the search space and computational complexity, and as a result, the system produced almost real-time responses. They have presented the research results at several international data engineering conferences.

Building the Largest Super Intelligent Computing Centre in Macao

UM's third-generation HPC Cluster (Coral) comprises 130 servers, offering over 4,200 computing units and 37 graphics processing units. It also provides eight high-memory computing nodes that contain a total of 24TB of memory. The laboratory has also established the Super Intelligent Computing Center in Macao, the largest of its kind in the city. Equipped with a management and computing server cluster, cloud computing platform software, high-speed network equipment, a high-capacity storage server, and NVIDIA DGX-2, the centre has the immense computing power to assist researchers in handling massive data streams and trillions of parameters, satisfying the demanding requirements for AI technology. These facilities and equipment significantly increase the computational speed of AI and can effectively meet the needs of smart applications for urban big data analysis and processing.

Image Tampering Detection System

At present, the intensive development of communications infrastructure in smart cities revolves around cloud computing. However, the development has also increased security risks due to the high amount of data shared in the process. To address security loopholes in the dissemination of information on the network, a team led by Zhou Jiantao, associate professor in the Department of Computer and Information Science and SKL-IOTSC, has developed a robust image tampering detection system based on AI algorithms. The system is designed to prove the authenticity of images in the face of ever-evolving anti-forensic techniques.

In 2021, the team proposed a new AI detection algorithm that can locate the forged area of a tampered image within 0.5 seconds. The algorithm stood out from over 1,500 teams at the Security AI Challenger Contest and won the championship in the image forgery track, as well as the third prize in the detection track, and was used by the judicial community to identify tampered images. Furthermore, the team was later invited and sponsored by Alibaba to develop Fake Pictures Crusher, a more powerful detection e-tool, which was made available to the public in 2022. Through industry-academia collaboration, the team strives to address security issues in smart city development.

The rapid development of cloud computing and the widespread use of various data acquisition and storage devices have led to increasing demands for better multimedia technology and social network security. To address key issues in multimedia and social network security, such as social network interference, poor generalisation ability, and low security reliability, the team took the initiative to establish an analysis mechanism for different social media platforms. The researchers developed highly robust multimedia forensic technologies and feature learning algorithms with data privacy protection. The project was awarded a third prize in the natural science category of the Macao Science and Technology Award and has been widely cited and applied by scholars in China and abroad.

Exploring the New Generation of Digital Technology

Building on the strength of the joint laboratory between UM and the Shenzhen Institute of Advanced Technology of the Chinese Academy of Sciences, the research group is constantly exploring the relevance and patterns of large urban datasets and expanding innovative AI research, with a focus on developing the new generation of digital technology. The group's fundamental algorithmic research will play a key role in supporting smart city applications, such as smart energy, intelligent transportation, and urban public safety and disaster prevention, enabling cities to achieve rational resource allocation and self-regulation.



「澳門大學智慧綜合能源管理平台」為智能電網應用於城市場景提供實踐經驗 The University of Macau Smart Integrated Energy Management Platform provides practical experience for the application of smart grids in urban settings

構建低碳高效智慧能源體系

Creating a Low-Carbon Smart Energy System with High Efficiency

文/余偉業、實習校園記者朱江舸·圖/何杰平,部分由受訪者提供·英文翻譯/蘇恩霆

Text / Kelvin U, Trainee UM Reporter Zhu Jiangge \cdot Photo / Jack Ho, with some provided by the interviewee \cdot English Translation / Anthony Sou

能源是城市的血液,綠色的智慧能源更是智慧城市 可持續發展的基礎。澳門大學智慧城市物聯網國家 重點實驗室智慧能源研究團隊透過攻關新能源綜合 系統關鍵技術,與領軍能源企業合作,引領城市構 建清潔、低碳、高效、安全的智慧能源體系,持續 發揮先行示範作用。

引領城市能源轉型

為使智慧城市的能源系統低碳、零碳運行,智慧能 源研究團隊近年積極探索優化物聯網能源系統的運 行與控制方法。澳大校長、電力系統專家宋永華講 座教授,兼任智慧城市物聯網國家重點實驗室主任 及智慧能源研究團隊學術帶頭人,他說:「我們針 對以澳門特區為代表的高負荷密度城市新能源佔比 不斷攀升,數據中心、電動車新型負荷需求極速增 長等迫切需求,展開多項交叉學科研究,以原創性 成果解決智慧能源體系的諸多挑戰。」 澳門特區是典型的高負荷密度城市,其能源消耗結構 與大部分城市相似。實驗室研究顯示,澳門電力、交 通、樓宇的直接能源消耗接近佔本地碳排放九成,因 此需綜合運用電氣化、智能電網、清潔能源替代、低 碳建築等技術手段,減少本地直接能源消耗。

宋永華教授牽頭研發出含高比例的新能源電力系統 需求側負荷調控系統,提出了靈活負荷調節能力跟 隨發電變化的新路徑,形成了創新理論和發明,其 關鍵技術亦應用於內地11個省市的電網,並出口海 外,對國家實現「雙碳」目標具支撐作用,亦有助 澳門建設低碳城市。宋教授表示,澳大成果對內地 東南沿海等地高度發達的城市具有示範引領作用。

智慧綜合能源管理平台

實驗室團隊結合澳門實際情況和需求,如城市建築密 集、電力負荷強度高、老舊建築較多等因素,從提高 城市電網的智能化水平著手攻克關鍵技術。在電力需 求側方面,團隊研究將柔性負荷模式納入常態化的電 力系統運行之中,從而能對電動車、中央冷氣等大型 設備作靈活自動的動態供電調控,同時開展儲能、直 流配用電等城市智能電網技術研究,以提高城市電網 供電質量和容量,改善城市電網經濟性、安全性。

同時,研究團隊逐步完善智慧能源監控系統、能源數 據建模與可視化,並已搭建「澳門大學智慧綜合能源 管理平台」,實現了大學校園建築、電力系統、關鍵 設備等實體的數字建模,能實時監測電壓、頻率、節 點能耗等多元能源數據,並開展了負荷智能化管理、 多能優化調度、用能健康度分析、安全防護等技術研 究,為未來智能電網應用於城市場景提供實踐經驗。

實驗室與澳門電力、格力電器、國家電投集團、廣 東電網、浙江大學等合作,基於物聯網、大數據、 人工智能技術,開展電、氣、冷/熱等綜合能源系 統全景感知與畫像、智能運行控制、異常監測與安 全防護等關鍵技術研究,並於澳門和內地分別開展 示範應用,以進一步提高城市綜合能源利用效率, 保障城市能源供應安全。此外,實驗室與國家電投 合作,開展橫琴區域製冷系統運行優化研究,為城 市節能減排提供科學依據。

研究電動車智能充電減碳排

電動車大規模發展對電網將有不可忽視的影響。實 驗室因此與澳門電力、清華大學合作開展澳門電動 車充電長遠發展規劃研究,融滙新能源、人工智 能、物聯網、大數據等技術,預測澳門未來不同發 展場景下電動車充電負荷水平,分析其對電網的潛



宋永華教授 Prof Yonghua Song

在影響,並系統性地研究澳門充電設施建設規劃、 「車一樁一網」協同優化運行、全週期收益模式等 關鍵問題,以促進電動車實現智能有序充電,提高 電網效率,保障城市供電質量。

實驗室團隊亦研究未來電動車智能充電的商業模式,探討未來可行的電動車分時充電電價政策等, 通過經濟激勵推動電動車及充電設施高效發展,為 制定相關發展規劃提供參考。團隊預計本澳通過交 通電氣化可減少碳排放約19%。

共建低碳灣區

澳大與南方電網共建「碳中和智慧能源電力聯合 實驗室」,為粵澳首個在能源領域的產學研合作平 台。雙方開展能源電力領域科技攻關、人才培養與 產業推廣,實現產學研深度融合。澳大科技學院助 理院長、電機及電腦工程系、智慧城市物聯網國家 重點實驗室副教授戴寧怡表示,隨著電動車增長及 都市更新,舊區通常會出現局部供電薄弱環節,透 過校企科研合作,能為未來困擾智慧城市發展的挑 戰帶來新的解決方案,助力粵港澳大灣區乃至全國 能源行業創新發展。

面向澳門、深圳等粵港澳大灣區城市節能的需求, 實驗室以先進的物聯網技術參與灣區城市能效調 控,實現配電網靈活資源調控潛力挖掘,採用「時 變建模一信息交互一調度控制一互動驗證」的研究 技術路線,正在和深圳供電局合作開展南方電網港 澳揭榜項目「雙碳目標下基於物聯網的城市電網靈 活資源評估與互動關鍵技術研究」,並計劃在大灣 區應用研究成果。



城市綜合能源系統優化調度示意圖

An optimal dispatching strategy for the urban integrated energy system

Energy, the lifeblood of a city, is crucial for sustainable smart city development, and researchers in a smart energy research group at the University of Macau (UM) State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) tirelessly advance clean, low-carbon, efficient, and secure urban smart energy systems by developing essential technologies, such as new integrated energy systems, and partnering with leading energy companies to create pioneering examples for the energy sector.

Promoting Energy Transition among Cities

To achieve the low-carbon or zero-carbon operation of the energy system in smart cities of the future, researchers in the group have studied the operation and control methods of energy systems based on the Internet of Things (IoT). Chair Professor Yonghua Song, rector of UM and director of SKL-IOTSC, is an expert in power systems and the head of the smart energy research group. Prof Song explains, 'Our group members have various interdisciplinary studies to address the pressing needs of high-density load cities, such as Macao, where there has been a substantial increase in the use of new energy, data centres, and electric vehicles. Our goal is to overcome challenges presented by the smart energy system through innovative research findings.'

As a city with a high-density load, Macao's energy consumption structure is similar to most other cities. Studies in the laboratory show that direct energy consumption in electricity, transportation, and buildings accounts for nearly 90 per cent of Macao's



戴寧怡教授 Prof Dai Ningyi

local carbon emissions. To reduce this consumption, it is necessary to use a combination of technologies such as electrification, smart grid, clean energy substitution, and low-carbon buildings.

Researchers in a project led by Prof Song have developed a demand-side load regulation system containing a high proportion of new-energy-based power systems. The new pathway for flexible load regulation capacity to follow the changes in power generation has given rise to a number of innovative theories and technologies. Not only have these key technologies found extensive applications in China (in the power grids in 11 provinces and cities) and abroad, but they are also expected to play a major role in facilitating China's realisation of its 'Dual Carbon' goals and in supporting Macao's low-carbon development strategy. According to Prof Song, UM's research results will provide guidance to the highly developed cities along the southeast coast of China.

Smart Integrated Energy Management Platform

The research group develops smart technologies to enhance the power grid of Macao. These technologies can address Macao's needs based on its urban characteristics, such as its high building density, high electrical loads and intensity, and many buildings. In terms of demand-side loads, the researchers are studying the incorporation of the flexible load mode into normal power system operation, so as to carry out flexible and automatic dynamic power supply for large electrical equipment, including electric vehicles and central air-conditioners. The group also conducts studies on energy storage, DC power distribution, and other urban smart grid technologies to boost the quality and capacity of electricity supply, as well as the affordability and safety of power grids.

At the same time, the group has focused on enhancing the smart energy monitoring system and methods for energy data modelling and visualisation. They built the University of Macau Smart Integrated Energy Management Platform to realise mathematical modelling of campus buildings, power systems, key equipment, and other entities. With this platform, voltage, frequency, node energy consumption, and other energy data may be monitored in real-time. Researchers have also studied topics such as smart load management, multi-energy optimal dispatching, energy usage, and safety protection, accumulating practical experience for the application of smart grids in urban scenarios in the future.

At present, SKL-IOTSC is collaborating with organisations such as Companhia de Electricidade de Macau, GREE Electric, State Power Investment Corporation, Guangdong Power Grid Corporation, and Zhejiang University to develop technologies based on IoT, big data, and artificial intelligence to realise panoramic sensing and imaging, smart operation control, abnormality monitoring, and safety protection in integrated energy systems for electricity, gas, and cooling/heating. These technologies will be applied in Macao and mainland China to further enhance the efficiency of urban energy use and ensure the safety of urban energy supply. In addition, the laboratory has been working with State Power Investment Corporation to study the optimisation of Henggin's regional cooling system, which will serve as a good example of energy saving and emission reduction in an urban scenario.

Research on EV Smart Charging to Reduce Carbon Emissions

The large-scale development of electric vehicles (EVs) has created a significant impact on the power grid. The laboratory therefore collaborates with CEM and Tsinghua University on a study of the long-term development of EV charging in Macao. Using advanced technologies such as new energy, artificial intelligence, IoT, and big data, researchers aim to predict the load level of EV charging in different scenarios in the future development of Macao, analyse the possible impact on the power grid, and systematically study such issues as the planning of Macao charging facilities, the optimisation of the charging operation, and the development of a full revenue cycle model. Through these efforts, researchers hope to promote EV smart charging, increase the efficiency of the power grid, and ensure the quality of the urban electricity supply.

The group also conducts research on the future business model of EV smart charging and explores the feasibility of future EV time-of-use pricing policies, with a view to promoting the development of EV and charging facilities through economic incentives and providing reference for relevant development plans. The group estimates that Macao can reduce carbon emissions by about 19 per cent through the electrification of transportation.

Building a Low-Carbon Greater Bay Area Together

UM and China Southern Power Grid recently established the Joint Laboratory of Smart Power and Energy for Carbon Neutrality, which is the first industry-academia collaboration platform in the field of energy between Guangdong and Macao. The joint laboratory is dedicated to scientific and technological research, talent training, and industrial promotion in the field of smart power and energy, in order to realise the deep integration of industry, universities, and research institutes. Dai Ningyi, assistant dean of UM's Faculty of Science and Technology and associate professor in the Department of Electrical and Computer Engineering and SKL-IOTSC, says that the growth of EVs and the urban renewal process have increased the burden on the power supply in Macao, making it difficult to maintain consistent energy levels in older districts of the city. Through research cooperation, universities and enterprises can find solutions to these new challenges that plague smart city development and contribute to the innovative development of the energy sector in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) and across the country.

To help Macao, Shenzhen and other GBA cities meet their target of energy conservation, the laboratory has advanced IoT technologies for regulating energy efficiency to ensure the flexible distribution of resources in power grids. Its research strategy highlights four aspects, namely time-varying modelling, information interaction, regulation and control, and interaction verification. It is currently working with Shenzhen Power Supply on an industrial project announced by China Southern Power Grid for research institutions in Hong Kong and Macao, namely 'key technologies for flexible resource assessment and interaction in IoT-based urban power grids under the double carbon goals', with the goal of applying the research results in the GBA.



未來城市智慧交通增強仿真實驗平台 The Future Urban Intelligent Transportation Augmented Emulation Platform

開發安全高效自動駕駛技術

Developing Safe and Efficient Autonomous Driving Technologies

文/余偉業、實習校園記者朱江舸·圖/何杰平,部分由受訪者提供·英文翻譯/關詠琪

Text / Kelvin U, Trainee UM Reporter Zhu Jiangge \cdot Photo / Jack Ho, with some provided by the interviewee \cdot English Translation / Winky Kuan

智能交通作為智慧城市的必備配套,讓人們遠離高 風險出行,其中開發自動駕駛、車路協同技術更是 全球科技競爭的高地。澳門大學智慧城市物聯網國 家重點實驗室智能交通研究團隊面向以自動駕駛和 智慧網聯技術為核心的未來交通場景,研究在大 規模複雜不確定環境下,「人工」與「自動」駕駛 並存的關鍵科學問題,助力形成「人一車一路」安 全、高效、智慧運行的交通體系。

智能駕駛關鍵技術

自動駕駛技術被視為人工智能標誌,是全球汽車工 業發展的趨勢,但相關技術的應用仍有諸多挑戰。 智能交通研究團隊在科技學院院長、協同創新研究 院代院長、電腦及資訊科學系講座教授須成忠領軍 下,聚焦「大規模、複雜場景下無人網聯車的群體 智慧協同控制」和「開放不確定性環境下無人駕駛 的高魯棒性和自適應性」兩大科學問題,綜合研究 物聯網、5G通信、雲計算、人工智能等前沿技術在 自動駕駛中的應用。

澳大科研項目「協同智能驅動的無人駕駛關鍵技術 與平台」於2020年獲批澳門科學技術發展基金的人 工智能重點研發專項,為澳門史上最大的單體研究 項目之一。該項目匯聚了國內多間在自動駕駛領域 具領先地位的機構,其中澳大和中國科學院深圳先 進技術研究院在過往三年聯合提出一組關於自動駕 駛技術的新型魯棒性評估機制,為實現真正安全的 自動駕駛系統打下基石。成果於人工智能領域公認 的兩大頂尖會議「國際計算機視覺與模式識別會議」 (簡稱CVPR) 2021,其論文錄取率僅為4.59%)、 「神經信息處理系統大會」(NeurIPS) 2022,以及 CVPR 2023發表。

研究團隊在智能駕駛「感知一認知一決策一規劃」 等研究方向有一系列原創性突破,已在中國計算機 學會推薦國際學術會議A類/B類及國際電機電子工程 師學會彙編期刊等頂尖會議和期刊上發表論文100餘 篇,並於「CVPR安全AI挑戰者賽2021」及「CVPR 2022 3D目標檢測賽」等國際重大競賽中多次獲獎。

自動駕駛巴士

大千世界的交通場景複雜多樣,數據驅動式的模 型數據難以覆蓋所有場景,是自動駕駛領域的關 鍵問題之一。為實現安全的智能駕駛,研究團隊 通過融合多種感測技術,不斷提升汽車對外部環 境的感知能力。澳大與中國科學院深圳先進技術 研究院、國防科技大學、百度及深圳海梁科技等 機構的團隊共同研發澳門首輛自動駕駛巴士,利 用人工智能、大數據處理、物聯網、雲計算等多 種技術收集道路訊息,並基於遷移學習的方法, 令巴士可在開放及不確定環境下安全可靠地行 駛,使其與環境聯成一體,形成「人一車一路」 高效運行的交通體系。

須成忠教授表示,在自動模式下,巴士利用基於多 種感測器數據融合的深度感知模型可檢測靜態、動 態障礙物及交通標示,如車輛、行人、斑馬線及交 通燈號,並按情況減速或停車。研究團隊亦運用融 合雷射雷達、慣性導航及同步定位與地圖構建技術 (SLAM算法)等高精度定位方法實現巴士自主規劃 和導航,提升駕駛安全。

澳大聯合研發的自動駕駛巴士於2022年8月從澳大校 園駛出,經連接澳門與橫琴的蓮花大橋跨過關口, 到珠海澳大科技研究院II期所在的粵澳合作中醫藥科 技產業園的內部道路開展為期17日的智能駕駛性能 測試。研究團隊結合了在澳大校園測試的結果和最 新研究成果,顯著提高巴士在環境適應與感知、精 確定位、障礙物檢測和自主局部路線規劃等方面的 能力,完善自動駕駛功能。團隊同時在巴士部署了 基於5G的車路協同系統,利用「雲一邊一端」智能 技術,加速自動駕駛車輛落地。 研究團隊將針對複雜交通環境下的車路協同、雲邊 端技術賦能的智能駕駛關鍵技術,以及面向行業應 用的測試平台,開展深入研究,並將於澳門開放性 道路及澳大內部作進一步智能駕駛巴士測試。澳大 師生有望不久將來可在校園體驗自動駕駛技術。

虛實結合交通平台

為探究在人工與自動駕駛並存的複雜情境下網聯汽車 的群體智能協同控制,研究團隊搭建了「虛實結合智 能交通平台」,協助自動駕駛車輛於虛擬世界測試現 實世界難以模擬的場景,並進行穩定、可靠、可控、 可信的單車智能與車路協同測試,進一步提高開放不 確定環境下智能駕駛的魯棒性及自適應性,以實現全 景感知、精準導航、智能決策、高效控制。

研究團隊於2022年11月借助此平台和利用元宇宙技 術完成構建澳門首個「賽車元宇宙MoCAM平台」, 致力建設全球領先的模擬與真實場景。MoCAM平台 模擬了車流及人流,同時與現實中的自動駕駛車輛 疊加的場景,形成一個多維空間、混合現實的元宇 宙實驗環境,協助推算自駕方案對各類交通情境的 適應性,以降低意外概率。

須成忠教授表示,研究團隊將善用澳大在智能駕駛 領域積累的深厚技術,充分發揮橫琴粵澳深度合作 區的政策和空間優勢,為粵澳兩地的自動駕駛廠商 提供自動化、標準化測試認證服務,致力在大灣區 建設一流的國際智能駕駛測試場。



智慧城市物聯網國家重點實驗室智能交通研究獲國際人工智能賽亞軍 An intelligent transportation research project from SKL-IOTSC has won the second prize in an international AI competition

24

Intelligent transportation is a key component of smart cities as it enables people to avoid risks on the road. Among the many technologies in this field, autonomous driving and the intelligent networking of vehicles and infrastructure have drawn a lot of attention and become alobal technology battlegrounds. Focusing on these core technologies in the future of transportation, an intelligent transportation research group of the State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) at the University of Macau (UM) strives to solve scientific problems to enable the coexistence of manual and autonomous driving in large-scale, complex, and uncertain environments. This will contribute to the development of a safe, efficient, and intelligent transportation system.

