CHULA ENGINEERING
Foundation toward Innovation

ICCBEI 2023

BANGKOK THAILAND

PROGRAM and BOOK OF ABSTRACTS

The 5th International Conference
on Civil and Building Engineering Informatics

July 19-21, 2023

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GREETINGS FROM THE CHAIR OF ICCBEI 2023

Sawasdee Krub. Welcome to the 5th International Conference on Civil and Building Engineering Informatics (ICCBEI 2023), Bangkok, Thailand. Chulalongkorn University is grateful and honored to host this prestigious conference. ICCBEI was organized from the previous series of Asian Construction Information Technology Roundtable Meeting, which had been sponsored by Japan Society of Civil Engineers (JSCE) and Japan Construction Information Center (JACIC). At that time, Asia did not have any international conferences on computing in civil and building engineering. The Board of Directors (BOD) of Asian Group for Civil Engineering Informatics (AGCEI) was established and organized the 1st ICCBEI in 2013. The following three conferences were held in Tokyo (2015), Taipei (2017), and Sendai (2019). Due to the COVID-19 pandemic, ICCBEI has not been organized since then.

In recent years, especially during the COVID-19 era, digital disruption has accelerated the digital transformation of every industry, especially construction. To be productive and competitive with their opponents, architecture, engineering, construction, and operations (AECO) organizations are obliged to smartly adopt and implement a variety of digital technologies to serve their various purposes. In addition to fundamental digital technologies such as building/construction information modeling (BIM/CIM), several modern information technologies have been emerging and widely used in construction business such as XR (VR, AR, MR); laser and image scanning; AI; big data; and ChatGPT.

ICCBEI 2023 covers a wide range of research fields in the application of Information and Communication Technology (ICT) to civil, building, and environmental engineering. The conference called for abstracts (optional) in January 2023, and the full papers were submitted in April 2023. With rigorous reviews by the scientific committee, the conference finally accepted 74 full papers, which are grouped into nine categories, namely, (1) Building and Construction Information Modeling, (2) Visualization and XR, (3) Laser and Image Scanning, (4) AI & Data Analysis, (5) Information Process and Management, (6) Construction Engineering and Asset Management, (7) Green Construction and Sustainability, (8) Digital Twin, and (9) Smart Cities and Infrastructure Management.

Finally, ICCBEI 2023 would like to express our gratitude for tremendous support from Professor Nobuyoshi Yabuki (the President of Board of Directors, AGCEI); Professor Supot Teachavorasinskun, Dean of Engineering, Chulalongkorn University; Professor Boonchai Stitmannaithum, Head of Civil Engineering Department, Chulalongkorn University; the Organizing Committee members; the Scientific Committee members; all organizing staff; and many others. Without your devotion, this conference will never happen. We hope you enjoy the conference and Bangkok.

Veerasak Likhitruangsilp
Chair of the Organizing Committee ICCBEI 2023
Associate Professor, Chulalongkorn University, Thailand

ICCBEI 2023 PROGRAM

Day 1: Wednesday July 19, 2023

13.00-16.00	**Conference** Excursion Future Tales Lab by MQDC
18.00-20.00	**Reception** Samyarn Mitrtown Hall (5th Floor of Samyan Mitrtown)

Day 2: Thursday July 20, 2023

9:00-9:30	Reception & Registration (Samyan Mitrtown Hall)	
9:30-9:45	Opening Ceremony (The Mitr-ing Room)	
9:45-10:30	**Keynote Lecture 1** (The Mitr-ing Room) ***Assoc. Prof. Wisanu Subsompon, Ph.D.*** *Vice Governor of Bangkok Metropolitan Authority* "Transforming Urban Living in Bangkok: The Role of Infrastructure Asset Management in Creating a Smart City"	
10:30-10:45	Coffee Break	
10:45-11:30	**Keynote Lecture 2** (The Mitr-ing Room) ***Professor Xiangyu Wang*** *Curtin University, Australia* "Engineering Brain: Metaverse for the Future Engineering"	
11:30-12:45	Lunch Break	
12:45-15:00	Session 1 (The Mitr-ing Room)	Session 2 (Meeting Room 2)
	[BIM1]-[BIM9] Building and Construction Information Modeling	**[XR1]-[XR4]** Visualization and XR and **[LIS1]-[LIS3]** Laser and Image Scanning
15:00-15:15	Coffee Break	
15:15-17:30	Session 3 (The Mitr-ing Room)	Session 4 (Meeting Room 2)
	[AI1]-[AI9] AI & Data Analysis	**[AI10]-[AI15]** AI & Data Analysis and **[IPM1]-[IPM3]** Information Process and Management
18:00-20:00	**Banquet** Chaloem Rajakumari 60 (Chamchuri 10) Building	

ICCBEI 2023 PROGRAM

Day 3: Friday July 21, 2023

9:00-9:45	**Keynote Lecture 3** (The Mitr-ing Room) ***Professor Photios G. Ioannou*** *University of Michigan (Ann Arbor), USA* "Decision Support Systems for Civil Engineering Construction"	
9:45-10:00	Coffee Break	
10:00-12:00	Session 5 (The Mitr-ing Room)	Session 6 (Meeting Room 2)
	[CEA1]-[CEA6] Construction Engineering and Asset Management	**[GS1]-[GS6]** Green Construction and Sustainability
12:00-12:45	Lunch Break	
12:45-15:00	Session 7 (The Mitr-ing Room)	Session 8 (Meeting Room 2)
	[DT1]-[DT6] Digital Twin and **[BIM10]-[BIM12]** Building and Construction Information Modeling	**[SCI1]-[SCI7]** Smart Cities and Infrastructure Management
15:00-15:15	Coffee Break	
15:15-17:15	Session 9 (The Mitr-ing Room)	Session 10 (Meeting Room 2)
	[BIM13]-[BIM18] Building and Construction Information Modeling	**[BIM19]-[BIM24]** Building and Construction Information Modeling
17:15-17:45	**Closing Ceremony** (The Mitr-ing Room) Best Papers and Best Presentation Awards Closing, Group Photo	

KEYNOTE LECTURE 1

TRANSFORMING URBAN LIVING IN BANGKOK: THE ROLE OF INFRASTRUCTURE ASSET MANAGEMENT IN CREATING A SMART CITY

Wisanu Subsompon

Ph.D., Associate Professor
Deputy Governor, Bangkok Metropolitan Administration

Abstract: The rapid urbanization and population growth in cities worldwide have presented numerous challenges, and Bangkok is no exception. In response to these challenges, the Bangkok Metropolitan Administration (BMA) has embarked on a transformative journey to establish a smart and sustainable metropolis. A crucial component of this transformation is Infrastructure Asset Management (IAM), which harnesses technology to enhance the efficiency, resilience, and quality of urban infrastructure. Two key areas of focus in this endeavor are Pavement Analysis for Maintenance and Lighting Control Systems. By integrating advanced technologies such as the Internet of Things (IoT), survey technology, artificial intelligence, and data analytics, the BMA effectively monitors, maintains, and optimizes the city's infrastructure assets.

The application of Pavement Analysis for Maintenance ensures that Bangkok's roads and sidewalks are in optimal condition. By utilizing survey technology, and data analytics, the BMA can proactively identify areas requiring maintenance, minimizing disruptions and enhancing overall transportation efficiency. This approach results in cost savings and improved safety for residents and commuters. The implementation of a sophisticated Lighting Control System is another significant aspect of Bangkok's smart city transformation. Through IAM, the BMA leverages advanced technologies to monitor and control street lighting. This enables efficient energy management, reduced light pollution, and enhanced safety in public spaces. By leveraging data analytics, the BMA can identify patterns and optimize lighting schedules, creating a more sustainable and citizen-centric urban environment. While Bangkok has made substantial progress in its smart city journey, several challenges remain. These include concerns related to privacy and security, the need for infrastructure upgrades, and ensuring equitable access to technology for all citizens. To address these challenges, Bangkok should continue to foster collaboration between the public and private sectors, invest in research and development, and place a strong emphasis on citizen engagement and inclusivity.

KEYNOTE LECTURE 1

Profile of Dr. Wisanu Subsompon

Dr. Wisanu Subsompon earned Ph.D. in Civil Engineering from Carnegie Mellon University, USA in 1996. He also received the Bachelor of Law degree from Sukhothai Thammathirat University, Thailand in 2001. After graduating Ph.D., he had been working at Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand. During his tenure at Chulalongkorn University, he served in many executive positions of the university, including the Vice President for Property and Physical Resources Management, the Vice President for Property and Innovation Management, the Assistant to the University President for Science and Technology Development, the Director General of Chulalongkorn University Intellectual Property Institute, and the Managing Director of Jamjuree Innovations Co., Ltd. (holding company). In addition, he was an advisor to the Minister of Transport (Dr. Chatchart Sittipunt), the Independent Director of Airports of Thailand Public Company Limited, the Independent Director of BFIT Securities Public Company Limited, and the Independent Director of Land and Houses Public Company Limited. He is currently the Vice Governor of Bangkok Metropolitan Authority.

KEYNOTE LECTURE 2

ENGINEERING BRAIN: METAVERSE FOR THE FUTURE ENGINEERING

Xiangyu Wang

Ph.D., Professor, School of Design and Built Environment, Faculty of Humanities, Curtin University, Perth, Australia. Email: Xiangyu.Wang@curtin.edu.au

Abstract: Engineering Brain is a sophisticated system that uses AI algorithms to analyse data and provide valuable insights to engineers. It allows engineers to simulate various construction scenarios and predict their outcomes, enabling them to make informed decisions in real-time. By integrating BIM, engineers can create a digital twin of the project that captures every detail of the physical structure, from the design to the construction phase. This technology enhances collaboration between all parties involved, including architects, engineers, contractors, and owners. This keynote presentation will provide attendees with an in-depth understanding of the engineering brain concept and its application in construction and civil engineering. The presentation will begin by introducing the basic principles of the engineering brain and its components. Then, the presentation will delve into the benefits of using the engineering brain in construction and civil engineering, including improved accuracy, efficiency, and sustainability. The keynote presentation will also discuss various case studies and real-world examples of successful engineering brain implementations. Attendees will have the opportunity to learn about the challenges faced during implementation and the solutions that were employed to overcome them. Finally, the keynote presentation will conclude with a discussion of the future of the engineering brain in construction and civil engineering.

KEYNOTE LECTURE 2

Profile of Professor Xiangyu Wang

Professor Xiangyu Wang is a global "Highly Cited Researcher" recognized by Clarivate Analytics, and a Fellow of the EU Academy of Sciences. He is affiliated with Curtin University and also the Executive Director/Distinguished Professor at the Institute of Intelligent Construction and Maintenance of Civil Infrastructure at East China Jiaotong University. He served on the panel of the Australian Research Council College of Experts in 2016-2018. He was also the Woodside Chair for a five-year term, the Australia's top ten ASX listed company and largest energy company. His research achievements have been applied in various sectors including energy, mining, infrastructure, and construction, resulting in billions of dollars in global economic benefits. He has published 400+ journal articles where over 30 articles were ranked as ESI top 1 % highly cited papers and nearly 10 articles were hot papers (top 0.1%). His Web of Science overall citation is over 10,000.

KEYNOTE LECTURE 3

DECISION SUPPORT SYSTEMS FOR CIVIL ENGINEERING CONSTRUCTION

Photios G. Ioannou

Ph.D., Professor, Civil & Environmental Engineering Department, University of Michigan, Ann Arbor, Michigan, USA 48109-2125. Email: photios@umich.edu

Abstract: Decision support systems have been developed and applied at all levels of civil engineering construction. This presentation will concentrate on two such applications. At the strategic level we will examine how competitive bidding models can help a contractor select the optimum price for a lump-sum construction contract. We will also examine the importance of cost uncertainty and the contractor's risk aversion on the optimum bid price. These are two factors that have traditionally been ignored even though they have a significant impact on how much the contractor should bid. At the operational level we will describe the discrete event simulation systems that have been developed at the University of Michigan, such as UM-CYCLONE, COOPS, STROBOSCOPE, and EZSTROBE, for modeling construction processes under uncertainty. The most modern of these, STROBOSCOPE and EZSTROBE, are used throughout the world for research, teaching, and practice, and are available from www.stroboscope.org. Applications of these systems to be presented include general earthmoving, dam construction, tunneling, and the scheduling of projects with repeating activities under uncertainty.

Profile of Professor Photios G. Ioannou

Photios G. Ioannou is Professor in the Department of Civil and Environmental Engineering at the University of Michigan, a Fellow of the ASCE, and a recipient of several awards including the Peurifoy Construction Research Award and the John O. Bickel Award from ASCE. Together with his former doctoral student J.C. Martinez are the designers and developers of the STROBOSCOPE Simulation System. He has also performed research in the development of other simulation systems, including UM-Cyclone, COOPS, EZStrobe, ProbSched, CPMAddon, and Chastrobe. His research is in construction engineering and management in the areas of simulation, tunneling, competitive bidding models, project finance, innovative project delivery systems, and project scheduling. His email address is photios@umich.edu and his homepage is https://www.ioannou.org

PARALLEL SESSIONS

Day 2: July 20, 2023 | 12.45-15.00

Session 1 (The Mitr-ing Room):
Building and Construction Information Modeling [BIM/CIM]

Chair: Prof. Koji Makanae (Miyagi University)
Co-Chair: Dr. Natthapol Saovana (King Mongkut's University of Technology North Bangkok)

[BIM1] Multi-Modal Deep Learning (MMDL)-Based Automatic Classification of BIM Elements for Construction Cost Estimation

Hao Liu (The Hong Kong University of Science and Technology), Shanjing Zhou (Imperial College London), Vincent J.L. Gan (National University of Singapore), Jack C.P. Cheng (The Hong Kong University of Science and Technology)

[BIM2] An Automatic Translation Framework based on Ontology to Building Energy Models

Zhaoji Wu (The Hong Kong University of Science and Technology), Jack C.P. Cheng (The Hong Kong University of Science and Technology), Zhe Wang (The Hong Kong University of Science and Technology), Helen H.L. Kwok (The Hong Kong University of Science and Technology)

[BIM3] GIS Based 3D Data Integration on Highway Tunnel through Lifecycle Management for Advanced Maintenance

Choijilsuren Batbaatar (Kyushu University), Yasuhiro Mitani (Kyushu University), Hisatoshi Taniguchi (Kyushu University), Hiroyuki Honda (Kyushu University)

[BIM4] A Building Information Model for Sensing and Simulation toward Net-Zero Energy Building Renovation

Kazuya Matsuba (Osaka University), Nobuyoshi Yabuki (Osaka University), Tomohiro Fukuda (Osaka University), Yoshiro Hada (Tokyu Construction Co., Ltd)

[BIM5] A Property Data Sharing Method of Building Information Models Using Remote Augmented Reality

Koji Yoshimura (Osaka University), Nobuyoshi Yabuki (Osaka University), Tomohiro Fukuda (Osaka University)

[BIM6] "To BIM or Not to BIM": A Simulation Game for Teaching AEC Students the Key Mechanisms in Project Delivery

Yun-Tsui Chang (National Taiwan University), Aritra Pal (National Taiwan University), Tzong-Hann Wu (National Taiwan University), Shang-Hsien Hsieh (National Taiwan University)

[BIM7] A BIM-Assisted Planning Tool for Facilitating the Application of an Aluminum Formwork System to Beam-Column Buildings

Kuan-Yi Chen (National Taiwan University), Tzong-Hann Wu (National Taiwan University), Budy Setiawan (FBC Formworks Systems Co., Ltd.), Cecilia Clarita Tandri (FBC Formworks Systems Co., Ltd.), Shang-Hsien Hsieh (National Taiwan University), Wen-Tung Chang (FBC Formworks Systems Co., Ltd.)

