IMMC 2022

第八屆國際數學建模挑戰賽

THE 8TH INTERNATIONAL MATHEMATICAL MODELING CHALLENGE

中華區域賽暨國際賽 答辯決賽

Greater China and International Finalist Presentation Competition

香港大學工程學院 承辦

Hosted by Faculty of Engineering of The University of Hong Kong

2022年4月22-23日

22-23 April, 2022

香 港 大 學 THE UNIVERSITY OF HONG KONG

Faculty of Engineering THE UNIVERSITY OF HONG KONG

IEEE

HKSIAM 香港工業與應用數學學會

儒蓮教科文機構 NeoUnion ESC Organization

中華國際數學建模挑戰賽委員會 IMMC Committee (Zhonghua)

國際數學建模挑戰賽
International Mathematical Modeling Challenge

國際數學建模挑戰賽(IMMC或者IM²C)於2014年創辦於波士頓，是一項面向全球中學生的國際性新型數學建模競賽，其創辦機構是美國數學及其應用聯合會和香港儒蓮教科文機構，競賽宗旨在於鼓勵參賽者應用數學建模探索和解決現實世界中的重要問題，以普及數學建模教育，增強中學生數學核心素養和科技創新能力。IM²C既是中學生數學建模實踐與歷練的舞臺，也是參賽中學數學與科技創新教育成果展示與交流的園地。

IM²C在中華賽區的主辦機構授權中華國際數學建模挑戰賽委員會，專門負責國際數學建模挑戰賽在中華區的評審與選拔等學術工作。中華國際數學建模挑戰賽委員會是經香港特區政府批准成立的公共性質慈善機構(慈善機構代碼91/14657)；主辦機構邀請各地區知名高校學者和專業人士組成學術顧問委員會及專家組，為區域內的青少年營建一個中華一體、普惠與共享的學習交流平臺，以學生為本，在地性與國際性相容。

International Mathematical Modeling Challenge (IMMC or IM²C), co-founded and co-sponsored by the Consortium for Mathematics and its Applications (COMAP) and NeoUnion ESC Organization (NeoUnion) in 2014 in Boston, is an innovative mathematical contest in modeling for secondary school students around the world. The IM²C aims to promote mathematical modeling education and enhance secondary school students' core competences in mathematics and innovation by encouraging its participants to explore the applications of mathematical modeling in solving significant real-world problems.

NeoUnion, the exclusive organizer of IM²C for the region of Greater China, authorizes the International Mathematical Modeling Challenge Committee (Zhonghua) to discharge the duties of adjudication, team selection, award decisions and other related academic affairs for the competition in the region. The IM²C Committee (Zhonghua) is a charitable institution of public character incorporated in Hong Kong SAR (charity certificate no. 91/14657). IM²C for the Greater China region is an inclusive platform for all secondary school students at both local and international level to experience the benefits of mathematical modeling and share their learning experience.

www.immchallenge.org
www.immchallenge.org.hk
immchallenge.org
immc_hk

國際數學建模挑戰賽聯合創始與主辦機構
IM²C co-founders and co-sponsors

COMAP

NeoUnion ESC Organization
儒蓮 教科文機構

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IMMC 2022 賽制 Rules

IM²C 2022 充分體現 STEM 教育所提倡的數學與科技、工程的學科交叉，數學與社會生產、生活的應用結合。儒蓮教科文機構聯合電氣電子工程師學會(IEEE亞太)及香港工業與應用數學學會(HKSIAM)，共同主辦 IM²C 2022 中華區域賽事。命題與評審委員會由來自 IM²C 、IEEE及HKSIAM的專家教授共同組成，他們的學科與專業涵蓋數學、科技、工程和社會科學的不同領域。

國際數學建模挑戰賽每支參賽團隊須由來自同一所中學的2-4名同學組成，且須有至少1位來自該校的教師擔任指導老師。來自世界各地的參賽團隊經過國家/區域賽的選拔，進入國際賽程；在國家/區域與國際層面，皆有機會獲取各級獎項。

來自大陸、台灣、香港及澳門的參賽團隊首先共同接受中華區域賽的挑戰。團隊可以自行選擇以「命題論文」方式，或者亦可選擇挑戰自我，即以「自主選題」方式參賽。在隨後的專家評審中，命題論文與自選題論文將分開評審，競逐晉級國際賽的機會。

入圍中華區域賽決賽與國際賽決賽的團隊獲得主辦機構的邀請，出席於2022年4月22及23日由 香港大學 工程學院 承辦的線上答辯決賽，做論文演示與答辯。IM²C 中華委員會及大評審團將從進入國際賽程論文答辯的隊伍中評選八篇最佳論文，推舉進入國際評審。

IM²C in Greater China Region is an interdisciplinary practice integrating mathematics with science, technology, engineering and socioeconomic application which reflects the essence of STEM education. NeoUnion works with the Institute of Electrical and Electronics Engineers (IEEE China) and Hong Kong Society for Industrial and Applied Mathematics (HKSIAM) to co-organize the IM²C 2022 for Greater China. The Problem Setting Committee and the Judging Panel consist of renowned experts and scholars from IM²C Committee (Zhonghua), IEEE and HKSIAM whose disciplinary fields cover mathematics, science, technology, engineering and social science.

IM²C 2022 requires each participating team to be composed of 2-4 students from the same secondary school, with at least one teacher from the same school to serve as team advisor. Participating teams from all over the world will go through a national/ regional selection process before they enter the international round of IM²C 2022. For both the national/regional and the international rounds of competition, the winning teams will receive different awards to recognize their respective achievements in the competition.

All participating teams from Mainland, Taiwan, Hong Kong and Macau first face the challenge from the Greater China regional IM²C 2022 contest. Upon registration, participating teams can choose either to work on the problems set out by the Problem Setting Committee of IM²C (Greater China) OR a meaningful problem of their own choice. Teams whose papers are judged under the two categories of papers respectively will be selected to enter into the International Round of IM²C.

The finalist teams of IM²C 2022, both for the Regional and the International rounds, receive invitation from the IM²C Committee to attend the Online Final Presentation Competition to be hosted by the Faculty of Engineering, The University of Hong Kong, presenting and defending their works in front of the Grand Jury. IM²C Committee (Greater China) will select the best eight papers from the finalists in the International Round for recommendation to the International Expert Panel.

評獎與峰會
Award Recognition & Summit

中華區各參賽團隊將有機會以中華區域賽論文或國際賽論文的評審結果，獲取區域及國際各級獎項。

IM²C 2022 中華區頒獎典禮暨 IM²C 中華峰會將會因應新冠肺炎疫情以適當方式安排。
The participating teams from Greater China Region will have the opportunity to be recognized with different awards at both regional and international levels.

An IM²C 2022 Greater China Summit and Regional Awards Ceremony will be held in an appropriate manner in response to the situation of COVID-19.

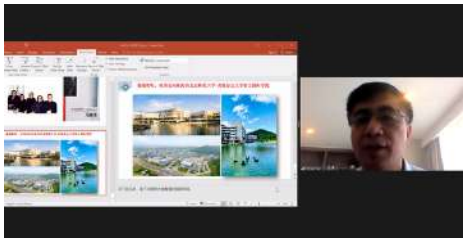


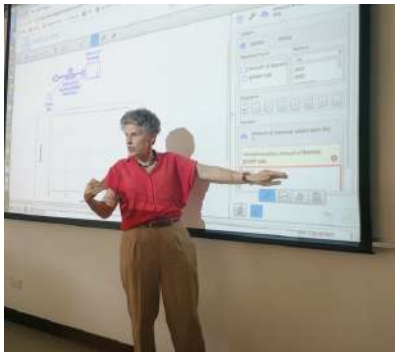
近年峰會(暨夏季工作坊） Summits (summer workshops) in recent years

2018年 香港理工大學(承辦） The University of Hong Kong Polytechnic University (Host)
2019年 香港中文大學 (承辦）The Chinese University of Hong Kong (Host)
2020年 遠程線上 Online
2021年 遠程線上 Online










第八屆國際數學建模挑戰賽 IM²C 2022
中華區域賽及國際賽答辯決賽名單公告
Announcement on the Finalist Teams for the Presentation Competition of the 8th IM²C(2022) from the Region of Greater China

根據第八屆國際數學建模挑戰賽 IM²C 2022 中華賽區的論文評審結果，循委員會命題論文評選或團隊自選題論文評選類別，來自大陸、台灣、香港和澳門的800支參賽團隊中共26支隊伍入選中華賽答辯決賽；同時，晉級國際賽的240支團隊中，共有26支隊伍入選國際賽答辯決賽。

因應新冠肺炎疫情風險和受到公共衛生情況的影響，IM²C 2022 中華區答辯決賽將采取遠程在線形式。中華賽及國際賽答辯決賽將分別於2022年4月22(星期五)和23日(星期六)舉行。

本屆答辯由 香港大學 工程學院 承辦。今年適逢香港大學111周年校慶，作為一所擁有輝煌歷史的世界著名學府，香港大學正在教學、科研和服務社會方面創造新的卓越。

委員會認為全部參賽學校和團隊都應該受到嘉許。專家組對全部論文進行了評審和覆核，對每個參參賽團隊在論文中展現的對數學建模的熱情和創造力，留下了極深的印象。每一名參賽同學都戰勝了挑戰，是真正的勝利者。國際數學建模挑戰賽委員會向每一位指導老師和參賽同學致敬和感謝！

Based on the judgement of the Paper Review by the Expert Panel and through tracks of Committee-set Problem and/or Freely-chosen Problem of the 8th Annual International Mathematical Modeling Challenge (IM²C 2022) for Mainland China, Taiwan, Hong Kong and Macau (the Region), 26 finalist teams out of 800 registered teams have been selected to enter the Final Presentation Competitions for the Regional Round, and another 26 finalist teams out of 240 qualified for International Round into the Final Presentation Competition.

In response to the risk of Covid-19 epidemic and the impact of public health condition, the Final Presentation Competitions of Regional and International Rounds of Greater China will be held online virtually on April 22 (Friday) and 23 (Saturday), 2022, respectively, hosted by Faculty of Engineering of The University of Hong Kong (HKU). This year is the 111th Anniversary of HKU. As a world-class university, HKU has reached new standards of excellence in teaching, research and service.

All teams who have submitted papers successfully will be issued a recognition certificate in May after the results of Presentation Competition are released. All participating schools and teams are worth being commended. The Expert Panel has spent a lot of time to review their submitted papers, and were impressed with the participants' passion and creativity in mathematical modeling. Each participant is a genuine winner who has overcome the challenge. Our appreciation shall go to each teacher advisor and student who have participated in the IM²C 2022.

香港大學
The University of Hong Kong

香港大學（港大）是香港歷史最悠久的高等教育院校，也是享譽國際的綜合性研究型大學。 早期校友中最著名者為「國父」孫中山先生。

香港大學一直積極與全球各大學和研究機構建立戰略性國際聯盟。大學亦致力推動校園國際化，並支持教職員、學生交流項目和國際性活動。

港大為Universitas 21的始創成員之一。Universitas 21是一個覆蓋全球研究型綜合大學的網絡，其中一個主要目標是協助成員成為國際性大學並推進其國際化計劃。

香港大學國際交流計劃的合作夥伴數量眾多，且遍布全球各地。來自逾46個國家的逾380所院校與港大合作，為本校學生分別提供每年為期一學期和長達一年的交流體驗。港大的大學夥伴包括在全球以及所屬國家中排名最高的大學。

除交流計劃外，學生更可以透過參與訪問活動、海外暑期課程及其他短期學生交流等獲得其他海外留學經歷。預計大多數本科生可在大學生涯中參與一次海外體驗。

此外，香港大學暑期項目為港大、海外本科生及高中生提供多項課程。在推動國際化校園的同時，港大亦在課程發展方面提供創新平台。多元化活動包括課程、實習、文化語言實踐的沉浸課程等。

中國視野計劃為港大學生提供前往中國大陸探索的機會。

港大的院系、研究中心及研究所與世界級的頂尖院校聯辦廣泛的合作活動，包括合作研究項目、訪問教授，以及與其他院校合辦的博士課程。

Established in 1911, the University of Hong Kong (HKU) is Hong Kong's oldest institute of higher learning and also an internationally recognized, research led, comprehensive university. Of the University's early alumni, the most renowned was Dr Sun Yat-sen, often regarded as the founder of modern China.

HKU has been actively establishing strategic international alliances with universities and research institutions worldwide. The University is also committed to cultivating internationalism on campus and to supporting staff and student mobility projects and international programmes at all levels.

The University is a founding member of Universitas 21, a network of comprehensive research-intensive universities covering all corners of the globe. One of the main objectives of Universitas 21 is to assist in the aspiration of its members to become global universities and to advance their plans for internationalisation.