Key Intelligent Driving Technologies

Autonomous driving technology, an iconic application area of artificial intelligence, is trending in the global automobile industry today. However, implementing this technology still presents many challenges. The research group, led by Xu Chengzhong, dean of the Faculty of Science and Technology, interim director of the Institute of Collaborative Innovation and chair professor in the Department of Computer and Information Science, focuses on two major scientific topics. These topics include 'swarm intelligence and cooperative control of connected vehicles in large-scale and complex situations' and 'high robustness and adaptability of autonomous driving in uncertain open environments.' The group studies the applications of advanced technologies such as the Internet of Things (IoT), 5G communications, cloud computing, and artificial intelligence in autonomous driving.

In 2020, a research project led by the group, titled 'Key Technologies and Platforms for Collaborative Intelligence-driven Autonomous Vehicles' was awarded funding by the Macao Science and Technology Development Fund as a key R&D project in artificial intelligence, becoming one of the largest research projects in Macao's history. The project brought together a number of leading institutes in the field of autonomous driving in China. In the past three years, UM has collaborated with the Shenzhen Institute of Advanced Technology of the Chinese Academy of Sciences (CAS) and proposed a new model robustness evaluation for autonomous driving



須成忠教授 Prof Xu Chengzhong

technology, laying the foundation for a truly safe autonomous driving system. The research results were presented at the Conference on Computer Vision and Pattern Recognition (CVPR) 2021, which had a paper acceptance rate of only 4.59 per cent. CVPR is one of two important conferences in artificial intelligence. The team's results were also presented at the Conference on Neural Information Processing Systems 2022, and will be showcased again at CVPR in 2023.

In addition, the group has made breakthroughs in the perceptual, cognitive, decision-making, and planning ability of intelligent driving technology and has published over 100 papers in top conferences and journals, such as international academic conferences recommended by the China Computer Federation (category A and B) and IEEE journals. The group has also won several awards in major international competitions, including the CVPR2021 Security AI Challenger and CVPR2022 3D Object Detection Competition.

Autonomous Bus

On the road, traffic scenarios vary with a high degree of complexity and diversity, so it is difficult to cover all scenarios with data-driven models. This is a key issue to address in the field of autonomous driving. To enable safe and intelligent driving, the group is constantly working to improve vehicles' ability to detect the external environment by using various perception technologies. The group has developed the first autonomous bus in Macao in collaboration with experts from the Shenzhen Institute of Advanced Technology of CAS, the National University of Defense Technology, Baidu, and Shenzhen Haylion Technologies. In the project, the researchers combined technologies such as artificial intelligence, big data, IoT, and cloud computing to collect traffic information. Based on a transfer learning method, the autonomous bus is able to operate safely and reliably in an open and uncertain environment, integrating itself with the environment to form an efficient transportation system.

According to Prof Xu, in autonomous driving mode, the bus can detect both static and dynamic obstacles, including vehicles and pedestrians, as well as traffic signs, zebra crossings, and traffic lights, by using a depth perception model based on data collected by multiple sensors. The bus would know when to slow down or stop based on the actual situation on the road. The group also applied a high-precision positioning method that integrates laser radar, inertial navigation, and simultaneous localisation and mapping (SLAM) algorithm to realise self-planning and navigation of the autonomous bus to improve driving safety.

In August 2022, the autonomous bus left the UM campus for a 17-day intelligent driving performance test. The bus travelled across the border via the Lotus Bridge between Macao and Henggin and navigated the roads within the Traditional Chinese Medicine Science and Technology Industrial Park of Co-operation between Guangdong and Macao, where the Zhuhai UM Science & Technology Research Institute Phase II is located. By combining the results of performance tests on the UM campus with the latest research findings, the researchers managed to significantly enhance the bus's capabilities in environmental adaptability and perception, localisation, obstacle detection, and path planning. Moreover, the group deployed a 5G-based vehicle-infrastructure cooperative system on the bus to strengthen its capabilities using cloud and edge computing technology.

As the next step in the project, the research team will conduct in-depth studies on vehicle-infrastructure cooperation in complex traffic environments, intelligent driving technologies based on cloud and edge computing technology, as well as test platforms for industrial applications. The autonomous bus will be further tested on open roads in Macao and roads within the UM campus. It is expected that UM members will experience autonomous driving technology on campus in the near future.

Combined Virtual and Real Transportation Platform

To investigate the swarm intelligence and collaborative control of networked vehicles in complex situations in which manual and autonomous driving coexist, the group has built the Combined Virtual and Real Transportation Platform that allows autonomous vehicles to be tested virtually in scenarios that are difficult to simulate in the real world. Using the platform, the group also performs stable, reliable, and controllable tests on single vehicle intelligence as well as vehicle-infrastructure cooperation systems to further improve the robustness and adaptability of autonomous vehicles in open and uncertain environments, so as to realise panoramic perception, precise navigation, intelligent decision-making, and efficient control.

In November 2022, using the platform and metaverse technology, the group built the Macao Car Racing Metaverse (MoCAM) Platform, the first of its kind in Macao, aiming to create world-leading simulated and real scenarios. The MoCAM Platform can simulate the flow of vehicles and people and superimpose real autonomous vehicles to create a multi-dimensional and mixed-reality metaverse platform. It can also calculate the adaptability of autonomous vehicles to various traffic scenarios on the road to prevent accidents.

According to Prof Xu, the group will make good use of UM's advanced technology in the field of intelligent driving and leverage the policies and geographical advantages of the Guangdong-Macao In-Depth Cooperation Zone in Hengqin. It will also provide automation and standardisation testing and certification services for autonomous vehicle manufacturers in Guangdong and Macao, and strive to build a first-class international intelligent driving test site in the Guangdong-Hong Kong-Macao Greater Bay Area.



城市基礎設施健康監測平台 The Platform for the Health Monitoring of Civil Infrastructure

提升城市結構監測及防災力

Enhancing Structural Health Monitoring and Disaster Response Capabilities

文/余偉業、實習校園記者張嘉禾·圖/何杰平,部分由受訪者提供·英文翻譯/蘇恩霆

Text / Kelvin U, Trainee UM Reporter Zhang Jiahe · Photo / Jack Ho, with some provided by the interviewees · English Translation / Anthony Sou

隨著人口不斷向核心城市聚集,城市基礎設施的維 運面臨的挑戰越趨複雜,其中降低安全隱患、減低 災害造成的損失是全球關注的議題。澳門大學智慧 城市物聯網國家重點實驗室城市公共安全與災害防 治研究團隊,致力探索極端天氣條件下濱海城市 海洋災害鏈、構建城市基建的健康監測預警智能維 養、風險評估體系,保障居民安全。

探索濱海城市海洋災害鏈

粵港澳大灣區內濱海城市位於西太平洋颱風西移路 徑,颱風季節常有洪澇、山體滑坡等次生災害鏈。 研究團隊以颱風風暴潮災害和濱海城市岩土工程災 害為主線,對極端天氣條件下濱海城市海洋災害 鏈,開展模擬及風險評估研究。

實驗室於2023年2月搭建澳大遙感衛星地面站,通過

接收氣象衛星、高分衛星數據,大幅提高災害要素 的觀測精度和區域機動探測能力。這標誌著澳大研 究在海洋科學、物聯網、遙感技術等領域的深度融 合,有利開展氣候變化、颱風暴雨、海洋環境、濱 海城市空氣污染等領域的研究。

研究團隊亦透過澳門城市水災害仿真平台,收集澳 門風暴潮增水模擬結果、潮水位監測結果和預警級 別、高精度地表水浸時空分佈、地表監測點對比情 況、各氣象水文站點監測數據,以及當降雨或風暴 潮造成洪澇時,地下管網的流量和水深的時空分佈 等數據,助力探索災害的孕災致災機理,提升濱海 城市的海洋災害綜合防治能力。

及時評估結構安全狀況

城市公共安全與災害防治研究團隊,探究災害對城

市不同承載體(包括人、車、重要基礎設施)的影響,研究結構健康監測、智能運維等防災前沿性研究,著力提升濱海城市的韌性能力,獲多項國家級、省部級科研基金支持,並取得豐碩成果。

針對城市基建的健康監測,研究團隊提出極具創新 價值的貝葉斯結構健康評估算法,可及時評估結構 安全狀況和預測結構性能變化,對突發事件預警。 土木及環境工程系特聘教授阮家榮長期研究貝葉斯 分析與應用。阮教授帶領團隊構建了貝葉斯結構健 康監測方法體系,為基礎設施安全服役提供重要的 理論依據和技術支撐,並引領相關領域的研究。

大型建築會偶現突發問題,嚴重時誘發倒塌風險, 阮教授說:「我們致力透過智能算法手段,以最短 時間偵測建築的結構損傷。」鑒於大型結構運作複 雜,團隊基於無線傳感,提出貝葉斯分佈式參數 識別算法解決數據不同步問題,當傳感器失靈時, 此算法亦能找出故障傳感器,保障數據分析的準確 度。這些研究成果獲發表於Springer專著。

三維智慧運維

在複雜濱海環境及極端災害荷載的共同作用下,跨海 交通基礎設施的安全運行面臨極大挑戰。團隊積極開 展跨海交通基建的智能算法與評估研究,以保障基礎 設施安全服役。實驗室2019年透過國家重點研發項 目「港珠澳大橋智能化運維技術集成應用」和廣東省 重點研發項目「重大跨海交通集群工程智能安全監測 與應急管控」,與港珠澳大橋管理局及相關單位合作



實驗室對基建作數字化健康監測 The laboratory conducts digital health monitoring for infrastructure projects 以前沿技術推進大橋的智慧營運、監測和維養。

針對島隧薄弱截面、沉管之間易變形位置,研究團 隊為大橋開發了「基於光纖光柵的三維變形傳感系 統」,結合物理模型、邊緣計算、無線網絡傳輸和 大數據智能算法,有效預測和判斷結構的健康狀 態。該項目負責人、土木及環境工程系主任、實驗 室教授周萬歡說:「我們發明的基於光纖光柵技術 的三維變形傳感系統可長期實時監測和判斷沉管結 構的變形特徵,以確保適時採取必要維養措施。」

助力灣區跨海基建監測

研究團隊基於青州航道橋、橫琴二橋、澳大N21科研 大樓等基礎設施的環境、荷載和動力響應等健康監測 數據,以貝葉斯系統識別、隨機模型修正和概率機器 學習等方面的理論優勢,搭建了「城市基礎設施健康 監測平台」。此平台可實現複雜環境和荷載耦合作用 下,對海量監測數據作智能分析,且能展示結構基準 有限元模型、關鍵健康指標提取與預測等成果。

韌性城市建設是城市治理風險防控的先決條件。 大灣區有眾多現存及在建的大型基建,包括跨海大 橋、跨海隧道、高聳結構,均面臨長期維養和安全 運營問題,涉及大灣區濱海城市群的融合發展。阮 教授説:「通過智能化、自動化手段及早發現基建 的結構損傷、受損程度和破損位置,有助我們爭取 更多時間對建築物補強。我們將持續積累濱海城市 防災及建築結構健康監測等實踐經驗,進一步健全 城市基建公共安全體系。」



阮家榮教授 Prof Yuen Ka Veng

28



實驗室對極端天氣條件下濱海城市海洋災害鏈開展模擬及風險評估 SKL-IOTSC researchers carry out simulations and risk assessments to study the marine disaster chain caused by extreme weather events in coastal cities

周萬歡教授 Prof Zhou Wanhuan

As the populations of major cities continue to grow, the challenges facing the maintenance and operation of civil infrastructure have become more and more complex. In particular, the reduction of safety hazards and mitigation of natural disasters are two alarming contemporary issues. In view of this, a research group on public safety and disaster prevention of the University of Macau's (UM) State Key Laboratory of Internet of Things for Smart City (SKL-IOTSC) studies the marine disaster chain caused by extreme weather events in coastal cities, and strives to build an intelligent maintenance and risk assessment system for monitoring structural health and issuing early warnings, in order to protect the lives of urban residents.

Studying the Marine Disaster Chain in Coastal Cities

Cities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) are located on the westward path of typhoons originating in the Western Pacific. During typhoon season, these cities are frequently hit by typhoons and may experience severe urban floods, landslides, and other secondary disasters. With storm surges and geotechnical hazards as the focus, the researchers conduct simulations and risk assessments to study the marine disaster chain caused by extreme weather events in coastal cities.

SKL-IOTSC inaugurated the UM Satellite Ground Station in February 2023. The station can receive data from meteorological satellites and high-definition satellites, which greatly improves the observation accuracy for detecting key elements of disasters as well as regional mobile detection capability. The establishment of the station also marked the deep integration of marine science, the Internet of Things, and remote sensing technology, which can facilitate future studies on topics such as climate change, typhoons and rainstorms, the marine environment, and air pollution in coastal cities.

The group built the Urban Flooding Simulation Platform to collect various data. The data include the results of hydrodynamic processes that simulate storm surge events, information about tide levels and relevant warning signals, the spatiotemporal distribution of surface flood flows, the measurements at each meteorological and hydrological station, as well as the spatiotemporal distribution and depth of flood discharges in the underground pipe network during flood events. These data help researchers better understand the marine disaster chain and improve the integrated capability of coastal cities in disaster response.

Assessing Structural Safety in a Timely Manner

The group is committed to exploring the impact of natural disasters on people, vehicles, and important fundamental facilities in an urban environment. The researchers have conducted many cutting-edge studies on topics such as structural health monitoring, intelligent operations, and intelligent maintenance, with the goal of enhancing the resilience of coastal cities. Many of them have received grants from national or provincial research funds and have achieved fruitful results.

To monitor the health of civil infrastructure, the group

has proposed innovative Bayesian methodologies to assess structural safety, predict structural performance changes, and issue early warnings for unexpected events in a timely manner. Yuen Ka Veng, distinguished professor of the Department of Civil and Environmental Engineering, is a long-time researcher of Bayesian analysis and applications. Headed by Prof Yuen, the group has built a Bayesian framework for structural health monitoring, which not only ensures the safe operation of fundamental facilities, but also provides an important theoretical basis and technical support for relevant studies in the field.

Large buildings occasionally experience emergencies, and in the worst-case scenario, face a risk of collapse. 'We strive to detect structural damage in buildings in the shortest possible time using intelligent algorithms,' says Prof Yuen. In view of the complexity of the operation of large structures, the researchers proposed a novel Bayesian distributed identification algorithm for structural parameters based on a wireless sensing network. The algorithm can address the problem of non-synchronised data. When a sensor failure occurs, the algorithm can also help to find the faulty sensor to ensure the accuracy of data analysis. These results have been published in a Springer monograph.

3D Intelligent Operation and Maintenance

It is challenging to ensure the safe operation of sea-crossing infrastructure considering the complex conditions in a coastal environment and the risk of natural disasters. To reduce their combined effect, the researchers have been studying intelligent algorithms and assessments for sea-crossing infrastructure. In 2019, SKL-IOTSC began working with the Hong Kong-Zhuhai-Macao Bridge (HZMB) Authority and other units to promote the intelligent operation, monitoring, and maintenance of the bridge with cutting-edge technologies. Two such projects are under the National Key Research and Development Programme and the Guangdong Provincial Key Research and Development Programme, respectively. The national-level project focuses on the applications of smart technologies in the operation and maintenance of HZMB, while the provincial-level project investigates intelligent safety monitoring and emergency control for sea-crossing projects.

Focusing on these weak connecting parts and the

deformable connecting parts between the immersed tubes, the researchers designed a 3D deformation sensing system for the bridge based on fibre grating technology. Combining technologies such as physical modelling, edge computing, wireless network transmission, and intelligent algorithms with big data, the system can effectively predict and assess the health of different parts of the bridge. Zhou Wanhuan, head of the Department of Civil and Environmental Engineering and professor in SKL-IOTSC, is the lead researcher of the project, 'Our 3D deformation sensing system is based on fibre grating technology. It can monitor the immersed tube over an extended period of time and detect signs of deformation in real-time to ensure that necessary maintenance measures are taken promptly,' Prof Zhou says.

Monitoring the Health of Sea-crossing Infrastructure in the GBA

The research group takes advantage of theoretical developments in Bayesian system identification, stochastic model updating, and probabilistic machine learning. Through the platform, the researchers analyse data from the environment, wind load data, and dynamic responses to monitor the health of structures such as the Qingzhou Channel Bridge, the Second Hengqin Bridge, and the N21 Research Building at UM. The platform can achieve intelligent analysis on massive environmental data and load data, and demonstrates research results such as the finite element model of the benchmark structure, as well as the extraction and prediction of key health indicators.

Urban resilience is a prerequisite for risk prevention and control in a city. The numerous existing and ongoing large-scale infrastructure projects in the GBA, including sea-crossing bridges, underwater tunnels, and high-rise structures, all face challenges brought by long-term maintenance and safe operation. They will also affect the integrated development of coastal cities in the region. 'Using intelligent and automated means, we are able to locate damage and evaluate the severity as early as possible in order to buy time to reinforce the structure,' says Prof Yuen. 'We will continue to accumulate practical experience in disaster prevention and mitigation in coastal cities and structural health monitoring, in order to further improve the urban public safety system.'