[BIM8] Development of a BIM-Based System for Assessment and Optimization of GHG Emissions in the Early Design Stage

Thanasak Phittayakorn (Chulalongkorn University), Chavanont Khosakitchalert (Chulalongkorn University), Lapyote Prasittisopin (Chulalongkorn University)

[BIM9] BIM-COBie Based Bridge-Defect Integrated Model for Condition Assessment of Bridge Superstructure

Jung-Bin Lee (Yonsei University), Sangho Lee (Yonsei University), Inseop Yun (Yonsei University), Sang-Ho Lee (Yonsei University)

Day 2: July 20, 2023 | 12.45-15.00

Session 2 (Meeting Room 2):
Visualization and XR [XR]/Laser and Image Scanning [LIS]

Chair: Prof. Xiangyu Wang (Curtin University)
Co-Chair: Assoc.Prof. Sy Tien Do (Ho Chi Minh City University of Technology-VNU-HCM)

[XR1] Construction of a Location-Based Mixed-Reality Visualization System Using Global Navigation Satellite System Data

Ryoudai Nakaso (Chuo University), Masahiro Suzuki (Chuo University), Hiroshi Okawa (Chuo University), Tsuyoshi Kotoura (Penta-Ocean Construction CO.), Kazuo Kashiyama (Chuo University)

[XR2] Advanced Augmented Reality Object Placement in Construction Sites Using Geospatial API and Visual Positioning Systems

Haein Jeon (Seoul National University of Science and Technology), Youngsu Yu (Seoul National University of Science and Technology), Sihyun Kim (Seoul National University of Science and Technology), Bonsang Koo (Seoul National University of Science and Technology)

[XR3] Automated Dimensional Checking in Mixed Reality for Staircase Flight

Michelle Siu Zhi Lee (Osaka University), Nobuyoshi Yabuki (Osaka University), Tomohiro Fukuda (Osaka University)

[XR4] BIM-Based and Augmented Reality Combined with a Real-Time Fire Evacuation System for the Construction Industry

Somjintana Kanangkaew (Chulalongkorn University), Noppadon Jokkaw (Chulalongkorn University), Tanit Tongthong (Chulalongkorn University)

[LIS1] Footprint Detection of Ceiling Equipment from TLS Point Clouds

Riho Akiyama (Hokkaido University), Hiroaki Date (Hokkaido University), Satoshi Kanai (Hokkaido University), Kazushige Yasutake (Kyudenko Corporation)

[LIS2] An Alternative Method for Cable Tension Evaluation based on the Terrestrial Laser Scanning Data

Thaniyaphat Srimontriphakdi (King Mongkut's University of Technology Thonburi), Peerasit Mahasuwanchai (King Mongkut's University of Technology Thonburi), Phutawan Yawananont (King Mongkut's University of Technology Thonburi), Chainarong Athisakul (King Mongkut's University of Technology Thonburi), Ekkachai Yooprasertchai (King Mongkut's University of Technology Thonburi), Sutat Leelataviwat (King Mongkut's University of Technology Thonburi), Somchai Chucheepsakul (King Mongkut's University of Technology Thonburi)

[LIS3] Integrating BIM into Web GIS to Enhance the Visualization of Port Infrastructure

Le Vin Tran (Ho Chi Minh City University of Technology (HCMUT)), Minh Chung Bui (Ho Chi Minh City University of Technology (HCMUT)), Van Tan Nguyen (Ho Chi Minh City University of Technology (HCMUT)), Tuan Anh Le (Ho Chi Minh City University of Technology (HCMUT)), Danh Thao Nguyen (Ho Chi Minh City University of Technology (HCMUT)), Bao Binh Luong (Ho Chi Minh City University of Technology (HCMUT)), Hiep Hoang (Portcoast Consultant Corporation)

Day 2: July 20, 2023 | 15.15-17.30

Session 3 (The Mitr-ing Room):
AI & Data Analysis [AI]

Chair: Prof. Nobuyoshi Yabuki (Osaka University)
Co-Chair: Asst. Prof. Chayut Ngamkhanong (Chulalongkorn University)

[AI1] Adaptive Kriging-Assisted Metaheuristic Method for Efficient Reliability-Based Design Optimization

Handy Prayogo (National Taiwan University of Science and Technology), I-Tung Yang (National Taiwan University of Science and Technology)

[AI2] ChatGPT in the Construction Domain: Opportunities, Risks, and Recommendations

Taegeon Kim (Yonsei University), Seokhwan Kim (Yonsei University), Namgyun Kim (University of Dayton), Hongjo Kim (Yonsei University)

[AI3] Training Data Generation with 3D CAD Models for Point Cloud Deep Learning for Underwater Objects

Hiroshi Okawa (Eight-Japan Engineering Consultants Inc.), Shota Yagi (Eight-Japan Engineering Consultants Inc.), Seiji Itano (Eight-Japan Engineering Consultants Inc.), Kazuo Kashiyama (Chuo University)

[AI4] Evaluation of AI's Generalization Performance for Detecting Construction Machinery from Video Images

Kentaro Hayakawa (Miyagi University), Koji Makanae (Miyagi University)

[AI5] Intelligent Design of Simply-Supported Planar Truss based on Reinforcement Learning

Xianzhong Zhao (Tongji University), Zhiyuan Liu (Tongji University), Weifang Xiao (Tongji University), Ruifeng Luo (East China Architectural Design & Research Institute Co., Ltd.)

[AI6] Model Building for Lane Line Extraction Using High-Definition Map

Ryuichi Imai (Hosei University), Kenji Nakamura (Osaka University of Economics), Yoshinori Tsukada (Setsunan University), Noriko Aso (Dynamic Map Platform Co., Ltd.), Jin Yamamoto (Hosei University)

[AI7] Fundamental Study on Extraction Method of License Plate Classification Number Using Video Images

Ryuichi Imai (Hosei University), Daisuke Kamiya (University of the Ryukyus), Yuhei Yamamoto (Kansai University), Masaya Nakahara (Osaka Electro-Communication University), Wenyuan Jiang (Osaka Sangyo University), Koki Nakahata (Kansai University), Ryo Sumiyoshi (Hosei University)

[AI8] A Quantitative Evaluation of Rough Ground Truth Labeling on Construction Scaffolding Image Segmentation

Natthapol Saovana (King Mongkut's University of Technology North Bangkok)

[AI9] Analyzing the Impact of COVID-19 Pandemic on Traffic Volume through Textual Data: A Bert-Based Approach

Mu-Chieh Chung (National Taiwan University), Albert Y. Chen (National Taiwan University)

Day 2: July 20, 2023 | 15.15-17.30

Session 4 (Meeting Room 2):
AI & Data Analysis [AI]/Information Process and Management [IPM]

Chair: Prof. I-Tung Yang (National Taiwan University of Science and Technology)
Co-Chair: Dr. Hang Le Thi Thu (University of Architecture Ho Chi Minh City)

[AI10] Electric Vehicle Emission Analysis through Thermal Image-Based Vehicle Classification

Chun-Ping Liao (National Taiwan University), Ta-Chih Hsiao (National Taiwan University), Albert Y. Chen (National Taiwan University)

[AI11] CSS-Onto: Construction Safety Situation Ontology

Zhe Zhang (University of Canterbury), Brian H.W. Guo (University of Canterbury), Yonger Zuo (University of Canterbury), Bowen Ma (University of Canterbury), Alice Chang-Richards (University of Auckland), Zhenan Feng (Massey University), Yang Zou (University of Auckland)

[AI12] Risk Assessment of Railway Tracks in Floodplain Area Using Digital Surface Model and Computer Vision

Watcharapong Wongkaew (Chulalongkorn University), Wachira Muenyoksakul (Chulalongkorn University), Krittiphong Manachamni (Chulalongkorn University), Tanawat Tangjarusritaratorn (Chulalongkorn University), Chayut Ngamkhanong (Chulalongkorn University)

[AI13] Graph Neural Network Integrating with Metaheuristic Search for Automated Multi-Layer Rebar Design Optimization

Mingkai Li (The Hong Kong University of Science and Technology), Vincent J. L. Gan (National University of Singapore), Jack C. P. Cheng (The Hong Kong University of Science and Technology)

[AI14] Data Analysis for Prediction and Visualization of Sensor Data in Railroad Proximity Construction

Atsushi Takao (Okumura Corporation), Nobuyoshi Yabuki (Osaka University), Yoshikazu Otsuka (Okumura Corporation)

[AI15] An Approach for Generating Hybrid Datasets of Construction Material

Bo Cheng (Tongji University), Yujie Lu (Tongji University), and Xianzhong Zhao (Tongji University)

[IPM1] The Integration of Design and Fabrication for Prefabricated UHPC Panels of Building Facades

Kevin Harsono (National Taiwan University of Science and Technology), ShenGuan Shih (National Taiwan University of Science and Technology), YenJui Chen (Taiwan Sobute New Materials Co. Ltd.)

[IPM2] Considering of BIM Data Scale Interfaces for Various Application: Case Studies of Smart Patrol Project in Chulapat 14 Building Chulalongkorn University

Kaweekrai Srihiran (Chulalongkorn University), Terdsak Tachakitkachorn (Chulalongkorn University), Chalumpon Thawanapong (Chulalongkorn University)

[IPM3] Development of Roadway Geometric Design Process Model for Knowledge Management

Koji Makanae (Miyagi University)

Day 3: July 21, 2023 | 10.00-12.00

Session 5 (The Mitr-ing Room):
Construction Engineering and Asset Management [CEA]

Chair: Prof. Jack C.P. Cheng (The Hong Kong University of Science and Technology)
Co-Chair: Assoc. Prof. Nathee Athigakunagorn (Kasetsart University)

[CEA1] Modeling and Pricing of Multiple Renewal Options Embedded in Short-Term Lease Contracts

Nakhon Kokkaew (Chulalongkorn University), Wisanu Supsompon (Bangkok Metropolitan Administration), Chanon Atipanya (Chulalongkorn University)

[CEA2] A Bayesian Network Model for Quantifying the Cost Impacts of Claim Causes in Building Projects

Sang Van (Chulalongkorn University), Veerasak Likhitruangsilp (Chulalongkorn University), Photios G. Ioannou (University of Michigan)

[CEA3] Comparison of Immersive and Non-Immersive VR Games for Assessing Safety Knowledge

Sabnam Thapa (Chulalongkorn University), Vachara Peansupap (Chulalongkorn University)

[CEA4] Implementing the Circular Economy Concept in Construction Supply Chain Management of Modular Steel Projects

Thet Htar San (Chulalongkorn University), Veerasak Likhitruangsilp (Chulalongkorn University)

[CEA5] Markov Deterioration Hazard Model for Road Network Deterioration Forecast for National Road Networks in Lao PDR

Souvikhane Hanpasith (Osaka University), Kotaro Sasai (Osaka University), Kiyoyuki Kaito (Osaka University)

[CEA6] Promoting Flexible Use of Open Data through Service Link Platform for Infrastructure Management

Yinyongdong Ma (Yamaguchi University), Kei Kawamura (Yamaguchi University), Junha Hwang (Yamaguchi University), Shuji Sawamura (Yamaguchi Prefecture Government), Hisao Emoto (Tottori University)

Day 3: July 21, 2023 | 10.00-12.00

Session 6 (Meeting Room 2):
Green Construction and Sustainability [GS]

Chair: Prof. Sang-Ho Lee (Yonsei University)
Co-Chair: Assoc. Prof. Nakhon Kokkaew (Chulalongkorn University)

[GS1] Circular Economy Critical Success Factors for Sustainable Construction: An Exploratory Approach

Abdulrahman Haruna (Abubakar Tafawa Balewa University), Veerasak Likhitruangsilp (Chulalongkorn University)

[GS2] A Blockchain-Based Carbon Auditing Framework for Construction Material and Product Certification

Yuqing Xu (The Hong Kong University of Science and Technology), Xingyu Tao (The Hong Kong University of Science and Technology), Moumita Das (The Hong Kong University of Science and Technology), Helen H.L. Kwok (The Hong Kong University of Science and Technology), Hao Liu (The Hong Kong University of Science and Technology), Jack C.P. Cheng (The Hong Kong University of Science and Technology)

[GS3] Research on Visualization based on Climate Analysis of the Influence of Green Space on the Thermal Environment Using MSSG Model

Takumi Makio (Osaka Metropolitan University), Kaoru Matsuo (Osaka Metropolitan University), Shigeaki Takeda (Osaka Metropolitan University), Hiroyuki Kaga (Osaka Metropolitan University), Makoto Yokoyama (Fukuyama City University)

[GS4] Emissions Tracking Control Optimization to Support Sustainable Construction in Road Construction Projects

Phattadon Khathawatcharakun (Chulalongkorn University), Charinee Limsawasd (Chulalongkorn University), Nathee Athigakunagorn (Kasetsart University)

[GS5] Green Infrastructure Planning with Population Decreasing for Adapting to Climate Change by Using GIS and Numerical Models: Case of Kure City in Hiroshima Prefecture

Takahiro Tanaka (Hiroshima University), Shinji Hirai (Hiroshima University), Ryota Araki (Hiroshima University), Riki Yamaga (Hiroshima University), Shota Tamura (Hiroshima University), Makoto Yokoyama (Fukuyama City University), Kaoru Matsuo (Osaka Metropolitan University), Toru Sugiyama (Japan Agency for Marine-Earth Science and Technology)

[GS6] Comparative Analyses of Simulation and Measurement Data of Buildings Energy Consumption Using Typical Weather Data and Real Weather Data in Hot-Humid Climate

Sarin Pinich (Chulalongkorn University), Terdsak Tachakitkachorn (Chulalongkorn University), Atch Sreshthaputra (Chulalongkorn University)

Day 3: July 21, 2023 | 12.45-15.00

Session 7 (The Mitr-ing Room):
Digital Twin [DT]/ Building and Construction Information Modeling [BIM/CIM]

Chair: Prof. Shang-Hsien (Patrick) Hsieh (National Taiwan University)
Co-Chair: Asst. Prof. Manop Kaewmoracharoen (Chulalongkorn University)

[DT1] Design of a Digital Twin for Real-Time Construction Pollution Management in Building Renovation Projects

Truong-An Pham (Chulalongkorn University), Veerasak Likhitruangsilp (Chulalongkorn University)

[DT2] Verification of Registration and Complementation of Point Cloud Data Obtained by Simplified Measurement

Ryuichi Imai (Hosei University), Kenji Nakamura (Osaka University of Economics), Yoshinori Tsukada (Setsunan University), Yasuhito Niina (Asia Air Survey Co., Ltd.), Ryo Komiya (Hosei University)

[DT3] Traffic Noise Simulation and Its Auralization Using VR Technology

Kazuo Kashiyama (Chuo University)

[DT4] Smart Home Adoption: Challenge and Opportunity for Digital Twin Building

Chalumpon Thawanapong (Chulalongkorn University), Terdsak Tachakitkachorn (Chulalongkorn University), Kaweekrai Srihiran (Chulalongkorn University)

[DT5] Consideration for Level of Digital Twin in Architecture

Terdsak Tachakitkachorn (Chulalongkorn University), Chalumpon Thawanapong (Chulalongkorn University), Kaweekrai Srihiran (Chulalongkorn University)

[DT6] From BIM to Digital Twin: A Case Study Experience

Prapaporn Rattanatamrong (Thammasat University), Jarunchai Srisawat (Thammasat University), Peemapat Podsoonthorn (Thammasat University), Thapana Boonchoo (Thammasat University), Wanida Putthividhya (Thammasat University), Veerasak Likhitruangsilp (Chulalongkorn University)

[BIM10] Situation of BIM Implementation in Comparison between the National University of Singapore and Chulalongkorn University

Gittigul Boonplien (Chulalongkorn University), Terdsak Tachakitkachorn (Chulalongkorn University), Kaweekrai Srihiran (Chulalongkorn University)

[BIM11] Strategic Development of Building Information Modeling (BIM) Implementation for Thai Construction Contractors

Parit Martpaijit (Chulalongkorn University), Vachara Peansupap (Chulalongkorn University)

[BIM12] BIM-Based Precast Building Optimization by Optimality Criteria and NSGA-II-GD Considering Constructability for Precast Concrete Sizing and Rebar Detailing

Weng-Lam Lao (Hong Kong University of Science and Technology), Mingkai Li (Hong Kong University of Science and Technology), Billy C.L. Wong (Hong Kong University of Science and Technology), Vincent J.L. Gan (National University of Singapore), Jack C.P. Cheng (Hong Kong University of Science and Technology)

Day 3: July 21, 2023 | 12.45-15.00

Session 8 (Meeting Room 2):
Smart Cities and Infrastructure Management [SCI]

Chair: Assoc. Prof. Sutee Anantsuksomsri (Chulalongkorn University)
Co-Chair: Dr. Pongsun Bunditsakulchai (Chulalongkorn University)

[SCI1] On the Visual Aspect of the Information Scape in the Built Environment: Shilin Night as an Example

Ye Yint Aung (National Taiwan University of Science and Technology), ShenGuan Shih (National Taiwan University of Science and Technology)

[SCI2] Accumulation and Classification of Smart Living Framework from Academic Studies and Real Sector

Suchanad Phuprasoet (Chulalongkorn University), Terdsak Tachakitkachorn (Chulalongkorn University), Kaweekrai Srihiran (Chulalongkorn University)

[SCI3] Crack Detection of Bridges from Self-Weight Deformation Profiles

Suphanat Wang (Chulalongkorn University)

[SCI4] Dynamic Response Evaluation of Railway Track Transitions with Resilient Materials

Surapan Noppharat (Chulalongkorn University), Anand Raj (Chulalongkorn University), Chayut Ngamkhanong (Chulalongkorn University)

[SCI5] One-Dimensional Compression Model for Unsaturated Crushable Granular Materials

Pongsapak Kanjanatanalert (Chulalongkorn University), Veerayut Komolvilas (Chulalongkorn University)

