THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Research Newsletter

INNOVATION DIGEST

Issue 10 | Nov 2026

On the Fast Track:

Smart Transport and UAV Research Shaping Future Mobility



Intelligent Traffic
Safe and Intelligent Control for Maglev Trains

Low-Altitude Tech
Smarter UAV Search in Uncertain Environments



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Editor's Message

Welcome to the 10th issue of *Innovation Digest*, themed "On the Fast Track: Smart Transport and UAV Research Shaping Future Mobility".

As cities worldwide embrace AI, the next generation of mobility is moving firmly into the spotlight. Smart mobility has long been identified as one of the six key domains in Hong Kong's Smart City Blueprint, reflecting its central role in the city's transformation into a smarter, more efficient urban environment.

The Hong Kong Polytechnic University (PolyU) continues to lead in transport innovation and research. In the 2026 ShanghaiRanking's Global Ranking of Academic Subjects, PolyU was ranked first worldwide in Transportation Science and Technology, a testament to its global standing in the field. This strength comes at a particularly timely moment.

China has designated the low-altitude economy as a strategic emerging industry and a national priority in the 15th Five-Year Plan. This policy direction underscores the growing importance of unmanned aerial vehicle (UAV) technologies, as the skies above our cities emerge as a new frontier for mobility.

Reflecting these trends, the current issue highlights two complementary research areas. The "Intelligent Traffic" section explores work that is reshaping movement on the ground, including:

- an AI-integrated control strategy for enhancing the stability of maglev trains
- an AI-controlled traffic-light system for smooth and efficient bus services
- a blockchain-AI digital solution for transforming a mature city into a circular city
- a deep multimodal network for multi-task trajectory prediction

Turning the spotlight upwards to UAV and GNSS research, the "Low-Altitude Tech" section presents:

- a dual control approach for exploration and exploitation in UAV autonomous search
- an RTK model specifically designed for low- and mid-latitude regions
- a system integrating GNSS-RTK, LiDAR and INS for accurate positioning in urban canyons
- a framework for planning trajectories of cellular-connected UAVs

Additionally, "Engagement & Partnership" showcases PolyU's recent collaborations with external organisations and stakeholder engagement activities, while "Student Corner" proudly features the achievements of the University's students.

Across roads and skies, the research featured in this issue reflects PolyU's determination to lead the global transition towards intelligent mobility. Through pioneering scholarship, our scholars continue to expand the frontiers of innovation, helping cities and societies move towards a safer, more connected and sustainable future.

Prof. Cheng DONG

Chairman of the Editorial Committee

Associate Vice President (Knowledge Transfer)

Chair Professor of Cell Engineering and ImmunoMedicine,
Department of Biomedical Engineering and Sports Technology



Safe and Intelligent Control for Maglev Trains

How Safety-Aware Deep Reinforcement Learning Can Stabilise Maglev Train–Guideway Systems

Maglev trains represent a promising frontier in the development of high-speed rail. Against the backdrop of rapid advances in AI, Prof. Ni, a railway expert at PolyU, and his research team have proposed a new control strategy that integrates safe deep reinforcement learning. This approach enhances the stability of maglev trains while ensuring that the system operates within prescribed safety ranges. Nationally recognised for his expertise, Prof. Ni has led pioneering research on maglev suspension control, resulting in several patents.

Ir Prof. Yi-Qing NI
Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures,
Chair Professor of Smart Structures and Rail Transit,
Department of Civil and Environmental Engineering
Director,
National Rail Transit Electrification and Automation Engineering Technology Research Centre (Hong Kong Branch)
Director,
PolyU-Hangzhou Technology and Innovation Research Institute



Maglev trains offer an advanced form of transportation with the potential for high-speed, comfortable and reliable travel. Unlike conventional railways, however, maglev trains rely on precise electromagnetic forces to maintain a stable air gap between the train and its guideway. Even small changes in this gap can affect the stability and safety of the system.

The challenge becomes more complex when the flexibility of the guideway is considered. As a maglev train interacts dynamically with its guideway, vibration and deformation can influence the levitation system, while changes in the levitation force can in turn affect guideway motion. Under disturbances or resonance conditions, this coupled interaction may lead to increasingly unstable vibrations and, in extreme cases, the risk of the train approaching or striking the guideway. *Figure 1* illustrates the configuration of the electromagnetic levitation (EMS)-type maglev system and its flexible guideway.

Published in *Mechanical Systems and Signal Processing* [1], Prof. Yi-Qing NI, Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures and Chair Professor of Smart Structures and Rail Transit of the Department of Civil and Environmental Engineering at The Hong Kong Polytechnic University, and his research team developed a new control strategy that combines safe deep reinforcement learning (SDRL) with a reciprocal control barrier function (RCBF). The approach aims to allow an intelligent controller to optimise maglev performance while explicitly maintaining the system within a predefined safe operating range.

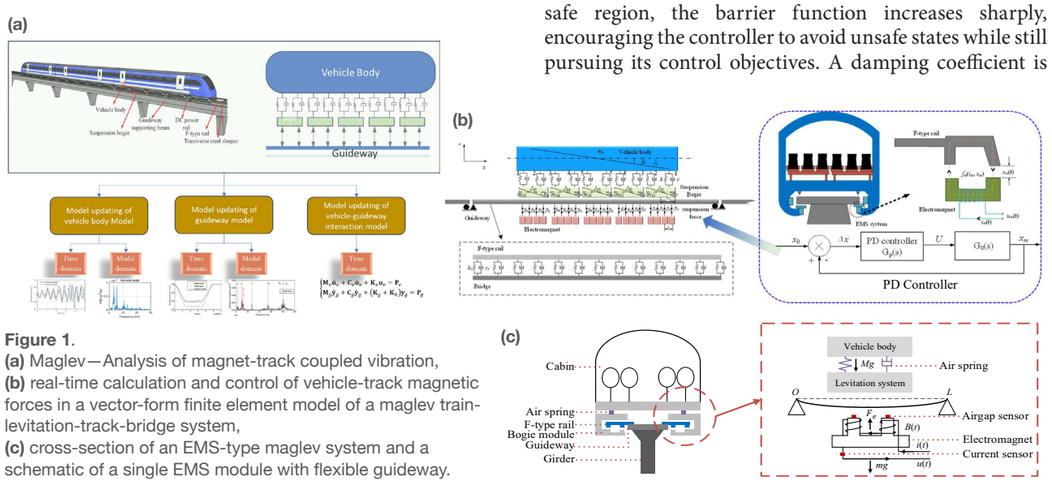


Figure 1.
(a) Maglev—Analysis of magnet-track coupled vibration, **(b)** real-time calculation and control of vehicle-track magnetic forces in a vector-form finite element model of a maglev train-levitation-track-bridge system, **(c)** cross-section of an EMS-type maglev system and a schematic of a single EMS module with flexible guideway.

Bringing Safety into Intelligent Learning

Deep reinforcement learning (DRL) enables a control system to learn how to make decisions by interacting with its environment. However, conventional DRL mainly seeks to maximise a long-term reward and does not automatically guarantee that the learned control policy will remain within practical safety constraints.

To address this limitation, the research team incorporated an RCBF directly into the reward function of the DRL controller. The RCBF acts as a safety mechanism: as the system approaches the boundary of the predefined safe region, the barrier function increases sharply, encouraging the controller to avoid unsafe states while still pursuing its control objectives. A damping coefficient is also introduced to regulate the balance between safety and control optimality.

The resulting RCBF–SDRL controller was designed for a nonlinear maglev system coupled with a flexible guideway. The controller aims to maintain the air gap close to its reference value while reducing control effort and preventing the system from reaching unsafe boundaries. The team also established theoretical analyses addressing the safety and stability of the resulting control system.

Learning to Control a Dynamic Maglev System

The team first developed a mathematical model that captures the interaction between the electromagnetic levitation system and the flexible guideway. The guideway was represented as a flexible beam, while the nonlinear electromagnetic force was incorporated into the levitation dynamics. This coupled model allows the controller to account for guideway deformation rather than treating the guideway as perfectly rigid.

The RCBF–SDRL controller was implemented using the twin delayed deep deterministic policy gradient (TD3) framework. During training, the controller learned to maintain a stable air gap while respecting the safety constraints. Compared with several baseline reinforcement-learning approaches, including TD3, DDPG, RCBF-DDPG and HJB-DDPG, the RCBF–SDRL approach achieved faster and more stable convergence during training.

Fast Response under Challenging Conditions

Numerical simulations showed that the proposed controller could rapidly bring the system towards its target air gap. In the simulated maglev system, the RCBF–SDRL controller reached the reference condition in approximately 0.15 seconds, compared with about 0.8 seconds for the PID controller (see *Figure 2*). It also maintained zero overshoot in the tested cases.

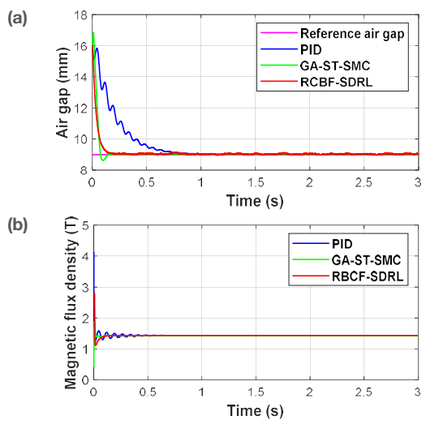


Figure 2. Air gap curves and control signal curves of the PID, the GA–ST–SMC and the proposed RCBF–SDRL controllers: **(a)** air gap curves, **(b)** control signal curves

More importantly, the controller remained effective when operating conditions changed. The team tested different train loads, sudden load fluctuations, external disturbances and track irregularities. Under changing train loads, for example, the RCBF–SDRL controller maintained zero overshoot in the simulated cases, while the PID controller exhibited substantially larger oscillations (see *Figure 3*). Under random disturbances and track irregularities, the proposed controller also maintained comparatively smooth air-gap responses.

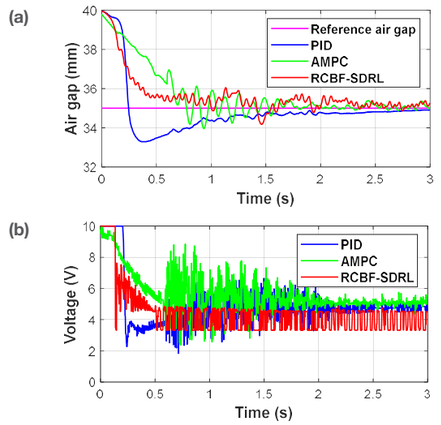


Figure 3. Air gap curves and control signal curves of PID, AMPC and RCBF–SDRL controllers under scenarios with vanishing disturbances: **(a)** Air gap curves, **(b)** Control signal curves

From Simulation to Laboratory Demonstration

To further examine practical control performance, the team conducted experiments using a magnetic levitation laboratory system (see *Figure 4*). The experimental setup consisted of a magnetic levitation unit, an electronic control box and a data acquisition system, with the control algorithm implemented through a computer-based closed-loop system.

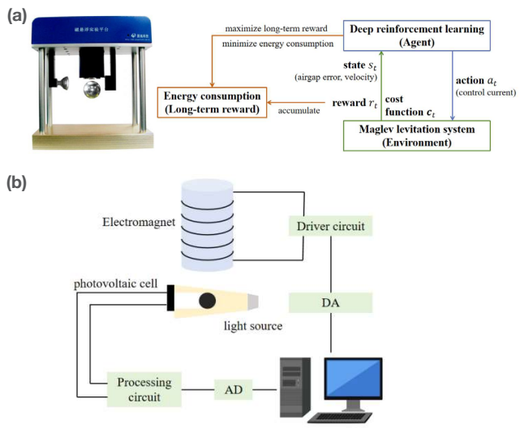


Figure 4. The magnetic levitation system: **(a)** setup of the system, **(b)** diagram of the system structure

Under disturbance-free conditions, the RCBF–SDRL controller reached the target air gap in approximately 0.5 seconds, compared with 2.5 seconds for PID and 0.6 seconds for adaptive model predictive control (AMPC). The RCBF–SDRL controller also showed favourable performance in cumulative error measures including IAE, ISE and ITSE.

The experiments further examined disturbances and different levitated masses. Under both persistent and vanishing disturbance conditions, the proposed controller reached the target air gap in approximately 0.6 seconds, while the PID and AMPC controllers required around 2 seconds and 0.8 seconds, respectively (see *Figure 5*). When different masses were tested to represent changing load conditions, the RCBF–SDRL controller consistently achieved convergence in about 0.5 seconds, compared with approximately 2 seconds for PID and 0.7 seconds for AMPC.

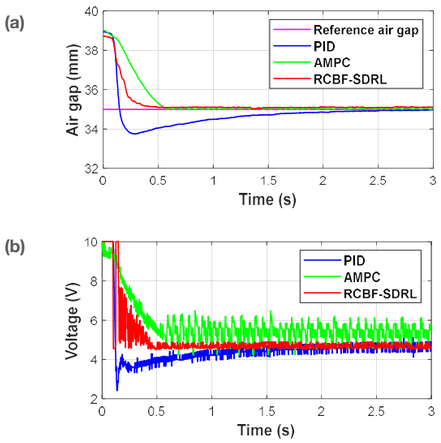


Figure 5. Air gap and voltage curves of PID, AMPC and RCBF–SDRL controllers: **(a)** air gap curves, **(b)** voltage curves

Towards Safer Intelligent Transportation

The study demonstrates how artificial intelligence can be combined with established control theory to address a key challenge in intelligent transportation: how to make learning-based control not only effective but also safety-aware.

By embedding the RCBF within the reinforcement-learning framework, the proposed approach provides a mechanism for incorporating explicit safety constraints into the learning process. The study therefore offers a potential pathway towards intelligent control systems that can adapt to changing operating conditions while maintaining stable and safe behaviour.