校友大道兩旁分別是以橙色為主調的住宿式書院建築群和以藍色為主調的學院建築群 On the two sides of Alumni Avenue are residential colleges and faculty buildings that are colour-coded in orange and blue, respectively

潤物細無聲: 澳大書院教育的探索與變革

Subtle Nourishment: UM's Exploration and Reform of Residential College Education

文 / 張愛華、校園記者李昌洲 · 圖 / 編輯部 \ 實習校園記者鄭應龍 · 部分由書院提供 · 英文翻譯 / 關詠琪 Text / Ella Cheong, UM Reporter Li Changzhou · Photo / Editorial Board, Trainee UM Reporter Chiang leng Long, with some provided by the colleges · English Translation / Winky Kuan

在澳門大學校友大道兩旁的建築物有著明顯的顏色分 野,一邊是藍色屋頂的學院建築群,另一邊是橙色外牆 為基調的住宿式書院建築群。這條大道在上下課時段人 來人往,從學院下課的本科生會徑直返回書院用膳、休 息或學習。在澳大,書院不只是住宿之所,也是學生接 受社群教育及知識整合的學習平台。

探索書院教育

從中國宋代的白鹿洞書院到13世紀牛津大學和劍橋大 學的書院,書院制度在中西教育史中源遠流長,為後 來者留下了寶貴經驗。澳門因其得天獨厚的歷史地理條 件,成為了中西方文明交融的中心。澳大的教育在繼承 中華傳統精神的同時引進了西方的教育體系,書院便是 重要一環。1 自2010年建立珍禧(現名為霍英東珍禧書院)和東亞 (現名為何鴻燊東亞書院)兩個住宿式書院開始,澳大 對書院制度的探索已超過10年。這些年來,書院教育 從最初的嘗試階段,逐漸發展成為大學踐行「專業教 育、通識教育、研習教育、社群教育」四位一體教育模 式中不可或缺的一部分。

富啟發性環境助學生成長

澳大辦學特色之一是採取學院與書院協同育人模式,書 院作為實踐社群教育及知識整合的學習平台,通過走出 課堂的體驗式教學幫助學生在本科教育階段獲得全方位 和多元化的栽培。「我們致力提供富有啟發性的環境和 體驗式的學習規劃,培養學有所成以及情操高尚的學 生。十年求索,書院系統已經成為澳大獨具特色的人才 培養模式。」副校長(學生事務)莫啓明教授說。

莫啓明教授在澳大有近30年育人經驗。他本身是一位 土木工程學專家,曾任科技學院院長、榮譽學院創院院 長,2017年擔任霍英東珍禧書院院長,2022年出任副 校長後仍兼任該書院院長至今。過去一年多,他經常奔 走於10間書院,跟院長、副院長、導師和學生會面, 關心書院和學生的情況,聆聽優化書院系統的建議,務 求更有效地推動學生全人發展。

澳大學生來自世界各地,書院在成為多元文化交匯地 帶的同時,也為院生提供了「家」一般的環境與氛 圍,書院的關懷與同儕的情誼,陪伴院生度過大學成 長中的重要階段。歷屆有著在書院生活和學習經驗的 畢業生,都能深深地體會到書院給予他們的是培育全 人的教育環境。莫教授說:「學生從書院帶走的不 僅是技能,還有因書院教育塑造的品格素養、團隊協 作、待人處事、積極學習的態度,這些軟實力都將令 他們終身受益。」

優化書院系統配合育人目標

2014年澳大全面搬入位於橫琴島現校址後全面推行住 宿式書院系統。珍禧書院和東亞書院更名為霍英東珍禧 書院和何鴻燊東亞書院,並相繼建立曹光彪書院、鄭裕 彤書院、張崑崙書院、蔡繼有書院、呂志和書院、馬萬 祺羅柏心書院、滿珍紀念書院和紹邦書院。10間書院



澳大辦學特色之一是採取學院與書院協同育人的教育模式 One of the features of UM's education setup is an education model in which faculties and RCs achieve synergy by complementing each other

為學生提供全方位體驗式學習,同時也確立學生要達到 的社群教育能力指標。

書院作為澳大實踐社群教育的重要機制和一個綜合性 的學習平台,為學生的專業教育、通識教育和研習教 育提供更有效的輔導及全面的支持。更重要的是,發 揮書院與學院的協同效應,為學生創造多學科、多文 化的交流協作環境。

2019年起,書院在試行和實踐時期的基礎和經驗之上 成長為發展與優化期,開始循序漸進地向新教育目的優 化方向前進。書院在發展與優化時期最鮮明特色是提 出培養學生具備公民責任心、全球競爭力、知識整合能 力、團隊協作、服務與領導、文化參與和健康生活的七 大勝任力。這七大勝任力體現了人的四種品格特質,彼 此相輔相成,形成完整的勝任力。莫教授說:「書院的 教育,也是培養完整的人的教育。學生除了在學院獲得 的專業知識外,在未來的人生裡,書院培養的勝任力會 潛移默化地在學生的人生或生涯發展中發揮著重要的影 響,這些勝任力也是引領他們全人發展的關鍵。」

培養公民責任是書院教育的重要一環。公民責任主要 培養學生家國情懷、社會責任感、遵守法紀和廉潔誠 信的特質。莫教授表示,學生無論來自哪裡,都需要 具備良好公民責任心的素養。書院成立了「兩法」 (《憲法》與《基本法》)推廣大使,以及進一步優



莫啓明教授 Prof Mok Kai Meng



書院開設導修課和各類型研習班,為學生提供學術支持。 The RCs offer non-credit-bearing tutorials and extracurricular workshops as academic support for students

化「兩法」書院導修課系列活動及推進計劃。書院也組 織學生積極參與社會服務,進一步培養公民責任和社會 責任感的勝任力,促進關愛文化和學習奉獻精神。

莫教授憑藉豐富的育人經驗,上任副校長後全力為 書院謀劃更長遠的育人目標。2022年起,莫教授與 團隊在前兩階段所訂立的基礎上,將書院的教育舉 措加以系統化,以配合「四位一體」教育模式中的 社群教育理念,以及更有效地實踐書院作為知識整 合學習平台的目標。

從書院最新的教育舉措所見,明確了書院圍繞「1752」 所開展的核心教育理念——1年書院住宿體驗、7項勝 任力培養、5大書院教育舉措(書院活動、共膳教育、 書院課程、定期與導師見面、高桌晚宴)和2種關懷 (關顧服務 + 學術支持),這系統清晰地展現了書院 緊密融合的全人教育體系。

1年書院住宿體驗:從生活的大型課室中學習

書院如何落實育人理念?在澳大,每位本科一年級學 生都有學院和書院兩個身份,會被隨機分配到10間書 院中,並住宿至少一個學年。每間書院平均約有500 名不同專業的住宿生,在富啟發性的書院氛圍裡學習 與不同背景和文化的人溝通和合作,為畢業後在全球 化的世界啟航作好準備。每間書院設有院長、副院長 各1名,來自學院各學系的非駐院導師約50名,以及 駐院導師約2名。書院院長、副院長和駐院導師均與 院生一道學習、生活於書院內,通過生活中、學習中 的互動共同成長。

書院的生活和學習設施一應俱全,每間書院又根據 自身特色舉辦配合社群教育理念的多元化學習計 劃,並設有讓學生實踐創意和非專業才能的空間。 有院生更在書院結識志同道合的創業伙伴,畢業後 開創企業,助力國家和澳門的產業發展。莫教授 說:「書院不只是住宿用膳的地方,它實際是一個 大型的社群教育的課室,學生在裡面上不同的課 程、參與各類型的活動,跟不同專業的院生交流, 從而提升7大勝任力,這也正是書院所擁有的獨具特 色的教育模式。」

7項勝任力+5大教育舉措

「7項勝任力」的培養主要通過書院5大教育舉措來 實現。書院舉行各類型的體驗式學習課程和活動, 從必修課程、知識講座到戶外鍛煉,從廚藝比拼到 舞台表演等,讓院生從中發展各項勝任力。在「共 膳教育」一環,書院鼓勵院生與老師一同進膳,聊 學業、未來發展等話題,從中建立情誼,同時互相 啟發。這種如「家」般的氣氛使每個院生對書院逐 漸建立起深厚的感情和歸屬感,書院也成為了一個 有著愛的大集體。

書院採用課程化的規劃方式,為學生提供體驗式學習,培養學生各方面的興趣,以增強他們的軟實

力。書院為學生提供的社群教育必修課程——「書 院體驗式學習」和「書院社區團隊項目」,前者指 導學生有效地規劃四年的大學生活,後者旨於培養 學生通過跨學科團隊合作發揮團隊協助、溝通能力 和公民責任心,並助學生全面了解社會需要,並為 一些社會議題提供解決方案。

書院定期舉行高桌晚宴並要求院生參與。佈置得典 雅莊重的禮堂、盛裝赴宴的師生和嘉賓、席間還有 來自不同領域的嘉賓進行主題演講,以其豐富的人 生閱歷拓寬學生的視野。院生從晚宴了解到許多餐 桌禮儀,很多首次參加高桌晚宴的大一學生,往往 因此有瞬間成長和成熟了的感覺,將來在面對類似 人際交往的場景也能從容應對。莫教授說:「院生 在高桌晚宴上可以學習到在正式的社交場合裡,如 何跟不同領域和專業的人士打交道,熟練社交技巧 對學生未來的職涯發展有莫大幫助。」

2 種關懷

2種關懷(關顧服務 + 學術支持)可以說是在書院全 人教育體系中起著支撐點的作用,也體現了書院所 獨有的引領學生達致學術、全人發展和成長的教育 目標。在生活方面,書院老師和社工為院生提供個 人成長和職業生涯的關顧和諮詢服務,培養他們積 極的人生態度,有規劃地去學習和豐富各種體驗,



書院通過各類型的體驗式學習課程,使學生從中發展各種勝任力。 The RCs offer a variety of experiential learning programmes to enable students to develop different competencies

提升7項勝任力,為將來的職業生涯作好預備。

書院為每名院生分配至少一位書院教學人員作為 其大學和生活的指導老師,定期面談,建立點對 點的溝通渠道和互信,並向院生提供各種關顧輔 導和正面思想價值觀教育。導師與院生的接觸時 建立他們的個人檔案,記錄院生的進步和提供更 精準的關懷和培養。

在學術支持方面,由不同學系和專業領域的教授 所組成的非駐院導師團隊擔任了重要的角色。遇 到學術上的難題,院生都可以在書院跟教授傾 談。書院也鼓勵學生融入學院的混合式課堂學 習。駐院及非駐院學術導師,除為院生提供個 人成長或學術指導以外,亦開設自由參加的導修 課,內容包括專業、通識以及專業語文等。書院 與學院還以專題形式合作開展課外知識研習班, 以及合作組織各類型學術活動等。

協助學生生涯規劃

在學生關顧服務方面,書院近年還重點協助深化學 生的生涯規劃。為了進一步優化學生的生涯規劃工 作和完善書院整合式學習平台,澳大在2022/2023 學年聯合澳門中華新青年協會首次引進全球職業生 涯規劃師雙證(全球職業規劃師證書與北森生涯規



每位澳大本科一年級學生,都有學院和書院兩個身份 Each first-year student at UM is given two identities, one by the faculty and another by the RC



書院庭園 An RC atrium

書院鼓勵學生與老師一同進膳,互相啟發。 mutual inspiration

劃師證書)課程,專為書院和負責學生事務工作的 教職員工而設,使學員透過標準化的職業生涯諮詢 流程及專業諮詢工具,系統化地為大學生規劃生涯
 發展,從而找到適合的發展道路。

「有不少院生因為參與書院的體驗學習得到啟發而 更加了解自己的能力,敢於不斷挑戰自我,拓展潛 能。我們希望不斷優化學生生涯規劃的關顧工作, 鼓勵更多學生提升生涯規劃意識,及早做好個人學 習及未來發展路向的規劃,為畢業後融入國家發展 大局、把握發展潮流機遇做好準備。」莫教授說。

Walking on Alumni Avenue at the University of Macau (UM), one can see colour-coded buildings on both sides. The buildings with blue roofs are faculty buildings, while those with walls in hues of orange are residential colleges (RC). During peak hours, the avenue is bustling with students rushing to classrooms for lessons or returning to RCs to have meals, rest, or study. At UM, the RCs are not only a place of accommodation, but also a platform for community and peer education and knowledge integration.

Exploring Residential College Education

College-based education systems can be found in the history of both China and Western countries, from the Bailudong Academy in the Song dynasty to colleges of the University of Oxford and the University of Cambridge in the 13th century, and they provide valuable experience for the implementation of modern Students are encouraged to have meals with professors for

教育應是潤物細無聲

教育工作應該是「潤物細無聲」,書院推行的種種 教育舉措都對學生起著潛移默化的影響。

莫啓明教授希望學生在書院支持下,提高創新思 維、培養領袖才能、具備全球視野,並且成為德 才兼備和能夠擔當重任的創新型人才,畢業後在 全球激烈的競爭環境立足,發揮公民責任心,為 社會貢獻力量。

college systems. Blessed with a unique historical background and advantageous geographical location, Macao became a centre for exchanges between Chinese and Western civilisations. UM, as a university rooted in the city, has inherited the Chinese tradition and has introduced elements of Western educational systems into its education layout, and the RC system is an important component.¹

UM has developed its RC system for more than ten years, starting with the establishment of two RCs in 2010, namely Pearl Jubilee College (now known as Henry Fok Pearl Jubilee College) and East Asia College (now known as Stanley Ho East Asia College). Over the years, the RC system has evolved from a trial project to an integral part of the university's '4-in-1' education model, which consists of discipline-specific education, general education, research and internship

education, and community and peer education.

Providing a Stimulating Environment for Students

One of the features of UM's education setup is the integrated education system in which faculties and RCs achieve synergy by complementing each other. Serving as a platform for community and peer education and knowledge integration, the RCs help undergraduate students achieve development through experiential learning outside the classroom. 'We are committed to providing a stimulating environment and adopting an experiential learning approach, with the goal of cultivating well-rounded students equipped with intellectual and moral capabilities. After ten years of development, the RC system has evolved into a distinctive model for talent cultivation at UM,' says Mok Kai Meng, vice rector (student affairs).

Prof Mok is an expert in civil engineering with nearly 30 years of education experience at UM, where he served as dean of the Faculty of Science and Technology and founding dean of the Honours College. Since 2017, he has been the interim college master of Henry Fok Pearl Jubilee College, a position he continues to hold today even after assuming the role of vice rector in 2022. Over the past year, he made frequent visits to



書院為學生舉辦領袖培訓 A leadership training activity for RC students

專題探討・TOPIC INSIGHT

the ten RCs to meet with college masters, associate college masters, college fellows, and students to listen to their suggestions on how to improve the RC system, hoping to more effectively promote the holistic development of students.

Accommodating students from all over the world, the RCs strive to create a home-like atmosphere in a multicultural environment, where students can achieve personal growth with guidance from their colleges and peers throughout their university life, a momentous stage of their development. Graduates who have lived and studied in the RCs over the years have come to appreciate the college environment that is conducive to whole-person education. 'The RCs not only cultivate practical skills in students, but also instil in them good moral character, team spirit, respect for others, and a positive attitude towards learning. These soft skills can benefit students greatly throughout their lives,' says Prof Mok.

Improving the RC System to Achieve **Educational Goals**

Following UM's relocation to its current campus on Henggin Island in 2014. Pearl Jubilee College and East Asia College were renamed Henry Fok Pearl Jubilee College and Stanley Ho East Asia College,

respectively. Since then, UM has also established eight new RCs, namely Chao Kuang Piu College, Cheng Yu Tung College, Cheong Kun Lun College, Choi Kai Yau College, Lui Che Woo College, Ma Man Kei and Lo Pak Sam College, Moon Chun Memorial College, and Shiu Pong College. The establishment of the ten RCs signified the full implementation of the RC system, which not only offers students a full range of experiential learning opportunities, but also defines the competencies that students need to develop through community and peer education.

Serving as an important vehicle for community and peer education and an integrated learning platform at UM, the RCs provide effective guidance and full support for students to achieve success in the other three aspects of whole-person education, namely discipline-specific education, general education, and research and internship education. More importantly, the RCs work in synergy with the faculties to create an environment conducive to multidisciplinary and multicultural interchange, as well as collaborative learning.

In 2019, the RC system began a phase of development and enhancement based on previous experience, and defined new educational goals by encapsulating the outcomes of RC education into seven competencies. These competencies include responsible citizenship. global competitiveness, knowledge integration,

teamwork and collaboration, service and leadership, cultural engagement, and healthy lifestyle, with each competency consisting of four attributes that complement each other. 'RC education is designed to promote whole-person development. Along with the professional knowledge students gain in the faculties. the competencies they develop in the RCs will have a positive influence on their future lives and careers. These competencies are essential for students to achieve whole-person development,' says Prof Mok.

Fostering responsible citizenship in students is an important part of RC education. This competency encompasses four attributes, namely affection for home country, social responsibility, law-abidance, and integrity. According to Prof Mok, students should demonstrate a strong sense of responsible citizenship, regardless of their background. To this end, the RCs have trained ambassadors for the promotion of the Constitution of China and the Basic Law of Macao SAR and the enhancement of related activities and programmes. The RCs also arrange for students to participate in community services with the goal of cultivating responsible citizenship and social responsibility in them, so that they will learn to care for others and serve those in need.

With extensive experience in education, Prof Mok has dedicated himself to creating long-term educational goals for the RCs since he assumed office as vice rector.



住宿式書院管理組織架構 The organisational structure of the RCs



書院學生到各地參與社區服務培養公民責任心 RC students engage in community services in different places to cultivate responsible citizenship

In 2022, upon the foundation laid during the previous stages, he and his team began building a system to align RC education initiatives with the objectives of community and peer education in the '4-in-1' education model, in order to enhance the effectiveness of RCs as a platform for knowledge integration.

At the heart of the RC education system is the core strategy of '1752', which includes a one-year RC residence experience, seven learning competencies, five major educational measures (RC activities, communal meal participation, RC courses, meeting regularly with mentors, and High Table Dinners), and two types of care (pastoral care and academic support). These educational initiatives exemplify the system of whole-person education underpinned by the RCs.

One-year Residence Experience: The RCs as a Mega Classroom

How does the RC system implement UM's vision for education? Each first-year student at UM is given two identities, one by their faculty and another by their RC. Students are randomly assigned to one of the ten RCs, where they will stay for at least one academic year. Each RC houses about 500 students from different disciplines and provides a dynamic environment for them to learn to communicate and collaborate with individuals from different cultural and academic backgrounds. This experience equips students with the necessary tools to succeed in the world outside the university upon graduation.

Interaction in life and learning between academic staff and students in the RC is also a crucial aspect of the RC system. Each college has a college master,

- an associate college master, and about two resident fellows. They live together with students in the RCs, working together to foster growth in the students in a supportive and engaging environment. In addition, each RC has about 50 non-resident fellows from various departments and faculties.
- All the RCs are equipped with a full range of living and learning facilities. In addition, each RC offers different learning programmes according to its own characteristics to meet the goals of community and peer education, and provides a space for students to leverage their creativity and soft skills. Some UM graduates met like-minded peers during their time in the RCs and they have gone on to become business partners after graduation and are now contributing to different industries in Macao and across China. 'The RCs are not merely a place to reside and have meals. They are actually a mega classroom for community and peer education, where students can take different courses, participate in various activities, and interact with their peers from different disciplines, thus developing their seven competencies. This is the unique education model embodied by our RCs,' says Prof Mok.

Seven Competencies and Five Educational Measures

The seven competencies are cultivated in students through five educational measures. The RCs organise a variety of experiential learning programmes and activities, including compulsory courses, talks, outdoor exercises, cooking competitions, and theatre performances, allowing students to develop competencies. For communal meal participation,





students are encouraged to have meals with professors and chat with them about their studies and future development, which helps students and professors build friendships and spark mutual inspiration. Such a home-like atmosphere can help students develop a strong sense of belonging to their RCs and makes the RCs their second home.