[SCI6] A Combined Drought Index (CDI) System for Drought Early Warning, Monitoring, and Risk Assessment in EEC Thailand

Sasin Jirasirirak (Chulalongkorn University), Aksara Putthividhya (Chulalongkorn University), Somkiat Prajamwong (Eastern Economic Corridor Office), Wimonpat Bumbudsanpharoke Kamkanya (Office of the National Water Resources)

[SCI7] Disaster Education on Flood Prevention Using Card Game through Digital Platform

Mari Tanaka (Gunma University), Kenji Nakamura (Gunma University Center for Mathematics and Data Science)

Day 3: July 21, 2023 | 15:15-17:15

Session 9 (The Mitr-ing Room):
Building and Construction Information Modeling [BIM/CIM]

Chair: Prof. Mari Tanaka (Gunma University)
Co-Chair: Asst. Prof. Chavanont Khosakitchalert (Chulalongkorn University)

[BIM13] Improving the Efficiency of ICT Earthwork through Automated Planning Using BIM

Hitoshi Ishida (Penta-Ocean Construction Co., LTD), Nobuyoshi Yabuki (Osaka University)

[BIM14] New Era of Mapping Products From UAV-Based Oblique Camera System

Thirawat Bannakulpiphat (Chulalongkorn University), Phisan Santitamnont (Chulalongkorn University)

[BIM15] Evaluation of Interoperability by Quantifying Data Integrity in the Integration of BIM and Structural Analysis for Multiple Levels of Development

Kayla Solis (University of the Philippines Diliman), Pher Errol Quinay (University of the Philippines Diliman), Karlo Daniel Colegio (University of the Philippines Diliman)

[BIM16] Quantitative Analysis for Applying Building Information Modeling(BIM) in Infrastructure Projects

Hwan Yong Kim (Hanyang University ERICA), Min Ho Shin (Woosong University) Leen Seok Kang (Gyeongsang National University)

[BIM17] BIM: A Successful Alternative for the Construction Quantity Take-Off in the Large-Scale Construction Project

Hang Le Thi Thu (University of Architecture Ho Chi Minh City), Huyen Nguyen Thi (University of Architecture Ho Chi Minh City), Huong Pham Thu (University of Architecture Ho Chi Minh City), Phong Thanh Nguyen (Ho Chi Minh City Open University)

[BIM18] Building Information Modeling Framework for Practical Implementation of a Mega-Project in Thailand

Pawaris Khammultri (Sino-Thai Engineering and Construction Public Company Limited), Kritsada Lappanichayakul (Sino-Thai Engineering and Construction Public Company Limited), Pithiwat Tiantong (Sino-Thai Engineering and Construction Public Company Limited), Athasit Sirisonthi (Sino-Thai Engineering and Construction Public Company Limited)

Day 3: July 21, 2023 | 15:15-17:15

Session 10 (Meeting Room 2):
Building and Construction Information Modeling [BIM/CIM]

Chair: Assoc. Prof. Charinee Limsawasd (Chulalongkorn University)
Co-Chair: Dr. Sarin Pinich (Chulalongkorn University)

[BIM19] State-of-the-Art of Historic Building Information Trends with Digitalization Integration on the Architecture Heritage Conservation in Vietnam

Thu Anh Nguyen (Ho Chi Minh City University of Technology (HCMUT)), Nhu My Uy Le (Ho Chi Minh City University of Technology (HCMUT)), Sy Tien Do (Ho Chi Minh City University of Technology (HCMUT)), Son Hong Nguyen (Ho Chi Minh City University of Technology (HCMUT)), Quang Trung Khuc (Ho Chi Minh City University of Technology (HCMUT))

[BIM20] On Practical Cases of Building Information Management in Construction Project Collaboration

Min Shih (Unique Engineering and Construction Public Company Limited), Yen-Hung Chen (National Taiwan University of Science and Technology), Shen-Guan Shih (National Taiwan University of Science and Technology)

[BIM21] Design and Implementation of BIM-Based Roadway Drainage Model

Jing-Ying Huang (Sinotech Engineering Consultants, Ltd.), Chi-Hsuan Lin (Sinotech Engineering Consultants, Ltd.), Jian-Bang Yang (Sinotech Engineering Consultants, Ltd.), Yi-Chiang Tsao (Sinotech Engineering Consultants, Ltd.), Shih-Yao Lan (Taoyuan City Government)

[BIM22] Automatic Creation of 3D Textured Simplified Model for Supporting Piled Pier Maintenance

Tomohiro Mizoguchi (Nihon University), Kenichi Mizuno (Penta-Ocean Construction Co., Ltd.), Osamu Taniguchi (Penta-Ocean Construction Co., Ltd.)

[BIM23] BIM Application for Resolving Construction Issues in Thailand: A Consultant's Case Study

Narong Leungbootnak (Khon Kaen University), Vuthea Min (Future Engineering Consultants Co., Ltd)

[BIM24] The Process of Applying AR/VR/MR in Design Implementation in Construction Projects

Nam Phuong Nguyen (Hanoi University of Civil Engineering), Tuan Sy Ho (Ho Chi Minh City University of Technology (HCMUT)), Sy Tien Do (Ho Chi Min City University of Technology (HCMUT))

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BOOK OF ABSTRACTS

[AI1]

ADAPTIVE KRIGING-ASSISTED METAHEURISTIC METHOD FOR EFFICIENT RELIABILITY-BASED DESIGN OPTIMIZATION

Handy Prayogo[1], and I-Tung Yang[2]

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Abstract: Reliability-based Design Optimization aims to find a design that minimizes the cost while adhering to the reliability constraints that consider the inherent uncertainties in the engineering process. Due to the ever-increasing complexity of today's engineering problems, an efficient way of solving RBDO problems is needed. Surrogate-based RBDO methods, particularly those that use Kriging or Gaussian Process Regression, have been studied intensively for their efficiency and accuracy. However, the existing methods still incur a high computation demand when paired with classical gradient-based optimization tools. This study proposed a new framework Meta-LAK that relies on the cooperation between metaheuristic optimization technique and Kriging model to tackle the RBDO problem. Using the information provided by the Kriging model, the method can avoid evaluating every sample, thus reducing the computation demand. The optimized design also limits the possible candidate samples used to enrich the Kriging model. The proposed algorithm is tested against a benchmark problem to evaluate its performance.

Keywords: Reliability-based design optimization, Adaptive Kriging, Metaheuristic

[AI2]

CHATGPT IN THE CONSTRUCTION DOMAIN: OPPORTUNITIES, RISKS, AND RECOMMENDATIONS

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Abstract: Chatbot technology based on a large language model is expected to have a great impact on most industries including the construction industry. This paper examines the potential implications of the current state-of-the-art of large language models such as ChatGPT for the construction domain. Based on a literature review and the authors' experience using ChatGPT for different tasks, we provide our analysis and conjecture on the potential applications, opportunities, risks, and limitations of ChatGPT in the construction domain. We argue that ChatGPT can offer valuable information, insights and solutions for challenges and problems the construction industry is facing, as well as foster creativity, communication and collaboration among civil engineers. We also acknowledge some challenges and risks that ChatGPT entails, such as ethical, legal issues, and the problems of data quality. We conclude with recommendations on how to leverage ChatGPT for the construction domain.

Keywords: Chatbot, ChatGPT, Large Language Model, Natural Language Processing, Impact of Chatbot Technology in Construction.

[AI3]

TRAINING DATA GENERATION WITH 3D CAD MODELS FOR POINT CLOUD DEEP LEARNING FOR UNDERWATER OBJECTS

Hiroshi Okawa[1], Shota Yagi[2], Seiji Itano[3] and Kazuo Kashiyama[4]

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Abstract: This paper proposes developing a method to automatically classify underwater structures quickly and accurately using point cloud deep learning methods and point cloud data acquired using a narrow multi-beam bathymetric surveyor attached to an autonomous unmanned robot. We propose using a point cloud deep learning method to determine the current state of the underwater environment. Deep learning of point clouds requires a large amount of training data; however, training data can be quickly generated by replacing existing 3D CAD models of underwater structures with point clouds. Furthermore, discriminators trained by replacing point clouds created from 3D CAD models exhibit low discrimination with measured point clouds.

This presentation proposes a method that addresses these issues by collecting training data more efficiently and enhancing the accuracy of the correct answers. We applied the proposed method to measured underwater point cloud data to verify the effectiveness of the method.

Keywords: Point cloud, Deep learning, Underwater structure, Multi-beam echo-sounding, Classification

[AI4]

EVALUATION OF AI'S GENERALIZATION PERFORMANCE FOR DETECTING CONSTRUCTION MACHINERY FROM VIDEO IMAGES

Kentaro Hayakawa[1], Koji Makanae[2]

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Abstract: We developed an object detection system that automatically detects construction machines in video images by performing machine learning. However, the detection accuracy was decreased when the object detection system was applied to a construction site different from where the training data was collected. Therefore, we improved the detection accuracy when the object detection system was applied to different sites by devising the structure of the training data used for machine learning.

As a result, the generalization performance was high by making the detection system include well-balanced training data on the orientation of construction machinery and its distance from the camera. By learning the appearance of various construction machines, we were able to construct a detection system that can be applied to different job sites without being influenced by specific situations.

Keywords: AI, Object detection, Generalization performance, Video image, Construction machinery

[AI5]

INTELLIGENT DESIGN OF SIMPLY-SUPPORTED PLANAR TRUSS BASED ON REINFORCEMENT LEARNING

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Abstract: Intelligent design is a multidisciplinary research field involving artificial intelligence (AI), mathematical optimization, and human experience. The aim is to realize the automatic design of structures. As an important research topic of intelligent design in civil engineering, the truss design is characterized by high complexity, strict constraints and diversity of decision-making, which are the obstacles to the application of AI in designing the trusses. How to realize "brain-inspired design" by combining human knowledge with intelligent thinking is still a major challenge in the intelligent design of structures. This study develops an intelligent design algorithm for simply-supported planar truss based on reinforcement learning. The layout design problem of simply-supported planar truss is modeled as a Markov Decision Process (MDP). In order to solve the model, Monte Carlo Tree Search (MCTS), which performs well in sequential decision problems, is applied. Furthermore, MDP can include the engineering logic and knowledge that are extracted from the remarkable characteristics of simply-supported planar truss. This significantly condenses the initial solution space and optimizes the decision-making process. A contrast experiment is conducted to demonstrate the validity and efficiency of the proposed algorithm.

Keywords: Truss layout design, Intelligent design, Reinforcement learning, Markov decision process, Monte Carlo tree search

[AI6]

MODEL BUILDING FOR LANE LINE EXTRACTION USING HIGH-DEFINITION MAP

Ryuichi Imai[1], Kenji Nakamura[2], Yoshinori Tsukada[3], Noriko Aso[4], and Jin Yamamoto[5]

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Abstract: In public works projects in Japan, a large amount of point cloud data has been measured and accumulated at various locations through the introduction of mobile measurement system (MMS) and terrestrial laser scanners (TLS). Point cloud data, which is the outcome of laser surveying, is a huge collection of 3D points having position coordinates, reflection intensity, and RGB. Various uses of point cloud data are expected to be developed. One of the main uses of point cloud data is the preparation of HD maps, which serve as basic maps for autonomous driving. Currently, the HD maps in Japan cover about 30,000 km and will be expanded to about 130,000 km including expressways and ordinary roads. Since HD maps are prepared by manually joining and processing point cloud data, it is desirable to improve the efficiency of preparing HD maps. Therefore, it is required to establish an efficient and comprehensive method of developing lane lines for the development, maintenance, and updating of HD maps. In this study, we proposed a method for automatically generating AI training data for automatic extraction of lane lines using the area data of lane lines generated from HD maps. This allowed extraction of lane lines from point cloud data with an average F-measure of 0.9 or higher.

Keywords: HD map, Point cloud data, Lane line, Deep learning

[AI7]

FUNDAMENTAL STUDY ON EXTRACTION METHOD OF LICENSE PLATE CLASSIFICATION NUMBER USING VIDEO IMAGES

Ryuichi Imai[1], Daisuke Kamiya[2], Yuhei Yamamoto[3], Masaya Nakahara[4], Wenyuan JIANG[5], Koki Nakahata[6], and Ryo Sumiyoshi[7]

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Abstract: Traffic surveys in Japan require a large number of people. However, it is becoming increasingly difficult to secure surveyors due to the population decline. In recent years, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been promoting survey methods using ICT and IoT; however, the cost of introducing machinery is huge. Against this background, survey methods that use AI for analyzing video images captured by CCTV cameras and video cameras installed to monitor roads are attracting attention. In existing studies, the number of passing vehicles is counted separately for light and heavy vehicles by using deep learning. We think that the survey method using AI can be advanced by adding an approach of subdividing vehicle types such as light passenger cars and heavy special-purpose vehicles based on the results of recognizing license plates to the function of this method for determining whether a vehicle is light or heavy. Vehicles in Japan can be distinguished between light and heavy vehicles by recognizing each classification number, which consists of three digits on the license plate. In this study, we devised a method for extracting classification numbers from the video images captured for traffic surveys, using an object detection technique based on deep learning. Experimental results show that the proposed method is capable of extracting classification numbers with high accuracy.

Keywords: License plate recognition, Vehicle type determination, Traffic volume investigation, Deep learning, Image processing

[AI8]

A QUANTITATIVE EVALUATION OF ROUGH GROUND TRUTH LABELING ON CONSTRUCTION SCAFFOLDING IMAGE SEGMENTATION

Natthapol Saovana[1]

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Abstract: Scaffolding is a temporary structure supporting the construction and maintenance of buildings. Although it is a crucial component for construction progress, it does not receive much attention. Thus, there is a need for a tool assisting scaffolding supervision. Image segmentation from deep learning has proved its ability in various knowledge fields and may be applicable to this challenge. Nevertheless, accurate ground truth labeling is necessary for artificial intelligence training to get a satisfactory image segmentation result, but carefully labeling each image is very labor-intensive and time-consuming, especially with the scaffolding that usually got occluded by both natural and fabricated objects. Reducing the quality of the labeling can decrease the processing time but may significantly reduce the accuracy of the segmentation. Therefore, it is crucial to compromise between the time and quality of the labeling to raise the productivity of the entire process. The result shows that using rough labeling to train deep learning for scaffolding segmentation can reduce the data preparation time while sacrificing only a small amount of segmentation precision.

Keywords: Scaffolds, Deep learning, Image segmentation, Rough labeling

[AI9]

ANALYZING THE IMPACT OF COVID-19 PANDEMIC ON TRAFFIC VOLUME THROUGH TEXTUAL DATA: A BERT-BASED APPROACH

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2) Ph.D., Prof., Department of Civil Engineering, National Taiwan University, Taipei, Taiwan. Email: AlbertChen@ntu.edu.tw

Abstract: The COVID-19 pandemic has caused a significant impact on various aspects of our lives, including transportation. This study aims to analyze transportation volume during the pandemic from a textual perspective using a BERT-based model. We collected textual data from the daily press release issued by Taiwan Centers for Disease Control (CDC) to capture people's reaction in terms of transportation under these pandemic-related information and policies. We explore people's behavior under the government's policy related to the pandemic by predicting the Taipei Metro's traffic volume based on the textual data. Our study demonstrates ways of using the Bidirectional Encoder Representations from Transformers (BERT) based models to predict the traffic volume during the pandemic through textual data. Policymakers could take our findings as reference to provide effective transportation services to meet people's changing needs during and after the pandemic.

Keywords: COVID-19, Transportation, Natural Language Processing (NLP), BERT

[AI10]

ELECTRIC VEHICLE EMISSION ANALYSIS THROUGH THERMAL IMAGE-BASED VEHICLE CLASSIFICATION

Chun-Ping Liao[1], Ta-Chih Hsiao[2], and Albert Y. Chen[3]

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3) Ph.D., Prof., Department of Civil Engineering at National Taiwan University, Taipei, Taiwan. Email: AlbertChen@ntu.edu.tw

Abstract: The increasing level of air pollution in urban areas has become a focus of many studies due to its detrimental impact on the health of the population. Vehicular emissions on roads have been identified as one of the primary sources of pollution. Numerous countries have proposed the complete electrification of vehicles as a measure to reduce pollution on roads; however, the actual impact of Electric Vehicles (EVs) versus conventional vehicles on pollution remains uncertain. Therefore, developing an accurate model to distinguish EVs on roads can enable us to better understand the impact of EVs on road pollution.

Since EVs and conventional vehicles have no significant visual differences, visible light-based object detection is highly unreliable. However, thermal imaging can accurately distinguish the differences among these two types of cars.

This study presents a transfer learning approach from a deep learning model and an open-source dataset with the thermal data we collected. Particularly, we count the portion of different type of cars with the car detection model and applied vehicle emission analysis.