For future maglev transportation, such safety-aware intelligent control could support more resilient operation in the presence of changing passenger loads, environmental disturbances and track irregularities. The research provides a foundation for further development and validation of intelligent control technologies for advanced rail transportation systems.

Prof. Ni was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (career-long & single-year) in the field of civil engineering for eight consecutive years, from 2019 to 2026. He is a leading expert in structural health monitoring and vibration control for large-scale infrastructure, including bridges, high-rise buildings, high-speed rail and Maglev systems. His research excellence has earned him major national and international recognition, including the 16th Guanghua Engineering Science and Technology Award from the Chinese Academy of Engineering (2026), regarded as the highest award in China's engineering sector; the Second Prize of the National Science and Technology Progress Award (2016); the First Prize of the Guangdong Science and Technology Progress Award (2014); Gold Medals (with Special Recognition) at the International Exhibition of Inventions of Geneva (2009 and 2013); and the "Structural Health Monitoring Person-of-the-Year" Award (2017).

Prof. Ni has published more than 440 SCI journal papers, with an h-index of 77 and over 26,500 citations on Google Scholar. He currently serves as a Co-Editor-in-Chief of the *Journal of Infrastructure Intelligence and Resilience* (Elsevier) and *Intelligent Transportation Infrastructure* (Oxford), as well as an Associate Editor of the *Journal of Civil Structural Health Monitoring* (Springer) and *Journal of Vibration and Control* (SAGE), and is a Fellow of the Hong Kong Institution of Engineers and the American Society of Civil Engineers (ASCE).

In 2015, the Ministry of Science and Technology of the People's Republic of China approved the establishment of the National Rail Transit Electrification and Automation Engineering Technology Research Centre (Hong Kong Branch) in recognition of Prof. Ni's significant contributions to the nation's rail sector, with Prof. Ni serving as its Director.

References:

[1] Zhu, Q., Wang, S.-M., & Ni, Y.-Q. (2025). Reciprocal control barrier function enhanced safe deep reinforcement learning control for maglev train–guideway coupling system. *Mechanical Systems and Signal Processing*, 241, 113495. DOI: 10.1016/j.ymssp.2025.113495.

AI-Controlled Green Lights for Better-Spaced Buses

A Cooperative AI Signal-Control System Reduces Bus Bunching and Passenger Waiting Times while Keeping Traffic Moving

Hong Kong boasts one of the world's most frequent and efficient public transport networks. It was also ranked first in *Time Out* magazine's 2025 list of the world's best cities for public transport. The development of smart transport technologies can make this already mature network even more efficient and reliable. Prof. Chung's AI-controlled traffic-light system considers the distances and intervals between bus services, helping to manage passenger flows while maintaining smooth traffic flow.



Prof. Edward Chin-shin CHUNG
Professor, Department of Electrical and Electronic Engineering

More than 90% of mechanised passenger trips in Hong Kong are made by public transport. Yet the city also has among the world's highest road and vehicle densities, leaving little room to absorb delays. In such an environment, a late bus is rarely an isolated inconvenience. Once gaps between buses become uneven, crowded buses fall further behind while lightly loaded buses catch up, which is a familiar phenomenon known as bus bunching.

To address the problem, Prof. Edward Chin-shin CHUNG, Professor of the Department of Electrical and Electronic Engineering at The Hong Kong Polytechnic University, and his research team developed a Cooperative Transit signal priority strategy with Variable phase for Headway adherence (CTVH)—a system for smart traffic signals that cooperate to keep buses evenly spaced without creating additional congestion for other road users. The study is published in *IEEE Transactions on Intelligent Transportation Systems* [1].

Why uneven bus arrivals become a self-reinforcing problem

Bus reliability is not simply about whether a vehicle follows its timetable. On frequent services, what often matters more is headway adherence, which means how consistently buses maintain the planned interval between consecutive services.

Suppose buses are scheduled to arrive every five minutes. If one bus is delayed, more passengers accumulate at the stop. It then takes longer time for them to board, delaying the bus further. Meanwhile, the following bus encounters fewer passengers, spends less time at stops and begins to catch up. Eventually, two buses may arrive almost together, followed by a long wait for the next one. This wastes capacity and worsens passengers' experience. The first bus becomes crowded, the second is underused and average waiting times rise.

Prof. Chung's central idea is more selective: use traffic signals to help a late bus close the gap ahead, while allowing an early bus to wait slightly longer when appropriate.

AI agents make signal decisions every second

CTVH uses multi-agent reinforcement learning (RL), a form of AI in which several decision-making "agents" learn to work together. Each signalised intersection is controlled by one agent. Rather than following a preset cycle, the agent observes current traffic conditions and selects the signal for the next second. Its decision considers both public transport and general traffic.

The system does not merely detect whether a bus is approaching. For each relevant bus, it considers how far the bus is from the stop line, whether it is running early or late, the gap to the bus ahead and the bus behind, passenger occupancy, whether the bus is currently at a stop, and traffic speeds and queues on the surrounding approaches.

This allows CTVH to distinguish between buses requiring different treatment. A bus with an unusually large gap ahead may benefit from priority, while giving the same priority to a bus already too close to its leader could make bunching worse.

The agents also cooperate across intersections. During training, the system evaluates how the signals collectively affect the road network, rather than optimising each junction in isolation. Once trained, each intersection can make its own decisions using local information while contributing to the network-wide objective.

Importantly, practical signal-control constraints are incorporated in the system. CTVH accounts for minimum and maximum green times, phase-skipping rules, and the yellow and all-red periods needed for safe phase changes. Treating these transition periods as separate actions enables the agents to remain synchronised and make second-by-second decisions.

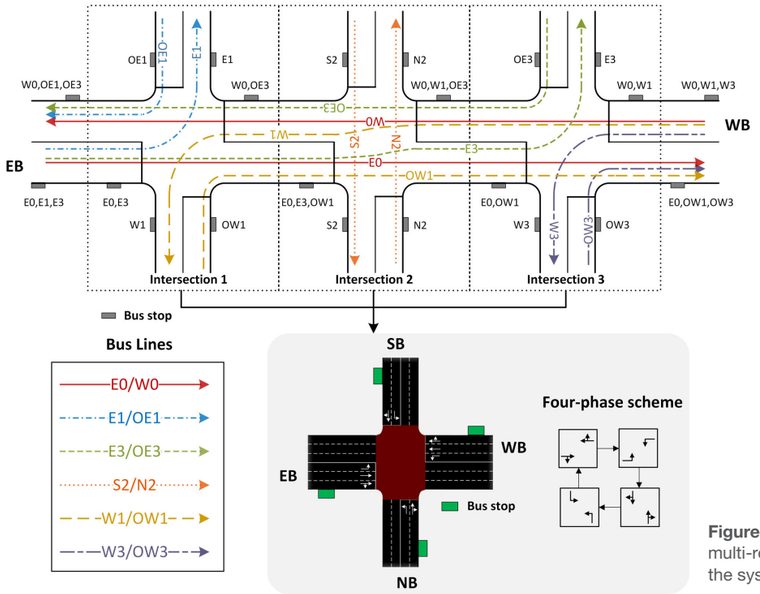


Figure 1. The simulated multi-intersection, multi-route setting used to train and test the system

The reward used to train the system balances two goals: reducing bus headway deviations and limiting queues for ordinary traffic. This prevents it from improving bus service at an unacceptable cost to cars and other road users.

Bus regularity improved by 6.1% as queues fell by 15.3%

The team first tested CTVH in a simulated arterial corridor with three signalised intersections, standard four-phase signals and six two-way bus routes (*Figure 1*). Traffic demand changed across five periods, including a peak period, while buses entered the network with varying initial delays.

The results were compared with coordinated fixed-time signals, a bus-holding strategy and two other reinforcement-learning approaches.

Against coordinated fixed-time control, CTVH reduced average bus headway deviation by 6.1% and the difference between forward and backward headways by 5.3%. At the same time, average person delay fell by 3.2%, queues by 15.3% and total passenger delay for bus users by 4.0%. Passenger waiting time at stops decreased by 1.7%.

Bus holding produced larger improvements in regularity within this small test network: average headway deviation dropped by 18.4% and waiting time by 16.5%. However, those gains came with substantial costs. Average person delay increased by 10.7%, queues by 9.4% and the delay experienced by passengers already on buses by 49.8%. Overall passenger delay for bus users rose by 16.7%.

The simulations revealed why. When one bus was held in a short bus bay, following buses could be forced to queue behind it. If several routes used the same stop, this bottleneck could spread to surrounding traffic. CTVH avoids this problem entirely: it never holds buses at stops. Instead, it uses selective signal timing, giving priority to late buses while gently delaying early ones, and is trained with a reward that explicitly balances headway regularity against general-traffic queues. As a result, it improves bus spacing without the delay and queue penalties of holding.

Figure 2 illustrates this process over several stops. By providing transit signal priority (TSP), CTVH helps a late bus move closer to its scheduled trajectory and reduce the excessive gap ahead. Conversely, an early bus can be gently delayed at intersections, preventing it from catching the preceding service and forming a bunch.

A full-route test cut passenger waiting by 6.3%

The relatively modest 1.7% reduction in waiting time in the first experiment reflected the short length of the three-intersection corridor. Bus bunching develops cumulatively: a small headway disturbance near the beginning of a route can grow as buses pass more stops and intersections.

To examine this longer-term effect, the team tested CTVH on a model of Bus Line 2 in Xi'an, China. The complete route included 34 stops and 22 signalised intersections, with buses departing every five minutes and traffic volumes changing between simulation runs (*Figure 3*).

Across 60 simulated episodes, CTVH reduced average headway deviation by 19.4% and the difference between forward and backward headways by 22.9%, compared with coordinated fixed-time control. Passenger waiting time fell by 6.3% on average.

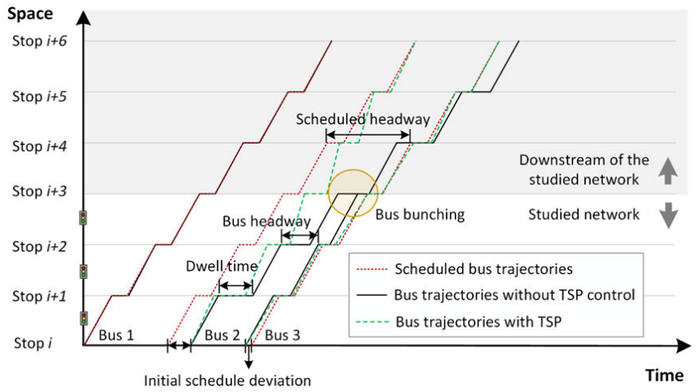


Figure 2. Bus trajectories showing how TSP brings a late bus closer to schedule and gently delays an early bus, reducing bunching. Orange dotted lines: scheduled; black lines: without TSP; green dotted lines: with TSP

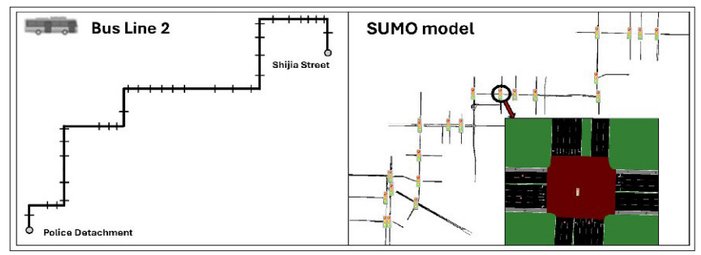


Figure 3. The complete Xi'an bus-line model used to assess whether CTVH could scale beyond a short arterial corridor

These improvements did not come at the expense of general traffic. Average person delay decreased by 4.4%, while queues fell by 7.4%.

The full-route results are important because the benefits of regularity become more visible over distance. By correcting small gaps repeatedly at successive intersections, cooperative signal control can prevent them from growing into severe bunching further downstream.

Second-by-second cooperation brings the system closer to reality

CTVH combines several practical advances. It makes decisions every second, handles several conflicting bus requests, observes the gaps both ahead of and behind each bus, and coordinates multiple intersections. Invalid or unsafe actions are automatically excluded, while the learning objective balances public-transport reliability with the movement of other vehicles.

The study also demonstrates the value of cooperation. Tests in which intersection agents learned independently converged more slowly and yielded smaller improvements in bus regularity and passenger waiting time. The cooperative architecture helped each intersection understand how its local decisions contributed to performance across the network.

Just as importantly, the method was evaluated at two scales: a complex three-intersection arterial and a complete urban bus route. This progression provides useful evidence that the approach could be extended to larger networks.

Towards more reliable urban mobility

In a dense, public-transport-dependent city like Hong Kong, keeping buses evenly spaced is not a minor operational concern. It directly affects waiting times, crowding, fleet utilisation and the capacity of the wider transport system.

CTVH offers a potentially cost-effective way to improve reliability using existing road infrastructure. The study shows how smart transport can move beyond simply accelerating vehicles: the more valuable goal may be to keep the entire service running regularly and efficiently.

Prof. Chung is an internationally recognised expert in connected vehicles and Intelligent Transport Systems (ITS). A Fellow of the Institution of Engineers Australia, he previously served as the Director of the Smart Transport Research Centre at Queensland University of Technology (QUT), where he secured over A$6 million in research funding in the first six years, the Head of the ITS Group at EPFL in Switzerland and a visiting professor at the University of Tokyo's ITS Centre. He was also QUT's co-leader in the A$55 million iMOVE CRC, a major Australian national collaborative research centre on connected mobility. He has led industry-partnered projects on cooperative ITS, traffic signal control and real-time traffic management, and served as Editor-in-Chief of the *International Journal of ITS Research*. Prof. Chung is currently leading multiple projects funded by the Smart Traffic Fund, including a HK$4 million project on an intelligent signal control system for temporary traffic arrangements and a HK$2.2 million project on an automated monitoring system for traffic detector status and non-recurrent events.