The RCs adopt a curriculum-based approach in their programmes to provide experiential learning for students and nurture their interests to enhance their soft skills. There are two compulsory courses for community and peer education, namely, 'RC Experiential Learning' and 'RC Community Team Project'. The former guides students in planning their four years of university life, while the latter aims to develop students' teamwork, communication skills, and responsible citizenship through interdisciplinary projects, as well as to provide students with a comprehensive understanding of the needs of society and explore ways to address social issues.

Furthermore, the RCs regularly host High Table Dinner and require students to attend. These events aim to inspire students with an elegant environment and formally dressed professors, guests, and peers. Keynote speakers from different fields are often invited to share their life experiences, which helps to broaden students' horizons. The events also offer opportunities for students to learn proper table manners and etiquette. Attending the first High Table Dinner

often gives first-year students a sense of newfound maturity, as if they have grown up in an instant. The experiences also enable them to handle similar social gatherings in the future with ease. According to Prof Mok, the High Table Dinners provide an excellent opportunity for students to learn to communicate and build a network with people from different fields and professions in a formal social setting, which will help them develop their future careers.

Two Types of Care

The two types of care (pastoral care and academic support) can be seen as the backbone of the system of whole-person education underpinned by the RCs. They also embody the RCs' unique education objectives of quiding students towards academic excellence, holistic development, and personal growth. In the RCs, academic staff and social workers provide guidance on personal and career development for students to help them cultivate a positive attitude towards life, pursue various experiences in a structured manner, develop the seven competencies, and prepare for their future careers.

Each student is assigned at least one residential academic staff member as a mentor, and one-on-one meetings are held between them on a regular basis to establish mutual trust and a communication channel, through which the mentor can effectively provide emotional support and positive values for the student. Mentors also create personal profiles

for their students to track their progress and ensure personalised care and cultivation.

In terms of academic support, a team of non-resident fellows, composed of professors from different departments and fields of expertise, plays an important role. Students can turn to the professors in the RCs when they encounter difficulties in their studies. They are also encouraged to join the blended learning courses offered by faculties. In addition to providing students with guidance on personal development and academic support, the resident and non-resident fellows in the RCs also offer non-credit-bearing tutorials on professional topics, general education topics, and academic language. RCs and faculties also collaborate to offer extracurricular workshops and academic activities on various themes.

Assisting Students in Career Planning

In terms of pastoral care, the RCs have stepped up efforts to assist students in career planning in recent years. To improve students' career planning skills and enhance the integrated learning platform of the RCs, UM partnered with the Macao New Chinese Youth Association to introduce the Global Career Development Facilitator training in the 2022/2023 academic year for staff members working in the RCs and in the area of student affairs. The course aims to enable staff to help students plan their careers through a standardised career counselling process using professional tools.

'Many of our students are inspired after participating in the experiential learning programmes offered by the RCs. Now they are more aware of what they are



為了進一步優化學生的生涯規劃工作,澳大在2022/2023學年首次引進全球職業生涯規劃師雙證課程。 UM introduced the Global Career Development Facilitator training in the 2022/2023 academic year to improve career planning services for students

capable of, and dare to challenge themselves and explore their potential. We hope that, by providing better assistance in career planning in the RCs, we can encourage more students to make plans for their future and improve their related skills. In this way, they will have a clear career path ahead, and will be able to integrate into national development and seize development opportunities upon graduation,' says Prof Mok.

Education in Subtle Nourishment

Education is a subtle nourishment, fostering growth without a sound. The various educational initiatives implemented by the RCs have a subtle but profound influence on the students.

Prof Mok hopes that with the support of the RCs. all students will cultivate their innovative thinking skills and leadership skills, which will help them become innovative and responsible global citizens with both expertise and integrity that can take on important tasks and gain a foothold in the highly competitive global environment to contribute to society.

1《住宿式書院實踐全人教育理念 澳門大學的探索》,浙江大學出版社。 Whole Person Education in Residential College: The Experience of University of Macau, published by Zhejiang University Press



住宿式書院系統網站 Website of the Residential College System



王瑞兵教授(中)及其博士生 Prof Wang Ruibing (centre) and his PhD students

超分子技術提升癌症靶向治療

Enhancing Targeted Cancer Therapy with Supramolecular Technology

文 / 葉浩男、校園記者鄭瑋璐 · 圖 / 何杰平 · 部分由受訪者提供 Chinese & English / Davis Ip, UM Reporter Emmige Zheng · Photo / Jack Ho, with some provided by the interviewee

澳門大學的研究團隊研發了一種新技術,結合納 米粒子、細菌膜和免疫細胞的力量,將藥物遞送 到腫瘤,從而攻擊癌細胞。在超分子化學專家、 澳大中華醫藥研究院、中藥質量研究國家重點實 驗室副教授王瑞兵帶領下,團隊期望研發成本更 低、效果更佳的個性化癌症療法。

用於藥物靶向遞送的超分子智能生物材料

王教授在2014年加入澳大,專長於超分子化學、 超分子生物材料、放射性藥物和分子醫學影像等 領域,2020年當選英國皇家化學會會士。他主要 研究分子之間如何以非共價鍵方式產生相互作用 和自我組裝,從而成為簡單、智能和具生物活性 的「超分子」結構,好比牽手的分子體系。這方 面的研究使科學家能按需要設計分子結構,例如 藥物和健康產品。

追擊實體瘤組織

王教授指出,部分抗癌藥物常在到達腫瘤組織前 已被體內的非癌組織或細胞所吸收,結果對身體 產生了副作用而療效甚微。

為解決這個難題,科學家開發了各種方法,將藥物和納米藥物遞送到腫瘤。其中一個方法是運用 患者體內容易被腫瘤組織所「招募」的細胞。科 學家可以取出這些細胞,在無菌環境下修飾它們 或放入藥物,再將細胞放回體內,通過靶向遞送來 協助殲滅癌細胞。然而,這種做法通常昂貴而費 時,也有細胞在體外被污染的風險。因此,王教授 的研究團隊開發了一種方法,讓納米藥物在體內搭 上「巨噬細胞順風車」,利用巨噬細胞(一種免疫 細胞)的炎症趨向性前往腫瘤組織。

具體而言,研究團隊設計出一款超分子納米藥物。這種藥物以大環化合物(β-環糊精)為主體 分子,以金剛烷作為客體分子,它們分別用於修 飾金納米粒子(一種常用於腫瘤診療的納米藥 物)的表面。

為了製備這些超分子納米藥物,研究團隊先用大 腸桿菌的外膜囊泡,分別包裹經β-環糊精和金剛 烷所修飾的金納米粒子。這些外膜囊泡一方面作 為保護屏障,避免金納米粒子在進入患者體內前 過早地因為β-環糊精與金剛烷的主客體作用而相 互結合。另一方面,這些外膜囊泡也可使納米藥 物擁有「仿細菌」特性。仿細菌的納米藥物一旦 被靜脈注射到患者體內,就會被巨噬細胞當作細 菌而「內吞」。這些免疫細胞有炎症趨向性,會 自然在腫瘤組織聚集。

巨噬細胞吞下納米藥物後,大腸桿菌外膜囊泡會 被巨噬細胞本身的溶酶體酶所分解,使經β-環糊 精和金剛烷所修飾的金納米粒子通過「牽手」(即 「超分子主客體相互作用」)組裝成超分子聚集 體。王教授說:「腫瘤組織是目的地,巨噬細胞 就是順風車,超分子藥物則是乘客。沒有順風車 的話,乘客恐怕難以順利找到目的地。」

光熱腫瘤治療

在巨噬細胞內,由於這些金納米粒子的表面會緊 密接觸,它們會通過「等離子體效應」而獲得光 熱性質,即被光照射時會發熱。當癌細胞附近 有足夠的納米藥物聚集,醫生可以採用「光熱療 法」,引導特定波長的光到腫瘤,產生高溫來破 壞腫瘤組織和細胞。

研究團隊為驗證仿細菌納米藥物的效力,對三組 實驗鼠採用光熱治療。這些實驗鼠均患有黑色素 瘤(一種皮膚癌)。第一組僅使用沒有外膜囊泡 包裹的金納米粒子;第二組使用有外膜囊泡包裹 的金納米粒子;第三組使用由外膜囊泡包裹、分 別經主體分子和客體分子所修飾的金納米粒子。

宫驗結果顯示,經注射這些藥物後,第一組小鼠 的腫瘤中積累了最少量的金納米粒子;由於第二 組小鼠使用的藥物採用基於仿細菌的巨噬細胞搭 便車方式進行遞送,它們的腫瘤中積累了較多的 金納米粒子; 第三組小鼠則因金納米粒子在巨噬 細胞內形成超分子聚集,使得藥物經過巨噬細胞 搭便車遞送時的早期流失減到最小,因此在腫瘤 組織中大量積累。當用激光照射時,第三組小鼠 的實體腫瘤組織達到了非常高的溫度,但除了腫 瘤外,周圍組織沒有明顯的損傷,再次表明大部 分超分子納米藥物已經到達了其預定目標:腫瘤 組織。相反,其他兩組小鼠的腫瘤部位只顯示出 非常温和的升温。因此,當仿細菌超分子納米藥 物與抗PD-L1(一種免疫檢查點抑制劑)相結合 時,它對黑色素瘤能發揮最佳的療效,幾乎將小 鼠的全部腫瘤消除。

進一步驗證和開發

這項研究在2022年於知名學術期刊《科學進展》 發表,題為《細菌仿生納米藥物介導的免疫細胞



本圖顯示小鼠的RAW264.7細胞接觸到由兩類經修飾的金納米粒子所形成的 混合物後,這些細胞第10、20、30和60分鐘時的情況。

This figure shows the changes in RAW264.7 cells in mice at 10, 20, 30 and 60 minutes after they have been exposed to a mixture formed by two types of modified gold nanoparticles.

42





本圖顯示三組小鼠接受金納米粒子光熱治療後在不同時間的情況。其中,第三 組小鼠體內有最多金納米粒子在腫瘤附近積累。

This image shows three groups of mice treated with gold nanoparticles at different times after injection, with the third group showing the most effective accumulation of gold nanoparticles at the tumour site.

內組裝體的構建及其搭便車式靶向抗腫瘤免疫治 療》。論文的通訊作者為王瑞兵教授,共同通訊 作者為澳大中華醫藥研究院特聘教授李銘源,博 士後研究員高成和碩士生王慶福為文章的共同第 一作者。澳大博士生李俊燕和鄺熙婷、研究助理 韋健文、博士後研究員謝貝貝等人也對此研究作 出重要貢獻。這項研究由何鴻燊博士醫療拓展基 金、國家自然科學基金、澳門特別行政區科學技 術發展基金和國家教育部澳大精準腫瘤學前沿科 學中心資助。

這項研究亦在2022年粵港澳大灣區高價值專利培育 佈局大賽中從數千個項目中脫穎而出,獲頒銀獎, 而該大賽只有25個項目獲金獎或銀獎。這項研究引 起不少內地企業的關注。他們正與團隊討論進一步 開發這項技術,以及深入驗證其功效和安全性。

以超分子技術改良各類治療

王教授的團隊近年開展了多項基於超分子技術在 智能藥物遞送上的前沿應用研究,上述癌症藥物 遞送技術只是其中之一。例如,他們也開發了一 種針對急性肺炎的技術,使藥物更有效地遞送到 發炎的肺部,做法是將β-環糊精錨定在紅細胞(又稱 紅血球)上、將二茂鐵錨定在納米藥物的表面, 並使兩者產生超分子作用,讓藥物搭上紅細胞的 順風車到肺部。王教授說:「紅細胞生物相容性 高,在體內血液循環的時間長,是持續遞送藥物 的理想載體。」研究團隊發現,以這種方式遞送 薑黃素可以有效治療小鼠的急性肺炎。

本 使 藥物 更 有 效 地 遞 送 到 ा 極 宛 , 從 而 聞 屈 光 執 治 療

This figure shows how a supramolecular drug can hitchhike and

self-assemble in immune cells inside the body, enhancing drug delivery to

tumours via immune cells hitchhiking for photothermal therapy (PTT).

此外,超分子技術可以用於控制體內和體外出 血。王教授說,創傷後或手術時過度出血是對人 類生命的一大威脅,常見的應對方法是輸送含豐 富血小板的血漿,藉以凝結受損的血管,但這些 血小板往往無法迅速抵達出血位置。因此,他的 團隊運用葫蘆脲[7]與其它化合物之間的超分子 作用,將普通的血小板改良為「超分子工程化的 血小板」,提升其對受傷血管的靶向性和凝血能 力。在實驗鼠身上,相比普通血小板,經改良的 血小板能顯著減少出血時間和出血量。

超分子化學的核心是研究分子之間獨特的非共 價鍵作用,例如靜電和疏水效應,成果早已廣 泛應用於日常生活用品,其在生物醫藥中和生 物材料中的應用有非常大的潛力。王教授說: 「持續研究超分子系統將有助我們設計出更智 能、功能更多的分子結構,更好地滿足生物醫 藥方面的需要。微小的超分子能為人類解決巨 大的難題。它們遞送的不單是藥物,還有源源 不絕的想法和解決方案。」 A team of researchers at the University of Macau (UM) has developed an innovative technology that combines nanoparticles, bacterial membranes, and immune cells to deliver drugs directly to tumours to attack cancerous cells. Led by Wang Ruibing, a supramolecular chemist and associate professor at UM's Institute of Chinese Medical Sciences (ICMS) and State Key Laboratory of Quality Research in Chinese Medicine, the team seeks to bring about more effective and personalised cancer treatments at a lower cost.

Supramolecular Smart Biomaterials Improve Targeted Drug Delivery

Since joining UM as a faculty member in 2014. Prof Wang has brought a wealth of experience in supramolecular chemistry, supramolecular biomaterials, radiopharmaceuticals, and molecular bioimaging to the university. Elected a fellow of the Royal Society of Chemistry in 2020, Prof Wang studies how molecules interact with each other and assemble themselves through non-covalent bonding, which creates simple yet smart structures with unique biological properties. He describes these structures, known as supramolecular molecules, as 'molecules holding hands'. Through studying supramolecular chemistry, scientists have developed molecular structures for various needs, such as medicines and healthcare products.

Hunting Down Solid Tumour Tissue

According to Prof Wang, some anti-cancer drugs are often absorbed by non-cancerous tissues and cells before they reach their intended target, which can lead to unwanted side effects and provide limited therapeutic benefit to the patient.

To address this issue, scientists have developed various methods to deliver drugs and nanomedicines to tumours. One approach is to use the patient's own cells that cancer tissues tend to attract. These cells are extracted from the patient's body, modified or infused with drugs in a sterile environment, and then reintroduced into the body to help destroy cancer cells via targeted drug delivery. However, this method is often costly, time-consuming, and carries the risk of cell contamination outside the body. In search of a better solution, Prof Wang's team has developed

專題探討・TOPIC INSIGHT

a technique that enables nanomedicines to 'hitch a ride' on macrophages in the body. In this way, nanomedicines can reach cancer cells by taking advantage of the innate ability of macrophages, which are a type of immune cells, to migrate to and accumulate in areas of inflammation in the body, a process known as inflammatory tropism.

In essence, the team has developed a supramolecular nanomedicine that uses a macrocyclic compound called β -cyclodextrin (β -CD) as the host molecule and adamantane (Ada) as the guest molecule to modify, respectively, the surface of gold-nanoparticles (GNPs), which are used commonly in cancer therapy and diagnosis.

To create the supramolecular nanomedicine, the researchers coated the β -CD-modified GNPs and the Ada-modified GNPs with the membrane of E. coli outer membrane vesicles. This membrane serves as a protective barrier that prevents the GNPs from prematurely interacting with each other via β -CD-Ada host-guest interactions before they are administered to a patient. In addition, the E. coli membrane coating makes this nanomedicine 'bacteria-mimetic'. Once intravenously injected into the patient's body, the E. coli-mimetic nanoparticles are engulfed by macrophages.

The membranes of E. coli are then broken down



王瑞兵教授的研究團隊於2022年粵港澳大灣區高價值專利培育佈局大賽獲 頒銀獎

Prof Wang Ruibing's research team was awarded a silver medal at the 2022 Guangdong-Hong Kong-Macao Greater Bay Area High-value Patent Portfolio Layout Competition

by lysosomal enzymes, paving the way for supramolecular assemblies of β -CD-modified and Ada-modified GNPs into supramolecular aggregates. These aggregates are formed via supramolecular host-guest interactions, also personified as 'hands-holding'. 'The cancer tissue is the destination, the macrophages are the transportation vehicles, and the supramolecular medicines are the hitchhikers. Without the vehicles, the hitchhikers alone may not efficiently reach their intended destination,' says Prof Wang.

Photothermal Cancer Therapy

Inside the macrophages, the supramolecular aggregates of GNPs also gain a photothermal property via 'plasmonic effects' as a result of the close contact of the gold surface of these nanoparticles. This means that they heat up when exposed to light, which doctors can use to their advantage. They can direct a specific laser wavelength to the site of the tumour once sufficient nanomedicines have gathered in them. This treatment, known as photothermal therapy (PTT), generates high temperatures that destroy the cancer tissue and cells.

The research team tested the efficacy of the bacteria-mimetic nanomedicine by performing PTT on mice with melanoma, a type of skin cancer. The mice were divided into three groups. The first group received gold nanoparticles without E. coli outer membrane vesicles, the second group received gold nanoparticles coated with E. coli outer membrane vesicles, and the third group received a combination of GNPs coated with an E. coli membrane vesicle, with half of the GNPs modified with host molecules and the other half modified with guest molecules.

After injection of these formulations, the first group of mice showed minimal accumulation of GNPs in the tumour, the second group exhibited improved accumulation due to the macrophage-hitchhiking driven by bacteria-mimics, while the third group showed a significant amount of GNPs deposited in the tumour, attributed to the intracellular supramolecular aggregation of GNPs that minimised premature loss during macrophage-hitchhiking delivery. When irradiated with laser, the solid tumour tissue in the third group of mice reached a very high temperature, yet no visible damage was found in the surrounding tissues apart from the tumour. This again indicates that most of the supramolecular nanomedicine had reached its intended target, the tumour tissue. Conversely, the tumour sites of the two other groups of mice showed a very modest temperature increase. Accordingly, when combined with anti-PD-L1, an immune checkpoint inhibitor, the bacteria-mimetic supramolecular nanomedicine exhibited the best therapeutic effect against melanoma, by having nearly eliminated all tumours from mice.

Towards Validation and Development

In 2022, the leading journal Science Advances published the team's paper, titled 'In vivo Hitchhiking of Immune Cells by Intracellular Self-assembly of Bacteria-mimetic Nanomedicine for Targeted Therapy of Melanoma.' Prof Wang is the lead corresponding author and Simon Lee, distinguished professor in the ICMS, is the co-corresponding author. Postdoctoral fellow Gao Cheng and master's student Wang Qingfu are the co-first authors. UM PhD students Li Junyan and Cheryl Kuong, research assistant Wei Jianwen, and postdoctoral fellow Xie Beibei also made important contributions to this research project. The project was funded by the Dr Stanley Ho Medical Development Foundation, the Macao Special Administrative Region Science and Technology Development Fund, the National Natural Science Foundation of China, and the Ministry of Education Frontiers Science Center for Precision Oncology at UM.

