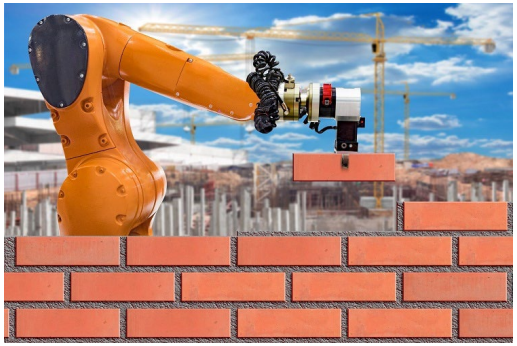
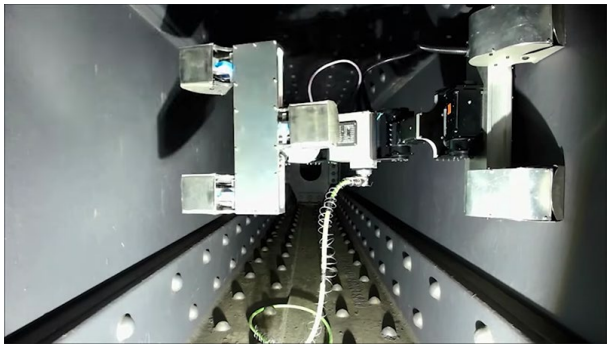


Robotics and Intelligence in Next-generation Infrastructure Management

Yang Zou

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Department of Civil and Environmental Engineering
University of Auckland

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI
National SCIENCE Challenges
SCIENCE FOR TECHNOLOGICAL INNOVATION
Kia kotahi mai – Te Ao Pūtaiao me Te Ao Hangarau
BRANZ
QuakeCoRE
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THE UNIVERSITY OF AUCKLAND
UNIVERSITY OF LIVERPOOL
UC UNIVERSITY OF CANTERBURY
SOUTHEAST UNIVERSITY

Outline

1. Research challenge and methodology

2. Current research progress

Deteriorating infrastructure is around the world

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

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Civil Engineering Magazine | Society News | Videos | Podcasts

News Releases

Deteriorating Infrastructure and Growing Investment Gap Will Reduce U.S. GDP By $10 Trillion in 20 Years: Economic Study