References:

[1] Long and E. Chung, Multi-Agent Reinforcement Learning for Cooperative Transit Signal Priority to Promote Headway Adherence, *IEEE Transactions on Intelligent Transportation Systems*, vol. 26, no. 3, pp. 3588-3602, March 2025, doi: 10.1109/TITS.2025.3533603.

AI and Blockchain Put Circular Cities in Motion

Digital Tools Offer Targeted Solutions to Urban Transport Challenges

Under the emerging smart transport paradigm, transforming a mature city into a circular city presents a new set of challenges. Harnessing the complementary strengths of AI and blockchain, Prof. Lai has proposed an integrated approach to addressing the six interconnected challenges involved in this transition. His research supports policymakers in developing policies that enable residents and public transport operators to collaborate in building the next generation of smart cities.



Prof. Kee-hung LAI
Chair Professor of Shipping and Logistics and Head,
Department of Logistics and Maritime Studies

In a dense metropolis like Hong Kong, mobility is both an everyday necessity and a complex systems challenge. Roads, railways, buses, taxis and emerging mobility services must accommodate large numbers of journeys within limited space. When one part of the network underperforms, the effects can spread quickly: congestion increases journey times and emissions, fragmented services make transfers less convenient and infrastructure constraints inhibit modal shifts.

As AI and blockchain technologies become increasingly advanced and widely adopted, Prof. Kee-hung LAI, Chair Professor of Shipping and Logistics and Head of the Department of Logistics and Maritime Studies at The Hong Kong Polytechnic University, examined their potential as digital solutions to persistent urban mobility problems. His research, published in *Transport Policy* [1], identified six interconnected challenges that hinder the transition towards circular transport systems: traffic congestion, air pollution from transport emissions, inefficient public transport, limited integration between transport modes, insufficient infrastructure and dependence on fossil fuels. The study then assessed which specific capabilities of AI and blockchain are most effective in addressing each challenge.

The circular city model offers a different way to approach these problems. Rather than following a linear pattern of consuming resources and replacing assets, circular cities seek to regenerate resources, extend asset life, reduce waste and emissions, and strengthen system resilience. In transport, this could mean maintaining infrastructure more effectively, using vehicles and capacity more efficiently, coordinating different modes and supporting low-carbon travel.

Digital technologies may help cities make this transition, but only when applied strategically. The key question is:

How can AI and blockchain address specific mobility challenges and advance circular city goals?

The study matches digital tools with specific problems

AI and blockchain have different strengths. AI can analyse large volumes of data, anticipate demand and optimise transport operations. Blockchain can create transparent, verifiable records and automate agreements between organisations.

The study investigated which of these capabilities are most relevant to each of the six mobility challenges. The research team first validated and ranked the challenges through expert surveys. They then used a two-round Delphi process to stabilise expert judgements and the Bayesian Best–Worst Method to produce probabilistic importance weights.

The expert panel included participants from academia, industry and the public sector, with 70 completing the Delphi process and 65 contributing complete and consistent judgements to the final prioritisation.

AI takes the lead on day-to-day operations

The clearest finding is that AI is particularly well suited to operational challenges that require rapid analysis and adaptive decision-making.

For traffic congestion, predictive analysis received the highest importance weight, followed by real-time monitoring. These capabilities can help transport authorities anticipate traffic flows, identify disruptions and adjust signals, routes or services before problems intensify.

For poor integration between transport modes, multimodal optimisation was the leading property. It can support better coordination among buses, trains, shared mobility and other services by aligning schedules, routes and capacity.

AI also performed strongly in public transport and infrastructure management. Demand prediction ranked first for inefficient public transport, reflecting its potential to match service frequency and capacity with changing passenger needs. Predictive maintenance was the top priority for insufficient infrastructure. By detecting emerging faults before failures occur, it can reduce downtime and extend the useful life of transport assets—a direct contribution to circular economy principles.

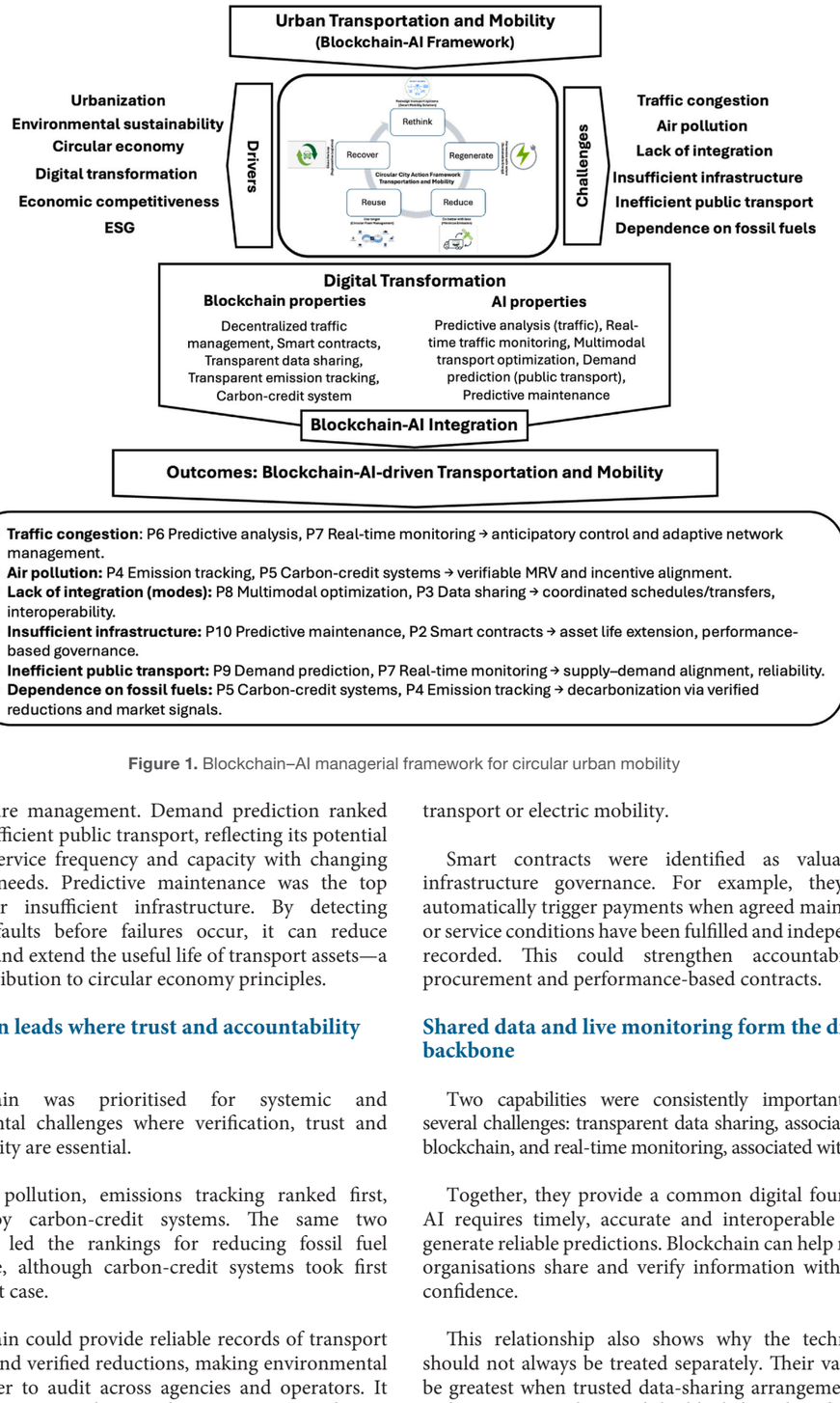


Figure 1. Blockchain–AI managerial framework for circular urban mobility

Blockchain leads where trust and accountability matter

Blockchain was prioritised for systemic and environmental challenges where verification, trust and accountability are essential.

For air pollution, emissions tracking ranked first, followed by carbon-credit systems. The same two capabilities led the rankings for reducing fossil fuel dependence, although carbon-credit systems took first place in that case.

Blockchain could provide reliable records of transport emissions and verified reductions, making environmental claims easier to audit across agencies and operators. It could also support carbon markets or incentive schemes that reward lower-carbon choices, such as cycling, public transport or electric mobility.

Smart contracts were identified as valuable for infrastructure governance. For example, they could automatically trigger payments when agreed maintenance or service conditions have been fulfilled and independently recorded. This could strengthen accountability in procurement and performance-based contracts.

Shared data and live monitoring form the digital backbone

Two capabilities were consistently important across several challenges: transparent data sharing, associated with blockchain, and real-time monitoring, associated with AI.

Together, they provide a common digital foundation. AI requires timely, accurate and interoperable data to generate reliable predictions. Blockchain can help multiple organisations share and verify information with greater confidence.

This relationship also shows why the technologies should not always be treated separately. Their value may be greatest when trusted data-sharing arrangements feed real-time AI analysis, while blockchain-based records make resulting decisions and outcomes more transparent.

The right technology depends on the problem



To translate the findings into action, the team proposes a framework connecting drivers, challenges, blockchain–AI digitalisation, impacts and outcomes (*Figure 1*).

When congestion, modal integration or public transport performance is the main concern, managers should prioritise AI-led interventions. Predictive analytics can anticipate traffic conditions, demand forecasting can inform service frequency, and multimodal optimisation can improve transfers and network operations.

When the challenge involves air pollution, decarbonisation or institutional accountability, blockchain becomes more relevant. Emissions tracking can create auditable environmental records, carbon-credit systems can support incentives for lower-carbon behaviour, and smart contracts can strengthen accountability in service delivery.

Hybrid systems can tackle high-stakes challenges

Complex situations may require AI and blockchain to be deployed together. An infrastructure operator could combine AI-based predictive maintenance with blockchain-enabled smart contracts. AI would identify when maintenance is needed, while the smart contract could record completion and trigger payment against agreed performance standards.

Similarly, AI demand forecasts could be linked to blockchain-based incentives that reward passengers for choosing lower-carbon modes or travelling outside peak periods.

Successful implementation, however, depends on more than software. Cities need interoperable data standards so that agencies and operators can exchange information securely. They also require clear arrangements for privacy, data stewardship and organisational responsibility.

Procurement should focus on measurable outcomes, such as minutes of delay avoided, reductions in downtime or verified emissions saved, rather than technology adoption alone. Incentives must also be aligned across transport authorities, private operators and technology providers. Without institutional cooperation and reliable data, sophisticated systems may remain isolated pilots rather than city-wide solutions.

Technology works best when paired with good governance

Digital technology is not a silver bullet for urban mobility. AI alone cannot resolve governance failures while blockchain cannot compensate for inadequate infrastructure, incomplete data or weak transport planning. The central lesson is the importance of matching the right tool to the right problem.

AI's predictive and optimisation capabilities can make transport networks more responsive. Blockchain's transparency and verification mechanisms can strengthen trust, environmental accountability and coordination. Used together, they could help cities develop mobility systems that are more efficient, resilient and circular.

Prof. Lai was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (career-long) in the field of operations research for eight consecutive years, from 2019 to 2026. He has also been recognised by Clarivate Analytics as a Highly Cited Researcher in 2019, with over 45,500 citations and an h-index of 102 on Google Scholar. He has published more than 300 journal articles (nearly 90% in Q1 journals), including papers in Financial Times Top 50 journals, and has authored or co-authored eight books. Prof. Lai serves as Editor-in-Chief of the *International Journal of Shipping and Transport Logistics* and the *Journal of Shipping and Trade*. He is a Fellow of the Chartered Institute of Logistics and Transport and a member of the Hong Kong Logistics Development Council. He has also received the Research.com Business and Management in China Leader Award for four consecutive years, from 2023 to 2026.

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AI Model Slashes Travel Prediction Errors by Up to 69%

Deep Multimodal Network Jointly Forecasts Location, Journey Time and Transport Mode

As smartphones and GPS technologies become integral to daily life, their travel data can support accurate traffic forecasts and personalised travel recommendations. Developed jointly by Prof. Wang and Prof. Xu, the AI model integrates predictions of travellers' locations, journey times and transport modes, reducing prediction errors by 69%. It is expected to support next-generation smart transport applications.

Prof. Hans Shuaian WANG
Professor, Department of Logistics and Maritime Studies
Deputy Director, PolyU Maritime Data and Sustainable Development Centre



Prof. Min XU
Associate Professor, Department of Industrial and Systems Engineering



The spread of smartphones, GPS devices and connected vehicles has given cities access to vast quantities of mobility data. When analysed effectively, these data can help transport authorities anticipate movement, manage congestion and provide more responsive services. A key capability is trajectory prediction: forecasting how an individual or vehicle is likely to travel based on previous movements.

Yet urban journeys are complex. As illustrated by the spatial distribution of walking, cycling, driving and public transport journeys in the Geolife dataset (*Figure 1*), people move at different speeds, at different times and through different parts of a city. These characteristics are interrelated, not independent.

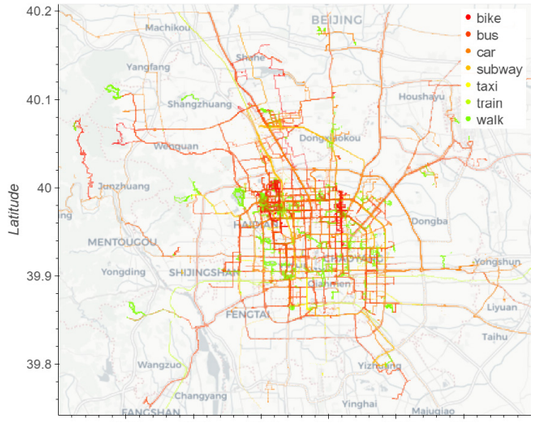


Figure 1. Spatial distribution of trajectories by travel mode in the Geolife dataset

Most existing prediction models focus on a single task, such as forecasting a traveller's next location, estimating journey time or identifying the transport mode used. Even multi-task models commonly predict only location and time, overlooking other useful information or combining data in relatively simple ways.