The research project was showcased in the 2022 Guangdong-Hong Kong-Macao Greater Bay Area High-value Patent Portfolio Layout Competition and received a silver medal, as one of only 25 gold and silver awardees, surpassing thousands of other entries. This success has drawn the attention of several companies in mainland China, which have expressed interest in partnering with the team to further develop and test the efficacy and safety of this innovative method.

Supramolecular Technology: A Versatile Tool to Improve Disease Therapies

Prof Wang's team has conducted cutting-edge studies on the application of supramolecular



王瑞兵教授的研究團隊 Prof Wang Ruibing's research team

technology for smart drug delivery in recent years, and this new method of cancer drug delivery is just one example. Another focus of the team is to combat acute pneumonia by enhancing drug delivery to the inflammatory lungs. To achieve this, the team has developed a technique that enables drugs to hitch a ride on red blood cells through a supramolecular interaction between β-cyclodextrin anchored on the cells, and ferrocene anchored on the surface of nanomedicine. 'Red blood cells are biocompatible and have a long circulation time in the body, which makes them ideal carriers for drugs that need sustainable delivery.' says Prof Wang. The team has found that curcumin, when delivered in this way, provides an effective treatment for acute pneumonia in mice.

Supramolecular technology also has the potential to control bleeding both inside and outside the body, which is a major threat to human life during surgery or after trauma. One way to tackle this issue is to inject plasma containing a lot of platelets, but they may not always reach the site of bleeding quickly. To enhance the platelets' ability to target and clot injured blood vessels, Prof Wang's team has used supramolecular interactions between cucurbit[7]uril (CB[7]), a type of macrocyclic molecule, and other compounds to modify platelets, turning them into 'supramolecularly functionalised platelets'. In experiments with mice, the supramolecularly engineered platelets were found to greatly reduce the time and volume of bleeding compared to using normal platelets.

Supramolecular chemistry is a fascinating field that studies non-covalent bonding between molecules, from electrostatic interactions to hydrophobic effects. Research results in the field have already been translated into many everyday products and have great potential for the future. 'Continued research into supramolecular systems will enable the design of increasingly smart structures that serve even more biomedical applications,' says Prof Wang. 'Tiny supramolecules have the potential to solve big problems for humanity, not just through drug delivery, but by unlocking an endless stream of ideas and solutions.'



心靈重於科技: 於興中探求理想社會框架

Mind over Machines: Yu Xingzhong's Pursuit for an Ideal Social Framework

文 / 葉浩男、校園記者張方博 · 圖 / 何杰平、校園記者陳錦澍,部分由受訪者提供

Chinese & English / Davis Ip, UM Reporter Zhang Fangbo · Photo / Jack Ho, UM Reporter Harry Chen, with some provided by the interviewee

在科技急速迭代引起全球關注之際,澳門大學人 文社科高等研究院院長、環球法律學系講座教授 於興中堅信,在人工智能時代我們的心靈力量始 終重於科技,每個人都應該進一步發展同理心和 道德感等機器難以複製的人性特質。

科技革新法律職業和教育

1994年起,於教授近30年來一直研究科技對法律

的影響,包括探討人工智能在法律推理方面的應 用。他採取「科技現實主義」的態度:「與其猜 測未來科技潛在的烏托邦式影響,不如基於現有 科技的能力和局限探索實際的應對之道。」

於教授表示,人工智能在合規審查、草擬合約和量 刑預測等法律工作方面的能力不斷提升,坦言「不 懂科技的律師一定會被懂科技的律師取代」,因此 今日的法律學生必須發展數字素養,但他強調數字 素養不單指對新科技工具的認識,而是包括思考科 技對社會影響的能力。

於教授認為,人工智能在法律應用的限制之一是 多數算法有如「黑箱」,就是人提出一個問題, 算法會給予一個答案,但無法充分解釋答案從何 而來,「可解釋的人工智能」技術尚未成熟。

於教授說,更重要的問題是,人工智能未能考慮 法律當中的道德因素。「很多時候,法官和律師 最重要的工作是作出道德判斷。道德考慮因素有 助確保法律反映社會的共同價值觀和期望,沒有 完全對錯,但必須合乎人性。「例如,在一宗案 件,有一個人有權繼承祖父的遺產,但他等不 及,於是殺害祖父,後來被判入獄。那麼他應不 應繼承遺產呢?按法律條文來說是可以,令大多 數人總會覺得道德上不妥,法官最終引用不得 『不當得利』的法律原則,使他無法獲得遺產。」 於教授指出,有研究者希望將道德原則納入人工 智能系統,但電腦依然無法洞悉人類道德推理的 複雜過程。

算法或加劇社會不公

於教授在2022年底推出新著作《數字素養:從算 法社會到網絡3.0》,其中探討算法盛行的社會有 何潛在風險,備受好評,旋即入選中國《法治週 末》2022年十大法治圖書榜單,並在2023年2月 份獲新華出版社列入「新華薦書」書單。

於教授在書中也探討了算法社會如何可能導致不 公。我們的日常生活早已深受人工智能算法(尤 其是深度學習算法)影響,但算法並非中立,而 是如美國數學家Cathy O'Neil所說是「嵌入於數 學內的意見」,反映了開發者的偏見。他直言: 「無論是挑選僱員還是預測社區內各族群的犯罪 率,如果濫用和過分依賴算法,人的偏見便會更 加系統化。」

新科技也可能加劇「數字鴻溝」。於教授說,掌握 先進人工智能算法的企業擁有難以比擬巨大的生產 力,而懂得開發和運用新科技的人也有愈來愈明顯 的就業優勢,但不是所有人都有同等機會接觸這 些科技。「科技巨企正爭相開發更智能的機器學習 模型和算法,政府和社會如果還不及時採取措施, 確保算法以公平和合乎人類基本價值觀的方式地應 用,數字鴻溝只會愈來愈大,我們距離心性與理性 全面發展的理想社會也只會愈來愈遠。」

從英語轉研法理學

於教授的法理學(又稱法律哲學)研究之路深受 多位導師和多個偶然的機會所塑造。生於甘肅岷 縣的他在1977年參加了文化大革命後首場高考, 後來到蘭州大學學習英語。畢業後,他在1983年 獲分派到西安的西北政法學院(現稱西北政法大 學)外語教研室工作。「那時在政法院校,外語 教研室是邊緣的單位,令我開始思考是否要在國 內讀一個法律碩士課程。」

然而,於教授在1985年遇上了到中國內地訪學的 一對澳洲學者夫婦:澳洲國立大學哲學家Eugene Kamenka和悉尼大學法理學家鄭汝純。當時兩人準 備寫一本關於馬克思主義在中國的書籍,因此邀請 於教授到澳洲國立大學思想史研究所工作一年半, 翻譯中文材料。於教授在澳洲接觸到不同文化、閱 讀大量西方文獻和認識各國著名法理學者。有了這 段經歷,他在1986年回到西北政法學院後便轉到



於興中教授的新書《數字素養:從算法社會到網絡3.0》

Prof Yu Xingzhong's new book Digital Literacy: From Algorithmic Society to Web 3.0

法理學教研室工作,正式開始法理學研究生涯。

從《大清律例》研習法律史

於教授很快再次得到海外深造的機會。1987年, 美國哥倫比亞大學中國法律史專家艾德華(R. Randle Edwards)來到西北政法學院,希望安 排一名學者往哥倫比亞大學訪問。於教授因此在 1988年首次赴美。「我小時候看了不少文言書 籍,加上在澳洲提升了英語能力,能夠比較順暢 用英語解釋《大清律例》的文言字句,這段經歷 激發了我研究中國法律史。」

在艾德華教授支持下,於教授後來入讀哈佛大學 法學院,在哈佛大學法學院知名中國法專家安守 廉教授的指導下研究社會理論、中國法和中國法制 史,1991年和1995年先後取得碩士和博士學位。 從哈佛畢業後,於教授在芝加哥一所律師事務所任 職三年,後來短暫在北京大學和哈佛大學任教, 之後在香港中文大學教學和研究超過10年,並在 2012年至2022年在美國康奈爾大學法學院擔任 Anthony W. and Lulu C. Wang中國法講席教授。



於興中教授攝於康奈爾大學Morrill Hall Prof Yu Xingzhong in Morrill Hall, Cornell University

2022年8月,於教授加入澳大擔任法學院講座教授,同年10月出任人文社科高等研究院院長。他多年來的重要著作包括《法治與文明秩序》《中國的法律實用主義》《法學中的現代與後現代》。

法律應以道德原則為基礎

於教授曾在不同法制的地區任職,對法理學形成 多元的思考。「西方很多學者研究中國時視中 國為研究材料,而非研究對象,我則把中國視為 研究對象。我相信中國數千年以道德主導的文明 中,總有一些優秀的思想元素有普世意義,可以 用於改良現代社會。」

於教授續說:「我認為法律應該以道德原則為基礎。我的目標是尋找平衡法律與道德、心性和 理性的理想社會框架。」他指近代西方和全球現 代社會均以智性文化為主流,注重規則和個人權 利;中國古代也講規則,但最重視的是人與人的 關係。「『關係』這個詞雖然偶然有負面意義, 令人聯想到不公平的對待,但它的本質是指人與 人的情感和連結,例如親人與朋友之間的情感關 係。在注重理性的現代法治社會,強調人與人的 關係和情感需求非常重要。」

推動澳大跨學科研究

於教授加入澳大前曾兩次到校園參與研討會,對 大學在跨學科研究方面的措施和理念深感認同。 身為人文社科高等研究院院長,他正帶領研究院 建設 一個突破學院界限的校級研究平台,建設澳 大在此範疇的跨學科國際水平研究團隊,實現學 術資源協同效應的戰略佈局。在澳大法學院,他 也參與籌設以英語授課的法學士學位(中國法與 環球法學)課程。

與此同時,於教授在編寫一本探討心性哲學的書 籍,從而更系統地疏理他多年來對社會、法律、道 德和人性的思考。「無論研究甚麼課題,我的目標 都是希望探索更理想的社會框架,當中必然包括對 心靈需求的關注。心靈遠比科技珍貴,人與人擁有 電腦始終無法模擬的感情和連結,這是我們必須緊 記的事,也是我從事學術研究的動力。」



於興中教授(右)主持一場圓桌會議,與傳播、法律和科技領域的澳大教授探討大型語言模型對社會的影響。 Prof Yu Xingzhong (right) moderates a roundtable discussion on the societal implications of large language models, featuring insights from UM professors in communication, law, and technology

In a world where rapidly evolving technology commands the spotlight, Yu Xingzhong, director of the Institute of Advanced Studies in Humanities and Social Sciences (IAS) and chair professor of the Department of Global Legal Studies at the University of Macau (UM), asserts that true power lies within the human mind. As society navigates the uncharted waters of AI development, he urges everyone to cultivate their uniquely human qualities, including empathy and morality, as they can never be replicated by machines.

Tech's Role in Shaping Legal Education and Practice

With almost three decades of experience researching the impact of technology on law, Prof Yu began exploring the application of artificial intelligence for legal reasoning in 1994. He takes a 'technological realist' view, avoiding speculation about technology's potential utopian outcomes and instead concentrating on practical solutions based on the capabilities and limitations of existing technologies.

Prof Yu notes that AI is making significant progress in many areas of law, including legal compliance evaluation, contract drafting, and sentencing prediction. He believes that lawyers who lack technological proficiency will be replaced by those who possess it. That is why today's law students must develop strong digital literacy skills, which are not just about understanding cutting-edge tools, but also include the ability to consider technology's broader societal impact.

Prof Yu identifies a significant issue with the current use of Al in law - the 'black box' nature of most algorithms. Although these algorithms can provide answers to queries, they do not explain how they arrived at their conclusions. While 'explainable Al' technology is in development, it has not yet reached maturity.

Prof Yu adds that AI also lacks moral considerations, which is crucial in legal work. He says that moral considerations, which are key to the work of judges and lawyers, help ensure that laws align with social values and expectations. While moral considerations do not have a definitive right or wrong answer, they must align with the fundamental principles of human nature. To illustrate this point, he refers to a previous case where a man killed his grandfather to inherit his estate. Although from a legal standpoint, the man was allowed to inherit the estate, most people considered it morally wrong. Eventually, a judge applied the 'unjust enrichment' principle

to prevent the inheritance. According to Prof Yu, while some researchers aim to integrate moral principles into AI systems, current technology is still incapable of comprehending the complexities of human moral reasoning.

Algorithmic Society May Exacerbate Injustice

In late 2022, Prof Yu published his latest book *Digital Literacy: From Algorithmic Society to Web 3.0*, which examines the potential pitfalls of an algorithm-driven society. The book has received critical acclaim, being included on China's *Legal Weekly*'s top ten list of books about the rule of law in 2022, as well as the Xinhua Reading List by Xinhua Publishing House in February 2023.

In his book, Prof Yu examines some potential ways in which an algorithmic society might exacerbate injustice. Firstly, he addresses the long-standing influence of Al algorithms, particularly deep learning algorithms, on our daily lives. As American mathematician Cathy O'Neil points out, algorithms are 'opinions embedded in mathematics' that reflect their designers' biases. Prof Yu warns that if algorithms are abused, biases will become more systematic, leading to problems such as unfair employee selection or inaccurate predictions of crime rates among ethnic groups.

In addition to addressing the issue of algorithm bias. Prof Yu also highlights the potential widening of the 'digital divide' as new technologies advance. Today, tech giants owning cutting-edge Al algorithms benefit from unparalleled productivity, while individuals skilled in developing and using new technologies enjoy career advantages. However, not everyone has the same opportunities to access such technologies. As companies compete to develop more intelligent machine learning models and algorithms, Prof Yu stresses the need for the government and society to take timely action to ensure these technologies are used fairly and align with fundamental human principles. Without such measures, he warns that the digital divide will continue to expand, pushing us further from an ideal society where both morality and rationality flourish.

Navigating from English Studies to Jurisprudence

Throughout his academic journey in jurisprudence, also known as legal philosophy, Prof Yu was profoundly influenced by his mentors and various serendipitous opportunities. Born in Min county, Gansu province, in Northwest China, Prof Yu took part in China's first college entrance examination following the Cultural Revolution in 1977 and proceeded to study English at Lanzhou University. After graduation, he was assigned to work in the Department of Foreign Languages at the Northwest Institute of Political Science and Law (now the Northwest University of Political Science and Law) in Xi'an in 1983. However. foreign language departments were regarded as peripheral units within China's political and legal institutions at that time, prompting him to consider pursuing a master's degree in law in China to improve his career prospects.

In 1985, Prof Yu encountered a visiting Australian scholar couple: Eugene Kamenka, a philosopher at the Australian National University (ANU), and Alice Tay, a jurisprudence scholar at the University of Sydney. The couple was working on a book about Marxism in China and invited Prof Yu to join the History of Ideas Unit at ANU for 18 months to assist with translating Chinese materials. This experience in Australia exposed Prof Yu to diverse cultures, Western literature, and many renowned scholars of jurisprudence from around the world. Upon returning to the Northwest Institute of Political Science and Law in 1986, he transitioned to the Department of Law, formally embarking on a career in jurisprudence.

Exploring Legal History through the Great Qing Code

Prof Yu soon found a new opportunity to study abroad when R. Randle Edwards, a Chinese legal history specialist from Columbia Law School, visited the Northwest Institute of Political Science and Law in 1987. Edwards sought a scholar to assist in researching the Great Qing Code, which led to Prof Yu's first trip to the United States in 1988. With his enhanced English proficiency after visiting Australia and a childhood fascination with classical Chinese literature, he was able to interpret the Great Qing Code written in Classical Chinese. 'This experience sparked my interest in Chinese legal history,' he says. With Edwards's support, Prof Yu later attended Harvard Law School to study social theory, Chinese law, and Chinese legal history under the guidance of Prof William P. Alford. Prof Alford is a distinguished Chinese law expert at Harvard, where Prof Yu obtained his master's degree in 1991 and SJD in 1995. After completing his studies, Prof Yu worked as an associate at a law firm in Chicago for three years before embarking on a career in academia. He briefly held teaching positions at Peking University and Harvard, and then spent over a decade teaching and researching at the Chinese University of Hong Kong. From 2012 to 2022, he served as the Anthony W. and Lulu C. Wang Professor in Chinese Law at Cornell Law School.

In August 2022, Prof Yu joined UM as a chair professor in the Faculty of Law (FLL). He was appointed director of IAS two months later, in October of the same year. His extensive publication record includes several influential works, including *Rule of Law and Civil Orders, Legal Pragmatism in the PRC,* and *Modern and Postmodern in Jurisprudence.*

The Moral Foundations of Law

With experience in jurisdictions following different legal systems, Prof Yu has developed a multifaceted perspective on jurisprudence. 'Many Western scholars study China as research material, but I see China as an object of study. I believe that China's millennia-long moral-driven civilisation contains elements of thought that have universal significance and could be applied to improve modern society.'

Indeed, for decades Prof Yu worked towards developing an ideal social framework to achieve a harmonious balance between law and morality. as well as intellect and reason. 'The foundation of law should be moral principles,' he says. From his observation, modern Western societies and the contemporary world in general are dominated by a culture that prioritises rationality, rules, and individual rights. In contrast, while ancient China also emphasised rules, it placed greater importance on human relationships, or the concept known as 'guanxi' in Chinese. 'Despite negative connotations of unfairness in certain contexts, "guanxi", in its essence, refers to emotional connections between people, such as those between family members and friends.' he adds. From his perspective,

人物專訪 • EXCLUSIVE INTERVIEW

emphasising human relationships and emotional needs is increasingly vital in a rationality-dominant and rule-of-law society.

Fostering Interdisciplinary Research at UM

Before joining UM, Prof Yu visited the campus twice to speak at seminars, and he has since been impressed by UM's vision and steps in fostering interdisciplinary research. Now as the director of IAS, he is leading the creation of a university-level research platform that transcends faculty boundaries. This involves establishing an internationally renowned interdisciplinary research team at UM and enables synergistic academic resource deployment. In FLL, he has been contributing to the development of a new English-taught bachelor of law programme in Chinese law and global legal studies.

Furthermore, Prof Yu is working on a book that delves into the philosophy of the heart. Through his book, he seeks to provide comprehensive insights into society, law, morality, and human nature in a systematic manner. In doing so, he aims to envision a social framework that recognises and nurtures our emotional needs. 'I believe in the indomitable power of the human mind, which remains unparalleled by machines. This belief in human values is something everyone should uphold, and it has been the driving force behind my academic pursuits,' he says.