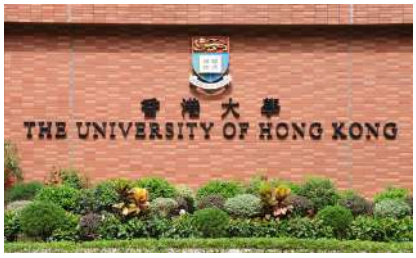
The HKU Worldwide Exchange programme continues to be extensive both in numbers and in the geographical spread of its partnerships. Over 380 institutions across 46 countries have chosen to partner with HKU, offering HKU students the experience of studying abroad on semester-long and year-long exchanges annually. Our partners as destination universities include those ranked highest worldwide and/or in their respective countries.

In addition to exchange programmes, students enjoy other study abroad experiences through visiting programmes, summer study abroad, and other short term student mobility initiatives. It is anticipated that absolute majority of the undergraduate students at HKU will benefit from an overseas experience during their student career.

Furthermore, a number of programmes are offered under the HKU Summer Institute for undergraduate students from HKU and overseas, as well as high school students. While maintaining a global campus, HKU provides a platform for innovation in programme development. Study programmes, internship placement, cultural and language immersion all contribute to the variety of programmes taking place at HKU.

The China Vision Programme provides HKU students the opportunities to go forth and explore the Mainland China.

The University has a wide range of collaboration activities involving faculties, research centres and institutes at HKU and international world-class institutions, including collaborative research projects, visiting professorships, and joint doctorate programmes.



- 港大在QS亞洲大學排名和泰晤士高等教育亞洲大學排名皆名列前茅
- 港大的全球大學排名在過去四年節節上升，2022年QS世界大學排名第22位，2022年泰晤士高等教育世界大學排名第30位
- 港大的QS畢業生就業能力排名由2018年第20位飆升到2021年第10位
- 港大在2021年泰晤士高等教育國際化大學排名第1位
- 港大教育在2021年泰晤士高等教育世界大學學科排名第5位

- HKU has been ranked top among Hong Kong universities by both Quacquarelli Symonds (QS) and Times Higher Education (THE)
- HKU's global ranking has risen over the past four years to 22nd in the world by QS and 30th internationally by THE for 2022
- HKU's position in the QS Employability Rankings also rose from 20th for 2018 to 10th for 2021
- HKU has been ranked 1st in the World's Most International University Rankings 2021 by THE
- In the 2021 THE subject rankings, HKU Education is ranked 5th in the world

工程學院
Faculty of Engineering

The Faculty of Engineering is one of the founding Faculties of The University of Hong Kong established in 1912. Since its foundation, the Faculty kept pace with developments in the engineering world and is always in the forefront of engineering research, and evolved into one of the largest Faculty in the University with five departments providing undergraduate, postgraduate and research degrees in a wide range of important fields of modern engineering, technology and computer science. The Faculty attracts the best students from the territory to study a wide range of engineering programmes. Since its foundation, the Faculty groomed more than 19,000 first-degree engineering graduates and over 16,000 postgraduate research and taught masters graduates as at 2020. Many of its graduates hold senior and prestigious positions in the engineering industry, commercial sector, education field and the government.

There are five departments in the Faculty providing a well-rounded curriculum and high quality engineering education covering a wide range of engineering disciplines in the global knowledge-based economy:

Civil Engineering
土木工程

Computer Science
計算機科學

Electrical and Electronic Engineering
電機及電子工程

Industrial and Manufacturing Systems Engineering
工業及製造系統工程

Mechanical Engineering
機械工程

The Faculty aims at providing all-round education to students equipping graduates not only with knowledge of cutting-edge technology, but also positive and lateral thinking, versatility of approach, excellent communication and social skills; professional integrity, international exposure and other highly-regarded personal attributes.

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IM²C 2022 中華賽區答辯決賽活動組織委員會
Organizing Committee of IM²C 2022 Finalist Presentation Competition of Greater China

主席 Chairman

Prof. David SROLOVITZ

香港大學工程學院院長、機械工程教授、材料理論講座教授
Dean of Faculty of Engineering, The University of Hong Kong,
Professor of Mechanical Engineering,
Chair Professor of Materials Theory

執行主席 Executive Chairman

黃國全 教授 Prof. George G.Q. HUANG

香港大學工業及製造系統工程系系主任、 工業及製造系統工程講座教授
Head of Department of Industrial and Manufacturing Systems Engineering,
Chair Professor of Industrial and Manufacturing Systems Engineering,
The University of Hong Kong

IM²C 2022 中華賽區答辯決賽 大評審團
Grand Jury of IM²C 2022 Greater China Region Final Presentation Competition
(姓氏字母排序 In alphabetical order of family name)

評審團主席 Chairman

汪揚 教授 Prof. Yang WANG

香港科技大學副校長(大學拓展)，數學系講座教授、工業工程及決策分析學系講座教授
香港科技大學大數據生物智能實驗室主任、香港科技大學大數據研究所副主任

HKUST Vice-President for Institutional Advancement,
Chair Prof. of Dept. of Mathematics, Chair Prof. of Dept. of Industrial Engineering and Decision Analytics
Director of HKUST The Big Data for Bio Intelligence Laboratory
Associate Director of HKUST Big Data Institute

大評審團成員 Members of Grand Jury

陳宏賓 副教授
Assoc. Prof. Hong-bin CHEN
台灣中興大學
Taiwan Chung Hsing University

陳豔萍 教授
Prof. Yanping CHEN
華南師範大學
South China Normal University

何岱海 副教授
Assoc. Prof. Daihai HE
香港理工大學
The Hong Kong Polytechnic University

郭永鴻 助理教授
Asst. Prof. Yong Hong KUO
香港大學
The University of Hong Kong

梁應德 副教授
Assoc. Prof. Ieng-Tak LEONG
澳門大學
University of Macau

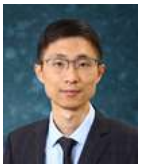
劉揚 博士, 首席科學家
Dr. Yang LIU, Chief Scientist
南京英銳祺科技有限公司
Nanjing Inrich Technology, Co.,Ltd

陸立強 教授
Prof. Liqiang LU
復旦大學
Fudan University

喬中華 教授
Prof. Zhonghua QIAO
香港理工大學
The Hong Kong Polytechnic University

舒宇宸 副教授
Assoc. Prof. Yu-Chen SHU
台灣成功大學
Taiwan Cheng Kung University

吳雲峰 副教授
Assoc. Prof. Yunfeng WU
廈門大學
Xiamen University



邢國良 教授*
Prof. Guoling XING
香港中文大學
The Chinese University of Hong Kong

袁昱 博士*
Dr. Yu YUAN
IEEE 標準協會候任主席
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IEEE Standards Association

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Assoc. Prof. Lei ZHANG
北京大學 Peking University -
北京國際數學研究中心、定量生物學中心
Beijing International Center for Mathematical Research,
Center for Quantitative Biology

張清鵬 副教授*
Assoc. Prof. Qingpeng ZHANG
香港城市大學
The City University of Hong Kong

* IMMC 2022 大中華區主命題人
Chief Expert for Problem Setting

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開幕儀式 Opening Ceremony	致辭 Speech
2022年4月22日 上午8:30-9:00 22 April 2022 8:30am-9:00am	**汪揚 教授 Prof. Yang WANG** 香港科技大學副校長(大學拓展)，數學系講座教授、工業工程及決策分析學系講座教授 HKUST Vice-President for Institutional Advancement, Chair Prof. of Dept. of Mathematics, Chair Prof. of Dept. of Industrial Engineering and Decision Analytics **Prof. David SROLOVITZ** 香港大學工程學院院長、機械工程教授、材料理論講座教授 Dean of Faculty of Engineering, The University of Hong Kong, Professor of Mechanical Engineering, Chair Professor of Materials Theory **黃國全 教授 Prof. George G.Q. HUANG** 香港大學工業及製造系統工程系系主任、 工業及製造系統工程講座教授 Head of Department of Industrial and Manufacturing Systems Engineering, Chair Professor of Industrial and Manufacturing Systems Engineering The University of Hong Kong

答辯決賽
Finalist Presentation

中華區域賽答辯
Regional Round Presentation

日期 Date 2022年4月22日 22 April 2022

時間 Time 9:00 am - 6:00 pm

平台 Platform ZOOM

國際賽答辯
International Round Presentation

日期 Date 2022年4月23日 23 April 2022

時間 Time 8:45 am - 6:00 pm

平台 Platform ZOOM

第八屆國際數學建模挑戰賽 (IM²C 2022) 中華區域賽入選答辯決賽隊伍名單

The 8th IM²C (2022) Finalist Teams for the Presentation Competition Regional Round for Greater China

(按控制號升序排列 in ascending order of control number)

IMMC22003053	成都市錦江區嘉祥外國語高級中學 Chengdu Jinjiang Jiaxiang Foreign Language High School
IMMC22022821	北京市十一學校 Beijing National Day School
IMMC22037326	北京市十一學校（龍樾實驗中學） Beijing National Day School Longyue
IMMC22046951	廣州市第七中學 Guangzhou No.7 Middle School
IMMC22052302	上海市實驗學校 Shanghai Experimental School
IMMC22070035	北京師範大學附屬實驗中學 The Experimental High School Attached to Beijing Normal University
IMMC22097140	吉林省實驗中學 Jilin Provincial Experimental School
IMMC22099456	深圳實驗學校中學部 Shenzhen Experimental School Middle School Department
IMMC22153654	上海市建平中學 Shanghai Jianping High School
IMMC22188723	青苗學校（成都校區） Beanstalk International Bilingual School(Chengdu Campus)
IMMC22207181	北京四中國際校區 Beijing NO.4 High School International Campus
IMMC22217224	中國人民大學附屬中學 High School Affiliated to Renmin University of China
IMMC22317067	北京中學 Beijing Academy
IMMC22326160	北京加拿大國際學校 Canadian International School of Beijing
IMMC22394252	上海市世界外國語中學 Shanghai World Foreign Language Academy
IMMC22545733	港大同學會書院 HKUGA College
IMMC22600203	南京師範大學附屬中學新城初級中學 High School Affiliated To Nanjing Normal University Xin Cheng Junior School
IMMC22639438	台北市立永春高級中學 Taipei Municipal Yongchun Senior High School
IMMC22661688	杭州市文海實驗學校 Hangzhou Wenhai Experimental School
IMMC22722184	杭州第二中學錢江學校 Hangzhou No.2 High School Qianjiang
IMMC22724694	上海中學國際部 Shanghai High School International Division
IMMC22775827	上海市實驗學校國際部 Shanghai Experimental School International Division
IMMC22855539	澳門培正中學 Pui Ching Middle School, Macau
IMMC22912435	南京外國語學校 Nanjing Foreign Language School
IMMC22938597	耀中國際學校香港 Yew Chung International School of Hong Kong
IMMC22946391	聖保羅男女中學 St. Paul's Co-educational College

第八屆國際數學建模挑戰賽 (IM²C 2022) 國際賽入選答辯決賽隊伍名單

The 8th IM²C (2022) Finalist Teams for the Presentation Competition International Round for Greater China

(按控制號升序排列 in ascending order of control number)

IMMC22102684	喇沙書院 La Salle College
IMMC22154209	西安交通大學附屬中學 The High School Affiliated to Xi'an Jiaotong University
IMMC22168571	北京中學 Beijing Academy
IMMC22178515	澳門勞校中學 Lou Hau High School, Macau
IMMC22237723	上海市世界外國語中學 Shanghai World Foreign Language Academy
IMMC22256878	台北市立中山女高 Taipei Municipal Zhongshan Girls High School
IMMC22324267	上海美國學校 Shanghai American School
IMMC22366296	澳門濠江中學附屬英才學校 Premier School Affiliated to Hou Kong Middle School, Macau
IMMC22396298	培僑書院 Pui Kiu College
IMMC22405217	上海民辦平和學校 Shanghai Pinghe School
IMMC22468942	上海中學國際部 Shanghai High School International Division
IMMC22494804	上海市建平中學 Shanghai Jianping High School
IMMC22560894	澳門浸信中學 Macau Baptist College
IMMC22584842	万科梅沙書院 Vanke Meisha Academy
IMMC22586774	北京市十一學校 Beijing National Day School
IMMC22590624	南陽市第二中學校 Nanyang No.2 Middle School
IMMC22616754	深圳國際交流學院 Shenzhen College of International Education
IMMC22689589	拔萃女書院 Diocesan Girls' School
IMMC22733021	台北市私立衛理女中 Taipei Wesley Girls High School
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IMMC22768821	上海市實驗學校 Shanghai Experimental School
IMMC22772076	浙江省杭州第二中學 Hangzhou No.2 High School Of Zhejiang Province
IMMC22817341	聖保羅男女中學 St. Paul's Co-educational College
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IMMC22963684	杭州市文海實驗學校 Hangzhou Wenhai Experimental School

IMMC 2022 - HKU
線上工作坊 Online Workshops

22 Apr 2022 Morning Session	
9:15 am - 10:30 am	**數學在人工智能和機器學習中的應用** **Application of Mathematics in AI and Machine Learning** 吳國寶 博士，香港大學數學系講座教授 Dr. Michael Kwok-Po, NG, Chair Professor of Department of Mathematics, The University of Hong Kong In this talk, Prof Ng will share some important issues in AI and machine learning and demonstrate how the application of mathematics can help in the development of technology.
午餐 Lunch	
22 Apr 2022 Afternoon Session	
2:15 pm - 3:30 pm	**數學與圖像處理** **Mathematics and Image Processing** 台雪成 博士，香港浸會大學數學系講座教授 Dr. Xue-Cheng TAI Chair Professor of Department of Mathematics, The Hong Kong Baptist University In this talk, Prof Tai will show some elementary concept about digital image processing through a mathematical perspective. We show how is a digital image represented. We see many image processing tools used in our hand phone and computers. We will show what are the mathematical ideas behind these image processing tools. More specifically, we will talk about how to take away noise from images and how to identify objects from digital images.