To address this limitation, Prof. Hans Shuaian WANG, Professor of the Department of Logistics and Maritime Studies at The Hong Kong Polytechnic University, together with Prof. Min XU, Associate Professor of the Department of Industrial and Systems Engineering at the same university, developed a Deep Multimodal Network (DMN) that jointly predicts future locations, travel times and transport modes by explicitly modelling relationships both within and between different types of trajectory data. The research has been published in *Information Fusion* [1].

Location, time and transport mode influence one another

A mobility trajectory contains several types of information. Spatial coordinates show where a traveller moves, temporal features indicate when and for how long the journey occurs, and mode data distinguish between options such as walking, cycling, driving and public transport. Each modality forms its own sequence over time, but it also interacts with the others.

Consider a person making three trips using different modes (*Figure 2*). Within the spatial data, previous locations help indicate likely future locations. Within the temporal data, past journey durations can provide clues about future travel times. These are intra-modal dependencies: relationships contained within the same type of information.

The modalities are also interdependent. A longer journey time will generally correspond to a greater distance, although factors such as congestion can alter that relationship. Similarly, a traveller using a car or train

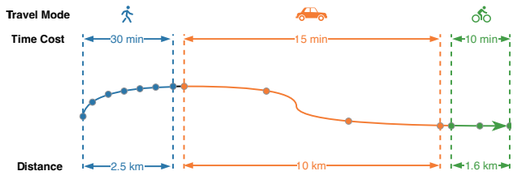


Figure 2. A trajectory comprising three trips with different travel modes

can usually cover a greater distance in a given period than someone walking or cycling. Knowing the time and likely mode can therefore improve location prediction, just as spatial movement can help identify the mode being used.

Earlier multi-task models have often processed each modality separately before merging the resulting features through concatenation or summation. Although such models may learn some relationships indirectly, this "brute-force" fusion does not explicitly calculate how one modality should inform another.

The research team therefore proposed an architecture that computes both intra-modal and inter-modal attention. This enables the model to identify not only patterns within location or time sequences, but also the relationships connecting them, improving all three prediction tasks within a unified system.

The network learns how different travel signals connect

The DMN is based on the Transformer model [2], which uses an attention mechanism to determine which parts of a data sequence are most relevant to a prediction. Its design consists of two main components: a feature extraction module and a multi-task prediction module. The framework is illustrated in *Figure 3*.

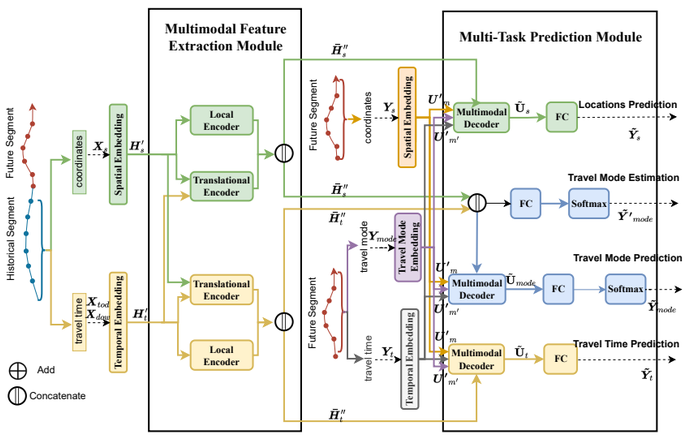


Figure 3. Framework of the Deep Multimodal Network

The feature extraction module first converts heterogeneous trajectory data into a shared numerical format. Continuous inputs, such as GPS coordinates and time of day, and discrete inputs, such as the day of the week, have different structures. Embedding layers project these inputs into a common feature space, while positional encoding preserves their order within each journey.

The embedded data then pass through two types of encoders. Local encoders learn intra-modal relationships—for example, how earlier locations relate to later locations or how previous time points influence subsequent ones. Translational encoders, the model's central innovation, calculate inter-modal attention. They allow the network to examine spatial information in relation to temporal information, and vice versa, rather than treating the two as isolated streams.

The second component, the multi-task prediction module, uses multimodal decoders to connect historical travel patterns with possible future sequences. It generates three outputs concurrently: predicted locations, travel times and transport modes. The decoders consider relationships within each future sequence as well as connections across the different outputs.

This explicit inter-modal attention distinguishes the DMN from earlier approaches that simply concatenate or add separately extracted features. Instead of leaving a downstream predictor to discover cross-modal relationships indirectly, the network is designed to focus dynamically on the relevant connections between space, time and mode.

The model was trained end-to-end using the open-source Geolife dataset, collected by Microsoft Research Asia. It contains GPS trajectories from 182 users recorded between 2007 and 2012, covering more than 1.2 million kilometres and 48,000 hours of movement. The journeys include walking, cycling, driving and public transport.

Training used a weighted combination of regression losses for location and travel-time forecasts and a classification loss for transport-mode prediction. This allows the entire network to learn the three tasks together.

A unified model also offers a computational advantage. Separate models must each learn their own representations and complete their own training process. By sharing feature extraction and attention calculations, the DMN can draw on synergies between tasks while reducing duplicated computation. In the ablation study, training three separate task-specific versions took a combined 16,200 seconds, compared with 6,600 seconds for the full multi-task model.

Table 1. Prediction results on the Geolife test set for a future sequence length of 150

Method	Location error (MAE, metres)	Travel-time error (MAE, seconds)	Travel-mode accuracy (%)
LSTM	314.23	356.32	54.52
Seq2Seq	267.95	339.44	59.34
DMN	**103.21**	**110.23**	**78.16**

Note: Lower mean absolute error (MAE) is better; higher accuracy is better. Sequence length denotes predicted trajectory points.

Prediction gains grow on longer trajectories

On the Geolife test set, the DMN outperformed two established sequence-modelling baselines, Long Short-Term Memory (LSTM) [3] and Sequence-to-Sequence (Seq2Seq) [4], across all three tasks and all tested trajectory lengths.

Its advantage was particularly evident for longer sequences. At a trajectory length of 150, the DMN reduced location prediction error by 67% and travel-time error by 69% compared with LSTM. Against Seq2Seq, the corresponding reductions were 61% and 67%. For short trajectories of length five, the DMN achieved 91.44% accuracy in predicting travel mode, exceeding LSTM and Seq2Seq by 3.41 and 2.28 percentage points respectively. The performance gap widened substantially for longer trajectories.

Wilcoxon signed-rank tests indicated that the improvements over both baselines were statistically significant across all three prediction tasks.

Ablation experiments also clarified why the model performed well. Removing inter-modal attention reduced performance across every task, confirming that explicitly learning the connections between location, time and mode adds predictive value. Meanwhile, single-task versions produced only marginal accuracy gains while requiring substantially more combined training time.

Better forecasts could make transport more responsive

Accurate multi-task forecasts could support several smart transport applications. Traffic management systems could use predicted locations and travel times to improve dynamic routing and adjust signal timings before congestion intensifies. Predicted transport modes could also help authorities coordinate services and synchronise transfers across road and public transport networks.

This study demonstrates that trajectory prediction becomes more effective when location, time and transport mode are treated as interconnected aspects of the same journey. By explicitly modelling these relationships, the DMN improves predictive performance while avoiding the computational duplication of separate models. This approach could provide a valuable foundation for more anticipatory, coordinated and efficient urban transport systems.

Prof. Wang was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (career-long) in the field of logistics and transportation for four consecutive years, from 2022 to 2025. His research focuses on big data in shipping, sustainable maritime transport, urban transport network modelling, green logistics and supply chain management. He has published more than 100 papers in leading journals, including *Transportation Research Parts A–E, Transportation Science, Management Science* and *Operations Research*. In 2023, he received the INFORMS Computing Society Harvey J. Greenberg Research Award. He currently serves as Co-Editor-in-Chief of *Transportation Research Part E* and Editor-in-Chief of *Cleaner Logistics and Supply Chain* and *Communications in Transportation Research*.

Prof. Xu was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (single-year) in the field of logistics and transportation for two years, from 2025 to 2026. Her research focuses on the application of operations research and data-driven analytics to intelligent decision-making, human–agent interaction, game-theoretic policy learning and predictive modelling in complex systems. She has published more than 100 papers in leading journals, including *Transportation Science, Transportation Research Parts B–E, Reliability Engineering & System Safety, Information Fusion* and *Computers & Operations Research*. Prof. Xu currently serves as an Associate Editor of *Transportation Science* and *Transportation Research Part D*, as well as an Editorial Board Editor of *Transportation Research Parts C and E*.

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Smarter UAV Search in Uncertain Environments

Cooperative Active Learning Enables 100-Fold Faster, More Efficient Hazardous-Source Detection

As UAV technology advances, UAVs are being applied to an expanding range of tasks, including the detection of hazardous materials in unfamiliar environments. Prof. Chen, an expert in control and autonomous systems, has proposed an autonomous-search method for UAVs that integrates exploration and exploitation within a unified framework. Using AI-driven active learning, the method enables UAVs to learn about their surroundings in real time, reducing computational costs while maintaining high detection accuracy.

Prof. Wen-Hua CHEN
Head and Chair Professor of Robotics and Autonomous Systems,
Department of Aeronautical and Aviation Engineering
Co-Director,
UM-PolyU Joint Research Centre for Robotics and Embodied Intelligence
Director, Research Centre for Low Altitude Economy



Locating an unknown chemical, biological or radiological source is a time-critical task in disaster response, environmental protection and industrial safety. Autonomous ground robots and unmanned aerial vehicles (UAVs) could search areas that are dangerous or inaccessible to people. Yet, these systems face a difficult combination of challenges: the source is unknown and the environment may be turbulent.

Existing autonomous-search methods either move towards the currently estimated source, making use of what is already known, or explore the environment to collect information that may improve the estimate. More advanced dual-control methods attempt to do both, but often depend on computationally intensive Bayesian estimation and large particle filters. This has limited some implementations to remote computing platforms rather than processors carried by the vehicle itself.

To address these limitations, a research team led by Prof. Wen-Hua CHEN, Head and Chair Professor of Robotics and Autonomous Systems of the Department of Aeronautical and Aviation Engineering at The Hong Kong Polytechnic University, proposed a new approach named Cooperative Active Learning-Based Dual Control for Exploration and Exploitation (COAL-DCEE). The study is published in *IEEE Transactions on Neural Networks and Learning Systems* [1]. Building on the dual-control framework first proposed by Prof. Chen's team in 2021 [2], the present work introduces a cooperative multi-estimator architecture that substantially reduces computational demand while retaining the dual benefits of exploration and exploitation.

A 100-fold reduction in computation

The central idea is to replace a very large population of Bayesian particles with a much smaller group of cooperating estimators. Each estimator forms a hypothesis about the unknown source, including its location and release rate. The estimators then share information through their collective average. The degree to which their estimates differ provides an indication of uncertainty: if the estimates are widely dispersed, the system has more to learn; if they are clustered, confidence is increasing.

COAL-DCEE combines this estimation process with active path planning. The robot does not simply travel towards the current best estimate. It also selects movements that are expected to reduce uncertainty of the current best estimate and improve future estimates [3]. The system therefore continuously optimally balances:

Exploration: gathering measurements that could make the source estimate more accurate; and

Exploitation: moving towards the believed source location.

The results are notable. COAL-DCEE uses approximately 100 estimators, compared with 10,000 particles in the Bayesian-filtering methods used for comparison. The team reported roughly a 100-fold reduction in computational time, while maintaining comparable or superior search performance. The study also establishes theoretical convergence and performance guarantees under bounded sensor noise and

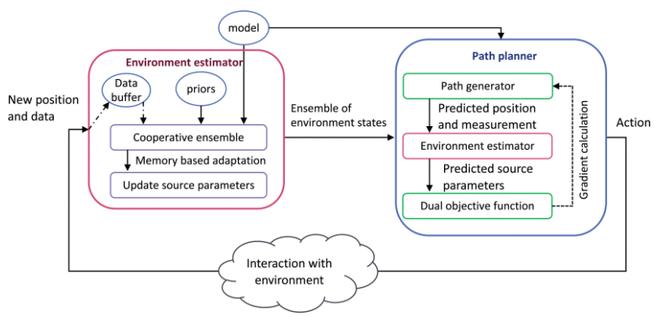


Figure 1. System-environment interaction in autonomous search using COAL-DCEE

position disturbances caused by factors such as turbulence and control error. This offers a unique feature of the active learning approach proposed in this paper—currently it is almost impossible to have this type of theoretic guarantee for other machine learning or AI algorithms. Numerical simulations and real experimental data were used to validate the approach.

Figure 1 presents the central architecture of COAL-DCEE. On the left, the environment estimator receives the UAV's position and sensor measurements. It then produces a group of estimated source and environmental parameters representing the UAV's current understanding of the unknown environment.

On the right, the path planner uses these estimates to determine the UAV's next movement. A candidate movement changes the UAV's position and, consequently, the measurements it obtains from the physical environment which affects the following estimation/learning. By predicting possible information gain of an action, active learning is realised by optimally selecting an action that not only moves towards the current best estimated location of the source, but more importantly actively probe the unknown environment [3]. The new measurements of the implementation of the selected movement are fed back into the estimator, forming a closed loop between learning, decision-making and the environment.

This arrangement allows the UAV to learn while it searches. For example, if a weak chemical signal suggests that the source may be located to the north but the estimate remains uncertain, the UAV does not necessarily fly directly north. It may first move across the suspected plume to obtain measurements that distinguish between competing possibilities. Once confidence improves, it can direct more of its movement towards the estimated source.