於興中教授 (右) 於2022年在澳大主持一場關於數字素養的講座 Prof Yu Xingzhong (left) hosts a talk about digital literacy in UM in 2022

52



袁毓林:研究語言學的終極性走向 是人文關懷

Yuan Yulin: The Ultimate Goal of Linguistics Research is to Benefit Humanity

文 / 張愛華·圖 / 何杰平,部分由受訪者提供·英文翻譯 / 關詠琪

Text / Ella Cheong · Photo / Jack Ho, with some provided by the interviewee · English Translation / Winky Kuan

2022年初,袁毓林從北京大學應聘到澳門大學,出 任中國語言文學系主任、講座教授。這位語言學研 究領軍者來到系裡的第一感想是:「中文系學術基 礎紮實。假以時日,我們在中國語言文學研究領域 會產生積極影響,贏得應有的學術地位。」研究語 言學30多年,袁教授認為研究語言學應該有一個宏 大的理想,「那就是走向終極性的人文關懷」。

不學自然科學,無以研究語言

袁毓林教授的本科、碩士和博士學位均在中文系攻 讀。他在1990年北京大學文學博士學位畢業後,曾 在北京大學和清華大學的中文系任教約25年。與中 文淵源深厚的他小時候卻對機械發明感興趣,夢想 長大後成為發明和製造機器的人,而非語言學家。 出身農村又受時代和家庭的條件限制,袁毓林沒有機 會學習科學技術方面的專業。1978年考入江蘇師範學 院修讀語言學,使他可在一個離自然科學較近的人文 科學領域中關注和學習自然科學的有關理論和方法, 並運用到語言研究中。袁教授笑言:「我覺得這是不 幸中的萬幸,感到這些年來沒有虛度年華。」

虚度年華只是袁教授的謙虛之辭。事實上,他一直 刻苦鑽研,博覽群書,將語言學和自然科學融會貫 通,提煉升華。他在句法學、語義學、語用學等 範疇下過的苦心,足以讓其在這些領域佔有重要一 席。他著有《漢語語法研究的認知視野》《漢語詞 類的認知研究和模糊劃分》《漢語句子的焦點結構 和語義解釋》等10多本具影響力的著作,還入選教 育部「長江學者特聘教授」和第三批國家「萬人計 劃」哲學社會科學領軍人才。

上世紀,國外知識界喊出口號:語言學是當代人文 科學的領先科學。袁教授認為,這主要是因為語言 學研究深受自然科學影響,形成了數理語言學、計 量語言學、計算語言學、神經語言學、心理語言 學、認知語言學、病理語言學等大批跟自然科學密 切相關的交叉學科。「古人說『不學詩(經),無 以言』;對語言學來說,可能是『不學自然科學, 無以研究語言』。」

學術生涯的指路明燈

袁教授與自然科學邂逅於1981年,當年他不到20 歲,正在江蘇省昆山縣千燈中學當老師。「我從 學校圖書室借閱了《控制論——或關於在動物和機



袁毓林教授的部分著作 Some of Prof Yuan Yulin's publications

人物專訪 • EXCLUSIVE INTERVIEW

器中控制和通信的科學》,其概念與論述令我異常 著迷。」他讀碩士時又學習了「老三論」(資訊理 論、控制論、系統論)的各種文獻,「當年我在認 識資訊的本質屬性時,逐漸確立起從通信與控制的 角度思考的思維態度。」可以說,計算的種子已悄 悄落在年輕的袁毓林心中,只待時機汲取更多營 養、生根發芽。

讀博士期間,袁毓林參與各種有關「人工智慧的哲 學基礎」討論班,並開始從電腦理解自然語言的角 度研究名詞的配價(Valency,也稱論元價位,是一 個語言學術語,主要用於說明一個動詞能支配多少 種不同性質的名詞性短語的數目,之後又拓展到形 容詞和名詞領域。)問題。這時,袁毓林還反複閱 讀了司馬赫(Herbert Simon)的《人類的認知》。

從此,袁毓林接受了一種符號主義的認知觀。他曾說, 在其多年的語言學研究中,符號主義認知心理學理論觀 點一直是其學術生涯的指路明燈,這種心智哲學解釋了 為甚麼他總要把語言的認知研究跟計算分析綑綁一起。

研究語言學的宏大理想

袁教授的研究體現了語言學研究的創新和跨領域獨 特性。他所著的《語言的認知研究和計算分析》嘗 試從認知科學的角度研究語言的結構方式和語義理 解的心理機制,並加以計算分析,以探索語言研究 怎樣為計算機理解自然語言提供恰當的方法和規 則。他說:「人的心智過程可理解為符號處理的計 算過程,而人的語言理解過程也可理解為一種在知 識表示上的計算過程,這使電腦理解自然語言在技

54

術上具可能性。因此,對語言的認知研究的一個自 然延伸,就是對語言的計算分析。」

既有紮實自然科學理論基礎,兼備人文學科素養的袁教 授始終堅持初心——研究語言學應該有一個宏大理想, 就是走向終極性的人文關懷。「作為人類種系,我們要 思考的是:人類是甚麼?我們人類從哪裡來?將要到哪 裡去?那麼,這些問題跟語言和 語言研究又有甚麼關係?當然有 關係。」

袁教授認為,通過語言研究,可 以更清楚了解人在世界或宇宙的 位置,更透徹地理解人的本質。 「這應該是一個根本性的哲學問 **題。一般認為,人之所以為人,** 是人有思想,會思考。而思維, 至少抽象思維,是離不開語言。 正如語言學家喬姆斯基(Avram Noam Chomsky)所言:思想所 用的概念跟詞語的意義,基本 上是同一回事。這樣,從語言 及其意義來看人類思維、看人 **類何以為人**,就有了切實的基 礎。因此認知科學界有句話: 語言是洞察人類心智的視窗。 語言是人類的標配,自然也是 認識人類的一個視窗。」

語言文字是民族的文化基礎

中國語言文學系(中文系)是澳 大最早建立的學科之一,學科相 對完備、師資較為雄厚、教學體 制完備、學風嚴謹開放。袁教授 說:「我們的教研團隊不大,但 老師大都來自海內外著名大學,學術基礎紮實,都有一 番努力在自己的專業創出成就的雄心壯志。」

袁教授認為,中文系師生通過對中國語言文字的研究 可更全面地了解國家的語言文字及其歷史沿革。「語 言文字是一個民族的文化基礎,尤其在今天的資訊 時代,語言文字的資訊化和電腦自動處理,都需要對 語言文字進行系統而精深的研究。」來到澳大後,袁 教授已積極建立研究團隊,並與澳大其它學系緊密合 作,計劃展開一些交叉學科的研究,例如面向可解釋 人工智能的語義推理模式與機制研究。

在2022年3月澳大語言學研究中心成立典禮上,袁教 授以《形容詞的極性程度意義及其完句限制條件》 為題在澳大主持其首場學術講座,談及人類感覺機 理對於語言中形容詞的意義和用法的影響。

中文系要建立的文化品格

對於澳大中文系治學和育人的目 標,袁教授提出建立「脫俗 求真、審美向善」的文化品格; 要培育中文人具備的「斯文 少年、博雅君子」的精神氣質, 「文化界常用『斯文在茲』來說 明培育青年人的最大的文化力量 在於『斯文』,在於道德人格的 自我完善。因此,我希望中文系 學生親近知識、培養人文情懷、 塑造健全人格、尊重生命和人格 尊嚴、進而探究和認識人類世 界的豐富性、生存意義和人生價 值。這些應該是中文人從內心深 虑透出的一種精氣神,也是我們 中文系畢業的學生行走於天地之 間的文化資本。」

教研之餘,袁教授幾乎用所有時 間博覽群書,積累了大量不同學 科的知識。他還為中文系學生列 出書單,平時閱讀到好的文章, 也會轉發給所有學生。「閱讀首 先是帶著興趣和求知的心態去 讀,再用批判性的眼光審視,形 成自己的見解。」

袁教授強調,學好關於中國語言文學的系統知識,還 要深刻領會中國文化和中國文明的精神特質。「學生 必須一方面從中國看世界,了解世界有多大、多精 彩,不坐井觀天、夜郎自大;另一方面要從世界看中 國,將中華文明置於世界文明的大格局中,發現其優 長和不足,並在長時段的人類文明史和全球史的歷史 大視野中觀察和體認中華文明的價值,思考其未來走 向和重獲生機的途徑。」 In early 2022, Yuan Yulin, a leading figure in linguistics at Peking University, joined the University of Macau (UM) to serve as a chair professor and the head of the Department of Chinese Language and Literature. In his new role, he was immediately impressed by the strong academic foundation of the department. 'I believe that in time we will create a positive influence on the study of Chinese language and literature and will earn a good reputation in the academic community,' he says. With over 30 years of experience in linguistics research, Prof Yuan believes there is a greater cause behind linguistics research: 'The ultimate goal of linguistics research is to benefit humanity.'

Knowledge of Natural Science Crucial for Linguistics Research

Prof Yuan's academic journey has been inextricably linked to Chinese language and literature, the field in which he obtained his bachelor's, master's, and PhD degrees. After receiving his PhD from Peking University in 1990, he worked in the Departments of Chinese Language and Literature at both Peking University and Tsinghua University for a total of 25 years. Surprisingly, as a child, Yuan was interested in mechanical design and he dreamed of becoming an inventor and a mechanical designer, instead of a linguist.

Because of his rural background and the particular generation to which he belonged, Yuan did not have the opportunity to pursue an education in science and technology. In 1978, he enrolled in Jiangsu Normal College-Suzhou to study linguistics, a branch of the humanities with a strong resemblance to natural science. For this reason, despite being a student in the humanities, he was able to learn theories and methods of natural science and apply them in linguistics research. 'There is always a silver lining in life, and I feel my time was well spent over these years,' says Prof Yuan modestly.

Driven by his passion, Yuan studied hard and read widely, aiming to integrate his knowledge of linguistics and natural science. His research efforts in the studies of syntax, semantics, and pragmatics have earned him a prominent place in these fields. Today, he is the author of more than ten influential books, including *Cognition-based Studies on Chinese Grammar*, *A Cognitive Investigation and Fuzzy Classification of Word-class in Mandarin Chinese*, and *Focal Structure and Semantic Interpretation of Chinese*



對於澳大中文系治學和育人的目標,袁毓林教授提出「脫 俗求真、審美向善、斯文少年、博雅君子」。書法由該系朱 壽桐教授所寫。

Prof Yuan Yulin has proposed 'seeking the truth, appreciating goodness, developing an erudite temperament, and building a wealth of knowledge' as the culture of the Department of Chinese Language and Literature. The calligraphy in the photo was done by Prof Zhu Shoutong in the department. *Sentences*. He was awarded the prestigious title of Changjiang Distinguished Professor and was selected into the third batch of leading scholars in philosophy and social sciences in China's Ten Thousand Talents Programme.

Over the past century, academics outside China have considered linguistics a pilot field in the humanities. According to Prof Yuan, this is because linguistics research has been strongly influenced by natural science, which has given rise to a large number of interdisciplinary fields, such as mathematical linguistics, quantitative linguistics, computational linguistics, neurolinguistics, psycholinguistics, cognitive linguistics, and pathological linguistics. As an old Chinese saying goes, 'Without learning poetry, it is impossible to speak with elegance and fluency.' This statement can also be applied to linguists: Without knowledge of natural science, you will not be fit to pursue research in linguistics.

The Guiding Star of an Academic Career

Prof Yuan's encounter with natural science took place in 1981. He was barely 20 years old and working as a teacher at Qiandeng Middle School in Kunshan county, Jiangsu province. He borrowed the book *Cybernetics: Or Control and Communication in the Animal and the Machine* from the school library and was fascinated by the concepts and arguments introduced by the author. In his master's programme, he studied information theory, cybernetics, and systems theory. 'From the literature, I learned about the nature of information, which helped me establish my way of thinking from the perspective of communication and control,' he says. It was during this time that his passion for computation took root, and began to inspire his academic journey.

During his PhD studies, Yuan participated in seminars on the philosophical foundation of artificial intelligence (Al). He also studied valency of nouns from the perspective of computational natural language understanding (In linguistics, valency is a measurement that describes the number of different noun phrases that can be governed by a verb, and has then been extended to adjectives and nouns). Moreover, Yuan immersed himself in Herbert Simon's *Reason in Human Affairs*, which he read extensively.

It was from this point that Yuan started to develop a conception of symbolic cognition. He explains that

the theoretical perspectives of symbolic cognitive psychology have been the guiding star of his academic career and the common thread running through his years of linguistics research. Such a philosophy of mind also explains why he associates the cognitive study of language with computational analysis in his research.

Pursuing Linguistics Research for a Greater Cause

Prof Yuan's studies provide insight into the innovative and interdisciplinary nature of linguistics research. His book A Cognitive Study and Computational Analysis of Language explores the structure of language as well as psychological mechanisms of semantic understanding from the perspective of cognitive science. Through computational analysis, the book explains how linguistics research can provide appropriate methods and rules to realise computational natural language understanding. 'While the human mind can be understood as a computational process for symbol processing, the process of understanding human language can be understood as a computational process of knowledge representation, which makes it technically possible for computers to understand natural language,' says Prof Yuan. 'The computational analysis of language is therefore considered a natural extension of the cognitive study of language.'

Prof Yuan has attained a solid theoretical foundation in natural science and accumulated rich knowledge of humanities. He is passionate about research and remains true to his original belief that those pursuing linguistics research should do so for a greater cause - to benefit humanity by seeking answers to the most profound questions. 'As a human race, we should think about the following questions: What are human beings? Where do we come from? Where are we heading to?' he says. 'You may ask what language and linguistics research have to do with these questions. In my opinion, they are all related,'

Prof Yuan believes that linguistics research can provide a better understanding of not only humans' role in the world, but also their nature. 'This is a fundamental philosophical question. It is generally accepted that what makes humans stand out from all the living beings in the world is that they can think and have thoughts. And thinking, at least abstract thinking, cannot happen without language,' he says.



袁教授認為中文系師生通過對中國語言文字的研究可更全面地了解國家的語 言文字及其歷史

Prof Yuan Yulin thinks that faculty members and students in the Department of Chinese Language and Literature can gain a comprehensive understanding of languages in China and their evolution through research

'According to the renowned linguist Avram Noam Chomsky, the abstract ideas in our thinking process and the meaning of words are essentially the same things. This is why there is a saying in cognitive science that language is a window into the human mind. Language ability is part of the basic configuration of every human being, so it provides a pathway for us to learn more about humans.'

Languages are the Foundation of a Nation's Culture

The Department of Chinese Language and Literature is one of the first departments established at UM. The department features a well-established discipline, a strong faculty, a comprehensive pedagogical framework, and a rigorous and open academic atmosphere. 'Although our faculty team is relatively small, most of the faculty members come from renowned universities in China or abroad. They all have strong academic backgrounds and the aspiration to achieve success in their fields,' says Prof Yuan.

He adds that faculty members and students in the department can gain a comprehensive understanding of languages in China and their evolution through research. 'Languages are the foundation of a nation's culture. In today's information age, both the digitisation and automation process of language data require a systematic and in-depth understanding of human language,' says Prof Yuan, who formed a research team after joining UM and is working closely with other departments at the university to conduct interdisciplinary research, including a study

on semantic reasoning models for explainable AI and their mechanisms.

At the plaque unveiling ceremony for UM's Centre for Linguistics held in March 2022, Prof Yuan gave his first academic lecture at the university. Titled 'Polarity in the Semantics of Adjectives and Relevant Syntactic Conditions', the lecture discussed how human sensory mechanisms affect the meaning and use of adjectives in a language.

Cultivating the Cultural Character of Students in the Department

Prof Yuan proposes cultivating the cultural character of 'seeking the truth and appreciating goodness' in students of the Department of Chinese Language and Literature. He also believes that students in the department should 'develop an erudite temperament and build a wealth of knowledge'. The department hopes to achieve these goals through academic and research activities. Prof Yuan adds that members of cultural circles often consider knowledge as the key to nurturing young adults, as it can develop their moral character: 'For this reason, I hope our students will continue to absorb knowledge, cultivate humanistic qualities, refine their character, and respect life and dignity. I also hope that they will explore the richness of the human world, search for the meaning of existence, and eventually find the value of life.



袁毓林教授為澳大通識課程學生主講《語言表達的藝術面面觀》 Prof Yuan Yulin gives a talk on the art of linguistic expression to students in a general education course at UM

人物專訪 • EXCLUSIVE INTERVIEW

These are the inherent gualities of esteemed scholars in Chinese studies, and they provide the cultural capital for our students to explore the world after graduation,' he says.

When he is not working, Prof Yuan spends most of his time reading books, and he has accumulated a wealth of knowledge from different disciplines. He has compiled a recommended reading list for students in the department and often shares articles with them. 'We read because we are driven by our interest and curiosity. The next step is to examine the content with a critical eye to develop our insights,' he says.

To gain a comprehensive understanding of the Chinese language and literature, Prof Yuan stresses the importance of developing a deep appreciation for the unique characteristics of Chinese culture and civilisation. 'Students should consider two perspectives,' says Prof Yuan. 'Firstly, they should broaden their knowledge of the world and keep themselves updated on global events to avoid developing a narrow-minded perspective. Secondly, they should analyse Chinese civilisation in the context of global civilisation and compare its strengths and weaknesses. By observing and experiencing the value of Chinese civilisation through the lens of human civilisation and global history, students can identify how Chinese civilisation should evolve to regain its vitality in the future.'



RhsP在自水解前後的結構比較 Structural comparison of RhsP before and after autoproteolysis

腸道菌群戰: RhsP毒素在海鮮食物中毒的角色 Exploring the Gut Microbial Warfare:

RhsP Toxin in Seafood-Induced Food Poisoning

文、圖 / 周昶行 · 中文翻譯 / 葉浩男、校園記者梁鎮鴻 Text & Photo / William Chao·Chinese Translation / Davis Ip, UM Reporter John Leung

海鮮引致的食物中毒問題廣受關注,學界不斷研究其 根本原因。我們的團隊發現,一種由腸炎弧菌產生、 名為RhsP的毒素在海鮮引致的食物中毒上發揮了關鍵 作用。我們研究了這種毒素如何釋放毒性,藉此揭示 它如何協助細菌在人類腸道內為生存而戰和誘發腸胃 炎。這些發現讓我們更深入地了解食物中毒的原因, 或會有助日後開發新的藥物和療法。

RhsP:腸炎弧菌的武器

腸炎弧菌常見於沿海水域和海產,尤其是扇貝、生蠔 和牡蠣等有殼海產,在夏季和秋季最為活躍。這種細 菌很容易經海產和海水進入人體腸道,在腸道內繁殖 和攻擊周圍的微生物。

腸道有大量微生物,包括種類繁多的細菌。這些微生 物統稱腸道菌群,其生態平衡一旦打破,往往會導致 各種健康問題,包括消化能力下降、免疫系統減弱和 慢性病風險增加。

進入腸道後,腸炎弧菌如何攻擊其它微生物?在腸炎 弧菌的基因組中,我們發現了一種名為RhsP的蛋白 質毒素。它擁有一個具1,381個氨基酸大結構,分子 量為157kDa(千道爾頓,一個經常用於表示蛋白質 等生物大分子的分子量的單位),是一種多態性毒 素, 能通過改變自身結構來釋放毒性。作為一種武器, RhsP能為腸炎弧菌創造出有利於在腸道內繁殖的條件, 也會導致腸道黏膜的炎症和損傷, 引起腹瀉和嘔吐等症狀。

自水解、二聚化和攻擊

我們的研究結果顯示,RhsP必須先經一個名為「自體 蛋白質水解」(簡稱「自水解」) 的過程自我分解為 碎片,再經一個名為「二聚化」的過程,兩個為一組 地結合起來,成為「二聚體」RhsP。這些二聚體有助 於釋放C端毒素(稱為「RhsPC」)。RhsPC是一種 核酸酶,能夠降解腸道內的其它細菌的DNA,以此殺 滅這些細菌。

那麼,這種毒素又是如何被傳遞到其它細菌?我們的研究結果顯示,腸道弧菌通過其6型分泌系統 (T6SS)傳遞RhsP毒素。該系統由多個蛋白質組成, 它們共同發揮功能,擁有一個針狀結構。為了通過 T6SS傳遞到目標,C端毒素RhsPC會與T6SS的其中一 部分、一種名為VgrG2的蛋白質結合。如果腸炎弧菌 是一支軍隊,T6SS就是它的炮台,RhsP則是炮彈。

腸炎弧菌如何自我保護

腸炎弧菌為了防止自殺,它本身會產生一種名為 RhsPl的免疫蛋白,免受其產生的毒素所害。這種蛋

Food poisoning from seafood remains a concern to many and there is ongoing research into the underlying causes. Our team has found that a toxin called RhsP, produced by the bacterium Vibrio parahaemolyticus, plays a key role in seafood food poisoning. We have studied the mechanism of this toxin and how



RhsP毒素通過自水解分解成三個片段 RhsP toxin autoproteolyses into three fragments 白質會與RhsPC結合,形成「RhsPC-RhsPI毒素-免 疫蛋白複合體」,通過與RhsPC核酸酶的活性位點發 揮相互作用,中和毒素的毒性。

揭示新的蛋白質結構

憑藉全球領先的第三代同步輻射光源裝置「中國科學院上海同步輻射光源」的支持,我們利用X射線晶 體學技術揭示了「RhsPC-RhsPI毒素-免疫蛋白複合 體」的原子結構,並且詳細了解RhsPI免疫蛋白如何 保護腸炎弧菌抵禦RhsPC的毒性。這是首次在澳門 利用X射線晶體學揭示新的蛋白複合體結構。

此外,我們與中國科學院廣州生物醫藥與健康研 究院研究員何俊博士的團隊合作,一同利用先進 的冷凍電子顯微鏡技術,揭示RhsP在自水解前 後的分子結構變化,以及這些變化所促成的二聚 化。這也是首次有澳門的研究機構使用冷凍電子 顯微鏡揭示新型蛋白質結構。這成果已於學術期 刊《細胞報告》發表。

揭示RhsP毒素傳遞機制的路徑

我們發現了二聚化是RhsP發揮毒性使腸炎弧菌得以攻 擊鄰菌的重要一步,但仍未了解背後原因,有待開展 進一步研究,分析RhsP二聚化到底是在腸炎弧菌內發 生,還是經T6SS傳遞至目標內時才發生。

it contributes to gastroenteritis by allowing the bacterium to compete for survival in the human gut. These findings lead to a deeper understanding of the cause of food poisoning and could be useful in developing new drugs and therapies.