1/12/2021 | 0

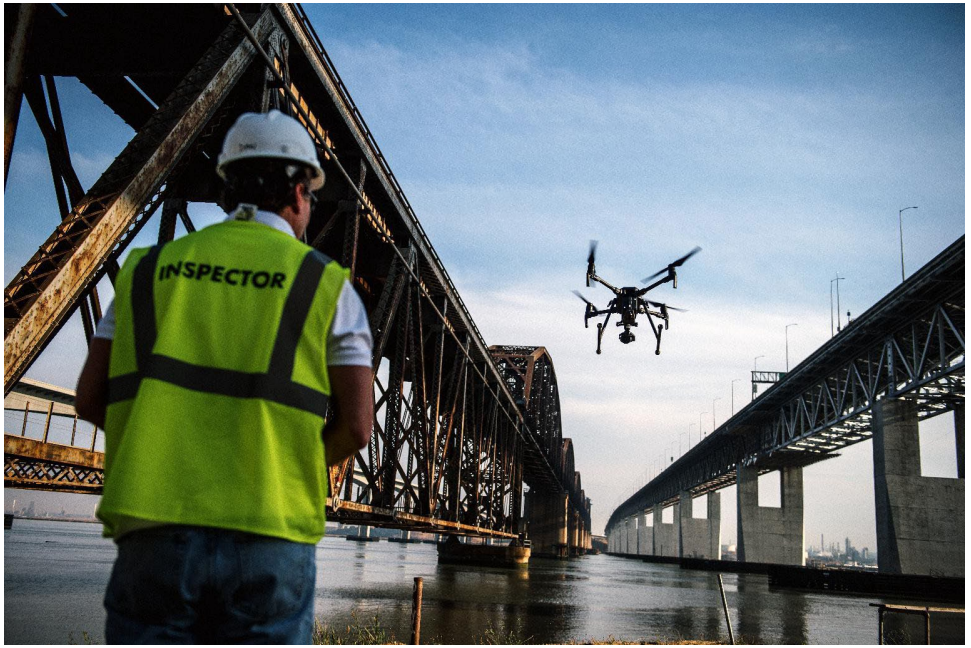




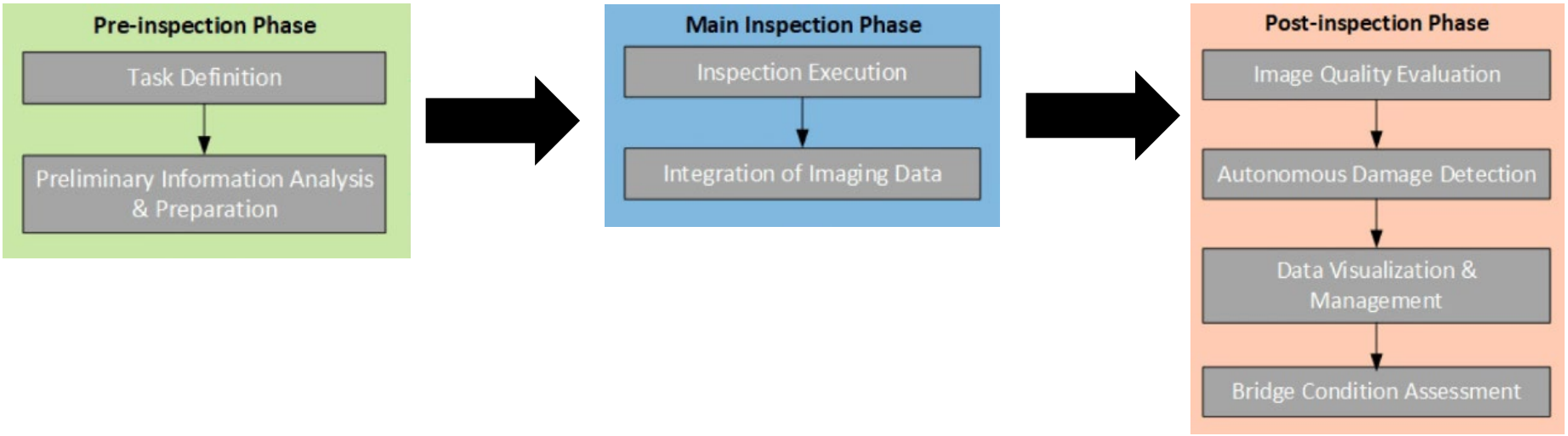

Source:
https://www.asce.org/publications-and-news/civil-engineering-source/society-news/article/2021/01/12/deteriorating-infrastructure-and-growing-investment-gap-will-reduce-us-gdp

Unmanned Aerial Vehicle (UAV) is a new method for bridge inspection

- Easy access to hard-to-access areas
- Safer
- More efficient
- More cost-effective
- Less disruptive



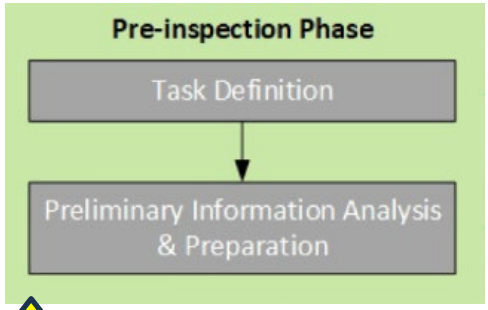
Typical procedure of bridge inspection using UAV



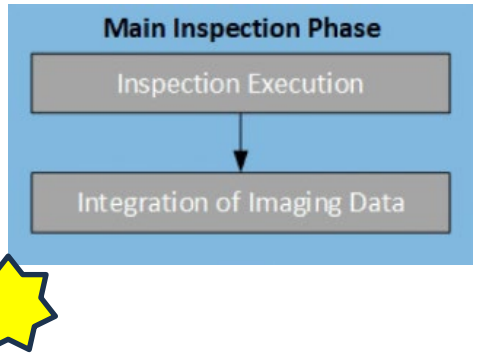
Main challenge:

Low level of automation and intelligence

My group's research methodology: Integrating robotic and digital technologies into infrastructure inspection and management



Automated mission planning

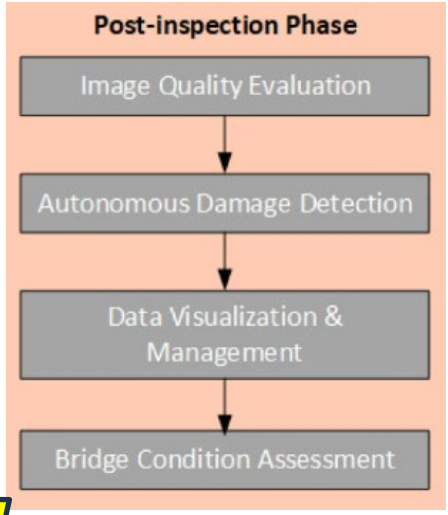


Autonomous inspection

UAV swarm for inspection

Human-robot collaboration

VR-based remote inspection

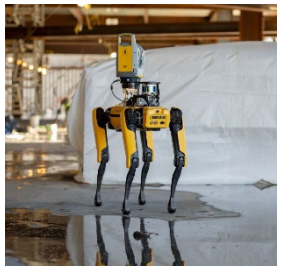


AI for automated data analysis

BIM for inspection data management

Automated generation of condition report and maintenance solutions

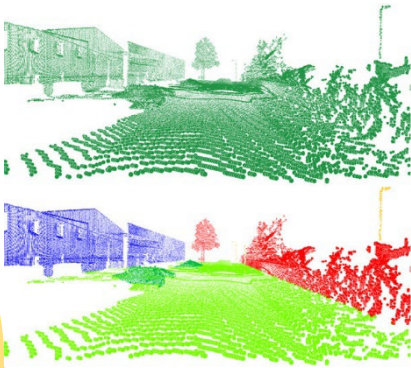
My methodology: integrating digital and robotic technologies into addressing grand challenges within built environment