The system therefore avoids two extremes. A purely exploitative strategy may follow an inaccurate estimate, while a purely exploratory strategy may gather information without reaching the source efficiently. COAL-DCEE brings both priorities into a single decision-making process.

The multi-estimator design is especially important. Instead of using thousands of computationally expensive particles, the UAV quantifies uncertainty through the spread of a small number of physically meaningful source estimates. This makes the dual objective practical for onboard processing, particularly for real-time implementation on robots like UAVs with a limited computational power. The theoretical analysis further shows that the estimators converge to a bounded neighbourhood of the true source parameters, while the UAV converges to a bounded neighbourhood of the source.

29 seconds instead of nearly 45 minutes

One of COAL-DCEE's most significant practical advantages is its computational efficiency.

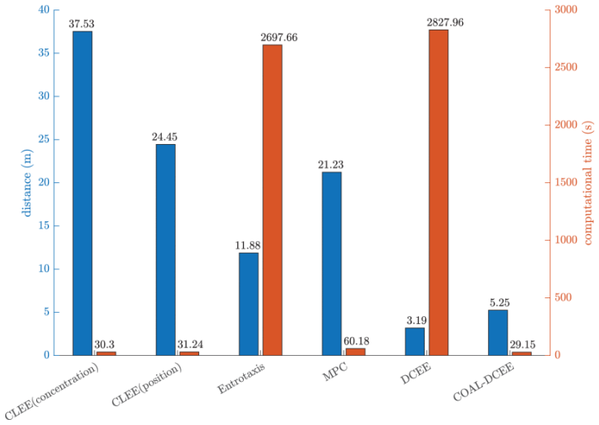


Figure 2. Comparison of steady-state tracking performance (blue bars) and computational time (red bars) over 200 trials

The numerical study compared six approaches, including CLEE, Entrotaxis, model predictive control, the original DCEE and COAL-DCEE. The Bayesian approaches used 10,000 particles and restricted movement to a small set of directions and fixed step lengths to maintain computational feasibility. By contrast, COAL-DCEE used only 100 cooperative estimators and allowed movement with arbitrary direction and length.

Figure 2 shows the resulting difference in computational demand. Across 200 trials, COAL-DCEE required only 29.15 seconds of total computation. Entrotaxis required 2,697.66 seconds, while DCEE required 2,827.96 seconds. The proposed method therefore reduced the computational burden by approximately two orders of magnitude.

This distinction matters for UAV operations. Computational time reflects the processing burden of the algorithm, whereas mission time depends on factors such as travel distance, vehicle speed and sensor sampling time. A method that requires extensive processing may need to rely on a remote computation centre, increasing communication requirements and potentially reducing operational independence.

COAL-DCEE's efficiency makes dual-control search more suitable for portable processors carried by UAVs and other unmanned vehicles. Notably, the computational gain did not come at the expense of active learning or search performance. In the simulation study, the method remained resilient when 40% of sensor readings were assumed to be nondetections.

Real-data validation with fewer samples

The team also evaluated COAL-DCEE using a real experimental dataset. The dataset contains 340 sequential frames of a changing concentration field, providing a demanding test of autonomous search under time-varying environmental conditions.

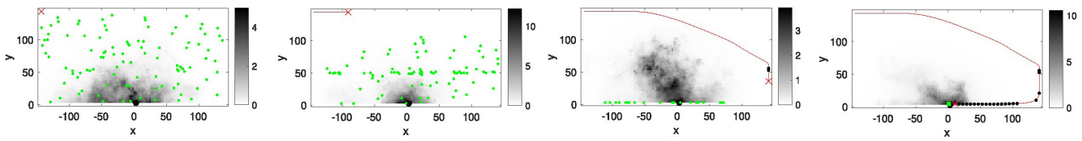


Figure 3. Representative search path of COAL-DCEE on real dataset. The subfigures were taken at 1, 10, 60 and 115 sample instances, respectively. The grey shade represents the instantaneous concentration field at the current time step, red lines indicate the paths of the search agent, the green dots are the estimated source position and the black dots are nonzero measurements

The original DCEE method was used for comparison. Although DCEE has demonstrated strong search performance, it relies on a much larger population of particles than COAL-DCEE.

Figure 3 illustrates representative COAL-DCEE search behaviour in four panels. The green dots show the evolving estimated source locations, while the red line represents the UAV's search trajectory. Initially, the green estimates are distributed across several possible source locations. As measurements accumulate, the estimates progressively concentrate. The UAV's trajectory responds to this changing belief: it first probes the environment, then increasingly moves towards the region in which the source is believed to be located. In the later panels, both the estimated source position and the UAV trajectory converge near the true source.

Across 200 experimental trials, COAL-DCEE achieved a 98% success rate, compared with 99% for DCEE. However, it required only 84.80 samples on average, compared with 119.26 for DCEE. The average mission times were 1,328.7 seconds for COAL-DCEE and 1,560.9 seconds for DCEE.

The computational difference was even more pronounced. COAL-DCEE completed the 200 searches in 15.26 seconds, whereas DCEE required approximately 1,560 seconds. COAL-DCEE therefore achieved essentially comparable search success while using only 100 estimators instead of 10,000 particles and with substantially lower processing demand.

A broader role for dual control

COAL-DCEE demonstrates how a UAV can turn uncertainty into an active decision-making resource. Rather than treating exploration and exploitation as separate strategies, it enables the vehicle to learn about its environment while moving towards its operational objective.

The dual-control framework pioneered by Prof. Chen's team provides a promising mechanism to implement active learning. Traditional machine learning focuses on how to develop more powerful and/or efficient learning algorithms with provided datasets (e.g. leaning by chance as no good learning outcome if a dataset is of low information value). In contrast, active learning seeks to generate most informative data through carefully planning actions to enable efficient learning. It is particularly suitable for embodied intelligence where the interaction between an agent and its physical environment is at its core. The dual control framework has also been extended beyond autonomous search. Recent work has applied the same principles to maximum power point tracking for solar energy systems under varying weather conditions, efficiency optimisation of electric motors, wave energy converters and automated robotic assembly tasks. Together, these developments demonstrate the broader potential of dual control for goal-oriented systems operating under uncertainty.

Prof. Chen was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (career-long & single-year) in the field of industrial engineering and automation for eight consecutive years, from 2019 to 2026. He was ranked 26th globally and 2nd in the UK in the field of Industrial Engineering and Automation in 2025. An internationally recognised authority in control theory and autonomous systems, he is a Fellow of the Institute of Electrical and Electronics Engineers, the Institution of Mechanical Engineers and the Institution of Engineering and Technology. He was awarded the prestigious EPSRC Established Career Fellowship (2020–2025), the only fellowship of its kind awarded to date in Control Engineering, and was appointed a Changjiang Chair Professor by China's Ministry of Education in 2013.

As an internationally renowned scholar at the forefront of control and autonomous vehicles, Prof. Chen brings more than 20 years of experience in the research and development of unmanned aircraft systems. He currently leads major initiatives at the University focused on the low-altitude economy, with particular emphasis on autonomous forced landing, which investigates how to safely recover a drone in emergence situations. He also serves as a Co-Principal Investigator for the RGC Collaborative Research Fund project "Coordinated Autonomy and Smart Infrastructure for Low Altitude Economy Systems", which continues to produce leading results.

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New RTK Model Halves Storm-Time Ionospheric Error

Nonlinear Interpolation Strengthens Centimetre-Level GNSS Positioning in Hong Kong During Solar Maximum

Located at a low latitude, Hong Kong experiences a complex and highly dynamic ionosphere, which can significantly disrupt ground-based RTK signals. This presents a particular challenge during periods of heightened solar activity. Prof. Chen, an expert in GNSS, has developed an RTK model specifically for low- and mid-latitude regions. Validated against data from the peak of Solar Cycle 25 in 2024, the model significantly reduced ionospheric errors and provided more stable positioning signals for UAVs and vehicle navigation systems.

Prof. Wu CHEN
Head and Chair Professor of Satellite Navigation, Department of Land Surveying and Geospatial Science
Director, PolyU-Hefei Technology and Innovation Research Institute
Associate Director, Research Institute for Artificial Intelligence of Things



Drones and autonomous vehicles increasingly rely on continuous centimetre-level positioning. Network real-time kinematic (RTK) GNSS provides this capability by using reference stations to estimate and broadcast corrections to users in the field. Yet, GNSS signals must pass through the ionosphere, a variable layer of charged particles that can delay and distort measurements.

When these distortions change sharply across space, conventional corrections become less reliable. This is a growing concern for automated applications and emerging mobility systems, where positioning accuracy affects safety, automation, efficiency and public confidence. To address the problem, Prof. Wu CHEN, Head and Chair Professor of Satellite Navigation of the Department of Land Surveying and Geospatial Science at The Hong Kong Polytechnic University, and his research team proposed a Nonlinear Interpolation Model (NIM) designed to maintain more dependable RTK performance under challenging ionospheric conditions. The study was published in *GPS Solutions* [1].

The research focuses on mid- and low-latitude networks, with particular attention to Hong Kong. The results suggest that adding satellite-path information to conventional RTK interpolation can reduce positioning errors, improve ambiguity resolution and accelerate convergence during both active ionospheric conditions and an extreme geomagnetic storm.

Solar maximum is exposing a low-latitude RTK weakness

As Solar Cycle 25 moves through its peak phase, elevated solar activity continues to produce intense and variable ionospheric disturbances. Low-latitude regions are especially exposed because of the equatorial ionisation anomaly (EIA). Solar energy lifts plasma near the magnetic equator, after which it spreads towards higher latitudes and forms bands of elevated electron density.

Hong Kong lies close to the northern EIA crest. Around sunset and during post-sunset hours, ionospheric gradients can intensify rapidly. For systems relying on network RTK, this creates a serious reliability bottleneck. Receivers may take longer to achieve a fixed solution, lose an existing fix or fail to resolve carrier-phase ambiguities altogether.

The implications extend to drone corridors, autonomous logistics, mobile mapping, precision agriculture, surveying and infrastructure monitoring. These applications need not only high accuracy, but also predictable performance when atmospheric conditions deteriorate.

Why conventional linear interpolation leaves errors behind

RTK obtains high precision by comparing carrier-phase measurements from satellites at a user receiver with measurements from nearby reference stations. It must resolve integer ambiguities: the unknown whole number of carrier wavelengths between each satellite and receiver. Even small residual errors can obstruct this process.

Most network RTK systems use a linear interpolation model (LIM) to estimate ionospheric corrections at the user's position. LIM represents delay variation principally as a linear spatial trend linked to the locations of ground stations. This assumption is often adequate for short baselines and relatively quiet mid-latitude conditions.

However, it becomes less reliable when ionospheric structure is nonlinear, dynamic and geographically uneven. These conditions are common near the EIA, during geomagnetic disturbances and across longer networks. The resulting errors can directly threaten the availability of reliable fixed solutions.

The missing satellite-path effect

The study identifies an important satellite-specific effect that conventional interpolation does not fully capture. Each

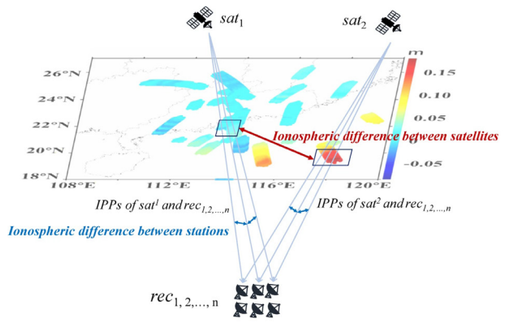


Figure 1. Schematic diagram showing ionospheric differences between satellites and between stations

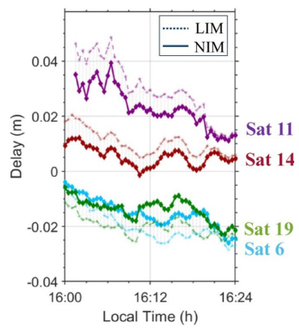


Figure 3. Comparison of ionospheric interpolation accuracy on 24 March 2024 via LIM and NIM

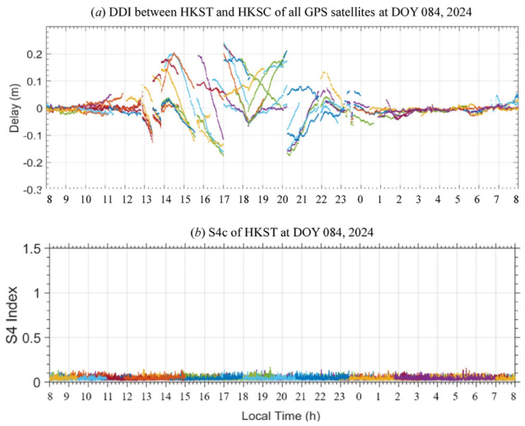


Figure 2. (a) Double differenced ionospheric delay and **(b)** S4 index observed on DOY 84, 2024. Different colours represent individual GPS satellites.

GNSS signal crosses the ionosphere at an ionospheric pierce point (IPP). These points move as satellites travel across the sky, sampling different ionospheric paths and gradients.

Figure 1 illustrates the conceptual gap. The conventional modelled component represents ionospheric differences between ground stations. However, an additional component arises from differences between satellite IPP trajectories. This satellite-related effect remains embedded in the double-differenced ionospheric delays used by RTK processing.

Because station coordinates alone do not adequately represent it, LIM cannot fully remove the residual error. *Figure 2* demonstrates the problem using observations from Hong Kong reference stations. Double-differenced ionospheric delays vary particularly strongly during the sunset transition and post-sunset period. Under these conditions, the residual can approach a substantial fraction of the L1 carrier wavelength, making ambiguity fixing significantly more difficult.