吳國寶 博士，香港大學數學系講座教授、同心基金數據科學研究院副主任、HKU-TCL 聯合人工智能研究中心主席

Dr. Michael Kwok-Po NG, Chair Professor of Department of Mathematics, The University of Hong Kong (HKU)
Associate Director, Musketeers Foundation Institute of Data Science, HKU,
Chairperson, HKU-TCL Joint Research Center for AI

Prof. Michael NG's research interests lie in artificial intelligence, data science and scientific computing, which are crucial for shaping the future of human life. He is a recipient of the Feng Kang Prize of Scientific Computing. Setting his vision far and wide, he is the pilot for the development of research in Mathematical Science in the Faculty of Science at the University of Hong Kong. He is among the inspiring ones who would share thoughts and experiences beyond academic knowledge.

台雪成 博士，香港浸會大學數學系講座教授，圖學圖像及視像中心主任，計算及理論研究所副主任

Dr. Xue-Cheng TAI, Chair Professor of Department of Mathematics, Hong Kong Baptist University (HKBU)
Director of the Centre for Mathematical Imaging and Vision,
Associate Director of Institute for Computational and Theoretical Studies

Prof. Xue-Cheng TAI's research interests include Numerical PDEs, optimization techniques, inverse problems, and image processing. He has done significant research work his research areas and published many research works in top quality international conference and journals. He served as organizing and program committee members for a number of international conferences and has been often invited speakers for international conferences. He has served as referee and reviewers for many premier conferences and journals.

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IMMC 2022 - HKU
線上工作坊 Online Workshops

23 Apr 2022
Morning Session

9:15 am - 10:30 am

工業工程: 當數學建模遇到數據科學
When Mathematical Modeling Meets Data Science in Industrial Engineering

郭永鴻 博士，香港大學工業及製造系統工程系助理教授
Dr. Yong Hong KUO
Assistant Professor, Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong

In this talk, Dr. Kuo will present some applications of mathematical modeling, powered by data science tools, for real-world problems in the industry:
i) How can we predict patient waiting time in an emergency department?
ii) Is it possible to track human activities to help contain an infectious disease outbreak?
iii) How should electric vehicle charging stations be located to enhance accessibility to the facilities? iv) How can we use bike trip data to facilitate repositioning operations of a bike-sharing system?

午餐 Lunch

23 Apr 2022
Afternoon Session

2:15 pm - 3:30 pm

常微分方程模型在生物學中的應用
Application of Ordinary Differential Equation (ODE) Models in Biology

張江文 博士，香港大學生物科學學院副教授
Dr. Jiangwen ZHANG
Associate Professor, School of Biological Sciences, The University of Hong Kong

This talk will introduce the application of ordinary differential equation (ODE) models in biology. We will learn
1) how to describe the molecules and interactions in a mathematical model,
2) how to explicitly formulate these interactions as ODE models,
3) how to do simulations of such a network in computer programming, and
4) how to analyze the behavior of the defined model with the ultimate goal of a complete quantitative model for the biological system and network.

郭永鴻 博士，香港大學 工業及製造系統工程系助理教授
Dr. Yong Hong KUO, Assistant Professor of Department of Industrial and Manufacturing Systems Engineering, HKU

Dr. Kuo's current research focus is on the integration of systems modelling, discrete optimization, and data analytics for solving decision-making problems in service systems, where most of his applications are in the domains of logistics and transportation services and healthcare service delivery. He is interested in modelling problems, devising solution procedures, and using these tools to improve operations, help system design, and derive managerial insights. His research, with his role as Principal Investigator, has been supported by a number of funding agencies, including Hong Kong Research Grants Council, Health and Medical Research Fund, Microsoft Research Asia, and Macao Science and Technology Development Fund. His solution methodologies and applications have been published in top journals in various fields, including industrial engineering, operations management, transportation, and healthcare informatics. He has served on the Editorial Advisory/Review Boards of Decision Sciences Journal and Transportation Research Part E and as Managing Guest Editor for several academic journals.

張江文 博士，香港大學生物科學學院副教授
Dr. Jiangwen ZHANG, Associate Professor of School of Biological Sciences, HKU

Dr. Zhang's lab has broad interest in genetic and epigenetic regulation in development and diseases. His lab employ high through-put 'omics' assays and large scale computation analysis in combination with molecular biology and biochemistry tools. Currently, they are focusing on epigenetic regulation in tumorigenesis and stem cell differentiation, and the crosstalk with gene regulatory network and signaling pathways.

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IMMC 2022 - 大中華區域賽 A題 GREATER CHINA REGIONAL CONTEST PROBLEM A

智慧燈柱部署

SMART LAMPPOST DEPLOYMENT

🔗 電子版本可以點擊頁頂題目了解更多。 Click the problem on the top for learning more in electronic version.

背景

如今自動駕駛技術發展迅速。美國汽車工程師學會(SAE)制定了自動駕駛的等級，依據車 輛的自動化程度劃定了從 L0(人工控制)到 L5(完全自動駕駛)共六個等級(自動駕駛級 別參考鏈接)。目前，自動駕駛技術已經開始從 L2 級別的部分自動駕駛向 L3 級別的有條件 自動駕駛前進。對於 L3 級自動駕駛汽車，駕駛員只需要在系統失效或者超過工作條件時， 對故障汽車進行接管。而車輛在自動駕駛系統被激活後，在自動駕駛系統所規定的運行條件 下，本身就能完成轉向、加減速以及路況探測和反應的任務。

問題與情境

為了讓車輛更好地完成 L3 級別的自動駕駛任務，以智慧燈柱為代表的智慧路端基礎設施被 視為一種強有力的解決方案。通過將現有的普通燈柱改裝成智慧燈柱(加裝傳感器及通信單 元)，智慧燈柱可以通過傳感器采集道路數據並上傳到雲端服務器，在服務器完成計算後再 下載到原燈柱或分享給其他燈柱。自動駕駛汽車通過與鄰近的智慧燈柱通訊，就能獲得其需 要的道路數據。

城市中的燈柱幾乎無處不在，但對每一根燈柱都進行改裝顯然不是一個好的選擇。因此，你 的團隊要為你們的客戶——智慧燈柱建設公司提供智慧燈柱改裝的規劃方案和評估框架。你 們得到的基本條件和信息如下:

1. 你們需要選擇一些燈柱進行改裝。燈柱上加裝的智能模塊有三種配置可供選擇，每根 被改裝的燈柱只能選擇其中一種配置(不同燈柱可采用不同的配置)。三種配置的信息 見表 1。

型號	硬件配置	價格
A	傳感器	5000
B	WiFi 接入點	3000
C	傳感器 + WiFi 接入點	10000

表1. 智慧燈柱配置及價格

2. 智能模塊中的傳感器包括一對激光雷達(LiDAR)。相比於傳統的攝像頭，激光雷達能 直接獲得 3D 場景信息，並且不受光照條件的影響，這意味著在夜晚它也能很好地工 作。特別地，激光雷達無法獲得細節的圖像信息，因此不論部署在哪裏，都能很好地 保護隱私。激光雷達的有效探測距離為 80 米，兩個激光雷達通過視野拼接從而實現 180°的水平視野(如圖 1 所示)。傳感器的數據被上傳到雲端完成處理和計算，以實現物體檢測、道路監控等功能。自動駕駛車輛可以利用 WiFi 與鄰近的智慧燈柱 建立連接，以獲取雲端的數據，從而間接地利用智慧燈柱的傳感器以實現更完善的場 景感知和路徑規劃功能。

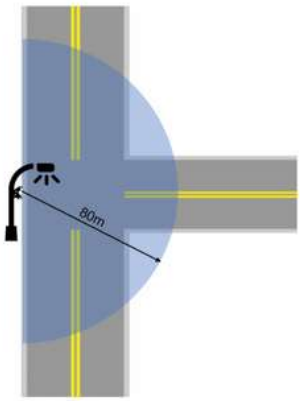

圖 1. 激光雷達探測範圍示意圖

3. 智能模塊中的WiFi可用來與自動駕駛汽車進行通信。WiFi作為一種廣泛使用且能力 強大的通信技術，可以很方便地部署在自動駕駛汽車和智慧燈柱上，把來自雲服務器 的信息(傳感器數據的處理結果)傳給自動駕駛車輛，從而使車輛能夠利用智慧燈柱 搭載的傳感器獲得道路信息。 L3 級別的自動駕駛需要細粒度的道路信息，因此需要 傳輸大量的數據。為了滿足通信需求，具有強大通信能力的第 5 代 WiFi(WiFi5 參考 鏈接)將被使用。一個 WiFi 接入點可以提供:最大 800 兆比特每秒的吞吐量，同一 時間支持與 4 輛自動駕駛汽車進行通信，以及 100 米的覆蓋範圍(如圖 2 所示)。

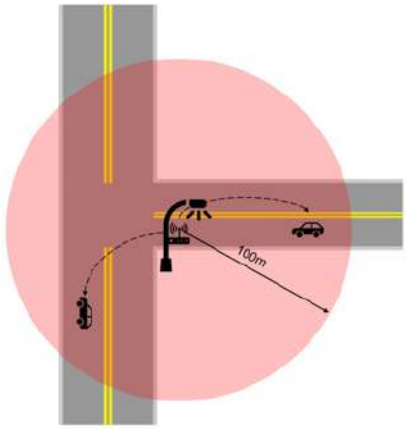

圖 2. WiFi 覆蓋範圍示意圖

4. 評估一個區域內燈柱改裝方案需要考慮三個方面的因素。1)第一是成本。改裝方案應當盡量節省單位區域內燈柱改裝的花銷; 2)第二是傳感器可探測區域對道路的覆蓋。我們希望道路上盡量多的區域能被傳感器探測到，尤其是一些重要的區域例如交通路口和人行橫道線等等; 3)第三是 WiFi 通信對道路的覆蓋以及支持的連接數量。我們希望車輛在大部分的區域能夠與燈柱通信以獲取數據，並且在車流密集的區域能夠實現同時讓盡量多的車輛與燈柱建立 WiFi 連接。

5. 您可以自由選擇感興趣的道路區域進行規劃。道路地圖和燈柱分布數據可以在當地政 府的官方網站查詢(例如香港的地圖數據: https://www.map.gov.hk/gm/map/)。

任務

1. 基於前面提到的評估一個區域內燈柱改裝方案需要考慮的因素，建立用於評估智慧燈柱改裝方案的指標框架，定義如何量化並測量這些指標; 並利用您的指標體系，建立評估智慧燈柱改裝方案的數學模型。

2. 選擇某座城市的某個區域(大於 200m×200m，燈柱數量大於 30 根)，給出智慧燈柱改裝的規劃方案，包括確定哪些燈柱需要改裝，以及分別使用哪種配置。

3. 使用您建立的模型對智慧燈柱改裝方案進行評估。請討論: 1)您建立的評估模型如何輔助您改進您的改裝方案; 2)評估改裝方案的過程中您是否發現您的模型有任何優勢或不足?談談您對您的模型打算進行哪些改進。

提交

你的團隊所提交的論文應包含 1 頁摘要，其正文不可超過 20 頁，包括摘要和選定城市區域 地圖等則最多不超過 23 頁。附錄和參考文獻應置於正文之後，不計入 23 頁之限。

Background

Nowadays, autonomous driving technology is developing rapidly. The Society of Automotive Engineers (SAE) has established the level of autonomous driving. According to the degree of automation of the vehicle, six levels of driving automation from L0 (manually controlled) to L5 (full driving automation) are defined (Reference link for autonomous driving levels). At present, autonomous driving technology has begun to move from partial driving automation at the L2 level to conditional driving automation at the L3 level. For L3 autonomous driving cars, the driver only needs to take over the malfunctioning car when the system fails or exceeds working conditions. After the automatic driving system is activated, the vehicle itself can complete the tasks of steering, acceleration, deceleration, road condition detection and reaction under the operating conditions specified by the automatic driving system.