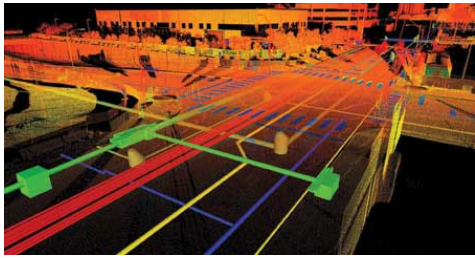


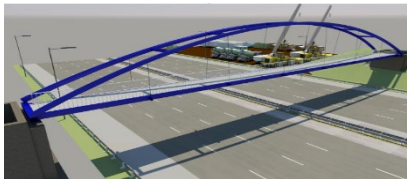
Robotics

Artificial Intelligence

BIM, VR & Digital Twin





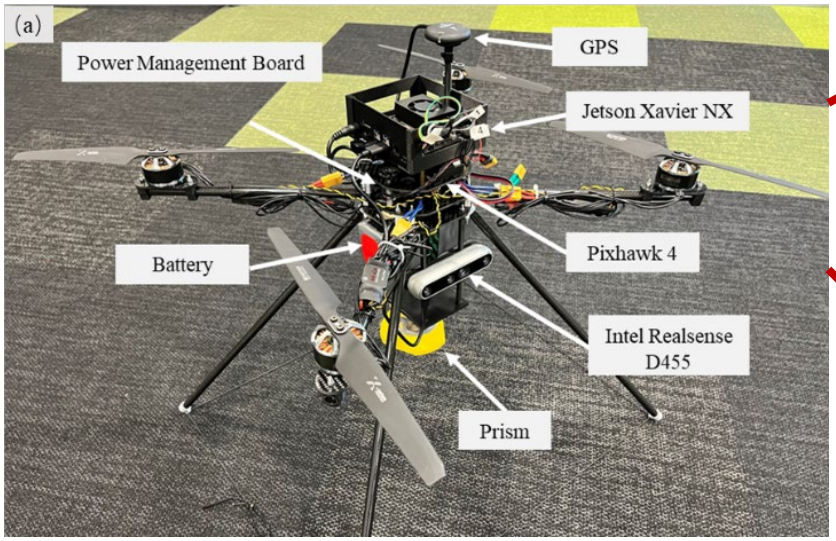


Outline

1. Research challenge and methodology

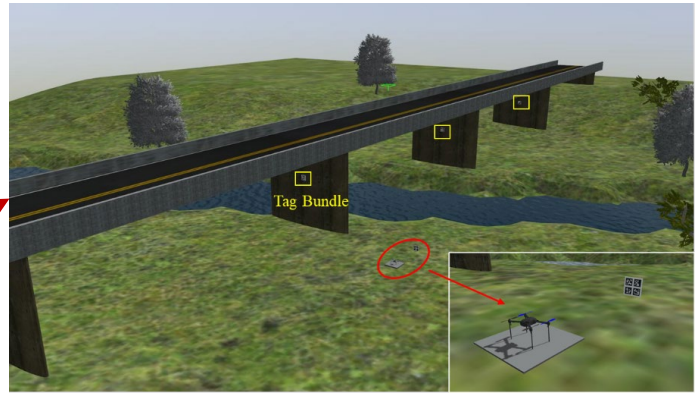
2. Current research progress

Drone localisation and navigation in GPS-denied bridge areas



New inspection drone system

Robotic operation simulation



Real-world testing

Wang, F., Zou, Y.*, et al., 2023, "UAV navigation in large-scale GPS-denied bridge environments using fiducial marker-corrected stereo visual-inertial localisation", Automation in Construction, Elsevier.

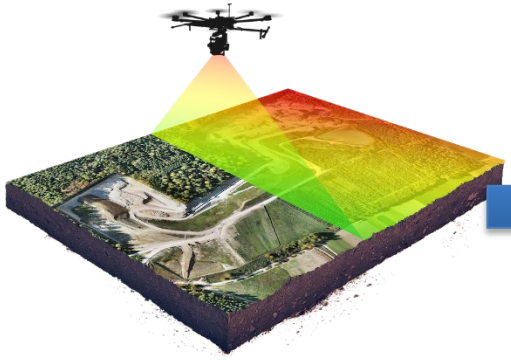
3D flight path planning for bridge inspection

Implementing the approach in real-world bridge environment

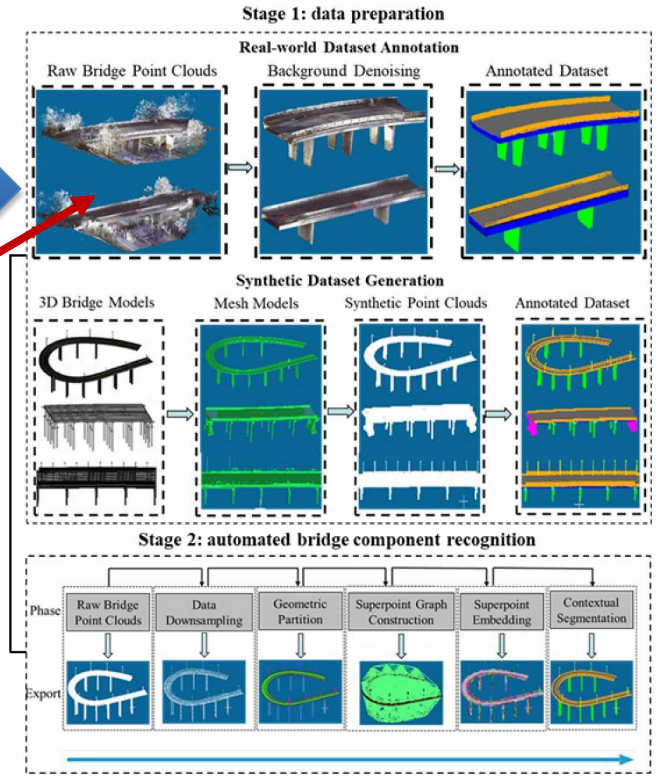
Real-time monitoring of the drone status on Android pad

Wang, F., Zou, Y.*, et al., 2022, "Automated UAV Mission Planning for High-quality 3D Bridge Reconstruction", Structure and Infrastructure Engineering, Taylor & Francis.