60

RhsP: The Weapon of Vibrio Parahaemolyticus

Vibrio parahaemolyticus is a common bacterium found in coastal waters and seafood, especially shellfish such as scallops, oysters, and clams. The bacterium is most active in the summer and autumn months. It can enter the human intestine through the consumption of seafood or contact with seawater, where it multiplies and attacks neighbouring microorganisms.

The intestine harbours a variety of microorganisms, including a wide range of bacteria, which are collectively known as the gut flora. A sudden change in the balance of bacteria within the gut flora can lead to various health complications, such as impaired digestion, a weakened immune system, and an increased risk of chronic diseases.

How does V. parahaemolyticus attack other microorganisms after entering the gut? Our analysis of the V. parahaemolyticus genome has identified a protein toxin called RhsP. This protein, with a large structure of 1381 amino acids and a molecular weight of 157 kDa (a non-SI unit of mass used to express molecular mass, especially for large molecules such as proteins), is a polymorphic toxin that can change its structure. As a weapon, RhsP creates an environment that favours the proliferation of V. parahaemolyticus in the intestine, causing inflammation and damage to the intestinal mucosa with symptoms such as diarrhoea and vomiting.

Autoproteolysis, Dimerisation, and Attack

Our findings have shown that RhsP must first undergo a process known as autoproteolysis, which means breaking itself down into fragments. The fragmented RhsP then stick together in groups of two through a process known as dimerisation, forming RhsP dimers. The dimer favours the release of the C-terminal toxic (RhsPC), which is a nuclease that kills other bacteria in the gut by degrading their DNA.

How is this toxin transferred to other microorganisms? Our results show that V. parahaemolyticus delivers the RhsP toxin via its type 6 secretion system (T6SS). This system consists of several proteins that function together as a needle-like structure. For the C-terminal toxin RhsPC to reach its target, it needs to bind to one of the T6SS proteins, called VgrG2. One could compare V. parahaemolyticus to an army, with the T6SS serving as their cannons and the RhsPC toxin as the cannonballs.



「RhsPC - RhsPI毒素-免疫蛋白複合體」的蛋白晶體結構 The crystal structure of the RhsPC-RhsPI toxin-immunity pair



周昶行教授及其研究團隊 Prof William Chao with his research team members



RhsP毒素的自體蛋白分解促進其二聚化。這是RhsP發揮毒性,使腸炎弧菌得以攻擊鄰菌的必要一步。 Autoproteolysis of RhsP toxin can promote its dimerisation, which is a necessary step for prey targeting

The Self-Defense Mechanism of Vibrio Parahaemolyticus

To prevent committing suicide, V. parahaemolyticus produces an immunity protein called RhsPI to protect itself against its toxin. This RhsPI immunity protein binds to RhsPC and forms an RhsPC-RhsPI toxin-immunity pair to neutralise the toxicity by interacting with the active site of the RhsPC nuclease.

New Protein Structures Revealed

With the support of one of the most advanced third-generation synchrotron light sources in the world, the Shanghai Synchrotron Light Source of the Chinese Academy of Sciences (CAS), we used X-ray crystallography to determine the atomic structure of the RhsPC-RhsPI toxin-immunity pair and gain a detailed understanding of how the RhsPI immunity protein protects against the toxicity of RhsPC. This discovery marks the first case where X-ray crystallography has been used to determine a new complex protein structure by researchers based in Macao.

周昶行是澳大健康科學學院副教授,擁有牛津大學生物化學本科/碩士學位、倫敦癌症研究院哲學博士學位。他運 用結構生物學技術來研究基本的生物學過程,聚焦領域包括細胞分裂、染色質結構和表觀遺傳學。

William Chao is an associate professor in the Faculty of Health Sciences at UM. He holds a PhD from the Institute of Cancer Research in London, and an MBiochem from the University of Oxford. He applies structural biology techniques to study fundamental biological processes, particularly in the areas of cell division, chromatin structure, and epigenetics.

「學術研究」為投稿欄目,內容僅代表作者個人意見。

Articles in the Academic Research column were submitted by UM scholars. The views expressed are solely those of the author(s).



In addition, we collaborated with the team of Dr He Jun, a researcher at the Guangzhou Institute of Biomedicine and Health of the CAS, to use advanced cryo-electron microscopy techniques to reveal the structural changes and dimerisation of RhsP caused by autoproteolysis. This is also the first time that a Macao-based research institute has used cryo-electron microscopy to determine a new protein structure. These findings were published in the journal Cell Reports.

A Path to Unravel RhsP Toxin Deliverv Mechanism

While our results have shown that RhsP dimerisation is a crucial step for V. parahaemolyticus to target its neighbours, the reason for this is still unclear. Further studies are needed to determine whether dimerisation occurs before RhsP is delivered via the T6SS or after the toxin has reached its target.





這些圖表顯示了二維和三維材料內的極子的試驗變分波函數、自陷態電位、能量和尺寸 These graphs show the trial variational wavefunction, self-trapping potentials, energy, and size of polarons in 2D and 3D materials.

極子研究開拓二維材料潛能 Polarons: A Key to Unlocking the Potential of 2D Materials

文、圖 / 蕭詠康 · 中文翻譯 / 葉浩男 Text & Photo / Sio Weng Hong · Chinese Translation / Davis Ip

二維材料早已引起科學界和工業界廣泛關注。為進一步探索這些材料的應用潛力,我們在澳門大學和德克 薩斯大學奧斯汀分校的團隊提出了新的理論框架,有助深入理解二維結構內的極子如何形成,以及認識二維結構和三維結構內的極子之間為何如此不同,期望藉此進一步推動這些材料在不同領域的新應用。

電子與聲子互動或引致材料變形

本研究項目是我與德克薩斯大學奧斯汀分校物理系的 Feliciano Giustino教授共同完成。「極子」這個概念 最早由蘇聯物理學家Lev D. Landau(1962年諾貝爾 物理學獎得主)在1930年代提出,在1950年代首次 在實驗時觀察出來。多年來,極子研究方面的發現 大大推動了光催化、發光二極管和太陽能採集等方 面的科技發展。

要深入了解我們的理論框架,必須先認識何謂極子。 你可以想像自己是一粒電子,正準備穿越一個由數萬 粒原子組成的晶格。進入這個結構後,你發現周圍的 原子都會微微搖晃,從而產生了一些像漣漪般的振動 規律。這些振動稱為「聲子」。 不久,你開始與這些聲子產生互動(稱為「電子一 聲子相互作用」)。當你們的互動非常強烈時,你 發覺自己變得笨重,因為一團聲子已經將你包圍起 來,而且跟你一起前行,使你和這團聲子共同看起 來像一粒大型的粒子。特別的是,現在你們還能使 周圍的晶體結構變形,從而影響材料的物理特性。 這種電子和振動之間的強烈相互作用稱為「電子極 子」,是極子的其中一種,會使電子的行為有別於 與在完美晶體內的正常自由電子。

極子這現象就像你在一棟建築物內行走時遇到一群好 友,然後他們決定圍著你一起走,這使你們共同獲得 一種能力,能使身處的建築物的結構變形。換言之, 極子不是一種基本粒子,而是一個概念,所指的有如 你與這些朋友之間的緊密互動,並非任何一人。

在某些情況下,一個極子會被「困在」材料內某處 (即處於「自陷態」)。處於自陷態的極子能改變 材料特性,包括調節其導電性、導熱性和帶重整化, 其影響比帶狀電子的影響更大和更穩定。

極子研究新框架

科學家研究極子已近一個世紀,但描述和預測極子的 行為依然非常困難,主要因為早期發展的極子理論是 建基於相對簡單的數學模型。事實上,研究極子及相 關材料變形時往往要描述成千上萬的原子和電子,對 一些現代的超級電腦來說也非易事。

為了填補相關的理論空白,我們提出了一個通用的 理論框架,計算二維和三維材料內與「電子一聲子 相互作用」有關的電子特性和結構特性。此外,我 們闡述了電子與聲子在遠距離互動時的分析形式 (即一些數學表達式)。

基於這個新框架,我們還提出了一個用來模擬二維材 料內的極子的新計算模型、以及一個用來預測這些材 料內處於自陷態的極子的基態能量(即極子在材料內 可佔據的最低能量狀態)的數學模型。

觀察白色石墨烯的極子

我們關注的二維單層材料與大多數人比較熟悉、有長度、闊度和高度的三維材料不同。它們的高度(也可 視為厚度)通常只有一粒原子。近年來,科學家在研

學術研究 · ACADEMIC RESEARCH

究三維材料內的極子方面突破不斷,但對二維材料內 的極子依然知之甚少。

利用新的理論框架,我們首次在一種名為「白色石墨 烯」(科學名稱為「六方氮化硼」)的二維材料內觀 察到一種「弗洛里希空穴極子」(一種以帶正電的空 穴為核心的極子),並確定了它的真實空間結構。這 種材料有類似蜂彙結構的重複幾何形狀,擁有獨特的 性質,可用於化妝品和人造衛星內的潤滑劑等。

電腦模擬二維材料

研究二維材料內的極子時,經常要在電腦模擬這些材 料。我們提出的新計算方法克服了一個稱為「庫倫發 散」的問題,可以準確描述各種二維材料內處於自陷 態的極子的幾何細節,並且計算其半徑和基態能量。

此外,我們提出了一個數學模型,憑三個獨立因素 (分別為電子的有效質量、二維材料的有效厚度、二 維材料的離子介電屏蔽)便可計算出二維材料內的電子 會否轉變為處於自陷態的極子,以及計算相關過程。

利用摻雜物開發新材料

在二維材料內,缺陷和摻雜物通常有助促進極子的形 成和進入自陷態,以及顯著影響極子的行為。我們相 信,這些新的框架和模型可能有助物理學家控制極子 的穩定性、流動性和其它特性,使他們得以更精確地 改變材料的性質,包括以利用材料內的本身缺陷或加 入摻雜物,從而開發特製的二維材料。

模擬10萬粒原子驗證成果

為驗證這些發現,我們需要模擬最多10萬粒原子的 情況,最終以德克薩斯大學奧斯汀分校Lonestar 6 超級電腦和數千個中央處理器核心完成。中國呂梁 雲計算中心和德克薩斯大學奧斯汀分校德克薩斯高 級計算中心亦為此項目提供計算能力。相關論文已 於《自然一物理學》期刊發表,題為「二維原子晶 體內的極子」。

人類不斷追求更小、更快的設備和材料,二維材料 內的極子正是其中一個潛力無限的研究領域。這驅 使了我們開展這項研究,也將激勵我們繼續開發新 的理論和計算方法。



本圖顯示了块體(即三維)的白色石墨烯的球桿模型;硼原子和氮化物原子分別以綠色和藍色標示。

This picture shows a ball-stick model of bulk (3D) white graphene, where boron and nitride atoms are visible in green and blue respectively.

2D materials have gained widespread attention in both the scientific community and industry. To tap into the potential of these materials, our team at the University of Macau (UM) and the University of Texas at Austin (UT Austin) has proposed a new framework to understand how polarons form in 2D crystals and why they are so different in 2D and 3D structures, seeking to advance novel 2D applications in different fields.

Interactions between Electrons and Phonons May Deform Materials

This research project is a collaboration between me and Prof Feliciano Giustino in the Department of Physics at UT Austin. The concept of polarons was introduced in the 1930s by the Soviet physicist Lev D. Landau, who won the Nobel Prize in Physics in 1962. In the 1950s, polarons were observed experimentally for the first time. Over the decades, discoveries in this field have significantly contributed to advancements in photocatalysts, light-emitting diodes, solar energy harvesting, and beyond.

To comprehend our theoretical framework, it is necessary to understand what a polaron is. Imagine yourself as an electron, attempting to enter a crystal lattice comprising several tens of thousands of atoms. As you move freely around, you quickly realise that the atoms surrounding you are shaking gently, thereby generating some vibrational patterns like ripples, namely phonons.

Soon after, you start to interact with these phonons,

a phenomenon known as electron-phonon interaction. When these interactions are strong enough, you find yourself becoming much heavier because you are now accompanied by a cloud of phonons that moves together with you. This not only makes you and the phonon cloud look like a massive particle, but also gives you the ability to deform the surrounding parts of the crystal structure and alter its physical properties. The intense interaction between the electron and the vibrations makes the electron behave differently than normal free electrons in a perfect crystal, which is called an electron polaron - a type of polarons.

Polarons may be understood as a group of interacting particles that can change the properties of their host materials, rather than being a particular fundamental particle. They function much like when you walk inside a building, your friends surround and walk with you, and then your close interactions provide a collective power able to deform the building's structure.

In some cases, a polaron can trap itself, or become 'self-trapped', somewhere within the material's structure. A trapped polaron can alter material properties, including an ability to modify the conductivities of electricity and heat, renormalise band gaps, and become more profound and stable than band electrons.

A New Framework for Studying Polarons

Nearly a century since polarons were first studied, it remains challenging to describe and predict the behaviour of polarons, largely because early polaron theories were developed based on relatively simple mathematical models. In fact, studying polarons and the related deformation of materials can involve describing at least ten thousand atoms and electrons within a material, a task that even certain modern supercomputers would find difficult.

To fill this theoretical gap, we have developed a general theoretical framework that enables the computation of electronic and structural properties related to electron-phonon interactions in 2D and 3D materials. We have also clarified the analytical form, essentially a mathematical expression, of the interactions between electrons and phonons separated by long distances.

Based on this newly developed framework, we have

proposed a computational model for simulating polarons in 2D materials, and a mathematical model for predicting the ground state energy (the lowest energy state that a polaron can occupy in materials) of self-trapped polarons in such materials.

Observing Polarons in White Graphene

Our research focuses on 2D single-layer materials. They are basically flat structures that are usually only one atom thick, unlike 3D materials with which most people are familiar. In recent years, we have witnessed significant advancements in polaron research in 3D materials, but much remains to be uncovered about 2D materials.

Using our new framework, we have for the first time observed a type of Fröhlich hole polarons (a type of polarons with a positively charged hole at its core) in white graphene, a 2D material known scientifically as hexagonal boron nitride (h-BN), and have determined its real-space structure. It has a repeating geometric pattern resembling a honeycomb, as well as unique properties that make it a suitable material for cosmetics, lubrication for satellites and other products.

Computer Simulation of 2D Materials

Studying polarons in 2D materials often require computer simulation of these materials. Our new computational method can overcome a problem known as the Coulomb divergence. This allows us to accurately describe the geometric details of self-trapped polarons in different 2D materials, and precisely calculate their radius and ground state energy.

Furthermore, we have proposed a mathematical model that allows us to calculate whether and how an electron can form a self-trapped polaron in 2D



蕭詠康是澳大應用物理及材料工程研究院的澳大濠江學者,擁有牛津大學計算材料科學博士學位,研究聚焦極子與電子一聲子相互作用、材料科學的計算方法、凝聚態和電子結構理論,以及二維材料等。

Sio Weng Hong is a UM Macao Fellow in the Institute of Applied Physics and Materials Engineering at UM. He holds a PhD in computational materials science from the University of Oxford. His research interests include polarons and electron-phonon interactions, computational methods for materials science, condensed matter and electronic structure theory, as well as 2D materials.

「學術研究」為投稿欄目,內容僅代表作者個人意見。 Articles in the Academic Research column were submitted by UM scholars. The views expressed are solely those of the author(s).

學術研究 · ACADEMIC RESEARCH

material by considering only three factors, namely the effective mass of the electron, the effective thickness of the 2D material, and the ionic dielectric screening of such a material.

Using Impurities to Develop Novel Materials

In 2D materials, defects and impurities can significantly affect the behaviour of polarons and can sometimes promote the formation and self-trapping of polarons. We believe that our framework and models may enable physicists to control more precisely the stability, mobility, and properties of polarons in materials, so that they can alter the materials more precisely, by leveraging defects already in the materials, or intentionally introducing impurities to the materials. This will help them more efficiently develop 2D materials with tailored properties.

Simulating 100,000 Atoms for Validation

We validated this discovery with a simulation of up to 100,000 atoms. This task used thousands of CPU cores of the Lonestar 6 supercomputer at UT Austin. Essential computing power was also provided for this research by the LvLiang Cloud Computing Center in China and the Texas Advanced Computing Center at UT Austin. Our related research article, titled 'Polarons in Two-dimensional Atomic Crystals', has been published in *Nature Physics*.

As the quest for smaller and faster devices continues, polarons in 2D materials have emerged as a promising avenue with endless possibilities. That is what propelled us to conduct this research, and what continues to motivate us to develop new theoretical and computational methods.