Problem and context

In order to facilitate vehicles to better implement the L3 level autonomous driving tasks, the smart roadside infrastructure represented by smart lampposts has been considered to be a powerful solution. By refitting existing ordinary lampposts into smart lampposts (installed with sensors and communication units), smart lampposts can collect road data through sensors and upload them to the cloud server, and then download to the original lamppost or share it with other lampposts after the server completes the calculations. Autonomous driving cars can obtain the road data they need by communicating with neighboring smart lampposts.

Lampposts are almost everywhere in the city, but it is obviously not a good choice to modify every lamppost. Therefore, your team is invited by your client, a smart lamppost construction company, to provide a planning scheme and evaluation framework for smart lamppost modification. The basic conditions and information for your team are as follows:

(1) You need to choose some lampposts for modification. There are three configurations for the smart modules installed on the lamppost. Only one configuration can be selected for each modified lamppost (but you can choose different configuration on different lampposts). The information of the three configurations is shown in Table 1.

Type	Hardware Configuration	Price (US$)
A	Sensor	5000
B	WiFi Access Point	3000
C	Sensor + WiFi Access Point	10000

Table 1: Smart lamppost configuration and price

(2) The sensor in the smart module contains a pair of LiDARs. Compared with traditional cameras, LiDAR can directly obtain 3D scene information and is not affected by lighting conditions, which means it can also work well at night. In particular, LiDAR cannot obtain detailed image information, so no matter where it is deployed, it can protect privacy well. The effective detection distance of the LiDAR is 80 meters, and the view of two LiDARs are combined together by view stitching to achieve a 180° horizontal field of view (as shown in Figure 1). The sensor data is uploaded to the cloud to complete processing and calculation to achieve object detection, traffic monitoring and other functions. Autonomous vehicles can use WiFi to establish connections with neighboring smart lampposts to obtain cloud data, thereby indirectly using smart lamppost sensors to achieve better scene perception and route planning functions.

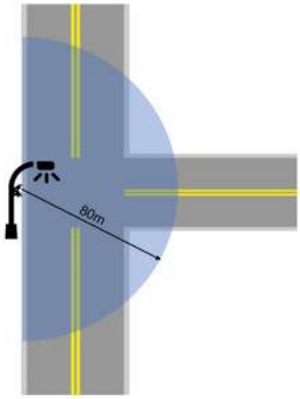

Figure 1. Schematic diagram of LiDAR detection range

(3) The WiFi in the smart module can be used to communicate with the autonomous driving car. As a widely used and powerful communication technology, WiFi can be easily deployed on autonomous vehicles and smart lampposts. It transmits the information (processing results of sensor data) from the cloud server to the autonomous vehicles, thereby enabling the vehicles to obtain traffic information using sensors mounted on smart lampposts. Driving automation at the L3 level requires fine-grained road information, so a large amount of data needs to be transmitted. In order to meet the communication needs, the fifth generation5G WiFi (WiFi5 reference link) with strong communication capabilities will be used. A WiFi access point can provide a maximum throughput of 800 Mbps, support for communication with 4 autonomous vehicles at the same time, and a coverage range of 100 meters (as shown in Figure 2).

(4) Three factors need to be considered when evaluating the lamppost modification plan in an area. 1) The first is cost. The modification plan should try to save the cost of lamppost modification in the unit area; 2) The second is the coverage of the road in the area that the sensor can detect. We hope that as many areas on the road as possible can be detected by the sensor, especially some important areas such as traffic intersections and crosswalks, etc.; 3) The third is the coverage of the road by WiFi communication and the number of connections supported. We hope that vehicles can communicate with lampposts in most areas to obtain data, and in areas with dense traffic, it is possible to enable as many vehicles as possible to establish WiFi connections with lampposts at the same time.

(5) You can freely choose the road area you are interested in for planning. The road map and lamppost distribution data can be acquired on the official website of the local government, for example, the map data of Hong Kong at https://www.map.gov.hk/gm/map/).

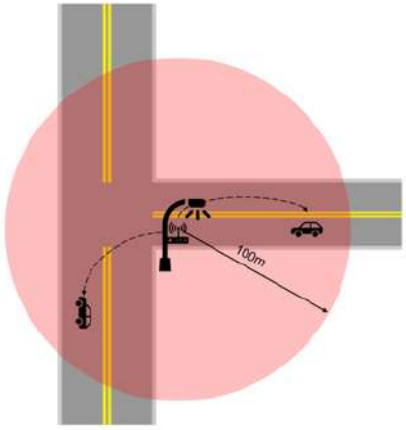

Figure 2. Schematic diagram of WiFi coverage

Tasks

1. Based on the aforementioned factors that need to be considered when evaluating lamppost modification plans in an area, establish an indicator framework for evaluating smart lamppost modification plans, define how to quantify and measure these indicators; and use your indicator system to establish a mathematical model to evaluate the smart lamppost modification plans.

2. Select an area in any city (more than 200m×200m, and the number of lamp posts is more than 30), and give a plan for smart lamppost modification, including determining which lampposts need to be modified with which configurations.

3. Use the model you built to evaluate the smart lamppost modification plan. Please discuss: 1) How the evaluation model you established can help you improve your modification plan; 2) During the evaluation of the modification plan, did you find any advantages or disadvantages in your model? Talk about what improvements you plan to make to your model.

Submission

Your team's solution paper should include a 1-page Summary Sheet. The body cannot exceed 20 pages for a maximum of 23 pages with the Summary Sheet and maps of selected city areas inclusive. The appendices and references should appear at the end of the paper and do not count towards the 23 pages limit.



IMMC 2022 - 大中華區域賽 B題 GREATER CHINA REGIONAL CONTEST PROBLEM B

在中國，我們可以在地下儲存多少二氧化碳?

HOW MUCH CO_2 CAN WE STORE WITHIN THE SUBSURFACE IN CHINA?

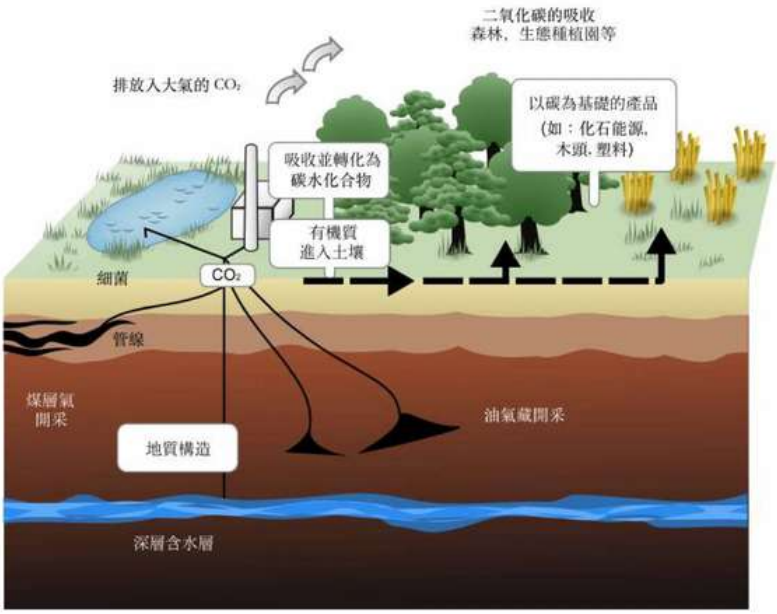

圖 1. 二氧化碳的地下封存示示意圖(取自自 https://en.wikipedia.org/wiki/Carbon_sequestration)

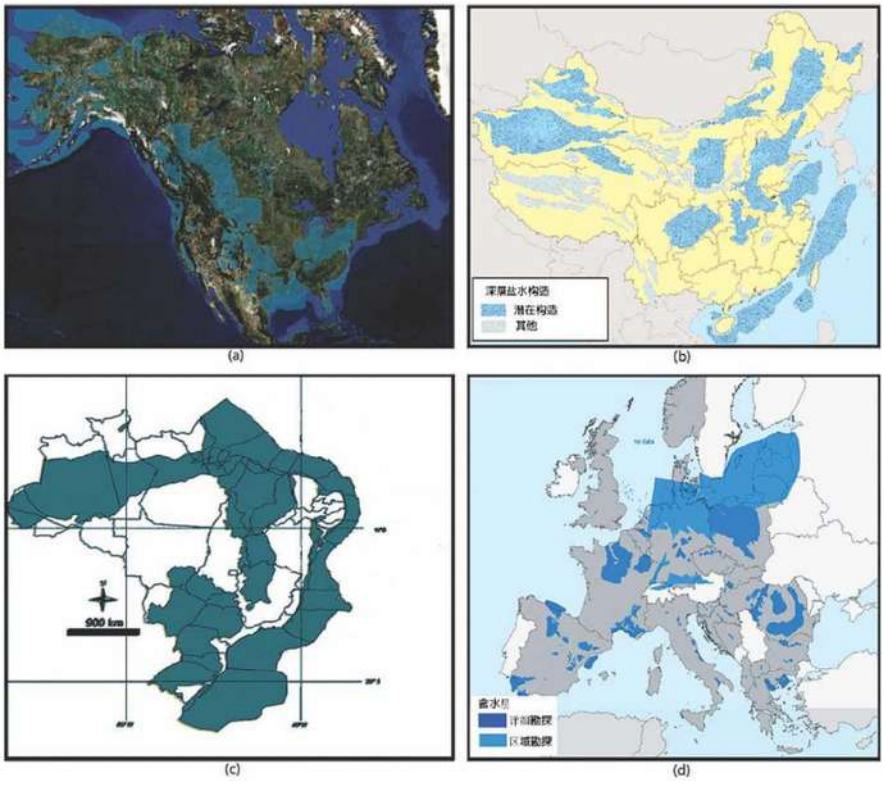

圖 2:世界各地區的含水層分布:
(a) 美國和加拿大，(b) 中國，
(c) 巴西，(d) 歐盟
(取自自 A. Firoozabadi 和 P. C. Myint 的论文“Prospects for Subsurface CO_2 Sequestration”， AIChE Journal，2010 年)

背景

自 20 世紀中葉以來，人類活動造成了全球變暖，極大地影響了地球氣候系統，這主要是由 於二氧化碳 (CO_2) 等溫室氣體的排放。碳減排和碳封存技術可以有效減少碳排放，從而減少碳排放對環境的負面影響。2020 年 9 月，中國政府宣布中國力爭在 2030 年之前實現“碳達 峰”，在 2060 年之前實現“碳中和”。碳中和是指國家在一定時間內直接或間接產生的二氧化 碳或溫室氣體排放總量，通過使用低碳能源取代化石燃料、植樹造林、節能減排等形式，以 抵消自身產生的二氧化碳或溫室氣體排放量，實現正負抵消，達到相對“零排放”。為了實現 碳減排，開發和應用清潔能源十分重要，如天然氣水合物、地熱、熱幹巖、核能、水電、風 能、太陽能和氫能等;同時，碳封存技術也同等重要。

碳的地下封存是將 CO_2 儲存在枯竭的油氣層、深部鹽水層或不可開采的煤層中(圖 1)。鹽水層的水通常不能用作飲用水或農業用水，但是可以用於固碳。而且深部鹽水層被認為具有世界範圍內最大的儲存潛力，適合儲碳的鹽水層在全世界也很常見(圖 2)。

問題與情境
估算CO_2 的儲集能力可以幫助我們評估未來可以存儲多少CO_2，也可以幫助我們決定二氧化 碳的儲存是否可以為減少大氣中的二氧化碳水平提供一個可行的方法。

體積法是估算二氧化碳儲存容量自然而直接的方法。在這種方法中，首先需要計算含水層的 總孔隙體積，CO_2 在孔隙體積中所占的比例以及 CO_2 的密度(或 CO_2-水的密度，或 CO_2-鹽 水的密度，該密度取決於所使用的模型)。總孔隙體積可以由含水層的面積、平均厚度和平均孔隙度的乘積計算得出。CO_2 密度取決於溫度和壓力，可以通過檢索含水層特定壓力和溫 度條件下的相應數據得到，或使用狀態方程來估算。孔隙空間比例的估計比較棘手和主觀， 受多個因素影響;但有一點很明顯，CO_2 是無法占據全部的孔隙空間的，因此孔隙中 CO_2 的比例為正數，且小於 1。

在大部分深部鹽水層注入 CO_2 時，內部壓力沒有明顯的增加;在這種情況下，上面提到的體 積法是合理的。但是在另外一些(相對較小的)含水層中，內部壓力也可能會升高;在這種 情況下，孔隙和鹽水會被進一步壓縮，CO_2 儲量會受到其壓縮性和最大平均壓力增加的影響。

任務
1. 請構建一個中國二氧化碳封存量的估算模型，並且估算中國深部鹽水層的 CO_2 總儲量。 模型的相關數據可以通過檢索互聯網和相關文獻獲得。

2. 對於任務 1 中的估算(即對中國所有深部鹽水層 CO_2 總儲量的估計)，分析 CO_2 密度(或 CO_2-水的密度，或 CO_2-鹽水的密度，該密度取決於所使用的模型)的敏感性。

3. 請根據你的模型及估算，撰寫一篇科普短文，闡述你的二氧化碳封存模型對於實現“碳達 峰”和“碳中和”目標的意義及公共政策建議。

提交
你團隊的解決方案論文應包括 1 頁的摘要和 1 篇科普短文。正文不能超過 20 頁，含摘要及 短文最多 23 頁。附錄和參考資料應出現在正文之後，不算在 23 頁的限制之內。

Background
Humans have had an unprecedented impact on Earth's climate system since the mid-20th century, causing undesired global warming of the Earth system. Emission of gases, in particular, carbon dioxide (CO_2) is the major driver of this global warming. Carbon emission reduction and carbon sequestration techniques have been proposed to address the negative impacts of carbon emission on climate change. In September 2020, Chinese government has declared that China would strive to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. Carbon neutrality of a country means that the carbon emissions by this country have been balanced out directly, or indirectly, by carbon saving measures such as replacing fossil fuels with renewable energy, planting trees, energy-saving and carbon reduction. Even though it is important to develop and apply carbon emission reduction and clean energy technologies such as natural gas hydrate, geothermal, hot dry rock, nuclear energy, hydropower, wind energy, solar energy, and hydrogen energy, carbon sequestration technologies are also crucial.