Automated recognition of bridge components from 3D point cloud using deep learning



3D point cloud



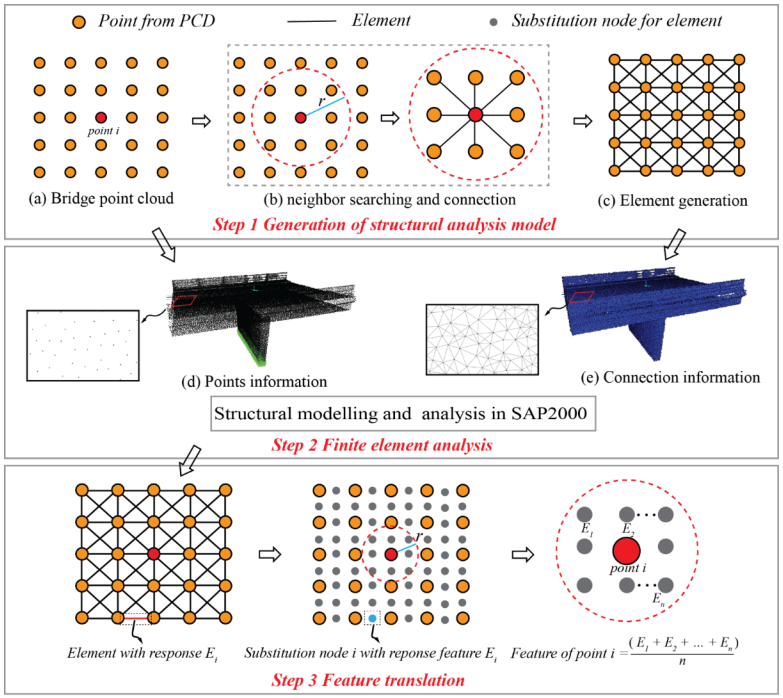
Challenges:

1) Raw 3D point cloud has no semantic meaning;
2) Point cloud is very heavy

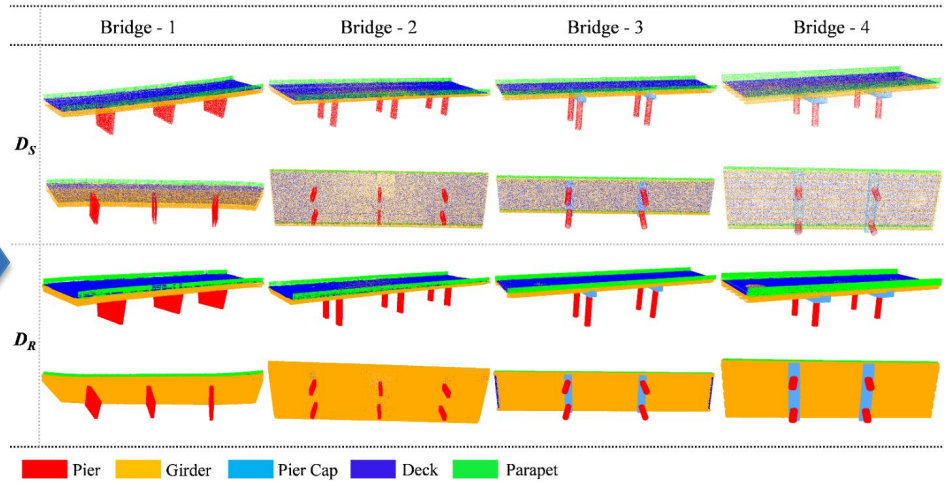
Overall framework

Yang, X.F.*, Castillo, EDR., Zou, Y., Wotherspoon, L. & Tan, Y., 2022, "Automated semantic segmentation of bridge components from large-scale point clouds using a weighted superpoint graph", Automation in Construction, Elsevier.
Yang, X.F.*, Castillo, EDR., Zou, Y. & Wotherspoon, L., 2023, "Semantic segmentation of bridge point clouds using superpoint-based deep learning network with synthetic data augmentation strategy and graph-structured deep metric learning", Automation in Construction, Elsevier.