This study could be applied for assessment of personal exposure to emissions and related health impacts. This work also provides a reliable method for distinguishing between EVs and conventional vehicles on roads using thermal imaging, which can be extended to the identification of other types of EVs such as electric motorcycles, electric buses, and electric trucks. The extracted data is expected to also facilitate in different domains such as environmental analysis, traffic control, smart cities, and other related research.

Keywords: Transfer learning, Deep learning, Object detection, Thermal imaging, Electric vehicle, Air pollution, Pollutant

[AI11]

CSS-ONTO: CONSTRUCTION SAFETY SITUATION ONTOLOGY

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Abstract: Despite research efforts in the digital technology-driven third wave of construction occupational health and safety (OHS) management since the early 2000s, the construction industry is still plagued by numerous accidents. This underscores the persistent need for a comprehensive approach to improving safety. The objective of this research is to develop a Construction Safety Situation Ontology (CSS-Onto) that enables a formal definition of "safety situation" and facilitates the development of intelligent systems that improve situation awareness on construction sites. The NeOn methodology was adopted to reuse ontological and non-ontological resources to develop the CSS-Onto. The ontology consists of 11 core classes: actor, physiological state, psychological state, group, social dynamics and norms, climatic conditions, equipment, material, building element, digital technology, and task. The CSS-Onto was evaluated through a showcase to demonstrate its competency in accurately representing the safety situation. The paper concludes with a discussion on defining safety situations in construction sites, underpinned by a two-part examination. Firstly, a set of principles was outlined to serve as a foundation for identifying safety situations. Secondly, philosophical perspectives (both monism and dualists) on matter and mind were explored aiming to provide a deeper understanding of the ontological assumptions on safety situation. The discussion endeavors to contribute to ongoing conversations around situation awareness in construction safety. The framework bridges the knowledge gap by providing formal language to facilitate future information fusion, retrieval, mapping, and reasoning. Future research should be conducted to evaluate the coverage and usefulness of the CSS-Onto.

Keywords: Situation awareness, Situational awareness, Construction safety, Ontology, Safety situation

[AI12]

RISK ASSESSMENT OF RAILWAY TRACKS IN FLOODPLAIN AREA USING DIGITAL SURFACE MODEL AND COMPUTER VISION

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Abstract: Monsoon region, which Thailand is situated in, experiences frequent heavy rainfall, leading to recurring flooding problems. This is one of the serious natural disasters that cause significant damage to Thailand's Infrastructure. Furthermore, human activities, such as the construction of railway tracks that obstruct the flow of water, and the inadequate natural drainage system also contribute to the problem. In order to analyze the area-based risk factors that cause railway track flooding, 5 major factors, including average total rainfall in rainy season, waterway density, land use, slope, and elevation must be considered. The study utilizes computer vision techniques such as Digital Surface Model (DSM) and flooding simulation to illustrate the topography of the flood-prone area and the right of way of railway tracks. A Digital Surface Model (DSM) is used to illustrate the topography of the flood-prone area and right of way of railway tracks. A comprehensive map showing the likelihood of railway track flooding in the area can be generated via the digital surface model and flooding simulation. Moreover, the results from these techniques can help identify the railway tracks damage, track structure, and surrounding areas due to the influences of different flooding conditions. The outcome of this study will provide a robust flood risk management process that can effectively prevent railway track's damages from natural disasters by utilizing computer vision technology to improve flood modeling accuracy.

Keywords: Digital Surface Model, Disaster risk, Flood, Railway tracks, Computer vision

[AI13]

GRAPH NEURAL NETWORK INTEGRATING WITH METAHEURISTIC SEARCH FOR AUTOMATED MULTI-LAYER REBAR DESIGN OPTIMIZATION

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Abstract: Rebar design is a crucial aspect of reinforced concrete structures, and existing optimization methods based on metaheuristic algorithms (MAs) are time-consuming. Emerging machine learning techniques like graph neural networks (GNNs) have the potential to solve the problem. This paper presents an automated design optimization approach for multi-layer rebar layouts integrating GNN and MA (GNN-MA). The graph representation of multi-layer rebar layouts is developed, integrating design information of rebars and interrelationship between them. The rebar design problem is formulated as a node prediction task, and a GNN with three outputs is trained to provide an initial design, including the number of rebar layers, the diameter and bar number of the outmost layer. MA is then employed to check and optimize the design from GNN. GNN-MA could learn from previous design and generate the same optimal design with that generated by MA alone for more than 97.92% of design cases, while saving about 60-80% of computational time. GNNExpaliner is adopted to explain the behaviour of the GNN network and important features and edges leading to the prediction could be identified.

Keywords: Reinforced concrete structure, Steel reinforcement design, Graph Neural Network, Metaheuristic algorithm

[AI14]

DATA ANALYSIS FOR PREDICTION AND VISUALIZATION OF SENSOR DATA IN RAILROAD PROXIMITY CONSTRUCTION

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Abstract: It is essential to lessen the effect of construction on railroads at sites where construction is taking place close to them. Therefore, various types of sensors are installed at various locations throughout the construction site to monitor its condition. In order to better utilize sensor data for monitoring, we developed a system that links live sensor data with the BIM 4D model of the construction site. The data is then consolidated into a centralized monitoring system to facilitate the management of the construction site. Using this data, the current state of the site can be easily grasped, and more accurate predictions can be made about the effects of construction on the nearby railroads. After that, we used the monitoring system to investigate the relationship between various types of construction works and the site conditions as measured by the sensors. We demonstrated that the construction work content and sensor observations are indeed correlated. Future work includes further clarification of the correlations of the observed data, and prediction of the effects of the various construction works on nearby railroads.

Keywords: Sensor, Visualization, Site condition prediction, 4D models, Data analysis

[AI15]

AN APPROACH FOR GENERATING HYBRID DATASETS OF CONSTRUCTION MATERIAL

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Abstract: The emergence of computer vision technology makes automatic quantity counting of construction materials possible. However, the industry and academia still face the problem of a lack of training data, resulting in weak performance of trained models. To solve the problem, this study utilizes Unreal Engine and data augmentation techniques to create digital construction material assets, generating ultra-realistic 2D and 3D renders of construction material for model training. Our experiments show that a hybrid of the real and generated data improves model performance. To demonstrate the effectiveness of the proposed method, a hybrid scaffold dataset containing several 3D digital models, and 907 2D images with 165,901 scaffold pipe instances is constructed. The results show that models trained with hybrid scaffold data gain about 4.6% promotion in average precision (AP) and 4.1% in average recall (AR), revealing that our method can generate high-quality hybrid data and improve the performance of the trained models.

Keywords: Hybrid dataset generating, Construction material, Unreal Engine, Data augmentation, Digital model.

[BIM1]

MULTI-MODAL DEEP LEARNING (MMDL)-BASED AUTOMATIC CLASSIFICATION OF BIM ELEMENTS FOR CONSTRUCTION COST ESTIMATION

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Abstract: In Building Information Modeling (BIM)-based cost estimation, elements shall be classified in a way that aligns with measurement standards and estimating practice. Traditional rule-based and machine learning methods are either time-consuming or cannot meet fine-grained classification requirements in cost estimation. To overcome this challenge, this paper presents a novel framework based on BIM and Multi-Modal Deep Learning (MMDL) for automatic fine-grained BIM element classification. It begins with the transformation of multi-modal (i.e., graphical and non-graphical) element features from BIM models. Subsequently, an MMDL model is developed and deployed to fuse the multi-modal BIM element features for end-to-end fine-grained classification. The framework is validated with a BIM element classification dataset. The results show that fine-grained elements can be classified with high accuracy (over 99%) in an end-to-end manner.

Keywords: Building information modeling, Multi-modal deep learning, BIM data fusion, Classification, Interoperability, Cost estimation

[BIM2]

AN AUTOMATIC TRANSLATION FRAMEWORK BASED ON ONTOLOGY TO BUILDING ENERGY MODELS

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Abstract: Under the trend of carbon neutrality, building energy is being paid more attention to in recent years. Building Energy Modeling (BEM) is a powerful and essential tool that assists building designers and managers to predict and manage building energy performance. Manually collecting data related to BEM from various sources is time- and expertise-demanding. Building Information Modeling (BIM) facilitates automatic BEM by the integration of multiple data, but recent studies showed that the seamless transfer of BIM to BEM has not been fully achieved. Ontology-based approaches provide another feasible solution to automatic BEM. Previously, we proposed an ontology model for BEM which can integrate data for BEM from key data domains, i.e., weather, building, internal heat gain and Heating, Ventilation, and Air-conditioning (HVAC) system. Automatic thermal zoning can be conducted via cross-domain reasoning based on the ontology model. However, to fully achieve automatic BEM, translation from the ontology model to the building energy model is needed. In this study, we propose an automatic ontology-to-BEM translation framework using instance-based mapping, dynamic data conversion and template-based configuration file generation. By the instance-based method, fields between the two different models can be identified and mapped at the entity level and the property level. By the dynamic data conversion algorithm, temporally-changing data can be retrieved from original databases based on the information provided by the ontology model, and the data can be automatically written to BEM configuration files. By the template-based configuration file generation workflow, the completeness of the BEM model is ensured. One floor of a campus building was selected as an illustrative example of the framework. The results showed that the proposed framework could automatically generate the building energy model while reducing the modeling time by over 99% with consistency of the manually dedicated modeling.

Keywords: Building energy modeling, Ontology, Model translation, Data mapping

[BIM3]

GIS BASED 3D DATA INTEGRATION ON HIGHWAY TUNNEL THROUGH LIFECYCLE MANAGEMENT FOR ADVANCED MAINTENANCE

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Abstract: Building Lifecycle Management (BLM) is becoming more important for the building and construction production process since that improves efficiency and productivity of the building and construction production process by considering each process from investigation, design, and construction to maintenance process in lifecycle. However, in the Lifecycle Management of tunnel, information on each process of the construction production process is managed in various formats and databases. Consequently, if it was able to be lifecycle management information on each process of the tunnel construction production process, advanced maintenance that considers the causes of deformation in tunnel from multiple aspects would be possible.

In this research, a candidate is an existing tunnel (Phase I) and a newly constructing tunnel (Phase II). Firstly, the Building and Construction Information Modeling (BIM/CIM) model for tunnel construction is created from the information of the construction production process for investigation, design, construction, and maintenance (inspection and repair) of the existing Phase I tunnel by integrating all information into 3D space by using ArcGIS Pro and other software. Then, the tunnel BIM/CIM model from Phase I tunnel information is updated to become a comprehensive BIM/CIM model that can be effectively used for the maintenance process of each tunnel by the construction information of the new tunnel Phase II is added in real time. Finally, a 3D geological model around each tunnel based on BIM/CIM model with integrated information is developed.

As a result, we have been able to centrally manage the information of each tunnel through the tunnel BIM/CIM model on ArcGIS Pro. The effectiveness of the tunnel BIM/CIM model for maintenance has been clarified through more advanced analysis of cracks and road surface deformations on the Phase I tunnel considering the real condition of the around tunnels.

Keywords: Building Lifecycle Management, Maintenance, Building and Construction Information Modeling, tunnel

[BIM4]

A BUILDING INFORMATION MODEL FOR SENSING AND SIMULATION TOWARD NET-ZERO ENERGY BUILDING RENOVATION

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Abstract: Net-zero energy buildings (ZEBs) are expected to become more widespread as efforts proceed to promote carbon neutrality and energy conservation in the building sector. Means to transform buildings into ZEBs include optimizing energy operations by detecting energy waste through in-building sensing, and optimizing heating, ventilation, and air conditioning (HVAC) design by simulating the indoor environment at the design stage. In addition, building information modeling (BIM) is increasingly being used in the construction industry. Linking data measured by sensors with BIM is expected to visualize equipment usage and the indoor environment. Furthermore, using BIM data for simulation is expected to facilitate the simulation process. However, BIM data operations often depend on the type and capabilities of the BIM software, making them less versatile. Therefore, the Industry Foundation Classes (IFC) are deployed for interoperable data management. However, there are two challenges with sensors and simulations for IFC: First, the definition of compound sensors is not provided; second, IFC data for HVAC equipment cannot be used for indoor environment simulation. This research attempts to overcome both challenges by developing a new integrated IFC data model for BIM and sensors. The integrated IFC data model clearly shows the relationship between the BIM model and sensors. Furthermore, a generic representation of sensors is demonstrated by developing an IFC data model of a compound sensor. In addition, a new IFC data model for HVAC equipment is developed to enable the use of IFC data for HVAC equipment as input data for indoor environment simulation. Future work will use the IFC data model developed in this research to operate data measured by sensors and to perform simulations.

Keywords: Net-zero energy building, Building information modeling, Sensing, Indoor environment simulation, Industry Foundation Classes

[BIM5]

A PROPERTY DATA SHARING METHOD OF BUILDING INFORMATION MODELS USING REMOTE AUGMENTED REALITY

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Abstract: Building Information Modeling (BIM) is being promoted to increase efficiency in Architecture, Engineering, and Construction (AEC). Augmented Reality (AR) is also being used to display BIM models at sites. However, when property data is modified on AR devices, the modifications are not reflected in the BIM models so it takes time to transfer them to other phases. Furthermore, the technology for multiple geographically remote users to share information in an AR environment is limited. Therefore, the purpose of this research is to develop a property data sharing system that allows users to synchronously modify property data of BIM models in the AR environment, and automatically reflect the modifications into data files that are effective for collaboration with other phases. As a proposed method, first, property data and 3D models are extracted from BIM models and uploaded to the server. Next, users retrieve the specified models and property data from the server and display them correspondingly by a given ID using a developed application on AR devices. The property data modifications entered by users are reflected in the BIM models via the server. Finally, Industry Foundation Classes (IFC) files reflecting the modifications are exported. Construction Operations Building information exchange (COBie) data can also be modified on AR devices. These processes can be implemented simultaneously by multiple users using each AR device. The result of the verification shows it is possible to modify the property data of various BIM models in the AR environment and reflect them to BIM and IFC models. This research can improve the efficiency of data collaboration because property data modifications can be shared with other users among multiple phases in the AR environment. Future challenges include enabling users to modify the geometry of BIM models with other users in the AR environment to further accelerate information sharing.

Keywords: Building Information Modeling, Property data, Augmented Reality, Industry Foundation Classes, Construction Operations Building information exchange

[BIM6]

"TO BIM OR NOT TO BIM": A SIMULATION GAME FOR TEACHING AEC STUDENTS THE KEY MECHANISMS IN PROJECT DELIVERY

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Abstract: Architecture, Engineering, and Construction (AEC) projects face various opportunities, challenges, and risks when adopting different information management technologies and collaboration strategies among stakeholders. Considerations for adopting new information management technologies go beyond the technical requirements. They are also related to the business value and culture of different stakeholders, the trust between them, the project delivery models, and so on. University students often face difficulties understanding the multifold considerations held by various project stakeholders in adopting different information management technologies, the complex relationships between stakeholders, and the diverse AEC project delivery models through didactic lecture-based teaching. A simulation game was designed and embedded in the course "BIM Technology & Application" offered by the Department of Civil Engineering at National Taiwan University to help students understand the actual AEC project delivery process.

Keywords: AEC education, Classroom teaching, Simulation game, Project delivery model

[BIM7]

A BIM-ASSISTED PLANNING TOOL FOR FACILITATING THE APPLICATION OF AN ALUMINUM FORMWORK SYSTEM TO BEAM-COLUMN BUILDINGS

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Abstract: Aluminum formwork systems are an onsite labor-saving and sustainable construction method. However, it requires detailed planning before construction, which is more challenging for beam-column buildings, commonly seen in regions facing seismic hazards, than slab-wall buildings. Also, the existing CAD-based planning tool for beam-column buildings is labor-intensive and time-consuming. Therefore, this research develops a BIM-assisted tool for formwork engineers to efficiently and effectively conduct layout planning. The tool is implemented by Revit API and consists of six modules: (1) Preparation of Layout Planning, (2) Corner Panel Initial Placement, (3) Flat Panel Generation, (4) Flat Panel Refinement, (5) Corner Panel Generation, and (6) Formwork Accessory Planning. The tool also considers the inventory of panels and assists in deciding the production of new panels during layout planning. Finally, a real case evaluation shows that the developed tool can save at least 50% of layout planning time, compared to the existing CAD-based layout planning tool.