In subsurface carbon sequestration, CO_2 is stored in depleted oil and gas reservoirs, deep saline aquifers, and/or unmineable coal seams (Figure 1). Saline aquifers are not typically useful as a source of water for either drinking or agriculture, and thus they are considered for carbon sequestration. In addition, deep saline aquifers are believed to have the greatest storage potential world-wide. Saline aquifers suitable for storage are plentiful in many parts of the world (Figure 2).

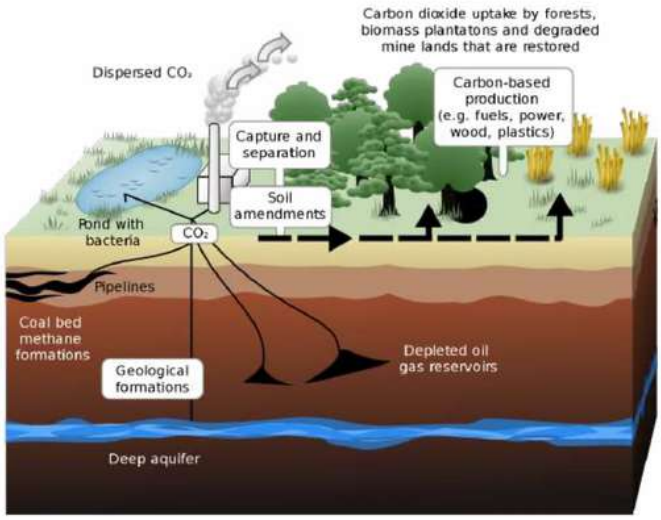

Figure 1. Schematic showing both terrestrial and geological subsurface sequestration of carbon dioxide (adapated from the website https://en.wikipedia.org/wiki/Carbon_sequestration)

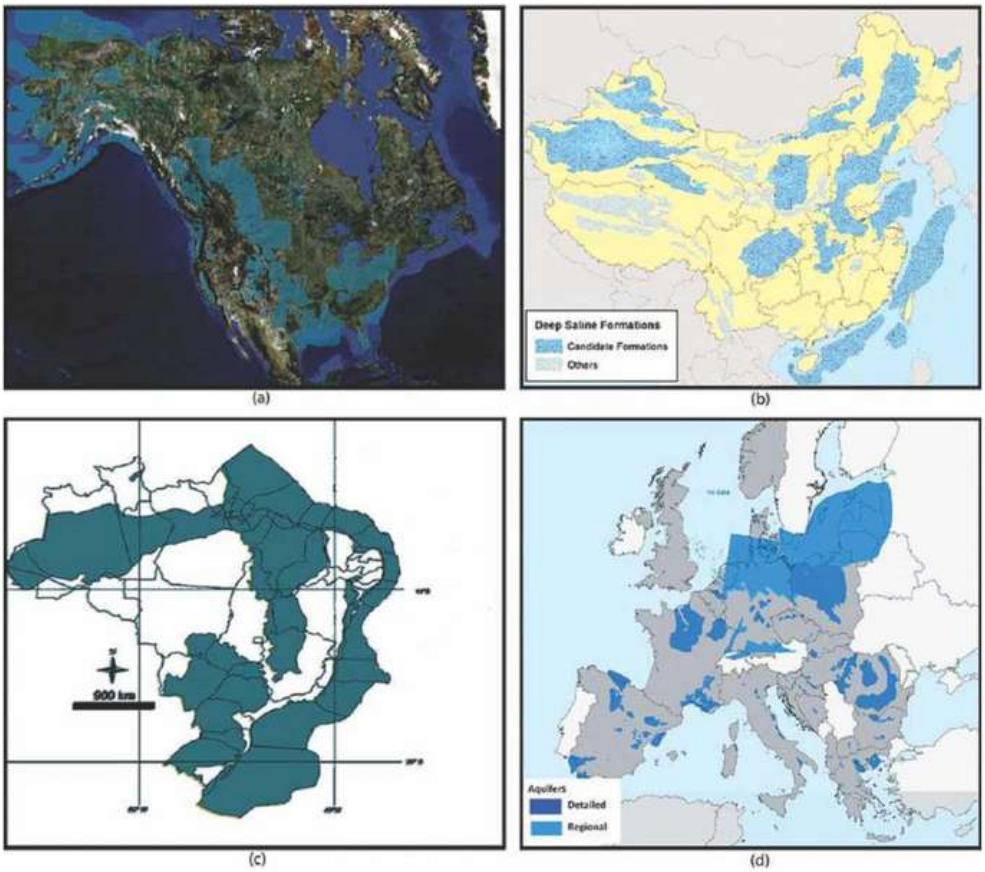

Figure 2: Aquifer distribution in selected regions of the world: (a) USA and Canada, (b) China, (c) Brazil, and (d) the EU (adapated from the paper "Prospects for Subsurface CO_2 Sequestration" by A. Firoozabadi and P. C. Myint, in AIChE Journal, 2010)

Problem Context

Estimation of CO_2 storage capacity can help us to assess how much CO_2 can be stored in the future and it can also help us to decide whether or not CO_2 storage can provide a feasible method for reducing the levels of CO_2 in the atmosphere.

The volumetric approach to estimate CO_2 storage capacity is natural and also quite straightforward. In this approach, you first estimate the total pore volume of the aquifer, the proportion of the volume which the CO_2 will occupy within the pore volume, and the density of CO_2 (or the density of CO_2-water or the density of CO_2-brine depending on your model). The total pore volume can be calculated from the product of the areal extent, the average thickness and the average porosity of the aquifer. The CO_2 density depends on temperature and pressure, and it can be estimated by searching the corresponding data under a certain pressure and temperature condition typically occurring in the aquifer, or by using an equation of state. The estimation of the proportion of pore space is trickier and more subjective, sometimes modeled as a product of several factors; but it is clear that the proportion of pore space is positive but less than one if we take account of the fact that CO_2 will not be able to access all of the pore space.

Many deep saline aquifers do not have significant build-up of pressure when injecting CO_2; in this case, the previously-discussed volumetric approach seems to be reasonable. Other (relatively smaller) aquifers might raise the pressure when CO_2 is injected; in this case, the compressibility of the pore space and the brine, and the maximum average pressure build-up in the aquifer might both affect CO_2 storage capacity.

Tasks

1. Construct an evaluation model for CO_2 storage capacity in China. Search the Internet and the literature to obtain relevant data for your model. Estimate the total CO_2 storage capacity within all deep saline aquifers in China.

2. For your estimation in Task 1 above (i.e., your estimation of the total CO_2 storage capacity within all deep saline aquifers in China), how sensitive does this estimation depend on the density of CO_2 (or the density of CO_2-water or the density of CO_2-brine depending on your model)?

3. Based on your model and estimation, please write a popular science essay stating the significance and policy implications of your CO_2 storage model in achieving the goals of "carbon emissions peaking" and "carbon neutrality".

Submission

Your solution paper should include a 1-page Summary Sheet and a piece of short public science essay. The body cannot exceed 20 pages for a maximum of 23 pages with the Summary Sheet and short essay inclusive. The appendices and references should appear at the end of the paper and do not count towards the 23 pages limit.

IMMC 2022 - 大中華區域賽 C題 GREATER CHINA REGIONAL CONTEST PROBLEM C

新冠疫情之後其他傳染病的暴發風險和挑戰

THE RISK AND CHALLENGES OF FUTURE OUTBREAKS OF OTHER NOTIFIABLE INFECTIOUS DISEASES IN THE POST-COVID-19 PANDEMIC PERIOD

(初中組別專用 For Teams of Junior Secondary School Only)

背景

你是否發現今年的流感季發病率比往年明顯減少?新冠疫情已經持續近兩年，長期的防疫措 施(包括佩戴口罩、使用洗手液、社交隔離、出行限制、接觸追蹤和數字健康碼、大規模檢 測、定點封禁等)在控制新冠疫情的同時，亦在一定程度上幫助人們降低了感染其他傳染病 的風險(Xiao, 2021)。

例如，2020 年中國大陸地區共報告法定傳染病(包括新冠)5806728 例，死亡 26374 人，報 告發病率為 413.63/10 萬，報告死亡率為 1.88/10 萬;而 2019 年共報告法定傳染病 10244507 例，死亡 25285 人，報告發病率為 733.57/10 萬，報告死亡率為 1.81/10 萬 (中國衛健委, 2021)。類似地，廣東省 2020 年全省共報告法定傳染病(包括新冠)657684 例，死亡 1240 人，報告發病率為 570.88/10 萬，死亡率為 1.08/10 萬。與 2019 年相比，2020 年發病率和 死亡率分別下降了 59.72%和 5.41%，而 2019 年的廣東省統計數據較 2018 年發病率和死亡 率分別上升了 51.96%和 4.77%(廣東省衛健委, 2021)。

任務

越來越多的文獻在世界各國和地區發現了新冠防疫措施降低了其他傳染病的風險。然而，亦 有研究和專家表示，長期的防疫措施使得整個人們長期沒有接觸到傳染病，從而對各類傳染 病的易感染性較高。一旦防疫措施徹底放開，各類傳染病也很有可能緊接著爆發，屆時各個 地區的公共衛生系統將面臨挑戰(Zhang, 2021)。**請參賽的同學們利用真實數據和有效的數 學模型對該問題進行探討，描述和分析新冠疫情之後其他傳染病的暴發風險和挑戰。**

請參照如下要求和提示:
1. 請選取一種非新冠的傳染病進行研究(例如流感、鼠疫、艾滋病等)。
2. 請選取一個中國省份或城市進行研究(例如你所在的省市、廣東省、深圳市、香港、上海等)。
3. 公共衛生數據可在國家和各省市的衛健委及疾控中心網站獲取(請參見參考文獻)。
4. 請保持思維開闊，靈活利用各類傳統和非傳統的相關數據。

提交

你團隊的解決方案論文應包括 1 頁的摘要。正文不能超過 20 頁，含摘要最多 21 頁。附錄和 參考資料應出現在正文之後，不算在 21 頁的限制之內。

參考文獻:

Xiao, Jianpeng, Jiya Dai, Jianxiong Hu, Tao Liu, Dexin Gong, Xing Li, Min Kang et al. "Co-benefits of nonpharmaceutical intervention against COVID-19 on infectious diseases in China: A large population-based observational study." *The Lancet Regional Health-Western Pacific* 17 (2021).
URL: https://doi.org/10.1016/j.lanwpc.2021.100282

Zhang, Qingpeng. "Benefits of COVID-19 non-pharmaceutical interventions on the prevention of other notifiable infectious diseases." *The Lancet Regional Health–Western Pacific* 17 (2021).
ULR: https://doi.org/10.1016/j.lanwpc.2021.100303

中國衛健委. “2020 年全國法定傳染病疫情概況.” (2021)
URL: http://www.nhc.gov.cn/jkj/s3578/202103/f1a448b7df7d4760976fea6d55834966.shtml

廣東省衛健委. “2020 年全省法定報告傳染病疫情.” (2021)
URL: http://wsjkw.gd.gov.cn/zwgk_gsgg/content/post_3227856.html

中國衛健委疾病預防控制局數據發布.
URL: http://www.nhc.gov.cn/jkj/pqt/new_list.shtml

廣東省衛健委數據發布.
URL: http://wsjkw.gd.gov.cn/zwgk_tjxx/index.html

香港特別行政區衛生署健康統計數字.
URL:https://www.chp.gov.hk/tc/statistics/submenu/26/index.html

Have you noticed that the incidence of this year's flu season is significantly lower than in previous years? The COVID-19 pandemic has lasted for nearly two years. Non-pharmaceutical interventions (NPIs), such as wearing facial mask, using hand sanitizer, social distancing, travel restriction, contact tracing, mass testing, targeted quarantine, etc., have been demonstrated to be effective in containing the pandemic as well as reducing the risk of other notifiable infectious diseases (NIDs) (Xiao, 2021).