學生在國情教育室觀看影視作品 Students watch a film in the national education room

以書院為家 心懷天下

Residential College — A Home for Worldly-Minded Students

文 / 劉京京 · 圖 / 紹邦書院提供 · 英文翻譯 / 蘇恩霆、葉浩男 Text / Liu Jingjing · Photo / Shiu Pong College · English Translation / Anthony Sou, Davis Ip

「昨天身體不舒服,還好有書院老師陪我去醫院。」

「書院的學長姐正在群裡解答選課的疑問呢,有不 明白的趕緊去問。」

澳門大學紹邦書院的學生微信群裡,經常會有這樣 的對話。在書院食堂、教室、中庭總會看到老師和 同學們的身影,或開心大笑,或認真討論。這種氛 圍,正是紹邦書院想要帶給同學的家的感覺。

追求「家」的味道

書院是澳大實踐社群教育理念的地方,為何要追求「家」的味道?這當然不只是因為同學們食住於此,它更蘊含了書院的教育理念。

無可否認,從中學進入大學,絕非求學之路上的最 難一關,大學學業是更甚一層的艱辛。 每個學生都在為自己的未來積蓄力量,也體驗著愈加 複雜的生活。在這一過程中,疲憊、挫折、膽怯、自 責、悲傷等……難以避免。若每逢此黯淡時刻,年輕 人只能獨自咬牙承受,那在他們心中所積累的,便不 是對未來的信心,而是對社會的不滿了。

我們希望學生回到書院之時見到同學和老師就像見 到家人,可以感受到關懷與溫暖,化解所有負能 量,砥礪前行。與此相伴,大學時光也必然少不了 各種快樂,諸如學業有成、技能提升、結交好友等 等幸福的滋味,也都可以在書院裡和師友分享,彼 此祝福,眾樂之樂,其樂無窮。各式各樣的文娛運 動設施,食堂傾情烹飪的美食,更可助同學勞逸結 合,釋放壓力,重新充電,再赴征程。

當然,要實現上述景象並不容易。同學們也不應只 是「關愛」的接受者,更需要學會成為可靠的伙 伴、堅實的臂膀,這是他們未來人生的關鍵所在。 高速發展的當代社會,固然物質極大豐富,但也容 易將一個個鮮活的生命變成一粒粒孤單的原子, 在高速運轉的社會機器中各自為戰。每一個年輕人 都應努力打破環境的約束,與他人建立積極正向 的連接。不管是家人,還是隊友,都能建立心靈的 契合,互相支持,彼此關懷,維護好愛與情感的紐 帶。如此,社會方能真正和諧,個人也更容易體會 到生存的意義。

「家」更是成長的基地

由此可見,書院不只是避風的港灣,更是成長的基 地。自2014年8月成立以來,紹邦書院經過多年的 探索和實踐,逐漸形成了有自己特色的學生成長模 式。其中的核心是一系列長期性體驗式學習項目, 例如,幫助學生提升英語交流能力的英語桌、在團 隊合作中陶冶藝術氣息的合唱團、引導學生踐行愛 與關懷的築夢小隊、鍛煉批判性思維和表達能力的 慧言堂,以及學習如何待人接物的學生大使等等。 這些項目通過每週至少一次的規律性活動,日積月 累,幫助學生在行為、態度和品格上獲得切實的成 長。此外,各式講座、院生會活動、樓層活動、興

'I wasn't feeling very well yesterday, but luckily, one of the residential fellows accompanied me to the hospital.'

'Upper-level students in the chat group can answer your questions about course selection. Don't hesitate, just ask away.'



供學生舒緩心理壓力的心靈小棧 A space for students to relieve their stress

書院發展 · RC DEVELOPMENT

趣小組等其它活動則通過靈活多樣的形式,為學生 提供全方位發展的鍛煉機會。

近年來,紹邦書院為學生提供的學術關懷日趨強化。 畢竟,學有所成,是我們對每一位學生的期待。因此,我們不斷把更多的書院空間佈置成設施齊全、氛 圍向上的自習室,讓同學們有更方便的溫書環境。每 到期末,這些空間就成了勤奮學子聚首的地方。高年 級的學長姐們也會把自己的學習筆記在這裡分享,還 有熱心的教授來給同學答疑。

在這一系列成長機會中, 紹邦書院尤其希望同學們 能心懷深厚的家國情。每逢學校在重要的日期舉行 升旗儀式, 院長和所有老師都會組織同學一同參 與。書院也積極通過參觀訪問、經驗分享、新聞觀 察等多元手段, 幫助學生了解國情世情, 熟悉中華 歷史文化, 強化國家的歸屬感、認同感和責任感, 無愧於國民的身份。

從「個人」到「家」,再到「國」,由己及人,心 懷天下,正是紹邦書院一直努力的方向。

Messages like the above often pop up in chat groups among students in Shiu Pong College (SPC) of the University of Macau (UM), which exemplify the homey atmosphere the college strives to create for its residents. Inside the college, SPC members enjoy both casual conversations and serious discussions, whether they are in the canteen, classrooms, or atrium.

每天都有學生在書院台球桌一較高下 Students compete at the college's billiard table

Creating a Homey Atmosphere

UM's residential colleges (RC) are a vehicle for implementing community and peer education. Unlike ordinary dormitories, the RCs strive to create a home-like environment that goes beyond mere living and dining on campus and embodies the essence of UM's educational philosophy.

There is no doubt that entering university is difficult for any student. However, the academic studies that follow are challenges on another level. Students must develop their strengths for the future while navigating an increasingly complex life, and this may lead to exhaustion, frustration, low confidence, self-doubt, or even sadness. Even though these feelings are common among university students, if left unaddressed, they can contribute to dissatisfaction with society rather than the confidence in a better future that we hope to instil in students through education.

In SPC, we hope students will think of the college as their second home, where they can find the care and



紹邦書院師生參與2022年國慶升旗儀式 SPC members attend a flag-raising ceremony for National Day 2022

comfort they need to cope with negative feelings. The college is also a place where students can share their joy from academic achievements, develop new skills, or make new friendships with fellow students and teachers. To help balance work and play, the college also offers a range of recreational and sports facilities, not to mention delicious food in the canteen. to help students relieve stress and recharge for their journey ahead.

Creating a residential college that feels like home is certainly no easy feat. To thrive, students need to become active partners and trusted allies rather than passive recipients of care and support, and this is crucial to their future success. In today's fast-changing and materialistic world, one often has to fight his or her own battles alone. That is why it is so important for young people to build meaningful relationships based on trust, support, and care for others, especially their family members and close friends. In this way, society may become more harmonious, and people's lives may become more meaningful.

A Home for Achieving Personal Growth

The RC provides more than a home from which to weather the storm; it also creates an environment conducive to students' personal growth. Since its inception in August 2014, SPC has developed its own approach to student development through years of exploration and experimentation. The college has implemented a series of long-term experiential learning programmes, such as the English Table, which develops students' English language skills; the Choir, which cultivates artistic expression through teamwork; the SPC Dream Building Team, which encourages students to volunteer; the Debate Team, which sharpens students' critical thinking and communication skills; and the Student Ambassador Team, which promotes respect and kindness towards others. Through weekly activities, these programmes aim to help students achieve concrete improvement in their behaviour, attitude, and character. In addition, the various lectures, floor-specific activities, House Association activities, and interest group activities available in the college also help to promote students' holistic development.

In recent years, SPC has stepped up efforts to provide support to help students achieve academic success. The college has transformed many of its premises



紹邦書院師生弘揚傳統中華文化 SPC members wear traditional Chinese clothing to promote Chinese culture

into well-equipped study spaces to create a positive atmosphere. Students occupy these spaces at the end of each semester when exams are approaching — upper-level students share their study notes and professors visit and answer students' questions.

Apart from personal growth, SPC hopes to foster in students a strong sense of belonging to their home and country. Whenever the university holds a flag-raising ceremony for an important day, teachers and students in SPC, led by the college master, attend the ceremony together. Moreover, the college organises visits, sharing sessions,



的老師,曾任公共政策記者,亦是澳大普通話辯論隊的教練組成員。

Liu Jingjing holds a PhD in biomedical sciences. He joined Shiu Pong College as a residential fellow in 2014 and currently serves as associate master of the college. As a dedicated educator, he constantly strives to develop new approaches to student development. Previously a public policy journalist, he is also a member of the coaching team for the UM Mandarin Debating Team.

「書院發展」為投稿欄目,內容僅代表作者個人意見。

RC Development is a submission column. The views expressed are solely those of the author(s).

澳大於2010年引入住宿式書院系統。書院作為多元文化與多元學科融會貫通的知識整合學習平台,致力培養學生具有公民 責任心、全球競爭力、知識整合能力、團隊協作、服務與領導、文化參與和健康生活的七項勝任力。 UM launched its residential college (RC) system in 2010 to create a multicultural and multidisciplinary learning platform for knowledge integration. RC education aims to cultivate seven competencies of students, namely responsible citizenship. global competitiveness, knowledge integration, teamwork and collaboration, service and leadership, cultural engagement, and healthy lifestyle

and discussions on current affairs for students to learn more about their country and the world and to familiarise themselves with Chinese history and culture, in order to strengthen their national identity and will to contribute to national development.

According to an old Chinese saying, 'Cultivate oneself, manage the family, govern the state, and bring peace to the world.' We hope that our students will learn to seek personal growth and benefits for their families and country. This is what we strive to instil in students in SPC.

京是生物醫藥學博士,2014年加入紹邦書院擔任導師,現任副院長。自我定位是一個永遠正在探索如何育人



住宿式書院系統網站 Website of the Residential College System



戶外攀岩訓練 An outdoor rock-climbing session

「給生命・生命」―體驗與生命之連結 曹光彪書院Me to We戶外領袖冒險計劃

Giving Life to Life — The Meaning of Experiential Learning Chao Kuang Piu College's 'Me to We' Outdoor Leadership Programme

文 / 鄭智明·劉潤東·圖 / 曹光彪書院提供·英文翻譯 / 蘇恩霆 Text / Cheang Chi Meng & Lau Yun Tung · Photo / Chao Kuang Piu College · English Translation / Anthony Sou

馬丁·路德·金說過:「智慧加上品格才是教育 真正的目標」。澳門大學住宿式書院教育透過體 驗學習模式創造知識整合的學習平台,致力培養 書院院生具備七大勝任力,既有卓越學業,也有 高尚情操和品格。

體驗學習不是口號,而是從實踐中引導院生反思並 提升自我、甚至發現更真實自己的過程。通過帶領 院生在符合國際標準及可控的風險評估與管理環境 中去探索、去冒險,院生能有效地把學到的知識融 入生活,並轉化成寶貴體驗。當院生能重視每一刻 的經驗,並珍惜從經驗中反思所得到學習機會,他 們就會獲得不一樣的人生感悟。

探索體驗與生命的體驗感悟

曹光彪書院的一項教育特色是Me to We (MTW)戶外 領袖冒險計劃,其核心價值為探索自然與生命,放 下身段成為僕人,並以體驗學習為基礎的「戶外教 育」。透過引導反思,院生學會用體驗學習模式來 解決困難與挑戰,再從得到的經驗學習及轉移,並 運用在日常生活。

戶外體驗教育有別於傳統的教學模式,能有效協 助院生在參與多元化戶外運動的同時,探索自我 與自然之連結。在自然界中,各種動植物的一動 一靜,都是為了適應環境。從體驗大自然,到觀 察大自然,從中發掘自然界的生動故事,讓院生 從這些細節學習評估環境,學習並加強自身能力,運用創新與改革,面對大氣候的挑戰,並發展院生的領導才能、人際互動合作、解困能力與抗逆力,鍛煉意志及堅毅的精神,藉以檢視自我效能,提升自信與自我價值。

我們也透過自然探索,學習風險評估與管理。例 如繩索挑戰,院生學到把每一件單獨的裝備組合 起來,形成一個系統,透過高規格的風險管理與 正確使用系統,有效並安全地去面對不同的任務 與難關。我們的生命也正是如此:把時間管理、 情緒控制、成就動機、社交領導、自信心、主動 積極組合成生命的運作系統,在可控的風險下發 揮生活中的最大效能。

MTW在建立團隊,鼓勵院生勇於挑戰自我的同時,強調「服務與世界公民意識」,催化院生關注 更多國家與社會需求。書院十分重視教育本質的價 值,希望讓院生看到「人,是寶貴與有價值的」。 「我們不需要做轟轟烈烈的大事,只要在每件小事 中看顧到別人,真正發揮從我到我們的意義,並以 行動回饋社會。」

生涯中的「跨越與面對」

MTW十分重視院生的生涯規劃,強調勇敢跨越舒適 圈的勇氣,並引導院生學懂如何透過「持續性的勇 氣」來面對跨越舒適圈後的生涯挑戰。

一位MTW團隊學員在攀岩課後的自我反思:「感 覺攀岩也可以看作是一個人的生涯,未來就像是從



獨木舟訓練 A canoe sessior

曹光彪書院的Me to We戶外領袖冒險計劃推行以體驗學習為基礎的戶外教育 The 'Me to We' outdoor leadership programme at CKPC emphasises outdoor education based on experiential learning

未接觸過的攀岩場及裝備,充滿了新奇、刺激以及 未知的恐懼,它會有不同線路、不同難度,也可能 遇到不同天氣,我們會在開始攀爬前做好準備,找 到工具(朋友)來幫助自己,也會提前選擇一條適 合自己的路線。當我們開始爬時,難度會跟設想的 有些不同,但我想要繼續向上,想要看見同體會更 多,就會不斷思考,不斷調整,聽取他人的意見。 可能我們一下,去勇敢突破,會感覺很累或者害怕, 這就像是生涯中可能遇到的困難挫折。我們可以稍 微休息一下,去勇敢突破,也可以慢慢後退,認真 思考反省後再次嘗試爬得更高。當我們不斷突破甚 至爬到最高,這會是人生中的一個小高峰。除此之 外,還有更多的高峰等著我們去挑戰,生涯是會有 不同階段及可能性的。」

「給生命·生命」

戶外體驗教育先驅謝智謀教授曾說:「透過體驗教 育,讓我們更像人。」

專業戶外教育指導員建立高規格的風險評估與管 理機制,創造可控的冒險元素,讓院生在看似「危 險」的戶外探索活動中實踐,並引導院生一起作反 思。反思的議題包括:舒適圈的擴張、自我認知、 鼓勵與陪伴、服務與擔當、領導與被領導、成功與 支持、我與團隊、文化共融、身體適能的認知、公 民責任等等。透過引導反思學習,院生就這些議題 把經驗轉化到生活中。比起單單坐在課室裡學習, 體驗教育能夠有效地讓院生產生感悟,這種感悟也 是「給生命,生命」的過程。



曹光彪書院院長劉潤東和導師鄭智明帶領學生走進大自然 CKPC College Master Lau Yun Tung and Resident Fellow Cheang Chi Meng lead students to explore nature

Martin Luther King Jr said: 'Intelligence plus character, that is the goal of true education.' In its residential colleges, the University of Macau (UM) created a platform for knowledge integration based on experiential learning, which strives to cultivate in students seven competencies to inspire them to attain academic excellence as well as high moral character and integrity.

Experiential learning is not a slogan, but a process of reflection, self-improvement, and self-discovery through practice. By exploring different possibilities in a controlled environment of risk assessment and management that meets international standards, students can effectively integrate what they have learned into their lives and transform it into valuable experience. If students value their experience and cherish the learning opportunities they receive through reflection, they may gain a different perspective on life.

Exploring the Connection between Life and Experiential Learning

The 'Me to We' (MTW) outdoor leadership programme is a highlight of the residential college education at Chao Kuang Piu College (CKPC). With an emphasis on outdoor education based on experiential learning, the MTW programme aims to encourage students to explore nature and life and serve others. Through guided reflection, students learn to use the experiential learning model to solve problems and challenges and transform their experiences into practical knowledge in their daily lives.

A departure from the traditional education model, outdoor experiential education can effectively help students explore their connection to nature as they participate in different outdoor sports activities. In nature, plants and animals develop different habits to adapt to their environment. By observing nature and discovering its vivid stories, students learn to evaluate the environment based on details and apply their creativity and innovative ideas to tackle challenges in different circumstances. They can also develop leadership skills, interpersonal skills, and problem-solving skills; build their resilience, willpower, and grit: examine their self-efficacy; and enhance their self-confidence as well as self-worth.

By exploring nature, students also acquire risk assessment and management skills. For example, in a rope challenge, students have to form a system using equipment to effectively and safely tackle various problems. The process involves high-level risk management skills and proper usage of the system and is analogous to how we achieve goals in life: combining skills of time management, emotional management, and social leadership with the need for achievement, self-confidence, and proactivity into a functional system that can maximise our performance under controlled risk conditions.

While building a team to encourage students to challenge themselves, the MTW programme also emphasises 'serving others and becoming global citizens' to bring about greater awareness among students of national and social needs. The college attaches great importance to the essence of education and hopes to show students that 'human beings are precious and valuable'.

Leaving the Comfort Zone and Facing Life Challenges

The MTW programme also emphasises life planning for students and encourages them to summon the courage to leave their comfort zones and overcome various life challenges.

'I feel that rock climbing and life are similar in some way,' says a member of the MTW programme after a rock-climbing session 'Our future is like a climbing wall or equipment that we have never met before, full of excitement and mysteries. There are different routes and different levels of difficulty, and we may encounter different weather conditions. Before climbing the wall, we must get ourselves ready, find the right tools (friends), and pick a route that suits us.'

'During the climb, we may find that the route is different from what we thought. However, as we want to keep going up and see more, we will reflect on our performance, adjust, and take the advice of others. We may feel tired or scared when we reach the middle point, which is like a difficult setback that we may encounter in our lives. At this time, we can choose to take a little break, continue forward, or take a step back and reflect on our performance before trying to climb higher,' he adds. 'As we make breakthroughs or when we reach the top, we will know that our efforts have paid off and are meaningful. This is a small peak in our life journey, and there are many more peaks ahead waiting for us, as there are always different stages and possibilities in life.'

Giving Life to Life

Prof Hsieh Chih-Mou, a pioneer of outdoor experiential education, once said: 'Experiential education makes us more human.'

Professional outdoor education instructors are responsible for developing risk assessment and management mechanisms with controllable elements of adventure to guide students in their



續成長。

Dr Lau Yun Tung is the college master of CKPC and a professor in the Faculty of Science and Technology. He leads a team of resident fellows and administrative staff to inspire lifelong learning, innovation, and continuous growth in students.



追逐夢想,讓他們知道自己有無限潛能。

Dr Cheang Chi Meng (Mike) is a resident fellow of CKPC and has been an educator for 28 years. He hopes to use elements of experiential learning and outdoor education to help young people pursue their dreams and let them know they have unlimited potential.

「書院發展」為投稿欄目,內容僅代表作者個人意見。

RC Development is a submission column. The views expressed are solely those of the author(s).

澳大於2010年引入住宿式書院系統。書院作為多元文化與多元學科融會貫通的知識整合學習平台,致力培養學生具有公民 責任心、全球競爭力、知識整合能力、團隊協作、服務與領導、文化參與和健康生活的七項勝任力。 UM launched its residential college (RC) system in 2010 to create a multicultural and multidisciplinary learning platform for knowledge integration, RC education aims to cultivate seven competencies of students, namely responsible citizenship. global competitiveness, knowledge integration, teamwork and collaboration, service and leadership, cultural engagement, and healthy lifestyle



绷索挑戰 A rope challenge session

reflection. Topics of reflection include enlarging the comfort zone, self-awareness, encouragement and companionship, service, and responsibility, leading and being led, success and support, my team and me, cultural inclusion, awareness of physical fitness, and civic responsibility. Through guided reflection, students translate their experiences on these topics into practical life knowledge. Compared to learning in a classroom, experiential education is more effective in helping students gain insight into life, which is also a process of 'giving life to life'.

劉潤東博士是曹光彪書院院長和科技學院教授,帶領導師及行政團隊啟發學生終身學習、不斷創新和持

鄭智明博十是曹光彪書院駐院導師,從事教育工作28年,希望運用體驗與戶外冒險教育的元素,陪伴年青人



住宿式書院系統網站 Website of the Residential College System



澳門大登 UNIVERSIDADE DE MACAU UNIVERSITY OF MACAU