Finite element analysis-guided recognition of bridge components from 3D point cloud



Structural modelling & generating point features through Finite Element Analysis

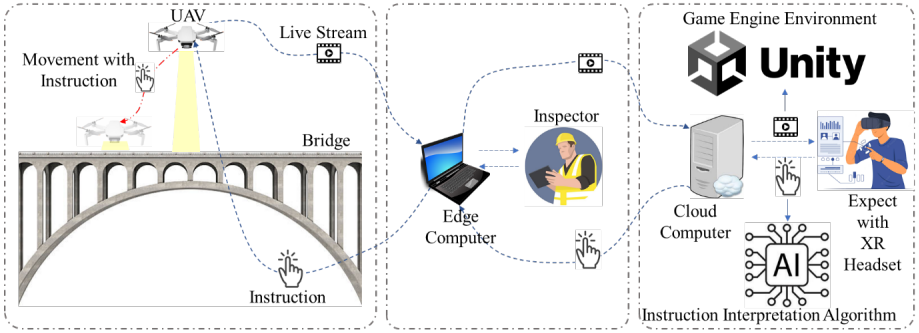


Very promising segmentation results
(lowest mIoU=93.44%)

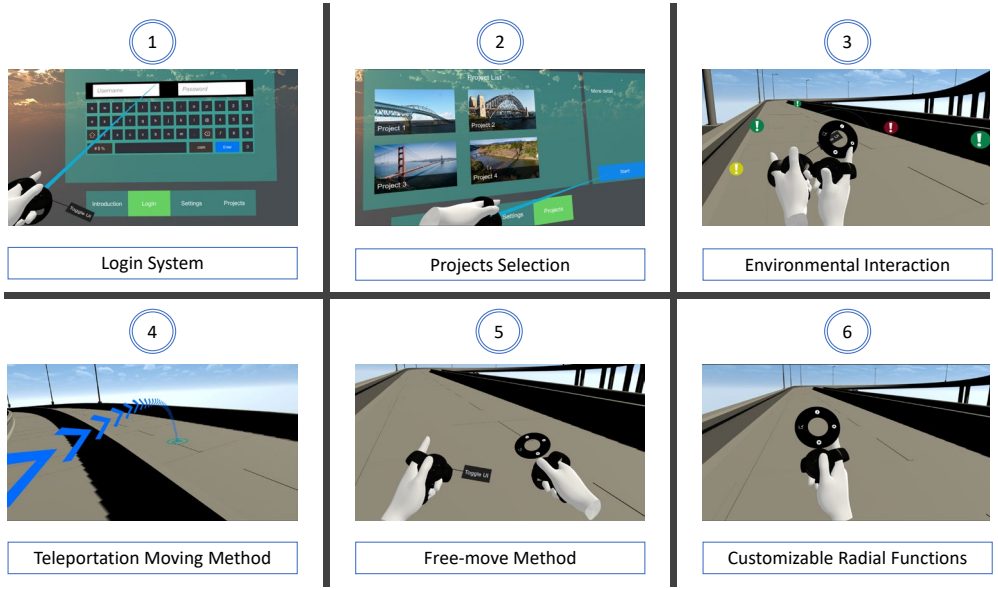
Yang, T., Zou, Y.*, Yang, X.F. & Castillo, EDR., 2023, "Domain Knowledge-enhanced Region Growing Framework for Semantic Segmentation of Bridge Point Clouds", Submitted to Automation in Construction, Elsevier. (**Under Review**)