For example, in 2020, there were 5,806,728 NIDs (including COVID-19) cases (morbidity rate: 413.63 per 100,000 people) and 26,374 deaths (mortality rate: 1.88 per 100,000 people) in Mainland China. In 2019, there were 10,244,507 NIDs cases (morbidity rate: 733.57 per 100,000 people) and 25,285 NIDs-related deaths (mortality rate: 1.81 per 100,000 people) in Mainland China (National Health Commission, 2021). Similarly, in Guangdong Province of China, there were 657,684 NIDs (including COVID-19) cases (morbidity rate: 570.88/100,000 people) and 1,240 deaths (mortality rate: 1.08 per 100,000 people). As compared to 2019, the morbidity rate and mortality rate reduced by 59.72% and 5.41%, respectively. Whereas the morbidity rate and mortality rate in 2019 actually increased by 51.96% and 4.77% as compared to that of 2018.

Tasks

There is increasing evidence that the COVID-19 targeted NPIs reduced the risk of other NIDs. However, latest research and experts indicated that the susceptible population for other NIDs increased while COVID-19-targeted NPIs were in place, and thus might pose a greater risk of future outbreaks of NIDs after the COVID-19 targeted NPIs are relaxed (Zhang, 2021). **Please use real-world data and appropriate mathematical models to characterize and analyze the risk and challenges of future outbreaks of other notifiable infectious diseases in the post-COVID-19 pandemic period.**

Please refer to the following requirements and hints:

1. Please select ONE non-COVID-19 NID (such as influenza, plague, HIV, etc.) for your study.
2. Please select ONE Chinese province or city for your study (such as your province or city, Guangdong Province, Shenzhen, Hong Kong, Shanghai, etc.).
3. Public health data can be obtained from the national and local health commissions and centers for disease control and prevention (see some examples in the references).
4. Please be open-minded and innovatively use various conventional and non-conventional data that is related to the problem.

Submission

Your solution paper should include a 1-page Summary Sheet. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary Sheet inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit.

References:

Xiao, Jianpeng, Jiya Dai, Jianxiong Hu, Tao Liu, Dexin Gong, Xing Li, Min Kang et al. "Co-benefits of nonpharmaceutical intervention against COVID-19 on infectious diseases in China: A large population-based observational study." *The Lancet Regional Health-Western Pacific* 17 (2021).
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Zhang, Qingpeng. "Benefits of COVID-19 non-pharmaceutical interventions on the prevention of other notifiable infectious diseases." *The Lancet Regional Health–Western Pacific* 17 (2021).
ULR: https://doi.org/10.1016/j.lanwpc.2021.100303

中國衛健委. “2020 年全國法定傳染病疫情概況.” (2021)
URL: http://www.nhc.gov.cn/jkj/s3578/202103/f1a448b7df7d4760976fea6d55834966.shtml

廣東省衛健委. “2020 年全省法定報告傳染病疫情.” (2021)
URL: http://wsjkw.gd.gov.cn/zwgk_gsgg/content/post_3227856.html

中國衛健委疾病預防控制局數據發布.
URL: http://www.nhc.gov.cn/jkj/pqt/new_list.shtml

廣東省衛健委數據發布.
URL: http://wsjkw.gd.gov.cn/zwgk_tjxx/index.html

香港特別行政區衛生署健康統計數字.
URL:https://www.chp.gov.hk/tc/statistics/submenu/26/index.html



IMMC 2022 - 大中華區域賽 D題 GREATER CHINA REGIONAL CONTEST PROBLEM D

在元宇宙中搭建虛擬香港
BUILDING A VIRTUAL HONG KONG IN METAVERSE

背景

「元宇宙」(metaverse)是近來大熱的科技概念和受到業界高度重視的發展方向。盡管關於什 麼是元宇宙仍然眾說紛紜，缺乏統一的定義，但業界公認的元宇宙的重要特征之一是允許用戶/ 玩家在虛擬世界中創造新的虛擬物品，參考案例有 Second Life(圖 1)、Minecraft(圖 2)、 Roblox (圖 3)等知名的虛擬世界系統。

圖1. Second Life

圖 2. Minecraft

圖 3. Roblox

問題與情境

上述這些虛擬世界系統的一個共同之處是，其中的虛擬物品，小到衣物首飾，大到樓宇城市， 都是由有限幾種基礎構件(building block)搭建而成，如圖 4、5、6 所示。盡管這樣構建 出的虛擬物品在外觀精美和逼真方面也許比不上同時期的其他遊戲裏由專業人士精心建模的虛擬物品，但卻為用戶/玩家提供了最多的可能性，允許他們充分發揮創意，通過簡單易 學的操作建設自己想要的虛擬世界。

圖 4. Second Life 的基礎構件

圖 5. Minecraft 的基礎構件

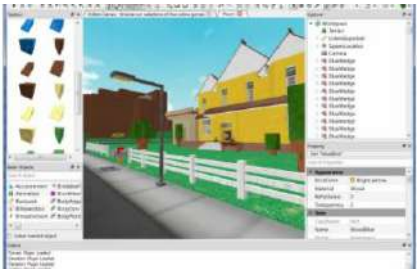


圖 6. Roblox 的基礎構件

如果要開發一個像 Second Life、Minecraft 或 Roblox 這樣，允許用戶/玩家創造虛擬物品的虛 擬世界系統，在設計用於搭建虛擬物品的基礎構件時，一般需要考慮以下幾點:

1. 基礎構件的種類不能過多，否則將增加用戶/玩家學習和操作的復雜度。但同時又必須兼 顧是否能用這有限種類的基礎構件搭建出盡可能豐富的虛擬物品，最大程度地模擬現實 世界中的萬物。某種程度上這有點類似樂高積木，用有限種類的樂高積木塊幾乎能搭出現實世界中的任何物體。

2. 基礎構件的粒度或尺度不能過小，因為每一個基礎構件都將占用若幹計算資源和存儲資源，基礎構件的總數越多，整個虛擬世界所需的計算資源和存儲資源越大。以虛擬世界 中的一堵墻為例，把每塊磚作為一個基礎構件，與把磚中的每粒沙作為一個基礎構件相 比，所需的計算資源和存儲資源顯然相差了好幾個數量級。

任務

1．試設計一組基礎構件，可用於在虛擬世界中搭建一個虛擬香港。虛擬香港中至少要包括 以下與真實香港一一對應的元素:建築物、交通工具、人。可以用簡單的圖形和偽代碼 (例如以偽代碼表示的數據結構)輔助描述你的設計，但不需要真正寫代碼實現。

2．基於你的設計，估算用於維持這樣一個虛擬香港與真實香港實時同步(即:虛擬香港是 真實香港的數字孿生體)所需的計算資源和存儲資源。請自行選擇同步的時間精度(如: 每分鐘、每秒、或每毫秒同步一次)，不需要考慮用以采集真實香港實時數據的傳感和通 訊。計算資源和存儲資源的估算也不必對應於真實的計算和存儲系統，以類似於“每秒需 進行多少次計算”和“共需占用多少字節的存儲”的描述方式回答即可。

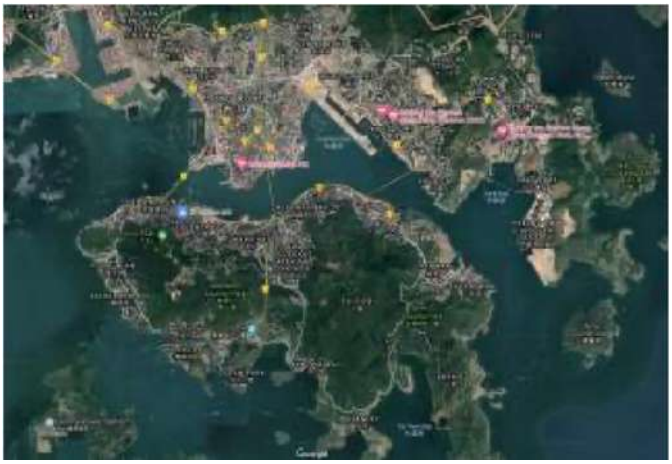


圖 7. Google 地圖上的香港

提交

你的團隊所提交的論文應包含 1 頁摘要，其正文不可超過 20 頁，包括摘要則最多不超過 21 頁。 附錄和參考文獻應置於正文之後，不計入 21 頁之限。

Background

Recently, *metaverse* has become a hot topic and direction of technology development that is highly valued by the industry. Although there are still different opinions about what the metaverse is and a unified definition is in vain, one of the important features of the metaverse recognized by the industry is that it allows users/players to create new virtual items in the virtual world. Examples include the well-known virtual world systems such as *Second Life* (Figure 1), *Minecraft* (Figure 2) and *Roblox* (Figure 3).

Figure 1. *Second Life*

Figure 2. *Minecraft*

Figure 3. *Roblox*

Problem and context

A common feature of the above-mentioned virtual world systems is that the virtual items, ranging from clothing and jewelry to buildings and cities, are constructed from a limited number of basic building blocks, as shown in Figures 4, 5, and 6. While such virtually built items may not be as beautiful and vivid in appearance as the virtual objects professionally modeled in other games of the same period, they provide the users/players with the most possibilities, allowing them to fully apply their creativity in building a virtual world they want through simple operations of easy-to-learn.

Figure 4. Building Blocks of *Second Life*

Figure 5. Building Blocks of *Minecraft*

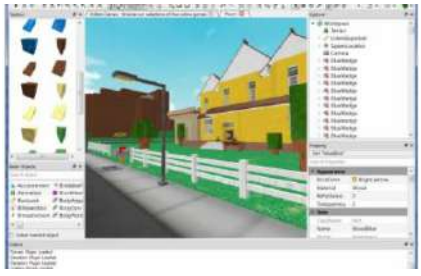


Figure 6. Building Blocks of *Roblox*

If you are developing a virtual system like *Second Life*, *Minecraft* or *Roblox* that allows users/players to create virtual items, you generally need to consider the following constraints when designing the basic blocks for building virtual items:

1. There should not be too many types of building blocks; otherwise it will increase the complexity for users/player's learning and operation. At the same time, you must consider whether you can use the limited type of building blocks to build as maximum virtual objects as possible to simulate everything in the real world. To some extent, it's a bit like Lego, with a limited variety of Lego blocks that you can build almost any object in the real world.

2. The granularity of building blocks, or sizes of building blocks, cannot be too small because each block will occupy some computing and storage resources. The more the total number of building blocks, the greater the computing and storage resources will be consumed by the entire virtual world. Taking a wall in the virtual world as an example, the computing and storage resources required are obviously different by several orders of magnitude when every grain of sands in a brick is used as a building block, compared to setting a brick as the basic block,

Task

1. Your team is requested to design a set of building blocks that can be used to build a virtual Hong Kong in the virtual world. The virtual Hong Kong should include at least the following elements that correspond to the real Hong Kong one-to-one: buildings, vehicles, and people. You can use simple graphics and pseudocode (such as data structures represented in pseudocode) to help describe your design, but you don't need to actually write code to implement it.

2. Based on your design, estimate the computing and storage resources required to maintain such a virtual Hong Kong in real-time, synchronized with the real Hong Kong; i.e., the virtual Hong Kong is a digital twin of the real Hong Kong. Please determine the time precision of synchronization by yourself (for example, every minute, second, or millisecond). You do not need to consider the sensing and communication for collecting real-time data of the real Hong Kong. Your estimates do not need to correspond to real computing and storage systems either. You can make your estimation with descriptions similar to "how many computations per second" and "how many bytes of storage" are needed in total.