Keywords: Aluminum formwork, Layout planning, BIM, Design automation, Beam-Column buildings

[BIM8]

DEVELOPMENT OF A BIM-BASED SYSTEM FOR ASSESSMENT AND OPTIMIZATION OF GHG EMISSIONS IN THE EARLY DESIGN STAGE

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Abstract: Greenhouse gas (GHG) emissions from the building sector are a significant contributor to global warming due to embodied and operational carbon produced during the entire building design and construction process. While the design process has the potential to effectively reduce GHG emissions, it is crucial for architects to integrate methods for minimizing environmental impact at each stage. Building Information Modeling (BIM) and Life Cycle Assessment (LCA) are widely used tools and methods for evaluating GHG emissions in the building sector. However, in the early design stage, there are numerous uncertainties and a lack of information on materials and processes that make it difficult to evaluate and minimize environmental impact. This research aims to develop a BIM-based system for evaluating and minimizing GHG emissions during the early design stage of a building when it is still in the conceptual mass stage. The focus of the research is on office buildings. The parameters that can be adjusted include the shape of the building, the windows-to-wall ratio (WWR), and the number of floors. The system calculates the GHG emissions and adjusts the parameters until the desired total floor area is reached with the lowest GHG emissions possible. The proposed system was developed using Visual programing in Rhinoceros with Grasshopper plug-in and the Environment Product Declarations (EPDs) database. The results demonstrate that the BIM-based system for conceptual design can effectively assist architects in assessing GHG emissions during the early design stage.

Keywords: Life cycle assessment, Building Information Modeling, Greenhouse gas emission, Design process, Design optimization, Parametric design.

[BIM9]

BIM-COBIE BASED BRIDGE-DEFECT INTEGRATED MODEL FOR CONDITION ASSESSMENT OF BRIDGE SUPERSTRUCTURE

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Abstract: In this study, various types of defects occurring on bridges were expressed as object elements to create a Building Information Modeling (BIM)-based bridge-defect model, and a methodology was proposed to digitally assess the condition grade of the bridge affected by defects by generating Construction Operations Building information exchange (COBie) files to a database. The presented method determined the level of development of the bridge superstructure member, classified the 10 representative types of defect, and defined its properties that mainly occur in bridge superstructure to create the bridge-defect model. Then, bridge members and defect information were parameterized based on bridge alignment, and a method for modeling based on parameters using Revit Dynamo was suggested. COBie data was derived and extracted from the bridge-defect model through the Add-in program of the BIM authoring tool and managed through the Structured Query Language (SQL) program to evaluate the condition rating of the bridge. Most of the condition assessment process was automated by making it easy to reference and use the information required at each stage of the condition assessment. The developed methodology was validated through testing based on inspection data of actual bridges, and its practicality and efficiency were verified. This study can be expanded to the entire bridge and has yielded much more accurate results than existing methods. Information on each type of defect can be individually managed and flexibly utilized in other maintenance activities.

Keywords: BIM, COBie, Defect element, Bridge-defect model, Bridge superstructure, Condition assessment

[BIM10]

SITUATION OF BIM IMPLEMENTATION IN COMPARISON BETWEEN THE NATIONAL UNIVERSITY OF SINGAPORE AND CHULALONGKORN UNIVERSITY

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Abstract: Building Information Modelling (BIM) is a part of the development of systems in the architecture, engineering, and construction (AEC) industry. It is acknowledged that the National University of Singapore (NUS) and Chulalongkorn University (CU) are the first educational institutions in the region to have led BIM since the 2010s. Nonetheless, Singapore is more substantially progressive than Thailand. Consequently, differences in level of implementation, standardization, and integration arise. For this reason, this research aims to study the BIM implementation on both Singapore and Thailand campuses. The objectives are to collect and compare the current BIM implementation and campus physical development plan by analyzing documents and interviewing those involved in this area.

As a result, this study found that Singapore possesses the BIM Roadmap, set up by the government, which has a standard and also integrates both professional and academic stakeholders. Hence, NUS built its own BIM standards. There is a prototype building for BIM operations, providing benefits for both learning and research. Whereas in Thailand, CU implements BIM into the campus physical development plan by gathering building data and utilizing it to manage some buildings on campus. In the case of a more complete level of implementation, it is still an incomplete process, unstandardized, and lacking the responsible organization for BIM implementation. However, the process of making the full system for BIM implementation part of the campus physical development plan will require modifications and developments in terms of academics, research and development, and responsible organization for the more complete implementation of BIM.

Keywords: BIM, BIM implementation, Campus physical development plan

[BIM11]

STRATEGIC DEVELOPMENT OF BUILDING INFORMATION MODELING (BIM) IMPLEMENTATION FOR THAI CONSTRUCTION COTRACTORS

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Abstract: Currently, BIM implementation is found in complex procedures involving people, processes, technology, and strategy. These characteristics may cause unsuccessful BIM implementation, adversely affecting several construction processes. Since the implementation of BIM is still new to the Thai construction industry; it requires a study of the factors affecting the construction organization. This research aims to study internal and external factors by applying SWOT analysis tools to analyze strengths, weaknesses, opportunities, and threats in BIM implementation for Thai construction contractors. The data analysis revealed that certain opportunities for BIM implementation in Thai contractor organizations differed when compared to contractor organizations in foreign countries. For instance, one notable difference is the absence of BIM regulations in the Thai construction industry. Moreover, they share similar weaknesses with contractor organizations in foreign countries, including the high cost of implementation and the time required to learn the program. Lastly, by utilizing all four factors, strategies will be developed through the TOWS matrix to promote and recommend suitable strategies for BIM implementation in Thai construction contractors. For example, an experimental BIM strategy could be employed for a pilot study, which would assess its advantages and disadvantages to inform future projects.

Keywords: Building Information Modeling, SWOT factors, BIM Implementation, Strategy

[BIM12]

BIM-BASED PRECAST BUILDING OPTIMIZATION BY OPTIMALITY CRITERIA AND NSGA-II-GD CONSIDERING CONSTRUCTABILITY FOR PRECAST CONCRETE SIZING AND REBAR DETAILING

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Abstract: Constructability is adopted as a concept to improve construction performance, including precast construction. Despite many attempts to enhance constructability factors such as logistics, sequencing, and transportation, standardization remains an area in need of development. The framework initiates by using Building Information Modeling techniques to extract semantic information from architectural plans, then uses gradient-based Optimality Criteria method to optimize the sizing variables of precast components. Finally, a hybrid approach called NSGA-II-GD, which combines Non-dominated Sorting Genetic Algorithm II and Great Deluge Algorithm, is used to optimize the rebar layout design of each precast component. Results from an illustrative example demonstrate an optimal point between construction cost and standardization, particularly for components subjected to similar stresses. The proposed NSGA-II-GD algorithm improves the searching efficiency in terms of convergence, computational time, and searching space.

Keywords: Precast optimization, Building information modeling, Constructability, NSGA-II, Optimality criteria

[BIM13]

IMPROVING THE EFFICIENCY OF ICT EARTHWORK THROUGH AUTOMATED PLANNING USING BIM

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Abstract: In Japan, Information and Communication Technology (ICT) earthwork has been deployed under the "i-Construction" policy proposed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in 2015, which aims to improve the productivity in construction through the consistent use of 3D data, Global Navigation Satellite System (GNSS), Total Station (TS), and sensors. In the creation of plans for ICT earthwork, efficiency is being improved through the use of Building Information Modeling (BIM) models. Specifically, a BIM model is created for each construction stage based on the BIM model of the final shape, and the way of proceeding with construction up to the final shape is visualized and studied. However, there are many small- and medium-scale earthworks in Japan, and there is a lack of personnel in charge of BIM modeling at such sites. In this study, we developed a method to automate daily earthwork planning by applying BIM to earthwork projects in which ICT earthwork was introduced and compared it with the construction flow in actual construction sites.

Keywords: ICT earthwork, BIM, 3D Model, Automated planning

[BIM14]

NEW ERA OF MAPPING PRODUCTS FROM UAV-BASED OBLIQUE CAMERA SYSTEM

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Abstract: Unmanned aerial vehicles (UAVs), equipped with small and compact oblique camera systems, are revolutionizing the field of mapping and surveying by providing highly detailed and accurate 3D maps of terrain that were previously difficult to generate. By processing oblique images captured by these systems, a range of products can be generated, including true orthophotos, 3D city models by colorized point cloud, 3D textured city models, oblique viewer with easy 3D measuring capability, and precise multi-view 3D object measurement. These products offer unparalleled flexibility and all-purpose applications with accuracy, making UAV-based oblique camera systems well suited for a wide range of applications supporting city administration, such as Building and Construction Information Modeling (BIM/CIM), urban planning, infrastructure development, building control regulation/legislation, and finally the digital twin. This paper explores the potential of these modern mapping products and highlights their benefits and limitations in the case of megacities, e.g., Bangkok. The paper discusses the impact of small and compact UAV-based oblique camera systems on the mapping and surveying industry and emphasizes the need for ongoing research and development in this rapidly evolving field.

Keywords: UAVs, Oblique camera system, 3D city model, 3D geoinformation, Multi-view object measurement

[BIM15]

EVALUATION OF INTEROPERABILITY BY QUANTIFYING DATA INTEGRITY IN THE INTEGRATION OF BIM AND STRUCTURAL ANALYSIS FOR MULTIPLE LEVELS OF DEVELOPMENT

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Abstract: In the Architecture, Engineering, and Construction (AEC) Industry, the model generation of structures and structural analysis are generally done in separate phases of a project. In order to achieve a more streamlined and efficient process for these phases, the interoperability of Building Information Modeling (BIM) and structural analysis was examined in this study. Since the integration of BIM and structural analysis involves data transfer between different platforms, there are interoperability challenges related to the accuracy and consistency of transferred data. This research study aimed to evaluate interoperability considering data integrity in the integration of BIM and structural analysis for multiple Levels of Development (LOD). Firstly, five LODs were considered to target a specific detail of structural analysis and digital modeling for a load-bearing system of a structure. Digital models employing BIM were created using the information gathered and identified LODs. Secondly, models suitable for structural analysis were generated and analyzed. Next, the data integrity was quantified based on a criterion involving different properties of the model, such as orientation, element type, connection, cross-section, length, compressive strength, and modulus of elasticity. In application to a study model and a model for an actual church wall structure, it is found that aside from data formats significantly affecting the data integrity, the mentioned properties influence the data integrity to varying degrees, thus, highlight the need for improvement in data transfer process for higher LODs. This study provides an evaluation of interoperability that may guide designers on how to proceed when conducting integration procedures during the modeling-analysis process by providing the data integrity values to be expected after the data transfer processes.

Keywords: Interoperability, Data Integrity, Structural Analysis, BIM, LOD

[BIM16]

QUANTITATIVE ANALYSIS FOR APPLYING BUILDING INFORMATION MODELING(BIM) IN INFRASTRUCTURE PROJECTS

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Abstract: Building Information Modeling(BIM) opened up many possibilities for construction industry. However, most studies focus mainly on its overall uses and management areas. By investigating real projects that could utilize BIM in design phases for a railway construction, the authors try to examine possible advantages and disadvantages in BIM implementation. To do so, the authors have selected three projects with BIM implementation during design process and three other projects with non-BIM, traditional design working environment. Similar scale projects were carefully chosen and their differences in costs, man-hours, and labor forces were analyzed quantitatively. In addition, an in-depth interview was conducted with four BIM designing firms to provide a more comprehensive perspective on advantages and issues in BIM implementation. The average results show that BIM implemented projects spent $65,800 less than their counterparts and can increase about 2.9% of productivity. More importantly, the difference between BIM and non-BIM projects are in their man-hours. BIM adopted projected spend 103.5 days less than non-BIM projects on average and required 3 less professional labor forces during the entire design process.

Keywords: Building Information Modeling(BIM); Cost Analysis; BIM Environments; Rail BIM

[BIM17]

BIM: A SUCCESSFUL ALTERNATIVE FOR THE CONSTRUCTION QUANTITY TAKE-OFF IN THE LARGE-SCALE CONSTRUCTION PROJECT

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Abstract: Building Information Modeling (BIM) is the effective process of creating and managing information in construction projects through a 3D virtual model that has been applied to a number of construction projects all over the world. From 2023, the BIM application will be compulsory for work class I or higher in public investment projects, projects funded by nonpublic investment state capital, and PPP projects in Vietnam. However, the accuracy of BIM in volume take-off is a big barrier to its application in practice. Therefore, in this paper, the authors present a successful alternative for using a BIM quantity take-off in a large-scale construction project (class I) in Vietnam. Revit is selected as a potential BIM authoring program for developing the 3D model and conducting semi-automatic quantity take-off in this study. Microsoft Excel is selected as an implicit spreadsheet tool for reporting the results. The authors compared the results from two methods: the BIM method and the traditional method, to evaluate the advantages and disadvantages of BIM technology for construction quantity take-off in large-scale construction projects.

Keywords: Building Information Modeling (BIM), Successful alternative, Construction quantity take-off, Large-scale construction project.

[BIM18]

BUILDING INFORMATION MODELING FRAMEWORK FOR PRACTICAL IMPLEMENTATION OF A MEGA-PROJECT IN THAILAND

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Abstract: Building Information Modeling (BIM) is used to create, collaborate and manage data throughout the engineering, procurement, and construction (EPC) as well as operations phases of the building. U-Tapao international airport (UTP airport) are a public-private partnership project and one of the mega-projects in Thailand (≈6500 rai) which utilized as a case study in the paper. However, UTP airport projects are divided into six categories including passenger terminal building, airside, landside, airport facilities, cargo terminal, and utilities. The 2nd runway, high speed railway, motorway M7, power supply, water supply, and aircraft fuel supply are other projects that require close coordination and collaboration. Therefore, the purpose of this paper is to provide a BIM framework for real-world mega-projects that focuses on issues of practicability. The complexity of the project and the number of parties involved cause the implementation of BIM to be planned from the design phase to the construction phase. The data transfer strategy was implemented for the future of operation and maintenance phase. Single data source, data migration to the cloud, design collaboration, and combining all disciplines with a BIM are essential to the successful implementation of BIM in this project. This paper demonstrated that BIM could overcome project constraints and resulted in a framework for realistic BIM execution which is able to be utilized in EPC projects to alleviate the problem of a lack of information and eliminate conflicts between another parties.

Keywords: Building Information Modeling (BIM), Engineering Procurement Construction (EPC), Airport.

[BIM19]

STATE-OF-THE-ART OF HISTORIC BUILDING INFORMATION TRENDS WITH DIGITALIZATION INTEGRATION ON THE ARCHITECTURE HERITAGE CONSERVATION IN VIETNAM

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Abstract: The protection of constructed heritage is increasingly intertwined with the routine upkeep of structures, making conservation a practical requirement daily. Despite the recent considerable development in the usage of BIM in the field of Cultural Heritage (CH), the application of Heritage Building Information Modeling (HBIM) of cultural property intended for preservation is still limited. One of them is the unique diversity of Vietnamese traditional architecture that needs to be considered to assess the status of restoration and conservation. The improvement of data capturing technologies like 3D Laser Scanning and enhanced photogrammetry, along with the ongoing capability of HBIM authoring tools, not only enables the storage of spatial information and metadata but also offers the means for recording structural changes. This research aims to overview the state of art implementation for digital historical building, specifically in the Scan-to-HBIM application, and propose a database of historical structures using HBIM that focuses on the measurement information contained in the model, particularly related to conservation from the Scan-to-HBIM process to apply in a specific case study, namely Hung Kings Temple. The research methodology is using a questionnaire survey to collect data from the sampling to evaluate the frequency of using the component information in the Heritage Building. It sought to demonstrate the efficacy of HBIM there in the information recording of small-scale historical monuments. The utilization of digital tools and data recording formats in the creation of object models presents opportunities for future modifications and the integration of HBIM technology for Vietnam in particular and works in the world in general.

Keywords: Cultural Heritage; Heritage Building Information Modeling (HBIM); 3D Laser Scanning; Conservation; Level of Development (LOD).

[BIM20]

ON PRACTICAL CASES OF BUILDING INFORMATION MANAGEMENT IN CONSTRUCTION PROJECT COLLABORATION

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Abstract: While traditional project management contracts tend to focus on delineating the work responsibilities of different teams, construction projects often require close collaboration between stakeholders to integrate various interfaces. Building Information Modeling (BIM) is not only a virtual modeling tool for detecting interface clashes but also an audit tool for streamlining information flow among all stakeholders. The exchange of information and mutual support between stakeholders is critical to successful teamwork in construction projects. This report draws on the practice in construction projects as cases to highlight the often-overlooked role of building information management in the project lifecycle. We demonstrate how BIM facilitates collaboration and enhances communication between stakeholders, ultimately leading to more successful project outcomes.

Keywords: Building information management, Multi-stakeholder team collaboration, Information transparency

[BIM21]

DESIGN AND IMPLEMENTATION OF BIM-BASED ROADWAY DRAINAGE MODEL

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Abstract: Despite the vigorous development of Building Information Modeling (BIM), research on the application of BIM for drainage systems mainly focuses on building drainage systems, while BIM applications for roadway drainage systems are less discussed. The most significant difference between the two systems is that roadway drainage systems are designed based on the geographic environment and hydraulic analysis, resulting in different object types, object usage, and object properties. For example, the design of a roadside ditch must conform to roadway alignment, and the upstream/downstream connection between roadway drainage objects may be one-to-many instead of one-to-one. Therefore, the existing frameworks for building drainage systems are not applicable to roadway drainage systems.