Virtual Reality (VR) for remote bridge inspection

Overall framework



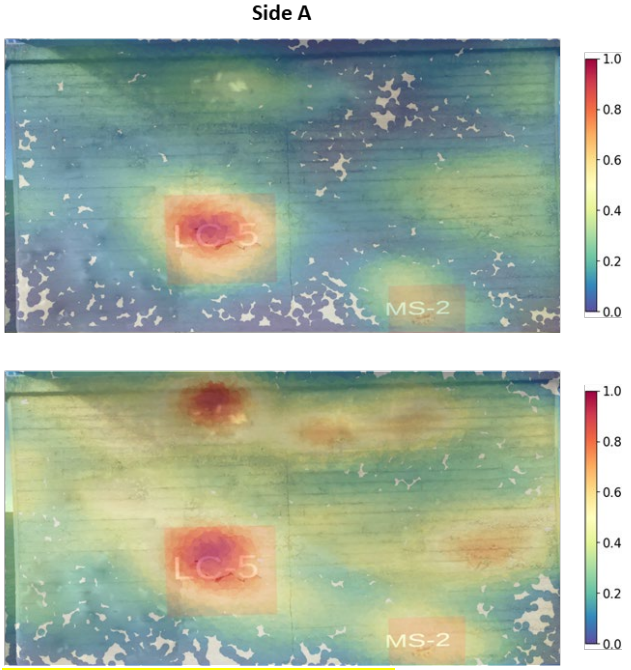
Snapshots of VR remote inspection prototype



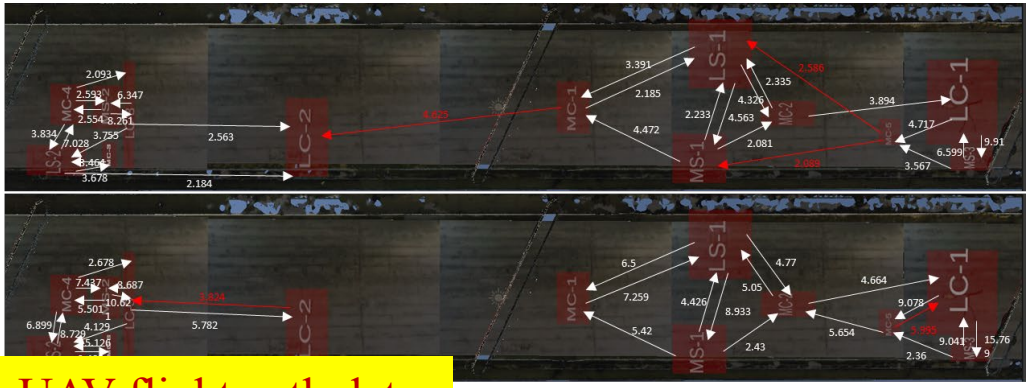
Wang, Z.*, Gonzalez, V., Zou, Y., Castillo, EDR., Arashpour, M. & Cabrera-Guerrero, G., 2023. "Immersive Virtual Reality Development Framework for Data Visualization and Decision-Making in Infrastructure Remote Inspections", Advanced Engineering Informatics, Elsevier.

Human-robot collaboration in bridge inspection: visual attention and UAV control behaviour

VR bridge inspection game



Eye tracking data



UAV flight path data

Chen, Z.X., Zou, Y.*, Gonzalez, V., Tang, P.B., Wotherspoon, L. & Ingham, J., 2024. "How People Inspect Bridge Using UAV: Visual Attention and UAV Control Behaviour in Immersive Virtual Reality", to be submitted to Automation in Construction, Elsevier.