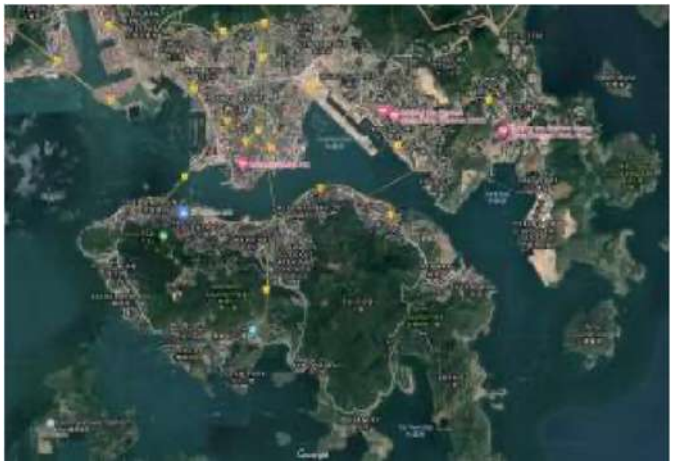


Figure 7. Hong Kong on Google Map

Submission

Your team's solution paper should include a 1-page Summary. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit.

IMMC 2022 - 大中華區域賽 E題 GREATER CHINA REGIONAL CONTEST PROBLEM E

區塊鏈如何幫助商戶社區聯盟推動商業價值?

HOW BLOCKCHAIN CAN HELP ALLIANCE AMONG MERCHANTS OF A COMMUNITY DRIVE BUSINESS VALUE?

背景與情境

我們正在經歷一場涉及不同行業應用的區塊鏈領域的革命。除了透明和去中心化的好處之外， 區塊鏈技術還推廣了社區概念，促進了社區利益相關者之間的協作。

我們來看一個與我們日常經濟活動相關的應用場景。客戶忠誠度積分或會員計劃是商戶為獎 勵客戶消費而發行的數字權利。全球每年生成約 1200 億美元的積分，包括信用卡支付獎勵、 零售積分、旅行積分等。作為商戶進一步刺激消費需求的手段，積分的實際使用率仍有較大 改善空間。據麥肯錫稱，發達國家的積分兌換率為 55%，而中國企業的平均積分兌換率只有 15%。目前，85%的積分被用於兌換發行者提供的商品和服務，只有 15% 用於發行者的業務範 疇之外。積分權益的跨企業、跨行業流通將有利於提高積分使用率，充分挖掘消費需求潛力。 有一種第三方積分平臺將不同企業的積分整合成一個通用系統，提供交叉消費場景。此類第 三方平臺通常由具有嚴格規則和條件的合作商家組成。

問題與任務

區塊鏈技術使得設計一個對所有商戶開放的去中心化的忠誠度積分系統成為可能。任何商戶， 甚至是競爭性商戶，都可以加入這樣的平臺，為更大的消費者群體提供服務。商戶之間可以 結成實效性聯盟或共同推廣服務——一種競合模式。區塊鏈上的隱私計算通過分析來自所有 商戶的集體數據池，讓商家更好地了解市場需求，同時它又可以保護每一個商戶的客戶特定 數據的隱私。這種去中心化的積分體系實現了跨商戶平臺權益的靈活轉移，從而提高了積分 的流動性和標準化。

在本次挑戰賽中，IMMC 聯盟公司希望您的團隊在去中心化忠誠度積分系統的背景下，通過 構建數學模型來量化商家協作的好處。您將需要考慮兩種場景，即一對一聯盟和多對多聯盟。

1. **一對一聯盟:** 在這種場景下，一個商戶與另一個商戶結盟。我們稱他們為 A 和 B. 通 過結盟，商戶 A 和 B 互相發行獎勵積分。積分在客戶從商戶購買時獲得發放。假設商 戶 B 向商戶 A 發行獎勵積分，然後商戶 A 將其分發給其客戶。客戶只能在向商戶 B 購 買商品時兌換這些獎勵積分，因為商戶 B 是原始發行人。當客戶兌換獎勵積分時，商 戶B向商戶A支付傭金。

    1) 請解釋商戶如何從這樣的聯盟中受益?
    2) 您認為對形成這樣的聯盟有什麼重要因素?是企業規模?產品類別?
    3) 開發一個數學模型來確定該一對一聯盟對商戶業務年收入變化的影響。

2. **多對多聯盟:** 在此場景下，一群商戶結盟並創建自己的獎勵積分經濟體。他們向他們的客戶發放積分獎勵，獎勵積分可在聯盟屬下的任何商戶處消費時得到兌現。您可 以將此獎勵積分經濟視為類似於 Yuu 積分獎勵系統。Yuu 積分可在任何 Yuu 商戶合作夥伴處得到兌換(參 Yuu Rewards Club:https://www.yuurewards.com/)。主要的 區別在於聯盟模型采用了區塊鏈技術，具有區塊鏈模型固有的去中心化和透明性;而 Yuu 積分系統是中心化管理的。

    1) 什麼因素對形成這樣的聯盟很重要?企業規模?產品類別?社區規模?嘗試將 每個因素建模為模型中的參數並確定其重要性。
    2) 是否存在形成這樣一個聯盟的最佳商家數量?如果是，請確定最佳數量，否則請 解釋原因。
    3) 每個商家年收入和利潤的變化對你的聯盟模型有影響嗎?

3. **商戶價值:** 假設一群商戶結成聯盟。他們想將獎勵積分分配給任何加入聯盟社區的 商戶。最初，他們同意向任何加入聯盟的商戶分配固定等量的獎勵積分。然而，一些 商戶聲稱他們應獲分配更多的積分，因為他們為社區帶來了更大的利益/價值。在為 這樣的社區中的每個商戶分配價值時，哪些因素很重要?請開發一個數學模型來確定 分配給該社區中特定商戶的獎勵積分數量。

提交

你團隊的解決方案論文應包括 1 頁的摘要。正文不能超過 20 頁，含摘要最多 21 頁。附錄和 參考資料應出現在正文之後，不算在 21 頁的限制之內。

Background and context

We are experiencing a revolution in the blockchain space with applications in various industries. Apart from its benefits of transparency and decentralization, blockchain technology has proliferated the concept of community and collaboration among its stakeholders.

Let's see an application relevant to our daily economic activity. Loyalty points or membership programs are digital rights issued by merchants to reward users for consumption. The world generates about 120 billion US dollars' worth of loyalty points each year, including credit card payment rewards, retail points, travel points etc. As a means for merchants to further stimulate consumer demand, the actual utilization rate of loyalty points still has a large room for improvement. According to McKinsey, the point exchange rate in developed countries is 55%, while the average point exchange rate for Chinese companies is only 15%. Currently, 85% are used to exchange points for goods and services provided by the issuers of the loyalty points, and only 15% are used outside the issuers' business. The cross-enterprise and cross-industry circulation of point rights will help improve the utilization rate of points and fully tap the potential of consumer demand. There is a kind of 3rd-party loyalty points platform which integrates the points of different enterprises into a general system to provide cross consumption scenarios. Such 3rd party platform is usually formed among collaborating merchants with rigid rules and conditions.

Problem and task

Blockchain technologies make it possible to design a de-centralized loyalty points system which is open to all merchants. Any merchants, even competing ones, can join such platform to provide service to a much bigger consumer base. Merchants can form alliance or jointly promote services with each other on a timely basis – a co-opetition mode. Privacy computation over blockchain gives merchants better understanding of the market demand by analyzing the collective data pools from all merchants, while at the same time it can maintain the privacy of the customers' specific data from each merchant. Such de-decentralized loyalty points system realizes the flexible transfer of rights and interests across merchant platforms, thereby improving the liquidity and standardization of the loyalty points.

In this Challenge, IMMC Alliance Company wants your team to quantify the benefits of merchant collaboration by forming a mathematical model in the context of de-centralized loyalty points system. You will be required to consider two scenarios, i.e., one-to-one alliance and many-to-many alliance.

1. One-to-one alliance: In this scenario, a merchant allies with one other merchant. Let's call them A and B. By forming an alliance, merchants A and B issue reward points to each other. The reward points are distributed to customers on their purchases from the merchants. Let's say Merchant B issues reward points to Merchant A, and then Merchant A distributes them to its customers. The customers can only redeem those points when purchasing items at Merchant B as it was the original issuer. Merchant B pays a commission to Merchant A when the customer redeems.

a. Explain how merchants can benefit from such an alliance?
b. What factors do you think are important in forming such an alliance? Business size? Producttype?
c. Develop a mathematical model to determine the change in business yearly revenue for a merchant from this one-to-one alliance.

2. Many-to-many alliance: In this scenario, a group of merchants ally and create their own reward points economy. They give out reward points to their customers which are redeemable upon purchase at any merchant who is part of the alliance. You can think of it as a reward system similar to Yuu reward points where Yuu points are redeemable at any Yuu partner (**Yuu Rewards Club:** https://www.yuurewards.com/). The main difference is that the alliance model utilizes blockchain technology with decentralization and transparency inherently; while Yuu is managed in a centralized way.

a. What factors will be important in forming such an alliance? Business size? Product type? Size of the community? Try to model each factor as a parameter in your model and determine its importance.
b. Is there an optimal number of merchants to form such an alliance? If yes, determine the optimal number, or else explain why not.
c. Would the change of yearly revenue and profit of each merchant have any effect on your alliance model?

3. Merchant Value: Assume a group of merchants have formed an alliance. They would like to allocate reward points to any merchant who joins the community. Initially, they agreed to allocate fixed and equal amounts of reward points to any merchant who joins the community. However, some merchants claim that they should be allocated a greater number of reward points as they bring greater benefit/value to the community. What factors are important in assigning value to each merchant in such a community? Please develop a mathematical model to determine the amount of reward point allocation to a particular merchant in this community.

Submission

Your solution paper should include a 1-page Summary. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit.


IMMC 2022 - 大中華區域賽 F題 GREATER CHINA REGIONAL CONTEST PROBLEM F

新冠病毒的跨境傳播預測

PREDICTING THE CROSS-BORDER TRANSMISSION OF COVID-19

(初中組別專用 For Teams of Junior Secondary School Only)

新冠疫情在 2020 年上半年迅速席卷全球，成為全球性大流行。病毒的傳播依賴人們的密切 接觸，所以跨國跨地區傳播不僅僅和國家及地區之間的距離有關，更緊密依賴不同國家及地 區之間的人口流動特征。傳統的公共衛生研究普遍認為，地理距離越近的地點之間發生疾病 傳染的風險越大，因為病毒是由人攜帶傳播的，而距離越近，人口來往的概率越大，疾病傳 播的風險也就越高。這種方法在小尺度的地區性傳染病疫情建模上一般比較有效。

然而，跨國跨地區城市之間的人口流動主要依賴於飛機航班，而非直接的陸路交通。跨國跨 地區跨地區人口流動行為也並非只與地理距離有關，例如歐洲和美國相隔千裏，但是人口流 動非常密集，遠勝於距離更近歐洲和非洲的人口流動。也就是說，除了地理距離，我們也要 考慮通過飛機航班的真實人口流動數據來了解疾病傳播風險，人口流動越頻繁，疾病傳播風 險越大。這種方法在大尺度的國際性傳染病疫情建模上可能更加有效。

任務

那麼，在新冠疫情中，哪種方法在何時何地更行之有效?新冠病毒的多種變異帶來了多次本 地和跨國跨地區爆發，早期的國際傳播特征和後期變種的國際傳播模式可能有所不同。

請你的團隊利用真實數據嘗試建立有效的數學模型對該問題進行探討，分析新冠病毒的國際 傳播特征並做預測。請參照如下要求和提示:

1. 新冠疫情分成幾次爆發進行分析。
2. 請使用有效的數學模型對新冠病毒(以及其不同變種)到達多個具有代表性國家及地區的時間和先後順序進行預測(不需要研究所有國家及地區)。
3. 公開數據可以從網絡獲取(參見參考文獻2、3)。
4. 請保持思維開闊，靈活利用各類傳統和非傳統的相關數據(例如飛機航班傳播之外的冷鏈物流等其他傳播方式等)。

提交

你團隊的解決方案論文應包括 1 頁的摘要。正文不能超過 20 頁，含摘要最多 21 頁。附錄和 參考資料應出現在正文之後，不算在 21 頁的限制之內。

參考文獻

1. Northwestern University, *Using air transportation data to predict pandemics.* https://www.eurekalert.org/news-releases/922733
2. JHU COVID-19 Resource Center, https://coronavirus.jhu.edu/map.html
3. OpenSky Network Data: https://opensky-network.org/community/blog/item/6-opensky-covid-19-flight-dataset

The COVID-19 has caused a global pandemic since early 2020. Virus transmission relies on the close contact between people. The cross-border transmission is not only related to the distance, but also the human movement patterns between countries and areas. Conventional public health approach assumes that the risk of virus transmission between two locations is associated with the geographical distance between them, because the closer the distance, the higher chance people travel, and thus the higher risk of virus transmission. This approach is usually effective in modeling small-scale regional infectious disease epidemic.