Drawing upon experience in major civil engineering projects in Taiwan dating back to 1994, Sinotech Engineering Consultants, Ltd. proposes a BIM-based roadway drainage model. Based on the framework of the model, a computer-aided design system for roadway drainage, SinoDrain, is developed to refine the design process. The model and SinoDrain provide a data structure to store massive data about the roadway drainage system, simplifying the design process and significantly reducing the likelihood of human error. Furthermore, SinoDrain has been verified in multiple projects, enhancing accuracy, and realizing significant cost and time savings, and bringing theoretical and practical benefits to the field of roadway drainage design. This research cites the Taoyuan Aerotropolis - Zone B2 project as an example. Sinotech Engineering Consultants, Ltd. first performed the detailed design of the roadway drainage system using traditional design methods, and then re-performed the detailed design using the proposed model and SinoDrain to establish the BIM model.

Keywords: BIM, Computer-Aided Design System, Roadway Drainage Model, Taoyuan Aerotropolis

[BIM22]

AUTOMATIC CREATION OF 3D TEXTURED SIMPLIFIED MODEL FOR SUPPORTING PILED PIER MAINTENANCE

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Abstract: For efficient and effective maintenance of aging piled piers, the camera-mounted radio-controlled boat was developed. This enabled the acquisition of 3D dense polygonal model with rich texture of undersurface of superstructure of piled pier by SfM/MVS process to multiple images. In this paper, for the effective use of 3D model in maintenance stage, we propose the method for automatically converting it to a simplified textured model. From a viewpoint of design and functionality of piled pier, multiple beam and pile head are arranged so that they configurate orthogonal grid. By utilizing such a domain specific knowledge of piled piers, our method automatically segments a dense polygonal model into major parts, such as slab, beam, and pile head, and converts it to a simplified polygonal model where each constituent region is represented by a planar surface. We also create ortho image of each planar region and reconstruct a 3D simplified textured model. We demonstrate the effectiveness of our proposed method through various experiments.

Keywords: Piled pier maintenance, SfM/MVS, Semantic segmentation, 3D modeling

[BIM23]

BIM APPLICATION FOR RESOLVING CONSTRUCTION ISSUES IN THAILAND: A CONSULTANT'S CASE STUDY

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Abstract: This technical paper reports on the benefits of implementing Building Information Modeling (BIM) in construction projects, drawing on two case studies. The first case study discusses the application of BIM to resolve an unanticipated issue that arose during the bore pile drilling work in the construction of a hospital in Bangkok. The second case study details the use of BIM to detect a significant design flaw in a hospital building in northeastern Thailand. The employment of BIM facilitated the optimization of the design and construction process, improved communication among project teams, and prevented the occurrence of safety hazards, variation orders, rework, project delays, and additional costs. Consequently, the adoption of BIM in these construction projects can enhance the efficiency and accuracy of the construction process.

Keywords: Construction Management, BIM, Building project, Construction issue, Thailand

[BIM24]

THE PROCESS OF APPLYING AR/VR/MR IN DESIGN IMPLEMENTATION IN CONSTRUCTION PROJECTS

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Abstract: Despite the prospective advantages of using virtual reality (VR), augmented reality (AR), and mixed reality (MR) in the construction industry, there are still obstacles that must be overcome, including high initial investment costs, equipment and application synchronization, and staff training. The purpose of this research was to establish a method for utilizing VR/AR/MR in the implementation of design in construction projects. This study employs design software and VR/AR/MR applications to generate 3D models, identify and resolve errors and problems, generate a virtual tour, and optimize 3D models. The primary outcome is a procedure for applying VR/AR/MR to design implementation that specifies personnel requirements and construction project implementation processes. This research will contribute to the development of best practices for implementing VR/AR/MR in the construction industry, thereby enhancing construction processes and project management.

Keywords: AR (Augmented Reality), VR (Virtual Reality), MR (Mixed Reality), Design phase, Interaction, Feasibility evaluation.

[CEA1]

MODELING AND PRICING OF MULTIPLE RENEWAL OPTIONS EMBEDDED IN SHORT-TERM LEASE CONTRACTS

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Abstract: Leaseholds have been increasingly used in real estate projects because of their flexibility advantages, such as flexible-use and contract renewal options. This paper presents a financial model for real estate development by which developers may employ short-term lease contracts (STLCs) with multiple renewal options (MROs) instead of a single long-term lease. To price flexibility value of renewal option embedded in short-term lease contracts under an equilibrium model, this paper proposes a computational framework based on market lease present value (*MLPV*) and a Monte Carlo option pricing method. The multiple renewal options are modeled as a series of European call options. The future *MLPV* of STLCs, an important underlying variable of renewal options, is then assumed to follow a stochastic process called geometric Brownian motion. The proposed method is then applied to a real estate project under construction in Bangkok. The results of our analysis revealed that using multiple short-term lease contracts with multiple renewal options may provide benefits for both developers and leaseholders.

Keywords: Building economics, Lease, Real estate, Renewal options, Monte Carlo Simulation

[CEA2]

A BAYESIAN NETWORK MODEL FOR QUANTIFYING THE COST IMPACTS OF CLAIM CAUSES IN BUILDING PROJECTS

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Abstract: Claims are a troublesome issue and often result in adverse consequences in construction projects. Claims stem from various causes. Even though these causes may or may not finally lead to claims, they still affect certain project objectives such as project cost, time, and quality. Thus, it is necessary to develop a tool that can assess the impacts of claim causes during project execution. In this paper, we quantify the cost impacts of claim causes in building projects using a Bayesian network (BN) model. Claim causes were first compiled by a comprehensive literature review and were then verified by a group of nine experts. Face-to-face interviews with the experts were conducted to define the cause-and-effect relationships among 13 claim causes, which were in turn used for developing a BN model. An ordinal scale was established for rating the cost impact of each claim cause, which is expressed by a cost overrun level of building projects. Through a structured questionnaire survey, the historical data of claim causes in 112 building projects were gathered to demonstrate the proposed model. The results show that the proposed BN model can be used to predict the cost impact levels of claim causes along with their associated probabilities. The proposed model can characterize critical claim causes in building projects, which can subsequently be used to choose appropriate response measures.

Keywords: Bayesian network model, Building projects, Construction claims, Claim causes, Claim responses.

[CEA3]

COMPARISON OF IMMERSIVE AND NON-IMMERSIVE VR GAMES FOR ASSESSING SAFETY KNOWLEDGE.

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Abstract: One of the major causes of accidents on construction sites is the unsafe behavior of construction personnel. Studies have shown that due to a lack of safety knowledge and experience, workers engage in unsafe behavior. By evaluating the existing safety knowledge, we can develop more specific safety programs, identify individuals prone to accidents, and improve safety knowledge. Recently, Virtual Reality (VR) has been extensively applied in hazard identification, training, and in classroom programs due to its immersive and interactive properties. Furthermore, VR games are effective for safety training, supporting dynamic learning in the classroom, and assessing knowledge, performance, and behavior. Past studies using VR games as assessment tools have employed either fully immersive or non-immersive setups. Both mediums offer equally convincing reasons for being effective in assessing safety knowledge, considering their advantages and disadvantages. However, determining which one, immersive VR or non-immersive, offers better options or preference effects in knowledge assessment could be beneficial for game developers. Thus, the objective of this research is to compare the experience of assessing safety knowledge with immersive and non-immersive VR to determine user preference and fundamental differences in their application. For this purpose, a pilot study was conducted, developing two VR games—an immersive VR game and a non-immersive VR game—and analyzing user preferences. The pilot study determined that most of the participants 63.33% of desktop games and, by extension, expressed a preference for the VR game instead for assessment of their safety knowledge.

Keywords: Safety knowledge, Safety assessment tools, Immersive VR games, Non-immersive VR games, Construction safety management.

[CEA4]

IMPLEMENTING THE CIRCULAR ECONOMY CONCEPT IN CONSTRUCTION SUPPLY CHAIN MANAGEMENT OF MODULAR STEEL PROJECTS

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Abstract: The circular economy (CE) is a modern economic model where the value of products, materials, and resources is maintained in the economy as long as possible, whereas the generation of waste is minimized. The CE primarily encompasses adding value to technological and biological cycles through design, material manufacturing, construction, and material recycling. Yet, it is a relatively new construction practice, which has been limitedly investigated. This paper examines how to implement the CE concept in construction supply chain management by focusing on modular steel projects. The supply chain, value chain, and life cycle of modular steel projects are thoroughly analyzed to define a modular steel supply chain, which consists of essential activities such as design, manufacturing, fabrication, and construction in a chronological order. We then identify all supply chain actors associated with these activities, their collaboration and interaction, as well as their responsibilities. The paper then examines the actions each actor must carry out in the pre-construction, construction, and post-construction stages. The main actors include architects, contractor, engineer, manufacturer, fabricator, supplier, and dismantler. Implementing circular economy principles in modular steel projects requires effective strategies for the stakeholders' engagement, collaboration, and knowledge sharing. Our results highlight new roles and responsibilities associated with the CE practice each supply chain actor must perform. These findings are a preliminary step toward the implementation of the CE concept in the supply chain of modular steel construction. They can subsequently lead to comprehensive circular supply chain management in the construction industry and can provide valuable insights and recommendations to advance sustainability, resource-efficient, environmentally-friendly built environments, and the circularity in the modular steel construction sector.

Keywords: Circular economy, Construction supply chain management, Circular supply chain, Sustainable construction, Modular steel project

[CEA5]

MARKOV DETERIORATION HAZARD MODEL FOR ROAD NETWORK DETERIORATION FORECAST FOR NATIONAL ROAD NETWORKS IN LAO PDR

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Abstract: The primary objectives of road management systems are to estimate short- and long-term budget demands and establish a priority list of projects under fiscal constraints. Understanding road network deterioration is critical for predicting future conditions and developing appropriate maintenance and rehabilitation strategies. Various factors affect the deterioration speeds of road surfaces including traffic volume and environmental conditions, which are also the main uncertainties in developing the deterioration model, particularly for the Lao road management system. This paper aims to develop a road deterioration forecasting model using a Markov deterioration hazard model for prediction of the deterioration process for the national road network in Lao PDR using the international roughness index. The Markov deterioration hazard model estimates the hazard rates which are used to determine the Markov transition probabilities between the pavement's condition states defined on a discrete scale during inspection time. Then, the estimated transition probabilities can be used to forecast and predict life expectancy. The Markov deterioration hazard model is also capable of handling roughness condition data containing irregular inspection intervals. The empirical study used historical roughness index records to develop the model, incorporating traffic volume and pavement type data from the Lao national road maintenance system. The data set from the Lao road management system was composed of 22 road sections totaling 2,769 km in length. The results reveal the service life expectancy of two core networks, core network 1 and core network 2, to be 9.28 and 7.51 years, respectively. The analyses on deterioration process and life expectancy help the Lao road management system improve its road maintenance strategy, determine the maintenance period, and prioritize road network sections for maintenance. Furthermore, this study's results could support decision-making in terms of performance-based road contracts for maintenance.

Keywords: Road management; Deterioration prediction; Markov hazard model; Bayesian estimation method; Laos RMS.

[CEA6]

PROMOTING FLEXIBLE USE OF OPEN DATA THROUGH SERVICE LINK PLATFORM FOR INFRASTRUCTURE MANAGEMENT

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Abstract: In 2014, periodical inspections of major infrastructure facilities in Japan became mandatory, and a large amount of periodical inspection data was generated. In addition, in 2012, the Electronic Government Open Data Strategy was enforced, and the Japanese government began promote utilizing open data for citizens. However, the data format and preservation method differ for each local government, and the level of Open Data is not sufficient. In this study, the authors focus on the utilization of periodical inspection data of infrastructure facilities, propose a method of distributing inspection data as machine-readable open data over the Internet, and put forward an efficient generation and distribution method of open data using a prototype system developed for this purpose. Moreover, as an example of open data utilization, a data visualization application was developed, which allows the user to instantly check the condition states of infrastructure facilities on a map.

Keywords: Infrastructure management, Open data, Web API, Data management, Data visualization.

[DT1]

DESIGN OF A DIGITAL TWIN FOR REAL-TIME CONSTRUCTION POLLUTION MANAGEMENT IN BUILDING RENOVATION PROJECTS

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Abstract: Construction pollution (e.g., dust, noise, and vibration) is a critical issue that must be addressed by every party in building renovation projects. Real-time data on noise, dust, and vibration parameters need to be collected and analyzed to issue prompt warnings when certain thresholds are exceeded. Comprehensive data management can promote site conditions that are environmentally friendly for construction workers and building users. In this paper, we develop a digital twin that combines a building information modeling (BIM) model with a behavioral model for real-time construction pollution monitoring and control. The real-time noise, dust, and vibration data is collected via sensors, and transmitted and integrated with an as-is/as-planned BIM model by the Internet of Things (IoT) technology. The proposed platform allows project supervisors to detect construction pollution problems in building renovation projects instantaneously. This paper also designs the common data environment (CDE) of the digital twin. It delineates the structure and components of the database associated with construction pollution monitoring and control. An actual renovation project of the auditorium at the Faculty of Engineering, Chulalongkorn University is used to illustrate the proposed digital twin platform.

Keywords: As-is BIM models, As-designed BIM models, Building renovation project, Common Data Environment (CDE), Construction pollution, Digital twin, Internet of Things (IoT)

[DT2]

VERIFICATION OF REGISTRATION AND COMPLEMENTATION OF POINT CLOUD DATA OBTAINED BY SIMPLIFIED MEASUREMENT

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Abstract: In recent years, digital twin has been attracting attention toward the realization of smart cities. In Japan, the Ministry of Land, Infrastructure, Transport and Tourism is promoting Project PLATEAU to construct a 3D urban model from photographs and point cloud data collected by aerial survey. The current 3D urban model faces the problems of collecting data on indoor spaces and areas shaded by street trees, which aerial survey is unable to obtain, and of collecting data on local deformations. These problems may be solved by utilizing point cloud data measured simply with inexpensive equipment. In this study, we improved the registration method and verified whether or not different point cloud data obtained by simplified measurement can complement each other. In the experiment, we registered point cloud data measured with a mobile terminal, which is one of the simplified measurement methods, using a transformation matrix calculated by an existing method, to complement the missing parts. As a result, it was proved that different sets of point cloud data obtained by two different applications of the mobile terminal allow complimenting the missing parts of the respective cloud data with each other. The experimental results suggest the applicability of point cloud data obtained by mobile terminals to complement 3D urban models.

Keywords: 3D urban model, Point cloud data, Voxel, GICP, Point cloud registration

[DT 3]

TRAFFIC NOISE SIMULATION AND ITS AURALIZATION USING VR TECHNOLOGY

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Abstract: This paper presents a traffic noise evaluation system based on geometrical acoustic theory. The computation of noise level is performed by the geometric acoustic theory. In order to investigate the validity and efficiency of the method, the present method is applied to several traffic noise problems. The computed results are compared with the measurement results. The present system is useful for planning and designing tool for various transportation facilities in an urban area, and also for consensus building for designers and the local residents.

Keywords: Traffic noise, Auralization, VR

[DT4]

SMART HOME ADOPTION: CHALLENGE AND OPPORTUNITY FOR DIGITAL TWIN BUILDING

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Abstract: Wireless Sensing Network (WSN) development in a household level has emerged smart home device with benefit of affordable cost, user friendly interface, easy entry in initial stage, has accelerated the widespread of smart building. Digital Twin (DT), a digital counterpart of physical object for monitoring, analysis, simulation, etc., has been use in manufacture, healthcare, building. DT building studies, integration of BIM and IoT data from WSN in virtual building platform, has create new possibility in operation and maintenance phase of smart building, with a real world demonstrator in Aalto university and Cambridge university, which emerge a DT system architecture, a framework for constructing DT building from the technical perspective. However, the existing framework is not compatible with smart home devices adoption in smart building since the lack of physical details of device installation on-site and various building data management. An inclusive DT framework with smart building involvement would increase the practicality of DT building development. According to the literature review on the existing DT framework and OSI reference model, the international standards of computer networks, this study proposes 6 layers of DT framework which clarify the whole details of DT development from the physical smart building to its digital counterpart. Based on the framework, a real world demonstrator, Pine and Grass building, DT was implemented in smart building development to improve the building aspect of well-being, performance, safety with smart home devices. The result provides the clarification in each layer, benefit and limitation of smart home device adoption in DT development, to improve understanding of DT building for building owner and building admin, an initiator and end users of DT building, which accelerate widespread of DT technology in the field of smart building.