Automated UAV image-to-BIM registration for building façade inspection

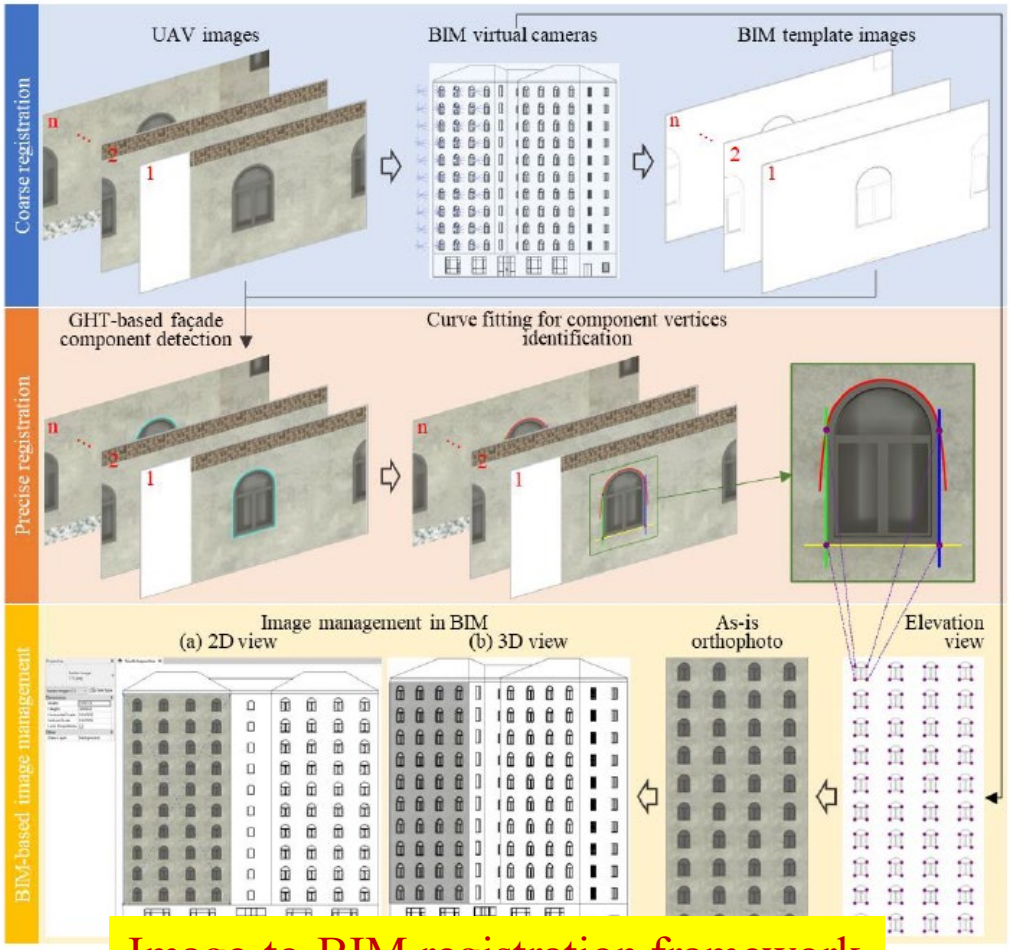
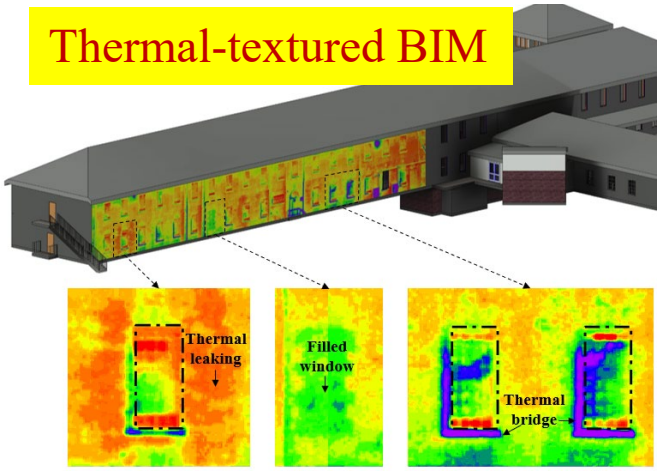


Image-to-BIM registration framework

RGB image-textured BIM

Fig. 14. GHT-based image-to-BIM registration: (a) image-to-BIM registration; (b) as-is orthophoto

Thermal-textured BIM



Zhang, C., Wang, F., Zou, Y.*, Dimyadi, J., Guo, B.H.W. & Hou, L., 2023. "Automated UAV Image-to-BIM Registration for Building Façade Inspection Using Improved Generalised Hough Transform", Automation in Construction, Elsevier.
Zhang, C., Zou, Y.* ,Dimyadi, J. & Chang, R.D., 2023. "Thermal-textured BIM Generation for Building Energy Audit with UAV Image Fusion and Histogram-based Enhancement", Energy and Buildings, Elsevier. (**Accepted with revision**)


Thank
You!!!