However, the cross-border human movements are mainly dependent on air transportation, not direct ground transportation. As a result, the cross-border human movement patterns are not only related to the geographic distance. For example, Europe and the United States are far away, but human movements between them are very intense, much more often than the human movements between Europe and Africa. In other words, in addition to the geographic distance, we also need to take into account the actual human movement data while modeling the risk of virus transmission. The higher the human movement, the higher the risk of virus transmission. This approach is usually effective in modeling large-scale global infectious disease pandemic.

Tasks

Which approach is more effective in modeling the transmission of the COVID-19? The COVID-19 viral mutations have caused multiple waves of local and global outbreaks. The global transmission patterns of early and latter waves could be different.

Your team is requested to use real-world data to build mathematical models to investigate this problem. Please characterise and predict the global virus transmission of the COVID-19. Note the following requirements and hints:

1. Please analyse the multiple waves of the COVID-19 pandemic.
2. Please predict when and in which order different strains of the virus arrived at different representative countries/areas (no need to analyse all countries/areas).
3. Open source data are available on the Internet (see reference 2 and 3).
4. Please be open-minded and use various traditional and non-traditional data in a flexible manner (such as cold supply chain and the transmission modes other than air transportation).

Submission

Your solution paper should include a 1-page Summary. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit.

References

1. Northwestern University, *Using air transportation data to predict pandemics.* https://www.eurekalert.org/news-releases/922733
2. JHU COVID-19 Resource Center, https://coronavirus.jhu.edu/map.html
3. OpenSky Network Data: https://opensky-network.org/community/blog/item/6-opensky-covid-19-flight-dataset

IMMC 2022 - 國際賽賽題 INTERNATIONAL ROUND PROBLEM

ABOARD!
BOARDING AND DISEMBARKING A PLANE

Background

In air transportation, efficiency is time and time is money. Even small delays in the schedules of passenger airplanes result in lost time for both air carriers and their passengers. During any passenger flight, there are two time-consuming operations that depend mostly on human behavior: boarding and **disembarking** the aircraft.

In commercial passenger air travel, airlines use various boarding and disembarking methods from completely unstructured (passengers board or leave the plane without guidance) to structured (passengers board or leave the plane using a prescribed method). Prescribed methods may be based on row numbers, seat positions, or priority groups. In practice, however, even when the prescribed method is announced, not all passengers follow the instructions.

The boarding process includes the movement of passengers from the entrance of the aircraft to their assigned seats. This movement can be hindered by aisle and seat interference. For example, many passengers have **carry-on bags** which they stow into the **overhead bins** before taking their seats. Each time a passenger stops to stow a bag, the queue of other passengers stops because narrow aircraft aisles allow only one passenger to pass at a time. Another hindrance is that some seats (e.g., window seats) are unreachable if other seats (e.g., aisle seats) are already occupied. When this occurs, some passengers must stand up and move into the aisle so other passengers can reach their seats.

The disembarking process is the opposite of boarding with its own possible hindrances to passenger movement. Some passengers are simply slow getting out of their seat and row, or slow moving to the exit. Passengers also block the aisle while collecting their belongings from either their seat or from the overhead bin forcing passengers behind them in the aircraft to wait.

Requirements

Your team is to create plane boarding and disembarking methods that will be the most time- effective in real practice.

1. Construct a mathematical model or models to calculate total aircraft boarding and disembarking times. Ensure your model is adaptable to various prescribed boarding/disembarking methods and varying numbers of carry-on bags to be stowed, as well as accounts for passengers who do not follow the prescribed boarding/disembarking methods.

2. Apply your model to the standard "narrow-body" aircraft shown in **Figure 1**.

a. Compare the average, practical maximum (95th percentile) and practical minimum (5th percentile) boarding times for the following widely used boarding methods:

- Random (unstructured) boarding.
- Boarding by Section: Examine varying the order of aft section (rows 23-33), middle section (rows 12-22), and bow section (rows 1-11).
- Boarding by Seat: In the order of window seats (A and F), middle seats (B and E), and aisle seats (C and D).

b. Analyze how these times vary based on the percentage of passengers not following the prescribed boarding method and on the average number of carry-on bags per flight (i.e., perform a basic sensitivity analysis). Based on your analysis, which of the above boarding methods is the best?

c. Consider the situation when passengers carry more luggage than normal and stow all their carry-ons in the overhead bins. How does this change affect the results?

d. Describe two additional possible boarding methods. Explain and justify your recommended optimal boarding method (from your two and the three in part 2.a.).

e. Explain and justify your optimal disembarking method.

3. Modify your model for the following passenger aircraft and recommend your optimal boarding and disembarking methods for each aircraft.

- The Flying Wing aircraft with relatively wide and short passenger cabins as shown in **Figure 2**.
- A Two-Entrance, Two-Aisle aircraft as shown in **Figure 3.**

4. Due to the pandemic situation, capacity limitations are sometimes implemented on passenger airliners. Will your recommended prescribed methods for boarding and disembarking of the three aircraft change if the number of passengers is limited to 70%, 50%, or 30% of the number of seats?

5. Write a one-page letter to an airline executive describing and explaining your results, recommendations, and rationale about passenger aircraft boarding and disembarking in a non- mathematical way.

Note that IM²C is aware of available resources and references that address and discuss this question. It is not sufficient to simply re-present any of these models or discussions, even if properly cited. Any successful paper MUST include development and analysis of your own team's model and a clear explanation of the difference between your model and any referenced aircraft boarding and disembarking models.

Your PDF submission should consist of:

- One-page Summary Sheet.
- Table of Contents.
- One-page letter to an airline executive.
- Your solution of no more than 20 pages (A4 or letter size), for a maximum of 23 pages with your summary, table of contents, and letter. Note that your font size must be no smaller than 12-point type.

Note: Reference List and any appendices do not count toward the page limit and should appear after your completed solution. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

Glossary
Carry-On Bag – a piece of luggage a passenger carries onto an airplane with dimensions such that it can fit in the overhead bin.
Disembarking – leaving (an airplane).
Overhead Bins – storage compartments attached to the ceilings of aircraft for baggage stowage during a flight.

Airline Figures

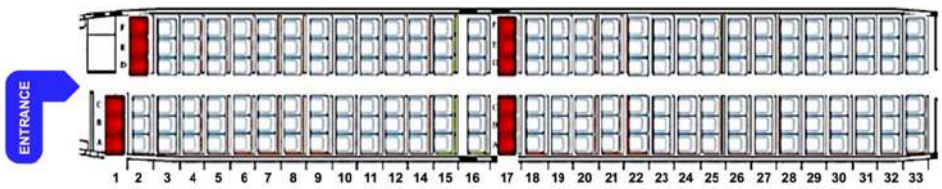


Figure 1. "Narrow-Body" Passenger Aircraft

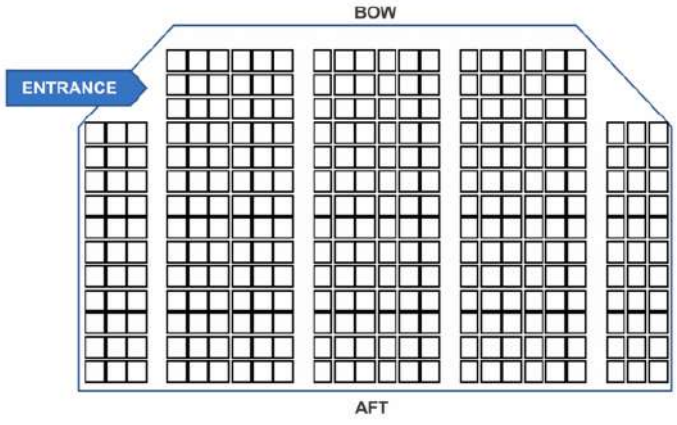


Figure 2. "Flying Wing" Passenger Aircraft

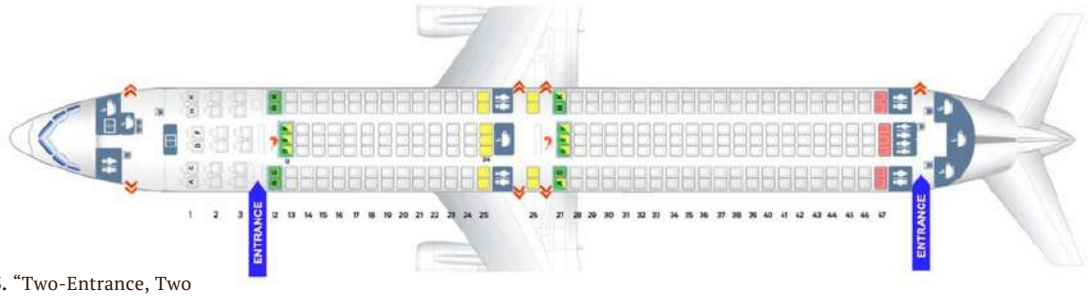


Figure 3. "Two-Entrance, Two Aisle" Passenger Aircraft

中華國際數學建模挑戰賽委員會「優質教育基金」項目展開
IM²C (ZHONGHUA) "QUALITY EDUCATION FUND" PROJECT CARRIED OUT

中華國際數學建模挑戰賽委員會年前榮獲香港特區政府「優質教育基金」（QEF），鼓勵IM²C 競賽與學校教學的結合，通過數學建模的教與學，深入推廣STEM教育。中華國際數學建模挑戰賽委員會已在香港中學當中開展該項目支持的「通過數學建模教與學促進STEM教育增益計劃 2021-2024」，旨在加深並發揮學生在數理科技工程及社會經濟中應用數學的潛力，提升解決實際問題與創新能力。詳情請到: www.istem.info/IMMC-QEF/

STEM是科學、技術、工程及數學四個學術領域的簡稱， 其中數學是其他三個領域的基礎和學科交叉的橋樑。STEM教育的要義是學科間的交叉與融合，在具體現實或學科情境中解決問題，而數學建模正是貫穿整個解決問題過程中的學科交叉的實現途徑。數學建模的學習與應用，將能夠幫助學生培養建模能力與計算思維，開拓在科技及工程界以至其他界別的學習和工作機會，讓他們對社會及經濟發展作出更大貢獻。

International Mathematical Modeling Challenge (IMMC or IM²C) Committee (Zhonghua) is proud to announce that it has received funding support from the Quality Education Fund of the HKSAR Government. The QEF project of IM²C (Zhonghua) aims to foster the collaboration between classroom teaching and the IM²C international contest, and further promote teaching and learning of science, technology, engineering, and mathematics (STEM) subjects in schools through mathematical modeling. With the support from QEF, IM²C (Zhonghua) has carried out the "The Advanced Program for Promoting STEM Education through Learning and Teaching Mathematical Modeling and its Applications 2021-2024" to build up Hong Kong students' capabilities to innovate through enhancing their creativity and skills in solving real-world problems. Please visit this website for detail: www.istem.info/IMMC-QEF/

STEM education is a worldwide trend to enhance the competitiveness in innovation for students. Among the 4 components of STEM, mathematics plays a critical role in connecting the other 3 fields by providing a reliable foundation for scientific and innovative achievements. Mastery of mathematical modeling therefore will definitely help our future generations improve the modeling competence and computational thinking to cope with the ever-changing environment, and boost the employability, thereby contributing to the socio-economic development of our country.

Our QEF-funded project titled "The Advanced Program for Promoting STEM Education through Learning and Teaching Mathematical Modeling and its Applications 2021-2024" is composed of three major parts as follows:

教師培訓 - 在項目期間，我們將向香港的中學教師提供結構化的培訓計劃。該培訓計劃旨在為高中教師提供必要的技能和知識，以教授學生數學建模。

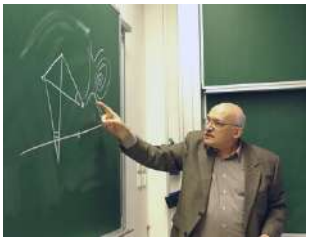
Teacher training - a structured training programme will be delivered to secondary school teachers in Hong Kong during our project period. The training programme aims to equip high school teachers with the necessary skills and knowledge to teach their students mathematical modeling.

學生工作坊 - 全港中學生將有機會體驗使用數學模型解決重大現實問題。他們不僅將接觸到數學建模的最新應用，還將有機會在研討會期間練習和提高他們的建模技術和技能。

Student workshop - secondary school students across the territory will have the opportunity to experience the use of mathematical modeling in solving significant real-world problems. Not only will they be exposed to the latest applications of mathematical modeling, but they will also have the opportunity to practice and sharpen their modeling techniques and skills during the workshops.

實地考察——我們將把參與的師生帶到不同行業的前沿，揭示如何應用數學建模來解決現實世界中的重大問題的奧秘。將安排參觀知名企業，包括應科院、優必選、中國銀行（香港）等。

Field study - we will bring the participating teachers and students to the forefront of different industries and reveal the mystery of how mathematical modeling could be applied to solve significant problems in real-world context. Tours will be arranged to visit renowned corporations including ASTRI, UBTech, and Bank of China (Hong Kong) among others.



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