30–40% lower interpolation errors with NIM

NIM addresses this omission through a dual-function spatial model. It retains a conventional station-related component, while adding a second component for nonlinear gradients along satellite IPP movement.

The new information is estimated using gradient along the IPP movement (GAIM). This method uses time-differenced dual-frequency carrier-phase observations and the distance travelled by each IPP to sense how ionospheric delay changes along its trajectory.

NIM first estimates the satellite-related nonlinear trend and detrends it from the ionospheric observations. It then models the remaining station-related linear trend. Combining both estimates produces a correction intended to more closely match the user's local ionospheric environment.

Across the evaluation, NIM reduced double-differenced ionospheric-delay interpolation errors by roughly 30–40% compared with LIM when gradients were most significant. The improvement is important because more accurate corrections bring float ambiguity estimates closer to their integer values, increasing the likelihood of a fast and reliable fixed solution.

Hong Kong mean error falls from 1.11 cm to 0.72 cm

The active-day Hong Kong experiment provides a practical example. Using a 9.3-kilometre connection between the HKST master station and HKSC user station, the team compared NIM and LIM on 24 March 2024.

Figure 3 shows that NIM retained lower errors as ionospheric activity intensified from noon onwards. Between 14:00 and 16:00 local time, LIM produced errors exceeding 3 cm for several satellite tracks, while NIM generally remained below that level. For selected satellites, NIM improved precision by approximately 0.5–1 cm.

Across the active noon-to-midnight interval, mean interpolation error fell from 1.11 cm with LIM to 0.72 cm with NIM. Root-mean-square (RMS) error decreased from 1.47 cm to 0.99 cm. These differences may appear modest in absolute terms, but centimetre-scale residuals can determine whether ambiguities fix correctly, convergence slows or a receiver remains in lower-accuracy float mode.

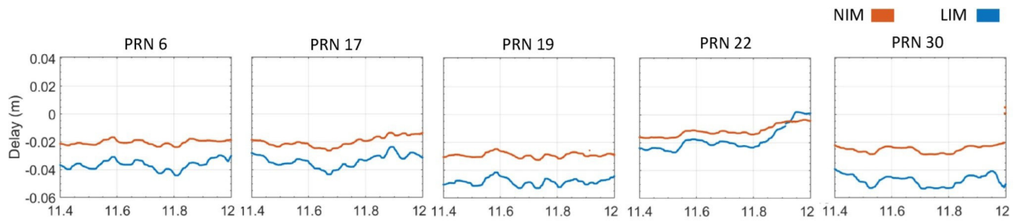


Figure 4. Comparison of the results obtained from NIM and LIM on 12 May 2024 against the reference values from double-difference ionospheric delays

Storm-time RMS error falls from 4.0 cm to 2.1 cm

Storm-time performance was even more striking. The May 2024 geomagnetic storm provided an exceptionally severe test, with the disturbance reaching a Dst index of −413 nT on 11 May. Strong electric fields and solar-driven disturbances increased total electron content and sharpened spatial gradients near the EIA.

In *Figure 4*, NIM reduced interpolation errors for several satellites by approximately half on 12 May. For one representative signal, error fell from 4 cm with LIM to 2 cm with NIM. During the storm's most active periods, NIM maintained interpolation accuracy below 2 cm for selected satellites where LIM exceeded 3 cm.

Across the storm interval, mean error declined from 2.4 cm to 1.1 cm, while RMS error fell from 4.0 cm to 2.1 cm. The three-sigma error range also narrowed from 9.5 cm to 5.0 cm. These results show that NIM remained more stable precisely when conventional linear interpolation was under the greatest pressure.

Ambiguity-resolution success improves by up to 10%

Improved ionospheric corrections translated directly into stronger positioning performance. During active periods, NIM increased instantaneous ambiguity-resolution success by 9.4% and continuous-epoch success by 7.6%. Around 14:00, success rates rose from roughly 60% under LIM to more than 80% with NIM.

The May storm assessment also found that NIM reduced average convergence time from approximately 2.7 seconds to 1.8 seconds, an improvement of around one-third. Positioning errors became more tightly distributed in both horizontal and vertical directions.

The reported positioning precision reached about 1.1 cm horizontally and 3.8 cm vertically. For a drone, faster fixing can support dependable take-off, route entry and recovery after a brief signal interruption. For intelligent transport, it can also improve confidence in automated decisions, navigation and control.

Better corrections strengthen RTK operations

NIM's advantage is operational as well as numerical. By addressing both station-related and satellite-path-related ionospheric variation, it improves the correction supplied to the user without abandoning the established network RTK architecture. This suggests that better modelling could complement, rather than simply replace, investment in denser reference-station networks.

NIM offers a practical advance for network RTK in regions vulnerable to strong ionospheric gradients. The results show that explicitly incorporating IPP trajectory information can reduce interpolation errors by 30–40%, nearly halve storm-time RMS error and improve both convergence and ambiguity resolution.

As solar activity remains elevated, this resilience will become increasingly important. For Hong Kong and other low-latitude regions, nonlinear interpolation could help make centimetre-level GNSS positioning more dependable when the ionosphere is most disturbed. This would strengthen the positioning foundation needed for scalable drone services, autonomous mobility and intelligent transport during Solar Cycle 25 and beyond.

Prof. Chen has been engaged in satellite positioning research for over four decades, with expertise in GNSS positioning and applications, network RTK, ionospheric effects, seamless urban navigation and multi-sensor integration. His work has been recognised through a series of awards, including the Smart Living Partnership Awards in 2022, the Hong Kong Smart City Awards in 2018, a Silver Medal at the Special Edition 2021 Inventions Geneva Evaluation Days, a Silver Medal at the International Exhibition of Inventions Geneva in 2023 and a Gold Medal in 2024. In 2026, Prof. Chen's project "Hong Kong GNSS signal quality monitoring and interference detection system", Hong Kong's first GNSS signal quality monitoring and interference detection platform, won a 2026 Edison Award. Through more than 300 publications and numerous funded projects, Prof. Chen has made sustained contributions to improving the reliability of high-precision positioning, particularly under the demanding ionospheric conditions of low-latitude regions such as Hong Kong.

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[1] Liu, T., Chen, W., Mi, X. et al. Ionospheric nonlinear interpolation model for Mid- and Low-latitude network RTK during solar maxima. *GPS Solutions* 30, 7 (2026). https://doi.org/10.1007/s10291-025-01976-9

Overcoming Urban-Canyon Positioning Challenges

3D LiDAR-Aided GNSS-RTK Tackles Signal Blockage and Poor Satellite Geometry

Dense urban canyons pose significant challenges for GNSS-RTK signal reception by UAVs and vehicle navigation systems. High-rise buildings can obstruct direct signal paths, while reflected signals introduce positioning errors. Prof. Hsu and his team develop a system integrating GNSS-RTK, LiDAR and INS that addresses these challenges. Tested successfully on Hong Kong's complex urban streets, the system improved positioning accuracy by more than 70%.

Prof. Li-Ta HSU
Associate Professor and
Limin Endowed Young Scholar in
Aerospace Navigation,
Department of Aeronautical and
Aviation Engineering



Global navigation satellite systems (GNSS) support applications ranging from everyday navigation to autonomous driving and low-altitude drone operations. With real-time kinematic (RTK) corrections, GNSS can achieve centimetre-level accuracy in open environments. That performance, however, can deteriorate sharply in urban canyons.

Buildings, trees and large vehicles such as double-decker buses may block direct satellite signals or reflect them before they reach the receiver. These non-line-of-sight (NLOS) measurements contain substantial errors that can corrupt the estimated position. Obstructions also reduce the number and spatial distribution of visible satellites, weakening positioning geometry and making it harder to resolve the integer ambiguities needed for precise RTK solutions.

In a recent study published in *IEEE Transactions on Instrumentation and Measurement* [1], Prof. Li-Ta HSU, Associate Professor of the Department of Aeronautical and Aviation Engineering at The Hong Kong Polytechnic University, and his research teams, address this problem by tightly integrating 3D LiDAR with GNSS-RTK and an inertial sensor. The resulting system improved positioning accuracy by more than 70 % compared with conventional GNSS-RTK in challenging urban environments while remaining suitable for real-time operation.

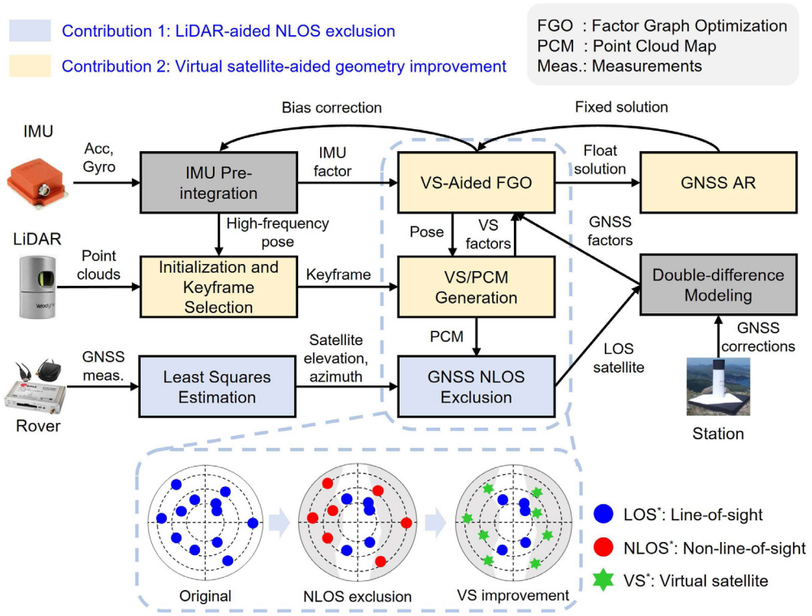


Figure 1. Pipeline overview of the proposed system

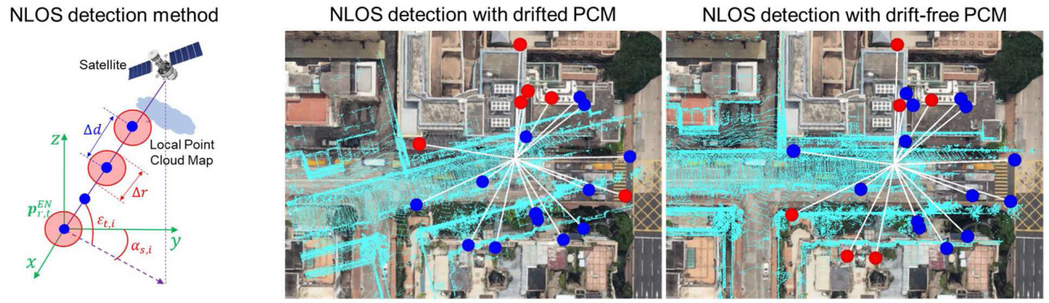


Figure 2. Illustration of the proposed 3D LiDAR-aided NLOS detection based on a drift-free PCM. **(a)** Details of the method **(b)** Comparison of satellites' occlusion in the same epoch by a drifted and a drift-free PCM. Red dots represent NLOS satellites and blue dots are LOS satellites

One system combines global position, local geometry and motion

The proposed approach combines three complementary sources of information. *Figure 1* shows the overall pipeline of the tightly coupled system. GNSS-RTK provides global position measurements, an inertial measurement unit tracks short-term motion and a 3D LiDAR continuously scans the surrounding buildings and objects. From the LiDAR data, the system constructs a live 3D point-cloud map (PCM). This map serves two essential purposes: first, it identifies which satellite signals are likely to have been reflected and are therefore unreliable; second, it generates additional "virtual satellites" that help fill geometric gaps left by the real constellation. All measurements are jointly processed in a factor-graph optimisation framework that estimates position, velocity, sensor biases and float ambiguities together.

Cleaning the signals and strengthening the geometry

Two technical contributions lie at the heart of the method. The first one concerns reliable detection of NLOS signals. Earlier LiDAR-aided techniques [2] sometimes suffered from a gradual drift in the PCM, which could lead to incorrect visibility decisions. The new system corrects this drift through periodic global pose-graph optimisation that incorporates the improved GNSS solutions. *Figure 2* illustrates how a drift-free PCM improves NLOS detection compared with a drifted map. With an accurate, drift-free map, the algorithm searches along each satellite's line of sight and checks for intersections with mapped structures, allowing contaminated measurements to be excluded before they affect the solution.

The second contribution addresses poor satellite geometry. After NLOS exclusion, only high-elevation satellites often remain, leaving large uncertainty in the cross-street direction. Planar features extracted from the LiDAR scans are therefore treated as virtual satellites. These virtual observations supply useful constraints at lower elevation angles and significantly improve the overall geometry. To keep the system efficient, only about 200 carefully selected LiDAR features are used in each optimisation window, and their weights are dynamically balanced against the real GNSS measurements so that neither sensor dominates. The complete process, including integer ambiguity resolution, takes an average of approximately 70 ms, which supports real-time operation.

Results from one of Hong Kong's most challenging urban canyons

The method was evaluated on three challenging sequences from the open-source UrbanNav dataset, collected in

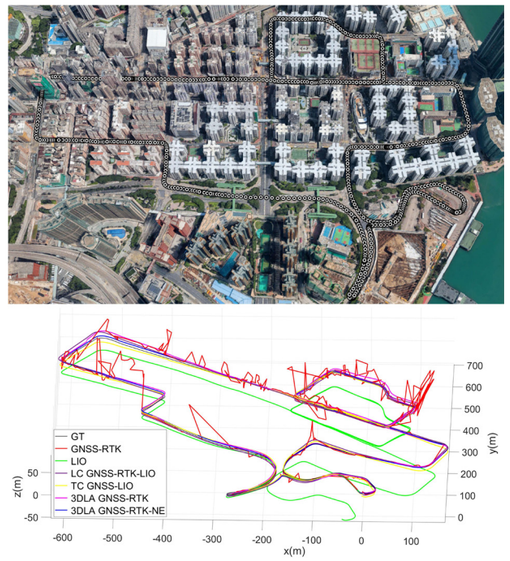


Figure 3. Trajectory in a highly urbanised area. The upper image shows the trajectory projected on Google Earth. The lower image shows the 3D trajectories produced by different methods

Hong Kong. *Figure 3* shows the longest and most difficult trajectory in the evaluation. Lasting roughly 25 minutes, it passes through areas of dense high-rise buildings, tree cover and frequent double-decker buses—conditions that severely degrade conventional GNSS-RTK.