Keywords: WSN, DT, Smart home device, Smart building

[DT5]

CONSIDERATION FOR LEVEL OF DIGITAL TWIN IN ARCHITECTURE

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Abstract: Digital Twin has been mentioned into the stage of application for many working fields both practical and theoretical, since a decade ago. However, lack of implementation with marketing approaches in architectural sector and enormous theoretical simulation without real on-site experiment, would mislead end-user or investor, and inevitably devalue its potential. Study from implemented case studies of Digital Twin utilization in architecture led to key points clarification, such as proportion of IoT device and networking for smart-living preparation, readiness of procedure framework, targeting function and its usage, that could be developed into a concept of Level of Digital Twin in architecture. This definition framing could regenerate perception from end-user perspective righteously, and reconvince for expansive utilization of DT in architectural sector.

Keywords: Level of Digital Twin, Demonstration, DT Building framework

[DT6]

FROM BIM TO DIGITAL TWIN: A CASE STUDY EXPERIENCE

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Abstract: In the construction business, Building Information Modeling (BIM) provides a digital representation of the geometrical and non-geometrical information of a building. A BIM model can be used for a range of tasks, including design collaboration, construction planning, and building management. The term “Digital Twin” (DT) refers to a recently developed technology that is used to represent a virtual replica of a building that includes not only physical properties but also dynamic data from various sources, such as sensors and BIM models. This paper explains our real case experience in creating a digital twin based on BIM for the administration and maintenance of an academic building in Thailand. A Unity application based on the building's BIM model is created and enhanced with the appropriate graphics for exhibiting real-time building states that were collected by Internet of Things (IoT) sensors as well as additional interactive controls for navigation and drill down focus. From data ingestion to dashboard presentation, the complete data pipeline takes place in the cloud. The digital twin development technique for building management is suggested for future applicants after we successfully overcame a number of challenges with the use of already accessible tools and technologies.

Keywords: Digital twin, Building information modeling, Smart building, Internet of things, Cloud computing

[GS1]

CIRCULAR ECONOMY CRITICAL SUCCESS FACTORS FOR SUSTAINABLE CONSTRUCTION: AN EXPLORATORY APPROACH

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Abstract: The circular economy agenda emphasizes the need of reducing carbon footprint and achieve sustainability in the construction industry. To maximize benefits while maintaining the functionality of Building projects, sustainability concepts should be applied throughout all decision-making stages in the construction of buildings particular with regard to CE. In this study, the critical successful factors (CSFs) needed to achieve the circular economy (CE) in residential construction projects were identified and studied. Regarding the long-term viability of such undertakings. The CSFs for CE were found in previous research and contextually modified utilizing semi-structured interviews and a pilot study using the Exploratory Factor Analysis (EFA) method. The EFA findings revealed three constructs into which the CE CSFs may be divided: Political Factors, Technological Factors and Organizational Factors. The Nigerian construction industry's stakeholders were then given a questionnaire to complete. The CSFs model was created and the results obtained indicated that political and technological factors were significant CSFs for implementing CE, despite the fact that Nigerian experts with limited practice experience were fairly informed about CE. The findings of this study will help increase sustainability in the Nigerian construction industry while also serving as a guide for decision-makers regarding the impact of global warming and carbon footprint.

Keywords: Circular, Economy, Exploratory, Success, Sustainability, Factors

[GS2]

A BLOCKCHAIN-BASED CARBON AUDITING FRAMEWORK FOR CONSTRUCTION MATERIAL AND PRODUCT CERTIFICATION

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Abstract: The construction industry has an indispensable role in global carbon reduction as it is one of the largest generators of carbon footprint emissions. Of various emission sources at different stages of the construction life cycle, construction materials and products contribute a considerable proportion, and thus their importance should not be neglected. Although multiple carbon certification or labelling schemes for Construction Materials and Products (CMPs) have been launched to assess their carbon emissions, such efforts and practices still rely heavily on traditional centralized data storage and publishment, which suffer data non-transparency and manipulation problems, making it difficult to identify and track carbon footprints of CMPs. Therefore, this paper proposes a transparent and reliable carbon auditing framework for CMP certification based on blockchain technology, which aims to facilitate the management of carbon footprints ranging from raw material extraction, transportation to plants, and manufacturing. In the proposed framework, a two-level privacy blockchain data model summarizing carbon footprints is first developed under data transparency and privacy concerns. An asymmetric encryption scheme integrating with an online document-sharing system, the InterPlanetary File System (IPFS), is then proposed to secure data storage and access during the carbon auditing process. Besides, smart contracts are developed to interact with the blockchain network, which supports generating immutable distributed ledgers of construction material and product carbon footprints. A prototype using Ethereum, a public blockchain development tool, was deployed and evaluated. The feasibility of the framework is validated through an illustrative example, showing that the blockchain-based framework is a promising solution in auditing and tracking the carbon footprints of CMPs.

Keywords: Carbon Auditing, Blockchain, Carbon Footprint, Carbon Tracking, Carbon Privacy

[GS3]

RESEARCH ON VISUALIZATION BASED ON CLIMATE ANALYSIS OF THE INFLUENCE OF GREEN SPACE ON THE THERMAL ENVIRONMENT USING MSSG MODEL

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Abstract: In addition to climate change, a lack of green space has caused urban warming. In Osaka city, severe urban warming reportedly leads to high temperatures. Under these circumstances, the "Grand Green Osaka" project is currently underway in a central business district in front of the Osaka central station. This urban development project will include a hotel, commercial facilities, and a large 8-hectare green space on a 17-hectare site. This study aims to visualize the impact of green space making in a development on the surrounding thermal environment based on the climate analysis result by numerical simulation. As a result, a relatively cooler temperature zone was further extended within the development area. On the west side of the developed area, the newly developed green space was contiguous with the existing green space, which enhanced the high temperature mitigation effect and lowered the temperature. On the east side of the developed area, the wind turbulence caused by the appearance of buildings and the lower temperature in the developed area brought cooler and stronger wind speeds than the current conditions, which contributed to the lower temperature.

Keywords: Green spaces, Climate analysis, Multi-scale simulator for the geoenvironment, 3D city model.

[GS4]

EMISSIONS TRACKING CONTROL OPTIMIZATION TO SUPPORT SUSTAINABLE CONSTRUCTION IN ROAD CONSTRUCTION PROJECTS

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Abstract: Utilizing green contracting is a prominent technique to advocate sustainable construction in reducing CO_2 emissions from nonroad heavy construction equipment. Although sustainable equipment regulations have established the standard for controlling emissions from equipment, it still mostly executes in the preconstruction phase. However, a method to control emissions during the construction phase to adhere to the green contracting requirements has not been fully developed. Therefore, there is a pressing need for new research to develop a tracking support and control system for monitoring emissions during the construction phase. This paper presented a tracking control optimization model with the capability to identify the potential key date(s) for monitoring the contractor's green performance to secure the onsite emissions within the terms of the contract agreement. The tracking control model is implemented based on the concept of earned value management for estimating emissions variation and predicting emissions toward project completion. The model is applied to a hypothetical example of a road construction project with an expected result presenting optimal solutions of the emission-tracking date that enables a suggestion for improving sustainable options on the construction equipment fleet. The proposed optimization model should prove useful as a sustainable tracking and control mechanism facilitating project owners in identifying sustainable key date(s) for monitoring the emissions to assure the effectiveness of green contract implementation.

Keywords: CO_2 emission, Optimization, Earned value management, Road construction projects.

[GS5]

GREEN INFRASTRUCTURE PLANNING WITH POPULATION DECREASING FOR ADAPTING TO CLIMATE CHANGE BY USING GIS AND NUMERICAL MODELS: CASE OF KURE CITY IN HIROSHIMA PREFECTURE

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Abstract: Due to climate change, many Japanese cities are experiencing severe flooding and severe summer thermal environments in the outdoor spaces. Under such circumstances, the use of green infrastructure is considered to be one of the effective options to adapt to climate change (mitigation of flood damage and severe thermal environment). On the other hand, many provincial cities in Japan are facing a declining population and an increasing amount of low-used lands and un-used lands, which will require land use re-arranging in the near future. This increase in low-used and un-used lands can be considered an opportunity to introduce green infrastructure. Therefore, in this study, authors utilized GIS and numerical simulation models to identify suitable sites for effective green infrastructure building by evaluating multiple scenarios. This study shows that the introduction of G.I. into underutilized land has some positive effects on both urban flood control and the improvement of the thermal environment.

Keywords: Green Infrastructure, Climate Change, Flood Control, Urban Warming, Population Decreasing

[GS6]

COMPARATIVE ANALYSES OF SIMULATION AND MEASUREMENT DATA OF BUILDINGS ENERGY CONSUMPTION USING TYPICAL WEATHER DATA AND REAL WEATHER DATA IN HOT-HUMID CLIMATE

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Abstract: For decades, improving energy efficiency and performance of buildings has been a challenge. Nowadays, in order to predict the building's energy performance to support decision-making in the selection of design retrofit options, energy simulation tools have become very useful and well-known among designers and researchers. Great accuracy in the related input parameters is required to generate a dependable simulation model. Outdoor climate is one of the most affected parameters in the simulation results. This study aims to investigate the reliability of simulation in a hot and humid climate. A Thai construction located in Bangkok is selected as a case study. The method is to compare measured values of energy consumption with the same parameters calculated in the software using outdoor climate data from in situ measurement and typical outdoor climate data. The evaluation of the predictive performance of the simulation model using local climate data and data from the ASHRAE weather database will be presented.

Keywords: Energy simulation, Typical weather file, Buildings energy consumption, Hot-humid climate

[IPM1]

THE INTEGRATION OF DESIGN AND FABRICATION FOR PREFABRICATED UHPC PANELS OF BUILDING FACADES

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Abstract: Prefabricated ultra-high-performance concrete (UHPC) panels have gained more and more attention for building facades due to their superiority of aesthetic appeal, strength, customization, sustainability, and ease of installation. Despite its many advantages, many barriers exist to using UHPC panels for construction. Most noticed is the cost of materials, limited availability, the complexity of fabrication, lack of standards, and limited experience in the industry. The key to resolving the difficult situations would be the ability to integrate the knowledge regarding the best use of the material, as well as the ways to optimize the fabrication and installation of UHPC panels in the design phases. This paper discusses the use of digital technologies to support the integrated project delivery process for building facades built with prefabricated UHPC panels. The scope of the study covers the communication pattern between the client, the architect and the UHPC experts across the schematic design phase, the design development phase, and the construction documentation phase. Parametric design tools, performance simulation tools, and a common data environment are used to facilitate communication across multiple disciplines so that domain knowledge regarding UHPC can be effectively integrated into the design decision process in all design phases. A construction project in which it was decided to use metal panels for the façade in the schematic design phase, but in the design development phase the architect and the client changed their decisions to use UHPC panels was used as a case study to uncover the difficulties for a conventional design communication process to integrate knowledge about new materials and technology. Scenarios that show how digital technology may facilitate communication among stakeholders that are not familiar with the domain expertise of others are displayed and explained in this paper.

Keywords: Ultra-High-Performance Concrete, Design Knowledge Integration, Fabrication, Digital Technology.

[IPM2]

CONSIDERING OF BIM DATA SCALE INTERFACES FOR VARIOUS APPLICATION: CASE STUDIES OF SMART PATROL PROJECT IN CHULAPAT 14 BUILDING CHULALONGKORN UNIVERSITY

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Abstract: BIM in the design and construction industry consists of graphical and non-graphical data, from the scale at the production level of parts and assembly to the scale at the design and construction level of elements and buildings to the scale at city levels of buildings and infrastructure, is big data for use in city management. However, when the data becomes larger, it causes problems in the efficiency of data management and processing. Case studies from digital twin experiment and BIM modeling procedure in Chulalongkorn university based on consideration of BIM data scale interfaces by organizing of a graphical data transformation to a non-graphical data from the scale at the production level of parts and assembly to the scale at the design and construction level of elements and buildings to the scale at city levels of buildings and infrastructure clarified significant procedures of data management efficiency.

Keywords: BIM data, Management, Processing, Scale interface

[IPM3]

DEVELOPMENT OF ROADWAY GEOMETRIC DESIGN PROCESS MODEL FOR KNOWLEDGE MANAGEMENT

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Abstract: This paper discusses a design process model for knowledge management in roadway geometric design. In this model, the design process is classified into four stages: Conceptual Design, Outline Design, Basic Design, and Recursive Design, and it shows that the roadway design process can be viewed as a function of the designer's thought process. Moreover, a method for analyzing the fluctuation in roadway distance was proposed. A distance-conversion table for each measurement that lengthens the roadway can be linked to the dispositional information. Using this method, we can start compiling knowledge from the beginning about changes in distance and will be able to reproduce the route-selection process in a system.

Keywords: Information management, Knowledge management, Roadway geometric design, BIM

[LIS1]

FOOTPRINT DETECTION OF CEILING EQUIPMENT FROM TLS POINT CLOUDS

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Abstract: In recent years, 3D scanning technology using a terrestrial laser scanner (TLS) has become widespread and is used in a wide range of fields such as plants, civil engineering, and architecture. The point clouds acquired by scanning are used for measurement, creating drawings, and 3D model generation and recognition. The reflected ceiling plan (RCP) is one of the 2D drawings of facilities that represents ceiling equipment such as lighting, fire alarm, inspection hole, and so on, and is often created for existing facilities for renovations, inspections, and safety standard checks. For large-scale facilities, the creation of RCPs becomes a labor-intensive and quite time-consuming process. This paper presents a method of footprint detection of ceiling equipment for supporting the creation of RCPs using laser scanning technology. The proposed method detects circle and square shape footprints of the equipment from TLS point clouds of the facility, and by labeling the equipment information, RCP can be created. In the experiment for two datasets, the performance of the method is evaluated, and footprints of about 90% are detected.

Keywords: Laser scanning, Point cloud, Ceiling equipment, Object detection, Reflected ceiling plan.

[LIS2]

AN ALTERNATIVE METHOD FOR CABLE TENSION EVALUATION BASED ON THE TERRESTRIAL LASER SCANNING DATA

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Abstract: This paper presents the results of applying terrestrial laser scanning (TLS) data to evaluate cable tension. TLS is a current technology for collecting building data with high precision. Consequently, TLS technology can be used to measure existing cable structure profiles. Generally, the actual slack cable shape profile indicates the cable tension. Therefore, the precise cable tension can be evaluated by matching the cable profile to the corresponding tension based on cable mechanics theory. In addition, the study used the nonlinear finite element method to assess the correct cable tension for the case in which bending rigidity has a significant effect. Finally, the paper presents experimental verification to demonstrate the accuracy of the proposed method.

Keywords: Cable tension evaluation, Cable structures, Nonlinear finite element, Terrestrial laser scanning, 3D point cloud data.

[LIS3]

INTEGRATING BIM INTO WEB GIS TO ENHANCE THE VISUALIZATION OF PORT INFRASTRUCTURE

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Abstract: This paper provides a detailed procedure to transform a seaport into a digital format, with the objective of creating a precise, effective BIM model of the port infrastructure. We execute on-site surveys to acquire point cloud data of the port infrastructure, encompassing a variety of data types from terrestrial to underwater regions. Additionally, we suggest a solution for data collection in inaccessible areas, by utilizing a range of equipment and combining advanced survey technologies to overcome the limitation of each separate survey type. The collected data undergoes processing to generate a comprehensive BIM model of the port, which encompasses data from the land to the underwater area. This BIM model is subsequently converted to a GIS-compatible format, and then integrated into the ArcGIS online platform. This fusion allows the merging of engineering design data with geospatial attributes into a comprehensive model. The final output, as demonstrated in a real case study of seaport in Vietnam, will be presented along with insights into optimizing data processing for integration.

Keywords: BIM, GIS, Laser scanning, USVs, UAS, Point cloud

[SCI1]

ON THE VISUAL ASPECT OF THE INFORMATION SCAPE IN THE BUILT ENVIRONMENT: SHILIN NIGHT MARKET AS AN EXAMPLE

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Abstract: How would a restaurant guest choose her favorite seat to dine in? How would prey animals place and orient themselves when feeding on grassland where predators might be around? Is it possible that the answers to the two questions might have similar traces of reasoning? Our perception of space is inherited from our ancestors, who were capable of sensing danger and opportunities for food and mates in the environment. An information scape is a representation of the flow of information that is accessible to a specific location in the environment. The hypothesis is that the tendency to locate oneself at an advantageous information scape is a part of human nature. The spatial experience of a person in a specific space can be diverse in terms of the availability of information within the environment. The information can be acquired through various senses such as odor, vision, taste, audition, and contact. Vision is the distinct sensory source of a human's perception of acquiring information in the built environment. Isovist analysis is a useful measurement of the visible field from a specified location in architectural and urban contexts. Isovist is adopted and extended in this study with Monte Carlo simulation to analyze information scape in an urban space. Shilin night market in Taipei, one of the well-known business and tourist attraction areas, exemplifies as the research area for information scape analysis. A measurement based on information scape analysis is used to quantify the accessibility and availability of information regarding the visible boundary from different spatial metrics of the Shilin environs. Overall, this paper displays that information scape analysis has the potential for studying the complex interaction between spatial configuration and human behavior in the aspect of information availability.