In this environment, the conventional GNSS-RTK solution produced a mean 3D error of nearly 10 m, with peaks approaching 100 m. The ambiguity-fixing rate was only about 1.2 % and positioning was available for just 60 % of the time. When the same data were processed with the proposed LiDAR-aided system, the mean 3D error fell to approximately 2.1 m and the largest errors were reduced to around 6 m. The ambiguity-fixing rate rose to nearly 9 %, and continuous solutions were maintained throughout the trajectory. These figures represent an improvement of roughly 78 % in average accuracy compared with standalone GNSS-RTK.

Consistent gains were observed in the two shorter sequences as well. In the least complex canyon, the method achieved a mean 3D error of 0.44 m. In the intermediate canyon, the corresponding figure remained below 0.8 m. Across all tests, the combination of reliable NLOS exclusion and virtual-satellite geometry improvement proved decisive. The system also demonstrated that a relatively small number of well-chosen LiDAR features is sufficient to constrain the state effectively, offering a practical balance between accuracy and computational cost.

Contribution of the improvement

Dependable positioning is a foundational requirement for both smart transport and the emerging low-altitude economy. Delivery drones operating between buildings, future air-taxi corridors above city streets and autonomous or highly automated ground vehicles all need continuous, trustworthy location information. Errors of tens of metres are simply unacceptable for safe navigation or precise landing. By reducing mean errors from nearly 10 m to about 2 m in the most difficult test, and to below 1 m in the two easier ones, while maintaining real-time performance, the demonstrated approach helps to lower a significant practical barrier. It also suggests that GNSS-RTK, when aided by LiDAR and inertial sensing, can reach sub-metre to metre-level accuracy even in demanding urban conditions.

Accurate positioning remains one of the most stubborn challenges for both ground vehicles and low-altitude aircraft operating in dense cities. By combining GNSS-RTK with 3D LiDAR and inertial sensing, the work presented here shows that the two classic problems of urban navigation, reflected signals and poor satellite geometry, can be substantially mitigated in real time. Tests on challenging Hong Kong urban sequences reduced average errors by more than 70 % compared with conventional GNSS-RTK and kept the system running at a practical computational cost. The result is a clearer path toward the reliable, metre-level positioning that smart transport and the low-altitude economy will need if they are to operate safely at scale.

Prof. Hsu was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (career-long) in the field of networking and telecommunications for three consecutive years, from 2024 to 2026, and one of the top 2% most-cited scientists worldwide (single-year) for seven consecutive years, from 2020 to 2026. He also received the Per Enge Early Achievement Award from the Institute of Navigation (ION) in 2022, which recognised his outstanding accomplishments in the early stages of his career in the field of navigation, as well as his significant contributions to GNSS positioning in urban environments. He has published more than 160 journal papers, many appearing in leading international journals in the fields of navigation, intelligent transportation and aerospace systems. For 2023 and 2024, papers co-authored by Prof. Hsu received the Most Cited Manuscript Award in the journal *NAVIGATION*, including a factor graph optimisation study first-authored by Dr Weisong WEN. Prof. Hsu currently serves as an Associate Editor for *IEEE Transactions on Aerospace and Electronic Systems* and leads the Intelligent Positioning and Navigation Laboratory at PolyU, focusing on GNSS, multi-sensor fusion and reliable positioning for autonomous systems in urban environments.

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[1] X. Liu, W. Wen, F. Huang, H. Gao, Y. Wang and L.-T. Hsu, 3-D LiDAR-Aided GNSS NLOS Mitigation for Reliable GNSS-RTK Positioning in Urban Canyons, *IEEE Transactions on Instrumentation and Measurement*, vol. 74, pp. 1-15, 2025, Art no. 9544915, doi: 10.1109/TIM.2025.3629836.

[2] W. Wen and L.-T. Hsu, 3D LiDAR Aided GNSS NLOS Mitigation in Urban Canyons, *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, no. 10, pp. 18224-18236, Oct. 2022.

When Connectivity Shapes the Flight Path

A Foundational Step Towards Reliable Network-Connected Aerial Operations

UAVs are increasingly used for large-scale missions, yet remote control becomes harder over greater distances. Cellular networks offer a reliable solution for command and data links. Prof. Zhang's paper, which received the 2022 IEEE Communications Society Young Author Best Paper Award, presented a pioneering systematic framework for planning trajectories of cellular-connected UAVs under continuous connectivity constraints. It enables communication-aware design and has laid key foundations for later research on trajectory optimisation.



Prof. Shuowen ZHANG
Assistant Professor,
Department of Electrical and Electronic Engineering

Imagine an unmanned aerial vehicle (UAV) carrying out tasks such as cargo delivery, aerial surveillance, video streaming or infrastructure inspection. In conventional systems, it communicates directly with a nearby pilot or ground control station, which can limit its range, reliability and data capacity.

Cellular-enabled UAV communication offers an alternative: the UAV functions as an aerial user of an existing cellular network and is served by ground base stations (GBSs) as it flies (*Figure 1*). This allows its control signals and mission data to use the network's broader coverage and higher-capacity connections. However, it also raises a new question: if the UAV must fly from point A to point B while maintaining connectivity, along what path should it fly?

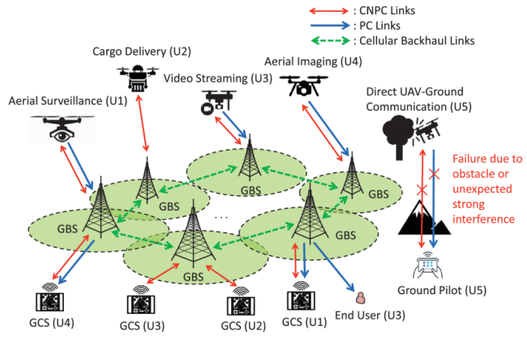


Figure 1. Schematic diagram for cellular-enabled UAV communication and the relationship between the UAV, ground base stations and its ground control station

The shortest route may pass through a coverage gap. A route with the strongest signal may require a lengthy detour. For beyond-visual-line-of-sight operations, losing the communication link is not simply an inconvenience: it may prevent the UAV from receiving commands, reporting its status, or transmitting mission data.

In a paper published in *IEEE Transactions on Communications* [1], Prof. Shuowen ZHANG, Assistant Professor of the Department of Electrical and Electronic Engineering at The Hong Kong Polytechnic University, and her collaborators addressed this problem. The work presented a clear and extensible framework for planning the movement of a cellular-connected UAV while preserving the quality of its communication link, which helped establish communication-aware trajectory design as a distinct and important problem in UAV research. Its contribution was later recognised with the IEEE Communications Society Young Author Best Paper Award in 2022, as one of the only two awarded papers worldwide.

From a flight route to a mathematical problem

This paper considered a focused but widely relevant setting. A UAV must travel from a given initial location to a specified final location in the shortest possible time. During the mission, it must remain connected to the cellular network, with the received signal quality never falling below a prescribed threshold.

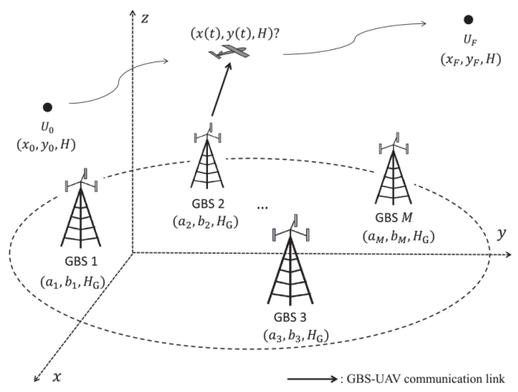


Figure 2. System model for a UAV travelling from an initial location to a final location while maintaining a required communication quality with the cellular network. U_0 denotes the initial location and U_F is the final location

The system model in *Figure 2* shows the basic arrangement: a UAV travels at a fixed altitude between two locations while several GBSs are distributed across the ground. As the UAV moves, it associates with the GBS offering the strongest channel and may hand over to another station when necessary.

This formulation captures an important requirement of network-connected aerial operations. A UAV may need to maintain a reliable command-and-control link while also transmitting images, videos or other mission data. The route must therefore satisfy a communication constraint at every point, not merely at the beginning and end of the flight.

That makes the problem difficult. The trajectory is a continuous function of time, and the connectivity requirement must hold continuously as well. The UAV must also decide where to fly, which GBS to use and when to hand over. Conventional route planning, which often optimises distance or time first and evaluates communication performance afterwards, cannot easily handle these decisions together.

The beauty of this paper's approach is that they did not treat this complexity as an obstacle requiring a purely numerical search. They looked for the mathematical structure hidden within the physical problem. By doing so, they transformed an apparently infinite-dimensional trajectory-design problem into a finite sequence of geometric and graph-based decisions.

The hidden structure of the optimal route

The first major insight was that the optimal trajectory is not an arbitrary curved path. Under the assumptions of the model, it consists of connected straight-line segments flown at the UAV's maximum speed.

During each segment, the UAV remains associated with one GBS. It hands over to another GBS at a point where their required coverage regions overlap (*Figure 3*). This result is both mathematically useful and physically intuitive: once feasible handover points have been chosen, slowing down or following a curved path would only increase the flight time.

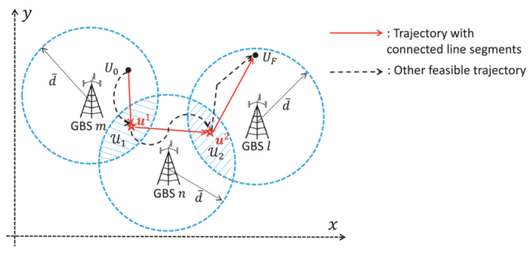


Figure 3. The optimal trajectory (red arrows) formed by connected straight-line segments, compared with longer feasible paths that include unnecessary curvature or detours (dotted arrows)

This finding substantially simplifies the original problem. Instead of designing an entire continuous trajectory point by point, the only remaining task is to determine:

1. the sequence of GBSs with which the UAV will associate; and

2. the locations at which handovers will occur.

The handover locations can further be restricted to the boundaries of overlapping coverage regions. These boundaries are the transition areas where the UAV can remain within the required communication range of both its current and next serving GBS.

The result illustrates the value of mathematical modelling in practical engineering. The original question "Where should the UAV fly?" is replaced by a more structured set of questions: "Which coverage regions should it pass through?" and "Where should it move from one region to the next?" A continuous flight path becomes a finite geometric object that can be analysed and optimised.

Turning coverage into a graph

This paper then used graph theory to represent the possible movement between coverage regions. Each GBS becomes a vertex in a graph (*Figure 4*). Two GBSs are connected by an edge when their coverage areas overlap sufficiently for the UAV to move between them without losing the required signal quality. The initial and final UAV locations are connected to the GBSs that can serve them.

This graph provides an efficient answer to a fundamental question: is the mission feasible at all? If the initial and final locations are connected through a sequence of overlapping coverage regions, the UAV has at least one possible route that preserves connectivity. If no such path exists, the required signal-quality threshold cannot be met, regardless of how the UAV attempts to fly.

The graph can also guide the optimisation itself. A path through the graph represents a possible sequence of GBS associations. The distance associated with that path provides a route cost, while convex optimisation is used to refine the precise handover locations.

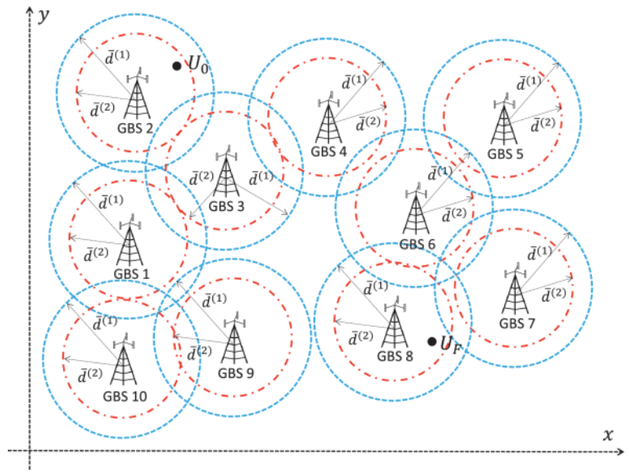
In this way, this paper converted a difficult engineering problem into a mathematically well-structured combination of graph connectivity, shortest-path search, and geometric optimisation. It revealed why feasible routes exist, what their structure should be and how solution quality can be balanced against computational complexity. Particularly, by judiciously exploiting the problem structure and proposing a novel quantization-based graph construction approach, this paper developed a polynomial-time algorithm that is analytically proved to arbitrarily approach the optimal solution of this challenging non-convex continuous optimization problem. This paves the way for fast yet performance-guaranteed UAV deployment in practical missions.

A milestone in UAV communication

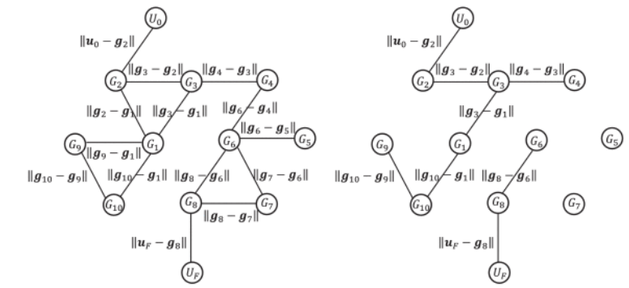
The lasting value of the study lies in the way it framed a problem that would become increasingly relevant as UAVs moved towards large-scale networked operation.

The study made a clear conceptual contribution: cellular connectivity should be incorporated into UAV trajectory design from the beginning, rather than assessed after a route has already been chosen. It also demonstrated how mathematical abstraction can make a practical problem easier to understand and solve. Physical coverage regions became geometric constraints; handovers became graph transitions; and flight planning became an optimisation problem with a clear structure.

The framework is also extensible. Subsequent studies have considered more complex settings involving interference, multiple UAVs, energy consumption, three-dimensional movement, non-line-of-sight channels, coordinated transmission and dynamic resource allocation. These extensions introduce new challenges, but they build on the same central insight: a UAV's movement and communication environment cannot be designed independently.



(a) Horizontal locations of U_0, U_F and $M = 10$ GBSs



(b) Graph G with $\bar{d} = \bar{d}^{(1)}$: Feasible case (c) Graph G with $\bar{d} = \bar{d}^{(2)}$: Infeasible case

Figure 4. Relationship between overlapping GBS coverage regions and the corresponding graph. A connected path from the initial to the final location represents a feasible sequence of cellular associations

In moving cellular-connected UAVs from an attractive concept towards practical deployment, this study provided an important early theoretical foundation. It showed that a connected UAV does not simply follow a route through physical space. It follows a route through the communication network as well.

Prof. Zhang was recognised by Stanford University as one of the top 2% most-cited scientists worldwide (single-year) in the field of networking and telecommunications for six consecutive years, from 2021 to 2026. She is a rising young scholar in communications technology. Her research frequently receives international recognition. She is the sole recipient of the 2021 Marconi Society Paul Baran Young Scholar Award and the 2025 IEEE Communications Society Communication Theory Technical Committee (CTTC) Early Achievement Award. She is a recipient of the 2024 IEEE Communications Society Asia-Pacific Outstanding Young Research Award, the 2023 PolyU Young Innovative Researcher Award, the 2023 IEEE Communications Society Best Tutorial Paper Award, and the 2022 IEEE Communications Society Young Author Best Paper Award. She is recognised by N2Women (Networking Networking Women) as one of the ten "N2Women 2024 Rising Stars in Computer Networking and Communications" and one of the Rising Stars in EECS, Class of 2019. Prof. Zhang is currently serving as an Editor for *IEEE Transactions on Wireless Communications* and an Associate Editor for *IEEE Transactions on Mobile Computing*. She is the Project Coordinator (PC) of a 2025/2026 Hong Kong Research Grants Council Collaborative Research Fund (CRF) Young Collaborative Research Grant.

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MTR and PolyU Co-Host 6th MTR GOSI Technical Seminar



The 6th MTR Global Operations Standards Institute Technical Seminar (GOSI TS6) was held in Hong Kong from 9 to 11 July 2026. Jointly hosted by MTR Corporation and PolyU, the seminar brought together experts and representatives from the railway, aviation, tourism, logistics, technology and academic sectors to exchange views on operational excellence, customer service, digital transformation, railway innovation and sustainable development.

At the opening ceremony, Ir KH LEE, Deputy Director – Operations Engineering Maintenance of MTR Corporation, and Ir Prof. Christopher CHAO, Senior Vice President (Research and Innovation) and Chair Professor of Thermal and Environmental Engineering of PolyU, delivered welcoming remarks and highlighted the importance of industry–academia collaboration in advancing railway innovation and operational excellence. The programme also featured keynote speeches, panel discussions, group presentations and project showcases by the GOSI Young Members Committee.

On 11 July, participants visited the Hong Kong Branch of the National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail (HK Branch)) at PolyU as part of the technical visit programme. Dr Vincent Wai Kei AO, Research Fellow of CNERC-Rail (HK Branch), introduced the centre's development, research areas and latest achievements, followed by a tour of its laboratories and research platforms. Discussions focused on smart railway technologies, intelligent maintenance, automated inspection and future research collaboration.

The seminar provided a valuable platform for knowledge exchange and further strengthened collaboration among railway operators, industry partners and academic institutions.

Partnership

PolyU and Lands Department Join Forces to Advance Geospatial Social Innovation for Smart and Inclusive Urban Development

The Research Institute for Land and Space (RILS) of PolyU, the Survey and Mapping Office (SMO) of the Lands Department, HKSAR Government, and The Jockey Club Design Institute for Social Innovation (J.C.DISI) of PolyU have officially established the Special Interest Group on Geospatial Social Innovation (SIG-GSI), marking a new milestone in promoting the application of geospatial technologies and social innovation for the public and community benefit.

The formation of the SIG-GSI builds upon the memorandum of understanding (MoU) established between PolyU and the Lands Department in September 2025 to advance smart surveying, mapping and geospatial services that incorporate authoritative standards.

As the first major initiative under this collaboration framework, the Group brings together RILS, SMO and J.C.DISI, with J.C.DISI joining as a new collaborating unit.

The convenors of the SIG-GSI are Prof. DING Xiaoli, Director of RILS; Mr CHOI Wai Man Raymond, Chief Land Surveyor/Land Information Centre, Mr SO Man Cheong Kenneth, Chief Survey Manager/Special Duties of SMO; and Ms Sam LAM, Interim Director of J.C.DISI.



The Group held its inaugural meeting on 9 July 2026 at PolyU.

The SIG-GSI provides a platform for academia, government and social innovation practitioners to collaborate in leveraging spatial data and geospatial technologies to address urban and community challenges. Through research exchange, capacity building, pilot projects and professional activities, the Group aims to advance applications of spatial data and geospatial technologies in areas such as community development, social inclusion, walkability and smart city development, while promoting innovative solutions that contribute to the public and social good.

PolyU and Geely Farizon Establish Joint Lab to Promote Methanol-Electric Mobility for Carbon-Neutral Hong Kong

PolyU and Geely Farizon New Energy Commercial Vehicle Group (Geely Farizon) recently held a signing ceremony on the PolyU campus to officially establish the "PolyU–Farizon Transport and Energy Joint Laboratory" (the Joint Lab), focusing on industrial development policies in relation to methanol-electric technologies, promoting their development across technical, economic and social dimensions, and building a new methanol ecosystem to help Hong Kong achieve its carbon neutrality goals.



PolyU's Department of Land Surveying and Geospatial Science (LSGS)[Note 1] has a proven track record in green transport, energy policy and smart city development, generating significant impact in the low-carbon transport sector. This new collaboration will leverage PolyU interdisciplinary research capabilities to provide solid academic support for the emerging methanol ecosystem.

The MoU was signed by Prof. CHEN Wu, Head of LSGS[Note 1] at PolyU, and Dr SONG Zhaohuan, Vice President and Chief Brand Officer of Geely Farizon. A project agreement marking the official launch of research on methanol-electric vehicles in Hong Kong was subsequently signed by Prof. Tony ZHUGE Chengxiang, Assistant Professor of LSGS[Note 1] at PolyU, and Mr Jack YANG, Head of Hong Kong Project Team at Geely Farizon.

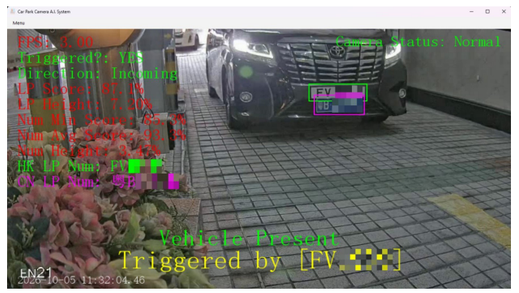
The Joint Lab will focus on three directions: research on policies for promoting and popularising methanol-electric technologies in public transport; development of a smart energy supply operation platform tailored to Hong Kong's green transport and urban traffic context; and feasible solutions and advisory reports for the local introduction of methanol-electric vehicles. Furthermore, a methanol-electric industry-academia-research fund and expert network will be established.

Notes

1. The Department of Land Surveying and Geospatial Science (LSGS) was retitled from the Department of Land Surveying and Geo-Informatics (LSGI) with effect from 1 July 2026.

Innovation

PolyU Scholar Licenses Patented LPR Technology to PSL for Smart Car Park Access Control



Prof. Edward Chin-shin CHUNG, Professor of the Department of Electrical and Electronic Engineering at PolyU, has recently signed a licensing agreement with Parking Systems Limited (PSL) for using his and his research team's patented License Plate Recognition (LPR) technology and software for automatic car park access control. The software is now in production phase at the PSL car parks.

Their LPR technology contains computationally efficient algorithms and computer vision AI models that search for the positions of licence plates and subsequently extract the correctly ordered licence plate numbers. It is designed and tested to perform well in extensive adverse conditions, such as high-speed vehicles, dim environments, the camera being flashed by vehicle head lights, blurry views caused by dust and raindrops and rotated camera views.

To facilitate the "Southbound Travel for Guangdong Vehicles" arrangement of the HKSAR government, the LPR technology previously developed for the Hong Kong licence plate format is now upgraded to include the Chinese Mainland and Macao formats.

Building on the LPR technology, a software for automatic car park access control was developed and integrated into PSL's car park management system through an application programming interface (API). The parking software also includes a graphical user interface (GUI) designed for car park management and is featured by extended functionalities, including (1) detection of vehicle retreat (without entering the gate) and reverse vehicle access, (2) dual camera channels for enhanced robustness and accuracy, and (3) camera anomaly detection for shifted, rotated and blurred camera views.

Paper Award

PolyU Team of Research Students and Researchers Receives Best Paper Award at CTS 2026



A PolyU team clinched a Best Paper Award at the 17th International Workshop on Computational Transportation Science (CTS 2026) held at Central South University in Changsha, China, from 7 to 9 August 2026.

The winning team included Mr LI Yu and Mr JIN Zhicheng, both PhD candidates from PolyU's Department of Electrical and Electronic Engineering, Dr FAN Wenbo, Research Assistant Professor, and Prof. GU Weihua, Associate Professor, from the same department, as well as Prof. WU Lingxiao, Assistant Professor from the Department of Aeronautical and Aviation Engineering at PolyU. The team was supervised by Prof. GU.

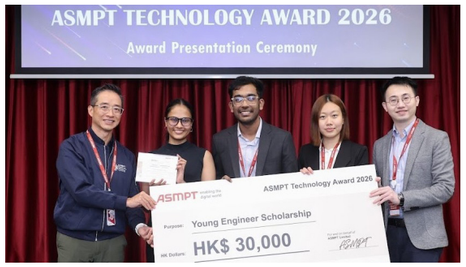
The winning paper, titled "Altitude-Aware Distributionally Robust Drone Delivery Routing under Wind Uncertainty", integrates three-dimensional drone routing, flight-level selection and battery configuration with weather-informed optimisation to support reliable urban delivery under uncertain wind conditions. Practically, it helps operators reduce delivery costs and manage delay and energy-shortfall risks, supporting smart logistics and the development of the low-altitude economy.

This year's workshop, themed "Digital Intelligence Empowerment and Resilient Collaboration", gathered more than 500 experts and scholars from 137 universities and research institutions both domestically and internationally.

The workshop was co-hosted by Central South University and the Organising Committee of the International Workshop on Computational Transportation Science (CTS). It was jointly organised by the School of Traffic and Transportation Engineering of Central South University, the State Key Laboratory of Heavy-duty and Express High-power Electric Locomotive, and the Key Laboratory of Complex Systems Analysis and Management Decision of the Ministry of Education, and co-organised by CRSC Low-Altitude Intelligent Technology Co., Ltd. It was also supported by "Future Urban Traffic Management", a project under the National Natural Science Foundation of China (NSFC) Excellence Research Group Programme.

Competition

PolyU's Then-Undergraduate Team Claims Bronze Award at ASMPT Technology Award 2026



An inter-departmental final year project accomplished by students who were undergraduates at the time from the Department of Aeronautical and Aviation Engineering (AAE), the Department of Electrical and Electronic Engineering (EEE) and the Department of Mechanical Engineering (ME) at PolyU won the Bronze Award at the ASMPT Technology Award 2026, held on 10 July 2026. Prior to this, the project was also recognised as the Best Project Award at the Inter-departmental Final Year Project 2025/26.

The awarded project is titled "Intelligent UAV Systems for GNSS-Based Remote Sensing on Vegetation". Traditional ground object detection (e.g., vegetation monitoring) relies on manual surveys, costly aerial imaging or low-resolution satellite images. This work integrates Global Navigation Satellite System Reflectometry (GNSS) onto an Unmanned Aerial Vehicle (UAV) platform with higher flexibility, achieving an intelligent remote-sensing system for ground object monitoring.

This complex project was supervised by Prof. ZHANG Guohao, Assistant Professor from PolyU's AAE, and co-supervised by Prof. HSU Li-Ta, Associate Professor and Limin Young Scholar in Aerospace Navigation from the same department.

The team members were Ms ZHOU Jiayi and Mr Md Sahat MAHMUD, both from AAE; Ms Sashenka GAMAGE from EEE; and Ms TAN Qing Lin from ME.

The ASMPT Technology Award, led by ASMPT Limited, is a symbol of its commitment to technological innovation in Hong Kong. This year marks the 11th ASMPT Technology Award, which aims to promote excellence in technology. It is an interdisciplinary award that invites participation from top faculties in Hong Kong and aims to recognise and reward students with extraordinary final year projects which showcase technological advancement and innovative thinking.

This year, 12 exceptional projects were nominated by the six participating universities to compete for the awards. The nominees presented their projects in 20-minute sessions, followed by a 10-minute Q&A with a panel of judges comprising ASMPT leaders, university faculty and industry experts. The judging criteria focused on technical performance, project quality, creativity, originality, applicability and practicability.

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Research Newsletter

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