Keywords: Information scape, Information availability, Isovist analysis, Visibility, Spatial experience.

[SCI2]

ACCUMULATION AND CLASSIFICATION OF SMART LIVING FRAMEWORK FROM ACADEMIC STUDIES AND REAL SECTOR

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Abstract: Information & Communication Technologies (ICTs) and Internet of Things (IoTs) are fundamental technologies of Industry 4.0. The technologies can be globally used to manage several fields. Due to 56% of the world's population living in cities nowadays, the management of Smart city projects over the World is increasingly getting attention. Integrating ICTs and IoTs with the electricity grid in a smart city creates alternative solutions for energy management and helps to increase the amount of energy saving in cities. This way of integration not only helps to handle urbanization and climate changes but also improves the citizens' all aspects of quality of life, which is called 'Smart living'. Smart living in an aspect of housing quality, also began to integrate IoTs into Smart buildings or Smart homes to enhance the quality of life. A Smart living idea is widely known but still lacks comprehensive and up-to-date data accumulation and classification to create a Smart living framework in an aspect of housing quality, used as the tool for considering several dimensions of Smart living projects from the real sector. This research aims to accumulate and classify the Smart living framework, which is comprehensive and applicable nowadays. A research methodology based on guidelines for performing systematic literature reviews. The researcher screened up to 30 academic studies about Smart buildings or Smart homes in a literature review. Academic studies that have proposed the kind of guidelines, main criteria, indicators, or conceptual models of Smart homes, Smart buildings, or Smart living, and have been published within five years were selected. Subsequently, data exploration, accumulation, and classification of similar keywords relating to Smart living have been done respectively. Later, the researcher refines the details and synthesizes the Smart living framework used to consider Smart living projects from the real sector. The result showed that the Smart living framework could be classified into 2 classes; Management and Enhancement. This Smart living framework includes 9 criteria and 32 indicators, and findings of gaps in Smart living studies were found. In this paper, academic studies have conceptual Smart living frameworks as guidelines, which are more comprehensive than the real sector. In other words, the real sector will not be able to completely follow academic studies until the levels of technological advancement can support them.

Keywords: Framework, Smart living, Academic sector, Real sector

[SCI3]

CRACK DETECTION OF BRIDGES FROM SELF-WEIGHT DEFORMATION PROFILES

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Abstract: Bridges have been a main part of transportation systems for a long time and their structures may be eroded and damaged by many kinds of effects. The Bridge Health Monitoring system has been applied to automatically observe the abnormal condition of the structures before the structures will lead to collapse. One practical monitoring technique is to install tiltmeters or inclinometers on the bridges to detect their damages. Previous researchers have proposed many methodologies to detect crack locations and damage severity in bending structures such as reinforced concrete beams and bridges using periodic measured load tests. Although their effectiveness is verified using finite element model, laboratory model and a real bridge. The researchers reported that the methodology can only predict the very severe locations of the damage but cannot detect other smaller damages or cracks. In addition, the method requires a repeated bridge load test which is rather time-consuming and expensive. Unlike the previous studies, the present research, therefore, proposes the new methodology for crack detection from bridge deformation profile due to self-weight. Using a simple comparison of bridge inclinations under its self-weight before and after damages, the Crack Index is then computed and used to indicate the damage along the bridge without any load test requirement. The algorithm of computing the Crack Index taking into account the measurement accuracy is presented. Based on the computer simulations of bridge cracks, the Crack Index is determined and compared to the existing methods under various crack patterns and crack depths. It is found from the obtained results that the newly proposed method can significantly improve the precision of crack detection of the bridges and can be approved by reliable numerical model.

Keywords: Bridge crack, Crack detection, Bridge deformation, Bridge inclination, Bridge self-weight, Bridge health monitoring system

[SCI4]

DYNAMIC RESPONSE EVALUATION OF RAILWAY TRACK TRANSITIONS WITH RESILIENT MATERIALS

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Abstract: Railway infrastructure development is a growing trend around the globe, offering numerous benefits. However, one of the significant challenges is the track transition problem that arises from changing track sections. This leads to abrupt changes in track stiffness, resulting in substantial damage to the track structure due to the differential settlement, thereby increasing maintenance costs. In Thailand, the first phase of Thailand's high speed rail project has introduced a slab track system from China combined with traditional ballasted tracks at several sections. It is important to note that transition area can be critical and. There have been several methods to reduce differential stiffness. However, the combined method of using both Under Sleeper Pads (USPs) and Under Slab Mats (USMs) has not been widely adopted, even though it has the potential to reduce track vibration, impact load, and differential settlement. This paper presents the 3D train-track-soil finite element model at railway track transition zone with USPs and USMs. Several types of pads are proposed at different locations on the tracks subjected to various train speeds. Numerical results from a train-track-soil model computed using LS-DYNA are validated with field measurements and previous numerical results. One of the main advantages of using USPs is that they help to reduce ballast degradation. Similarly, USMs can be used to control track stiffness. While there are various ways to address these problems, the mixed method of using USPs and USMs is found to be an alternative to mitigate the problem at railway track transition. It is important to use resilient pads with caution, as improper selection or application of these pads can lead to further problems. Therefore, additional research is required to assess the potential benefits of this approach in reducing track vibration, impact load, and differential settlement on other tracks and soil types.

Keywords: Track Transition, Dynamic Train-Track-Soil Interactions, Under Sleeper Pads (USPs), Under Slab Mats (USMs)

[SCI5]

ONE-DIMENSIONAL COMPRESSION MODEL FOR UNSATURATED CRUSHABLE GRANULAR MATERIALS

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Abstract: Particle crushing is a phenomenon that occurs in crushable materials, such as granular soils, when subjected to high stress conditions that exceed the crushing strength of the particles, resulting in the breakdown of particles into smaller fragments. This can cause soil stiffness reduction and significant soil deformation. Furthermore, an increase in degree of saturation can also contribute to hydraulic collapse due to the higher stiffness of unsaturated soil compared to saturated soil. Experimental evidence suggests that the presence of water can further reduce the crushing strength of the soil. Consequently, the combined effects of particle crushing and changes in the saturation degree can cause excessive deformation and a reduction in soil strength. While existing constitutive models can predict the effects of unsaturated soils and particle crushing separately, a model that can simulate the combined effect of both phenomena is required to study the behavior of unsaturated crushable soils. Therefore, this study aims to propose a one-dimensional compression model for unsaturated crushable soils that can simulate the combined effect of particle crushing and unsaturated soils.

Keywords: One-dimensional compression model, Crushing strength, Particle crushing, Unsaturated soils.

[SCI6]

A COMBINED DROUGHT INDEX (CDI) SYSTEM FOR DROUGHT EARLY WARNING, MONITORING, AND RISK ASSESSMENT IN EEC THAILAND

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Abstract: Thailand is facing increasing water risks as a growing population, economic growth and the looming threats posed by climate change are expected to make sustainable water management and water security significantly more difficult. The government thus needs to move from a crisis response to a risk-management approach by maintaining acceptable levels of risk in 4 main areas including (1) drought risk; (2) flood risk; (3) the risk of inadequate water quality (water pollution); and (4) the risks of undermining the resilience of freshwater systems (water use and water allocation). This paper aims to enhance and facilitate the move to a risk-based approach to water security by making better use of drought analysis instruments using appropriate indices/indicators to reduce water shortages in drought-stricken areas especially under prolonged weather events hopefully to formulate water policies for justified spatio-temporal water allocation and access in the Eastern Economic Corridor (EEC) region. Long-term analysis of meteorological and hydrological drought indices is conducted to characterize and monitor drought trends in EEC using the Standardized Precipitation Index (SPI), the Standardized Precipitation Evapotranspiration Index (SPEI), and the Streamflow Drought Index (SDI). Computed time series of the 3 selected indices are compared with observed drought events by assimilating the weekly rainfall and monthly streamflow and evapotranspiration (PET) data from ground observations and remotely-sensed Earth observing satellites (i.e., MODIS, Aqua MODIS, TRMM, and GPM) data and climate drought indices are calculated. The performances of 3 climatic indices seem to be able to capture the main characteristics of drought conditions in EEC region and the indices also designate extreme drought frequency and severity since early 2000s. The 2 indices obviously can also detect notable drought episodes during year 1997-98, 2003-04, and 2015-16 consistent with El Niño years. The overstating the frequency of droughts at the 1-month timescale by SPEI and SDI still exists just like the case of SPI. SPEI indicated substantial higher severity and longer duration of drought events compared to those of SPI especially for the year 1991-92 drought episode, while SPI under-quantified the magnitude and missed to represent extreme droughts during that period. SPI climatic indices shows diverse effects on drought conditions under the prolonged records with certain restrictions, while multivariate index (i.e., SPEI) illustrates the obvious advantage of temporal variation of drought frequency, magnitude, and severity characteristics detection. The better performance of SPEI indices compared to SPI emphasizes that PET plays an important role in hydrologic cycle in Thailand with tropical monsoon weather system and its variation is primarily affected by precipitation as well as land use and land coverage change. Development of multiple drought indices demonstrated in this study can be beneficial for drought assessment, early warning, and future projections for planning and support the implementation of preventive measures or mitigation of drought impacts.

Keywords: Drought index, Drought early warning, EEC Thailand, Drought risk, ENSO.

[SCI7]

DISASTER EDUCATION ON FLOOD PREVENTION USING CARD GAME THROUGH DIGITAL PLATFORM

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Abstract: In General, disaster management has been mentioned in term of engineering both soft and hard implement hardly understand by local people. On the other hand, disaster education would be an efficient tool for getting community to recognize this. In disaster education, it is important not only to focus on the dangers of disasters, but also to develop a sense of attachment to and pride in the community in which one lives, while enjoying the benefits of nature, so that one can proactively evacuate in the event of a disaster.

In this study, a workshop was planned and conducted to deepen understanding of the wisdom and ingenuity of predecessors and their lifestyles in dealing with floods, and to create cards to introduce the local knowledge of the community and their predecessors' flood response. Then we created a digital card game using these cards, which enables participants to learn about the local wisdom of the community and its response to flood disasters while playing the game by themselves. The digital karuta system was constructed so that it could be run on low-spec equipment, and was designed to be simple enough to be implemented by elementary school students. In addition, brain activity was investigated using NIRS to see if the digitalization of the system had any effect on the learning effect.

Keywords: Disaster education, Living environment, Local wisdom, Digital disaster prevention card game

[XR1]

CONSTRUCTION OF A LOCATION-BASED MIXED-REALITY VISUALIZATION SYSTEM USING GLOBAL NAVIGATION SATELLITE SYSTEM DATA

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Abstract: Visualization techniques are increasingly being used in civil engineering. Mixed reality (MR), which allows hands-free visualization with eye contact, is suitable for civil engineering because safety can be ensured during visualization. Location-based methods (as examples of superimposition techniques) in which the accuracy is affected only by location information does not require marker placement so it is suitable for use on construction sites. This paper presents the development of a location-based MR visualization system based on global navigation satellite system (GNSS) data, aiming to support work at construction sites. This system uses GNSS receivers capable of centimeter-level positioning using network real-time kinematic surveying to superimpose accurately and automatically a three-dimensional model onto real space. The visualization position was recalculated every second so that it could be moved. The effectiveness of this system was evaluated by comparing the accuracy of the superimposition of the marker-based method with that of a real, buried underground structure.

Keywords: Mixed reality, Hololens2, Location-based visualization, Global navigation satellite system

[XR2]

ADVANCED AUGMENTED REALITY OBJECT PLACEMENT IN CONSTRUCTION SITES USING GEOSPATIAL API AND VISUAL POSITIONING SYSTEMS

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Abstract: Augmented Reality (AR), used in conjunction with Building Information Modeling (BIM) models, has enabled 3D models and associated information to be used directly on-site. Alignment of AR content is generally achieved using fiducial markers, namely QR codes. However, these markers are not suited for construction sites, as placement needs constant changes and updates with the progress of the project. Recent studies for BIM and AR have also focused on content creation rather than investigating technical advances to improve the practical application of AR use in the field, especially towards placement accuracy and stability. This study explored the use of Geospatial API which places AR content within a 3D map created by integrating the local GPS coordinates of AR devices and the global coordinates attained from Google Street View via a Visual Positioning System (VPS). Experiments on a bridge expansion project identified that additional images must be uploaded onto Google Street View for remote locations. This study determined the optimal conditions for image number, location, and spacing to enhance and secure the performance of Geospatial API in such cases. The results demonstrated that the approach obviated the need to first map a space of interest, previously a prerequisite and time-consuming task for marker-based approaches.

Keywords: Augmented Reality, Building Information Modeling, Geospatial API, Visual Positioning System, Projection Stability, Placement Accuracy

[XR3]

AUTOMATED DIMENSIONAL CHECKING IN MIXED REALITY FOR STAIRCASE FLIGHT

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Abstract: Building inspections have always been required to serve as a quality check to ensure that constructed building elements comply with national and local standards. Some of these checks involve dimensional checks such as checking for minimum headroom or clear widths. These checks are often done as spot checks using a tape measure. The efficiency of such checks could potentially be improved with new technology such as the use of Mixed Reality (MR) solutions that have in-built native sensors. Current and previous research for MR in the construction industry involves using MR for visualizing designs, facilitating information transfer in construction management, training construction workers, or operations and maintenance purposes. The objective of this research is to identify the accuracy of automatically computed dimensional checks in MR against dimensions measured from generated meshes, against ground truth. The results computed by the MR application are compared with dimensions measured from the exported mesh object in Computer-aided Design (CAD) to determine the accuracy of the MR-generated dimensions. Preliminary results show that MR-generated dimensions are generally accurate in conditions where meshes have sufficient coverage, but are not accurate when identified surfaces are too small to generate proper meshes. Future research includes ways to improve the accuracy of dimensional checks for smaller surfaces.

Keywords: Wearable technology, Mixed reality, Smart inspection, Digital inspection, Construction inspection

[XR4]

BIM-BASED AND AUGMENTED REALITY COMBINED WITH A REAL-TIME FIRE EVACUATION SYSTEM FOR THE CONSTRUCTION INDUSTRY

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Abstract: In the past decade, the drawings of construction projects' standard fire evacuation routes are usually presented in two-dimensional (2-D) views to explain the construction area and evacuation routes. Common users find it difficult to interpret the 2-D drawings quickly, accurately determine their position within the building, and choose the appropriate evacuation routes. Thus, in the event of a fire, the construction project can lead to damage and result in numerous fatalities and injuries among the workers. Nowadays, Visualization technology such as Building Information Modeling (BIM) and Augmented Reality (AR) are used in construction projects to create construction in a three-dimensional (3-D) visualization. This study aims to develop a prototype application that combines Building Information Modeling (BIM) and Augmented Reality (AR) to improve the fire evacuation system and provide real-time access to information for evacuating from hazardous locations. A marker-based location system was implemented, using a marker as a spatial index to link the physical location and virtual information. The results showed that the proposed system could provide real-time access to information such as the current location, exit, distance of the shortest route from the current location to the destination, and virtual green line, voice, and arrow direction for evacuation guidance. Regarding obstacle avoidance, the proposed system recommended the appropriate evacuation route to the user in real-time. Therefore, this proposed system is effective and convenient for decision-making, helping users find destinations quickly and efficiently.

Keywords: Fire Evacuation System, Building Information Modeling, Augmented Reality

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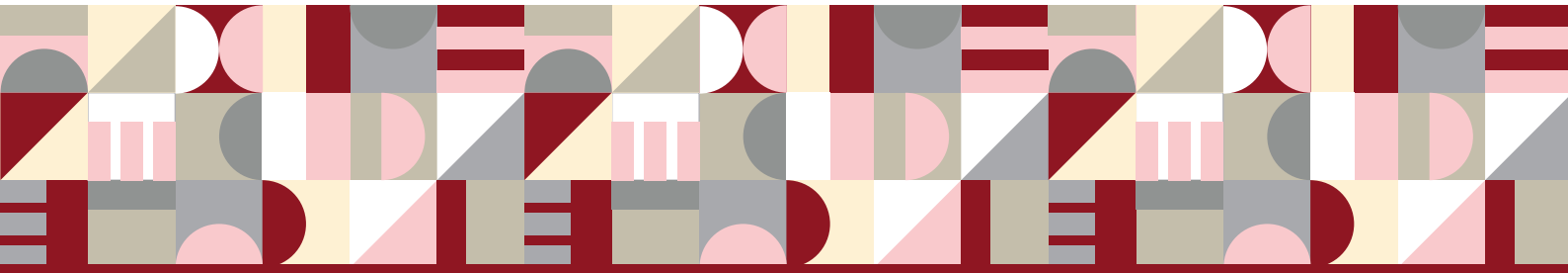

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